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Health effects of nitrogen oxides as air pollution

Skutki zdrowotne zanieczyszczenia powietrza tlenkami azotu

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The article is based on a lecture presented on 21 April 2016 during the 6th Scientific Conference in honor of Brig. Gen. Assoc. Prof. Wojciech Lubiński MD, PhD: *Health effects of air pollution* at the Military Institute of Medicine in Warsaw.

Abstract. The exposure of the population to the nitrogen dioxide (NO_2) in the air results from emissions of nitrogen oxides from diverse combustion processes, in particular from vehicle engines. Studies conducted in recent decades indicate that both short- and long-term exposure to air pollution containing NO_2 in concentrations close to or even lower than the currently binding norms is associated with increased mortality and more frequent hospital admissions. It is probable that NO_2 exposure contributes to the development of asthma, while different clinical studies conclude that increased NO_2 exposure exacerbates asthma. The prevention of these significant health effects requires lowering the exposure of the population to air pollution from road transport. This is feasible primarily through reducing road traffic in densely populated urban areas. Changing from cars to public transport, cycling and walking should also contribute to an increase in physical activity, another important issue in chronic non-communicable disease prevention.

Key words: respiratory diseases, circulatory diseases, nitrogen dioxide, mortality, air pollution

Streszczenie. Narażenie ludności na dwutlenek azotu (NO_2) w powietrzu jest następstwem emisji tlenków azotu z różnych procesów spalania, zwłaszcza z silników samochodowych. Badania prowadzone w ciągu ostatnich dziesięciu lat wskazują, że zarówno krótko-, jak i długookresowe narażenie na zanieczyszczenia powietrza NO_2 w stężeniach bliskich lub nawet mniejszych niż obecne obowiązujące normy jest związane ze zwiększoną umieralnością i częstszymi pobytami w szpitalu. Prawdopodobne jest również to, że NO_2 przyczynia się do rozwoju astmy, a badania kliniczne pozwoliły stwierdzić, że zwiększone stężenia NO_2 są przyczyną zaostrzeń astmy. Zapobieganie tym istotnym skutkom zdrowotnym wymaga zmniejszenia narażenia ludności na zanieczyszczenia powietrza z transportu drogowego, co jest możliwe do osiągnięcia głównie przez zmniejszenie ruchu pojazdów w gęsto zaludnionych częściach miast. Zamiana podróży samochodem na przemieszczanie się transportem publicznym, rowerem i pieszo przyczyni się również do zwiększenia aktywności fizycznej, będącej ważnym aspektem w prewencji chorób przewlekłych.

Słowa kluczowe: choroby układu krążenia, choroby układu oddechowego, dwutlenek azotu, umieralność, zanieczyszczenia powietrza

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Introduction

Every combustion process involving nitrogen from the air combines it with oxygen to create nitrogen oxides (NO_x). This reaction is particularly rapid at the high temperatures produced in vehicle engines, especially compression ignition engines, or in highly efficient power plants. In ambient air, nitrogen oxide quickly reacts with oxygen, forming nitrogen dioxide (NO_2). Further reactions involving NO_2 in the atmosphere result in the creation of nitrates (solid particles) and, in the presence of solar radiation, of ozone. Increased concentrations of nitrogen oxides can also be observed in rooms having gas burners, including kitchens and bathrooms, especially in the absence of proper ventilation.

Toxicological studies demonstrate that NO_2 at very high concentrations may result in reduced immunity to bacteria and viruses, while at concentrations slightly above those found in cities it may cause bronchial hyper-reactivity in asthma patients [1]. Due to the omnipresence of the sources of nitrogen oxides associated with human activity, most people are exposed to this highly oxidative gas in their environment. The effects of exposure to NO_2 at concentrations observed in the human environment have been studied in numerous epidemiological and clinical studies, which in 2005 resulted in the formulation of the global WHO

guidelines regarding acceptable exposure to NO_2 (1-hour mean of 200 µg/m^3, and annual mean of 40 µg/m^3) [1]. The same values were adopted by the European Union as limit exposure values, and are binding as acceptable limits in Poland.

In recent years, there has been significant progress in our understanding of the health consequences of our exposure to NO_2 at concentrations commonly observed in many Polish and foreign cities, close to or lower than those recommended by the current standards. The main source of exposure is road transport; therefore, increased NO_2 concentrations are accompanied by increased levels of other pollutants produced by car engines as well as due to tire, road surface and brake wear. Much of this pollution takes the form of fine particulate matter or volatile organic substances, and demonstrates adverse effects to the health. One important challenge for the studies was to establish the specific effect of NO_2 on the health, as opposed to the general effect of pollution associated with road traffic. The aim of this article is to present and summarize the most important results of recent studies and literature reviews dedicated to the health consequences of air pollution involving NO_2, as well as to discuss the impact this knowledge has for protecting the health of the population in Poland.

Exposure to NO2 and mortality

The assessment of the relation between short-term changes in NO_2 concentrations in ambient air and mortality was studied in numerous studies using time series analysis. The most recent systematic review identified 123 such studies published until March 2011 [2]. Most were related to the populations of cities in Europe (54), the West Pacific region (31) or North America (24). The greatest number of studies (101) evaluated mortality due to all causes, but many of them also analyzed deaths due to cardiovascular (84) or respiratory (70) causes.

According to previously established criteria for the quality and comparability of such studies, those that could be included in the qualitative metaanalysis were selected. The results of the metaanalysis confirmed a slight, but statistically significant increase in daily general mortality, as well as mortality due to all the analyzed death causes, on or after those days with increased NO_2 concentrations in the air (Table 1). The increase in mortality rates due to cardiovascular or respiratory diseases associated with increased exposure was greater than the rise of mortality rates due to all causes. Significant differences between the results of individual studies were revealed, and the metaanalysis of the studies conducted in different regions of the world demonstrated a slightly more pronounced effect in European and Asian cities than in American ones. For instance, general mortality increased by 0.9% (95% CI: 0.45 –1.35% per 10 µg/m³ increase in NO_2 concentration) in Europe and by 0.32% (-0.01-0.67%) in developed countries in America.

Table 1. Increase in daily mortality (in%) associated with increases in daily mean NO_2 concentrations by 10 µg/m³ as estimated in the meta-analysis [2]
Tabela 1. Zwiększenie dobowej umieralności (w %) związany ze zwiększeniem średniego dobowego stężenia NO_2 o 10 µg/m³ oszacowany w metaanalizie [2]

Cause of death (ICD 10 codes)	% (95% CI)
All causes (categories A-R)	0.71 (0.43–1.00)
Cardiovascular diseases in general (I00–I99)	0.88 (0.63-1.13)
Heart diseases (I00–I52)	1.00 (0.36-1.66)
Ischemic heart disease (I20–I25)	1.61 (0.24-2.99)
Cerebral stroke (I60–I69)	1.35 (0.74-1.97)
Respiratory diseases in general (J00–J99)	1.09 (0.75-1.42)
Obstructive pulmonary diseases, including asthma (J40–J47)	1.11 (0.72-1.50)

In 36 of the available studies, the relation between NO_2 and mortality was analyzed, considering simultaneous exposure to particulate matter pollution, measured primarily as particulate matter with an aerodynamic diameter of <10 µm (PM_{10}, in 23 studies) or <2.5 µm ($PM_{2.5}$, in 7 studies) [3]. In most of the studies, daily mortality significantly associated with mean daily NO_2 concentrations, including after consideration of the effect of particulate matter pollution. Quantitative metaanalysis covering the results for 26 cities located in 5 regions of the world indicated an increase by 0.78% (95% CI: 0.47-1.09%) in general daily mortality rates per 10 µg/m^3 of the mean daily NO_2 in models disregarding particulate matter pollution, and by 0.60% (95% CI: 0.33-0.87%) if their influence was considered. Moreover, the relationship between NO_2 and mortality due to cardiovascular and respiratory diseases did not change significantly after including the effect of particulate matter pollution.

In the last decade, results of epidemiological studies on the relationship between long-term exposure to NO_2 and mortality have become available. The results of 19 cohort studies published between 2004 and 2013 were included in the metaanalysis conducted by Faustini et al. [4]

Table 2. Association of mortality with long-term exposure to NO_2 and fine particulate matter: results of cohort studies
Tabela 2. Związek umieralności z długookresowym narażeniem na NO_2 i drobne pyły: wyniki badań kohortowych

Study	Estimated relative risk per 10 µg/m³ (95% CI)	
	NO_2	$PM_{2.5}$ (*PM_{10})
All causes of death		
Metaanalysis by Faustini et al. 2013 [4]	1.04 (1.02-1.06)	1.05 (1.01-1.09)
ESCAPE – a study of 22 cohorts (model 3) [5]	1.01 (0.99-1.03)	1.14 (1.04-1.26)
ACS cohort [8]	1.04 (1.01-1.07)	1.06 (1.04-1.12)
National English cohort [9]	1.06 (1.03-1.07)	1.21 (1.11-1.31)
Dutch cohort [10]	1.03 (1.02-1.03)	1.08 (1.07-1.09)*
CanCHEC Canadian cohort [11]	1.03 (1.03-1.04)	1.07 (1.06-1.08)
Cardiovascular diseases		
Metaanalysis by Faustini et al. 2013 [4]	1.13 (1.09-1.18)	1.20 (1.09-1.31)
ESCAPE – a study of 22 cohorts (model 3) [6]	1.01 (0.97-1.06)	0.98 (0.82-1.16)
ACS cohort [8]	1.06 (1.01-1.11)	1.12 (1.03-1.34)
National English cohort [9]	1.03 (1.00-1.07)	1.10 (1.00-1.26)
Dutch cohort [10]	1.00 (0.99-1.01)	1.06 (1.04-1.08)*
CanCHEC Canadian cohort [11]	1.03 (1.02-1.04)	1.06 (1.04-1.08)
Respiratory diseases		
Metaanalysis by Faustini et al. 2013 [4]	1.02 (1.02-1.03)	1.05 (1.01-1.09)
ESCAPE – a study of 16 cohorts (model 3) [7]	0.97 (0.89-1.05)	0.78 (0.34-1.24)
ACS cohort [8]	0.99 (0.91-1.09)	1.09 (0.91-1.34)
National English cohort [9]	1.14 (1.09-1.19)	1.63 (1.42-1.84)
Dutch cohort [10]	1.02 (1.01-1.03)	1.13 (1.10-1.17)*
CanCHEC Canadian cohort [11]	1.02 (1.01-1.04)	0.95 (0.90-0.99)
Pulmonary neoplasms		
Metaanalysis by Hamra et al. [12]	1.04 (1.01-1.08)	–
ESCAPE – a study of 17 cohorts (14 for $PM_{2.5}$) [13]	0.99 (0.93-1.06)	1.36 (0.92-1.92)
ACS cohort [8]	1.14 (1.03-1.27)	1.11 (0.91-1.34)
National English cohort [9]	1.10 (1.05-1.16)	1.21 (0.89-1.47)
Dutch cohort [10]	1.10 (1.09-1.11)	1.26 (1.21-1.30)*
CanCHEC Canadian cohort [11]	1.05 (1.03-1.06)	1.06 (1.03-1.09)

The analysis of long-term exposure to NO_2 has also been demonstrated in a number of other publications, presented since 2013, based on large cohorts (from 73 thousand adult subjects observed for 18 years in the ACS study, to 7.1 million adult subjects observed for 7 years in the Dutch cohort) [5-13]. Most of them indicated a significantly increased risk of death due to all causes along with the increase in long-term exposure to NO_2 (Table 2). In numerous studies, the relative risk of exposure to NO_2 was only slightly lower than that estimated for $PM_{2.5}$ in the same populations. In the majority of the studies the risk of death due to cardiovascular, respiratory and neoplastic pulmonary diseases was also significantly related to exposure to NO_2.

Both formal metaanalysis and simple comparison of the power of the relationships observed in individual studies indicate the presence of considerable differences. The authors of the works suggest that the differences may be due to various methods of exposure assessment or data analysis used in the individual studies. The importance of the precise assessment of exposure to NO_2 was emphasized in the analysis conducted in the Canadian cohort (over 735 thousand citizens in 10 Canadian cities, observed in the years 1983-2006) [14]. It demonstrated the relationship between the risk of all deaths, as well as deaths due to cardiovascular and respiratory diseases, and exposure to NO_2, but only when the assessment of exposure included the variability of the pollution levels in the city. The analysis based on comparisons between the exposures in different cities did not reveal a correlation with mortality.

However, the differences in the study outcomes might result from different characterizations of the air pollution mixture, and the disregarding of important elements of the same, especially those from the same source. The possibility that NO_2 concentrations measured or modeled in cities as indicators of the presence of other contaminations associated with motor transport, the primary source of NO_2 in cities, was already taken into consideration in 2005 when the WHO air quality guidelines were formulated [1]. Many of the recently published cohort studies consider in their analyses the potentially disturbing effect of particulate matter pollution. The results of these analyses also demonstrated a high variability: the relative risk of general mortality due to exposure to NO_2 was reduced by 10% in the model including $PM_{2.5}$ in the Roman cohort [15], and by 95% in the English cohort [9]. The data analysis from the ACS and Canadian cohorts also indicated that the combined effect of exposure to several concurrent contaminations (fine particulate matter, NO_2, ozone) was larger than the influence of each of the pollutions estimated separately [8, 11].

Regardless of the degree in which NO_2 concentration reflects the direct effect of the gas on mortality, and in which it is an indicator of another correlated factor (or factors) in the mixture of pollutants associated with transport, it is important to note that an increased risk of mortality was already observed at levels of NO_2 significantly lower than 40 $\mu g/m^3$, as recommended by WHO, and considered a limit value for the Polish and European air quality standards. An increasingly higher risk of death, starting with the lowest observed concentrations, was found in the Canadian cohort (from a few µg /m³) [16], Danish cohort (from about 10 µg /m³ NO_2) [17], Roman cohort (from about 13 µg/m³ NO_2) [15] and Dutch cohort (5^{th} percentile 19 µg/m³ NO_2) [10].

According to the latest evaluation of the scientific knowledge regarding the health effects of exposure to NO_2, conducted by the United States Environment Protection Agency (US EPA), the collected data is suggestive, but insufficient to determine a causal relationship between mortality and exposure to NO_2 [18]. The main source of uncertainty as to the causal character of the relationship is the difficulty in extracting the effect of NO_2 from the effects of other air pollutants emitted by vehicles, and an insufficient understanding of the pathophysiological process that associates exposure to NO_2 with mortality, especially due to cardiovascular diseases. In the assessment prepared by Health Canada, the relationship between mortality and long-term exposure to NO_2 was similarly classified [19]. However, this assessment considered the short-term exposure to NO_2 as a factor "probably demonstrating a causal relation" with daily variations in mortality due to cardiovascular and respiratory diseases.

Exposure to NO2 and health indicators other than mortality

Recording the number of daily hospitalizations in a city enables analysis of the relationship between changes in hospitalization and the level of pollution. A systematic review of the literature published since 2011 identified 94 studies on the relationship between hospitalization and NO_2 concentrations, conducted using the time series method [2]. The metaanalysis of these study results indicated that the number of daily hospitalizations due to all respiratory and cardiovascular diseases was higher on (or after) the days when the NO_2 concentration was increased (Table 3). Increased NO_2 concentration significantly increased the number of hospitalizations of children suffering from asthma or other respiratory diseases, and the number of hospitalizations of patients with chronic obstructive pulmonary disease or asthma aged over 65 years.

Although a few studies on the relationship between hospitalization and NO_2 concentrations also considered the disruptive effect of fine particular matter, the metaanalysis of these studies indicated that the effect of NO_2 was slightly reduced after consideration of the various indicators of fine particulate air pollution in the analysis [3].

The probability of an actual relationship between an increased incidence (including hospitalizations) of respiratory diseases and exposure to NO_2 was indicated by the causal effect of NO_2 on asthma exacerbations found by US EPA [18]. This relationship is independent of the effects of other types of pollution. This conclusion, stronger than in the US EPA 2008 review, was based on the data from clinical trials, and on a coherent and biologically probable cause-and-effect chain, associating exposure to NO_2 with asthma exacerbations. The observations from clinical studies confirming increased bronchial reactivity in adult asthma patients after a 30-minute exposure to 380-560 $\mu g/m^3$ of NO_2, or after 1 hour following exposure to 188 µg/m³ of NO_2, were of key importance [20]. Exposure to NO_2 was also found to reduce by half the dose of a substance stimulating a clinically significant reaction of the bronchi. The biological reliability was also confirmed by the results of clinical studies conducted among adult patients with asthma, which demonstrated intensification of allergic inflammation after a 15-minute or 30-minute exposure to 500 µg/m³ of NO_2 [21].

Table 3. Increase in the daily number of hospital admissions (in %) associated with increases in daily mean NO_2 concentrations by 10 µg/m³ estimated in the meta-analysis [2]
Tabela 3. Zwiększenie dobowej liczby przyjęć do szpitali (w %) związane ze zwiększeniem średniego dobowego stężenia NO_2 o 10 µg/m³ oszacowanym w metaanalizie [2]

Cause of hospitalization (ICD 10 codes)	% (95% CI)
All respiratory diseases (J00-J99), all age groups	0.57 (0.32-0.38)
All respiratory diseases (J00-J99), age 65+ years	0.69 (0.17-1.21)
All respiratory diseases (J00-J99), age < 19 years	1.20 (0.35-2.05)
Asthma (J45-J46), age < 18 years	1.27 (0.28-2.27)
Obstructive pulmonary disease (J40-J44, J47), all age groups	1.24 (-0.01-2.50)
Obstructive pulmonary disease, including asthma (J40-J47), age 65+ years	1.42 (1.07-1.76)
All cardiovascular diseases (I00-I99), all age groups	0.66 (0.32-1.01)
Heart diseases (I00-I52), all age groups	1.10 (0.76-1.43)
Heart failure (I50), all age groups	1.41 (-0.01-2.86)
Ischemic heart disease (I20-I25), all age groups	0.86 (0.52-1.20)
Cerebral strokes (I60-I69), all age groups	0.30 (0.02-0.57)
Arrhythmias (I44-I49), all age groups	0.50 (0.15-0.86)

There are also studies which indicated a relationship between short-term exposure to increased NO_2 concentrations and other respiratory reactions, such as exacerbations of allergic diseases, COPD, or respiratory infections [18]. However, due to the inconsistencies between the different types of studies, and the limited knowledge regarding plausible biological mechanisms, the role of NO_2 in causing those symptoms remains unclear.

According to both US EPA and health Canada, the relation between long-term exposure to NO_2 and the development of asthma is described as "probably causative" [18, 19]. This conclusion was based on the results of numerous epidemiological studies, including cohort studies in children. One of the examples is an analysis regarding the potential effect of genetic factors on the relationship between asthma occurrence and a long-term exposure to transport-induced air pollution, performed in six birth cohorts covering over 5,000 children from Europe and Canada, observed until the age of 7-8 years [22]. The analysis, conducted on the basis of the data from six cohorts included in the European ESCAPE study, involving over 23,000 adult subjects observed for 10 years, suggested a link between asthma incidence and the degree of exposure to NO_2, also among adults [23]. However, the studies were unable to separate the effects of NO_2 from the potential influence of other air pollutants associated with motor traffic.

Effects of exposure to NO_2 on health in Poland

Although it is still difficult to distinguish the health effects of NO_2 independently of other co-existing air pollutants, the collected data suggest that at least some of the outcomes of exposure to transport-related pollution can be attributed to NO_2 [24]. Many observed health consequences occur at NO_2 concentrations within the air quality standards presently binding in Poland and Europe.

In Poland, the annual limit value of NO_2 concentration (40 µg/m³) is exceeded in the Warsaw, Krakow, Wrocław and Silesia agglomerations. The mean annual NO_2 concentration measured in Warsaw in 2015 was between 24-28 µg/m³ in residential areas, and 43-59 µg/m³ in the proximity of streets with intense traffic [25]. The results of the analyses and estimations of the Mazowieckie Voivodeship Environmental Protection Inspector in Warsaw indicate that 12% of the population of Warsaw live in areas where NO_2 standards are exceeded. As the standards are exceeded on the roads in the city center, used by many pedestrians and drivers, the number may be higher. In Krakow, the mean annual concentrations were between 28-63 µg/m³ [26]. In Katowice, the mean annual NO_2 concentrations in 2014 were 30-58 µg/m³ [27]. In Wrocław, the highest annual concentration of 53 µg/m³ was observed in 2014 in the proximity of the main transit routes, where traffic congestions often occur [28]. Pollution models demonstrate that mean annual concentrations of 25-35 µg/m³ are observed along those roads with intense traffic outside urban areas. The European Environment

Agency (EEA) estimates that the mean annual exposure of the population of Poland is approximately 16 μg/m³ [29].

Most of the Polish population is exposed to NO_2 (and other pollutions related to motor transport) at concentrations associated with an increased risk of asthma incidence, the occurrence of symptoms of asthma and other pulmonary diseases, increased rates of related hospitalizations, and higher mortality. Contrary to particulate pollution, diffused in the atmosphere at large distances, the direct impact of NO_2 on the health is observed primarily in the proximity of busy roads and streets. However, due to the transformation of nitrogen oxides into ozone and particulate nitrates (ingredients of fine particulate matter), the emission of nitrogen oxides contributes to their indirect effect on health over considerably larger areas.

According to EEA estimates, in Poland about 1,600 premature deaths per year can be attributed to NO_2 at mean annual concentrations exceeding 20 μg/m³, and approximately 1,100 to ozone at mean 8-hour concentrations of over 70 μg/m³ [29]. Quantitatively, this is a significantly lower impact on health than that attributed to particulate matter pollution, which, according to the latest WHO estimates, is associated with over 26,000 premature deaths per year, and according to the Global Burden of Disease project with more than 5% of all health damage measured with DALY (disability adjusted life years) in Poland [30, 31]. The most pronounced effect of NO_2 is observed among those people living in large city centers, or near busy streets and roads, where the harmful effect of NO_2 adds to that associated with increased concentrations of fine particulate matter. The reduction in the emission of pollution by vehicles, mostly those with compression ignition engines, is necessary to reduce the negative health effects not only of NO_2 but also other pollutants related to transport, including fine particulate matter. It will primarily require changes in transportation policy, including the limitation of traffic in city centers, and increasing the role of low-emission public transport, and active mobility (bike riding and walking). Apart from reducing the negative health effects associated with air pollution, it may contribute to the prevention of chronic diseases related to a lack of or insufficient physical activity in society. It corresponds well with the *Physical activity strategy for the European Region* [32].

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Air pollution and the cardiovascular system. Does the source of pollution matter?

Zanieczyszczenia powietrza a układ krążenia. Czy źródło zanieczyszczeń ma znaczenie?

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The article is based on a lecture presented on 21 April 2016 during the 6th Scientific Conference in honor of Brig. Gen. Assoc. Prof. Wojciech Lubiński MD, PhD: *Health effects of air pollution* at the Military Institute of Medicine in Warsaw.

Abstract. Air pollution is both an environmental and social issue that can lead to many adverse effects on human life and health. It is commonly associated with the development of respiratory diseases, but in recent years more attention is being paid to its impact on the development and progression of cardiovascular diseases. In assessing the correlations between the presence of individual air pollutants and health effects, the source of air pollution seems to have significant impact. This study considers only the impact of anthropogenic sources. Exposure to suspended particulate matter and nitrogen oxides increases the risk of myocardial infarction and heart failure. Currently, this is one of the strongest single risk factors for cardiovascular death.
Key words: air pollution, cardiovascular system diseases, particulate matter, mortality, nitrogen oxides

Streszczenie. Zanieczyszczenie powietrza jest problemem zarówno środowiskowym, jak i społecznym, prowadzącym do wielu niepożądanych skutków dla życia i zdrowia ludzi. Powszechnie kojarzone jest z rozwojem chorób układu oddechowego, jednakże w ostatnich latach coraz większą uwagę zwraca się również na ich wpływ na rozwój i postęp chorób układu sercowo-naczyniowego. Ocena korelacji między występowaniem poszczególnych rodzajów zanieczyszczeń powietrza a skutkami zdrowotnymi wskazuje na niebagatelny wpływ źródła obecnych w powietrzu zanieczyszczeń. W tym opracowaniu uwzględniono wyłącznie wpływ źródeł antropogenicznych. Ekspozycja na pyły zawieszone i tlenki azotu zwiększa ryzyko zawału serca oraz niewydolności serca. Obecnie jest to jeden z najsilniejszych pojedynczych czynników ryzyka zgonu z przyczyn sercowo-naczyniowych.
Słowa kluczowe: zanieczyszczenie powietrza, choroby układu sercowo-naczyniowego, pyły zawieszone, tlenki azotu, śmiertelność

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Introduction

Air pollution is the main factor associated with the condition of the environment that adversely affects human health, and the most harmful air pollutants include suspended particulate matter (PM), ozone in the boundary layer of the atmosphere (O_3) and nitrogen dioxide (NO_2). Particulate matter <2.5 μm in diameter ($PM_{2.5}$) is primarily responsible for the most negative health effects. According to the European Environment Agency (EEA), the assessment of health effects due to long-term exposure to $PM_{2.5}$ demonstrated that in Europe this pollution contributed to 432,000 premature deaths in 2012 [1]. The estimated effects of exposure to NO_2 and O_3 were approximately 75,000 and 17,000 premature deaths, respectively. The WHO report indicates that in 2013, only one in 10 people breathed air in which the acceptable pollution norms were not exceeded [2]. Air pollution is commonly associated with

the development of respiratory diseases; however, its adverse effect on the development and progression of cardiovascular diseases has recently been emphasized. The assessment of correlations between the presence of individual air pollutants and their health effects indicates the considerable importance of the source of pollution emitted into the air. The results published by international organizations, together with the results of epidemiological studies, enable us to derive indicators of disease burden, such as years of life lost (YLLs) or disability-adjusted life years (DALYs), which are directly related to air pollution [3].

Sources of pollutant emissions

Suspended particulate matter is a mixture of particles demonstrating complex physical and chemical properties. They typically include sulfates, nitrates, ammonium salts, ions of sodium, potassium, calcium and magnesium, metals (such as cadmium, copper, nickel, vanadium and zinc), as well as polycyclic hydrocarbons and other organic carbon compounds. The combination of particulate matter also contains biological factors, such as allergens or microorganisms.

Particulates may be emitted directly into the air (primary pollution), or form in the atmosphere on the basis of gas precursors, such as sulfur dioxide, nitrogen oxides, ammonia, methane or other volatile organic compounds. Both the primary particulate matter and gas precursors may be of natural origin, or result from human activity (anthropogenic). The most common anthropogenic sources include: combustion engines (both diesel and petrol), heating systems in households based on solid fuel combustion (bituminous coal, lignite, heavy fuel oil, or biomass), agriculture, industry (building industry, mining, production of cement, ceramics and bricks), surface erosion due to road transport, as well as brake and tire wear. Secondary precursors are emitted primarily in the transformation processes of nitrogen oxides (road transport, combustion engines) and sulfur oxides (combustion of solid fuels, mostly coal). Natural pollutions will not be discussed in detail in this article, despite their potential and locally significant effect on human health.

The EEA report [1] demonstrated that the estimated exposure to PM_{10} concentrations in the air exceeding the acceptable limits affected 17-30% of the population, and in the case of $PM_{2.5}$ affected 9 to14%. WHO estimated that the concentrations of PM_{10} were exceeded for 61-83% of the European population, and the concentrations of $PM_{2.5}$ were exceeded for 87-93% of the EU population [1]. The differences result from different threshold values for the standards adopted by the European Union and WHO. With regard to benzo(a)pyrene, for which the annual norm in Europe is 1 ng/m^3, the excessive concentrations affected 25-28% of the population, but considering the values recommended by the WHO, i.e. 0.12 ng/m^3, 85-91% of the population were affected [1]. At the same time, people living in the proximity of busy roads are additionally exposed, especially to increased concentrations of nitrogen oxides. In 2010, increased concentrations of NO_2 were recorded in 44% of the air monitoring stations located near roads [4].

Numerous studies that assess the information from databases of pollution emissions and analyze the composition of particulate matter confirm that the principal source of suspended particulate matter during the heating season is coal combustion in domestic households. The results of studies conducted in Wrocław, using equipment that helps to determine the source of the suspended particulate matter, indicate that during the heating season most suspended particulate matter in the city comes from coal combustion. Outside the heating season, the researchers observed an increased share of emissions from local industrial sources [5]. Figure 1 presents the share of the largest sectors in the emission of the main air pollutants in Poland.

In Krakow, one of the most polluted cities in Poland with regard to suspended particulate matter, a study was conducted in 2009 to determine the sources of pollution. The measurements included 20 principal sources of pollution (e.g. small household furnaces and coal boilers), with the particulate matter samples being analyzed for the presence of 52 chemical compounds. Air pollution concentrations significantly above the national norms, over 50% for PM_{10} and 90% for benzo(a)pyrene, occurred due to the use of coal-based heating in domestic households [6]. The principal sources of $PM_{2.5}$ included road transport and household furnaces burning coal, waste coal, biomass (e.g. wood) and waste (which is illegal) [7, 8]. Based on the collected data, the researchers were unable to separate clearly the two sources of suspended $PM_{2.5}$.

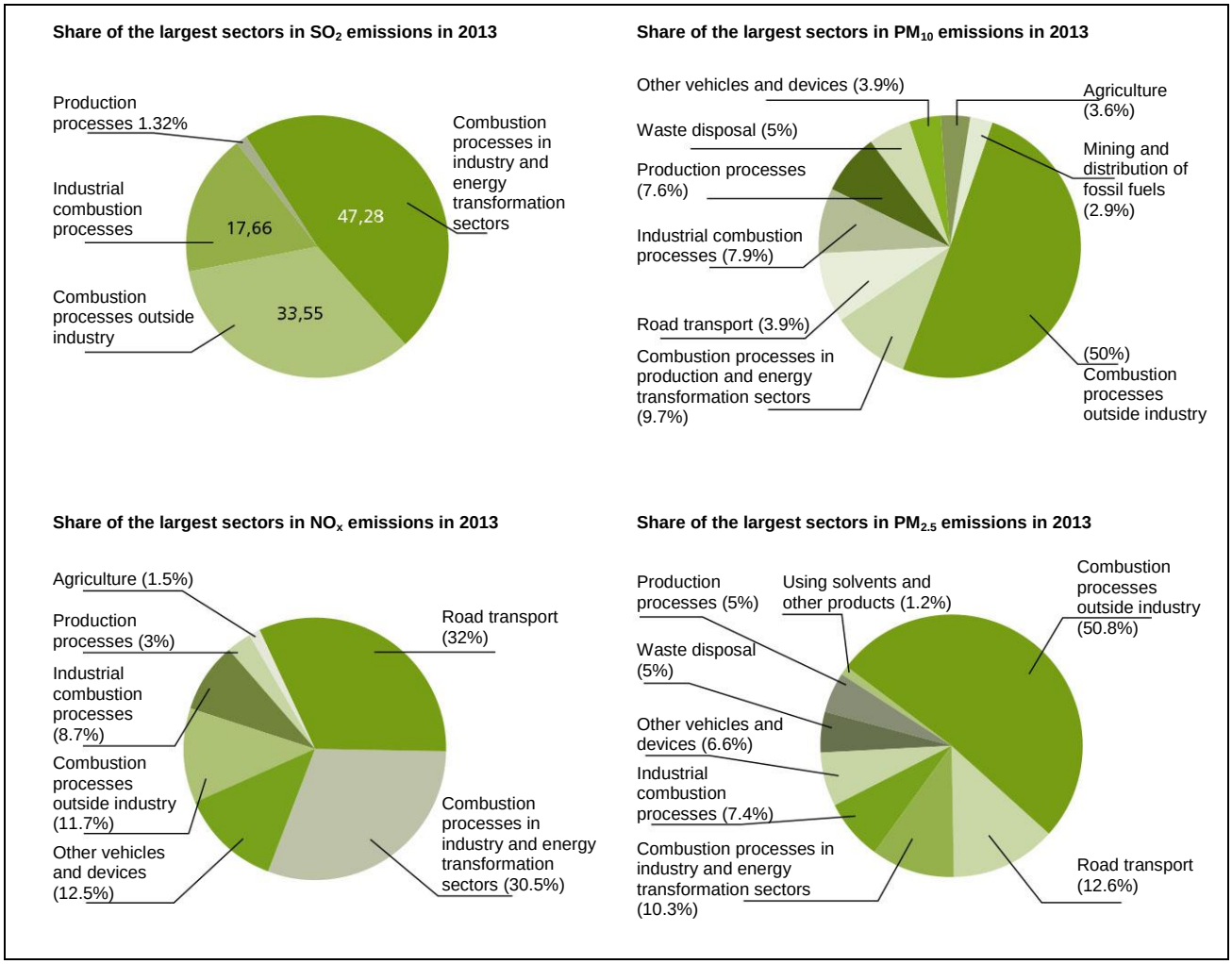

Figure 1. Share of the largest sectors in SO_2, NO_x, PM_{10} and $PM_{2.5}$ emissions in 2013 (based on IOŚ-PIB, KOBZE [8])
Rycina 1. Udział największych sektorów w emisji SO_2, NO_x, PM_{10} i $PM_{2,5}$ w roku 2013 (wg IOŚ-PIB, KOBZE [8])

Health consequences of exposure to air pollution

The observed differences in the results of international epidemiological studies regarding the harmful effects of particulate matter may be associated with differences between the populations analyzed [9-12]. The fundamental effect of exposure to PM is spreading of generalized oxidative stress, secondary to local inflammation in the respiratory tract. Moreover, the trigger factors overlap with structural and functional changes in blood morphotic elements, inducing cardiac rhythm disorders, prothrombotic activity, long-term progression of atherosclerotic lesions, or local instability of existing plaques in patients previously diagnosed with coronary disease [13], due to the increased production of foam cells, expression of adhesive molecules, recruitment of monocytes to the arterial wall, stimulation of prothrombotic tissue factors, and reduced activity of NO synthase [14]. The risk of health deterioration is increased not only by long-term exposure to air pollution at the place of residence, but also by short-term exposure at the work place, or while travelling in the course of daily activities. The results of ESCAPE (European Study of Cohorts for Air Pollution Effects) [15] indicated that long-term inhalation of suspended particulate matter increased the risk of coronary incidents by 13%. Also, a linear increase in the risk was observed already at concentrations below those acceptable in the European Union. This means that no level of exposure to air pollution is safe for the health.

The largest studies assessing the effects of acute exposure include European APHEA-2 (Air Pollution and Health a European Approach project) [16] and American NMMAPS (National Morbidity and Mortality Air Pollution Study) [17, 18]. In NMMAPS, 50 million people in 20 of the largest American cities were included in the

observation. Mean mortality rates were independently related to PM concentration on the day before death. Each increase in PM_{10} concentration by 10 μg/m^3 was associated with an increase in cardio-pulmonary mortality and everyday incidents by 0.21% and 0.31%, respectively [18]. The Aphea-2 study demonstrated a stronger correlation between adverse health effects and air pollution [16]. For 43 million individuals in 29 European cities the estimated increase in daily mortality was 0.6%, for every increase in PM_{10} by 10 μg/m^3 [19]. Additional analyses of the Aphea-2 results regarding mortality in a 40-day period demonstrated that the risk of adverse health effects due to air pollution with the above increase in PM_{10} concentration by 10 μg/m^3 was two times higher [19]. The collective analysis of the causes of hospital admissions demonstrated a significant increase in hospitalization ratio by 0.8% and 0.7% due to cardiac failure and ischemic heart disease for every increase in PM_{10} concentration by 10 μg/m^3 [20]. More detailed assessments revealed an increased risk of myocardial ischemia during an exercise test [21], myocardial infarction [22], or necessity of ICD implantation [23]. The impact of urban geographical location, socioeconomic status and education on the increased risk of cardiovascular diseases was also observed. In a study by Hoek et al. [24], the observation of a group of 5,000 adults for 8 years revealed that exposure to air pollution due to traffic was more closely correlated with mortality than the average contamination level in the city. Out of the assessed parameters, a variable indicator of living close to a main transportation artery most strongly correlated with cardio-pulmonary mortality. The results suggested that individual exposure to toxic air contaminants may vary not only between different cities, but also within a single agglomeration. The Aphea-2 study [16] revealed a closer relation between changes in PM concentrations and mortality in the cities with higher NO_2 concentrations and warmer climates. Observed differences in population susceptibility, climate, time spent outdoors or on transport, as well as the general composition of the pollution, were indicated in the description of regional variability in the estimated risk of death in both studies. Direct relations with ischemic heart disease, dysrhythmia and cardiac failure were identified [15]. A statistically significant relation between $PM_{2.5}$ and general mortality due to cardiovascular diseases was confirmed in the ACS study [25]. If PM increased by 10 μg/m^3 in long-term exposure, the risk of death increased by 12% [16]. The total risk of dysrhythmia [23], cardiac failure and cardiac arrest was also higher, without an increase in mortality ratio due to other causes. Asian studies also demonstrated an increased prevalence of ischemic strokes directly connected to changes in pollution concentrations [26].

The outcomes demonstrate that air pollution contributes to the occurrence of both ischemic and non-ischemic vascular incidents. The mechanisms promoting the progression of atherosclerotic lesions are inherently associated with dysfunctions of the vascular endothelium. Possible acute systemic inflammation and oxidative stress are responsible for lesions leading to vascular stenosis [27]. Recent studies regarding the effects of PM revealed impaired endothelial function, assessed by ultrasound measurement of the ability of the brachial artery to increase vascular lumen in response to congestion (*flow mediated dilatation* – FMD) [28]. Other markers indicative of endothelial function include: assessment of microalbuminuria [29, 30] or von Willebrand factor activity [31], which increased after an experimental 2-hour exposure to ultrafine PM (<0.1 μm) in type 2 diabetes patients [32].

Brook et al. [33] demonstrated that inhalation of ozone and urban air pollution at high concentrations for 2 hours resulted in arterial spasm in healthy adults. Moreover, it has been shown that decreased endothelium-mediated arterial relaxation due to reduced production of NO and a concomitant increase in endothelin production occurs in people exposed to diesel exhaust particles [34]. Risk factors in atherosclerosis, myocardial infarction, stroke and thrombosis in people exposed to traffic-related pollution include mainly organic and inorganic coal particles [35, 36]. In a study by Pekanen et al. [21], a significant relation was found between a maximum depression of the ST segment during a submaximum exercise test and exposure to PM within a period of more than 2 days before the test. Significant relations were also identified between symptom occurrence and acute (within 2 hours before the symptoms occurred) and subacute (a few days) exposure to $PM_{2.5}$ [22]. In patients with ischemic heart disease, acute coronary syndrome can be caused by reduced perfusion of the cardiac muscle due to a sudden arterial spasm, or destabilization of the atherosclerotic plaque. The exponents of increased risk of cardiovascular events, for which a direct correlation with exposure to PM was demonstrated, included mostly inflammation and endothelial damage indicators, such as the C-reactive protein [37-39], fibrinogen [40], interleukin 6 (IL-6) [41, 42] and the adhesion molecules ICAM-1 (*intracellular adhesion molecule-1*) and VCAM-1 (*vascular cell adhesion molecule-1*), which are found both on the surface of cells and dissolved in the blood serum. Concentrations of IL-6, IL-1 and granulocyte-macrophage colony-stimulating factor are elevated in the blood serum of healthy males following exposure to the increased air contamination associated with forest fires,

as well as *in vitro* after exposure of human macrophages to PM_{10} [43]. Simultaneously, the elevation is associated with an increased risk of cardiac incidents and death [44, 45]. Short-term exposure to air pollution results in elevated platelet and leukocyte count in the peripheral blood [46, 47]. Studies on animals demonstrated that exposure to diesel exhaust particles stimulates the bone marrow to release these cells into the blood circulation [48, 49]. The Traffic-Related Air Pollution study conducted in Boston [50] found a correlation between exposure to traffic-related pollution and increased concentrations of fibrinogen, leukocytes and blood platelets. The results indicate that short-term increases in air contamination may cause cardiac rhythm disorders, exacerbation of cardiac failure and acute cardiac ischemia of atherosclerotic origin, or cerebral stroke. The authors of MESA Air [51] assessed the correlation between progression of the calcification of coronary arteries and exposure to PM and nitrogen oxides. Statistically significant results were obtained for $PM_{2.5}$ and NO_x, but not for NO_2. The authors conclude that the assessment of NO_x concentrations is a better marker for the pollution associated with road transport. The strongest correlations between $PM_{2.5}$ and arterial calcification were observed in patients having hypertension, obesity and an age of over 65 years. The relationships indicate the synergistic effect of air pollution and recognized cardiovascular risk factors.

Another, often underestimated, harmful environmental factor is noise. Contrary to the study by Huss et al. [52], in which exposure to noise of >60 dB *vs* <45 dB over a period of more than 15 years was associated with a significantly elevated risk of death due to myocardial infarction (OR 1.5; 95% CI: 1.0–2.2), the study by Bodin et al. [53] involving over 10,000 subjects did not reveal a relationship between the incidence of myocardial infarction and the mean annual and three-annual exposure to NO_x and noise associated with street traffic, neither in one variable analyses, nor in the combined effect of exposure to noise of >55 dB and exposure to NO_x >20 μg/m^3. However, it should be noted that mean exposure to noise was 51 dB, and NO_x concentration was 11 μg/m^3. The European Union norm for NO_x exposure of 40 μg/m^3 in the presented study was exceeded in only 9 subjects. The prevalence of myocardial infarction in the described population was also over 25% lower than in the general population. These factors might have significantly affected the obtained correlation results.

With regard to the effect of street traffic on health, the results of a study by Goel [54] are very interesting. Spending only 2% of travel time in a traffic jam is responsible for 25% of the total exposure to traffic-associated pollution. The greatest reduction in exposure (70%) inside the driver's compartment was obtained during slow, but continuous driving, with outside air intake on and heating switched off. In urban traffic, the authors recommend keeping the windows closed, switching off the air intake and heating, and maintaining the longest possible distance from the car ahead.

The results of interventional studies [55] demonstrated that after an intentional reduction of air pollution concentrations, the number of deaths due to causes other than injuries was reduced by 5.7%, and due to cardiovascular causes by 10.3%. The researchers compared data regarding mortality before burning coal was prohibited in Dublin and 72 months after introduction of the prohibition. They estimated that, as a result of the above prohibition, the number of deaths due to circulatory diseases was reduced by 243 cases annually.

Summary

Air pollution is an environmental and social problem, as it contributes to a short-term and long-term deterioration in health, as well as to increased incidence and mortality due to cardiovascular causes. Anthropogenic sources are the principal source of air pollution, the most important of which include the so-called low emissions, associated mainly with individual house heating (PM, benzo(a)pyrene), and road transport (NO_x).

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Atopy and allergic diseases among farmers

Atopia i choroby alergiczne u mieszkańców wsi

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Abstract. The article presents an overview of the literature on the impact of the rural environment on the prevalence of atopy and allergic diseases, and summarizes the findings of the author's published studies.
Key words: atopy, rural environment, allergic diseases, protective factors, risk factors

Streszczenie. W artykule przedstawiono przegląd piśmiennictwa dotyczącego ochronnego wpływu środowiska wiejskiego na występowanie atopii i chorób alergicznych oraz omówiono wyniki opublikowanych badań własnych.
Słowa kluczowe: atopia, środowisko wiejskie, choroby alergiczne, czynniki ochronne, czynniki ryzyka

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In the past few decades, many countries have observed a significant rise in the incidence of allergic diseases, especially allergic rhinitis and bronchial asthma. In many countries, including Poland, the number of patients suffering from these diseases is constantly increasing [1]. The high incidence rates of allergic rhinitis and bronchial asthma in Poland are confirmed by the results of the recently conducted ECAP (Epidemiology of Allergic Diseases in Poland) epidemiological study [2].

The causes of such a dynamic increase in the number of patients with allergies are still being investigated. The effects of environmental factors and interactions between genes and the environment are considered to be the most significant. Initially, the focus was on the progress of environmental pollution due to the development of industry. However, Professor Erika von Mutius demonstrated that other factors may also contribute to the increased incidence of allergies [3]. Her study, conducted after the German reunification, documented the rising prevalence of allergic rhinitis and asthma in children from Munich, in comparison to the more polluted Leipzig [3].

