

## Epidemiology of abdominal aortic aneurysm

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### ABSTRACT

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**Introduction:** Abdominal aortic aneurysm is a localized widening, located below the renal arteries. The exact etiology is not fully understood. Probably the main role in the formation of abdominal aortic aneurysm plays a correlation between genetic and environmental factors, especially smoking. The disease is primarily diagnosed in older men although in recent years there is an increased prevalence of the disease among women. Untreated abdominal aortic aneurysm increases in size until it ruptures, which often leads to the death of patient. The disease is generally asymptomatic and most of the aneurysms are detected accidentally, eg., during ultrasound examination of the abdominal cavity.

**Literature search:** The PubMed database was

searched in order to collect the literature needed to elaborate the aspects of abdominal aortic aneurysm epidemiology. The search was limited to the review of the original publication from the last 10 years.

**Conclusions:** Analysis of the results indicates that the incidence of abdominal aortic aneurysm in Australia is higher than in America and Europe. The total incidence in Western countries is higher than in Asia. AAA incidence in men is higher than in women. Aneurysms having a diameter of 30 to 39 mm were diagnosed more often than aneurysms with a diameter of more than 40 mm.

**Key words:** abdominal aortic aneurysm, epidemiology, risk factors, incidence, prevalence, mortality.

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Received: 05.05.2015

Accepted: 02.06.2015

Progress in Health Sciences

Vol. 5(1) 2015 pp 238-245

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## INTRODUCTION

The aorta is the main blood vessel that carries blood from the heart throughout the body. It extends from the chest through the abdominal cavity, below which it branches to the femoral arteries that supply blood to the lower extremities. When it comes to widening and weakening of the aortic wall, it stretches and becomes thinner. Such a pathological change is called aortic aneurysm. Depending on the location of the vessel enlargement, a condition is called abdominal aortic aneurysm (AAA), thoracic aortic aneurysm or thoracoabdominal aortic aneurysms. Most, even 80% of aortic aneurysms are located in the abdominal stretch [1].

Aortic aneurysms can be divided into [1]:

- Depending on the type: true aneurysm, pseudoaneurysm, dissecting aneurysm;
- Depending on the shape: saccular aneurysm, fusiform aneurysm
- Depending on the location: thoracic aortic aneurysm, abdominal aortic aneurysm, thoracoabdominal aortic aneurysm.

### *Pathophysiology of abdominal aortic aneurysm*

The basic structural element of the aortic wall is elastin and collagen [2]. Collagen fibers are arranged circumferentially and form multiple layers in the form of plaques with a wavy shape. Abdominal aorta wall has a thickness of 0.7 mm, the membrane in the middle contains about 30 elastic laminae. Extending elastin fibers can double their length and easily return to their original state, which is responsible for the elasticity of the vessel. Number of elastic laminae in vessels decreases in the abdominal section, the amount of collagen compared to the amount of elastin increases which results in a more rigid and thinner wall of the abdominal aorta with respect to the thoracic aorta [3]. Such structure may explain the tendency to intensify the development of aneurysms in the abdominal aorta. There are several factors that contribute to the weakening of the aortic wall, the natural degradation of elastin is one of them. This protein is produced only in early childhood and the time of its half-life is 70 years. This may explain the fact that abdominal aortic aneurysms occurs primarily in older age. There is a suspicion that genetically determined abnormalities in the proteins in the aortic wall can make some people susceptible to the formation of aneurysms. However, until now specific important genetic defects in the primary structure of the aorta have not been identified [4].

More and more scientific evidence suggests that an imbalance between proteolytic activity and activity of in the aorta is associated with the formation of abdominal aneurysms. Numerous studies have shown that people with abdominal aortic aneurysm have a higher level of

elastolytic activity than those with aortic occlusive disease and patients without abdominal aneurysm and occlusive disease [4]. In addition to increased elastolytic activity, some studies show reduced antiproteolytic activity as the cause of changes in the aortic wall resulting in the formation of aneurysm [4]. Inflammation was also identified as a factor leading to the weakening of aortic wall and formation of the aneurysm. Pathological studies have shown that abdominal aortic aneurysm is often characterized by infiltration of inflammatory cells comprising the aorta and outer membranes. The role of inflammatory stimulus in the creation of an abdominal aortic aneurysm has not yet been precisely defined. However, the researchers consider the role of autoimmunity in the process [5].

### *Course of the disease*

While some abdominal aortic aneurysms are stable in size, most of them are slowly expanding. Studies of clinical cases have shown that the rate of expansion is variable, and some of abdominal aortic aneurysms do not appear to change significantly in size. In most studies, the average expansion varies from 0.25 to 0.50 cm per year [6]. In the case of abdominal aortic aneurysms, which reached the diameter of 3 to 4 cm, rate of expansion during the year was 0.2 cm and, for the size of 5-6 cm, 0.4 cm per year. Such observations have been made on the basis of patients' autopsies with abdominal aortic aneurysms [7,8].