Some of the studies published at the beginning of the 21st century indicated that living in rural areas could reduce the risk of atopy and the incidence of allergic diseases among children. The first such studies were conducted in villages in the Alps [4], and involved children 6 to 13 years old. The effect of exposure at different stages of life to environmental factors typical for farms was analyzed. It demonstrated that contact with farm animals and the consumption of unpasteurized milk, especially in the first year of life, had a protective effect, reducing the risk of asthma, pollinosis and atopy [4]. Further studies conducted in this region, as well as in other parts of the world, confirmed that spending the first years of life in the countryside may protect people from allergic diseases [5-7].

Interesting results of studies conducted in the USA have been published recently [8], involving Hutterite and Amish children – representatives of two closed religious communities leading very traditional lifestyles, where farming is the main occupation. There are numerous similarities between the two groups, such as the large number of children in families, long breastfeeding, diets rich in fats, salt and unpasteurized milk, and minimal

exposure to tobacco smoke and air pollution. The Amish ignore any technical innovations, including those related to farming, they live on traditionally built and maintained farms, and use horses for transport and field work. The expression "frozen in time" is used to describe them. Hutterites use all the available modern conveniences in agriculture, and run huge, highly industrialized farms.

In this study, bronchial asthma was found in 5.2% of Amish children, and in 21.3% of Hutterite children. The incidence of atopy in these populations was 7.2% and 33.3%, respectively.

The question of how contact with rural environments can reduce the risk of allergy is still under discussion. The exact mechanism behind the protective effect of environmental factors is still unknown. It is believed that the rural environment, rich as it is in microbiological factors, may demonstrate an immunomodulatory effect by the interaction of genes and environmental factors, as well as in affecting human microbiome and stimulating non-specific immune responses [9]. Environmental factors that demonstrate proven protective effects include: contact with cattle and pigs, consuming unpasteurized milk, time spent in stables and barns, contact with animal fodder, and the type of cultivated crops [10-12]. However, the test results are not entirely consistent [13, 14] which indicates that the protective effect may be associated with a number of different factors found in the rural environment.

GABRIEL, a cross-sectional, epidemiological study conducted by our hospital team, which involved 23,331 children from the Śląskie region, aged 7-12 years old, demonstrated that children living on farms suffered from atopy less often than their peers from small towns, although the differences in the incidence of bronchial asthma were not very pronounced [15]. This indicates that the effects of the environment on different phenotypes of allergic diseases vary.

Most studies related to the relationship between contact with the rural environment and allergies involved children. The exposure to protective environmental factors associated with farm life are believed to be of the greatest significance in early childhood, while few studies have confirmed that the protective effect may also be achieved in older subjects [16, 17]. Little is known about the way in which living in rural areas affects allergy incidence in adults. The prevalence of atopy and bronchial asthma was lower in adult farmers, and the prevalence of asthma was inversely proportionate to the number of childhood years spent in a rural environment [18, 19]. In German studies, contact with animals on farms during childhood reduced the risk of allergy in adult life, but continued exposure after the childhood period did not lower the risk of allergy [20].

The results of our two cross-sectional epidemiological studies involving rural populations, conducted at a 9-year interval, confirmed the effect of the environment and its changes on the prevalence of atopy and allergic diseases in adult life [21-23]. The first study was carried out in 2003, i.e. one year before Poland joined the European Union. It involved 1,700 subjects aged 5-59 years old, living in the Dolnośląskie region, in seven small villages and the nearby town of Sobótka. This study revealed a very significant difference in the prevalence of atopy in villagers and town dwellers. In the town, 20% of the subjects had positive results from the allergy patch tests using at least one of the studied inhalatory allergens, compared to only 7% of the subjects from the villages. Allergic rhinitis was found twice more often in the people from the town, although no significant differences were demonstrated in the prevalence of bronchial asthma, defined as a disease diagnosed by a physician. The analysis of the prevalence of atopy in various age groups demonstrated that the most pronounced differences occurred between young subjects (36% in teenagers from the town, and 6% from the villages), while atopy was more prevalent in those subjects from towns in all age groups.

Logistic regression analysis indicated that contact with the rural environment reduced the risk of atopy in all age groups, but the past is also important. We analyzed the period of life spent in the town or in the villages, and found that in both children and adults the prevalence of atopy was inversely proportionate to the number of years spent in a rural environment [21].

We also analyzed the effect of individual factors related to the rural environment in different periods of life on the incidence of atopy, bronchial asthma and allergic rhinitis. The past and present consumption of unpasteurized cow milk reduced the risk of atopy and bronchial asthma, both in children and adults. The protective effect was, interestingly, more pronounced in the urban population than in the rural population [22].

After nearly 10 years, we returned to the same population, to the same town and villages, to conduct another epidemiological study, using identical research tools and methods. Most of the study subjects also participated in the first study, and it is worth noting that almost 90% of the individuals invited to participate in both studies agreed to do so.

In the period between the studies, the Polish countryside changed significantly. Due to the necessary adjustments to EU regulations regarding breeding farm animals and milk production, the number of cattle decreased in the villages by 84%, the number of pigs decreased by 60%, and in 2012, only 9% of people from rural areas declared the consumption of unpasteurized milk, compared to 36% in 2003. Due to these changes in

exposure to factors unrelated to the rural environment, it was possible to check the effect of such changes on the previously studied population. We were interested in evaluating whether the significant modifications to the countryside could reduce the protective effect of this environment on the prevalence of atopy and allergic diseases.

In 2012, the prevalence of atopy in the village population was significantly higher than in the previous study (19.6% in 2012 vs. 7% in 2003), reaching the level observed in the town population. At the same time, no changes were observed in the town (20% in 2012 vs. 19.9% in 2003). The prevalence of allergic rhinitis also doubled in the village areas, while the prevalence of asthma did not change in either the town or in the villages.

The analysis of the results from the subjects participating in both studies revealed that the increased prevalence of atopy was found not only in children and youths, but also in all age groups up to 60 years. New cases of atopy were usually found in individuals who had lost contact since 2003 with the environmental factors typical for farming, with the lowest risk of developing atopy being observed in individuals who remained in regular contact with cattle [23]. The results of these studies indicate that environmental exposure and changes in such exposure may affect the immune responses associated with atopy throughout life, not only in early childhood.

In summing up, it should be emphasized that there are considerable differences in the prevalence of atopy and allergic diseases even between neighboring populations sharing the same genetic background. The differences are found between children as well as adults. Exposure to environmental factors related to the rural environment (contact with animals, unpasteurized milk) may demonstrate a protective effect regarding allergic diseases throughout life, not only in childhood. The risk of developing atopy and allergic diseases is probably reduced by the large and varied quantity of bacteria and fungi (a microbiological cocktail) in the environment, while the immune response to changing environmental conditions is flexible, and may vary in individuals of all ages.

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Economic costs of air pollution on the basis of selected examples

Koszty ekonomiczne zanieczyszczeń powietrza na wybranych przykładach

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Abstract. Air pollution is currently one of the most significant factors influencing the deteriorating levels of health in the world population. Electricity generation, transportation, industry and constantly increasing world population (according to predictions for 2025, the world population will exceed 8 billion people) significantly contribute to the decrease in the quality of atmospheric air. Scientific research confirms the effect of air pollution on human health, expressed as premature deaths, and chronic respiratory, cardiovascular and nervous system diseases. The latest research shows the correlation between exposure to air pollution and cancer, diabetes, hypertension and Alzheimer disease. The deterioration in public health decreases the productivity of society, generating significant health and social costs. However, air pollution is recognized not only as a health and social issue, it is also considered an economic burden for the economies of individual countries and the world as a whole. Air pollution is also a significant issue in Poland, since both the production of electricity in power plants and household heating are based on the combustion of coal and other fossil fuels. Furthermore, increasing road traffic in urban areas directly affects the health of Polish society. This generates significant losses for the Polish economy, decreasing the GDP (gross domestic product). The results of epidemiological studies performed during the last 20 years indicate the harmful effects of air pollution on human health. Based on this data, governmental and non-governmental organizations make predictions and estimate the health costs incurred by individual countries and regions due to the exposure to air pollution.
Key words: air pollution, public health, external health costs, ExternE project, monetization of health effects

Streszczenie. Zanieczyszczenie powietrza jest obecnie jednym z najpoważniejszych czynników wpływających na pogorszenie zdrowia światowej populacji. Produkcja energii, transport, przemysł oraz wciąż zwiększająca się liczba ludności świata (wg prognoz do 2025 roku przekroczy ona 8 mld osób) przyczyniają się znacząco do pogorszenia jakości powietrza atmosferycznego. Liczne badania naukowe potwierdzają wpływ zanieczyszczeń atmosferycznych na zdrowie, zarówno w zakresie przedwczesnych zgonów, jak i przewlekłych chorób układu oddechowego, sercowo-naczyniowego lub nerwowego. Najnowsze badania potwierdzają zależność pomiędzy ekspozycją na zanieczyszczenia powietrza a występowaniem nowotworów złośliwych, cukrzycy, nadciśnienia tętniczego czy choroby Alzheimera. Pogorszenie zdrowia publicznego skutkuje zmniejszoną zdolnością produkcyjną społeczeństwa, generując duże koszty zdrowotne i społeczne. Zanieczyszczenie powietrza nie jest jednak postrzegane jako problem wyłącznie zdrowotny i społeczny – jest również obciążeniem ekonomicznym gospodarki poszczególnych państw i całego świata. W Polsce zanieczyszczenie powietrza również jest zagadnieniem ważnym, gdyż zarówno produkcja energii elektrycznej w elektrowniach, jak i energii cieplnej w gospodarstwach domowych nadal opiera się głównie na spalaniu węgla lub innych paliw kopalnych. Dodatkowo zwiększający się udział transportu kołowego w aglomeracjach miejskich bezpośrednio wpływa na pogorszenie stanu zdrowia Polaków. Z tego tytułu Polska gospodarka ponosi duże straty ekonomiczne, co zmniejsza jednocześnie wartość polskiego PKB. Wyniki badań epidemiologicznych przeprowadzonych w ciągu ostatnich 20 lat potwierdzają szkodliwy wpływ zanieczyszczenia powietrza na zdrowie człowieka. Na podstawie tych danych instytucje rządowe i pozarządowe dokonują prognoz oraz wyliczeń szacunkowych kosztów zdrowotnych poniesionych przez poszczególne państwa lub regiony w związku z ekspozycją społeczeństwa na działanie szkodliwych zanieczyszczeń.
Słowa kluczowe: zanieczyszczenie powietrza, zdrowie publiczne, zewnętrzne koszty zdrowotne, projekt ExternE, monetaryzacja skutków zdrowotnych

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Introduction

Air pollution increases the incidence and exacerbation of many respiratory and cardiovascular diseases, increases the risk of neoplasms and both neurodegenerative and prenatal diseases, as well as the prevalence of cardiovascular incidents, such as the myocardial infarction of cerebral stroke [1]. Recent studies demonstrate a close relationship between the harmful effects of air pollution on the human organism and the development of diseases such as diabetes, arterial hypertension or Alzheimer's [2, 3]. Breathing polluted air generates immense health costs due to the reduced productivity of society, and is directly related to an increased number of hospitalizations or lost work days.
The aim of this article is to explain the concept of health costs due to the adverse effects of air pollution on the human organism, to present the most common methodologies used to calculate these costs, as well as to demonstrate examples of health costs published in recent studies.

Definition of health costs

Health costs are often referred to as "external health costs". To explain this concept, the term "external costs" should be clarified. External costs (or externalities) refer to the monetary value of health costs, losses in ecosystems, losses in agricultural crops, material losses and other social losses associated with air and water pollution, waste storage, and other activities due to the production, transport and use of fuels [3]. In the case of energy production and distribution systems, the term refers to all the negative effects associated with the technology of electrical energy and heat production, including the construction and closure of power plants, the extraction and transport of energy resources, and the emission of pollution. External costs are determined for the entire technological cycle, and are calculated for the entire cycle of obtaining, transporting, and using individual energy fuels. They include losses in the area of public health (professional diseases, chronic diseases, inability to work, and premature deaths), damage to buildings, materials, agricultural crops, the fishing industry, forests, and natural ecosystems, as well as reduced levels of life comfort due to the location of energy producing devices. To determine an external cost, two conditions need to be met: the activity of one entity results in a loss in another entity's welfare, and there is no compensation for this loss [4]. For example, a newly built power plant using fossil fuel (the activity of the first entity) is designed to operate for approximately 40 years (mean operating time of a power plant), which leads to a number of disease cases and premature deaths in the local population (loss of welfare of the second entity). All the costs associated with treatment, rehabilitation or hospitalization, disability benefits, early pensions and costs for employers due to work absenteeism (uncompensated loss of welfare) are not considered during the implementation of the new power plant project, which means that the "external health costs" mentioned above will be covered exclusively by individual citizens, the state pension scheme and the healthcare system.

The term "external cost" has long been used in economics; however, only in the late 1980s and early 1990s were the first studies conducted regarding the effects of energy production on the environment and human health. The dynamic development of industry and global energy networks at that time contributed to the increased use of fossil fuels in energy production. The scientific community and governments of some countries began to pay more attention to the harmful effect of human activities on the environment.

One of the first attempts to estimate the environmental external costs of using fossil fuels in energy production was the report from 1988 developed in the Federal Republic of Germany [5]. The report included the direct effect on the incidence and mortality in German society, expressed in millions of dollars per year (million USD/year).

As the methodological assumptions of the first studies were too general, and based on insufficient scientific or technological knowledge, in 1991 a report prepared by the European Commission and Department of Energy of the United States was published. The report contained the estimated external costs of energy production, with special focus on the effects on the natural environment [6]. The document comprised the results of studies and expert opinions prepared by engineers, economists, ecologists, specialists in natural science and healthcare experts.

The next stage was the publication of the ExternE project [7-11], which involved over 50 working groups from 15 European countries, and which considerably increased the scope of the studied matter as well as significantly improving the methodologies used. The ExternE project presented the estimated external costs generated by the energy system in the "old" European Union. The calculations were made using EcoSense, an integrated environment impact model, while the information about emissions from individual sources were provided by the CORINAR database. The applied model enabled estimation of the external costs for individual European countries on the basis of their specific structures of pollution emission, as well as technical conditions and location [4]. The health consequences of the emission of pollution in different

areas were determined, and they were expressed in the monetary value of the external costs. After this their value in terms of individual energy technologies was determined.

The ExternE project soon gained international recognition. Numerous national and international organization used the results presented in ExternE as model data to calculate external costs [6]. Due to the increasing popularity of the ExternE methodology, it was used in cost-benefit analysis (CBA) as part of the European environmental policy. Unfortunately, in the initial phase of the ExternE project the results of epidemiological studies were not considered (e.g. mortality due to long-term exposure to air pollution), as they were believed to overestimate the actual external costs, and were therefore considered to be uncertain values (uncertainties) [6]. However, due to the increasing body of published scientific studies, this data was included in future analyses.

Calculation of external health costs – methodology

Modeling the external health costs is performed according to a 5-stage method, based on a 4-stage impact pathway approach (IPA), developed for the ExternE project [7, 10]. Stage one determines the source and level of pollution emission, e.g. concentration of suspended particulate matter from a coal-based power plant per cubic meter. Stage two characterizes the diffusion of a given substance in the air, based on geographical and meteorological data, e.g. from satellite images. Stage three consists of a quantitative determination of the population exposed to pollution. Stage four analyzes the effects of air pollution on health using the dose-response function (DRF). There are several sources for such functions, but the most commonly used method involves the WHO and European Commission calculations [12, 13]. Stage five consists in monetizing the health effects, which is the most demanding and complex aspect of the entire process.

In the case of ExternE project, the value of statistical life (VSL) indicator is used, which expresses the tendency to avoid the risk of premature death. In previous versions of ExternE, its assumed value was 3.5 million dollars (approx. 14 million zloty), and currently is 1 million euros (approx. 4.5 million zloty). As the VSL indicator is more accurate in the case of sudden death than mortality due to long-term exposure to pollution, the value of life year (VOLY) indicator was introduced in the ExternE methodology. Converting VSL to VOLY means estimating the change in lifespan associated with the reduction in the risk of death of 5 in 1,000 people within 10 consecutive years. The derived indicator, using a 3% discount rate, is 40,000 euros (long-term exposure), and 60,000 euros (short-term exposure) [14]. This means that an average person is willing to spend a given sum per year for 10 years to extend their life. The total economic effect of increased mortality is expressed as a VOLY indicator multiplied by the expected reduction in the lifespan, referred to more simply as "years of life lost (YLLs)", i.e. the sum of years lost due to premature death, calculated on the basis of average life expectancy [14].

Recent studies of the European Commission and WHO [13, 14] also employ the 5-stage methodology. In order to monetize the health effects of air pollution, the following indicators are used: total number of deaths, years of life lost, and disability-adjusted life years (DALYs). Moreover, in the recent World Band report [15], the financial losses to the world economy were estimated on the basis of reduced productivity and welfare loss indicators. The welfare loss indicator is used to calculate the economic costs associated with life risk; in other words, it comprises the costs incurred by a potential citizen in order to prolong life and temporarily reduce the adverse effects of air pollution. The reduced productivity indicator reflects a decrease in state revenues due to gradual depletion of human resources, e.g. as a result of premature mortality.

The presented indexes, as well as the modeling itself, have their limitations. If a required database is unavailable, or only partially accessible, cost estimation is difficult, which increases the share of uncertainties and results in underestimating the final results. According to WHO, the share of uncertain values regarding YLLs is about 1% with respect to highly-developed countries, and 15-20% with respect to African countries, which is due to the insufficient availability of databases, especially those regarding mortality among adults [13]. The share of uncertainties in calculations is also expressed by the uncertainty interval, which according to the World Bank estimations [15] lies between 2.5-97.5 percentile. The lower interval corresponds to more accurate calculations.

Examples of health costs published in recent studies

The studies presented in the recent reports of the World Bank and IMHE (Institute for Health Metrics and Evaluation) indicate that in 2013 premature deaths due to the harmful effects of air pollution generated health costs of 225 billion dollars (approx. 864 billion zloty) with regard to reduced productivity, and 5.1 trillion dollars (approx. 21 trillion zloty) with regard to welfare loss [15]. The economic costs of the health consequences (e.g.

premature death or years of life lost) due to air pollution were estimated using VOLY and VSL.

The Organization for Economic Cooperation and Development (OECD) warns that unless more ambitious and effective actions are undertaken to improve air quality, the number of premature deaths due to ambient air pollution may double in 2060, and affect 8-9 million people per year globally. This will also have consequences for the economy: the costs due to air pollution will amount to 1% of the world GDP [16]. Apart from premature deaths, the estimation of the health costs includes the number of hospitalizations, lost work days, and cases of bronchitis in children and adults.

The data published in "Niepłacony rachunek. Jak energetyka węglowa niszczy nasze zdrowie'' ("The unpaid bill. How the carbon-based energy system ruins our health") report indicate that in the European Union emissions from coal-based power plants will cause 18,200 premature deaths, 8,500 new chronic bronchitis cases, and 4 million lost work days [17]. The financial costs of the health impact of coal-based energy production in Europe are estimated at 43 billion euros (approx. 180 billion zloty) per year. Including emissions from coal power plants in Croatia, Serbia and Turkey, the number of premature deaths increases to 23,300, which translates to an annual increase in the related costs to 55 billion euros (approx. 230 billion zloty). In Poland, pollution from the carbon-based energy production sector is responsible for approximately 3,500 premature deaths, and nearly 800,000 lost work days, which generates annual costs of 8.2 billion euros (approx. 34 billion zloty) [17]. The costs of premature deaths were estimated using VOLY and VSL.

The "Lifting Europe's Dark Cloud. How cutting coal saves lives" report presents how introducing specific regulations on emissions from large combustion plants could contribute to a reduction in health costs in European countries. The report demonstrates that the emission limits proposed in an updated Large Combustion Plants, Best Available Techniques Reference Document (LCP BREF) would lead to a reduction in the number of premature deaths due to coal combustion from 22,900 to 8,900 per year by mid-2021 [18]. The new standards could also help to decrease the number of chronic bronchitis or asthma cases, at the same time reducing the health costs on a European level from 63 to 24 billion euros (approx. 104 billion zloty) [18]. In the prognosis report, next to the mentioned premature mortality, the prevalence of bronchitis and asthma in children and adults, as well as data on lost works days were included, based on the value of statistical life.

Summary

Air pollution is one of the most pressing problems for the global population, as it not only poses a threat to human life, but also limits economic growth. To determine the costs associated with those limitations, a number of commonly recognized functions and statistical models are used. They require an extensive database that includes a variety of information types, e.g. emission concentrations as well as meteorological, epidemiological and economic data. The process of data processing and preparing a prognosis, especially on a global level, is a complex and precision process. Moreover, the availability of data in individual countries is varied, which considerably affects the accuracy and scope of any prognosis. The valuation of non-material effects, such as pain, suffering and human life is difficult, and often considered controversial. However, to counter effectively the health and economic effects of air pollution, such calculations need to be made, as "purely financial" information is necessary to plan future endeavors, which will significantly improve the quality of the natural environment and public health.

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Impact of environmental pollution on the prevalence of allergic diseases in children and adolescents in Krakow

Wpływ zanieczyszczenia środowiska na występowanie chorób alergicznych u dzieci i młodzieży szkolnej w Krakowie

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The article is based on a lecture presented on 21 April 2016 during the 6th Scientific Conference in honor of Brig. Gen. Assoc. Prof. Wojciech Lubiński MD, PhD: *Health effects of air pollution* at the Military Institute of Medicine in Warsaw.

Abstract. Currently, allergies constitute a public health problem at a pandemic level, especially in industrialized countries. In Europe, 30% of the population show the symptoms of at least one allergy. In Poland, allergies affect as many as 40% of the population. In the years 2007–2015, the first stage of a survey was undertaken in Krakow, involving children aged 7–8 years and adolescents aged 16–17 years. The total number of respondents was 75,000, with over 50% of the respondents reporting allergic symptoms, 60% of these neither diagnosed nor treated. In the second stage of the study, spirometry, skin prick tests, patch tests and an Fx5 panel were performed. Nearly 30% of the children and 25% of the adolescents showed allergic rhinitis, while 12% and almost 9%, respectively, showed asthma. Eczema affected one in four children and one in eight teenagers. The data show that in large urban areas, such as Krakow, the risk of allergic diseases is higher than in the general population for the analyzed age ranges. One possible explanation of this phenomenon is growing up surrounded by severe air pollution.

Key words: allergy epidemics, children and adolescents, asthma, allergic rhinitis, air pollution, eczema

Streszczenie. Alergia stanowi obecnie problem zdrowia publicznego o zasięgu pandemicznym, zwłaszcza w krajach uprzemysłowionych. W samej Europie objawy alergii występują u 30% mieszkańców. W Polsce dotyka ona już 40% społeczeństwa. W latach 2007–2015 w Krakowie przeprowadzono badanie ankietowe, którym na pierwszym etapie objęto dzieci w wieku 7–8 lat i młodzież w wieku 16–17 lat. Łączna liczba respondentów wyniosła 75 000. Ponad 50% respondentów zgłaszało objawy alergiczne, 60% z nich nie miało ustalonego rozpoznania i nie było leczonych z tego powodu. Na drugim etapie badania wykonywano spirometrię, punktowe testy skórne, testy płatkowe oraz oznaczenie panelu pokarmowego Fx5. U niemal 30% dzieci i 25% młodzieży stwierdzono alergiczny nieżyt nosa, a astmę odpowiednio u 12% i prawie 9% badanych. Wypryskiem alergicznym dotknięte było jedno na czworo badanych dzieci i jeden na ośmiu nastolatków. Uzyskane dane wskazują, że w dużej aglomeracji miejskiej, jaką jest Kraków, ryzyko rozwoju chorób alergicznych jest większe niż w ogólnej populacji w tych przedziałach wiekowych. Jednym z możliwych czynników tłumaczących to zjawisko jest dorastanie w warunkach nasilonego zanieczyszczenia powietrza. **Słowa kluczowe:** epidemiologia alergii, dzieci i młodzież, astma, alergiczny nieżyt nosa, wyprysk alergiczny, zanieczyszczenie powietrza

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Introduction

Allergies presently form a public health problem of pandemic proportions, especially in developed countries. In Europe alone, the symptoms of allergies are found in 30% of citizens (including 50% of undiagnosed patients, and 20% of severe cases) [1]. The European Academy of Allergology and Immunology (EAACI) estimates that in 2025, 50% of the European population will suffer from some sort of allergy. According to the World Allergy Organization (WAO), in 2050 4 billion people in the world will have allergies [2, 3]. The ECAP 2006-2008 study (Epidemiology of Allergic Diseases in Poland) estimates that 40% of Poles suffer from allergies, and the number of people with allergies in Poland doubles every 10 years, on average [4].

It is believed that the increased prevalence of allergic diseases in the present population is due to various environmental factors, rather than genetic ones [5]. These factors include increased hygiene, elimination of most parasitic infestations, changes in house heating and ventilation systems, as well as reduced physical activity and dietary changes due to a different lifestyle [5].

Material and methods

In 2007-2015 a survey was conducted in Krakow that involved children aged 7-8 years and adolescents aged 16-17 years. The total number of respondents was 75,000. In the first edition (2007-2009), over 28 thousand students were surveyed: 11,530 aged 7-8 years old and 16,809 aged 16-17 years old. All the legal guardians of the children and the adolescents gave their informed consent to participate in the study. The survey questionnaire was based on the questionnaire from the International Study of Asthma and Allergies in Childhood (ISAAC) [6], supplemented with a screening questionnaire form (Appendices 1 and 2) and a questionnaire for those allergic to chemical substances (Appendices 3 and 4). In the last edition (2013-2015), organized for comparison purposes, over 20 thousand students were surveyed: 11,245 aged 7-8 years, and 9,197 aged 16-17 years. After the first stage of the study (survey questionnaire), in which 11 nurse internships conducting studies in Krakow schools were involved, those participants with a positive history of allergies found on the basis of the questionnaire were referred to the second stage, in order to undergo specific allergological tests and consultations with allergologists. The second stage was implemented by allergologists in 6 centers in Krakow. Any participants with suspected allergies received a spirometric test (Lung Test 1000, MES, Poland), with validity control and reference values based on those of the European Respiratory Society (ERS), and the applied criteria of asthma based on the International Consensus on Pediatric Asthma (ICON) [7]; skin prick tests using 10 inhalatory allergens (Allergopharma GmbH & Co. KG, Germany), patch tests with the European Baseline Series (Chemotechnique MB Diagnostics AB, Sweden) and Fx5 food allergy panel (chicken egg white, cow milk protein, fish, cod, wheat, peanut, soy; Phadia ImmunoCAP, Sweden) performed according to the manufacturer's recommendations. Allergic diseases (asthma, allergic rhinitis) were diagnosed on the basis of the EAACI and ICON guidelines [7, 8].

Results

In 2007-2009, allergic rhinitis was found in nearly 30% of the children and 25% of the adolescents, with asthma being observed in 12% and 9%, respectively. Allergic eczema was found in one in four of the children, and one in eight of the adolescents. Half of the students with recurrent or chronic eczema were allergic to at least one chemical substance (Table 1). The most allergenic haptens were metals, thiomersal and aromatic composition (Table 2).

The results were compared with the available data for Poland, obtained in the ECAP study [4]. The prevalence of the most common allergic diseases (allergic rhinitis and asthma) in the students of Krakow schools was higher in both age groups (Table 1).

Continuation of the study in 2013-2015 enabled the observation of epidemiological trends regarding the prevalence of allergic diseases in the population of children and adolescents in Krakow (Table 3). The profile of inhalatory and food allergens was analyzed closely (Table 4). The increased prevalence of allergic rhinitis in the older age group, compared to the study from 2007-2009, was visible. Moreover, despite the fact that over 50% of respondents reported allergic symptoms, 60% of them were not diagnosed or treated for allergies.

Discussion

The study conducted in 2007-2009 and repeated in 2013-2015 demonstrated the size of the prevalence of allergic diseases in children and adolescents in Krakow. The data indicates that in a large urban agglomeration, such as Krakow, the risk of allergic diseases is higher than in the general population for these age groups. Similar observations were made in other countries in Europe (Germany) and Asia (Taiwan) [9-11]. A possible explanation of this phenomenon is growing up in an area with severely polluted air.

school stamp

City Program for Prophylaxis and Promotion of Health
Healthy Krakow 2007-2009/5/II

Asthma and allergic diseases prevention program for school children – Stage II

QUESTIONNAIRE for children 7-8 years old

Surname: ..... First name:..... Grade: .....
PESEL (Personal Identification No.) of the child: .....Year of birth: .....
Address:..... Telephone: .....

PART I (circle the correct answer [**YES** or **NO**])

1.	**Does the child have or has had:**	YES	NO
	Year-round or seasonal **rhinitis**, with or without conjunctival irritation	YES	NO
	Acute **allergic reaction** after: food, exercise, stings, medications	YES	NO
	Episodes of shortness of breath, cough, wheezing (underline as applicable)	YES	NO
	Skin lesions: eczema, urticaria, wheals, swelling, erythema, itching (underline as applicable)	YES	NO
2.	**Is the child allergic to anything?** If so, what is the allergen?	YES	NO
3.	**Did the child have allergic skin lesions in childhood?**	YES	NO
4.	**Did the child have recurrent bronchitis with episodes of cough, wheezing, shortness of breath?** (underline as applicable)	YES	NO
5.	**Is the child a patient or has been a patient of an Allergology Clinic?**	YES	NO
	If so, provide the address of the clinic:	YES	NO
6.	**What is the distance between the child's place of residence and a road with intense traffic?** <200 m 200-500 m >500 m	YES	NO

IF YOU ANSWERED **NO** TO ALL THE QUESTIONS,
PLEASE JUST COMPLETE THIS PART OF THE QUESTIONNAIRE

If allergies are suspected in the child, and the parent or guardian gives written consent,
an allergological test will be offered
[including skin tests, blood tests, spirometry, as required].

I consent:

date ....
signature of Mother/Father/Guardian

Appendix 1. Screening questionnaire for adolescents aged 7-8 years

Załącznik 1. Ankieta przesiewowa dla młodzieży w wieku 7-8 lat

school stamp

City Program for Prophylaxis and Promotion of Health
Healthy Krakow 2007-2009/5/II

Asthma and allergic diseases prevention program for school children – Stage II
QUESTIONNAIRE for adolescents aged 16-17 years old

Surname: .....First name:..... Grade: .....
PESEL (Personal Identification No.) of the child: ..... Year of birth:.....
Address:..... Telephone: .....

PART I (circle the correct answer [**YES** or **NO**])

1.	**Do you have / have you had:**	YES	NO
	Year-round or seasonal **rhinitis**, with or without conjunctival irritation	YES	NO
	Acute **allergic reaction** after: food, exercise, sting, medications	YES	NO
	Episodes of shortness of breath, cough, wheezing (underline as applicable)	YES	NO
	Skin lesions: eczema, urticaria, wheals, swelling, erythema, itching (underline as applicable)	YES	NO
2.	**Are you allergic to anything?** If so, what is the allergen?	YES	NO
3.	**Did you have allergic skin lesions in childhood?**	YES	NO
4.	**Did you have recurrent bronchitis with episodes of cough, wheezing, shortness of breath?** (underline as applicable)	YES	NO
5.	**Are you or have you been a patient of an Allergology Clinic?**	YES	NO
	If so, provide the address of the clinic:	YES	NO
6.	**What is the distance between your place of residence and a road with intense traffic?** <200 m 200-500 m >500 m	YES	NO

IF YOU ANSWER **NO** TO ALL THE QUESTIONS, PLEASE JUST COMPLETE THIS PART OF THE QUESTIONNAIRE, IF YOU ANSWERED **YES** TO AT LEAST ONE QUESTION, COMPLETE **PART II** OF THE QUESTIONNAIRE

With the written consent of a parent or guardian, allergic tests will be offered, free of charge [skin tests, blood tests], and a consultation with allergologist.

I consent:

date ....
signature of Mother/Father/Guardian

Appendix 2. Screening questionnaire for adolescents aged 16-17 years
Załącznik 2. Ankieta przesiewowa dla młodzieży w wieku 16-17 lat

PART II D

QUESTIONNAIRE FOR CHILDREN AGED 7-8 YEARS OLD
WITH CONTACT ECZEMA

(hand eczema, eczema at the contact site with environmental substances, e.g. jewelry, cosmetics)

(circle the correct answer: **YES** *or* **NO***)*

1.	Does the child wear **artificial jewelry** (earrings, clips, chains, bracelets made of metals other than gold, silver or platinum)?	NO	YES	since the age of... years
2.	How often does the child **wear artificial jewelry**? **(every day or almost every day)**	from time to time		almost never or never
3.	Does the child have **their ears** or **any other body part pierced**?	NO	YES	since the age of ... years
4.	Does the child have a **permanent tattoo** (i.e. made with a needle)?	NO	YES	since the age of ... years
5.	Does the child have or has the child had a **temporary tattoo** (i.e. painted on the skin)?	NO	YES	
6.	Does the child wear or used to wear **dental braces** (for teeth correction)?	NO	YES	since the age of ... years
7.	How often does the child use **cosmetics** (skin care creams, perfumes, makeup)?	everyday		almost everyday
8.	Has the child ever dyed her/his hair?	NO	YES	for the first time at the age of ...
9.	Have you noticed that **contact** with certain substances or items causes eczema (itchy rash) in the child?	NO	YES	
	Contact with (underline as applicable): metals, cosmetics, medications, rubber, other (name the allergens)	NO	YES	
10.	Does the child have an itchy rash NOW?	NO	YES	
11.	Has the child had such rash within the last year?	NO	YES	
12	Did the child have such rash earlier than within a year?	NO	YES	

Appendix 3. Questionnaire for symptoms of contact dermatitis in children aged 7-8 years

Załącznik 3. Kwestionariusz dotyczący objawów wyprysku kontaktowego u dzieci w wieku 7-8 lat

PART II D

QUESTIONNAIRE FOR ADOLESCENTS AGED 16-17 YEARS OLD
WITH CONTACT ECZEMA

(hand eczema, eczema at the contact site with environmental substances, e.g. jewelry, cosmetics)

(circle the correct answer: **YES** *or* **NO***)*

1.	Do you wear/did you wear **artificial jewelry** (earrings, clips, chains, bracelets made of metals other than gold, silver or platinum)?	NO	YES	since the age of ... years
2.	How often do you wear **artificial jewelry**? **(every day or almost every day)**	from time to time		almost never or never
3.	Do you have **your ears** or **any other body part pierced**?	NO	YES	since the age of ... years
4.	Have you got a **permanent tattoo** (i.e. made with a needle)?	NO	YES	since the age of... years
5.	Have you got or have you ever had a **temporary tattoo** (i.e. painted on the skin)?	NO	YES	
6.	Have you worn **dental braces** (for teeth correction)?	NO	YES	since the age of ... years
7.	How often do you use **cosmetics** (skin care creams, perfumes, makeup)?	everyday		almost everyday
8.	Have you had your hair dyed?	NO	YES	for the first time at the age of ...
9.	Have you noticed that **contact** with certain substances or items gives you skin eczema (itchy rash)?	NO	YES	
	Contact with (underline the applicable): metals, cosmetics, medications, rubber, other (list)	NO	YES	
10.	Do you have an itchy rash NOW?	NO	YES	
11.	Have you had such rash within the last year?	NO	YES	
12.	Did you have such rash earlier than within a year?	NO	YES	

Appendix 4. Questionnaire for symptoms of contact dermatitis in adolescents aged 16-17 years

Załącznik 4. Kwestionariusz dotyczący objawów wyprysku kontaktowego u młodzieży w wieku 16-17 lat

Table 1. Incidence of allergic diseases in the population of children and adolescents in Krakow in 2007-2009
Tabela 1. Częstość występowania chorób alergicznych w populacji dzieci i młodzieży w Krakowie w latach 2007-2009

Disease entity	Age 7-8 years	Age 16-17 years
Allergic rhinitis	29.5% (24%*)	25.8% (25%*)
Bronchial asthma	12% (4.4%*)	8.9% (6.5%*)
Allergic eczema (atopic dermatitis or allergic contact dermatitis)	25.9%	13%

* ECAP results

Table 2. Contact allergy in children and adolescents with allergic eczema symptoms in 2007-2009
Tabela 2. Alergia kontaktowa u dzieci i młodzieży z objawami wyprysku alergicznego w latach 2007-2009

Population	in total (percentage with allergy)	The most common haptens causing allergies
7-8 years	44%	Nickel (30%) Thiomersal (10%) Cobalt (8%) Aromatic composition (7%) Chromium (6%)
16-17 years	53%	Nickel (26%) Thiomersal (25%) Cobalt (12%) Chromium (7%) Aromatic composition (3%)

In the study analyzing the relationships between the prevalence of allergic diseases in children and adolescents and the place of residence, a higher prevalence of asthma and allergic rhinitis was demonstrated in respondents living less than 200 m from main transport arteries, compared to those living 200-500 m and over 500 m away [12]. The correlation was significantly stronger in the younger age group.

Ambient air pollution is a result of introducing solid, liquid or gas substances, or wave energy into the air, in quantities or concentrations harmful for the environment. It is believed that the role of air pollution in causing allergic diseases consists of the adjuvant effect at the stage of allergy development, as well as in allergenic provocation resulting in the development of allergic disease [13]. In combination with air pollutants, allergens have a higher allergenic potential [14]. Pollutant particles can be transported on the surface of pollen or suspended in the air. They cause a reaction due to irritation, and facilitate allergen penetration though the mucosal membranes or skin into the organism [15].

Table 3. Incidence of allergic disease in the population of children and adolescents in Krakow in 2013-2015
Tabela 3. Częstość występowania chorób alergicznych w populacji dzieci i młodzieży w Krakowie w latach 2013-2015

Disease entity	Age 7-8 years	Age 16-17 years
Allergic rhinitis	28.8% (24%*)	34.4% (25%*)
Bronchial asthma	5.2% (4.4%*)	5.1% (6.5%*)
Allergic eczema (atopic dermatitis or allergic contact dermatitis)	9.2% (25.9%*)	4% (13%*)

* ECAP results

Table 4. Allergy profile characteristics in the population of children and adolescents in Krakow in 2013-2015
Tabela 4. Charakterystyka profilu alergii w populacji dzieci i młodzieży w Krakowie w latach 2013-2015

Allergy to allergens (in general in age groups, and according to frequency)	Age 7-8 years	Age 16-17 years
Inhalatory	47.2% Mites (dust/flour) Grass Trees Cats	31.5% Mites (dust/flour) Trees Grass Cats
Food	22.7% (positive result of Fx5 food allergy panel)	17.9 % (positive result of Fx5 food allergy panel)

Early detection of the etiology of the allergic disease, possible thanks to a prophylactic program, allows the limiting of exposure to the offending allergen, prevent disease development, prevent severe allergic reactions associated with the risk of life-threatening acute asthma or anaphylactic shock, and reduce the costs incurred by therapies for allergic diseases.

The avoidable indirect costs due to the lack of proper treatment for allergic diseases in the European Union (EU) are estimated to be 55-151 billion euro per year. Urgent actions to increase the awareness and reduce the load of allergic diseases are necessary [16].

Every year over 400 thousand Europeans die prematurely due to air pollution [17]. Current EU standards of air quality are obsolete and do not comply with the World Health Organization (WHO) recommendations regarding air quality. There is no safe level of air pollution [17]. The strong will of society may help to overcome the politician's strong resistance to undertaking further cost-effective actions to combat air pollution [18].

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Local influence of particulate matter on the lower respiratory tract

Miejscowe oddziaływanie pyłu zawieszonego na dolne drogi oddechowe

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Abstract. Air pollution is now the main cause of environmental hazards and shows adverse effects on human health. It contributes most often to the development of respiratory and cardiovascular system diseases, with consequences including myocardial infarction, stroke and lung cancer. The factors determining its toxicity include its structure and chemical composition, as well its pulmonary deposition. Macrophages with their phagocytic function play an important role in the degradation of the particulate matter and initiation of inflammatory processes. The mobilization of the intracellular mechanisms of oxidative stress and the stimulation of transcriptional nuclear factors affect the inflammatory mediators, in particular cytokines, chemokines and adhesion molecules. The suppression of the lung immune system induced by the particulate matter creates favorable conditions for impairment of its defense functions and promotes the Th_2 lymphocyte response. Understanding the molecular mechanisms of cell structure damage can contribute to the synthesis of drugs inhibiting the adverse effects of the oxidative stress mediators.

Key words: air pollution, particulate matter, oxidative stress, local inflammation, lower respiratory tract

Streszczenie. Zanieczyszczenia powietrza atmosferycznego są obecnie głównymi przyczynami zagrożeń środowiska i wpływają niekorzystnie na zdrowie człowieka. Przyczyniają się do rozwoju głównie chorób układu oddechowego i sercowo-naczyniowego z wszelkimi ich konsekwencjami, takimi jak zawał serca, udar mózgu czy rak płuca. Czynnikiem determinującym ich toksyczność, oprócz budowy i składu chemicznego, jest ich depozycja płucna. Ważną rolę w degradacji cząstek pyłu zawieszonego i inicjacji procesu zapalnego odgrywają makrofagi z ich funkcją fagocytarną. Uruchomienie wewnątrzkomórkowych mechanizmów stresu oksydacyjnego i stymulacji jądrowych czynników transkrypcyjnych wpływa na syntezę mediatorów zapalnych, zwłaszcza cytokin, chemokin i cząsteczek adhezyjnych. Indukowana działaniem pyłu supresja układu immunologicznego płuc sprzyja upośledzeniu jego funkcji obronnych oraz promocji odpowiedzi Th_2-zależnej. Poznanie molekularnych mechanizmów uszkadzających strukturę komórki może się przyczynić do syntezy leków hamujących niekorzystne skutki działania mediatorów stresu oksydacyjnego.

Słowa kluczowe: zanieczyszczenia powietrza, pył zawieszony, stres oksydacyjny, zapalenie miejscowe, dolne drogi oddechowe

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Introduction

Ambient air pollution is today the most significant cause of global environmental risk, and is defined in the Act of 31 January 1980 on Environmental Protection and Development as "the emission into the air of solid, liquid or gaseous substances in quantities which may adversely affect human health, the climate, flora and fauna, the soils and waters, or cause other damage to the environment" [1, 2].

Epidemiological studies conducted in the last 15 years clearly indicate that air pollution demonstrates adverse effects on human organisms and other living nature. The effects may be present in different forms, sometimes causing mild symptoms such as irritation, conjunctival itching and lacrimation, which are difficult to associate with pollution, while other times they may cause sudden and severe dyspnea in asthma or COPD patients, and exacerbation of cardiovascular symptoms [3, 4]. According to the WHO data, in 2012 the impact of air pollution was responsible for approximately 72% of premature deaths due to ischemic heart disease and cerebral strokes, 11% of deaths due to COPD or acute infections of the lower respiratory tract, and 12% of deaths due to lung cancer [5]. Today we are well aware of the consequences of the 'great smog' in December 1952 in London, when pollution norms were exceeded by 50-fold, and approximately 12 thousand people died, mostly newborns, young children and the elderly [6].

The majority of epidemiological studies demonstrate a significant linear relationship between the level of particulate matter (PM) concentrations and health effects, taking into consideration the season of the year, location and duration of exposure: in days, months or years. The observations are confirmed by the reduction in total mortality and the prevalence of respiratory diseases during strikes in local steel factories, which result in decreased air pollution, as described in the Utah Valley study. During the 1996 Olympics in Atlanta, modifications to the urban transport system reduced the emission of pollution from passenger cars (e.g. ozone) by approximately 30%, which resulted in a 40% decrease in the number of asthma exacerbations, and a reduction in emergency interventions by 19% [8]. In Hong Kong the requirement to use fuels with reduced sulfur content by all power plants and road vehicles, although introduced for one weekend only, immediately lead to a reduction of SO_2 concentrations in the environment, and as a consequence, the seasonal death rates decreased from 3.9% to 2% [8].

Deposition of suspended particulate matter

Air pollution is usually grouped into gaseous forms (gases and vapors) and solid forms in the form of aerosols (suspended particulate matter with various degrees of fragmentation, and different molecular sizes) [9]. Particulate matter has natural and anthropogenic sources, and its health effect is due to the cytotoxic, genotoxic and mutagenic compounds present on the surface of the particles [10]. The most common sources include the industrial combustion of coal and liquid fuels, especially in compression ignition engines, the production of electric energy, or burning biomass in household ovens and furnaces [3]. Particulates are classified by size as coarse [approximately 10 μm (PM_{10})], fine [<2.5 μm ($PM_{2.5}$)], and ultra-fine [<0.1 μm] [11]. Among the organic compounds absorbed on their surface, polycyclic aromatic hydrocarbons and their amino- and nitroderivatives demonstrate the greatest effect on the health of living organisms, especially humans [12].

Human lungs provide about 80-120 m^2 of the surface for respiratory gas exchange (oxygen and carbon dioxide), and they daily ventilate 10-20 thousand liters of the surrounding air, which contains gas fractions and suspended particulates of different sizes [13]. An important factor that determines their toxicity is their dosimetric characterization, which includes their deposition, retention, transportation and solution in different pulmonary areas [14]. Deposition depends on the aerodynamic size and shape, as well as on the speed and depth of breathing and the structure of the lungs. Generally, if the particles are large and the breathing rate is high, deposition is limited to the proximal section of the respiratory tract, whereas small lungs and slow, deep breathing are conducive to peripheral deposition [12, 13]. Particulates of <10 μm are the most dangerous, as they can penetrate into the pulmonary alveoli, cause damage, and subsequently enter the blood circulation. Thus they may spread all over the organism and this leads to the development of diseases, in particular cardiovascular and CNS disorders [14-16]. Studies performed with the use of radioactive-labeled molecules showed that 83% of the 2.5 μm particles reached peripheral pulmonary deposition, whereas only 49% and 31% of the larger particulates (8.2 μm and 11.5 μm) were deposited in this area [13]. Their size was also associated with longer "retention" in the lungs. The smaller diameters resulted in longer exposure times: after 24 hours, 77% of particles of 2.5 μm were retained, while only 15% of particles of 8.2 μm [17].

The defense mechanisms of the lungs usually enable the removal of pollution from the surface of the lower

respiratory tract, due to ciliary clearance and subsequent expectoration with the sputum [12]. This applies especially to large particles. In the case of smaller particles, which penetrate directly into the peripheral areas of the lungs, their neutralization involves macrophage phagocytosis, and subsequent intracellular deposition. As a result, macrophages often accumulate in the local thoracic lymph nodes [18-20].

The smallest particulates are smaller than cells, so they can easily penetrate into and damage intracellular structures. On the other hand, they also directly enter the blood circulation, and are transported to different organs [21]. As previously mentioned, healthy lungs can be effectively cleared of most suspended particulates via muco-ciliary transport. However, as the influx of particulate matter is increased, the respiratory or immune function is disturbed, or when the particulate matter is highly toxic the mechanisms may be disturbed and insufficient. On the surface of the particulate matter molecules found in the breathed air can be found metal particles, which can induce oxidation reactions, and create reactive oxygen species. These damage the cells of the bronchial respiratory epithelium and pulmonary alveolar cells [22, 13].

Local effects of suspended particulate matter

The current knowledge and previous studies on the mutual relationships and mechanisms resulting in local damage to the bronchial respiratory epithelial cells, pulmonary alveoli and macrophages and neutrophils, enable tracing of the sequences of the intracellular processes which lead to inflammation. These involve intracellular oxygen transformations, which play an important role [24, 25]. Oxygen, a biogenic element, is necessary for these biochemical processes, thus affecting the cell survival. However, in certain adverse situations, highly reactive oxygen species (ROS) are synthesized excessively, and can demonstrate a direct toxic effect on the cellular organelles, nucleic acids, proteins, lipids and carbohydrates [26]. ROS comprise the products of oxygen stimulation and its full or partial reduction, resulting from the "escape" of electrons from a respiratory chain through the internal mitochondrial membrane. They include in particular free oxygen radicals, such as superoxide anion ($O_2^{\bullet -}$), hydroperoxide radical ($HO_2^{\bullet}$), hydroxyl radical ($HO^{\bullet}$), hydrogen peroxide (H_2O_2), ozone (O_3) and singlet oxygen ($^1O_2$) [11]. They are produced in every living cell, as a consequence of oxidoreduction reactions. In small concentrations they are important elements of the mediators and regulators of biological processes, affecting proper cellular function. However, the excessive synthesis of free radicals, which cannot be neutralized effectively by the antioxidative systems, leads to oxidative stress, and to damage to the structures and functioning of cells, thus contributing to various pathological reactions and the development of many diseases (Figure 1) [27, 28]. From a physiological point of view, ROS play the role of signal pathway mediators and the regulators of the cellular genes participating in the process of their differentiation, aging, defense mechanisms, and the induction of the synthesis of proinflammatory cytokines and nitrogen oxide. Therefore, low oxidative stress levels contribute to the dominance of the cellular antioxidative system, and stimulation of a transcription factor (nuclear-factor-erythoid 2-related factor 2 (Nrf2) [11, 12]. This controls the expression of numerous genes whose products induce antioxidative response, and demonstrate cytoprotective effects due to enzymes such as glutathione S-transferase (GST), NAD(P)H reductase, heme oxygenase 1 (HO-1), and γ-glutamylcysteine synthetase (γ-GCS) [11, 29]. High oxidative stress also results in the stimulation of the nuclear factor kappa B (NF-kB) and activating protein 1 (AP-1), i.e. inflammatory reaction and synthesis of cytokines, chemokines, and increased expression of adhesive molecules [11, 30]. The effect of oxidative stress metabolites on the lipid structures leads to oxidation of polyunsaturated fatty acids, which are elements of cellular membranes and intracellular structures. This results in modification of their physical and chemical properties, and increases their permeability. As a consequence, the flow of ions and the membrane potential may be disturbed. Therefore, suspended particulates significantly affect the production of oxidative stress products in the mechanism of lipid peroxidation, such as 4-hydroxynonenal, and generate an oxidized form of glutathione disulfide (GSSG), or its reduced form, glutathione (GSH) [29, 31]. The disturbed oxidation-reduction balance, shifted towards oxidation, contributes to histone acetylation, and loosens the contact between histones and DNA, which provides access for the transcription complex to the promoter region, and subsequent gene transcription [11, 30].

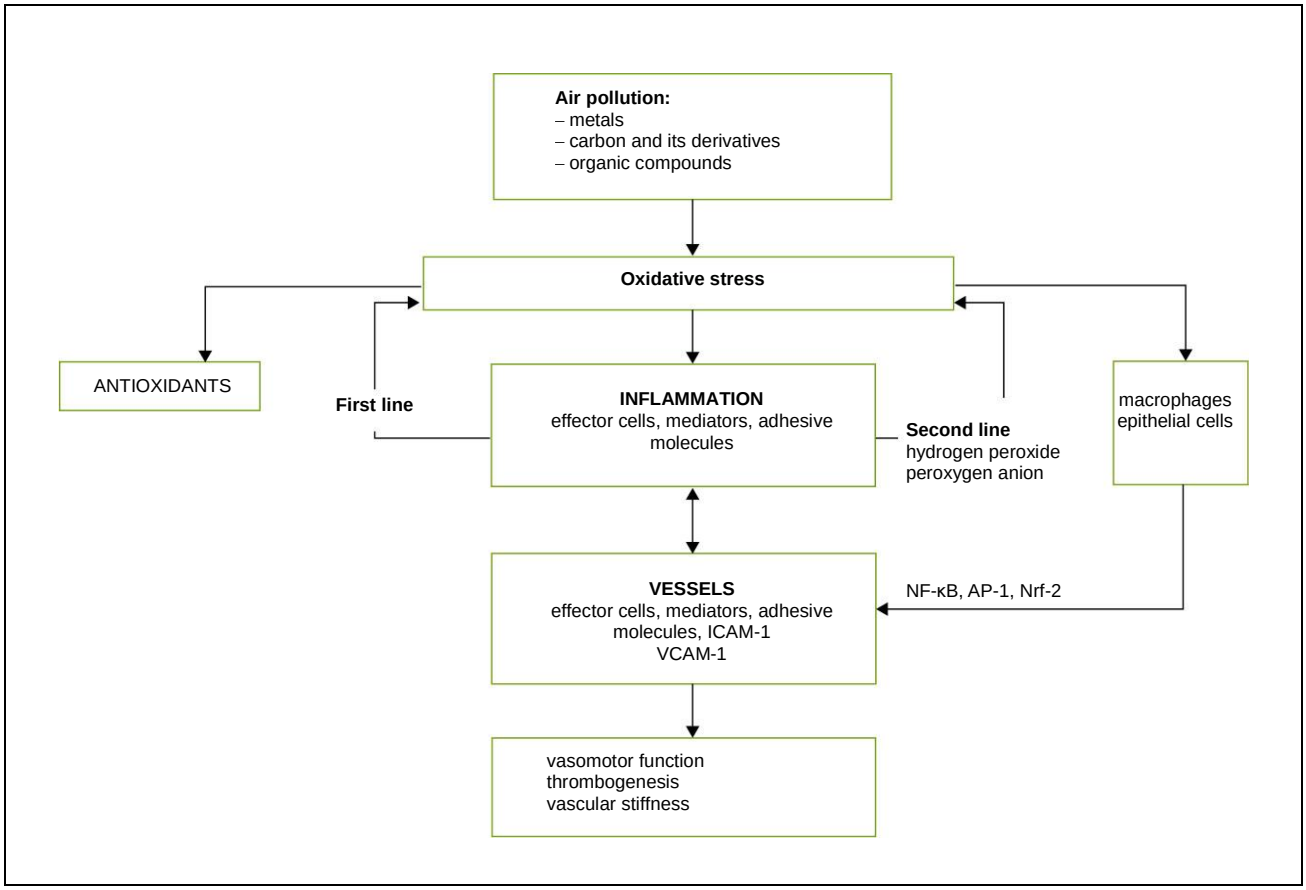

Figure 1. Suspended particulate matter ─ consequence of oxidative stress

Rycina 1. Pył zawieszony ─ następstwa stresu oksydacyjnego

Oxidative stress products affect the NF-kB transcription factor, its translocation into the cell nucleus, as well as access to the promoter regions of the cytokine genes and growth factors, such as TNF-α, IL-8, IL-2, IL-6, GM-CSF, intracellular adhesion molecule-1 (ICAM-1), E-selectin and inducible nitric oxide synthase (iNOS) [26, 28]. Moreover, oxidative stress or the direct impact of particles stimulate increased intracellular Ca2+ concentration [32], which may also cause the activation of NF-kB [33]. Calcium ions can lead to further production of ROS. The combination of these processes results in an intensification of gene transcription, which leads to inflammation. The inflammation induced by the above changes may trigger mechanisms that may contribute to restoration of the disturbed oxidation-reduction balance, due to the removal of the primary source of the oxidative stress and increased synthesis of antioxidants, while also may in many ways be conducive to oxidative stress (Figure 2) [33, 34].

In a healthy, properly functioning organism, oxidation processes are balanced by the activity of cellular antioxidative mechanisms, which counter the effects of oxidative stress through elimination of individual compounds, or reconstruction of the damaged structures. These processes involve the internal enzymatic mechanisms, including superoxide dysmutase (SOD) which accelerates degradation of the superoxide radical to hydrogen peroxide and molecular oxygen; catalase (CAT), which degrades hydrogen peroxide to water and oxygen; or glutathione S-transferase (GST), especially in its reduce form (GSH), which degrades the hydrogen peroxide found in the lipid structures, in particular in cellular membranes of antioxidants, such as SOD, CAT or γ-glutamylcysteine synthetase [11].

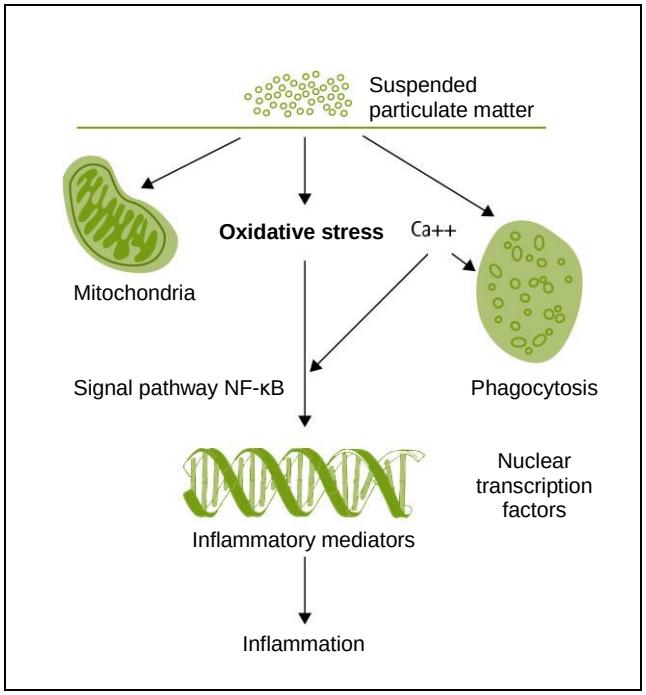

Fig 2. Sequences of intracellular interactions leading to the development of inflammatory process induced by suspended particulate matter

Rycina 2. Sekwencje wewnątrzkomórkowych oddziaływań prowadzących do rozwoju odczynu zapalnego w wyniku działania pyłu zawieszonego

The effect of the lung defense mechanisms

Suppression of the pulmonary immune function, induced by the suspended particulate matter, is one of the most important factors promoting recurrent respiratory infections. $PM_{2.5}$ reduces the elimination of bacteria from the lungs by inhibiting the synthesis of proinflammatory cytokines stimulated by LPS (lipopolysaccharides), including IL-1β, TNF-α, and through reducing phagocytosis [35]. Exposure to PM 2.5 increases microorganic colonization in the lower respiratory tract, and increases adhesion of pneumococci to the epithelial cells, which leads to a higher prevalence of exacerbation hospitalizations due to pneumonia [36]. Also pulmonary macrophages, elements of the first-line defense, are responsible for the elimination of microorganisms and harmful particles, and play an important role in innate immunity [36]. It has been demonstrated that exposure to $PM_{2.5}$ contributes to the impairment of their defense function regarding viruses, bacteria, and other microorganisms, due to impairment of their phagocytic function. A study conducted by Matthews et al. [37] indicated that exposure to $PM_{2.5}$ inhibits lymphocytes T with the Th1 phenotype, thus reducing IFN-γ concentration, which promotes the mediators of lymphocytes Th2 initiating the allergic reaction. As a consequence, the antiviral and antibacterial response is impaired.

The relationship between PM_{10} or $PM_{2.5}$ and the immune function of the respiratory system is complex. Suspended particulate matter activates innate immunity and intensifies inflammatory reactions. For instance, $PM_{2.5}$ stimulates the epithelial cells to secrete chemokine MIP-3a (CCL20), which helps to recruit dendritic cells to the respiratory tract [38]. Though the oxidative stress mechanisms, diesel exhaust particles (DEP) directly affect the costimulatory molecules (CD40 and CD86) participating in the presentation of antigen, and contributing to a Th2-dependent immune response. Initially this takes place on a limited area of the bronchial mucosa. However, frequent exposure promotes the spreading of the inflammatory process, and triggers clinical symptoms. DEP pollution contributes to increased nRNA expression of the histamine H1 receptors on the epithelial cells, and to histamine-induced increased synthesis of cytokines and growth factors [39]. This explains the symptoms of allergic rhinitis, bronchial hyperreactivity, and other clinical symptoms associated with increased exposure [40].

Interactions between pollution particles and Toll-like receptors (TLR), especially receptors 2 and 4 (TLR-2 and TLR-4) are also prominent [36]. It has been demonstrated that $PM_{2.5}$ helps to reduce TLR expression, as well as the synthesis and secretion of TNF-α and IL-8, by which it inhibits the antibacterial efficiency of the respiratory system [40]. Using the anti-TLR-2 antibody results in increased IL-8 secretion from the respiratory epithelial cells [41]. Another very important factor of the innate immune system, primarily giving protection from viral infections of the respiratory tract, is surfactant protein A (SP-A). A study by Wang et al. [42] demonstrated that suspended particulates contribute to reduced concentrations of SP-A, Clara cell secretory protein, and INF-γ, resulting in decreased antiviral immunity.

The effect of air pollution, especially of suspended particulate matter, on human health, has long been observed - in particular with regard to the promotion of respiratory and cardiovascular diseases, or the increased number of hospitalizations and deaths among elderly patients with chronic diseases. Understanding of the molecular mechanisms which damage the cellular structures via oxidative stress constitutes significant progress in explaining their role in the initiation and maintenance of a local inflammatory process, leading to different diseases, including asthma, COPD, lung neoplasms, ischemic heart diseases and cerebral strokes. Hopefully, experimental studies conducted on a

large scale will soon enable the synthesis of drugs that could inhibit the adverse effects of oxidative stress, and prevent the development of inflammation [43, 44].

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Air pollution – what are we breathing in Poland?

Zanieczyszczenia powietrza – czym oddychamy w Polsce?

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Abstract. Air pollution is currently one of the most critical determinants of environmental degradation, negatively affecting not just plants and animals, but also structures, construction materials, and especially the health and quality of human life. The European Environment Agency indicates that the premature deaths of 520,000 EU citizens (including more than 51,000 people in Poland) per year can be attributed to fine particulate matter (i.e. $PM_{2.5}$), nitrogen dioxide and tropospheric ozone. This phenomenon is to the greatest extent related to emissions from the municipal sector and transport, whereas emissions from the energy production and distribution sector and industry are of less importance. These emissions result in one of the highest concentrations of air pollutants (in particular PM_{10} and $PM_{2.5}$ and benzo(a)pyrene) across the whole European Union. The consequence is unusually high exposure for people in Poland to polluted air, resulting in a higher mortality rate in comparison to the remaining 27 countries of the EU.

Key words: air pollutants, air pollution emission sources, air quality, health threats

Streszczenie. Zanieczyszczenie powietrza atmosferycznego stanowi obecnie jeden z najbardziej kluczowych czynników warunkujących degradację środowiska naturalnego, wpływających negatywnie zarówno na świat roślin i zwierząt, jak i na konstrukcje oraz materiały budowlane, a przede wszystkim na zdrowie i jakość życia człowieka. Europejska Agencja Środowiska wskazuje, że przedwczesne zgony 520 tys. mieszkańców Unii Europejskiej (w tym ponad 51 tys. Polaków) w skali roku przypisuje się zanieczyszczeniu powietrza bardzo drobnym pyłem (tzw. $PM_{2,5}$), dwutlenkiem azotu i ozonem troposferycznym. W największym stopniu są z tym zjawiskiem związane emisje z sektora komunalno-bytowego oraz z transportu, w mniejszym zaś stopniu z sektora produkcji i dystrybucji energii oraz z przemysłu. Emisje te przekładają się na jedne z największych stężeń zanieczyszczeń powietrza, zwłaszcza pyłów PM_{10} i $PM_{2,5}$ oraz benzo(a)pirenu, w skali całej Unii Europejskiej. Skutkiem tej sytuacji jest ponadprzeciętnie duże narażenie Polaków na zanieczyszczone powietrze, skutkujące m.in. wspomnianym dużym wskaźnikiem umieralności na tle pozostałych 27 krajów UE.

Słowa kluczowe: zanieczyszczenia powietrza, źródła emisji zanieczyszczeń, jakość powietrza, zagrożenia zdrowotne

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Why what we breathe is so important

One of the most important factors responsible for the degradation of the natural environment is the introduction into the ambient air substances of different physical and chemical properties, which change its natural composition and are commonly referred to as air pollution. The substances have either a direct (through their effect on plants, building materials etc.) or indirect (e.g. as a result of washout into the soil or accumulation in plant tissues), but always adverse, affect on virtually all components of the environment, including humans.

According to the World Health Organization (WHO), 3.7 million premature deaths reported globally in 2012

can be attributed to ambient air pollution alone, whereas if all the pollution to which people are exposed in buildings (pollution of so-called indoor air) is also included in the estimation then the number increases to 8 million [1]. These numbers are primarily due to deaths observed in large urban agglomerations, where air quality is poor, while in less urbanized areas the air quality is generally better [2].

Ambient air contains a number of pollutants with various potentials for health effects, including nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon monoxide (CO), tropospheric ozone (O_3), organic compounds (e.g. volatile organic compounds, aromatic hydrocarbons, dioxins) or solid particles, usually classified as PM_{10} and $PM_{2.5}$ (particulate matter fractions where the particles have an aerodynamic diameter of less than 10 μm or 2.5 μm, respectively). Each of these substances can lead to symptoms of impaired ventilation in the functional respiratory tests, increase the prevalence of bronchial hyperactivity and lower respiratory infections, intensify the symptoms of existing allergic diseases (especially asthma), and cause structural lesions in pulmonary parenchyma. The broadest spectrum of acute and chronic diseases, primarily respiratory and cardiovascular disorders, is associated with exposure to solid particles in the air.

The European Environment Agency data indicates that almost 470 thousand premature deaths of Europeans in 2013 may have been associated with their exposure to $PM_{2.5}$. The majority, i.e. nearly 440 thousand, were EU citizens, but many countries outside the European Union do not provide information on the subject. The number of Polish citizens included in this report was over 48 thousand. The number of premature deaths in Europe and Poland due to the combined effects of NO_2 and O_3 was nearly 90 thousand and 2.7 thousand, respectively [3].

Air pollution with PM_{10} and $PM_{2.5}$ is currently a global problem, one that is difficult or even impossible to solve in those countries with low or moderate income levels [4]. The assessment of the actual effect of air pollution, including solid particles, on human health, as well as undertaking effective actions to reduce the exposure and its health-related consequences depend on the reliability and availability of data reflecting the actual situation, i.e. concentrations of substances in the air, their spatial and temporal variability, and especially the sources and quantities of these pollutants. The collection of the data, ensuring its reliability and representativeness, as well as its reasonable use, should be priorities in environmental protection management.

What are the sources of the pollution emitted into the air?

Air quality is characterized mostly by concentrations of different types of pollution. As this is monitored primarily in areas inhabited by humans, it is commonly assumed that the greatest levels of air pollution are found in large urban centers [5-7]. Clearly, air quality in areas adjacent or close to such centers will also be worse than in distant regions [8]. One can therefore imagine that, globally, urban centers are the fundamental sources of air pollution. On a national level, these may be individual cities combining urban and industrial activities, and on a regional scale as urban clusters, industrial areas or even individual centers, such as a power plant, smelter or residential site comprising several buildings [9, 10]. This classification is based on the assumption that air pollution originates exclusively from anthropogenic sources. However, it should be noted that certain pollutants, e.g. volatile organic compounds or particulate matter, come mostly (*en masse*) from natural sources (oceans, plant vegetation, volcanoes, deserts etc.). There are two principal explanations for the common belief that air quality is attributable to anthropogenic emission. Firstly, most strongly toxic or cancerogenic compounds (e.g. certain heavy metals, such as lead, mercury or cadmium, dioxins or polycyclic aromatic hydrocarbons) are derived from emissions associated with human activity [11, 12]. Secondly, compounds and substances emitted from natural sources are more or less equally distributed on a global level, and constitute a specific natural background, so it is the excess relative to this background, due to anthropogenic emissions in those areas exposed to it, that is classified as excessive air pollution with a given substance [13, 14].

The pressure on the environment resulting from the emission of pollutants into the ambient air is corrected by local climatic, meteorological or topographic conditions, which facilitate or impede the diffusion and chemical transformations of air pollution, thus reducing or increasing their concentrations in the air, and the load for other environmental components. However, the size of the emission alone is the key factor which conditions the concentration of air pollution, at least locally. In terms of the temporal and spatial variability of air pollution concentrations, the processes taking place in the atmosphere are of essential importance [15]. These include air transport, turbulence diffusion, dry and wet deposition or physical and chemical transformations of air components, especially those which contribute to secondary pollution (e.g. tropospheric ozone, secondary organic and inorganic matter). The intensity of these processes depends not only on the quantity of pollution in the air, but also on numerous other factors, primarily

land use, topography, and meteorological conditions (type of atmospheric circulation, atmospheric balance, wind speed and direction, air temperature and its vertical gradient, height of the mixing layer, size and type of atmospheric precipitation, intensity of solar radiation or air humidity) [15-17].

Moving to a purely local dimension, but still bearing in mind that local pollution may be a source of regional, national or global level air pollution, the dominant sources of the anthropogenic emissions can be determined. These include: energy production and distribution, industry (including procurement and production of different resources and materials, as well as the processing and utilization of resources and waste), domestic sources (including households and related-use fuels and other resources), and all kinds of transport (in cities the most important type is road transport, as well as the associated general transport) [18, 19].

These sources are classified in emission inventories as sectors, and are reported in compliance with the requirements of the Geneva Convention on Long-Range Transboundary Air Pollution (LRTAP) [20]. The data from the emission inventory conducted in 2014 indicate that the energy production and distribution sector is the primary source of the emission of sulfur oxides in the European Union, and on average is responsible for 58% of the total emission of sulfur oxides in the EU, and for 53% in Poland. It is also a significant source of the nitrogen oxide emission (about 20% in the EU, and about 34% in Poland). In the case of other pollutants, the participation of the energy production and distribution sector in their total emission is relatively low. Poland is an exception, with a high participation of the energy sector in particulate matter emissions (over 14% for PM_{10} and nearly 12% for $PM_{2.5}$), which probably results from the high share of carbon-based energy in total electric and heating energy production in Poland.

The industry sector (production processes and use of energy in industrial processes) is a significant source of the emissions of non-methane volatile organic compounds (NMVOCs). The mean emission from this source in EU countries is over 51%, whereas in Poland it is nearly 45%. As for the emission of most other pollutions recorded under the above mentioned convention, the industry sector is a visible source of emissions, although not the dominant one. In the European Union it accounts for approximately 24% of the total emission of carbon monoxide and sulfur oxides, 22% of PM_{10} emissions, 17% of $PM_{2.5}$ emissions, over 15% of nitrogen oxides emissions and 11% of polycyclic aromatic hydrocarbon emissions. In Poland, the industry sector is responsible for almost 15% of the total emission of sulfur oxides, although in the case of other types of pollution the analogous participation is lower (13-15% for particulate matter, approx. 11% for carbon monoxide, slightly more than 9% for nitrogen oxides, and below 2% for polycyclic aromatic hydrocarbons). This is partially due to the relatively lower degree of industrial development in Poland, compared to some other EU countries, as well as to the sector's investments in modern technological solutions and installations, including exhaust after-treatment devices. These investments, to a certain degree enforced by increasingly strict regulations, contributed to the reduction of the sector's pressure on the environment in Poland. The observed trends may be partially due to a considerably higher contribution of other sectors in the emission (especially of the domestic sector), compared to mean values in the European Union.

The domestic sector is presently the dominant source of particulate matter, polycyclic aromatic hydrocarbons, and carbon monoxide emission. The mean participation of this sector in particulate matter emissions in the European Union is 40% for PM_{10} and over 56% for $PM_{2.5}$. In Poland, the corresponding values are 52% for PM_{10} and 56% for $PM_{2.5}$. In the case of polycyclic aromatic hydrocarbons and carbon monoxide, the domestic sector is responsible for 54% and 45% of their total emission in the EU, respectively, and for 86% and 65% in Poland. This is particularly important due to the health consequences of the presence of polycyclic aromatic hydrocarbons in the air and the fact that domestic sources are not equipped with any exhaust after-treatment devices. Emissions from this sector, due to their specific locations and the construction of their sources (emissions take place in areas inhabited by people, usually low above the ground) and the types of substances emitted (particulate matter pollution, including toxic metals and metalloids, hydrocarbons etc.) are particularly harmful for the environment, and especially for human health. They are considered the key factor responsible for air quality in many urban areas in Europe, mostly in its central and eastern part, including Poland [10, 21].

Table 1. Emission of selected air pollutants from different sectors of the economy in 28 European Union countries in 2014
Tabela 1. Emisja wybranych zanieczyszczeń powietrza z poszczególnych sektorów gospodarki w 28 państwach Unii Europejskiej w 2014 roku

	CO	NMVOCs	NO_x	PM_{10}	PM 2.5	SO_x	PAHs
	[Gg]						[Mg]
All sources in total	**21440.8**	**6722.6**	**7819.5**	**1869.6**	**1214.4**	**3082.9**	**1115.6**
Energy production and distribution	707.2	628.0	1582.3	110, 3	61.7	1773.3	35.5
Energy use in industry	2770.8	134.4	982.7	101.2	81.8	546.5	53.6
Road transport	4575.9	715.2	3078.0	214.5	158.7	6.2	59.1
Other types of transport	440.7	99.0	552.1	32.7	25.9	66.5	1.2
Domestic sector	9726.1	1047.0	1126.7	748.8	684.6	480.0	603.4
Production processes and product use	2413.9	3319.7	211.5	315.4	125.1	201.4	70.1
Agriculture	682.9	715.3	275.0	318.9	54.8	6.1	280.9
Waste disposal	110.6	62.9	11.0	25.0	19.4	2.9	10.4
Other sources	12.7	1.0	0.2	2.8	2.5	0.0	1.6

Based on the data from the European Environment Agency for 7 December 2016 www.eea.europa.eu/data-and-maps/data/ data-viewers/air-emissions-viewer-lrtap

In many areas of Europe, especially in large cities, the dominant source of air pollution emissions is transport, mostly road transport [9, 19, 22]. On the EU level, it is the key source of nitrogen oxide emissions (39%), and a significant source of carbon monoxide emissions (21%). This sector is also responsible to a considerable degree for the emission of volatile organic compounds (nearly 11%) and particulate pollution (12% for PM_{10} and 13% for $PM_{2.5}$). In Poland, the contribution of the transport sector in the emission of most of these pollutants is slightly lower than in the EU, at 30% for nitrogen oxides, 21% for carbon monoxide, 19% for volatile organic compounds, 9% for PM_{10}, and 13% for $PM_{2.5}$.

Table 1 presents the emission sizes from basic sources (sectors) in all EU countries. Figure 1 shows the participation of individual sectors in the total emission of selected air pollutants on the basis of data from the European Environment Agency for 2014.

The data presented above appear to demonstrate a considerable knowledge about the sources of emissions and their share in concentrations of individual pollutants. However, the knowledge is limited to the global and national levels. Both the sources of emissions and the individuals exposed to atmospheric pollution are not distributed evenly in the world, country or even city. A small town (or a suburban residential area) population will not be exposed to a transport or industrial pollution to the same degree as the population of a large urban or urban-industrial agglomeration. In the city outskirts, or areas outside the city, higher exposures may be caused by emissions from domestic sources, associated with intensive heating of individual residential buildings (especially detached houses), waste or biomass burning, and barbecues. This means that reducing industrial or traffic emissions on a regional level will not translate to reduced exposure of the entire population, as concentrations of a given pollutant will not be equally reduced in all parts of the area.

Another problem is the effect of location, land use and climatic conditions on the distribution of pollution. Depending on the place and time, the concentrations will change regardless of changes in emissions. Certain regions where concentrations of pollutants should be low (due to a lack of significant sources) may be exposed to an influx of pollution from other regions. Therefore, the data concerning the emission of pollution, whose purpose is to ensure the reliable and effective reduction of concentrations, and thus exposure of people to pollution, must be collected on the small scale, comprehensively, and taking into account various factors that can affect the observed values. An inventory of emissions from burning solid fuels in houses and flats serves well to illustrate this concept. To be reliable the inventory should include not only the amounts of coal and wood combusted by the population of a given region, but also the exact parameters of the fuels used (quality class of coal, type of wood, humidity of the fuel etc.), information about the parameters of the combustion process (quality class of the heating devices), and other materials processed in the same furnaces, especially waste.

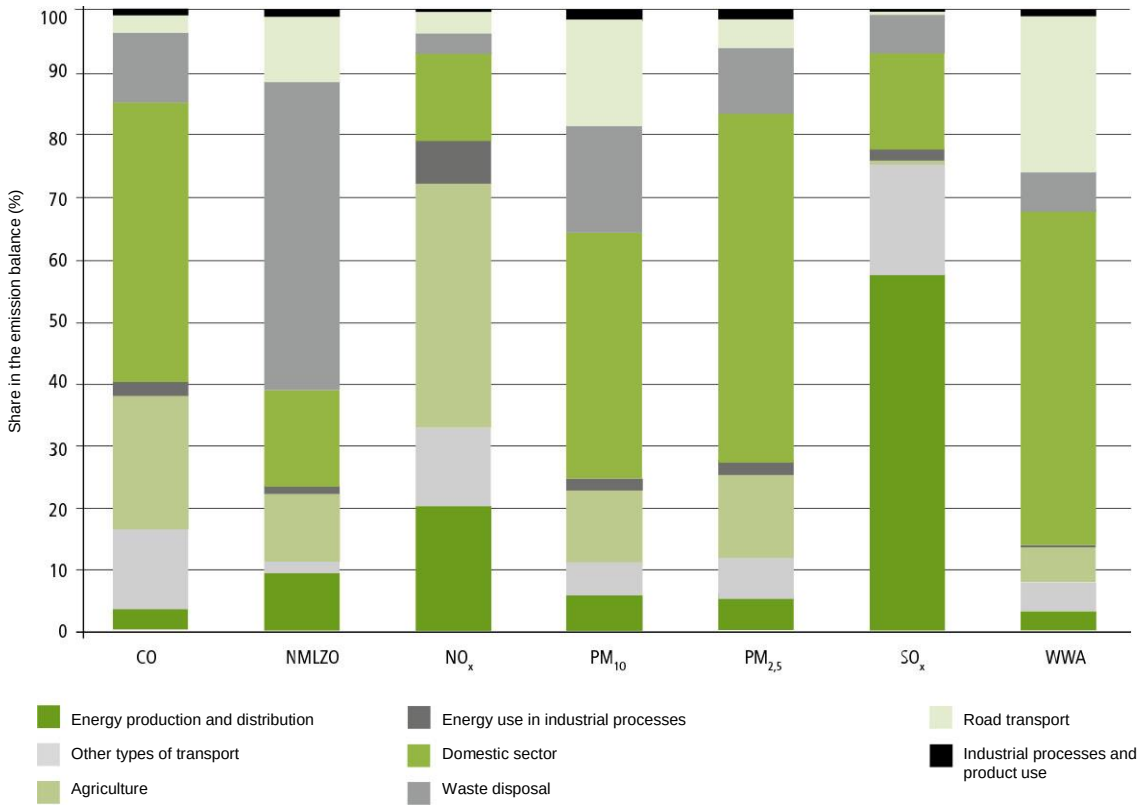

Figure 1. Percentages in the emission balance of selected air pollutants in the European Union in 2014 by economic sector
Rycina 1. Udział poszczególnych sektorów gospodarki w bilansie emisji wybranych zanieczyszczeń powietrza w Unii Europejskiej w 2014 roku

The situation is similar with road transport-related emissions. While it is relatively easy to assess the number, category (passenger car, light commercial vehicle, lorry, bus etc.) and age of the vehicles in any region, it is more difficult to establish the traffic speed profile on certain road sections, and the quantities of fuel used, or any of the parameters that determine the size of pollution emissions (including direct emission resulting from fuel combustion, and emissions due to wear to brake and clutch friction material, tires and bodywork). It is impossible to determine the precise profile of the technical condition of these vehicles (especially regarding their equipment, such as presence of a solid particle filter, functioning catalytic convertor etc.), or the actual parameters of the combusted fuel.

Due to these limitations, a number of studies have been conducted to enable the assessment of origin of the pollution in a given location or area, based on the analysis of pollution concentrations in the area, and their mutual relations. It is assumed that each source of pollution has a specific emission profile; therefore, a mixture of substances emitted from a given type of source has a relatively constant chemical composition [23-25]. The chemical compounds found in a source are usually observed also in the place of measurement. This allows connections to be made between particular pollutants at the measurement site and local pollution sources, or, more broadly, attributing the origin of individual pollutants thanks to linking the measured concentrations with meteorological or climatic conditions. Information about the chemical composition of air in a given area, obtained using different methods, has long been used around the world to identify the sources of air pollution. Both simple methods, based on establishing correlations between monitoring data and meteorological conditions (wind speed, precipitation, ambient temperature, atmospheric pressure, relative air humidity) [26-30] or comparison of the concentrations measured in the background (e.g. regional) with concentrations in selected places in urban areas (urban background, street gulley etc.) [19, 31, 32], and more advanced statistical techniques (e.g. Principal Component Analysis

(PCA) and its modifications) [10, 21, 33-35] or receptor models [33, 35-38] have been successfully used. If several sources of pollution with similar chemical profiles have an impact on a measurement site, such as emissions from traffic and certain industrial processes), then emission markers specific for the identified sources need to be found and used [10, 21, 39, 40], or the actual relationships between the components emitted from the sources [41-43].

What is the quality of the air in Poland?

In Poland, there is insufficient data on the chemical profiles of the gases introduced into the air from different sources, as well as on the relationships between the chemical composition of air in different areas and the sources of air pollution. Most information about the composition of exhaust and waste gases from different processes is based on emission factors [44-46]. However, there is an extensive database giving the ingredients of the particulate matter emitted from different sources, developed on the basis of long-term studies [11, 47-49].

Due to the key importance of solid particles in the assessment of air quality, most studies regarding the relationship between the chemical composition of air in various areas of Poland and the sources of pollution focus on suspended particulate matter: $PM_{2.5}$ and PM_{10} [10, 50, 51]. The analysis of previously published data shows that municipal emissions in southern Poland form the most serious source of air pollution. It is practically impossible to control, due to the diffused nature of the key sources of particulate matter emissions (individual households), which are presently not controlled in any way with regard to the emission of pollutants into the air. The emission of pollutants from domestic sources results obscures the differences between the properties (concentration and chemical composition) of fine particulate matter inside and outside the urban environment. Depending on the season, in southern Polish cities (e.g. Zabrze, Katowice, Racibórz) 50-70% of the $PM_{2.5}$ mass originates from municipal and industrial emissions, while in northern cities (e.g. Gdańsk) this is 15-40%. Depending on the season of the year, about 2-8% in the southern cities and about 4-15% in the central and northern cities of the $PM_{2.5}$ mass may come from road transport, while 8-25% from the energy industry. In the area considered to be the air pollution background for Poland (Diabla Góra), as much as 40% of the $PM_{2.5}$ mass comes from the energy production and the distribution sector. The share of the natural emission of fine particulate matter concentrations has also been estimated. The mineral/soil matter in Polish cities constitutes approximately 5-15% of the $PM_{2.5}$ mass, depending on the season, while sea salt constitutes 10-15% of the $PM_{2.5}$ mass in urban areas in northern Poland.

Monitoring the air quality in Poland is performed as part of the State Environmental Monitoring, and the scope of information produced within this system is regulated by articles 25 and 26 of the Environmental Protection Law act [52]. Voivodeship Environment Protection Inspectors perform an annual assessment of air quality in designated zones, for the protection of human health and the protection of plants. A total of 12 pollutants are monitored and assessed, including: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), benzene (C_6H_6), ozone (O_3), suspended particulate matter PM_{10} and $PM_{2.5}$, as well as pollutants determined in PM_{10} - heavy metals (lead, cadmium, nickel and arsenic) and benzo(a)pyrene. The quality of air is assessed separately for each pollutant in each of 46 zones (for plant protection, in 16 zones) covering the entire country. Air quality in Poland is assessed on the basis of criteria set in other regulations [53-56].

The zones are classed based on the results of the annual air quality assessment. Those zones where the accepted level of a given pollutant is exceeded are classified as class C, whereas those in which the concentration of the substance in the air is lower than the norm, i.e. where no limit values are exceeded, are classified as class A. Classifying a zone as class C indicates that suitable remedial actions need to be undertaken to reduce the concentration of the pollutant which exceeds the acceptable values.

Table 2 presents information about the number of zones classified as areas with the lowest air quality class of C, according to the data from the last two annual assessments (2014 and 2015). As demonstrated, six pollutants determine the classification of certain areas in Poland as class C: NO_2, O_3, PM_{10}, $PM_{2.5}$, As and benzo(a)pyrene. In the case of NO_2, O_3 and As only a few (or one) zones in Poland are class C, i.e. concentrations of a given pollutant there exceed the acceptable standards; however, for $PM_{2.5}$, PM_{10} benzo(a) pyrene associated with PM_{10} , the safe values are exceeded in numerous zones, and in virtually all the voivodeships. In 2014, all 46 zones were graded as class C due to benzo(a)pyrene, whereas in 2015 to 42 zones. Due to PM_{10}, in 2014 class C was attributed to 42 zones, and in 2015 to 39 zones. As for PM_{10}, in 2014 class C was attributed to 22 zones, and in 2015 was attributed to 23 zones.

Table 2. Number of zones classified as class C in each region (voivodeship) of Poland in the years 2014 and 2015 (Source: State Environmental Monitoring – Environmental Protection Inspectorate; 2015; 2016
Tabela 2. Liczba stref zaliczonych do klasy C w poszczególnych województwach w latach 2014 i 2015 (Źródło: Państwowy Monitoring Środowiska – Inspekcja Ochrony Środowiska; 2015; 2016

Voivodeship	Number of areas in the voivodeship	NO_2		O_3		PM_{10}		As		B(a)P		PM2.5	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Dolnośląskie	4	1	1	1	1	4	4	2	2	4	4	2	3
Kujawsko-Pomorskie	4					4	4			4	4		1
Lubelskie	2					2	2			2	2		2
Lubuskie	3					2	1			3	3		
Łódzkie	2					2	2			2	2	2	2
Małopolskie	3	1	1		1	3	3			3	3	2	2
Mazowieckie	4	1	1			4	4			4	4	4	2
Opolskie	2			1	1	2	2			2	2	1	1
Podkarpackie	2					2	2			2	2	2	1
Podlaskie	2					1	1			2	2	1	1
Pomorskie	2					2	2			2	2	1	
Śląskie	5	1	1	1	3	5	5			5	5	5	5
Świętokrzyskie	2					2	2			2	2	1	1
Warmińsko-Mazurskie	3					2	1			3	2		
Wielkopolskie	3					3	3			3	3	1	2
Zachodniopomorskie	3					2	1			3	2		
Total	46	4	4	3	6	42	39	2	2	46	44	22	23

Source: www.powietrze.gios.gov.pl/pjp/maps/air/quality/type/R

Regarding the concentrations of most air pollutants assessed in the air quality evaluations (SO_2, NO_2, CO, C_6H_6, O_3, lead, cadmium, nickel and arsenic), the regulations pertaining to the acceptable concentrations of these substances in the air are met. However, with regard to air pollution with PM_{10}, $PM_{2.5}$ and benzo(a)pyrene, the air quality is very poor in almost every area of Poland. Reports and scientific information generally confirm this conclusion, demonstrating the air quality in Poland with respect to these three air pollutants is one of the worst in the European Union [3, 57]. The situation is alarming due to two facts. Firstly, the exceeded values concern substances of particularly strong adverse health effects [58-61]. Moreover, in the context of reducing the particulate pollution emissions, and pollution emissions in general (including aromatic hydrocarbons represented by benzo(a)pyrene) that have been taking place for several decades, it seems very complicated to find a solution that allows the significant reduction in the concentrations of PM_{10}, $PM_{2.5}$ and benzo(a)pyrene. Limiting the emissions by industry, and from the energy or transport sectors, by introducing new emission norms and standards is not likely to solve the problem [56]. The thesis is best supported by the picture of long-term PM_{10} and benzo(a)pyrene concentrations in Poland (Tables 3-4).

Concentrations of particulate pollution and associated polycyclic aromatic hydrocarbons in Poland have maintained a similar level for several years, and in certain voivodeships they have increased in recent years. It should be emphasized that the number of pollution monitoring stations changes on an annual basis, and the number of measurement sites, that is of data for a given voivodeship, affects the observed values. Nevertheless, the maximum concentrations observed in most voivodeships maintain a level close to or exceeding the acceptable values (40 $\mu g/m^3$ for PM_{10} and 1 ng/m^3 for benzo(a)pyrene, according to directives 2008/50/EC and 2004/107/EC) [54, 55]. The course of the minimum mean annual concentrations of PM_{10} and benzo(a)pyrene in voivodeships outlines a pessimistic perspective.

Table 3. Mean PM_{10} concentrations (μg m^{-3}) in the years 2000-2015 in Polish regions (voivodeships) (annual mean concentration in region, average annual minimum and maximum)
Tabela 3. Średnie stężenia PM_{10} (μg m^{-3}) w latach 2000-2015 w województwach (średnie stężenie roczne w województwie, średnie roczne minimalne i maksymalne)

Voivodeships		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dolnośląskie	No. of stations	1	2	2	26	35	43	39	38	37	35	28	29	34	31	24	25
	Average	36.4	27.3	25.3	24.1	23.3	27.0	29.9	25.3	24.6	27.6	34.5	33.3	31.7	28.4	34.2	32.7
	Min.	36.4	18.0	13.2	7.6	5.9	8.0	7.4	7.5	8.4	6.1	18.6	16.9	14.3	15.9	20.4	18.7
	Max.	36.4	36.7	37.4	48.8	61.0	53.2	90.2	51.9	60.2	60.1	71.3	62.1	81.7	47.0	68.6	61.8
Kujawsko-Pomorskie	No. of stations	1	2	3	8	12	20	25	27	28	24	25	20	22	14	18	21
	Average	37.0	27.5	30.8	33.5	24.0	27.4	30.2	24.9	25.5	29.3	28.9	28.6	29.5	28.3	33.0	31.5
	Min.	37.0	23.5	23.5	16.0	15.9	15.8	15.2	10.6	11.8	12.7	13.9	13.4	9.5	10.2	19.3	17.5
	Max.	37.0	31.4	37.1	57.1	41.9	42.8	53.3	43.1	43.5	59.5	43.4	47.0	39.7	43.7	48.3	43.4
Lubelskie	No. of stations		1	5	5	10	10	13	18	18	14	13	8	8	8	7	8
	Average		15.3	31.7	27.6	26.1	27.2	36.8	30.3	29.8	29.9	32.3	33.9	30.8	29.9	31.9	32.6
	Min.		15.3	10.7	9.8	13.0	13.2	26.4	24.4	20.0	16.5	18.1	30.6	28.3	27.6	30.1	29.2
	Max.		15.3	53.2	42.3	37.8	37.5	46.6	37.6	42.4	37.0	40.5	37.6	33.8	33.6	34.1	36.5
Lubuskie	No. of stations						4	4	5	8	7	6	5	7	7	11	11
	Average						29.5	32.2	24.7	26.5	32.4	31.9	32.1	27.6	26.4	29.2	26.0
	Min.						17.8	19.3	13.0	14.8	15.7	19.5	22.7	20.3	21.6	23.9	20.0
	Max.						35.3	40.7	31.1	42.7	61.1	45.7	41.3	38.4	31.1	36.1	29.8
Łódzkie	No. of stations	1	1	1	9	17	18	15	18	16	17	16	24	22	21	24	26
	Average	45.8	42.1	41.6	42.7	37.1	33.4	36.7	28.5	27.7	33.7	43.7	44.1	40.7	39.3	39.5	37.3
	Min.	45.8	42.1	41.6	28.1	22.2	16.6	26.2	19.1	18.6	23.6	28.4	26.6	24.3	24.4	25.2	23.6
	Max.	45.8	42.1	41.6	61.7	54.3	55.5	60.7	52.6	36.9	61.5	58.3	64.4	60.2	53.3	55.0	55.8
Małopolskie	No. of stations	2	2	1	12	20	25	25	23	24	28	29	23	24	22	29	26
	Average	36.2	34.9	89.1	49.9	40.5	51.9	65.8	55.4	49.6	49.4	57.8	55.0	47.8	43.1	40.0	42.1
	Min.	35.5	27.3	89.1	30.5	6.3	10.1	19.8	42.6	35.3	25.7	26.7	34.5	34.0	27.2	29.4	27.6
	Max.	37.0	42.6	89.1	80.6	70.6	88.2	146.8	90.8	80.9	78.5	107.6	87.0	65.8	59.7	63.9	72.4
Mazowieckie	No. of stations	1	1	1	5	30	31	31	29	24	25	19	17	18	20	19	18
	Average	38.0	36.9	40.9	35.2	30.4	32.6	37.1	28.7	31.1	32.4	36.7	36.8	35.6	32.2	33.1	33.2
	Min.	38.0	36.9	40.9	24.2	18.7	15.4	23.2	17.9	21.8	16.9	30.8	25.0	22.9	21.5	25.3	23.9
	Max.	38.0	36.9	40.9	41.6	50.8	52.0	59.3	47.1	47.4	50.4	52.4	49.1	43.7	39.7	41.9	43.7
Opolskie	No. of stations				3	9	11	10	10	10	9	8	8	7	6	10	10
	Average				51.7	40.9	34.0	44.9	34.7	32.9	36.6	41.8	47.3	36.6	36.4	37.4	34.1
	Min.				42.4	27.2	3.3	30.2	27.1	19.5	28.4	35.2	35.4	32.4	29.4	32.2	30.7
	Max.				64.5	54.6	48.8	61.0	39.7	39.6	47.4	48.3	71.0	41.7	40.5	45.4	39.2
Podkarpackie	No. of stations	1	1		2	3	8	10	14	18	16	11	8	11	10	13	14
	Average	56.5	59.7		53.8	37.3	37.3	36.6	32.3	33.6	34.3	43.7	42.4	37.5	34.1	31.8	32.5
	Min.	56.5	59.7		31.0	25.0	23.8	21.3	20.9	21.5	22.1	38.2	35.1	15.5	27.9	28.3	29.9
	Max.	56.5	59.7		76.6	52.6	44.8	52.6	47.3	55.0	49.9	53.8	48.5	49.9	42.7	38.5	44.4

Table 3. Mean PM10 concentrations (μg m-3) in the years 2000-2015 in Polish regions (voivodeships) (annual mean concentration in region, average annual minimum and maximum)

Tabela 3. Średnie stężenia PM10 (μg m-3) w latach 2000–2015 w województwach (średnie stężenie roczne w województwie, średnie roczne minimalne i maksymalne) – cd.

Voivodeships		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Podlaskie	No. of stations			2	3	6	6	5	5	6	6	5	6	6	4	4	5
	Average			52.0	40.7	29.3	29.0	32.2	25.9	25.3	28.0	26.4	28.7	26.3	24.1	27.6	27.4
	Min.			50.1	26.8	23.6	24.5	26.3	21.9	21.5	23.4	22.1	21.4	19.9	19.2	24.9	24.2
	Max.			54.0	53.1	43.4	32.1	37.9	30.7	31.3	34.4	30.2	34.3	30.9	27.3	30.0	32.4
Pomorskie	No. of stations				9	9	10	15	17	19	19	21	22	27	16	26	26
	Average				33.4	25.8	28.1	30.6	24.3	22.0	24.9	27.2	24.8	24.5	22.2	27.2	23.4
	Min.				22.4	20.4	23.3	17.0	16.4	11.7	14.6	17.0	15.5	10.9	15.9	14.2	14.2
	Max.				53.2	32.8	37.9	43.2	41.2	35.0	39.7	44.5	36.0	42.3	38.6	44.6	39.4
Śląskie	No. of stations				10	10	26	33	31	28	31	31	30	30	30	32	32
	Average				51.2	40.4	44.7	47.9	36.4	38.2	40.9	51.1	49.8	47, 6	43.1	43.5	40.3
	Min.				32.9	26.9	23.6	19.4	11.2	13.1	14.7	29.4	26.7	30.0	20.5	27.8	23.2
	Max.				71.6	56.4	64.1	72.6	57.6	66.2	69.2	79.9	77.0	77.6	58.3	55.8	52.1
Świętokrzyskie	No. of stations				6	8	10	10	11	8	6	8	7	10	9	10	10
	Average				32.3	29.1	33.3	34.4	28.1	28.6	30.6	36.8	34.8	36.2	31.6	33.1	31.8
	Min.				26.8	23.7	25.4	25.7	23.5	21.9	22.9	26.8	24.6	23.1	21.9	21.8	22.3
	Max.				42.2	35.9	45.7	43.7	33.0	35.8	34.8	53.3	43.5	45.8	38.1	43.1	41.0
Warmińsko-Mazurskie	No. of stations				1	3	10	9	9	9	10	9	9	7	7	10	10
	Average				26.9	19.9	23.3	27.5	21.1	21.2	22.5	23.5	23.8	22.7	22.7	24.2	24.1
	Min.				26.9	17.8	18.0	20.6	15.9	15.7	16.3	18.8	17.0	16.0	15.7	18.8	17.3
	Max.				26.9	21.5	28.3	39.2	27.6	34.8	33.3	30.2	31.1	30.1	28.3	29.6	28.5
Wielkopolskie	No. of stations			1	4	8	10	10	9	9	10	12	11	14	13	13	17
	Average			53.5	43.7	29.3	31.2	35.1	26.4	27.5	30.4	33.8	34.3	32.7	30.9	34.3	32.0
	Min.			53.5	34.2	22.0	19.9	17.5	11.8	22.6	24.7	25.8	26.5	24.7	21.0	26.2	26.1
	Max.			53.5	54.6	46.0	40.3	55.7	31.5	30.4	35.8	39.5	39.5	39.8	41.1	41.8	39.4
Zachodniopomorskie	No. of stations			1	3	5	8	7	9	13	12	14	12	9	8	12	12
	Average			27.7	24.3	18.7	22.5	26.6	20.8	18.1	22.4	27.0	26.6	24.3	23.9	26.9	23.9
	Min.			27.7	18.1	14.3	14.9	17.2	13.1	11.8	15.4	14.1	13.8	20.7	19.6	21.3	21.4
	Max.			27.7	28.4	25.8	31.0	33.7	27.2	24.5	33.3	36.3	35.8	29.3	28.0	31.1	27.6

Own work on the basis of data from www.powietrze.gios.gov.pl/pjp/home
Average: an average value from all the mean annual concentrations observed in a voivodeship (one for each station)
Min.: minimum mean annual concentration observed in a voivodeship (in any station)
Max.: maximum mean annual concentration observed in a voivodeship (in any station)

The values in most cases are clearly lower than the acceptable standards; however, broadly speaking, they are significantly higher in recent years than previously.

The numbers presented in Tables 3 and 4 contradict the intuitive assumption that reductions in the observed emissions to the air reported according to the requirements of the Geneva Convention [20] should be reflected in a corresponding reduction in the mean annual concentrations of PM_{10} and benzo(a)pyrene in the air.

Table 4. Mean benzo(a)pyrene concentrations (µg m-3) in the years 2000-2015 in Polish regions (voivodeships) (annual mean concentration in region, average annual minimum and maximum)

Tabela 4. Średnie stężenia benzo(a)pirenu (µg m-3) w latach 2000–2015 w województwach (średnie stężenie roczne w województwie, średnie roczne minimalne i maksymalne)

Voivodeship		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dolnośląskie	No. of stations		3	2	4	6	6	6	7	8	7	9	9	11	13	13	12
	Average		0.8	2.2	1.7	2.7	2.2	2.8	3.3	3.3	5.1	5.3	5.0	5.7	4.7	5.0	4.9
	Min.		0.4	1.7	0.7	0.8	0.8	0.9	0.5	0.4	0.8	0.7	0.7	1.2	1.3	1.0	1.8
	Max.		1.2	2.6	2.9	8.7	4.1	5.7	6.6	9.8	12.5	10.9	12.2	13.6	13.1	17.0	15.3
Kujawsko-Pomorskie	No. of stations							4	4	13	6	12	9	10	10	9	9
	Average							2.2	2.0	2.9	3.7	3.0	2.8	2.3	1.8	3.1	4.1
	Min.							0.0	1.1	1.1	1.8	0.8	1.0	0.4	0.6	0.8	0.6
	Max.							6.3	2.9	6.9	8.2	6.1	8.3	5.0	4.4	7.7	8.6
Lubelskie	No. of stations									8	7	8	5	5	5	5	5
	Average									0.3	0.9	0.9	0.7	0.7	1.1	2.4	3.9
	Min.									0.2	0.6	0.4	0.5	0.4	1.0	1.8	2.8
	Max.									0.5	1.0	1, 3	0.8	0.8	1.1	3.2	5.4
Lubuskie	No. of stations									2	2	4	3	4	5	6	6
	Average									1.5	1.9	2.0	1.7	2.3	3.2	3.0	2.6
	Min.									1.3	1.9	1.6	1.1	1.7	2.0	2.1	2.0
	Max.									1.7	2.0	2.6	2.5	3.5	4.2	3.9	3.4
Łódzkie	No. of stations									3	4	6	6	13	11	14	15
	Average									3.9	4.3	10.5	7.9	8.9	8.1	7.2	7.1
	Min.									1.7	2.8	5.2	4.3	4.5	4.0	4.0	3.9
	Max.									6.3	7.8	24.6	18.0	19.2	14.6	14.6	15.6
Małopolskie	No. of stations					1		1		10	11	12	11	13	11	19	16
	Average					4.2		15.8		8.0	8.4	9.3	9.4	8.8	8.6	7.5	7, 3
	Min.					4.2		15.8		5.7	3.6	5.2	3.3	2.9	4.4	2.6	3.1
	Max.					4.2		15.8		13.4	12.6	16.5	21.3	19.0	16.2	15.2	12.0
Mazowieckie	No. of stations							7	16	19	15	8	6	7	11	11	11
	Average							5.0	2.5	3.6	3.2	3.4	4.4	5.2	3.8	4.5	2.9
	Min.							3.0	0.8	0.9	0.4	1.0	3.2	3.1	1.9	2.2	1.5
	Max.							7.6	6.7	7.6	7.0	5.3	5.5	7.1	5.4	8.0	5.4
Opolskie	No. of stations									4	4	5	4	3	3	3	3
	Average									4.7	5.9	12.2	14.7	5.4	6.5	5.4	6.8
	Min.									3.6	2.3	7.5	5.5	2.8	4.6	4.5	3.4
	Max.									6.0	9.8	15.7	33.4	8.9	9.5	6.6	11.0
Podkarpackie	No. of stations							1	5	8	7	8	6	8	9	9	10
	Average							11.9	5.9	4.5	5.1	5.1	5.4	5.0	3.6	3.1	4.7
	Min.							11.9	4.2	3.3	3.9	3.9	4.1	3.2	2.3	2.7	3.3
	Max.							11.9	9.1	6.3	8.5	7.1	7.6	6.3	5.2	3.4	7.8

Table 4. Mean benzo(a)pyrene concentrations (μg m^{-3}) in the years 2000-2015 in Polish regions (voivodeships) (annual mean concentration in region, average annual minimum and maximum)
Tabela 4. Średnie stężenia benzo(a)pirenu (μg m^{-3}) w latach 2000–2015 w województwach (średnie stężenie roczne w województwie, średnie roczne minimalne i maksymalne) – cd.

voivodeship		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Podlaskie	No. of stations										1	1	1	1	1	2	2
	Average										2.2	0.9	2.2	1.8	1.7	1.9	1.8
	Min.										2.2	0.9	2.2	1.8	1.7	1.8	1.8
	Max.										2.2	0.9	2.2	1.8	1.7	2.1	1.8
Pomorskie	No. of stations								1	9	8	11	11	13	6	13	13
	Average								0.9	2.0	3.0	4.8	3.3	3.1	2.6	2.6	2.9
	Min.								0.9	0.5	1.4	1.9	0.9	1.2	1.1	0.5	0.4
	Max.								0.9	3.6	5.8	9.4	7.1	7, 4	7, 3	6.4	9.8
Śląskie	No. of stations						7	7	9	10	15	16	15	15	13	14	14
	Average						8.1	11.1	5.6	6.0	8.9	9.3	8.8	8.2	6.7	6.6	6.5
	Min.						3.8	6.3	1.6	1.3	4.1	3.7	3.8	3.4	3.1	3.1	3.0
	Max.						13.7	19.7	11.4	16.1	15.6	18.2	16.1	15.1	11.3	12.1	10.5
Świętokrzyskie	No. of stations									1	1	3	3	4	4	4	4
	Average									5.6	3.2	3.9	6.1	6.7	5.0	5.0	5.2
	Min.									5.6	3.2	3.1	5.8	6.0	4.5	4.3	4.3
	Max.									5.6	3.2	5.1	6.6	8.4	5.9	6.1	6.1
Warmińsko-Mazurskie	No. of stations									3	4	4	4	3	5	5	5
	Average									1.3	0.8	2.2	2.3	3.0	2.5	2.3	2.0
	Min.									0.3	0.5	0.7	0.7	0.8	0.6	0.6	0.5
	Max.									2.9	1.3	3.9	3.8	4.9	4.4	3.8	3.3
Wielkopolskie	No. of stations							2	2	5	6	5	5	6	7	7	7
	Average							2.5	3.5	2.4	2.4	3.0	1.8	3.9	3.3	3.2	2.6
	Min.							2.3	3.1	0.9	0.9	1.4	0.5	1.6	2.2	2.0	1.9
	Max.							2.6	3.9	3.5	4.5	4.4	2.9	5.6	5.1	3.6	3.8
Zachodniopomorskie	No. of stations						1	1	6	6	5	6	6	6	6	7	7
	Average						0.9	3.5	2.1	2.1	6.2	4.2	2.9	3.1	3.0	2.8	2.2
	Min.						0.9	3.5	0.6	0.4	1.4	2.1	1.6	1.8	1.5	1.7	0.9
	Max.						0.9	3.5	3.8	4.8	13.9	7.6	5.4	5.4	5.6	4.9	4.7

Own work on the basis of data from www.powietrze.gios.gov.pl/pjp/home
Average: an average value from all the mean annual concentrations observed in a voivodeship (one for each station)
Min.: minimum mean annual concentration observed in a voivodeship (in any station)
Max.: maximum mean annual concentration observed in a voivodeship (in any station)

This is despite technological progress or the regular introduction since the 1990s of legal and administrative tools for air protection, as well as in spite of the increasing ecological awareness of Polish society. The conclusion of the previous section provides an explanation to this situation. The observed reductions refer to those emissions which are and can be quantified, whereas the constantly increasing rate of urban population and the degree of urbanization must be reflected in the increased emission of pollution into the air, both from the domestic sector and from road transport. Not everything, however, can be measured and balanced. Certain conditions regarding climatic processes and the geographic location of Poland determine the values of pollution concentrations; this applies in particular to suspended particulate matter [5, 62, 63].

The results of the air quality assessment in the zones cannot be identified with poor air quality for the entire zone area. Air quality monitoring stations are placed in a small number of selected sites, and pollution concentrations, especially PM_{10} levels, demonstrate a strong spatial variation [64]. However, the assessment presents the scale of the problem, which still requires a comprehensive solution, as well as the coordinated and one-directional actions of central and local authorities. The current policy in that respect cannot be referred to as pro-ecological. For instance, in many areas of Poland

the heating and gas infrastructure is poorly developed (as a result, coal is the only available fuel for heating buildings), while on the other hand there are no effective legal tools which could oblige anyone to join the existing heating networks. Another example is the discrepancy between the awareness of the hazards associated with transport emissions, and a very liberal state policy regarding the import and registration of cars of obsolete design and technology, or the permanent reduction in the availability of public transport by city authorities.

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Functional Movement Screens for evaluating the fundamental movement patterns of soldiers from various branches of the Polish Armed Forces: a pilot study

Zastosowanie testu FMS do oceny wzorca ruchu żołnierzy różnych rodzajów Sił Zbrojnych RP: badanie pilotażowe

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Abstract. The Functional Movement Screen (FMS) is a new and quick method for evaluating the fundamental movement patterns and risk of injury resulting from functional movement deficits. This method was used for the first time to examine 124 soldiers from various branches of the Polish Armed Forces. The goal of the pilot study was to assess fundamental movement patterns in soldiers of the Polish Armed Forces and to determine possible differences in the functional movement deficits among the soldiers from various branches of the military. A number of different fundamental movement patterns were found in the study groups assessed by the FMS. The identified asymmetries and fundamental movement pattern dysfunctions in the study groups differed between the branches of the military.

Keywords: fundamental movement pattern, soldiers

Streszczenie. Test Functional Movement Screen (FMS) to nowa szybka metoda oceny wzorca ruchu i potencjalnego ryzyka urazu wynikającego z zaburzeń wzorca. Po raz pierwszy w historii SZ RP wykorzystano go do oceny wzorca ruchu 124 żołnierzy reprezentujących różne formacje SZ RP. Celem badań pilotażowych było zbadanie, w jaki sposób kształtuje się model wzorca ruchu wśród żołnierzy SZ RP, oraz stwierdzenie, czy istnieją różnice między rodzajem służby a występującymi nieprawidłowościami wzorca ruchu. W badanych grupach żołnierzy ocenianych testem FMS stwierdzono zróżnicowanie wzorca ruchu. Stwierdzone asymetrie i zaburzenia wzorca ruchu w grupach badanych żołnierzy różniły się zależnie od reprezentowanego rodzaju służby.

Słowa kluczowe: wzorzec ruchu, wojsko

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Introduction

At the beginning of the 21st century, the US Army argued that accidental injuries and deaths not only significantly impaired military readiness, but also generated enormous costs associated with treatment and absence from work. In October 2005, the army set up a commission comprising 30 members to identify the 10 main types of injury and disease that generated the greatest costs. This data was to serve as the basis for developing recommendations for preparing a corresponding prevention program. Following the mortality analysis, the commission established that car accidents, followed by suicide, were the leading causes of such deaths. The major types of injury included those affecting the lower extremities, such as broken ankle,

broken shin bone, sprain and partial tear, especially in the knee joint [1-3].

Motor system injuries are commonplace, both among athletes and people who are not very physically active. As shown by domestic data published on www.zus.pl, in 2013, osteoarticular system diseases accounted for as much as 14.5% of ZUS costs, and, following cardiovascular system disorders (15.1%), generated the highest costs. Motor system disorders are a serious health concern and are responsible for considerable costs associated with work incapacity, treatment and rehabilitation. One of the causes of injuries involves abnormal fundamental movement patterns. Now, abnormal fundamental movement patterns can be corrected by functional training, which uses various mobilization techniques.

The Functional Movement Screen (FMS) is a fast new method of verifying whether fundamental movement patterns are correct. The FMS was developed in the USA in the first decade of the 21st century [4, 5] and was immediately employed by the US Army. Fundamental movement patterns are assessed using the FMS system.

The FMS comprises seven physical exercises that assess neuromuscular coordination, mobility, and local and global stability. The FMS evaluates the quality of global fundamental movement patterns to identify any weak links in the kinetic chain.

With its methodology, the FMS identifies any deficiencies in coordination and mobility, and asymmetries in global fundamental movement patterns. The results of each part of the FMS provide feedback that can form the basis for developing individual programs of corrective exercises in order to restore correct fundamental movement patterns, thus reducing the risk of injury. FMS results make it possible to identify basic dysfunctions in the examined group of soldiers. The scores achieved in the FMS can provide important feedback that might be useful for assessing predispositions and the performance of special forces soldiers and other individuals prepared for special operations.

To the authors' knowledge, the FMS has not previously been used by the Polish Armed Forces. The purpose of this pilot study was to assess the fundamental movement patterns of soldiers from various branches of the Polish Armed Forces, to evaluate:

- whether there were any differences in fundamental movement patterns between soldiers serving in various branches of the Armed Forces,
- whether there were any correlations between military branches and specific fundamental movement pattern dysfunctions.

Material and methods

The study included five groups of professional soldiers representing various branches of the military. The first group included 18 men aged 45.9±9.90 years, who were instructors in various sport disciplines. The second group, representing ground forces, included 65 men aged 34.7±6.62 years. The third and youngest (30.4±4.09 years) group consisted of 18 horse squadron riders. The other two groups served in the Air Forces: high maneuverability aircraft pilots (10 subjects) aged 35.7±5.81 years, and supporting ground crew (14 subjects) aged 38.9±4.03 years. The fundamental movement patterns of the subjects were assessed using the FMS [4, 5].

The FMS consists of the following screening tests:

- Deep Squat,
- Hurdle Step,
- In-Line Lounge,
- Shoulder Mobility,
- Active Straight Leg Raise,
- Trunk Stability Push-Up,
- Rotary Stability.

All these fundamental movement patterns are scored using a scale from 0 to 3, where:

- 3 means unquestioned ability to perform a fundamental movement pattern,
- 2 means ability to perform a fundamental movement pattern but with some degree of compensation,
- 1 means inability to perform or complete a fundamental movement pattern,
- 0 means that movement was painful; even if a test is completed correctly, but with pain, the subject is scored 0 for that test.

FMS tests were taken by subjects without any warm-up, in sports clothing and sports shoes, as recommended by the FMS authors [4]. If the scores for asymmetrical patterns (left- and right-hand side tested separately) differed, the final score was always the lower score. All participants agreed in writing to the screening, and were interviewed about their weekly schedule and types of physical activity.

Results

The scores of subjects participating in the FMS ranged from 9 to 20 points. Table 1 shows the average scores achieved for each pattern by the examined groups of soldiers. Taking into consideration the total FMS scores, it can be observed that the highest average scores were achieved by pilots.

Table 1. Average scores achieved in FMS test by study groups
Tabela 1. Średnie wartości ocen uzyskanych w teście FMS dla badanych grup żołnierzy

n-124	Deep Squat	Hurdle Step	In-Line Lounge	Shoulder Mobility	Active Straight Leg Raise	Trunk Stability Push-Up	Rotary Stability	Score
Instructors n-18	2.0 ± 0.34	2.11 ± 0.58	2.39 ± 0.61	2.22 ± 1.0	2.44 ± 0.62	2.39 ± 1.14	2 ± 0	15.56 ± 2.50
Army n-65	**1.93** ± 0.68	2.17 ± 0.57	**2.20** ±0.63	**2.62** ± 0.58	1.93 ± 0.51	**1.90** ±1.06	**1.97** ± 0.29	**14.51** ± 2.20
Squadron riders n-17	**2.29** ± 0.46	**2.65** ± 0.48	2.35 ± 0.59	**2.12** ± 0.76	**1.82** ± 0.78	2.29 ± 0.57	2.06 ± 0.24	15.59 ± 1.78
Ground Crew n-14	2.04 ± 0.30	**2.04** ± 0.61	2.36 ± 0.81	2.36 ± 0.81	2.36 ± 0.89	**2.93** ±0.26	2.14 ± 0.52	16.14 ± 2.45
Pilots n-10	2.1 ± 0.30	2.1 ± 0.30	**2.7** ± 0.46	2.4 ± 0.49	**2.8** ± 0.4	2.9 ± 0.3	**2.2** ± 0.4	**17.4** ± 1.28

Minimum and maximum average values for each screen test are in bold.

Out of the seven tests, the pilots achieved the highest average scores for three tests: In-Line Lounge, Active Straight Leg Raise, and Rotary Stability. In this group, none of the average scores were the lowest calculated for the test across the five study groups (Table 1). In the group of instructors, the average scores for each pattern occupied the middle ground between the highest and the lowest scores achieved by other groups. The scores achieved in four tests (Deep Squat, In-Line Lounge, Trunk Stability Push-Up, and Rotary Stability) by the group representing Ground Forces were the lowest of all. The only highest average score in this group was for Shoulder Mobility. Squadron riders achieved the highest scores for Deep Squat and Hurdle Step, but the lowest for Shoulder Mobility and Active Straight Leg Raise. The Ground Crew had the highest scores for Trunk Stability Push-Up, but the lowest for Hurdle Step.

In order to identify the tests that were the most and the least difficult for the subjects, the study calculated the average score for each movement pattern. The lowest scores were observed for Deep Squat (2.1 ±0.14) and Rotary Stability (2.1 ±0.09). The highest average scores were achieved for Trunk Stability Push-Up (2.5 ±0.44) and Shoulder Mobility (2.3 ±0.19). Another interesting finding was the proportion of scores suggesting asymmetry during exercise performance, i.e., different scores for each limb.

The lowest proportion of scores indicating asymmetries was recorded for the group representing the Ground Forces. Other groups showed a significant proportion of asymmetries identified during the assessment of Shoulder Mobility in the groups of pilots and riders (Table 2.).

If a subject reported pain during any FMS test, that test was scored 0 points. In a few cases, despite flawless performance, subjects reported pain, which resulted in 0 points.

None of the riders or pilots experienced any pain during the tests. The most 0 scores, representing pain during tests, were obtained by the instructors (Table 3).

Discussion

In the American literature, there are a number of publications that identify injury risk factors and corresponding prevention measures [6-12]. As was mentioned earlier, the high costs of injury treatment in the US Army gave the impulse to establish a special commission to identify the 10 major types of injury in the army [3]. The findings of this commission served as the basis for developing countermeasures [1-3], with the FMS being introduced as a standard tool for screening purposes to assess the quality of fundamental movement patterns and their impact on injuries. The FMS assesses whether the fundamental patterns are correct, and identifies any dysfunctions that require compensation. In other words, it flags the weakest links in the kinetic chain, and by doing so the FMS scores facilitate the prescription of appropriate corrective exercise programs.

Table 2. Proportion of scores indicating movement asymmetry
Tabela 2. Procentowy udział ocen wskazujących na asymetrię wykonania próby

n-124	Hurdle Step (%)	In-Line Lounge (%)	Shoulder Mobility (%)	Active Straight Leg Raise (%)	Rotary Stability (%)
Instructors (n -18)	27.8	5.5	22.2	27.8	16.7
Army (n-65)	18.5	16.9	20	16.9	9.2
Squadron riders (n -17)	5.9	23.5	47.1	17.6	35.3
Ground Crew (n -14)	28.6	28.6	21.4	21.4	28.6
Pilots (n -10)	20	10	60	10	40

Table 3. Proportion of "0" scores indicating pain during test
Tabela 3. Procentowy udział ocen 0 wskazujących na ból podczas wykonania próby

n-124	Shoulder Mobility (%)	Trunk Stability Push-Up (%)
Instructors (n -18)	11.1	11.1
Army (n-65)	3.1	10.8
Squadron riders (n -17)	–	–
Ground Crew (n -14)	7.1	–
Pilots (n -10)	–	–

When used regularly, the FMS can be very useful for monitoring purposes at various stages of training to identify any fundamental movement pattern dysfunctions early on.

The purpose of a study by Schneider et al. [13] was to develop FMS reference values for young (21.9 ±3.7 years), physically active populations. The average score achieved by this age group was 15.7 ±1.9 points. No significant differences were identified between the final scores obtained in the groups of men and women. O'Connor et al. [14], examining 874 candidates for the Marine Corps, reported an average score of 16.6 ±1.7 points.

When benchmarked against data from the available literature, the scores achieved by the Polish Armed Forces participating in the study can be considered good. In addition, it is important to note the age differences between the study groups and the candidates for the Marine Corps. The Polish subjects were older than the American subjects, which affected their FMS scores. The Polish study was not only a pilot one, it was also the first time the FMS was used to assess fundamental movement patterns in the Polish Armed Forces. Compared across different branches of the Polish Armed Forces, the scores showed differences between each service type. The wide spread of the scores indicates the existence of various pattern deviations, and in addition the dysfunctions were found to vary by service type.

The group that achieved the highest scores was that consisting of high maneuverability aircraft pilots. This was also the most homogeneous group, in which all group members declared increased physical activity, with scores ranging from 16 to 20. As a group they also showed a substantial proportion of shoulder asymmetries (60% [Table 2]), and it seems that this group requires an exercise program to improve their range of motion and symmetry within their shoulders, as well as to strengthen their cervical spine. As a result of loads of up to G9, this part of the spine is the most vulnerable.

The instructors, who represented the oldest group, achieved interesting scores. They performed all the exercises correctly, but usually used compensation. This group achieved the greatest proportion of zero scores (Table 3) due to the presence of pain during the

exercises, which indicated that they did not exercise due care for their own health and made light of their injuries, which, when untreated, often result in chronic conditions that are difficult to manage.

The authors found it surprising that many of the horse squadron riders experienced limited shoulder and hip mobility. In the majority of subjects from this group, this might be due to the lack of any physical activity other than horse riding. The FMS scores for the riders ranged from 12 to 19. The lack of any stretching and general strength exercises could cause fundamental movement pattern limitations.

The majority of the subjects found it difficult to do Deep Squat and Rotary Stability tests. When such patterns are introduced to regular training programs for soldiers, it is important that they be performed correctly. Progressive overload exercises facilitate the development of correct movement patterns.

To sum up, it can be concluded that this screening could be used on a greater scale to diagnose asymmetries and fundamental movement pattern dysfunctions in various branches of the Polish Armed Forces. Used on a large-scale in the military, the FMS could help to develop training programs recommended for each branch of the military to reduce the risk of motor system injuries. This pilot study tested each group of soldiers only once. The next step, following deficiency identification, should be to provide soldiers with a result overview and a description of the recommended exercises, as well as assistance in the organization of appropriate programs to correct any aberrant movement patterns, and to repeat the FMS in order to evaluate the adopted measures.

Conclusions

1. Soldiers examined using the FMS showed various fundamental movement patterns.

2. The identified asymmetries and fundamental movement pattern dysfunctions in the study groups were specific to each branch of the military.

Literature

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Evaluation of sleeve gastrectomy effectiveness in the treatment of morbid obesity

Ocena skuteczności rękawowej resekcji żołądka w leczeniu otyłości olbrzymiej

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Abstract. The primary aim of the study was to examine the long-term results of bariatric surgery (Sleeve Gastrectomy, SG) in the treatment of morbid obesity. A longitudinal study was conducted in the Military Institute of Medicine in Warsaw. The method used in the study was the interview questionnaire.
Analyzed indicators: Body Mass Index (BMI) and Percentage of Excess Weight Loss (%EWL). The average weight of the examined patients a year after the surgery was M = 91.8; SD = 16.37 and M = 91.3; The SD = 13.15 2.5 years following the surgery, considering the average weight before the surgery of 141.2 kg; SD = 22.54, means a weight loss of 44.7 kg; SD = 15.48. This difference was statistically significant. The average BMI of the patients before the surgery was M = 47.55; SD = 6.82, a year after the surgery was M = 31; SD = 4.56, and 2.5 years after the surgery was M = 30.85; SD = 3.46. The average effectiveness rate (%EWL) a year after the surgery was M = 61.97%, SD = 14.43%; and 2.5 years after the surgery was M = 60.78%, SD = 12.88.
Bariatric surgery is effective in the treatment of morbid obesity and the results are long-term.
Keywords: morbid obesity, bariatric surgery, effectiveness of surgery

Streszczenie. Cel badania. Celem badania było sprawdzenie odległych wyników rękawowej resekcji żołądka w leczeniu otyłości olbrzymiej. Procedura. Przeprowadzono badanie podłużne w Klinice Chirurgii Ogólnej, Metabolicznej, Onkologicznej i Torakochirurgii WIM w Warszawie. Materiał i metody. W badaniu zastosowano kwestionariusz wywiadu. Przedmiotem analizy były: wskaźnik BMI [body mass index) oraz wskaźnik %EWL [percent of excess weight loss). Results. Średnia masa ciała badanych po roku od operacji wyniosła M=91,8 kg; SD=16,37, a po 2,5 roku M=91,3 kg; SD=13,15, co przy średniej wyjściowej masie ciała równej 141,2 kg; SD=25,54, oznacza redukcję o 44,7 kg; SD=15,48. Otrzymana różnica jest istotna statystycznie. Średnia wartość BMI u badanych przed operacją wynosiła M=47,55; SD=6,82, rok po operacji M=31; SD=4,56, a 2,5 roku po operacji M=30,85; SD=3,46. Skuteczność operacji %EWL rok po jej wykonaniu wynosiła średnio: M=61,97%, SD=14,43%, a po upływie 2,5 roku średni %EWL wynosił: M=60,78%, SD=12,88. Wnioski. Chirurgia bariatryczna jest skuteczna w walce z otyłością olbrzymią, a jej wyniki są trwałe w długim okresie.
Słowa kluczowe: otyłość olbrzymia, chirurgia bariatryczna, skuteczność operacji

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Introduction

Obesity refers to the excessive accumulation of adipose tissue in the body. Obesity has been identified by the WHO as the most dangerous chronic disease, one that can contribute to the development of many other disorders, such as diabetes, heart conditions, arterial hypertension, arteriosclerosis, gall bladder disorders, hormonal dysfunctions, etc. [1, 2]. Excessive body weight is a global issue. According to recent data,

Poland is among the top European countries in terms of the prevalence of overweight and obesity. The latest Global Food Security Index shows that more than 25% of people in Poland are obese [3].

Table 1. Descriptive statistics of the body weight of bariatric patients: before surgery, 1 year after surgery, and 2.5 years after surgery
Tabela 1. Statystyki opisowe masy ciała chorych bariatrycznych przed operacją oraz rok i 2,5 roku po jej wykonaniu

body weight in kg	N	**min.**	**max.**	M	SD
body weight in kg before surgery	38	96	223	141.16	25.54
body weight in kg 1 year after surgery	31	58.88	146.77	91.76	16.37
body weight in kg 2.5 years after surgery	28	68.00	124.00	91.34	13.15

Obesity and its co-morbidities are associated with a decrease in biological, psychological and social life quality [2]. On average, morbidly obese people (above 40 kg/m^2) live 20 years less, and the consequences of this condition are more serious than the consequences of smoking or drinking [4, 5]. Obesity is usually managed using conservative treatments, but non-surgical methods often prove ineffective and tend to have impermanent outcomes. Research shows that the ineffective treatment of obesity and the weight fluctuations resulting from the yo-yo effect can be more harmful to obese people than if they did not take any action to reduce their body weight [6]. This is why it is so important to determine how effective bariatric surgery is and to develop standards for supporting and treating morbidly obese patients.

Material and methods

This longitudinal study was conducted between January 2014 and July 2016, and was divided into three stages. The first stage took place prior to bariatric surgery at the General, Oncological, Metabolic and Cardiothoracic Surgery, Military Institute of Medicine at 128 Szaserów Street in Warsaw. The second stage was conducted 1 year after the surgery, and the third stage 2.5 years after the surgery. Data was collected using a questionnaire developed by the authors, via a telephone survey, with all personal data being encrypted. The researchers read out the questionnaire questions, asking patients to answer using a choice of pre-defined answers. The first stage covered 38 people aged 23-60 referred for sleeve gastrectomy (SG), the second stage included 31 patients who had undergone bariatric surgery, and the third stage involved 28 patients. The other patients did not wish to continue to participate in the study. The obtained empirical data was subject to quantitative analysis, using SPSS 22.0.

Results

The study involved patients referred for a gastric bypass using sleeve gastrectomy. The lowest weight among the patients was 96 kg, and the highest was 223 kg, with an average body weight of M = 141.16; SD = 25.54 (Table 1).

Sleeve gastrectomy helped in significantly reducing body weight: $t(30) = 16.20$; $p < 0.001$.

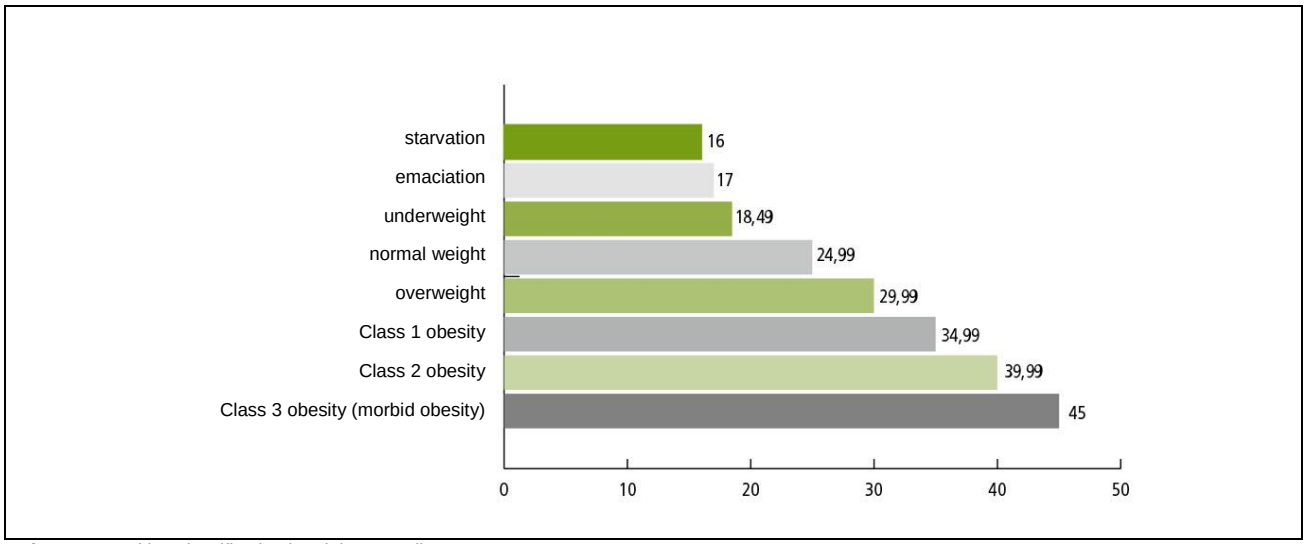

Figure 1. Nutrition classification in adults according to BMI
Rycina 1. Klasyfikacja stanu odżywienia u osób dorosłych wg BMI

On average, patients weighed M = 141.2 kg before the surgery, and then M = 91.8 kg a year after surgery with no significant increase in the next eighteen months: t(27) = 1.15; p = 0.262, with the patients weighing an average of 91.3 kg.

Body Mass Index (BMI)

The lowest BMI among those referred for surgery was 34 and the highest 69; average BMI was M = 47.55; SD = 6.82, which, according to BMI criteria, represents morbid obesity. Such obesity is when BMI > 40 kg/m2 and is considered life-threatening [7, 8]. Nutrition classification in adults according to BMI is shown in Figure 1 [7].

Bariatric surgery helped to significantly reduce BMI – t(30) = 17.01; p < 0.001, which was M = 31 kg/m^2 in the study group one year after the surgery. In addition, it is important to note that the minimum BMI in the study group one year after the surgery was within the norms. The index reduced as a result of the surgery decreased significantly over the next 1.5 years – t(27) = 1.19; p = 0.246 and on average was 30.8 kg/m^2, while the minimum BMI in the study group remained within the norms (Table 2).

Effectiveness of treatment based on the amount of weight lost

The effects of surgery for morbid obesity can be evaluated using many indicators that account for the amount of weight lost. The oldest and, at the same time, the simplest one is the number of kilograms lost. The long-term effects of the bariatric surgery are presented using body weight loss expressed in kilograms (Table 3). On average, the amount of weight loss as a result of bariatric treatment in the study group a year after the surgery was M = 46.63 kg. As a result of sleeve gastrectomy, 2.5 years after the surgery, the body weight had decreased by M = 44.7 kg; this change was significant: t(27) = 15.28; p < 0.001.

Percent of excess weight loss (%EWL)

In order to determine the effectiveness of bariatric surgery in the study group, the study measured percent of excess weight loss (%EWL) [9]. According to this criterion, surgery is considered effective if the patient score is > 50 %EWL and remains at this level in the long term.

A year after the surgery, average %EWL in the study group was 61.97%. Bariatric surgery proved effective in 80.6% of subjects, who had %EWL > 50%. There was no significant change in %EWL in subjects over the following 1.5 years: t(27) = 1.25; p = 0.221, at an average of 60.78%. Two and a half years after the surgery, %EWL > 50% was observed in 75% of the subjects (Table 4).

Table 2. Descriptive statistics of patient BMI before surgery, 1 year and 2.5 years after surgery
Tabela 2. Statystyki opisowe wskaźnika masy ciała BMI przed operacją oraz rok i 2,5 roku po jej wykonaniu

BMI	N	min.	max.	M	SD
BMI before surgery	38	34	69	47.55	6.82
BMI 1 year after surgery	31	23	45	31.00	4.56
BMI 2.5 years after surgery	28	24.68	37.44	30.85	3.46

Table 3. Descriptive statistics of body weight changes 1 year and 2.5 years after surgery
Tabela 3. Statystyki opisowe zmiany masy ciała w rok po operacji i 2,5 roku po jej wykonaniu

change in body weight	N	min.	max.	M	SD
reduced body weight 1 year after surgery	31	17.67	7 7.2 0	46.63	16.02
reduced body weight 2.5 years after surgery compared to body weight before surgery	28	23	82	44.70	15.48

Table 4. Descriptive statistics of %EWL 1 year and 2.5 years after surgery
Tabela 4. Statystyki opisowe wskaźnika utraty masy ciała %EWL rok po operacji i 2,5 roku po jej wykonaniu

%EWL	N	min.	max.	M	SD
%EWL 1 year after surgery	31	36.27	91.96	61.97	14.43
%EWL 2.5 years after surgery	28	39.15	88.92	60.78	12.88

Discussion

In this day and age, excess body weight has become a major health concern. According to specialist reports, Poland ranks 5th in Europe in terms of the proportion of obese citizens [3]. A number of reports show that obesity and its co-morbidities constitute a significant burden for patients and affect their quality of life [2]. Bariatric surgery is now considered the most effective method of treating morbid obesity [9, 10, 16-18].

The purpose of this study was to determine the long-term effectiveness of sleeve gastrectomy in patients suffering from morbid obesity. The longitudinal study comprised 3 stages – prior to bariatric surgery, one year after surgery, and two and a half years after surgery. As a result of sleeve gastrectomy (SG), the average weight of the examined patients was M = 91.8; SD = 16.37 at 1

year after surgery, and then M = 91.3; SD = 13.15 at 2.5 years after surgery. Considering the average weight before the surgery of 141.2 kg; SD = 22.54 means an average weight loss of 44.7 kg; SD = 15.48. The difference is statistically significant.

These findings are consistent with those available in the literature. For instance, Coupaye, who examined the effectiveness of weight loss a year after surgery reported an average weight loss of 35.9 kg [11]. In a study by Major, the subjects lost an average of 53.4 kg [12]. A Swedish study by Targerson and Siostrom, who observed their patients for 2 years, reported an average weight loss of 28 kg [13].

One year after the surgery, the average BMI in patients was 31 kg/m2, and 2.5 years after surgery 30.85 kg/m^2, indicating that it remained constant. The minimum BMI in the study group 1 year (min = 23) and 2.5 years (min = 24.7) after surgery was within the norms (18-24.99).

Other analyzed data included the percent of excess weight loss (%EWL). The average value was 61.97% 1 year after surgery, and 60.78% 2.5 years after surgery. This change was not statistically significant. Given that bariatric treatment is considered effective if excess body weight loss is 50%, the obtained results show that bariatric surgery offers effective treatment of morbid obesity. By comparison, a similar percent of excess weight loss a year after surgery was reported by Major (12) at 61.2%, and Lakdawal (14) at 50.8%. Vidal [15] reported a %EWL of 65% four years after surgery.

This study confirmed effective treatment outcomes in 80.6% patients a year after surgery. Two and a half years after surgery, the proportion of subjects with %EWL > 50% had changed by 6% to 75%. This may be due to a number of biological, metabolic, or psychological factors, or their return to former eating habits. Therefore, it seems reasonable to use appropriate therapeutic interventions and motivational and volitional training not only to support treatment outcomes over time, but also to increase the success rate of bariatric surgery (%EWL > 50%). This hypothesis, however, requires further study.

Conclusions

The results of this study show that surgical treatment of obesity using sleeve gastrectomy is effective for managing morbid obesity, and its outcomes seem to be long-term. Furthermore, it is important to note that treatment outcomes depend on the individual characteristics of each patient.

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Prognostic factors for progression-free survival and overall survival in patients with advanced gastric cancer treated with fluoropyrimidine-based first-line chemotherapy

Czynniki prognostyczne dla czasu wolnego od progresji oraz przeżycia całkowitego u pacjentów z zaawansowanym rakiem żołądka leczonych chemioterapią pierwszej linii opartą na fluoropirymidynie

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Abstract. Fluoropyrimidine-based chemotherapy (FBC) continues to be the standard in first-line palliative treatment for patients suffering from advanced gastric cancer (AGC). The identification of features may influence progression-free survival (PFS) and overall survival (OS) in this group of patients. This retrospective study included consecutive patients with AGC who had begun treatment with a first-line FBC during the 2010-2015 period at the Department of Oncology, Military Institute of Medicine (Warsaw, Poland). The Kaplan-Meier method was used to estimate medians for PFS and OS. Multivariate Cox proportional hazards regression was used to identify factors independently associated with PFS and OS. A total of 129 patients were included in the analysis. The median PFS and OS were 4.3 and 8.0 months, respectively. Eastern Cooperative Oncology Group performance status (ECOGPS) (Hazard Ratio [HR]: 2.198, p = 0.029), peritoneal metastases (PM) (HR: 1.920, p = 0.025) and lung metastases (LM) (HR: 2.259, p = 0.046) were prognostic factors for PFS. ECOGPS (HR: 2.419, p = 0.017), PM (HR: 1.776, p = 0.037), LM (HR: 2.864, p = 0.007) and serum albumin (SA) (HR: 0.524, p = 0.047) were prognostic factors for PFS. ECOGPS, PM and LM were independently associated with PFS, whereas ECOGPS, PM, LM and SA with OS.

Keywords: advanced gastric cancer, chemotherapy, fluoropyrimidine, overall survival, prognostic factors, progression-free survival

Streszczenie. Wstęp. Chemioterapia oparta na fluoropirymidynie [fluoropyrimidine-based chemotherapy - FBC) pozostaje standardem w pierwszej linii leczenia paliatywnego pacjentów chorych na zaawansowanego raka żołądka [advanced gastric cancer - AGC). Cel pracy. Identyfikacja czynników wpływających na czas wolny od progresji choroby [progression-free survival - PFS) oraz czas przeżycia całkowitego [overall survival - OS) w tej grupie chorych. Materiał i metody. Badanie retrospektywne objęło kolejnych pacjentów z AGC, u których rozpoczęto pierwszą linię FBC w latach 2010-2015 w Klinice Onkologii Wojskowego Instytutu Medycznego (Warszawa, Polska). Estymatora Kaplana-Meiera użyto do wyznaczenia median dla PFS i OS. Wieloczynnikowej regresji proporcjonalnego hazardu Coxa użyto do identyfikacji czynników niezależnie związanych z PFS i OS. Wyniki. Do analiz włączono 129 pacjentów. Mediany PFS i OS wyniosły odpowiednio 4,3 i 8,0 miesięcy. Czynnikami prognostycznymi dla PFS były: stan sprawności według skali ECOG (Eastern Cooperative Oncology Group performance status - ECOGPS; hazard ratio [HR]: 2,198, p = 0,029), obecność przerzutów do otrzewnej [peritoneal metastases [PM]; HR: 1,920,p = 0,025) i obecność przerzutów do płuc [lung metastases [LM]; HR: 2,259,p = 0,046). (HR: 2,419, p = 0,017), PM (HR: 1,776, p = 0,037), LM(HR: 2,864,p = 0,007) i stężenie albuminy we krwi [serum albumin [SA]; HR: 0,524,p = 0,047). Wnioski. ECOGPS, PM i LM były niezależnie związane z PFS, a ECOGPS, PM, LM i SA - z OS.

Słowa kluczowe: zaawansowany rak żołądka, chemioterapia, fluoropirymidyna, czynniki prognostyczne, czas wolny od progresji choroby, czas przeżycia całkowitego

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Introduction

Gastric cancer is the fifth most common cancer and the second leading cause of cancer-related deaths worldwide [1]. When diagnosed, in more than 1 in 3 patients the disease is in its advanced stage, and the five-year survival rate in this group of patients is no more than 5% [2]. Surgical resection at an early stage of the disease is the only way that can lead to full recovery. However, due to the initially scarce symptoms of the disease, which make it difficult to diagnose it early, when finally diagnosed the disease is usually at a stage not suitable for resection and/or disseminated. Moreover, more than half of all patients who undergo potentially successful gastrectomy have a relapse [3].

Patients with advanced gastric cancer are referred for systemic palliative chemotherapy to extend their life and improve its quality. Now the standard first-line chemotherapy are fluoropyrimidine-based treatment options, usually combined with platinum derivatives, epirubicin or transtuzumab in 10-15% of patients with overexpression of the gene coding for the human epidermal growth factor 2 (HER2) receptor. The median progression-free survival (PFS) is only about 6 months [4-7]. At least 50% of patients qualify for second-line treatment [8, 9].

Despite treatment, the prognoses for patients are usually poor and the overall survival (OS) is approximately 12 months, starting from the beginning of the first-line systemic treatment [5, 9]. Given such unfavorable prospects for this patient population, it has become crucial for everyday clinical practice to select both those patients who have the chance of benefiting from the planned chemotherapy, and those with poorer prognosis, for whom it would be more reasonable to receive symptomatic treatment only. This is achieved through the identification of factors that influence PFS and OS. They are necessary for the decision-making involved in tailoring treatment to each patient individually.

Aim of the study

The purpose of this study was to identify independent prognostic factors for PFS and OS in patients suffering from advanced gastric cancer and receiving first-line fluoropyrimidine-based chemotherapy.

Material and methods

AGC patients who underwent treatment at the Department of Oncology, Military Institute of Medicine, were subject to a retrospective analysis.

The inclusion criteria included:

- histopathological confirmation of gastric cancer,
- disease at a metastatic stage and/or not suitable for resection,
- advanced stage of disease confirmed with chest, abdominal and pelvic CT scans,
- first-line palliative fluoropyrimidine-based chemotherapy started between 1/01/2010 and 31/12/2015,
- underwent at least one complete treatment cycle.

The exclusion criteria included:

- adjuvant chemotherapy finished less than 6 months from the beginning of the first-line fluoropyrimidine-based palliative chemotherapy,
- first cycle of treatment received outside the Department of Oncology, Military Institute of Medicine in Warsaw,
- diagnosed with more cancers, other than basal cell carcinoma and cervical intraepithelial neoplasia.

Patient data was collected on the basis of their individual medical history. The study was cleared by the Bioethics Committee, Military Institute of Medicine in Warsaw.

Due to the retrospective nature of the study, the sample size was not calculated.

The endpoints were defined as follows:

- PFS, defined as the time between the commencement of treatment and disease progression according to the Response Evaluation Criteria In Solid Tumors (RECIST), version 1.1, or death, regardless of its cause.
- OS, defined as the time between the commencement of treatment and death, regardless of its cause.

Endpoint data was collected until 15/08/2016. Patients who were in the middle of their treatment or

were alive were removed from the PFS or OS, as appropriate. The patients who were lost to follow-up in the course of their treatment were also removed. Corrected serum calcium levels were calculated using the formula: serum calcium level + 0.8 x (4 - serum albumin level). Neutrophil-to-lympthocyte ratio (NLR) was defined as the ratio of neutrophils to lymphocytes in the blood. Platelet-to-lympthocyte ratio (PLR) was defined as the ratio of platelets to lymphocytes in the blood.

Patients were characterized using descriptive statistics. The Kaplan-Meier estimator was used to calculate survival curves, medians, and 95% confidence intervals (CIs) for PFS and OS. Median follow-up time was calculated using the Schemper-Smith method [10]. In order to identify factors that independently affect PFS and OS, the study used the two-stage Cox proportional hazard regression model. The first stage involved univariate analyses to identify the characteristics that could potentially affect study endpoints. Those with $p < 0.01$ were included in stage two, i.e., the multivariate analysis. The factors with $p < 0.05$ at this stage were considered as independently affecting PFS and OS. Due to missing data, stage two used multiple imputation by chain equations to create 10 new, complete databases [11]. Then, using Rubin's Rules, the study combined the results from the analyses conducted on each database [12]. Statistical calculations were made using such software as Stata, version 14 (StataCorp), and R, version 3.2.3 (The R Foundation for Statistical Computing) with survival, version 2.38-3, and mice, version 2.25, packages.

Results

In total, the study covered 129 patients. The detailed patient characteristics are presented in Table 1.

Median patient follow-up time was 40.0 months (95% CI: 30.1 months, not achieved). In the analyzed period, there were 111 disease progressions and 115 deaths. Median PFS was 4.3 months (95% CI: 3.4-5.5 months), and median OS was 8.0 months (95% CI: 6.9-9.4 months). The Kaplan-Meier curves for PFS and OS are presented in Figures 1 and 2, respectively. Second-line chemotherapy was administered to 54 (42%) patients.

Table 1. Patient characteristics
Tabela 1. Charakterystyka pacjentów

			complete follow-ups
	median	**range**	
age (years)	61	29-83	129
BMI (kg/m^2)	23	11-43	129
AST (U/ml)	22	9-176	129
ALT (U/ml)	22	6-213	129
bilirubin (mg/dl)	0.4	0.1-3.0	129
urea (mg/dl)	28	4-74	129
creatinine (mg/dl)	0.8	0.4-1.6	129
albumin (g/dl)	3.8	1.7-4.8	91
corrected calcium (mg/dl)	9.5	8.3-10.3	85
hemoglobin (g/dl)	11.5	8.2-15.9	129
leukocytes (number/ml)	7.7	3.1-19.5	129
neutrophils (number/ml)	5.0	1.5-13.5	129
lymphocytes (number/ml)	1.5	0.7-10.4	129
platelets (number/ml)	324	121-860	129
NLR	3.5	0.2-15.2	129
PLR	221	12-775	129
	number	**%**	
sex, male	76	59	129
gastrectomy	43	33	129
histological type			101
tubular	31	24	
mucinous	28	22	
undifferentiated	16	12	
other	26	20	
grade			96
1	5	4	
2	39	30	
3	72	40	
HER2 status			41
positive	8	6	
negative	33	26	
ECOG performance status			129
0	33	25	
1	77	60	
2	19	15	
body weight loss *	64	50	129
ascites	18	14	129
tumor/local recurrence	29	22	129
lymph node metastases	86	67	129
lung metastases	14	11	129
liver metastases	53	41	129

Table 1. Patient characteristics
Tabela 1. Charakterystyka pacjentów – c.d.

number of organs affected by metastasis	58	45	129
1-2	71	55	
>2			
first line therapy overview			129
EOX	50	39	
DCF	21	16	
CF + trastuzumab	7	5	
other	51	40	

ALT – alanine aminotransferase, AST – aspartate aminotransferase, BMI – body mass index, CF – cisplatin + fluorouracil, DCF – docetaxel + cisplatin + fluorouracil, ECOG – Eastern Cooperative Oncology Group, EOX – epirubicin + oxaliplatin + capecitabine, NLR – neutrophil-to-lymphocyte ratio, PLR – platelet-to-lymphocyte ratio
* ≥5% over 3 months from the commencement of treatment

In the univariate Cox regression, $p < 0.1$ was observed for 13 factors for PFS and 14 factors for OS (Table 2). In the multivariate analysis, factors that independently affected PFS were the ECOG performance status (HR: 2.198, 95% CI: 1.086-4.449, p = 0.029), peritoneal metastases (HR: 1.920, 95% CI: 1.087-3.390, p = 0.025) and lung metastases (HR: 2.259, 95% CI: 1.016-5.025, p = 0.046), and those that affected OS included ECOG performance status (HR: 2.419, 95% CI: 1.175-4.983, p = 0.017), peritoneal metastases (HR: 1.776, 95% CI: 1.034-3.050, p = 0.037), lung metastases (HR: 2.864, 95% CI: 1.330-6.166, p = 0.007) and blood albumin level (HR: 0.524, 95% CI: 0.278-0.989, p = 0.047) (Table 3).

Discussion

The systemic chemotherapy currently used to treat advanced gastric cancer is designed to extend and improve the quality of the patients' lives. Unfortunately, its effectiveness is limited, and often entails a substantial risk of serious side effects [4-7]. Therefore, special care should be taken when referring patients for chemotherapy. This should be an informed decision based on the understanding of the factors that can adversely affect treatment outcomes and, if such factors come into play, this toxic treatment should be abandoned in favor of symptomatic treatment.

This study was intended to identify factors independently affecting PFS and OS, which are the endpoints constituting key indicators of treatment effectiveness.

The multivariate analysis showed that ECOG performance status and peritoneal and lung metastases significantly affect PFS, and ECOG affect performance status, peritoneal and lung metastases, while blood albumin levels significantly affect OS.

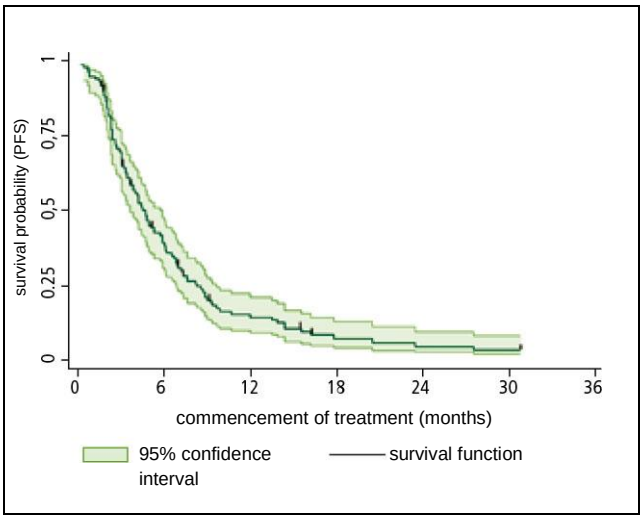

Figure 1. Kaplan-Meier curve for progression-free survival
Rycina 1. Krzywa Kaplana-Meiera dla czasu wolnego od progresji

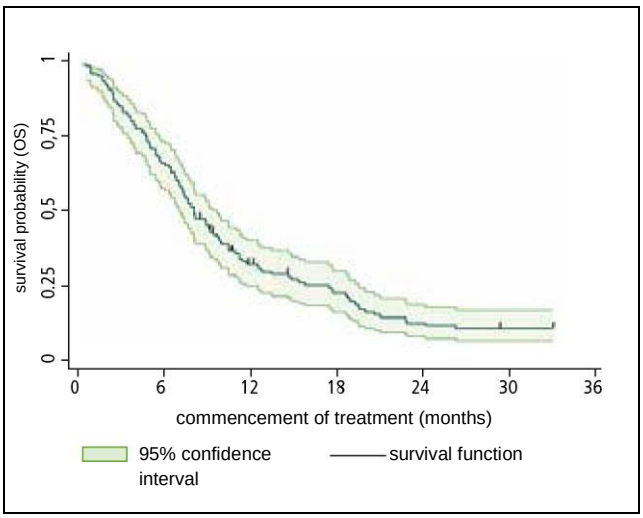

Figure 2. Kaplan-Meier curve for overall survival
Rycina 2. Krzywa Kaplana-Meiera dla przeżycia całkowitego

Performance status is one of the main factors that affect prognosis in cancer patients in general, including patients suffering from advanced gastric cancer [8, 13-15].

Table 2. Results of univariate Cox regression for progression-free survival and overall survival
Tabela 2. Wyniki jednoczynnikowej regresji Coxa dla czasu wolnego od progresji oraz przeżycia całkowitego

	PFS		OS	
factor	**HR (95% CI)**	**p**	**HR (95% CI)**	**p**
sex				
male	1	0.505	1	0.481
female	0.879 (0.601-1.286)		0.875 (0.602-1.270)	
age	0.997 (0.983-1.011)	0.704	0.993 (0.980-1.007)	0.314
BMI	1.011 (0.967-1.056)	0.636	1.005 (0.961-1.051)	0.719
gastrectomy				
no	1	0.002	0.481 (0.322-0.720)	<0.001
yes	0.514 (0.336-0.786)			
grade				
1-2	1	0.642	1.121 (0.727-1.728)	0.606
3	1.110 (0.715-1.722)			
HER2 status				
negative	1	0.023	2.884 (1.244-6.684)	0.014
positive	2.808 (1.156-6.820)			
ECOG performance status				
0-1	1	<0.001	3.378 (1.966-5.805)	<0.001
2	3.307 (1.892-5.780)			
body weight loss				
no	1	0.997	0.978 (0.677-1.412)	0.905
yes	0.999 (0.688-1.451)			
ascites				
no	1	0.032	2.180 (1.294-3.673)	0.003
yes	1.816 (1.052-3.132)			
tumor/local recurrence				
no	1	0.016	1.800 (1.166-2.778)	0.008
yes	1.735 (1.110-2.712)			
lymph node metastases				
no	1	0.340	1.428 (0.967-2.109)	0.073
yes	1.213 (0.816-1.804)			
peritoneal metastases				
no	1	<0.001	2.029 (1.398-2.945)	<0.001
yes	2.087 (1.408-3.093)			
lung metastases				
no	1	0.033	2.153 (1.190-3.896)	0.011
yes	1.871 (1.053-3.322)			
liver metastases				
no	1	0.570	0.855 (0.588-1.244)	0.414
yes	0.798 (0.541-1.175)			
number of organs affected by metastasis				
1-2	1	0.001	2.156 (1.475-3.150)	<0.001
>2	1.978 (1.337-2.924)			
AST	1.002 (0.995-1.009)	0.604	1.004 (0.997-1.011)	0.321
ALT	1.000 (0.993-1.008)	0.978	1.001 (0.994-1.007)	0.876
bilirubin	0.988 (0.666-1.467)	0.954	1.056 (0.704-1.583)	0.793
urea	0.990 (0.973-1.007)	0.259	0.992 (0.976-1.009)	0.380

ALT – alanine aminotransferase, AST – aspartate aminotransferase, BMI – body mass index, CI – confidence interval, ECOG – Eastern Cooperative Oncology Group, HR – hazard ratio, OS – overall survival, NLR – neutrophil-to-lymphocyte ratio, PFS – progression-free survival, PLR – platelet-to-lymphocyte ratio

Table 2. Results of univariate Cox regression for progression-free survival and overall survival
Tabela 2. Wyniki jednoczynnikowej regresji Coxa dla czasu wolnego od progresji oraz przeżycia całkowitego

creatinine	0.896 (0.349-2.303)	0.820	1.185 (0.491-2.861)	0.706
albumin	0.555 (0.361-0.855)	0.008	0.420 (0.276-0.638)	<0.001
corrected calcium	1.270 (0.639-2.524)	0.496	1.230 (0.656-2.308)	0.519
hemoglobin	0.924 (0.822-1.038)	0.184	0.912 (0.816-1.020)	0.106
leukocytes	1.033 (0.962-1.110)	0.372	1.063 (0.988-1.144)	0.104
neutrophils	1.077 (0.992-1.170)	0.078	1.130 (1.038-1.230)	0.005
lymphocytes	0.724 (0.534-0.982)	0.038	0.736 (0.551-0.982)	0.037
platelets	1.001 (1.000-1.002)	0.201	1.001 (1.000-1.002)	0.115
NLR	1.140 (1.063-1.223)	<0.001	1.179 (1.110-1.264)	<0.001
PLR	1.002 (1.001-1.004)	0.001	1.002 (1.001-1.003)	<0.001

ALT – alanine aminotransferase, AST – aspartate aminotransferase, BMI – body mass index, CI – confidence interval, ECOG – Eastern Cooperative Oncology Group, HR – hazard ratio, OS – overall survival, NLR – neutrophil-to-lymphocyte ratio, PFS – progression-free survival, PLR – platelet-to-lymphocyte ratio

Table 3. Results of multivariate Cox regression for progression-free survival and overall survival
Tabela 3. Wyniki wieloczynnikowej regresji Coxa dla czasu wolnego od progresji i przeżycia całkowitego

	PFS		**OS**	
factor	**HR (95% CI)**	**p**	**HR (95% CI)**	**p**
gastrectomy yes	0.727 (0.320-1.648)	0.445	0.587 (0.247-1.395)	0.227
HER2 status positive	1.747 (0.334-9.134)	0.479	1.507 (0.544-4.170)	0.410
ECOG performance status 2	2.198 (1.086-4.449)	0.029	2.419 (1.175-4.983)	0.017
ascites yes	0.968 (0.350-2.677)	0.948	1.086 (0.448-2.631)	0.854
tumor/local recurrence yes	0.943 (0.384-2.315)	0.897	0.875 (0.318-2.409)	0.795
lymph node metastases yes	–	–	0.948 (0.534-1.685)	0.856
peritoneal metastases yes	1.920 (1.087-3.390)	0.025	1.776 (1.034-3.050)	0.037
lung metastases yes	2.259 (1.016-5.025)	0.046	2.864 (1.330-6.166)	0.007
number of organs affected by metastasis >2	1.047 (0.573-1.913)	0.881	1.358 (0.678-2.721)	0.386
albumin	0.772 (0.417-1.430)	0.402	0.524 (0.278-0.989)	0.047
neutrophils	0.997 (0.825-1.204)	0.973	1.027 (0.876-1.204)	0.743
lymphocytes	0.955 (0.640-1.424)	0.819	0.952 (0.638-1.420)	0.806
NLR	1.016 (0.834-1.238)	0.871	1.012 (0.854-1.201)	0.886
PLR	1.001 (0.998-1.003)	0.518	1.001 (0.998-1.003)	0.564

ALT – alanine aminotransferase, AST – aspartate aminotransferase, BMI – body mass index, CI – confidence interval, ECOG – Eastern Cooperative Oncology Group, HR – hazard ratio, OS – overall survival, NLR – neutrophil-to-lymphocyte ratio, PFS – progression-free survival, PLR – platelet-to-lymphocyte ratio

This observation is supported by this study, in which the risk of disease progression and death was twice as high for an ECOG performance status of 2, compared to statuses of 0 and 1. Remote metastases to more than one organ are a well-known unfavorable predictive factor [15, 16]. One of the most frequently reported locations in which the presence of metastases significantly impairs the prognosis is peritoneum [13-15]. Indeed, the study population showed that the organs that significantly predisposed patients not only to shorter OS but also PFS are peritoneum and also lung metastases. Contrary to the results of other research work [14, 16], this study did not support the claim that liver metastases affect treatment outcomes. In terms of peripheral blood parameters, previous publications show that albumin level [8], alkaline phosphatase level [8, 14], total bilirubin level [15], hemoglobin level [13], and NRL [16] significantly affect the OS prognosis. In this study, only albumin level proved statistically significant in the multivariate analysis, as its increase by every 1 g/dl was associated with a reduction in the relative risk of death by 47.6%. Other clinical characteristics that contributed to unfavorable prognosis, such as the lack of previous gastrectomy [8, 16] and the presence of ascites during the referral for chemotherapy [8, 13], proved statistically significant in the study population in relation to PFS and OS only in the univariate analysis.

This study was limited by its retrospective character, low number of patients in the study group, and exclusion of other factors that could affect expected treatment outcomes, e.g., C-reactive protein level [17], alkaline phosphatase level [8,14], or, especially, the molecular characteristics of the cancer [18-20]. Nevertheless, study findings are consistent with those cited in the literature, and they can be helpful in everyday clinical practice. However, further study is required to take into account larger populations and other characteristics that could affect the effectiveness of treatment, so that prognoses can be made as accurate as possible and appropriate therapeutic decisions are taken in relation to each patient individually.

Conclusions

In patients suffering from advanced gastric cancer and receiving first-line fluoropyrimidine-based chemotherapy:

- ECOG performance status and the presence of peritoneum and lung metastases significantly affect progression-free survival.
- ECOG performance status, the presence of peritoneum and lung metastases, and serum albumin levels significantly affect overall survival.

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The impact of changes in body position on hemodynamic profiles as assessed by impedance cardiography

Ocena wpływu zmiany pozycji ciała na profil hemodynamiczny oceniany metodą kardiografii impedancyjnej

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Abstract. Hemodynamic adaptation to changes in body position determines the required organ perfusion. Impedance cardiography (ICG) enables the non-invasive assessment of cardiovascular response to orthostatic stress, measuring: mean blood pressure (MBP), heart rate (HR), stroke volume index (SI), systemic vascular resistance index (SVRI) and thoracic fluid content (TFC). For the correct interpretation of ICG, it is very important to determine the impact of body position on those parameters. Therefore, the aim of the study was to evaluate the impact of verticalization on the hemodynamic profile. A total of 30 patients (aged 22-74 years) underwent a 20-minute ICG in different body positions, and the hemodynamic parameters were recorded. The change in body position from the supine to the sitting was associated with increased MBP, HR, SVRI and decreased SI and TFC. The most significant change in MBP, HR and TFC was observed in the first minute after the position change, while the changes in SI and SVRI were gradual. The return to the horizontal position showed the return of the parameters to their original supine values. Body position has a significant impact on the hemodynamic parameters measured by ICG. Sequential testing should be performed in the same body position.

Key words: impedance cardiography, cardiovascular system, verticalization, cardiac output.

Streszczenie. Wstęp. Adaptacja hemodynamiczna do zmiany pozycji ciała warunkuje prawidłową perfuzję narządową. Kardiografia impedancyjna (ICG) umożliwia nieinwazyjną ocenę reakcji układu krążenia na stres ortostatyczny w zakresie m.in. średniego ciśnienia tętniczego (MBP), częstotliwości rytmu serca (HR), wskaźnika objętości wyrzutowej (SI), systemowego oporu naczyniowego (SVRI) oraz zawartości płynu w klatce piersiowej (TFC). Określenie wpływu pozycji ciała na te parametry jest istotne dla prawidłowej interpretacji ICG. Celem badania była ocena wpływu pionizacji na profil hemodynamiczny. Metody. U 30 osób w wieku 22-74 lat wykonywano 20-minutowe badanie ICG z rejestracją parametrów hemodynamicznych w różnych pozycjach ciała. Results. Zmiana pozycji ciała z leżącej na siedzącą wiązała się ze zwiększeniem MBP, HR, SVRI oraz zmniejszeniem SI i TFC. Dla MBP, HR i TFC najistotniejszą zmianę zaobserwowano w 1. minucie po zmianie pozycji, zaś SI i SVRI zmieniały się stopniowo. Powtórne przyjęcie pozycji leżącej wiązało się z powrotem parametrów do wartości wyjściowych. Conclusions. Pozycja ciała ma istotny wpływ na parametry hemodynamiczne mierzone metodą ICG. Badania sekwencyjne powinno się wykonywać konsekwentnie w tej samej pozycji ciała.

Słowa kluczowe: kardiografia impedancyjna, układ krążenia, pionizacja, rzut serca

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Introduction

A change in body position significantly impacts the functioning of the circulatory system by the initiation of a range of adaptation mechanisms. The most important among them is an increase in the activity of the sympathetic nervous system. This causes both inotropic and chronotropic positive effects, as well as spasms

related to peripheral vasoconstriction [1, 2]. The adaptation of the hemodynamic profile to gravitational changes preconditions correct blood supply in the main organs, especially the central nervous system. Quick adaptation of the hemodynamics of the circulatory system to a change in the body position from the lying to the standing (or sitting) position is particularly significant, as the orthostatic stress resulting from transporting approximately 10% of the blood to the lower parts of the body is related to the risk of brain hypoperfusion [1, 3, 4]. The key role here is played by the arterial baroreceptors responsible for adapting the heart function response to sudden verticalization [5].

Hemodynamic differences related to different body positions can be significant in clinical terms. In our study, significant differences were noted in the values of blood pressure (BP) in the sitting and lying positions [6]. It seems evident that they also concern other hemodynamic parameters. Researchers using new non-invasive hemodynamic assessment tools, such as impedance cardiography (ICG), should be particularly aware of this issue. It is a simple diagnostic method coming into widespread use, allowing not only the assessment of BP and heart rate (HR), but also stroke volume (SV), cardiac output (CO), systemic vascular resistance (SVR), and thoracic fluid content (TFC). These parameters are useful in optimizing the treatment of patients with arterial hypertension and cardiac failure [7-11]. They are usually measured in the supine position, but in certain clinical situations (e.g. orthopnea) measurement in this position is not possible. The interpretation of an examination conducted in the sitting position is difficult as the influence of a change in body position on the above-mentioned parameters has not been studied in detail before. It seems therefore justified to determine the trends and scales of the changes related to changes in body position, as well as their individual variability.

Aim of the study

The aim of the study was to assess the influence of a change in body position from the supine to the sitting on the hemodynamic profile assessed with the ICG method in patients with circulatory system diseases.

Material and methods

Study group

The study group consisted of 30 patients from the Department of Cardiology and Internal Diseases at the Military Institute of Medicine, available in the department for the study as members of the "Cardiacus" student scientific association. Volunteers who expressed consent to an ICG examination were tested.

Table 1. Basic characteristics of the study group
Tabela 1. Charakterystyka podstawowa grupy badanej

	study group (n=30)
age, n (%)	52.7 ± 14.7
male gender, n (%)	20(66.6)
height (cm), mean ± SD	172.5 ± 8.2
body weight (kg), mean ± SD	84.1 ± 15.2
BMI [kg/m^2], mean ±SD	28.2 ± 4.4
arterial hypertension, n (%)	24(80.0)
ischemic heart disease, n (%)	8(26.7)
diabetes, n (%)	4(13.3)

BMI – body mass indicator, SD – standard deviation

Inclusion criteria:

- age of 18-75,
- any gender,
- a history of chronic disease of the cardiovascular system (other than in the exclusion criteria).

Exclusion criteria:

- unstable condition preventing safe examination according to the specified protocol,
- a history of orthostatic fainting,
- lack of consent or cooperation in the course of examination,
- implanted pacemaker,
- cardiac rhythm other than the sinoidal rhythm,
- lack of the technical capability to conduct the examination (height >200 cm and <150 cm, BMI >40 kg/m^2, significant aortic regurgitation).

Anamnesis and physical examination

The clinical examination was conducted with particular focus on the diseases of the cardiovascular system and the factors related to their emergence (height, body weight, body mass index [BMI]).

Impedance cardiography

The ICG examination was conducted with the use of a Niccomo device (Medis, Germany), which recorded the hemodynamic parameters five times at selected time points according to the scheme presented in Figure 1. After the initial preparation the patient assumed the supine position and remained in this position for 10 minutes. After that time the first set of hemodynamic parameter readings was made. The patient then changed position to the sitting position, with the second set of readings being made in the first minute after the change in body position, and the third set of readings being made after 5 minutes in the sitting position. Then

the patient returned to the supine position, where they remained for 5 more minutes, with the fourth and fifth sets of readings being made in the first and the fifth minute in this position. Taking the measurements at the specified time points allowed the changes to be observed in the hemodynamic parameters directly after the patient changed their body position, as well as during the stabilized period.

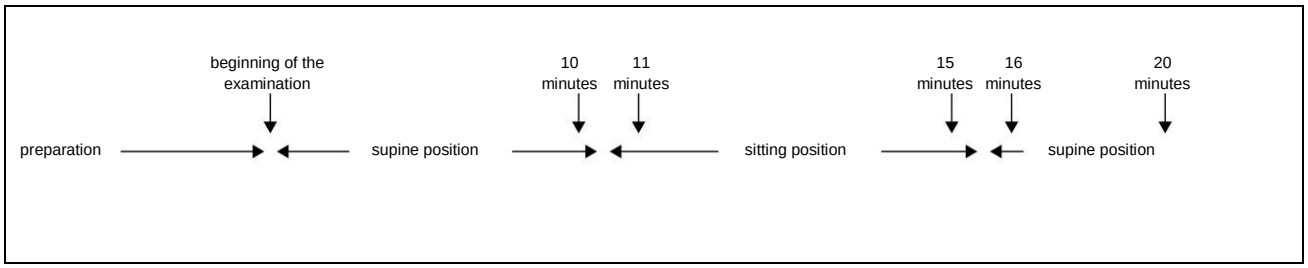


Figure 1. Methodology for measurements in different body positions
Rycina 1. Schemat metodyki pomiarów w różnych pozycjach ciała

The data were analyzed with the use of Niccomo Software (Medis, Germany). The final analysis covered changes in systolic blood pressure (SBP), mean blood pressure (MBP), diastolic blood pressure (DBP), pulse pressure (PP), heart rate (HR), stroke value and its index *(*SV, SI), cardiac output and its index (CO, CI), systemic vascular resistance and its index (SVR, SVRI), thoracic fluid content (TFC), total arterial compliance (TAC), velocity index (VI) – depending on preload and aortic blood flow peak velocity, as well as acceleration index (ACI) – describing peak aortic blood acceleration.

The analysis covered absolute values and the maximum change in parameters, calculated as:

delta (%) = (maximum [minimum] value in the sitting position) - (minimum [maximum] value in the supine position) x 100% / (minimum [maximum] value in the supine position).

Statistical analysis

Statistical analysis of the obtained results was conducted with the use of Statistica 7.0 software (StatSoft Inc.). Normality of distribution was assessed visually and with the Shapiro-Wilk test. The results were expressed as mean values ± standard deviation (SD) for continuous variables, whereas quantity and percentage were used for qualitative variables. Comparison between groups was conducted with the ANOVA test for normal-distribution data and the Kruskal-Wallis test for data with distributions other than normal. $p < 0.05$ was considered statistically significant.

Results

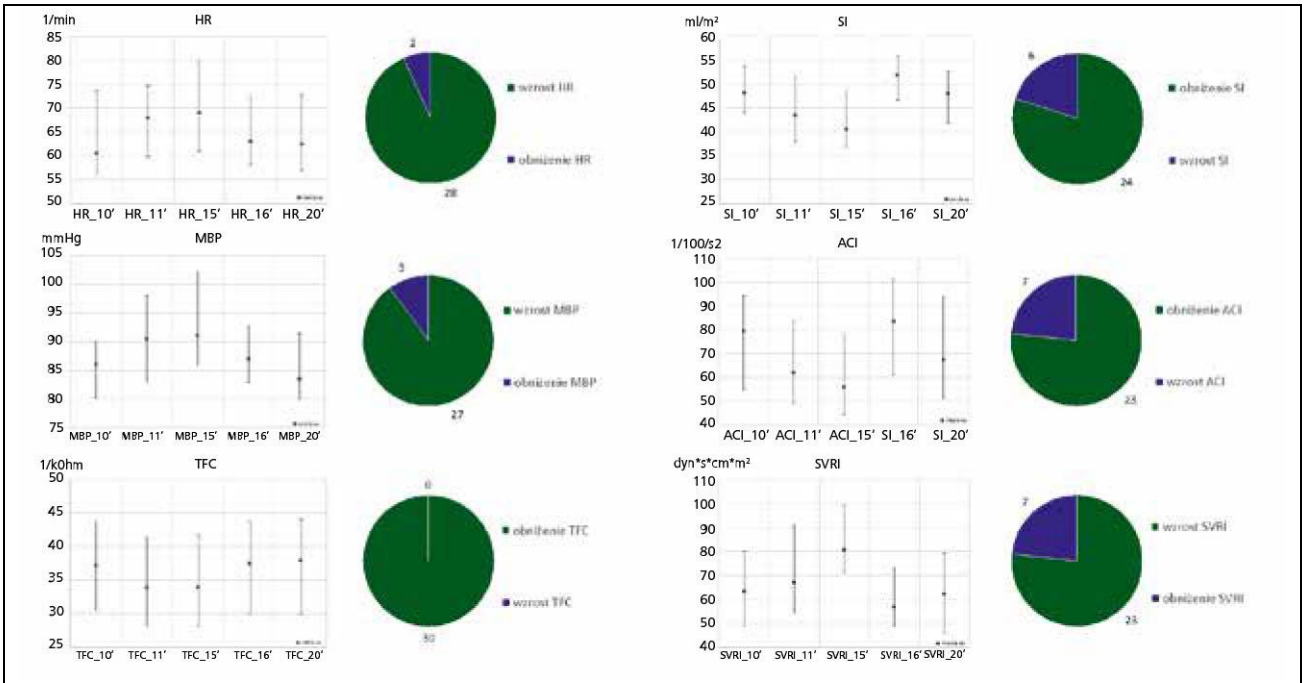
The changes in body position from the supine to the sitting were associated with changes in the hemodynamic profile, while the return to the supine position restored the parameters to values close to the initial ones. The most noticeable changes were observed for HR, MBP, DBP, TFC, SI, SVRI, and ACI (Tab. 2, Fig. 2).

The most noticeable and varied changes were observed for the following hemodynamic parameters: MBP, HR, TFC and ACI, the most significant being observed in the first minute after the change in position, whereas the values for SI, SVRI and DBP increased or decreased gradually.

The following issues were observed in assessing the conformity of the individual changes with the group trend: TFC decreased in all 30 subjects, HR increased in 28 subjects, MBP increased in 27 subjects, DBP increased in 26 subjects, SI decreased in 24 subjects, SVRI increased in 23 subjects and ACI decreased in 23 subjects.

Discussion

The observed hemodynamic changes confirm the influence of body position on the function of the circulatory system. The study indicates a significant increase in the heart rate, blood pressure, vascular resistance, as well as a decrease in the thoracic fluid content and markers of the cardiac function, related to the change to the sitting position. These observations can be explained by the mechanisms aimed at adapting the organism to suit the new hemodynamic conditions. They have significant implications in terms of methodology for users of impedance cardiography in clinical practice.



CI – cardiac index, MBP – mean blood pressure, SD – standard deviation, SI – stroke index, SVRI – systemic vascular resistance index, TFC – thoracic fluid content

Figure 2. Changes in selected hemodynamic parameters (line charts) and distribution of individual changes (ring charts); consistent (green) and inconsistent (blue) with the general group trend

Rycina 2. Zmiany wybranych parametrów hemodynamicznych (wykresy liniowe) oraz rozkład zmian indywidualnych (wykresy kołowe): zgodnych (kolor zielony) i przeciwnych (kolor niebieski) trendowi w całej grupie

A change in body position from the horizontal to the vertical causes an increase in pressure in the venous vessels of the lower part of the body. This results in vasodilation and the retention of up to 400 ml of blood [1]. In physiological terms the exclusion of such a large volume of blood from circulation initiates regulatory mechanisms. Arterial baroreceptors and mechanoreceptors in the heart and lungs are decompressed, which results in an increase in the activity of the sympathetic nervous system. The effect is an increase in the peripheral resistance, heart rate and myocardial contractility. As a result, regardless of the reduced venous return, proper organ perfusion is maintained [1]. Due to the complexity of reactions in the human organism to orthostatic stress and frequent disorders of adaptation of the circulatory system to changes in body position this phenomena has been a subject of research for many years. In the assessment of different populations, attention is drawn to differences in the hemodynamic reaction in relation to age, gender and coexisting diseases [4, 12-14].

One of the most pronounced changes in our study was an increase in the HR. This observation is confirmed in many publications [1, 4, 12, 13, 15, 16]; however, it has been noted that young healthy subjects react with a greater increase in the HR than the elderly [4, 14, 15]. Differences in the changes of hemodynamic parameters in the elderly are caused by structural and functional changes in the circulatory system, a decrease in the activity of the autonomic system and impaired activity of the muscle pump. There is a certain difference of opinion on the issue of the influence of gender, with some reports indicating a more pronounced increase in HR in women [12], and others indicating greater HR in men [17].

The decrease in SI we observed, caused by the reduction in venous return at the time of verticalization, was also noted by other researchers [13, 15, 16]. In our study, this parameter changed gradually over the course of several minutes, whereas Smith et al. [15] stated that SI decreased in the first seconds and then this parameter stabilized. It should be emphasized that regardless of the increase in HR related to the assumption of the sitting position, the decrease in SI is significant enough for CI – their derivative (CI = HR X SI) – to manifest a downward trend.

Table 2. Changes in hemodynamic parameters at subsequent time points
Tabela. 2. Zmiany badanych parametrów hemodynamicznych w kolejnych punktach czasowych

hemodynamic parameter	measurement time point						delta
	10 min	11 **min**	15 **min**	16 **min**	20 **min**	**p (for the trend)**	**(%)**
HR (bpm)	65.2 ± 13.0	69.9 ± 14.4	70.6 ± 14.0	66.1 ± 12.0	65.1 ± 12.0	<0.00001	**8.4**
SBP (mmHg)	124.0 ± 16.7	127.3 ± 18.6	130.4 ± 17.3	125.5 ± 15.9	124.6 ± 17.4	0.014	**5.1**
DBP (mmHg)	72.8 ± 10.0	78.0 ± 12.1	81.1 ± 10.6	74.6 ± 8.0	73.1 ± 9.9	<0.00001	11.4
MBP (mmHg)	85.9 ± 10.7	91.0 ± 12.9	94.2 ± 11.2	88.0 ± 8.7	85.9 ± 10.7	<0.00001	9.7
PP (mmHg)	51.2 ± 12.2	49.4 ± 15.9	49.3 ± 14.4	50.9 ± 14.1	51.5 ± 14.8	0.572	3.0
TFC (1/kOhm)	37.8 ± 11.1	35.3 ± 10.5	35.2 ± 10.5	37.8 ± 11.3	38.0 ± 11.5	<0.00001	**7.4**
SI (ml/m^2)	47.9 ± 8.4	44.7 ± 10.3	41.8 ± 11.9	50.4 ± 10.4	48.2 ± 10.9	0.0003	17.1
CI (l/min/m^2)	3.15 ± 0.66	3.05 ± 0.66	2.88 ± 0.78	3.28 ± 0.64	3.10 ± 0.71	0.062	12.2
VI (1/1000*0hm/s)	52.6 ± 16.9	46.3 ± 16.8	42.1 ± 16.1	54.7 ± 17.5	51.0 ± 17.1	<0.00001	29.9
ACI (1/100*Ohm/s^2)	77.1 ± 31.7	70.9 ± 34.2	64.8 ± 30.3	82.4 ± 34.4	73.2 ± 32.1	0.0006	21.4
SVRI (dyn*s*m^2*/cm^5)	2122 ± 548	2295 ± 577	2652 ± 846	2105 ± 532	2181 ± 621	0.002	26.0
TAC (ml/mm Hg)	1.13 ± 0.50	1.08 ± 0.41	1.01 ± 0.42	1.19 ± 0.51	1.16 ± 0.58	0.203	15.1

The results are presented as mean ± standard deviation
ACI – acceleration index, CI – cardiac index, DBP – diastolic blood pressure, HR – heart rate, MBP – mean blood pressure, PP – pulse pressure, SBP – systolic blood pressure, SD – standard deviation, SI – stroke index, SVRI – systemic vascular resistance index, TAC – total arterial compliance, TFC – thoracic fluid content, VI – velocity index

However, this is not a simple correlation. In a study by Smith et al. [15] detailed analysis of ultra-short-period changes showed that CI is increased in the first seconds of verticalization and only after that does it decrease.

The use of ICG enabled the assessment of other markers of the cardiac function. This included a statistically significant change in the dynamics of blood ejection at the time of contraction of the left ventricle. The ACI and VI parameters changed significantly, which suggests their major sensitivity in the assessment of hemodynamic response of the left ventricle to gravitational changes. The observed phenomenon is probably related to the Frank-Starling law, according to which lower preload results in lower myocardial contractility (decrease in ACI and VI).

The reaction of resistance vessels to a change in the body position is also very important [2, 13, 15]. The increase in SVRI we observed was most probably a result of their constriction. This reflects the activation of the vascular part of the sympathetic system as a response to orthostatic stress [1].

The result of the hemodynamic reaction of the vessels and heart muscle is a change in BP. In our study, we observed a significant increase in the mean and diastolic blood pressures. This was most probably an adaptation aimed at maintaining proper perfusion of the tissues. As indicated by other researchers [15], compensation may not occur immediately though, since in the first seconds they observed a decrease in MBP [15]. The variability of this reaction depending on age and gender has also been proven. The elderly manifest a less pronounced DBP reaction [15], while the increase in MBP is lower in women than in men [12]. Interestingly, there is a correlation between HR and SBP – those subjects with lower SBP prior to verticalization and in its course responded with a greater increase in HR in comparison to those with a higher initial SBP [17].

Also characteristic of the assumption of the sitting position is a decrease in TFC. Such a change occurred in all the subjects and amounted on average to -7.4%. This observation is particularly valuable from the point of view of methodology. The assessment of TFC is useful in many clinical situations, both in patients with heart failure [8, 18] and in the selection of optimal arterial hypertension therapy [7]. Awareness of the necessity of taking into account body position and the scale of possible differences in the interpretation of test results is essential for proper use of the already established therapeutic algorithms based on ICG.

Study limitations

The main limitation of our study was the small size of the study group and its incomplete homogeneity. The overlap of certain confounding factors (e.g. age, gender) may explain the differences in reactions within the scope of some of the assessed parameters. Nevertheless, for the most essential ones (HR, BP, SI, TFC), the consistency of individual reactions with the general trend was significant. One should also emphasize the limitation of the use of non-invasive measurements in the assessment of sudden hemodynamic changes, of which the method we used was not free.

Conclusions

Body position bears significant influence on the hemodynamic parameters determined with the use of the impedance cardiography method, which should be taken into account in the interpretation of test results. Sequential testing should be consequently performed in the same body position.

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Use of Amedo - Laser Navigation Systems and spiral computed tomography in planning diagnostic and therapeutic procedures at the Military Institute of Medicine - a case report

Zastosowanie systemu nawigacji laserowej Amedo oraz obrazowania w spiralnej tomografii komputerowej w planowaniu procedur diagnostyczno-terapeutycznych w Wojskowym Instytucie Medycznym – opis przypadku

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Abstract. Computed tomography (CT) is the most frequently used diagnostic procedure carried out in the Department of Medical Radiology at the Military Institute of Medicine in Warsaw. In January 2013, the Institute had a high-definition dual energy CT system installed (Discovery 750HD). An Amedo Laser Navigation System (Amedo-LNS) was introduced in 2015. The Amedo-LNS expanded the range of available procedures with CT-controlled biopsy, drainage and thermal ablation. A 69-year-old patient was admitted to the Department of General Surgery, Oncology, Metabolic and Thoracic Surgery. He had undergone a low frontal rectal resection due to a tumor, with complications in the form of a fistula in the anastomosis and abscess in the presacral area, carried out in another hospital. In a CT test with intravenous contrast, the size and location of the abscess was determined and the patient was qualified for drainage. Due to poor access, ultrasound-controlled drainage was abandoned. The patient underwent successful drainage of the presacral area using the LNS. The combined use of CT scanner and Amedo-LNS enables CT to be used for therapeutic activities. The LNS is an intuitive device that improves the quality of procedures. The ability to puncture at various angles is particularly useful, a process that is technically difficult without a navigator and requires multiple scans of the patient. The use of LNS shortens the intervention time, decreases the amount of absorbed radiation and reduces the risk of complications. Using the system requires close cooperation between clinician and radiologist in terms of qualification, preparation, methodology and post-operative monitoring.

Keywords: Amedo-LNS, Discovery 750HD, decreasing a radiation dose, surgery, drainage

Streszczenie. Badania w tomografii komputerowej (TK) są obecnie najczęściej wykonywanymi procedurami diagnostycznymi w Zakładzie Radiologii Lekarskiej Wojskowego Instytutu Medycznego w Warszawie. W styczniu 2013 roku w WIM zainstalowano nowoczesny wieloenergetyczny skaner tomograficzny Discovery 750HD. W roku 2015 pracownię wzbogacono o system nawigacji laserowej Amedo-LNS, poszerzając spektrum działania o wykonywanie biopsji, drenaży i termoablacji pod kontrolą obrazowania TK. 69-letni pacjent został przyjęty do Kliniki Chirurgii Ogólnej, Onkologicznej, Metabolicznej i Torakochirurgii WIM po wykonanym w innym ośrodku zabiegu niskiej przedniej resekcji odbytnicy z powodu nowotworu, powikłanej przetoką w zespoleniu i ropniem okolicy przedkrzyżowej. W badaniu TK z dożylnym podaniem kontrastu określono wielkość i położenie ropnia okolicy przedkrzyżowej i zakwalifikowano chorego do jego drenażu. Ze względu na położenie odstąpiono od drenażu pod kontrolą obrazowania ultrasonograficznego. Wykonano udany drenaż przestrzeni przedkrzyżowej, wykorzystując LNS. Wspólne wykorzystanie skanera TK i Amedo-LNS umożliwia zastosowanie TK w terapii. LNS jest intuicyjnym urządzeniem poprawiającym celność interwencji. Szczególna przydatność dotyczy nakłuć pod różnymi kątami, które bez nawigatora są technicznie trudne i obarczone koniecznością kilkukrotnego skanowania chorego. Wykorzystanie LNS skraca czas interwencji, zmniejsza dawkę pochłoniętego promieniowania i ryzyko wystąpienia powikłań. Jego stosowanie wymaga ścisłej współpracy lekarza klinicysty i radiologa w zakresie kwalifikacji, przygotowania, sposobu przeprowadzenia i monitorowania pooperacyjnego.

Słowa kluczowe: Amedo-LNS, Discovery 750HD, zmniejszenie dawki promieniowania, chirurgia, drenaż

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Introduction

Computed tomography (CT) is the most frequent diagnostic procedure carried out in the Department of Medical Radiology at the Military Institute of Medicine in Warsaw. This is a result of the popularization of this diagnostic method, interdisciplinarity of application, use in diagnostic examinations and drug prescription programs, as well as monitoring of the state of health of patients treated within inpatient and outpatient systems. In January 2013, the Military Institute of Medicine had a modern Discovery 750HD CT scanner installed, enabling the potential for dual energy imaging based on processing multiple single-energy X-ray absorption maps for the examined tissues. This extended the capabilities of diagnostics, particularly in the areas of cardiology, nephrology, orthopedics, oncology, surgery and urology.

Further development of imaging diagnostics occurred in 2015, after the installation of the Amedo-LNS laser navigation system at the lab. This device is used for planning diagnostic and therapeutic procedures with the use of CR images. By integrating the operation of the Amedo-LNS with computed tomography it is possible plan even the most complicated procedures related to drainage, biopsy or drug administration for any anatomical space in a quick and simple way. The Amedo-LNS consists of the following parts: 220° gantry arc with motorized laser positioning unit weighing about 10 kg, a support arm for mounting of the gantry arc weighing about 20 kg and a control computer with planning software. It can be mounted on a wall, ceiling or floor. The Amedo-LNS is equipped with motorized lifting and swivel arms, class 2 laser; 0.95 mW; 635 nm; 4.8 V DC and has CE certification (Fig. 1). The system automatically and precisely implements the plan of the procedure designed on the screen of the monitor. Planning of the procedure includes the designation of the puncture site, depth and angle. Once the coordinates are introduced, the laser sends a beam of visible light (Fig. 2), which allows the location to be found and the appropriate angle and the depth for the needle to be set prior to the intervention (Fig. 3). Accurate navigation reduces the treatment time and the amount of radiation absorbed by the patient and the physician. Two CT scans are sufficient (the first one to plan the procedure, the second one to verify it), in order to be certain of the puncture. The procedure is planned on the monitor screen, and the puncture, along with the procedure, is conducted while the CT is not working. Planning a procedure without the support of Amedo-LNS navigation requires constant corrections to the puncture site and angle. A major value of this fusion of both methods is therefore the decrease in the risk related to the procedure and the alleviation of the pain and stress experienced by the patient. Examples of procedures conducted with the use of the Amedo-LNS include: biopsies, spinal blocks, periradicular treatment of back pain, ablations, thermal ablations, lump punctures, removal of infiltrations, bone punctures, abscess drainage, and targeted therapies including brachytherapy. There are few centers in Europe in possession of an Amedo-LNS, such as Gronemeyer Institut fur Microtherapie in Bochum (Germany), Universitatsklinikum Frankfurt (Germany), Institut fur Diagnostische und Interventionelle Radiologie, Frankfurt (Germany), Universitatsspital Basel Radiologisches Institut in Basel (Switzerland), Okmeydani Egitim ve Arastirma Hastanesi, Istanbul (Turkey), CT-MRT Institut Berlin-Steglitz (Germany) and recently also the Oncology Centre in Białystok (Poland).

Case report

A 69-year-old patient was admitted to the Clinic of General Surgery, Oncology, Metabolic and Thoracic Surgery. He had undergone a low frontal rectal resection due to a tumor, with complications in form of a fistula in the anastomosis and an abscess in the presacral area, carried out in another hospital. In the CT test with intravenous contrast, the size and location of the abscess was determined and the patient was qualified for drainage (Fig. 4). Initially, an ultrasound-guided attempt to puncture the lesion was made.

Figure 1. Amedo-LNS and Discovery 750HD scanner at the Military Institute of Medicine in Warsaw
Rycina 1. Amedo-LNS i skaner Discovery 750HD w Wojskowym Instytucie Medycznym w Warszawie

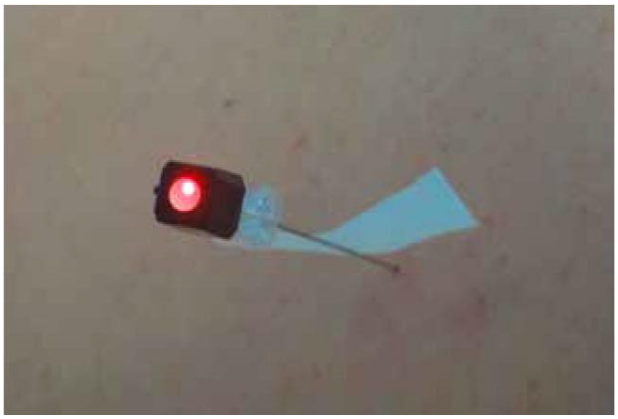

Figure 3. Correct direction of intervention along the laser beam
Rycina 3. Prawidłowy kierunek interwencji wzdłuż wiązki laserowej

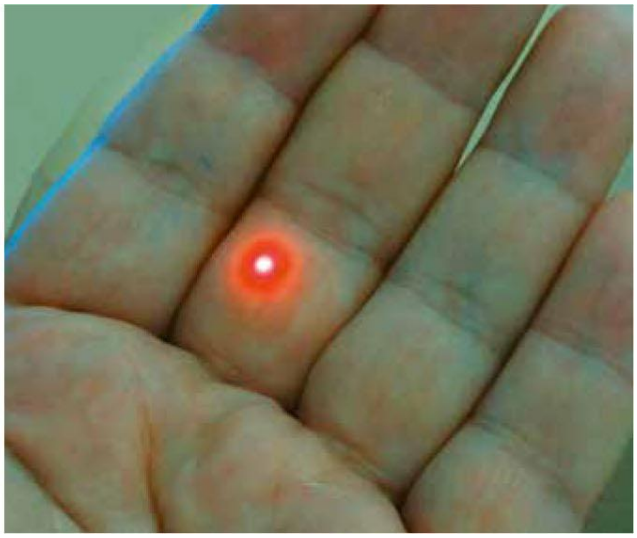

Figure 2. Laser beam of the Amedo-LNS
Rycina 2. Wiązka światła emitowana przez laser Amedo

Due to the location of the focus directly under the sacrum, which strongly suppressed the signal of the ultrasound beam, the puncture was not possible. Another attempt was made at qualification for a drainage procedure with the use of CT image-guided laser navigation. A preliminary scan was made of the patient's pelvis in the prone position. The examination scans were used to plan the intervention. A computer-based line for the puncture was drawn and the Amedo-LNS software initiated the laser beam. The successful drainage of the presacral area was achieved by means of puncture into the area of the abscess on the first attempt, without the necessity of repositioning the pigtail drain (Fig. 5). Several CT scans were made, confirming the correct position and volume rendering of the examined section (Fig. 6). An outflow of purulent contents into a syringe was achieved, and the material was collected for bacteriological examinations. The patient was returned in good condition to his ward.

Discussion

In recent years, there has been clear technological progress in imaging diagnostics, partly as a result of coordinating many devices and creating fusions of the resulting diagnostic images.

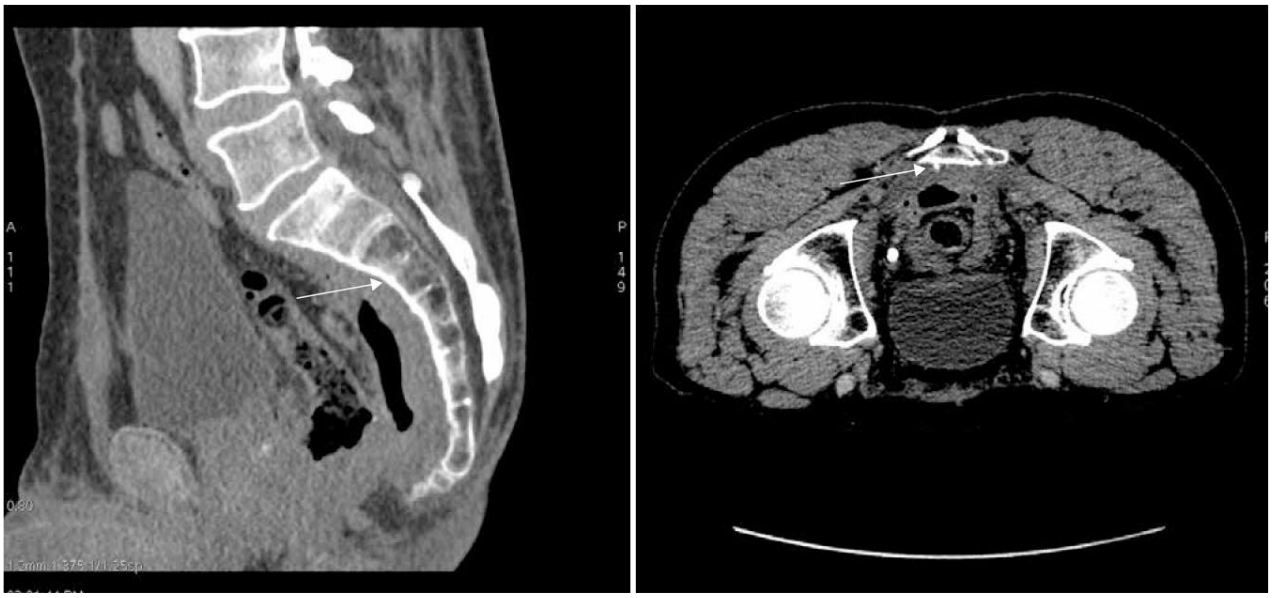

Figure 4. CT scan of the presacral area with abscess displayed (arrows)
Rycina 4. Skan TK okolicy przed krzyżowej z obecnością ropnia (strzałki)

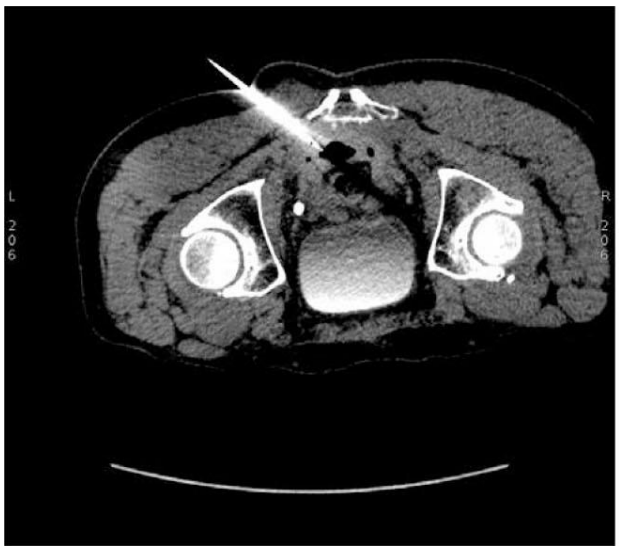

Figure 5. Amedo-LNS-controlled drain insertion
Rycina 5. Dren wprowadzony pod kontrolą Amedo-LNS

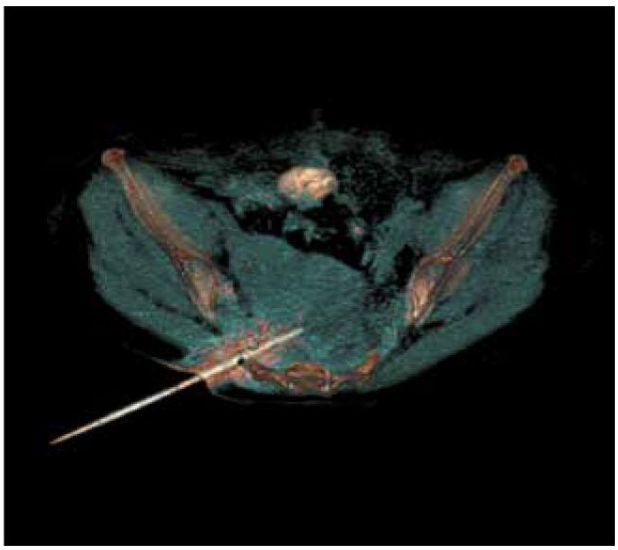

Figure 6. Volume reconstruction. State upon drain insertion
Rycina 6. Rekonstrukcja objętościowa. Stan po założeniu drenu

Coupling a CT scanner with laser navigation is one such example. It enables the multi-faceted application of computed tomography, including in the therapeutic area. The first reports on LNS appeared in 2011 [1], and it has been stated that LNS is a promising and intuitive device, which in the hands of an experienced medical team results in puncture procedures being made faster, safer and in a more patient-friendly manner. The authors emphasized the usefulness of the ability to puncture at different angles, which is technically difficult without a navigator and requires multiple scans of the patient.

Others emphasized the greater accuracy of the punctures conducted with the use of the LNS system in comparison to punctures without navigation, even with experienced medical personnel [2]. The greater speed and reduction of exposure to radiation were also emphasized. Using LNS in a therapy combined with the use of CT results in a reduction of the intervention time

and a smaller dose of absorbed radiation [3]. The laser navigation system improved the accuracy, decreased the intervention time and reduced the dose of CT radiation [4].

The author has not found any negative conclusions in the literature concerning the clinical application of the Amedo-LNS navigation. Our own experiences also allow the formulation of a positive opinion on the method and the safety of conducting CT procedures planned with the use of a laser navigation system.

In this example the LNS system allowed precision puncturing in the presacral area in a patient who was originally disqualified from an ultrasound-guided procedure, and for whom it was not possible earlier to apply safe drainage due to the limitations of ultrasound beam imaging. At the same time, it saved the patient from surgery and its potential complications.

Summary

The Amedo-LNS laser navigation system is a modern, convenient and safe device using CT examinations for planning minimally invasive procedures, such as biopsies, drainages, pharmacological blocks and other treatments related to an interruption of integument continuity. It is also a highly precise tool in the hands of experienced medical personnel. It allows planning of the procedure, minimizing the risk of occurrence of complications, limiting the amount of radiation, reducing the treatment time as well as exposure to stress and pain. At the same time, the use of the system requires close cooperation between clinician and radiologist in terms of qualification, preparation, methodology and postoperative monitoring.

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Atypical endometrial cyst in the round ligament of the uterus located in the canal of Nuck

Rzadki przypadek torbieli endometrialnej więzadła obłego macicy zlokalizowanej w kanale Nucka

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Abstract. Endometriosis is a common disease in women during their reproductive years. It generally manifests as a solid or polycystic mass. Exceptionally rare, it can create a monocystic cyst in the canal of Nuck.

In the presented case, the cyst was descending to the right labia majora and was misdiagnosed as an inguinal hernia, hydrocele of the inguinal canal and simple cyst of the inguinal region. After excision, the specimen underwent histological examination, which revealed an endometrial cyst. After surgery the patient was referred to a gynecologist for further treatment.

Keywords: round ligament of the uterus, cyst, endometriosis

Streszczenie. Endometrioza jest częstą patologią wieku rozrodczego u kobiet. Na ogół manifestuje się jako guzek lity lub litotorbielowaty. Wyjątkowo rzadko występuje jako pojedyncza torbiel jednokomorowa w kanale Nucka. W przedstawionym przypadku torbiel schodząca do wargi sromowej była rozpoznawana jako przepuklina pachwinowa, wodniak kanału pachwinowego, torbiel prosta pachwiny i sromu. Po usunięciu badanie histologiczne wykazało, że jest to torbiel endometrialna. Po leczeniu operacyjnym chorą przekazano do dalszego leczenia ginekologicznego.

Słowa kluczowe: więzadło obłe macicy, torbiel, endometrioza

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Introduction

Endometriosis is a common disease in women during their reproductive years. Although it can appear in the digestive tract, urinary system, chest, skin and wall of the abdominal cavity, the endometriosis of the inguinal canal has only rarely been reported in the literature [1], as solid or polycystic lesions. The canal of Nuck in humans is a rudimentary organ, a remnant of the vaginal process of the peritoneum, which may remain unobstructed. It is an extension of the peritoneum that accompanies the round ligament and stretches from the inguinal canal to the labia majora.

Case report

A 45-year old patient complained of an enlargement of the right labia. This lesion caused pain, which periodically increased to highly acute, especially in the standing position.

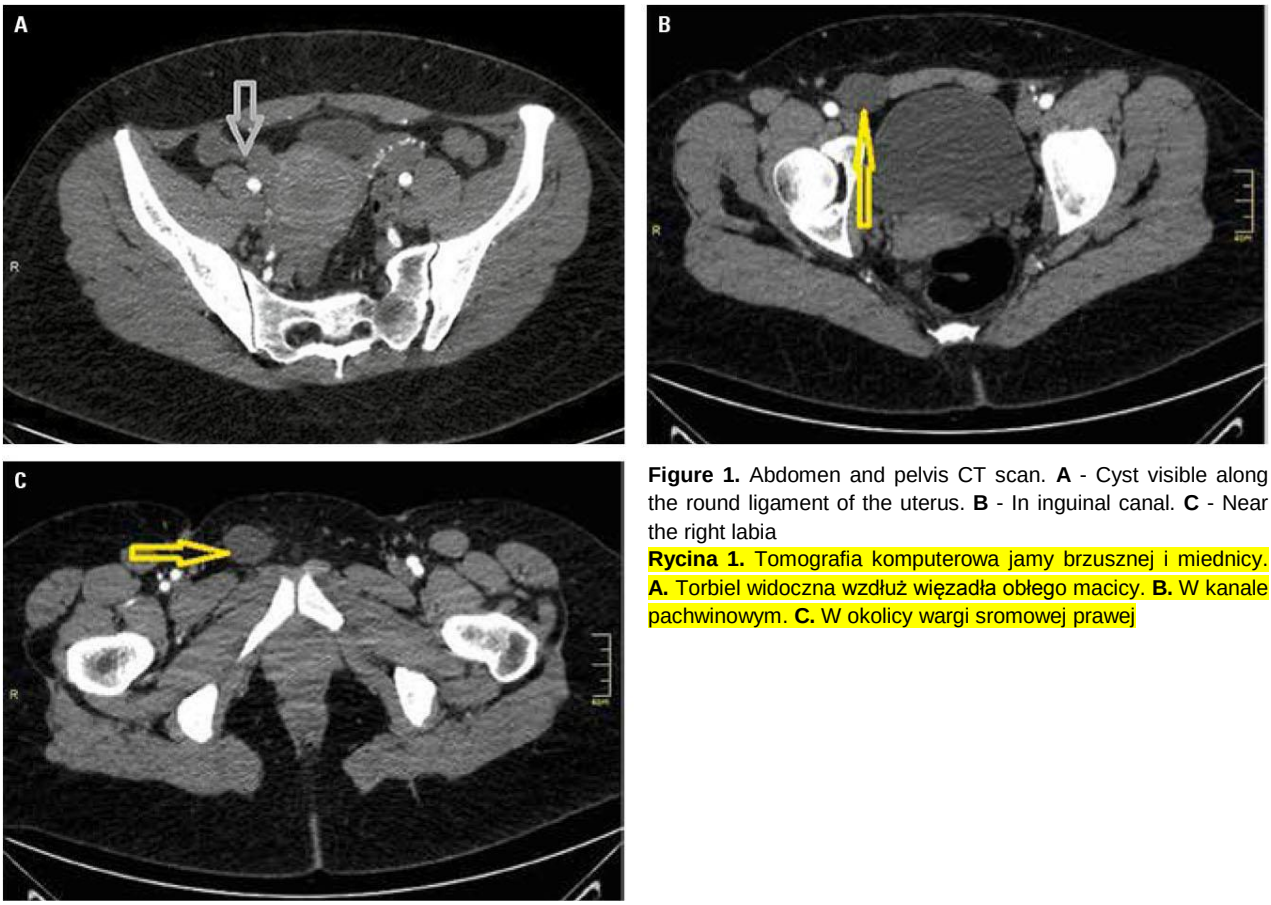

Figure 1. Abdomen and pelvis CT scan. **A** - Cyst visible along the round ligament of the uterus. **B** - In inguinal canal. **C** - Near the right labia

Rycina 1. Tomografia komputerowa jamy brzusznej i miednicy. **A.** Torbiel widoczna wzdłuż więzadła obłego macicy. **B.** W kanale pachwinowym. **C.** W okolicy wargi sromowej prawej

The lesion grew over the course of several months. No changes in size at the time of tension or coughing were observed. A temporary decrease in the size of the lesion was observed after changing the body position to the recumbent; no correlations were observed between the size of the lesion and the stage of the menstrual cycle. The patient denied nausea, vomiting and diseases of the abdominal cavity. A physical examination revealed a detectable lesion spreading from the labia majora all the way to the superficial inguinal ring, with a detectable clear resistance over the course of the entire inguinal canal. The lesion could not be transferred to the peritoneal cavity during the examination.

The patient consulted surgeons and gynecologists without resulting in a correct diagnosis. Many ultrasound examinations of the abdominal cavity, inguinal canal and transvaginal ultrasounds were conducted. Finally, a CT scan of the abdominal cavity showed a cyst in the right round ligament of the uterus (Fig. 1).

The patient was directed to our clinic, where another ultrasound examination of the abdominal cavity and gynecological consultation were conducted (Fig. 2). The ultrasound examination of the inguinal canal and the abdominal cavity revealed a homogeneous hypoechoic fluid area with a length of approximately 120 mm and a width of approximately 25 mm along the right inguen, going down to the level of mons pubis; it seemed that at the top pole it connected to the peritoneum. In addition, a trace of fluid was revealed in the Douglas pouch. The other organs of the abdominal cavity showed no lesions.

After the gynecological consultation with a repeated transvaginal ultrasound the patient was qualified for a surgical procedure conducted by a surgical and gynecological team.

The cystic lesion was entirely enucleated from the inguinal canal after its posterior wall was cut with a part of the round ligament of the uterus, which was then stabilized in the channel with anaplasty of the inguinal canal with the use of the Lichtenstein technique (using a PTFE mesh [Figs. 3-5]).

The specimen was sent for histopathological examination. A result of the direct examination showed that the unicameral cyst contained a low-protein fluid with morphotic elements of blood. The final histopathological result was an endometrial cyst.

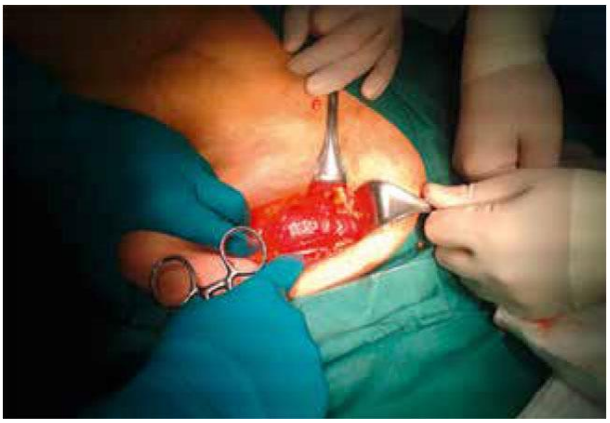

Figure 2. Cyst in the bottom of inguinal canal
Rycina 2. Torbiel w dnie kanału pachwinowego

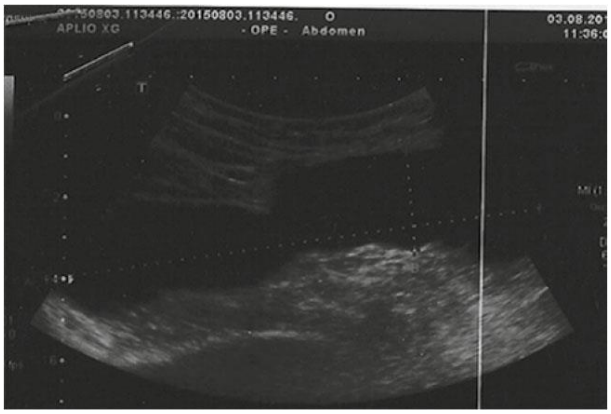

Figure 3. Ultrasound examination. Visible unicameral cyst extending from the labia majora into the inguinal canal
Rycina 3. Badanie ultrasonograficzne. Widoczna jednokomorowa torbiel ciągnąca się od wargi sromowej większej do kanału pachwinowego

Discussion

Endometriosis is a disease located in the area of the uterus, especially the ovaries. Other locations include peritoneum, urinary bladder and navel. It is rarely found in the intestine, breasts or pleura [2]. Acquired endometriosis is located in the scars of abdominal integuments [3]. This disease is defined as the presence of the glands of the endometrium and the stromal cells outside the uterine cavity. Tubercles, adhesions and chocolate cysts appear. Pathogenesis of endometriosis located in the canal of Nuck consists in slight bringing forth of the peritoneum neighboring with the round ligament through the deep inguinal ring to the inguinal canal. Under normal conditions this pouch undergoes spontaneous atresia right after parturition. If it remains unobstructed, a connection is created between the peritoneal cavity and the inguinal canal. In these cases the endometrial tissues can be implanted in the soft tissues of the labial and the inguinal region.

Figure 4. After enucleation of the cyst from the labia area
Rycina 4. Torbiel po wytuszczeniu z okolicy wargi sromowej

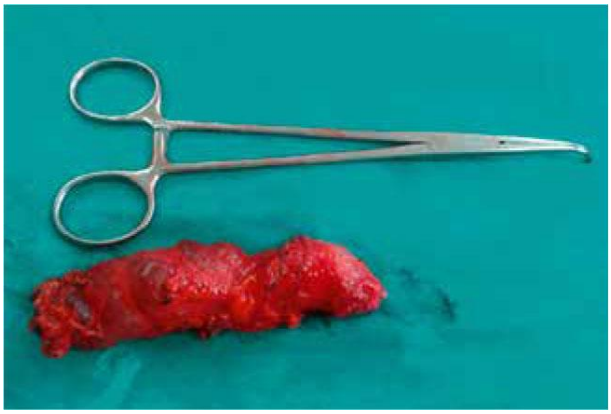

Figure 5. Whole specimen after enucleation
Rycina 5. Preparat w całości po wytuszczeniu

The characteristic symptoms of endometriosis are: pain in the lesser pelvis, menstrual cycle disorders, abundant menstrual bleeding and problems with becoming pregnant. More rare symptoms include acyclic bleeding, hematuria, bleeding into the digestive tract and spotting on contact.

Typical symptoms in the inguinal location of endometriosis include a detectable lesion in that area, swelling and pain in the groin related to menstruation [4, 5].

The ultrasound images in endometriosis are different, where well-differentiated solid, solid-cystic, and cystic

lesions may be visible [1]. However, inguinal endometriosis is usually a hypoechoic solid lesion. In this case the lesion in the inguinal region was hypoechoic, cystic, filled with fluid, without partitions, and clearly suggested a simple cyst or a hydrocoele.

Endometriosis in the inguinal area should be differentiated from neoplasms, such as sarcomas, lymphomas, mesotheliomas and neoplasm metastases, as well as from mild lesions, such as inguinal hernia, abscess and hematoma [6-9]. If we are dealing with a cystic lesion in this area, then hydrocoele of the Nuck canal, which manifests as a cystic unicameral lesion, as in the reported case, should also be excluded.

The difference in treatment of cystic lesions and hydrocele consists in the need to always remove the encysted lesions in their entirety in order to prevent their possible spread, whereas in the case of a hydrocele the fluid is a typical content of the peritoneal cavity and such a risk does not exist.

When differentiation of lesions in the inguinal region is not possible with the use of imaging examinations, biopsy by fine needle aspiration using ultrasound guidance is conducted. We did not conduct such a biopsy in our patient [10].

Summary

It should be noted that endometriosis located in the inguinal region can manifest as a solid, multicystic lesion and, as in this case, as a monocyst. We believe that endometriosis should be taken into account in the differential diagnosis of each detected lesion in the inguinal region in women.

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Acute intermittent porphyria with acute tubulointerstitial nephritis - a case report

Ostre cewkowo-śródmiąższowe zapalenie nerek w przebiegu ostrej porfirii przerywanej - opis przypadku

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Abstract. Diagnosis of tubulointerstitial nephritis in the course of acute intermittent porphyria is rare. The paper presents the case of a 29-year-old female. Initially she presented with acute pain in the hypogastric region, polyuria and dysuria, and no fever. She was initially treated for urinary tract infection. The pain intensified and was accompanied by paraesthesia of the upper and lower extremities with hyperesthesia, through increasing pain and muscle weakness to quadriparesis. Tetany and epileptic seizure occurred. Laboratory results revealed elevated inflammatory markers, signs of kidney failure, severe electrolyte imbalance: hyponatremia, hypokalemia and hypocalcaemia. Blood and urine cultures revealed growth of Klebsiella pneumoniae (ESBL+), which was treated with meropenem. Analysis of the daily urine output suggested the loss of sodium, potassium and calcium ions to be of renal origin. Analysis of daily urine output suggested loss of sodium, potassium and calcium ions to be of renal origin. Because of the red-brown urine color, acute intermittent porphyria (AIP) was considered. The level of delta aminolevulinic acid in the urine and the fluorescence spectra of plasma porphyrin were assessed and the patient was diagnosed with acute intermittent porphyria with acute tubulointerstitial nephritis.
Key words: acute intermittent porphyria, acute kidney failure, acute tubulointerstitial nephritis, hyponatremia, hypokalemia, hypocalcemia, hypoosmolarity

Streszczenie. Rozpoznanie ostrej cewkowo-śródmiąższowej niewydolności nerek w przebiegu ostrej porfirii przerywanej jest rzadkością. Prezentujemy przypadek 29-letniej pacjentki, która zgłosiła się z powodu utrzymującego się silnego bólu okolicy podbrzusza, częstomoczu i dysurii, bez gorączki. Początkowo leczona była z powodu zakażenia układu moczowego (ZUM). Ból okolicy podbrzusza nasilał się, pojawiły się parestezje kończyn górnych i dolnych z przeczulicą skóry, narastające bóle i osłabienie mięśni aż do niedowładu wiotkiego czterokończynowego. Wystąpiły tężyczka i napad drgawkowy. W badaniach laboratoryjnych stwierdzono zwiększone wykładniki stanu zapalnego, cechy ostrej niewydolności nerek oraz zaburzenia elektrolitowe: hiponatremię, hipokaliemię i hipokalcemię. W posiewach moczu i krwi stwierdzono wzrost bakterii Kelbsiella pneumoniae (ESBL+). Włączono meropenem. Z powodu czerwonobrunatnego zabarwienia moczu wysunięto podejrzenie ostrej porfirii przerywanej. Wykonano oznaczenie stężenia wydalanego z moczem kwasu delta-aminolewulinowego oraz stężenie i widmo fluorescencji porfiryn całkowitych we krwi. Rozpoznano ostrą porfirię przerywaną z ostrym cewkowo-śródmiąższowym zapaleniem nerek.
Słowa kluczowe: porfiria ostra przerywana, ostra niewydolność nerek, ostre cewkowo-śródmiąższowe zapalenie nerek, hiponatremia, hipokaliemia, hipokalcemia, hipoosmolalność

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Introduction

Autosomal dominantly inherited acute intermittent porphyria is caused by a decrease or lack of activity of an enzyme catalyzing the second stage of heme biosynthesis – porphobilinogen deaminase (PBGD) [1]. This leads to the accumulation of an excess of porphyrins and their precursors, which are toxic to the organism [1, 2]. In the case of acute intermittent porphyria, one of the types of hepatic porphyria, the nervous system is particularly prone to damage [3, 4]. Clinically, patients demonstrate neurological and abdominal symptoms; acute tubulointerstitial kidney failure appears sporadically [2, 4]. In recent years, attempts have been made to study the influence of accumulation of porphyrin precursors on kidney functions. It appears that this correlation is not as significant as reverse correlation, where kidney diseases, particularly chronic ones, are conducive to more frequent attacks of porphyria and greater concentrations of porphobilinogen *(*PBG) and aminolevulinic acid (ALA) accumulated in an organism [5].

Case report

A 29-year old woman has been treated by the Department of Internal Diseases, Nephrology and Dialysis of the Military Institute of Medicine and the Nephrology Outpatient Clinic (Military Institute of Medicine) for 36 months. The original reasons were: intense abdominal pain, pollakiuria and dysuria. The patient did not have a fever. Three days before entering the clinic she was admitted to the emergency department due to similar symptoms. Kidney failure was not diagnosed, urinary tract infection was identified and ciprofloxacin was included. The patient was not previously treated for chronic diseases. The family history was not eventful either, the father was only treated for arterial hypertension, and the mother was healthy. The patient gave birth to a healthy daughter at the age of 18.

The additional tests conducted on the day the patient was admitted identified elevated inflammatory markers together with leukocytosis in the peripheral blood *(*[WBC] 12.0x10^9/l), with an elevated concentration of C-reactive protein ([CRP] 13.2 mg/l, norm: < 0.5 mg/dl). Moreover, signs of acute kidney failure with creatinine concentration of 3.4 mg/dl, and urea concentration 84.0 mg/dl, and electrolyte imbalance with hyponatremia (Na 130 mmol/l) and hypokalemia (K 2.8 mmol/l) were identified. General urinalysis showed: abnormal red urine color (without erythrocyturia), low urinary specific gravity 1.010 g/l, with leukocyturia of 100 cells/µl and ketonuria of 50 mg/dl. The ultrasound of the abdominal cavity showed an increased echogenicity of the renal cortex and features of hepatic steatosis. After blood and urine cultures were taken, empiric antibiotic therapy with ciprofloxacin and ceftriaxone was included.

In the course of hospitalization at the Department of Internal Diseases, Nephrology and Dialysis of the Military Institute of Medicine, regardless of the antibiotic therapy and appropriate supplementation of electrolytes, the condition of the patient continued to deteriorate systematically. At the same time, the morphological markers of inflammation continued to increase (the highest values of WBC in the course of hospitalization: 32 x 10^9/l, neutrophils: 24.72 x 10^3/µl, blood platelets [PLT]: 591 x 10^9/l). The control urinalysis showed: sample not fully transparent, erythrocyturia. Urinary sediment contained fine granular casts, numerous bacteria and squamous epithelial cells in the field of vision, leukocytes 4-6 in the field of vision, partially dysmorphic and dysmorphic erythrocytes 4-6 in the field of vision. The next urine culture showed an increased number of *Klebsiella pneumoniae* bacteria (ESBL +). The same microorganism was cultured in a blood culture taken in the course of hospitalization. A definitive treatment with meropenem was included. The control urine cultures were negative, but the urinalysis still showed erythrocyturia of 10/µl, and numerous squamous epithelial cells in the urinary sediment, leukocytes 7-9 in the field of view and hyaline-granular casts.

Regardless of the definitive treatment, the clinical picture was poor. Pain in the abdomen, abdominal distension, dyspnea and vertigo intensified. Urinary retention appeared, praesthesia of the upper and lower extremities with hyperesthesia appeared, through increasing pain and muscle weakness to quadriparesis. The patient manifested symptomatic tetany with epileptic seizure. A head CT scan was urgently conducted and no abnormalities were identified. The encephaloelectrographic record was within normal limits.

The electrolyte imbalance increased: severe acute hyponatremia (Na: 103 mmol/l), hypokalemia (K: 3.2 mmol/l) and severe hypocalcemia (concentration of ionized calcium Ca^{2+} of 0.64 mmol/l). In a 24-hour urine sample the concentration of Na amounted to 105 mml/l (74 mmol/24 h), K 31.5 mmol/l (22 mmol/24 h) and Ca 10.4 mg/dl (73 mg/24 h). The results indicated a renal cause of ion loss – acute tubulointerstitial nephritis was diagnosed.

Due to the clinical symptoms that did not yield regardless of the abnormalities in the urinary sediment, the electrolyte imbalance remained regardless of appropriate supplementation, the leukocytosis remained regardless of antibiotic therapy and the lack of other features of inflammation (concentration of CRP and

procalcitonin within normal limits), difficult blood pressure control, low osmolality of the serum (169 mOsm/kg mc. [N 280-310 mOsm/kg mc.]) and urine (1.015 g/l [N 1.016-1.022 g/l]), lack of abnormalities in hormone tests (concentrations of cortisol, prolactin, thyrotropin, thyroxine, triiodothyronine), negative medical history for alcohol use disorder and negative tests for autoimmune diseases, anti-nuclear antibodies (ANA), double strain DNA antibodies (dsDNA), and anti-neutrophil cytoplasmic antibodies (ANCA), suggested acute intermittent porphyria as the primary disease of the patient.

In order to verify the accuracy of the diagnosis, the concentration of the delta aminolevulinic acid excreted in the urine was assessed (34 mg/l [N 0-8 mg/l]), as well as the concentration and fluorescence spectra of total blood porphyrins (5.2 µg/dl [N <2 µg/dl] using the method of high-performance liquid chromatography (HPLC). The tests were conducted in a laboratory in Berlin. The tested values were elevated in relation to the norm. Finally, acute intermittent porphyria with acute tubulointerstitial nephritis and *Klebsiella peumoniae* (ESBL +) urosepsis were diagnosed. The applied symptomatic treatment with glucose, conversion of administered drugs allowed in porphyria patients, and definitive antibiotic treatment led to an improvement of the general condition of the patient. The parameters related to inflammation, kidneys, liver enzymes, electrolyte concentrations and urinalyses normalized. Intensive rehabilitation was initiated. The disease was diagnosed within 28 days from the first time the patient was admitted to the clinic. The patient was referred for further care and diagnostic investigation to the Department of Disorders of Hemostasis and Internal Medicine at the Institute of Hematology and Transfusion Medicine. The patient is currently under the constant outpatient care of the Nephrology Outpatient Clinic due to the occurrence of episodes of exacerbation of kidney failure, which is related to the primary disease crises.

Discussion

Acute intermittent porphyria is the most common inherited form of porphyria; it occurs with a frequency of 1-2/100,000 people in Europe, except for Sweden, where due to the "founder effect" it is more frequent (1/10,000 people) [6,7].

The first symptoms of the disease appear fairly late, between the age of 15 and 45. However, even 80-90% of the affected may not manifest any symptoms, due to variable penetrance of the mutated gene responsible for the disease [8, 9]. This in particular applies to men, who are exposed to a lower extent to porphyrinogenic factors, such as hormonal disorders stimulating attacks of porphyria [10, 11]. Also, in the reported case, the reason for the manifestation of the disease could have been the hormonal disorders caused by the discontinuation of oral contraception, and the effect was further reinforced by a urinary tract infection and the initially administered antibiotic therapy (ciprofloxacin and ceftriaxone). The symptoms not only appeared typically for the acute form of the disease: suddenly, but they were also characteristic of it. Abdominal pain dominated, with nausea and vomiting, weakness, muscle pain, tachycardia, increased blood pressure, convulsions, paresis of extremities and adjustment disorders of a psychiatric nature. Regardless of this, seemingly specific, clinical picture [12] these symptoms are not pathognomonic for this disease unit. Moreover, they appeared in different intensities and in different intervals during the course of the disease, which significantly hindered the initiation of early targeted diagnostics and accurate diagnosis. These in turn are necessary to increase the effectiveness of treatment [13]. In the reported case the diagnosis was also delayed due to the rapidly deteriorating condition of the patient, where the primary focus was on the treatment of the progressing urinary tract infection and to compensate for the extreme electrolyte disorders, especially the severe hyponatremia as this is very difficult to control without identification of its cause [14]. In addition, there were misleading abnormal liver markers, particularly GGTP forcing the inclusion of alcohol use disorder in the differential diagnostics. The still unexplained increase in the creatine kinase activity was probably a result of the general exhaustion of the organism in the acute phase of the disease and, possibly, the accompanying electrolyte imbalances conducive to rhabdomyolysis and, in consequence, acute renal tubule injury.

The literature contains analyses of different theories related to the connection between porphyria and acute tubulointerstitial kidney injury [15]. However, there is a dominant view that the most important factor affecting this relation is hypertension stimulated in an attack of porphyria through the mechanism of vasospasm [4, 16]. This could also have occurred in this case. The other element affecting the electrolyte imbalances is neurological hypothalamus dysfunction and inadequate vasopressin secretion. Hiponatremy can by intensified by vomiting and other gastrointestinal disorders [19].

The most important factor of porphyria diagnostics is time, as well as taking this rare disease into account in the differential diagnosis together with other units causing "acute abdomen": urinary tract infections, neurological and psychiatric, autoimmune, endocrynological, gynecological, alcohol use disorders, as well as other types of porphyria. Therefore, detailed anamnesis of the patient is important in order to identify

the potential porphyrinogenic factors (infections, drugs, endo-/exogenous steroid, sex hormones, alcohol, low-calorie diet or a recently undergone surgery), physical examination and targeted diagnostics. It should include surgical consultation, electrocardiographic examination (tachyarrhythmia), radiological examination – plain X-ray of the abdominal cavity (visible levels of fluid) and laboratory tests concerning: blood (hyponatremia, hypomagnesemia, leukocytosis, spectra of porphyrins in the plasma), urine (red color of urine and elevated concentration of PBG and ALA in the course of an attack), enzymes (decrease in the activity of the PBG deaminase in erythrocytes, leukocytes and skin fibroblasts in the periods between attacks), whereas the latter two tests constitute the necessary criteria for the diagnosis of porphyria [13, 17, 18]. It is most important for a clinician to note the presence of a characteristic symptom – the dark russet color of the urine, appearing under the influence of sunlight. A simple test allows the elimination of the suspicion of porphyria and inclines towards conducting more sensitive and specific confirmation tests. Similar issues were presented in a work from 1998, published in "Polski Merkuriusz Lekarski", which originated from the parent center [20]. Due to a major variability in the symptoms in the periods between attacks, the diagnosis should always be unequivocally confirmed by means of genetic tests detecting specific mutations [18]. Unfortunately, full range of assessments cannot be conducted in every hospital laboratory; therefore for the purpose of detailed diagnostics and treatment, as also happened in this case, the patient should be sent to a reference center. In Warsaw such a center is the Institute of Hematology and Transfusion Medicine.

Summary

Acute tubulointerstitial kidney failure is not the most frequent form of clinical manifestation of acute intermittent porphyria. This is also probably why porphyria is often not considered in the course of differentiation when acute tubulointerstitial kidney failure is diagnosed. However, this is important, as the sooner the diagnostics in this direction is initiated, the diagnosis pronounced and appropriate treatment initiated, the better the prognosis for this disease is, as in the present case. The symptom that should warn the physician is the dark russet color of urine exposed to sunlight.

The levels of aminolevulinic acid and porphyrins were assessed at the Central Laboratory in Berlin through the medium of Synevo Poland Laboratory.

Literature

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Health Services in the Polish Armed Forces - the need for organizational change

Służba zdrowia Sił Zbrojnych RP – potrzeba zmian organizacyjnych

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Abstract. The assessment of the current geopolitical conditions shows some instability in the existing international systems. In this context much significance is attached to the national capacity to maintain security and ensure the potential of the Polish Armed Forces. This article refers to the major issues related to the medical support of combat operations. The authors focus on key factors conditioning the restoration and effective reorganization of the military health service. It vital to undertake certain actions to adjust the military health service to meet the current security and defense challenges facing the country. However, the time available to introduce these changes is limited.
Keywords: military health service, medical support

Streszczenie. Analiza uwarunkowań geopolitycznych ostatnich lat ukazuje niestabilność struktur międzynarodowych. Na tym tle istotne stają się narodowe gwarancje bezpieczeństwa oraz aktualne możliwości Sił Zbrojnych RP. W artykule odniesiono się do problematyki zabezpieczenia medycznego działań bojowych. Autorzy skupiają się na zagadnieniach warunkujących odbudowę i efektywne zreorganizowanie wojskowej służby zdrowia (WSZ). Działania dostosowujące WSZ do aktualnych wyzwań w zakresie bezpieczeństwa i obrony terytorium kraju są niezbędne i limitowane czasem.
Słowa kluczowe: wojskowa służba zdrowia, zabezpieczenie medyczne

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After the fall of the Berlin Wall in 1989, an American political scientist, Francis Fukuyama, advanced a thesis on "the end of history". He stated that a historical victory of democracy had occurred and conflicts between major political systems had come to an end [1, 2]. After less than three decades, analysts, including Fukuyama himself, came to the conclusion that this statement was made prematurely.

One of the most acknowledged geopoliticians, George Friedman, declared a downright fall based on the thesis of "the end of history", making a note in an analysis concerning Poland that the basic goal of Polish strategy should be to retain its national identity and independence [3]. On the other hand, Robert Kaplan, in his book "The Revenge of Geography", writes that Poland and Germany are currently the most important countries in Europe, but he makes a note that the appearance of differences in political interests between these two countries could undermine this system, and Poland could become a target of further invasions – both from the east and from the west. He thinks that due to the strategic location of Poland, its population and ethnically homogeneous society, the issue of its defense system remains very important [4].

Poland's accession to NATO and the European Union as an implementation of the main objectives of foreign policy in the 1990s formed a basis for guarantees of international security. However, the intensification of the aggressive policy of Russia in the east of Europe, as well as the changes that occurred in Poland, such as "Lenin's dreams come true", i.e. the decrease in the numerical strength of the Polish Armed Forces (PAF) down to 100 thousand, do not instill optimism [3]. The quoted analysts think that due to its geographical position Poland needs new alliances, guaranteeing support in case of an armed conflict.

The fundamental guarantee is having the military potential that allows the simultaneous pursuit of irregular activities that would allow the suppression of aggression until help comes from the outside.

Table 1. Expected general and sanitary losses during a 10-day defensive operation by the Mechanized Corps [6, 7]
Tabela 1. Przewidywane ogólne i sanitarne straty powstałe podczas dziesięciodniowej operacji obronnej Korpusu Zmechanizowanego [6, 7]

battle day	killed	missing	battle injured	stress	diseased	non-battle injured	headcount of the Mechanized Corps at the end of a day of battle
			medical losses				
1	434	204	1479	434	2025	75	145,350
2	426	201	1454	426	1962	73	140,808
3	419	197	1429	419	1901	70	136,373
4	412	194	1405	412	1841	68	132,042
5	405	190	1381	405	1750	66	127,845
6	398	187	1357	398	1731	64	123,710
7	391	184	1334	391	1693	62	119,654
8	384	181	1312	384	1615	60	115,717
9	378	178	1289	378	1562	59	111,873
10	372	175	1268	372	1510	56	108,122
total	4018	1891	13,708	4018	17,591	653	

Decisive steps in the direction of improving the situation include: the decision to increase the numerical strength of the Polish Armed Forces and to develop the structures of territorial defense, improve the quality of armament, develop the skills required in coalition activities, and most importantly undertake political measures aimed at improving the situation and reinforcing alliances. It is also important for the PAF to have full logistical support, including medical.

As a part of medical support, the task of the military health service during the time of peace is to care for the good psychological and physical condition of soldiers and to maintain the capability of mobilization. In the period of crisis and war, the military health service implements the assumptions of the medical support system for combat operations in all aspects, performing tasks within the scope of:

- evacuation and medical support,
- medical-hygiene and anti-epidemic support,
- medical support against the weapons of mass destruction,
- supply with medical materials and equipment,
- management of the forces and means of the health service during combat operations,
- training personnel of the Polish Armed Forces,
- maintaining medical documentation.

The capabilities of the military health service are tested by conducting medical support for defensive operations conducted in the country.

It should be noted that, as a result of the restructuring and systemic changes that took place, the military health service, like no other service in the army, lost its autonomy to a significant extent, while its potential, including that related to the personnel, decreased disproportionately to the numerical strength of the PAF [5].

The medical detachments of military units are incomplete in relation to the needs of the numerical strength in the time of peace, which is not without consequences for the quality of their functioning. They also have a varied organization, which does not always depend on the specificity of the unit. The changes that moved the military health service outside the general military structures resulted in difficulties related to proper implementation of medical support.

The binding national health care system has made it impossible to provide comprehensive medical care for the personnel of the Armed Forces. Most of the soldiers receive primary medical care from general practitioners and specialized physicians outside the military health service, while the binding documentation – or rather lack thereof – ceased to serve as a source of information on their health status.

Changes in the PAF concerning the military health service should follow the direction of:

- legislative changes concerning the organization and functioning of the military health service,
- determination of the requirements concerning the strength and means of the military health service in the times of peace, crisis and war, including the estimation of the level, structure and dynamics of the occurrence of medical losses in a potential armed conflict.

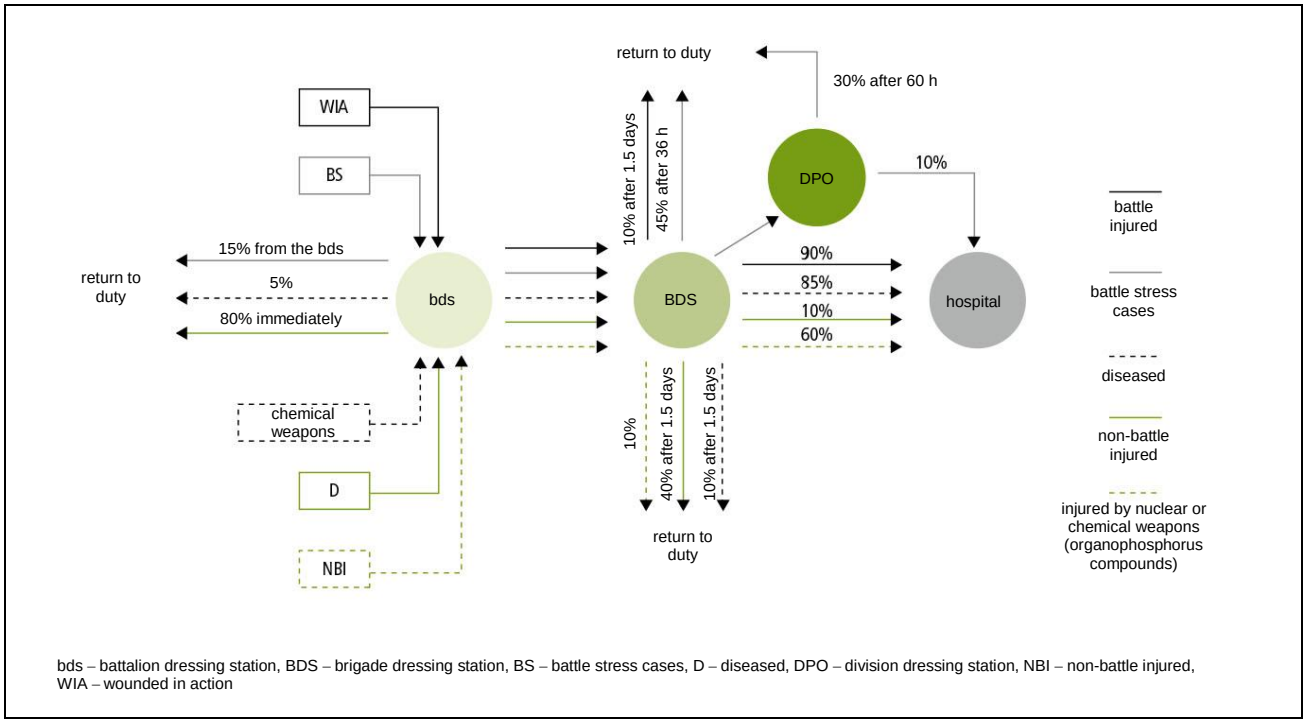

Figure 1. Routes of evacuation and return to duty under the medical support and evacuation system [8]
Rycina 1. Kierunki ewakuacji i powrotów w szeregi walczących wojsk w ramach systemu leczniczo-ewakuacyjnego [8]

The example shows a forecast of the medical losses occurring during a 10-day defensive operation involving 150,000 soldiers of the Mechanized Corps (MC) (Tab. 1).

It should be emphasized that not everyone from the group of medical losses will make it to the hospitals within the medical support system. In accordance with Directive AD 85-8, hospitals will only admit a specified percentage of the casualties presented below, and at the same time some of the casualties, once they receive medical support on a specified level, will return to duty (Fig. 1).

Taking into account the above-mentioned outline, assistance provided at the 3rd level of medical support (military and civil medical facilities within the framework of allotting medical capabilities for the requirements of the PAF and field hospitals) will be required by:

- 10% of the casualties with mental disorders, battle stress cases (402 soldiers),
- 90% battle injured (12,338 soldiers),
- 10% diseased (1760 soldiers),
- 60% non-battle injured (392 soldiers).

The calculations of the predicted level of medical losses presented above only apply to conflicts with the use of conventional weapons. In the case of an enemy using weapons of mass destruction, the ratios of medical losses will be multiplied and 85% of the injured as a result of its influence will require medical assistance in hospitals at the 3rd level of medical support.

Further analyses supporting the determination of the requirements for the strength and means of the health service should concern:

- optimization of the structures of medical detachments and units of the 1st and 2nd levels of medical support, with particular focus on their modular construction, including the assessment of capability to act as part of the support for operations outside the country,
- identification of requirements in terms of the number of particular medical specialists at particular levels of medical support,
- determination of the number of hospital beds allotted for the needs of the Armed Forces, such as to support a 10-day defensive operation of the MC,
- determination of the role of Prevention and Treatment Districts within the country and assignment of tasks to implement for them, as well as the development of new organizational structures of the centrally subordinated medical support units with the capability of reinforcing the 1st and 2nd levels of medical support,
- restoration of the medical corps by means of developing principles for hiring candidates, methods of pre- and post-graduate education and preparation of personnel reserves in the case of mobilization of medical detachments.

The implementation of the presented issues creates the opportunity to make changes in the system of medical support for the PAF and the possibility of making use of the previous experience of the military health service arising from participation in operations outside the home country, the decreasing medical potential of the PAF and the analysis of the political and military situation in Europe should result in the fastest possible activities aimed at implementing a recovery program for the military health service. Properly implemented medical support of the PAF will influence both the combat capabilities and the morale of the soldiers.

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Deep infiltrating endometriosis (DIE) - a relevant clinical problem in gynecology

Endometrioza głęboko naciekająca – istotny problem kliniczny w ginekologii

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Abstract. Endometriosis is a chronic disease that mainly affects women of the reproductive age, while Deep Infiltrating Endometriosis (DIE) is a particular form of endometriosis that penetrates more than 5 mm under the peritoneal surface. Endometrial nodules may infiltrate different pelvic and abdominal organs and cause intense pain. The key symptoms are: cyclic pelvic pain related to menstruation and ovulation, deep dyspareunia, intestinal complaints associated with defecation, and infertility. Chronic pelvic pain, fatigue and urinary symptoms are also frequently observed. In the presence of this symptoms clinicians should particularly consider endometriosis, as it is reported that such a diagnosis is still being made too late. Patients suspected of deep endometriosis should be referred to reference centers that employ multidisciplinary specialist staff.

Keywords: endometriosis, deep infiltrating endometriosis (DIE), dysmenorrhea, infertility, pelvic pain

Streszczenie. Endometrioza jest chorobą przewlekłą dotyczącą głównie kobiet w wieku rozrodczym, a jej postać głęboko naciekająca *[deep inflitrating endometriosis* - DIE) to stan, w którym tkanka endometriozy nacieka otrzewną na głębokość ponad 5 mm. Guzki endometrialne mogą znajdować się w różnych organach miednicy mniejszej lub jamy brzusznej, powodując silne dolegliwości bólowe. Klasyczne objawy to bóle podbrzusza związane z cyklem miesiączkowym, takie jak bolesne miesiączki i owulacje, głęboki ból w czasie stosunku, a także objawy jelitowe związane z wypróżnieniami i niepłodność. Inne często występujące objawy to przewlekły ból w miednicy mniejszej, zmęczenie i objawy bólowe ze strony dolnego odcinka układu moczowego. Stwierdzenie opisanych powyżej objawów zawsze powinno skłaniać lekarza do zwrócenia szczególnej uwagi na możliwość występowania endometriozy, gdyż rozpoznanie to często jest ustalane zbyt późno. Pacjentki z podejrzeniem endometriozy głębokiej powinny być kierowane do referencyjnych ośrodków zatrudniających wielodyscyplinarny zespół specjalistów.

Słowa kluczowe: endometrioza, głęboko naciekająca endometrioza, ból miesiączkowy, niepłodność, ból w miednicy mniejszej

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Introduction

Endometriosis is a chronic disease affecting mainly women of reproductive age, which usually causes pain and infertility, and hence has a negative impact on their quality of life. It is diagnosed in 12% of women of reproductive age and affects 30-50% of infertile women complaining of chronic pain [1]. An epidemiological study conducted in the USA indicate that approx. 7 million women there have endometriosis, with about 5 million suffering from chronic pain and about 1 million being infertile. From the clinical and the histopathological points of view, one can distinguish three different forms of this disease: ovarian endometriosis (mucosal type), peritoneal endometriosis (multifocal morphologically diverse lesions) and deep infiltrating endometriosis (adenomatous type).

Deep infiltrating endometriosis was described for the first time in 1920 by Cullen. According to the definition proposed by Koninckx [2] it is a condition in which endometriotic tissue penetrates over 5 mm into the perioneum. Endometrial nodules are usually greater than 1 cm in size and can infiltrate different pelvic and abdominal organs, such as the broad ligaments of the uterus (71-83%), the recto-uterine pouch (58%), the large intestine (the rectum and the sigmoid colon; 37%), the rectovaginal septum (32%), the parametrium (10-14%), the vaginal wall (12%), and more rarely the ureters (3-6%), the urinary bladder (4%) and the diaphragm (0.19%). The foci are usually located on the left side of the body [3]. Adenomyosis is the presence of endometrial stroma and mucosa within the uterine muscle; it occurs in approx. 10% of cases at advanced stages of endometriosis. It can pose a challenge in terms of diagnostics and treatment. New methods of conservative treatment of adenomyosis allowing the elimination of pain and retaining the patients' fertility are being sought around the world.

Symptoms

Women suffering from endometriosis require medical help more often than other women, and are more susceptible to absenteeism due to pain [1, 4]. The classic symptoms include lower abdominal pain related to the menstrual cycle, painful menstruation, dyspareunia, and intestinal complaints associated with defecation, tiredness, bleeding and infertility. These symptoms require differential diagnostics in respect of other gynecological causes of pain, as well as alimentary tract, urological, neurological, musculoskeletal system, and psychiatric diseases. Non-gynecological causes of pain often include irritable bowel syndrome and interstitial cystitis *(cystitis interstitialis).* The presence of the aforementioned pain symptoms should always prompt physicians to pay special attention to the possibility of endometriosis, since in many cases such a diagnosis is made too late.

The problem of endometriosis being diagnosed too late also applies to very young women. It is estimated that about two thirds of teenage girls reporting menstrual pain or chronic pain in the pelvis suffer from endometriosis; in about 30% of the cases it is already at an advanced stage of the disease (3^{rd} or 4^{th} stage, according to ASRM). Making the correct diagnosis facilitates appropriate specialist care for the patient, which gives the potential chance for a better quality of life and even avoiding severe complications.

In the United States, the delay in diagnosing endometriosis is, on average, approx. 12 years (11.73 ±9.05), and in the United Kingdom, on average 8 years (7.96 ±7.92). This is still too long a period for us to call it optimal diagnostics, as the patients suffer for many years not knowing the cause of the pain, and are often misjudged by their environment [5].

Endometriosis is diagnosed primarily based on a well-prepared case history, the present symptoms, a gynecological examination and a transvaginal ultrasound performed by a physician specializing in diagnosing endometriosis. Additional examinations can also be very helpful in the pre-operative evaluation of the stage of disease (staging), and can help to plan the extent of the surgical procedure. However, due to their cost and invasiveness, they should not be routinely used for the confirmation or exclusion of the diagnosis. The most helpful are: MRI to better describe the foci of endometriosis and adenomyosis, computed tomography and scintigraphy in those cases of endometriosis infiltrating the ureters and causing hydronephrosis, as well as other radiological examinations, such as contrast examinations of the large intestine, which make it easier to evaluate the infiltration of the intestinal wall by the endometriosis. Laparoscopy makes it possible to confirm the diagnosis and is considered the ''gold standard'' in diagnosing endometriosis [6]. At the same time, it facilitates the surgical removal of the foci of the disease, which translates into less severe pain and improves fertility [7] and the quality of the patients' lives.

The simplest and most often used tool to assess the degree of pain is the visual analogue scale (VAS), from 1 to 10 (with 10 meaning the maximum intensity of the symptom one can imagine, and 1 meaning no symptom). Other frequently used scales are the McGill Pain Questionnaire and scales concerning quality of life, such as SF-36. These are useful in terms of both symptom intensity and treatment efficacy.

Infertility

Infertility can be regarded as one of the signs of endometriosis: according to the latest ESHRE guidelines [1], asymptomatic endometriosis is a form of endometriosis that does not cause any pain or infertility. Endometriosis is more often diagnosed in infertile women (according to some authors [8] even 6-8 times more frequently) than in fertile patients. At the same time, infertility more often affects women with endometriosis than individuals free from this disease, as approx. 30-50% of patients with endometriosis have difficulties becoming pregnant [1]. The interrelation between endometriosis and infertility is not entirely clear. In more advanced stages, the following factors can cause infertility: pain that makes normal intercourse

impossible and anatomical changes due to infiltration or adhesion. In early-stage endometriosis, there are no such factors; however, it has been demonstrated that fertility in this group of patients is lower than in the group of women with unexplained infertility, and the time to conception is longer. There can be various responsible immunological and pro-inflammatory factors, acting at the intrauterine, salpingeal or peritoneal fluid levels, impacting on the ovum, sperm cells, the insemination process and the embryo [9].

The pain mechanism

In endometriosis pain is associated primarily with the cycle, but patients can also experience chronic pain. The pathophysiological mechanism of pain has not been entirely explained. Three basic and possible pain mechanisms have been proposed: the first is the presence of growth factors and cytokines produced by activated macrophages and other cells; the second is the direct and indirect effect of cyclic bleeding from the endometriotic tissue; and the third is associated with nerve fiber irritation, and their direct infiltration by the endometriotic tissue, especially in the posterior compartment *(cul-de-sac).* The role of the last mechanism has been repeatedly highlighted recently; nevertheless, all the indicated processes can occur simultaneously.

Research into the pain mechanisms in endometriosis indicates the presence of interactions between immune cells and sensory nerve fibers. It appears that a key role [10] is played by retrograde menstruation, which causes the direct and indirect stimulation of the sensory nerve fibers. Direct stimulation is achieved by a change in pH and the production of prostaglandins as a result of menstrual tissue degeneration, and indirect stimulation by the local immunological activation of mastocytes and macrophages producing inflammatory mediators. In response, nerve endings release pro-inflammatory mediators, contributing to neurogenic inflammation. The activation of sensory neuron endings leads to a nociceptive pain signal being transmitted to the central nervous system.

It appears that in the pathogenesis of pain connected with endometriosis, an important role is played by the nerve growth factor (NGF), which not only stimulates the growth of nerve fibers, but also the occurrence and persistence of chronic pain in various stages of the disease [10]. Some studies demonstrated that in DIE, the depth of infiltration correlates with pain intensity [1].

Pain in endometriomas is probably caused by their sheer presence, impinging on the neighboring tissues. Adhesions and tissue fibrosis impair blood flow to the nerve plexuses and create tension in the small nerve fibers pulled by the adhesions, causing pain. In addition, it was demonstrated that nerve fibers are also present in the capsules of endometrial ovarian cysts. Studies also indicated an increased number of nerve fibers in the endometrium of women with endometriosis. Their presence, accompanying chronic inflammation, can lead to an excessive increase in the sensitivity of nociceptors with the creation of new nerve fibers, resulting in pain hypersensitivity (hyperalgesia). In addition, endometriosis can also be accompanied by the increased intensity of pain signals transmitted to the brain [10].

The impact of hormones on symptoms

It is believed that estrogens reduce the perception of pain by increasing the pain threshold. It has been observed that the exacerbation of pain in selected diseases, such as irritable bowel syndrome, takes place in the premenstrual and menstrual periods, when the concentration of estrogens is the lowest. A meta-analysis concerning experimentally triggered pain demonstrated that the somatic pain threshold was approx. 30% lower in the premenstrual and menstrual periods [11]. Estrogens also directly influence the tissue of endometriosis foci, increasing their proliferation.

Progesterone influences the sensation of pain, as its high concentrations decrease the transmission of pain stimuli. These mechanisms underlie the hormonal treatment of endometriosis. To this end we can use progesterones and drugs reducing the concentration of estrogens. Endometrial implants can be characterized by a varying number of receptors for estrogens (ER) and progesterone (PR), and have different response intensities to these hormones. High aromatase activity in endometriotic foci can cause the local concentration of estradiol and, thereby, stimulate endometriotic tissue growth. This mechanism can explain the cases of poor response to drugs or, in rare but possible cases, the recurrences of the disease in spite of hormonal treatment.

Cyclic and chronic pain

The cyclic nature of lower abdominal pain is characteristic of endometriosis and logically connected with the cyclic nature of changes in the endometrium, including the ectopic endometrium. The ectopic endometrial tissue located in various endometriotic foci undergoes, throughout the menstrual cycle, the same changes as the endometrium within the uterine cavity, causing pain and bleeding from various affected organs,

e.g. from the rectum, during menstruation and ovulation. Some rare cases can entail catamenial pneumothorax (*pneumothorax catamenialis*), recurring during menstruation, in thoracic endometriosis syndrome. Case-specific catamenial hemoptysis was also described. In the case of nerves being infiltrated by morbid tissue, pain can be experienced along the nerve route. This applies primarily to the pudendal nerve *(pudendalgia)* or the sciatic nerve, which causes premenstrual sciatica *(sciatalgia catamenialis).*

Ovulation pain is a simple symptom to eliminate, by estrogen-progesterone hormonal treatment. If, however, a woman wishes to become pregnant, this form of treatment is not possible, and the pain can hinder intercourse in the periovulation period and cause infertility.

Menstrual pain *(dysmenorrhea)* is among the most common symptoms of endometriosis. In an extensive (5540 patients) retrospective analysis based on a database of general practitioners in the United Kingdom, among women with endometriosis, menstrual pain was eight times more prevalent (OR 8.1, 95% CI: 7.2-9.3) than among the controls [4].

Other common symptoms include deep pain during intercourse (dyspareunia) and chronic pain in the lesser pelvis, which can radiate towards the lumbar or sacral spine or the rectum. The involvement of the myenteron in the disease can cause intestinal symptoms, such as painful spasms, the sensation of inflation, constipation or alternating constipation and diarrhea, pain during defecation (dyschezia) and the feeling of incomplete defecation *(tenesmus).* In extreme cases endometriosis can cause ileus, requiring emergency surgical intervention. The presence of intestinal symptoms can also be caused by adhesions in the peritoneal cavity, resulting in a change in the course of the intestine, and its mechanical stenosis and peristaltic disorders. Pain during urination (dysuria) is a rarer symptom of endometriosis.

The pain often significantly impairs the patient's quality of life, influencing her private life and professional activities. If this is the case, they require pharmacological or surgical treatment. Non-steroidal anti-inflammatory drugs (NSAIDs) are used as the first-choice treatment for chronic pain and menstrual pain *(dysmenorrhea);* these act by inhibiting prostaglandin production. Drugs from this group are, however, ineffective in some cases of pain caused by endometriosis, especially chronic pain.

Studies conducted among women with chronic pelvic pain demonstrated increased pain sensitivity outside the lesser pelvis [12], indicating the possible role of the discussed modification in the pain-sensation processes, causing hyperalgesia. This process might explain why some women fail to experience improvement even after the removal of the endometriotic foci.

The difference between deep infiltrating endometriosis (DIE) and cysts in pain pathogenesis

Ovarian cysts often cause pain, but can also be asymptomatic. Histopathological studies have demonstrated the presence of sensory, sympathetic and parasympathetic nerve fibers in cyst capsules, and thus can be regarded as pain locations of endometriosis [13].

As illustrated by Chapron [13], the severe pain associated with ovarian cysts tends to be caused by the associated deep infiltrating, often multifocal, endometriosis, which can infiltrate the intestinal walls. Pain intensity is not proportional to cyst size, as the location of the cyst in the left ovary has been associated with severe chronic pain, and the bilateral location of cysts with severe menstrual pain *(dysmenorrhea).*

Adhesions, often accompanying endometrial cysts, can contribute to pain. Inflammatory cells that can cause pain were identified in periadnexal adhesions [14]. Furthermore, the very presence of adhesions can exacerbate the pain, by immobilizing the adnexa or connecting them closely to other lesser pelvis organs.

Ovarian cysts are a form of endometriosis that is the easiest to diagnose, taking into account the widespread nature of ultrasound diagnostics. Diagnosing deep infiltrating endometriosis is much more difficult and requires experience. This type of endometriosis should be suspected, confirmed or rejected in the case of severe pain [13].

Pain in deep infiltrating endometriosis – DIE

DIE is associated with the occurrence of more severe pain than its peritoneal form and ovarian endometriosis. From the histopathological perspective, this can be explained by a higher concentration of NGF and other pain-triggering factors, in the proliferation, as well as the secretion stages present in DIE foci [10, 11]. Also, the density of nerve fibers, determined in immunohistochemical analyses, is greater in DIE foci, especially those infiltrating the intestine, than in superficial endometriosis. The infiltration of nerve fibers with endometriosis is observed only in DIE, and is not present in other forms of endometriosis [11]. Symptom intensity does not always correlate with the stage of the disease [1].

Endometriotic foci present in the uterosacral ligaments are associated with more severe pain during

intercourse (dyspareunia) and chronic lower abdominal pain [13, 15]. Endometriosis infiltrating the vaginal wall can cause pain in the inferior urinary tract [13, 15] and painful defecation [15], while endometriosis infiltrating the intestine causes symptoms in the alimentary tract, menstrual pain [13] and chronic non-cyclical pelvic pain [15]. Nodules infiltrating the urinary bladder can cause complaints connected with urination (dysuria) [15].

In centers specializing in diagnosing and treating endometriosis, a transvaginal ultrasound makes it possible to diagnose and evaluate the stage of deep infiltrating endometriosis before surgery [16], and should be the first, basic imaging test, due to its availability, low cost and minimal invasiveness. Additional testing that can prove useful in the evaluation of deep endometriosis includes MRI, a transrectal ultrasound and computed tomography [17]. Such tests can be performed with various modifications, such as the use of a contrast agent in the intestine or vagina, to determine the dimensions of the endometriotic nodules and the depth of infiltration with even greater accuracy [18]. Some diagnostic methods, such as barium enema and contrast-enhanced MRI, make it possible to also evaluate the degree of intestinal stenosis resulting from endometriotic infiltration, which can prove useful in the assessment of indications for surgical treatment and the type of planned operation [19].

Absolute indications for surgical treatment

Laparoscopic removal of endometriosis is associated with considerable alleviation of pain and fertility improvement in patients [1, 2, 7]. A decision to pursue surgical treatment should be made jointly with the patient, after examining the indications, possible results and complications [1, 7, 9]. Severe pain that does not subside after hormonal treatment is a common indication for surgical treatment. There are also absolute indications for operation, which are connected with endometriosis that considerably infiltrate important organs (intestine, ureter), and the associated risks of their functional disorder. Such indications can be warranted even in the absence of pain. As indicated in studies, asymptomatic endometriosis is found in 14% of women who have undergone laparoscopic tubal sterilization [1, 11, 20].

Asymptomatic deep endometriosis requires particular attention due to the possibility of the ureters being infiltrated with morbid tissue, which can cause hydronephrosis leading to kidney failure or even silent kidney loss. This is the most serious complication of endometriosis. Unfortunately, in 47% of cases, ureteral endometriosis is in such an advanced stage upon diagnosis that the only course of procedure is nephrectomy [20]. Therefore, ureteral endometriosis causing hydronephrosis or ureteral dilatation constitutes an absolute indication for surgical treatment (Fig. 1). Endometriosis not infiltrating the muscular coat of the ureter *(endometriosis estrinseca)* requires the removal of the tissue impinging on the ureter *(ureterolysis).* In the case of endometriosis infiltrating the muscular coat of the ureter *(endometriosis intrinseca)*, the stenosed section is removed, and the ends of the ureter are joined, or the ureter is connected to the urinary bladder, which may be carried out laparoscopically [20].

Another absolute indication for the operative treatment of deep endometriosis is the presence of a nodule causing stenosis of the intestinal lumen to a degree that poses a risk of acute ileus. In such cases, conducting a planned procedure makes it possible to avoid emergency operations, thus allowing the endometriosis to be removed completely, with a smaller risk of complications as it is possible to prepare the patient appropriately for the procedure and to carry it out in a specialized center.

Conclusions

Patients suspected of deep endometriosis should be referred to reference centers that employ multidisciplinary specialist staff. This necessity is underlined by the latest ESHRE guidelines [1] for endometriosis. In such centers the cooperation between gynecologists, surgeons and urologists facilitates effective operative treatment when the disease affects various organs (Fig. 2). Such cooperation is crucial in the event of possible inter- and postoperative complications.

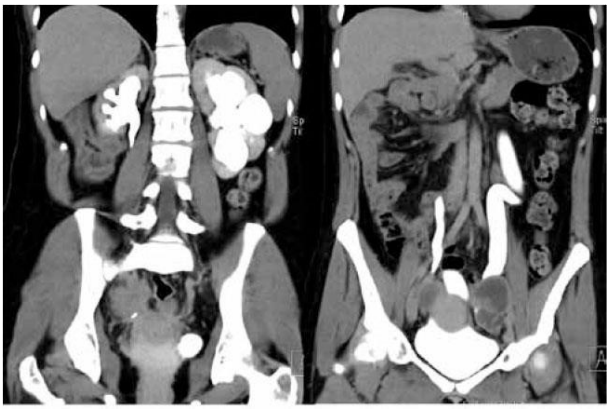

Figure 1. Image of bilateral hydronephrosis and hydroureter associated with asymptomatic DIE, on a CT scan with contrast. A 26-year-old patient with a 3-year history of infertility, showing no other symptoms. On the transvaginal ultrasound, bilateral ovarian endometriomas and a bilateral hydro-ureteronephrosis were found. The patient underwent CT, scintigraphy, had ureteral stents placed and was qualified for surgical excision of endometriosis.
Rycina 1. Bezobjawowa endometrioza głęboka powodująca obustronne poszerzenie moczowodów i miedniczek nerkowych (obraz z tomografii komputerowej z kontrastem). Pacjentka lat 26, diagnozowana z powodu niepłodności od 3 lat, poza tym bez objawów. W badaniu USG widoczne obustronne torbiele endometrialne jajników oraz poszerzenie moczowodów i miedniczek nerkowych. Wykonano CT, scyntygrafię nerek, a następnie założono cewniki do moczowodów i zakwalifikowano do operacji eradykacji endometriozy.

Figure 2. Laparoscopic image of "frozen pelvis" DIE-adhesions affecting the uterus, adnexa and large intestine. In this case, a surgery is recommended in reference centers that offer treatment by a multidisciplinary specialist team, due to the high risk of urinary tract and bowel damage.
Rycina 2. Laparoskopowy obraz endometriozy głębokiej, tzw. *frozen pelvis* - zrosty obejmujące macicę, przydatki i jelito grube. W takim przypadku zalecane jest leczenie chirurgiczne w ośrodku referencyjnym posiadającym ekipę multidyscyplinarna, ze względu na duże ryzyko operacyjne dotyczące jelita i układu moczowego.

The leading role in the team should fall to the gynecologist, who should be well aware of the potential course of the disease, maternity-related aspects, the possibility of hormonal and surgical treatment, and who can provide the patient with care in different stages of her life. Centers specializing in treating endometriosis should have high-quality diagnostic facilities. Patients with the aforementioned disorders must be referred there not only to undergo operations, but also in the event of any diagnostic or therapeutic doubts in patients suspected of deep endometriosis. Quick specialist consultation is necessary for patients experiencing severe pain.

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When human memory fades away, stones remain to tell the story - in memory of Lt. Col. Kazimierz Malanowicz MD, PhD (1884-1933)

Gdy gaśnie pamięć ludzka, dalej mówią kamienie - pamięci ppłk. dr. Kazimierza Malanowicza (1884-1933)

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Abstract. The article presents a Polish military physician who lived in Vilnius for many years. He was born in Brest-on-the-Bug, on February 26, 1884. In 1911, he graduated from the Imperial University in Moscow. He served in the Russian Army as a physician of the 75th and the 259th Infantry Regiments. He took part in the First World War, and then in 1919 he became a Polish soldier and participated in the war against Russia in 1920. In the interwar period, he worked as the head of the Bacteriology Laboratory of the Military Hospital in Vilnius, and then became the commander of the 3rd Regional Hospital in Grodno. It was one of the most important military hospitals in Poland in the interwar period. Lieutenant Colonel Kazimierz Malanowicz died in Grodno, on June 6, 1933. He was buried at the Antakalnis Cemetery in Vilnius. As the years passed, his gravestone deteriorated considerably until in 2016 when the Military Physician Association in Warsaw financed its renovation.
Key words: Malanowicz, physician, officer, military hospital, Vilnius, Grodno

Streszczenie. W artykule przedstawiono sylwetkę polskiego lekarza wojskowego przez wiele lat związanego z Wilnem. Urodził się 26 lutego 1884 roku w Brześciu nad Bugiem. W 1911 roku ukończył Cesarski Uniwersytet w Moskwie. Następnie służył w armii rosyjskiej jako lekarz 75. i 259. Pułku Piechoty. Brał udział w I wojnie światowej. W 1919 roku został polskim żołnierzem i wziął udział w wojnie 1920 roku przeciwko Rosji. W okresie międzywojennym pełnił funkcję kierownika pracowni bakteriologicznej Szpitala Wojskowego w Wilnie, potem został komendantem 3. Szpitala Okręgowego w Grodnie. Był to jeden z najważniejszych szpitali wojskowych w Polsce w okresie międzywojennym. Podpułkownik Kazimierz Malanowicz zmarł w Grodnie 6 czerwca 1933 roku. Został pochowany na Cmentarzu Antokolskim w Wilnie. Po wielu latach jego grób uległ znacznemu zniszczeniu, jego renowację sfinansowała w 2016 roku Wojskowa Izba Lekarska z Warszawy.
Słowa kluczowe: Malanowicz, lekarz, oficer, szpital wojskowy, Wilno, Grodno

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"... *Vilnius, do you remember me?...*"

Introduction

"When human memory fades away, stones remain to tell the story." For all those who see national identity and patriotism as something more than cheap slogans, these famous words uttered by the Primate of Poland, Cardinal Stefan Wyszyński, still reverberate and inspire. They prove to be an excellent illustration of thousands of Polish graves, where people often lie forgotten by the following generations, engrossed as they are in their daily struggles. The only evidence for their existence can be found in the tomb inscriptions, slowly vanishing as time and nature leave their mark on the silent stones.

This problem is of particular relevance to the former region of Kresy Wschodnie, now no longer a part of Poland, but of Lithuania, Belarus, Ukraine, Russia, and other countries. Following the infamous conferences in Yalta and Potsdam, those Poles who had inhabited those areas for hundreds of years were forced out. Only those who had the courage and determination to stay there continue to give their testimonies about the real history of those lands.

A very special example of such a place is Vilnius, a jewel in the crown of the Commonwealth, right next to that of Lviv and Hrodna. This gorgeous city upon the Vilnia River, acknowledged both by Poland and Lithuania, was once the capital of the Grand Duchy of Lithuania, and then later became the hub of Polish science, culture and art. It is where Stephen Báthory founded the Vilnius University, whose Department of Medicine produced numerous renowned physicians and scientists. Throughout the years, Vilnius University took pride in its exquisite academics, not only in the field of medicine. Students filled the lecture halls to listen to Jędrzej Śniadecki, Joachim Lelewel, Marian Zdziechowski, Kornel Michejda and many others.

As to art, it would suffice for a layman to visit a few of the temples to be found in Vilnius, such as Church of SS. Peter and Paul, or the Church of St. Anne, to recognize the value of the artists who used to work here. During literature classes at school, every Polish student must have surely heard of the real story behind Mickiewicz's drama "Dziady", Part III – and namely the apprehension of the student activists in the Philomaths and Filaret Association, who were imprisoned by Nikolay Novosiltsev, the tsar's commissar, in the former Basilian monastery near the Gates of Dawn.

Throughout the interwar period, the city of Vilnius hosted a large garrison, where one of the most famous field hospitals was located: the Hospital of the Fortified Area of Vilnius (S.O.W.W.). The army physicians working in Vilnius contributed to the unique atmosphere of the city. They managed to play a significant role in the medical community, dominated by the professors of Vilnius University. Thanks to the cooperation between the leading physicians of the time and the military health service, the level of healthcare in the field hospital continually grew, making it one of the most prominent medical facilities in the entire Vilnius voivodeship.

Many of the S.O.W.W. staff were executed by the Soviet NKVD in the Katyn Massacre in 1940. Those who died before World War II were buried in local cemeteries, mostly in Antakalnis Military Cemetery or Rasos Cemetery. Their tombs still bear witness to the presence and activity of the Polish military health service in the Vilnius region, although they gradually wither and wane, falling victim to time and nature.

Figure 1. Lt. Col. Kazimierz Malanowicz MD, PhD (1884-1933) (courtesy of Zygmunt Malanowicz)
Rycina 1. Ppłk dr Kazimierz Malanowicz (1884-1933) (za zgodą Zygmunta Malanowicza)

In September 2015, the co-authors of this paper found the grave of that military physician of Vilnius, Kazimierz Malanowicz MD, PhD. The gravestone was in poor technical condition, and a large part of the inscription was impossible to decipher. An average passer-by would deem this tomb anonymous, yet the person buried underneath deserves our recognition and respect [1-4].

The fate of this Vilnius physician

Kazimierz Malanowicz was born in Brest-on-the-Bug, on February 26, 1884, as the son of Józef Malanowicz. His mother, Konstancja née Pętelska, died three years later, leaving him to be raised by his father's second wife, Sabina née Sawicka. Kazimierz had a brother, Aleksander, who was two years his senior, as well as four step-siblings: Zofia, Bronisława, Jan and Maria (later known as Maria Malanowicz-Niedzielska, a famous

actress). Vilnius became an important part of his life very early on, as he attended a secondary school and then passed his final exams there in 1904.

At that time, the country of Poland did not exist, its territory seized by three aggressive neighbors: Russia, Prussia, and Austria. Due to the partitions, talented Polish youth willing to continue their education and study medicine had to attend universities located far from their hometowns, such as in Petersburg, Moscow, Kiev, Tartu, Berlin, or Vienna. At the time when Malanowicz was graduating from school and was making plans for the future, there was a large Polish community in Moscow, the second largest and most important colony throughout Russia after Petersburg (not including the occupied areas). This close-knit group with its strong esprit de corps defied Russification and put much effort into nurturing young Poles migrating to the capital from the entire territory seized by Russia. The students could count on the help, care and company of their compatriots, and from among whom they often met their future wives. Whether such patriotic education worked or not can be easily seen on the example of numerous graduates from Moscow university, such as Jan Kołłątaj-Srzednicki, Zygmunt Raźniewski, Michał Żakowicz, Jan Czyż, and many others, who later on enrolled in the Polish Army and fought for their true motherland.

The political situation was unusually tense when Kazimierz Malanowicz arrived in Moscow. Russia was currently at war with Japan, and the whole empire was trembling with revolutionary restlessness, but what mattered most for the newly admitted medical students were their normal anatomy classes in a dissection room, where each group could practice on a separate cadaver. The Poles tried to keep close to each other, usually forming a group together. The friends of Malanowicz included Zygmunt Klukowski, Adam Beczkowicz, Stefan Maciejowski, Stefan Mończuński, Witold Umiastowski, and Franciszek Zalewski. During this fervid period, it was not easy to focus on studying. The lecture hall where dissections were performed was at the same time the largest hall on the campus, making it perfect for student rallies. The unrest resulted in a strike, which led to a temporary closure of the university.

Some friends of Malanowicz chose to leave Moscow and continue their education somewhere else, but he preferred to stay and wait. The university resumed work as the smoldering fire of the 1905 revolution was quelled. The following years were rather calm, enabling him to successfully graduate from the Department of Medicine at the Moscow State University and to receive a Doctor of Medicine degree [5, 6].

Young physicians who were less well-off but willing to quickly improve their financial status, frequently decided to enroll in the army. The tsarist army offered good working conditions, attractive remuneration and career opportunities. To serve in the partitioner's army was not considered treason back then, but was widely accepted and treated as a natural step, a choice for a particular path, which gave a doctor possibilities to grow, develop, and gain the knowledge that a modern military physician would require. The threat of Russification among those who received a proper moral and patriotic education was rather mild. Thousands of Polish officers who formerly served in the tsarist army joined the Polish army after Poland re-emerged as a state and largely contributed to the victory over the Soviets in 1920.

After graduation, Malanowicz returned to Vilnius, where he lived at Didžiosios Pohuliankos 49/1 (pol. Wielka Pohulanka, currently Jono Basanavičiaus Street). He applied to join the military health service in the tsarist army, and was soon assigned to the 75th Sevastopol Infantry Regiment, stationed in Ladyzhyn (later Haysin) in the Podolia Governorate. As a doctor, his main area of interest was bacteriology, a field he tried to study in all ways possible. On 13 January 1913, he began to attend a half-year course in hygiene and bacteriology in Kiev Regional Hospital. At the beginning of July 1914, shortly before the First World War broke out, Malanowicz was moved to the 259th Olhopil Infantry Regiment in the 65th Infantry Division in the territory of the Podolia Governorate. In March 1915, he left his regiment and became a medic at the sanitary-hygiene department of the hospital stronghold in the Kiev fortress, where he spent the rest of the war until disarmament on 17 April 1918. He achieved the rank of Collegiate assessor, which correlated with the office of infantry major. For his service, he was awarded a 3rd class Order of Saint Stanislaus with a bow and swords as well as an Order of Saint Anna, 3rd class, with a bow and swords.

Upon the disarmament, Malanowicz returned to Vilnius to join the resurgent Polish Army, ranked as a major, with seniority dating from 1 June 1919. Between 2 November and 9 December 1919, he was the head of the infectious diseases ward at the Field Hospital in Vilnius. It is worth remembering that this was a time when epidemics of dangerous infectious diseases (such as typhoid, dysentery, and smallpox) were sweeping the entire Kresy region. To run a hospital was therefore quite a hazard, as many healthcare professionals died themselves while working to aid others. Fate was kind to the young Vilnius medic, though, he managed to perform his duties in good health [5, 7]. He was afterwards assigned to the Ujazdowski Hospital in Warsaw, initially as staff reserve, but soon to pursue his interests in the hospital's bacteriology lab, where he began working on 10 February 1920. For a year, he was able to gain knowledge, skills and experience in his favorite field of medicine, before returning to Kresy Wschodnie. On 3

March 1921, he was appointed Head of the 1st Field Bacteriology Laboratory in Baranovichy. The moment the war was over and disarmament was underway, on 5 September 1921, Malanowicz was appointed Head of the Bacteriology Laboratory in the Military Hospital in Vilnius.

The ten years to follow were a time of bliss – a lucrative job in one of the largest medical institutions of his beloved city meant that he could finally settle down. The perfect possibility for intellectual growth and the pursuit of his professional ambitions was beyond any doubt an advantage. The Military Hospital in Vilnius, renamed in 1922 to 3rd Regional Hospital, ranked among the most renowned medical institutions in Poland at that time. The hospital offered a unique advantage both to the patients and the military physicians in that it cooperated closely with the Department of Medicine of Vilnius University, providing a high level of healthcare as well as allowing many possibilities for professional improvement. It hosted clinics and university institutes, including surgery, the 2nd Clinic of Internal Medicine, departments of otolaryngology, ophthalmology, dermatology, hygiene, and pathological anatomy. Senior assistant Maj. Kazimierz Malanowicz MD, PhD also worked in the department of pathological anatomy from 1922, while still running the Bacteriology Lab.

Working under the excellent Prof. Kazimierz Opoczyński was a splendid opportunity to gain profound medical knowledge and develop intellectual skills. At the turn of 1923 and 1924, Malanowicz assumed the role of the hospital's liaison officer, in addition to the job in the laboratory.

As the year 1925 was drawing to a close, the hospital lost its regional status to the 3rd Regional Hospital in Grodno and changed its name to the Hospital of the Fortified Area of Vilnius. It was not, however, any sort of degradation for an institution working so closely with the Department of Medicine of Vilnius University. The cooperation was effective for the most part of the period that the Hospital functioned. January 1928 marked the last promotion of Kazimierz Malanowicz, to the rank of lieutenant colonel [5, 8]. Apart from his duties as the Head of the Bacteriology Laboratory and the hospital's liaison officer, he regularly attended diverse professional training courses in Warsaw. During the holiday season of 1930, he also worked as the commissioner of the Seasonal Military Hospital in Druskininkai, which was a department of the 3rd Regional Hospital in Grodno.

The medical health service organized seasonal hospitals in spa resorts for the staff and their families. Druskininkai was one of the most prominent spa towns, favored by Marshal Józef Piłsudski himself. Since 1926, the Grodnian military hospital organized a spa branch in Druskininkai from May to September. The resort was mostly visited by people suffering from motor disorders, lymphatic and blood diseases (34-35%), vaginal diseases (14%), as well as nervous system diseases (10%). The most popular treatments among the patients were brine baths (44%), mud baths and treatments (30%), carbonic acid bath (20%), and hydrotherapy (20%).

Between May and September 1930, the hospital was overseen by Lt. Col. Kazimierz Malanowicz MD, PhD. For him, it was a good opportunity to meet some of the doctors and nurses working in the 3rd Regional Hospital in Grodno, of which he was to become a Head on 28 January 1931. One of the ten highest-ranking field hospitals in Poland, the military hospital in Grodno was the crowning achievement of his long career as a military physician. The hospital was located in the stunning New Castle on the cliff over the Neman River. It had 400 beds and almost all the crucial departments: Department of Internal Medicine, Surgery (with a Sub-Department of Obstetrics and Gynecology), Neurology, Infectious Diseases, Skin and Venereal Diseases, Otology, Ophthalmology, X-Ray Laboratory, Bacteriology Laboratory, dental clinic, hospital pharmacy, garrison pharmacy, as well as a specialist outpatient department. The doctors employed at the hospital were exceptionally experienced army officers, who fought in the First World War and in 1920. Every commander could profit from their support, and it greatly facilitated his ability to run the entire institution. It must be noted that the 3rd Regional Hospital was of critical value for the entire Grodno region community, as the doctors employed there were actively engaged in several social organizations, and it was not unusual for them to play a key role. Probably the most important institution was the Polish Red Cross, which organized training courses for sanitary and professional nurses in the Hospital. The courses encompassed 2-3 months of theory classes and 2 months of practice. The lectures were held by the officer physicians, whereas the entire course would be usually managed by the hospital commander. The 8th and 9th Sanitary Emergency Courses were led by Lt. Col. Kazimierz Malanowicz MD, PhD. He was equally committed to the activities run by the Mother and Child care station, which operated in Grodno from 1925. It focused on the distribution of healthy baby food ("A Drop of Milk" program) and on the outpatient services for pregnant women, women in labor and newborn children. This institution was initially managed by Capt. Tadeusz Eysymont MD, PhD, of the 76th Infantry Regiment. On the first day of the year 1932, this role was assumed by Lt. Col. Kazimierz Malanowicz MD, PhD. Unfortunately, he was not able to hold this position for a long time as his health began to fail substantially. He was soon replaced by Stanisław Obrębowski, PhD.

On 6 June 1933, Malanowicz passed away as a result of atrophic cirrhosis, "having suffered shortly but severely". He died on duty, in "his own" hospital in Grodno, at the age of 49. The memorial service was held in the garrison church in Grodno. The coffin was then transported to the Church of Our Lord Jesus and the Trinitarian monastery, which was then the church of the Hospital of the Fortified Area of Vilnius. At 9 a.m. on 10 June 1933, the funeral procession left the church, heading to the military tombs in the nearby Antakalnis Cemetery.

Personally, Lt. Col. Malanowicz was a rather unhappy person. He was married twice and had two daughters (according to his family), yet at the time of his death he was alone. Interestingly enough, he had ordered for the entire sum of his death benefit collected in the fund at the Warsaw-Białystok Medical Chamber to be transferred to another military physician from Vilnius, Maj. Stanisław Garniewicz. Another fact worth noting is that Zygmunt Malanowicz, a renowned actor who played Fr. Mucha in the film "Hubal" by Bohdan Poręba, is the hospital commander's grandnephew.

Kazimierz Malanowicz MD, PhD, devoted most of his short life to various military positions in the sanitary field. He always put all efforts into whatever he was doing, which cost him his leisure time and quality time with his family. At this point, it would be reasonable to quote Col. Mikołaj Werakso, PhD, who was the Head of the Sanitary of the Corps District Command number 3 and considered Malanowicz to be: "exceptional, energetic, eager, with a great sense of honor and dignity. Persistent, composed, disciplined, loyal. Remarkable organizational and administrative skills." [5, 9-15].

Later, 83 years later, long after Poland lost Vilnius, hardly anyone remembered this distinguished figure, while his gravestone gradually became dilapidated.

Mysterious grave of the Vilnius physician

The story of Malanowicz's gravestone is quite peculiar itself. It is located on a picturesque wooded hill in the Antakalnis Cemetery. The technology used to manufacture the stone is interesting – concrete cast of a very good quality accommodating a marvelous reiteration of a cross theme. The memorial plaque holding the inscription, which informs the passer-by of the person buried underneath and paying him honor, was carefully crafted in state-of-the-art terrazzo, containing fine black and white marble and a superb binder. It was cast in an excellent way, which makes the letters look as if they were carved in stone. The tombstone order, however, must have been filled illegibly or incorrectly, or the contractors simply failed, as the inscription on the grave is incorrect in several places. First of all, it reads that Malanowicz died on 6 July 1933, whereas the real date of his death is one month earlier. There is also a small spelling mistake in the word for 'hospital': it should read "komendant Szpitala" instead of "komendant Szpitalu". This might be, however, considered an example of typical Vilnius dialect, since the older generation of Polish people in Vilnius still inflects the word "szpital" this way. It can also be observed that there is no diacritical mark over the letter "s" in the word "Cześć" (Jego Pamięci) [Honor to his memory!]

The unrelenting passage of time damages gravestones, makes the inscriptions indecipherable, and eventually ruins them completely. The authors of this paper encountered the decrepit tomb of Kazimierz Malanowicz, MD, PhD, in September 2015. It was covered in layers of algae, moss and lichen, stained with humus and corrupted by weather, while the concrete elements were cracked and defective. The inscription was illegible, making the grave basically anonymous for the average passer-by.

At that moment it became clear that a grave of a Polish military physician, who participated in the Bolshevik war in 1920 and was the head of one of the largest military hospitals in Poland, should not be forsaken and left to vanish. The authors then addressed the Military Physician Association with a motion to finance renovation of the gravestone.

They also contacted a well-known art conservator and artist, Prof. Janusz Smaza, who has a large portfolio of spectacular renovations performed worldwide on stone monuments, including gravestones (e.g. the tombstones of Ignacy Domeyko in Chile or Frédéric Chopin in Paris, the mausoleum of Piłsudski's mother and the Marshal's heart in the Rasos Cemetery, and many others). The president of The Public Maintenance Committee for the Rasos Cemetery, Alicja Tomaszewska, was of great help in respect of the formal arrangements in Lithuania. Despite her advanced age, she is a woman full of devotion and energy. Prof. Smaza prepared a conservation note on the gravestone's condition and all the necessary works completely free, as a gift. The Committee has been actively saving Polish cemeteries in the Vilnius region for over 25 years. Numerous valuable tombs were salvaged thanks to its work. Over the last few years, Vilnius physicians from the Polish Medical Association in Lithuania joined these actions, along with Polish medical communities from Poznań, Silesia and Warsaw. Thanks to their support, it has been possible to renovate the gravestones of such distinguished physicians as August Becu, Ludwik Michał Czarkowski, and Anicet Reniger. That military physicians are engaged in such splendid acts is of great importance and value.

Figure 2. Malanowicz's grave before renovation, Vilnius, September 2015
Rycina 2. Grób K. Malanowicza przed renowacją, Wilno, wrzesień 2015 r.

Thanks to the positive reaction of the Military Physician Association and the approval of the financing project by its authorities, the gravestone of Kazimierz Malanowicz MD, PhD was fully and professionally renovated in July and August of 2016. The team of contractors was run by Prof. Janusz Smaza along with his assistant from the Academy of Fine Arts in Warsaw, Piotr Owczarek, MA. The authors of this paper also contributed to the works by performing simple physical tasks, supervised by the conservators. It was an honor and an adventure at the same time to participate directly in such an initiative, aimed at maintaining a living memorial of a senior colleague, a distinguished Vilnius physician. The tomb regained its original form and it may now tell everyone passing by who lies beneath.

Figure 3. Malanowicz's grave after renovation, Vilnius, July 2016
Rycina 3. Grób K. Malanowicza po renowacji, Wilno, lipiec 2016 r.

To conclude, it would be worth citing the words Prof. Smaza directed at Polish military physicians: "...It is praiseworthy indeed that another physician community takes steps to discover, fix and secure such objects for generations to come..." [16-18]. Should the memory of a former commander of the 3rd Regional Hospital in Grodno fade completely, his tombstone shall remind our successors of his deeds.

The authors would like to thank all the people who contributed to the renovation of the gravestone of Kazimierz Malanowicz MD, PhD, especially to the President and the Vice-Presidents of the Military Physician Association, as well as the President of the Public Maintenance Committee for the Rasos Cemetery, Alicja Klimaszewska, Prof. Janusz Smaza and Piotr Owczarek, MSc. Piotrowi Owczarkowi, the authors of this publication thank you with all my heart.

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They were the authors of the Military Physician journal in the interwar period. Polish professors publishing in the journal's first decade. Part V: Vilnius and Poznań

Oni tworzyli „Lekarza Wojskowego" w okresie dwudziestolecia międzywojennego. Wykładowcy polskich uniwersytetów w pierwszym dziesięcioleciu działalności czasopisma. Część V. Wilno i Poznań

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Abstract. The aim of the fifth paper from "They were the authors of the Military Physician journal in the interwar period" series, describing the outstanding personalities associated with the journal, is to present seventeen researchers associated with the universities of Vilnius (13) and Poznań (4) in the 1920s.
Key words: history of 20th century medicine, universities - history, medical journals, physicians

Streszczenie. Celem piątego z cyklu artykułów „Oni tworzyli »Lekarza Wojskowego« w okresie dwudziestolecia międzywojennego" na temat wybitnych postaci związanych z czasopismem, jest zaprezentowanie siedemnastu naukowców związanych z uniwersytetami w Wilnie (13) i Poznaniu (4) w latach dwudziestych XX wieku.
Słowa kluczowe: historia medycyny XX w., czasopisma medyczne, lekarze

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Only a life lived for others is a life worth living.
Albert Einstein

Introduction

In 1920, Zygmunt Dmowski, the president of the Military Sanitary Council, wrote in the first issue of Military Physician: "(...) There is no particular program for this magazine, nor do we promise anything, since it is so difficult to edit and publish these days. We only wish to remind you one more time of the reason behind our efforts. We would like our reader, the physician, to have access to all the novel discoveries in the field of medicine in their entirety (...)" We have continued to pursue this objective from the very first pages of the magazine [1].

Figure 1. Vilnius University (from: Schummer E. Dzieje i rozwój Uniwersytetu Wileńskiego [History and development of the Vilnius University]. World, 1928: 5)
Rycina 1. Uniwersytet Wileński (za: Schummer E. Dzieje i rozwój Uniwersytetu Wileńskiego. Świat, 1928: 5)

In his Order No. 15 from 1921 to the medical heads of General Districts and the Army, Lt. Gen. Franciszek Zwierzchowski MD, the Head of the Medical Department, said: "(...) This periodical known as Military Physician is a strictly specialist magazine aimed at familiarizing physicians with advances in the field of military medicine. It is a duty of the officer corps to support this magazine (...). We have observed that this duty has not been understood and fulfilled by all military physicians, which may have a negative effect on maintaining the level of knowledge among military physicians at a sufficiently high level (...)" [2].

The year when this order was issued saw 30 magazines in the field of medicine and pharmacy being published on the Polish market. These included: "Wychowanie Fizyczne" [Physical education], also issued for the first time in 1920, "Pediatria Polska" [Polish Paediatrics] from 1921, "Ginekologia Polska" [Polish Gynaecology] and "Polski Przegląd Chirurgiczny" [Polish Journal of Surgery] from 1922, "Klinika Oczna" [Eye Clinic] from 1923 and "Nowiny Psychiatryczne" [Psychiatric News] from 1924. For the most part these journals focused on general medicine, but the 1920s saw the development of specialization and specialist magazines, mostly published by scientific societies.

In order to maintain the high level of the publications, Military Physician invited the representatives of leading research centers to publish their work. This part presents the authors who worked at Vilnius University after its reactivation in 1918 (Figs. 1-3), as well as the newly established Poznań University.

Vilnius University

Vilnius University was supposed to resume the work of the academy that operated under that name until 1832. It was organized by the citizens of the former Grand Duchy of Lithuania along with the graduates of universities in Petersburg, Kiev, Moscow, Tartu, Kazan, and Kharkiv. The staff was also reinforced by academics from other Polish universities. On 30 December 1918, Stanisław Władyczko was assigned the position of Dean of the Department of Medicine[1] (1878-1936) (Fig. 4).

One of the first issues of Military Physician included an article by that excellent ophthalmologist, **Kazimierz Noiszewski** (1859-1930), entitled "O badaniu ostrości wzroku" [On visual acuity examinations]. In his work, Noiszewski reviewed the traditional methods of sight examination and referred to the modern methods: "(...) the method I find the most suitable is a tool with a movable target in the form of a disc on a stationary white board, moved by the means of two cords by the person being tested, one cord in each hand" [3]. It is worth noting that Prof. Noiszewski was a renowned scientist, inventor, surgeon, pedagogue and a tutor for numerous Polish ophthalmologists. One of his achievements involved the theoretical basics and the construction of the electrophthalm, dubbed the "artificial eye". In 1920, he published a course book entitled "Badanie ostrości wzroku dla studentów i lekarzy" [Visual acuity examinations for students and doctors"] [4].

Another work he had published in Military Physician was the lecture "Ujednostajnienie oznaczania ostrości wzroku z uwzględnieniem specjalnem metod stosowanych w wojsku" [Unification of visual acuity taking into consideration the methods employed in the military"]. He gave this lecture in 1924 on the 2nd Convention of Polish Ophthalmologists in Lviv.

Health problems in society were an object of attention, with many publications appearing in Military Physician on the subject, especially in the first month after the war was over. These included works by **Marian Eiger** (1873-1939), who was a physiologist and a Lieutenant Colonel in the Polish-Bolshevik war, and who ran the Department of Physiology from 1922 [5]. His article "O odżywianiu niedostatecznem pod względem jakościowym" ["On the insufficient quality of nutrition"] constituted a comprehensive review of the literature at that time. The three articles to follow documented the author's vast scientific interest, encompassing the issues of the muscles and nerves in the biliary system, as well as the electricity produced by the human body as a physical phenomenon. Marian Eiger was one of the

[1] Stanisław Wtadyczko, appearing in the first part of Mil. Phys., 2015; 93 (4): 345-346

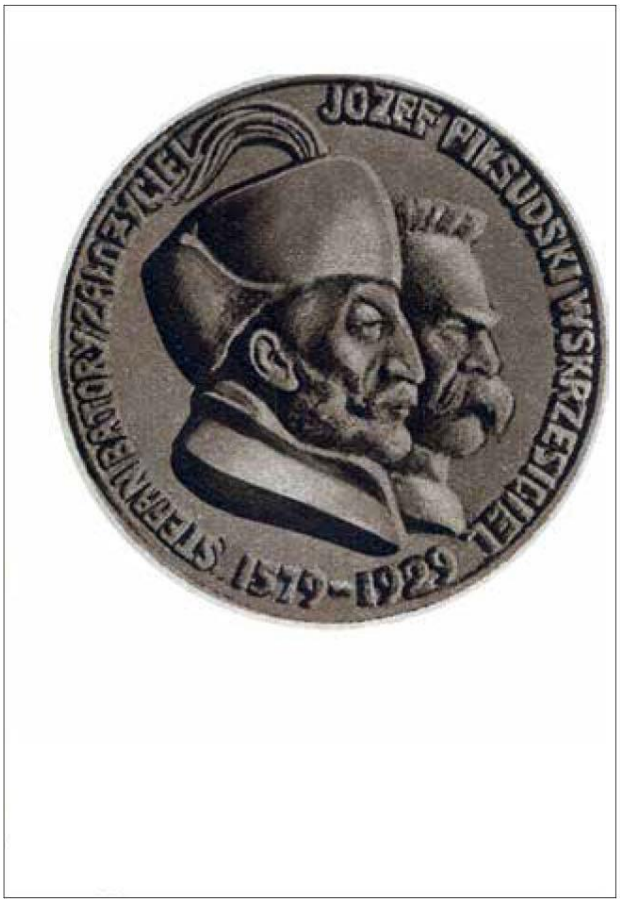


Figure 2. Memorial medal (obverse) (from: Świadowid [Svetovid] 1928; 191 [14])
Rycina 2. Medal pamiątkowy (awers) (za: Świadowid 1928; 191 [14])

Figure 3. Memorial medal (reverse)
Rycina 3. Medal pamiątkowy (rewers)

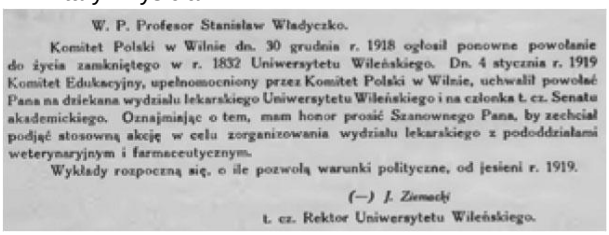
pioneers in the field of ECG and the role of organs for the immunity traits of blood. In 1921, working as a Privatdozent at Bern University, he published his work "O zwieraczu brodawki Vatera i przewodu żółciowego wspólnego oraz o wpływie nań nerwu błędnego" ["On the sphincter of the ampulla of Vater and the common bile duct, as well as the impact exerted on them by the vagus nerve"]. With the note "Temporary Report", it focused on the methodology of Eiger's "preliminary" experiments.

Nutritional problems were also an area of interest of **Kazimierz Karaff-Korbutt**[2] (1878-1935), the Head of the Hygiene Department, for whom proper nutrition was fundamental for human health. In his research, he focused mostly on meat, meat preservation, new methods of salting, the quality of sausage products, botulism, as well as wines and vodkas. He initiated sanitary examinations of the meat preserves produced in Vilnius, performed in the city laboratory run by one of his students, **Feliks Kasperowicz,** who published his work on the chemical analysis of the sparkling waters produced in Vilnius in 1929. The study encompassed 23 plants, where water samples were taken along with their production components. The results showed that the sparkling waters produced and sold in Vilnius were below the basic level of hygiene.

Other authors who also published in Military Physician included **Aleksander Safarewicz** (1876-1936), **Jan Kiewlicz** (1882-1968) and **Stanisław Rondomański** (1897-1940), and were also connected with the Hygiene Department. **Aleksander Safarewicz** was a bacteriologist and hygienist, and was the only specialist in the field of hygiene examinations of clothing material. He cooperated closely with the authorizing body of officers. His research focused on environmental protection, especially in respect of air and potable water

[2] Kazimierz Karaffa-Korbutt was portrayed in the 4th part of this series. Mil. Phys., 2016; 94 (3): 319

[6], which formed the basis of his three works published in Military Physician.



W. P. Profesor Stanisław Władyczko.

Komitet Polski w Wilnie dn. 30 grudnia r. 1918 ogłosił ponowne powołanie do życia zamkniętego w r. 1832 Uniwersytetu Wileńskiego. Dn. 4 stycznia r. 1919 Komitet Edukacyjny, upełnomocniony przez Komitet Polski w Wilnie, uchwalił powołać Pana na dziekana wydziału lekarskiego Uniwersytetu Wileńskiego i na członka t. cz. Senatu akademickiego. Oznajmiając o tem, mam honor prosić Szanownego Pana, by zechciał podjąć stosowną akcję w celu zorganizowania wydziału lekarskiego z pododdziałami weterynaryjnym i farmaceutycznym.

Wykłady rozpoczną się, o ile pozwolą warunki polityczne, od jesieni r. 1919.

(—) J. Ziemecki
t. cz. Rektor Uniwersytetu Wileńskiego.

Figure 4. Part of a letter addressed to Prof S. Wtadyczko (from: S. Trzebiński, Faculty of Medicine at the Stefan Batory University in Vilnius in the years 1919-1929)
Rycina 4. Fragment listu skierowanego do prof. S. Wtadyczko (za: Trzebiński S. Wydział Lekarski Uniwersytetu Stefana Batorego w latach 1919-1929)

In his work "W sprawie oczyszczania ścieków na terenie Szpitala Wojskowego w Wilnie" ["On sewage treatment in the Military Hospital in Vilnius"], he put forward the requirements for a sewage treatment station in Vilnius. As to the conditions in the city, he wrote: "(...) below the sewage outlet from the Hospital into the Vilia River, both river banks, and especially the left one, where the outlet is located, are densely built-up; the buildings nearby include the facilities of the 3rd Sapper Regiment and the Military Investigation Prison, right on the bank, with rowing harbors and sports swimming areas a little further away, whereas on the other side of the river there are public bathing areas. It is therefore beyond any doubt that the sewage treatment must be of the highest precision possible (...)". [7]. In 1924, A. Safarewicz and K. Karaffa-Korbutt began to publish "Archiwum Higieny" ["The Hygiene Archive"] on their own. These books were distributed free of charge as an addition to the "Zdrowie" [Health] magazine, and later on along with Military Physician.

In 1925, **Jan Kiewlicz** was working in a laboratory in the city analytical station located in the Hygiene Department, performing various analyses for the department. The scientific activities of the stations were assumed to be in close connection with the department. At that time, Safarwicz and Kiewlicz published a work on which they worked together, entitled "W sprawie odżeleziania wody wodociągu m. Wilna" [On deironing the water pipes in the city of Vilnius"].

Stanisław Rondomański, who worked at the Ujazdowski Hospital from 1919, was also a liaison assistant of the Department of Hygiene. In 1928, Military Physician published the results of his study on the content of carbonic acid anhydride in the air found in the city barracks. According to this research, the air in the barrack rooms was below the standards, due to the overcrowded rooms, lack of ventilation, furnace heating and insufficient space.

The issues of military medicine were also developed in the works prepared in the **2nd Clinic of Internal Medicine** of the university. The first of these was a work published in Military Physician in 1926, written by **Stanisław Cypryński-Ciekawy** and **Kazimierz Pawłowski** (an assistant to the clinic). It was devoted to "a case of self-inflicted damage with the use of picric acid in order to avoid military service". Their observations were related to the results of studies conducted previously, including the work of Marcel Garnier[3], who examined 1300 similar cases in the years 1915-1918.

Wacław Zajączkowski, the Head of the Department of Internal Medicine of the Hospital of the Fortified Area of Vilnius, along with **Władysław Łobza** (1898-1940), who was a younger assistant to the clinic, co-authored a study on statistical data concerning blood pressure in soldiers and school students, aimed at analyzing the research results on primary hypertension. The study encompassed 2700 soldiers and 303 students aged 16-20.

Another work in the field of military medicine published in Military Physician was written by **Ludwik Rostkowski** (1894-1973) from the Department of Ophthalmology of the 3rd Regional Hospital and the Ophthalmology Clinic at the University. In his article from 1925, he referred to the newly introduced rules that deemed individuals suffering from trachoma ineligible for military service, which led to the closure of the trachoma unit in the 3rd Regional Hospital. This work was an attempt by Ludwik Rostkowski to defend this unit, where he claimed that this disease was sometimes misused by individuals who wished to avoid military service. In the summary of his work, he wrote: "(...) from the military perspective, it is inadvisable to close the trachoma unit, as it is run on the basis of scientific reason (...)" [8].

The magazine editors invited extraordinary scientists from various fields of medicine to contribute. One of them was **Jan Muszyński** (1884-1957), who organized the Pharmacy Institute at the Department of Medicine, where he opened the first independent Department of Pharmacognosy and Medicinal Plant Growth, including a specialist garden for that purpose (Fig. 5). Muszyński's research aimed to obtain natural substances from plants, and he then promoted their application in treatments [9, 10]. In his 1927 work on phytotherapy and the stabilization of herbal medicines, he criticized the increasingly popular approach whereby raw plant medicines were being replaced by chemical substances obtained from plants or synthetics. He wrote: "These preserves have earned well-deserved recognition in

[3] Gamier M.: Intoxication par l'acidepicrique. Noveau Traite de Medicine VI (in French)

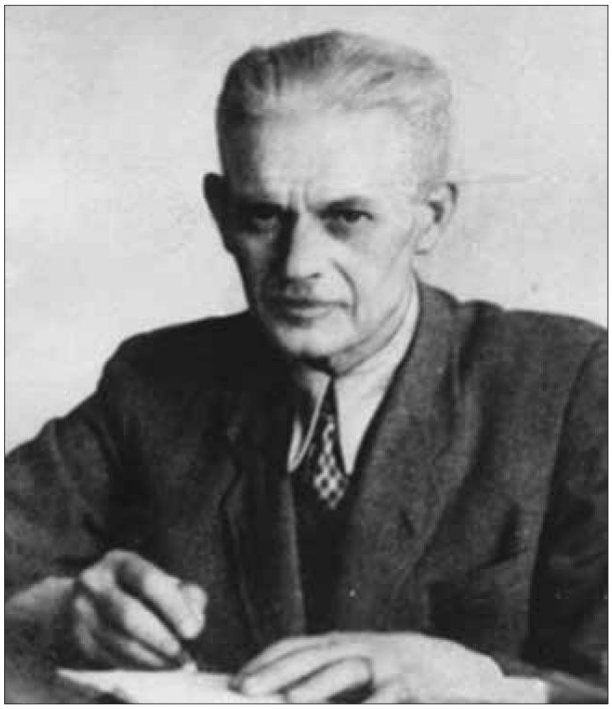


Figure 5. Jan Muszyński
Rycina 5. Jan Muszyński

France and England[4]. Medicine and pharmacy in Poland still neglect the old and traditional plant preparations and instead fall for the chemicals that the German chemical industry pumps in us". [11]

The index of Military Physician also included Stanisław Trzebiński (1861-1930), a professor of general pathology and a historian of medicine [12]. He published three reviews of books on the history of medicine, including the publication by Władysław Szumowski "Krakowska szkoła lekarska po reformach Kołłątaja" ["Medical school in Kraków after the Kołłątaj reforms"] published in 1929 by the Association of Kraków History and Monument Enthusiasts.

Poznań University

The Department of Medicine at Poznań University was the youngest among the five medicine departments in resurgent Poland. It was highly promoted and acclaimed by the "father of surgery in Poland", Prof. Ludwik Rydygier (1850-1920), former rector of the Jan Kazimierz University in Lviv. The resolution on the creation of the Department was adopted on 25 July 1920. Prof. Adam Wrzosek (1875-1965) was assigned to be the Dean of the Department.

Table 1. Publications in the Military Physician journal – Vilnius

Tabela 1. Publikacje w "Lekarzu Wojskowym" – Wilno

1.	**Kazimierz Noiszewski** O badaniu ostrości wzroku [On visual acuity examinations]. 1920; 1 (3): "Ujednostajnienie oznaczania ostrości wzroku z uwzględnieniem specjalnem metod stosowanych w wojsku" [Unification of visual acuity taking into consideration the methods employed in the military"]. (Lecture held on 19 September 1924 as the main theme of the 2nd Convention of Polish Ophthalmologists in Lviv. 1924; 5 (11): 1003-1011
2.	**Marian Eiger** O odżywianiu niedostatecznem pod względem jakościowym [On the insufficient quality of nutrition]. 1920; 1 (47-50): 14-24 Rola narządów w powstawaniu własności odpornościowych krwi. [Role of organs in the creation of the immunity of blood]. 1921; 2 (34): 1070-1081 Elektryczność, wytwarzana przez ustrój żywy, jako zjawisko fizyczno-chemicznej przemiany materji. [Electricity produced by live organisms as a phenomenon of the physical-chemical metabolism]. 1921; 2 (12): 358-372 O zwieraczu brodawki Vatera i przewodu żółciowego wspólnego oraz o wpływie nań nerwu błędnego [On the sphincter of the ampulla of Vater and the common bile duct, as well as the impact exerted on them by the vagus nerve]. 1921; 2 (5): 129-133
3.	**Feliks Kasperowicz** Badanie chemiczne wód gazowych, wyrabianych w Wilnie [Chemical examination of sparkling waters produced in Vilnius]. 1929; 14 (6): 288-293
4.	**Aleksander Safarewicz** O znaczeniu sanitarnej analizy wody [On the importance of the sanitary analysis of water]. (Based on a speech given at the Convention of Poviat Physicians of the Vilnius Region, 5-6 April 1929 in Vilnius). 1929; 14 (5): 243-255 W sprawie oczyszczania ścieków na terenie Szpitala Wojskowego w Wilnie [On sewage treatment in the Military Hospital in Vilnius]. 1929; 14 (9): 403-410
5.	**Aleksander Safarewicz, Jan Kiewlicz** W sprawie odżeleziania wody wodociągu m. Wilna. [On deironing the water pipes in the city of Vilnius]. 1928; 11 (3–4): 293-298
6.	**Stanisław Rondomański** Badanie chemiczne wód gazowych, wyrabianych w Wilnie [Chemical examination of sparkling waters produced in Vilnius]. 1929; 14 (6): 288-293
7.	**Stanisław Cypryński-Ciekawy, Kazimierz Pawłowski** Przypadek symulacji przewlekłej żółtaczki, wywołanej i podtrzymywanej kwasem pikrynowym [A case of chronic jaundice self-inflicted and sustained with the use of picric acid]. 1926; 8 (3): 231-237
8.	**Wacław Zajączkowski, Władysław Łobza** Statystyczne dane o ciśnieniu tętniczym wśród żołnierzy i młodzieży szkolnej [Statistical data on blood pressure in soldiers and school students]. 1929; 14 (5): 209-219
9.	**Ludwik Rostkowski** W sprawie chirurgicznego leczenia jaglicy [On the surgical treatment of trachoma]. 1924; 5 (9): 829-833 Znaczenie kompanji jagliczej [The importance of a trachoma treatment unit]. 1925; 6 (9): 801-806
10.	**Jan Muszyński** O fytoterapji i utrwalaniu (stabilizacji) leków roślinnych [On phytotherapy and stabilization of herbal medicines]. 1927; 10 (2): 99-105
11.	**Stanisław Trzebiński** Zarys historji Wileńskiego Instytutu Medycznego [A historical review of the Vilnius Medical Institute]. Vilnius. 1927 (Review). 1927; 9 (4): 362-364 Lachs J. Kronika lekarzy krakowskich XVII w. [A chronicle of physicians in 17th century Kraków]. Poznań. 1929 (Review). 1929; 13 (11): 587-588 Szumowski Władysław. Krakowska szkoła lekarska po reformach Kołłątaja [Medical school in Kraków after the Kołłątaj reforms]. 1929 (Review). 1929; 13 (10): 528-531

[4] This work concerns the stabilization of herbal preserves

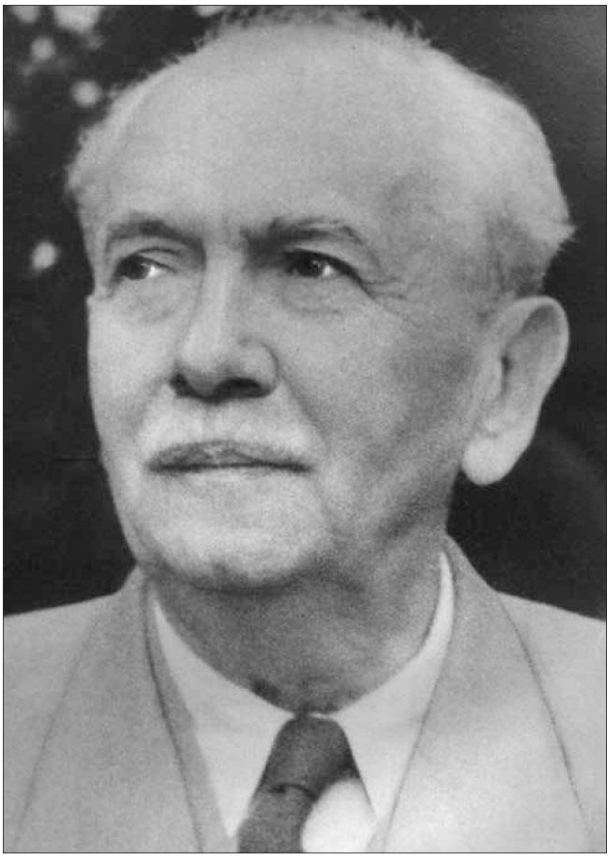


Figure 6. Ludwik Skubiszewski
Rycina 6. Ludwik Skubiszewski

The cooperation of the university staff with Military Physician began in the first year of the operation of the department. The second issue of the magazine from 1921 included the work "Patogeneza kamicy żółciowej" ["Pathogenesis of cholelithiasis"] by **Ignacy Hoffman** (1873-1947), a professor of general and experimental pathology and a creator of such an institute. The subject of this work was connected with professor's main area of interest, namely the biological basis for heredity [13]. Apart from a comprehensive literature review, including mostly German and French works, Hoffman presented his own ideas: "Step by step, we have pointed out a whole range of external factors, conditions of the organism and disorders which lead to suffering, but the final factor must be liver disorders, sometimes induced by external factors, often by hereditary diseases and poisoning, but, as shown by experience, mostly occurring due to hereditary predilections (...)" [14].

1921 was also the year when the work of **Ludwik Skubiszewski** (1886-1957) was published, soon to be the university's professor and the first head of the Pathological Anatomy Department (Fig. 6 [15]. The paper described a rare case of gangrene in the lower lip as a result of typhus complications.

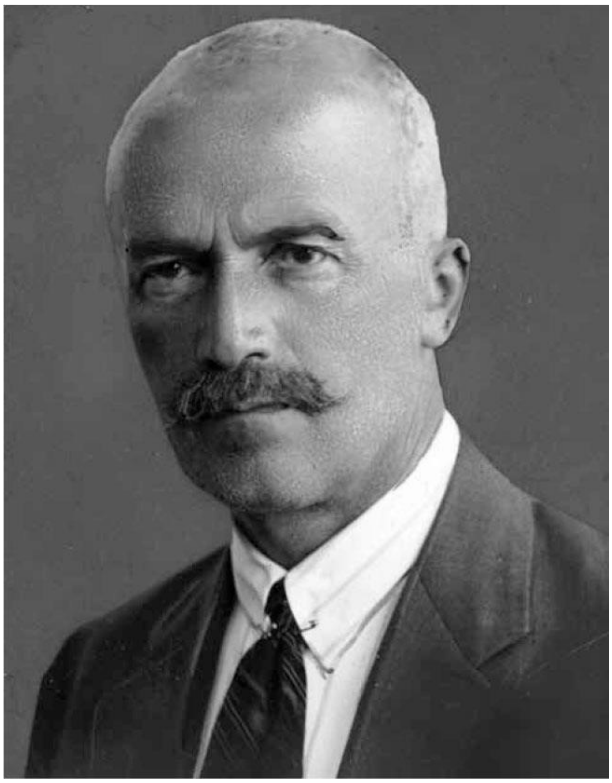


Figure 7. Eugeniusz Piasecki
Rycina 7. Eugeniusz Piasecki

In 1922, the magazine published a work by Prof. **Eugeniusz Piasecki** (1872-1947), the head of the Physical Education and School Hygiene Department [16], which was the first of its kind in Poland and the third in Europe (Fig. 7). The work was devoted to the first instruction courses organized by the Central Military School of Sports and Gymnastics (renamed in 1929 to Central Institute of Physical Education [25-27], currently known as the University of Physical Education).

In the first year that the university was open, **Kazimierz Dziembowski** (1860-1921) [17] held lectures. He was the author of the article "Badanie i leczenie krwinek białych jako czynnik rozpoznawczy w chorobach zakaźnych" ["Examination and treatment of white blood cells as a distinctive factor for infectious diseases"], reproduced from "Dziennik Poznański" [Poznań Daily].

Final remarks

It was not always possible for the authors of the article series on the participation of particular academic centers in the work on Military Physician to state clearly to where individual people belonged on the medical map of Poland.

Table 2. Publications in Military Physician – Poznań
Tabela 2. Publikacje w "Lekarzu Wojskowym" – Poznań

1.	**Ignacy Hoffman** Patogeneza kamicy żółciowej. Streszczenie zbiorowe. [Pathogenesis of cholelithiasis. Joint review]. 1921; 2 (36): 1143-1152
2.	**Ludwik Skubiszewski** Ś.P. professor Ludwik Rydygier general p.por. Wojsk Polskich [Prof. Ludwik Rydygier, General of the Polish Army] (lecture held on 10 July 1920, at a meeting of the Scientific-Medical Club in the Regional Hospital of the Polish Army in Grudziądz). 1920; 1 (35/36): 1-2 Przyczynek do anatomji patologicznej zgorzeli dolnej wargi po durze plamistym [Preliminary study on the pathological anatomy of gangrene in the lower lip as a result of typhus complications]. 1921; 2 (11): 332-340
3.	**Eugeniusz Piasecki** Trzy pierwsze kursy instruktorskie Centralnej Szkoły Gimnastyki i Sportów [Three first instruction courses of the Central Military School of Sports and Gymnastics]. 1922; 3 (5): 345-356
4.	**Kazimierz Dziembowski** Badanie i leczenie krwinek białych jako czynnik rozpoznawczy w chorobach zakaźnych [Examination and treatment of white blood cells as a distinctive factor for infectious diseases]. 1920; 1 (39/40/41/42): 6-11

The renaissance in education in the newly independent state required experienced teachers. It was not unusual for the finest scientists to move constantly, working on the creation of several Departments of Medicine at the same time. The same notable figures may be found in Warsaw, Kraków, Lviv, Vilnius, and Poznań. To link them with single academic centers would have a merely conventional value. Moreover, the first two years of the magazine were also a time when a large part of the academic staff either enrolled or enlisted in the Polish Army. They continued to publish from various military units, military or field hospitals, sharing their experiences. An excellent source of information could be found in the reports of scientific sessions of particular hospitals, created by the physicians who were directly engaged in the treatment. Quite often, these bear the signatures of renowned scientists.

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