Similar data have been obtained after completing studies among patients with abdominal aortic aneurysm. Among people with abdominal aortic aneurysm with a diameter less than 4 cm, average growth lesion per year was 0.08 cm and in people with abdominal aortic aneurysm greater than 4 cm, the average growth was recorded at 0.33 cm in the initial phase. The increase in early detection and improvements in after surgery prognosis failed to completely eliminate deaths, the cause is mainly the rupture of the aneurysm. The risk of rupture is related to the size of the aneurysm. Although data on the natural history of abdominal aortic aneurysms are limited due to increasingly frequent surgical interventions, it is estimated that the five-year risk of rupture for aneurysms larger than 7 cm is 75%. The risk drops significantly the smaller the diameter is to about 1% in the case of aneurysm smaller than 4 cm [9].

Most cases of rupture of abdominal aortic aneurysm are fatal, about 50% of people coming to the hospital with a ruptured aneurysm do not survive, 70% of patients do not even reach the hospital. Overall mortality from abdominal aortic aneurysm rupture is 80%. Perioperative mortality in the nineties decreased from about 20% to 2-5% despite increasing numerous co-morbidities of the disease [10,11].

### Screening for abdominal aortic aneurysm

Early detection and appropriate surgical or drug treatment reduces the risk of adverse effects associated with AAA. The best method for early detection of the disease is screening, namely the use of relatively simple and inexpensive diagnostic tests in studies of large groups of people in order to detect early stages of the disease [12]. In the case of abdominal aortic aneurysms such a trial is abdominal ultrasonography, the sensitivity is within the range of about 95% and specificity 100%. Evaluation of the diameter of the aortic aneurysm uses two dimensions: anterior-posterior and lateral. Worldwide, screening for abdominal aortic aneurysm are directed at males over 65 years of age, smokers, genetically burdened or struggling with cardiovascular diseases [13,14].

### Literature search

In order to collect the literature needed to elaborate the aspects of abdominal aortic aneurysm epidemiology in Poland and worldwide the PubMed database was searched. Keywords used in the search were: "abdominal aortic aneurysm" in conjunction with "epidemiology", "occurrence", "morbidity", "mortality", "risk", "risk factors", "sex", and "age". Search was limited to the review of the original publications from the last 10 years. Articles excluded from the search were devoted to treatment of abdominal aortic aneurysm and where the aneurysm was not the main subject of study.

## Review

### Disease factors

Despite many known factors causing the weakening of the aortic wall, clear indication which of them are responsible for the formation of an aneurysm is lacking. The pathogenesis of AAA in most cases is multifactorial. Abdominal aortic aneurysm is a disease conditioned by complex interacting genetic and environmental factors.

Genetic factors. Wall of the vessel is made of proteins encoded by the particular gene. When mutations occur, synthesized altered proteins have less strength than the proper proteins. Vessel wall thusly weakened can easily be deformed by the blood pressure. The mutated gene can be inherited, leading to familial occurrence of aneurysms. It is likely that up to 19% of patients have at least one relative with first degree AAA. The best known genetic syndromes predisposing to the disease are the Marfan and Ehlers-Danlos syndrome. Some proteins that build mucosa are identical to those included in the ligaments and muscle fasciae which results in presence of inguinal hernias and defects of the musculoskeletal system. Other genetic factor associated with aneurysm is congenital defect of protease inhibitors. This dysfunction leads to not

yet fully described degradation of elastic fibers [15, 16].

Thrombus. Coagulation system is activated by running intramural inflammatory processes. This simulates the formation of thrombus area, where fibrinolysis processes are in effect. These processes, by activating proteolytic enzymes, have influence on the vessel wall proteins [17].

Infectious agents. Aortic aneurysms are accompanied by inflammation of varying severity. It consists of interactions of immune cells produced by cytokines and enzymes, the complement system, the coagulation system, and the proliferation of capillaries. Modern theories assume that it is directed against the antigen contained in the wall of the aorta, which may be Chlamydia Pneumoniae (atypical intracellular bacterium). The bacterium is not present in the healthy vessel wall, it is detected in only half of ruptured aneurysm walls and in one third of symptomatic aneurysms [18]. Other possible infectious agents are *Helicobacter*, *Brucella*, *Salmonella*, *Mycobacterium tuberculosis*, *Treponema pallidum*. The inflammation process involves lymphocytes T and B and interleukins synthesized by them as well as previously mentioned proteolytic enzymes produced by macrophages and neutrophils. A special role is attributed to: interleukin-1, which is responsible for an increased activity of collagenase; TNF- $\alpha$ , which stimulates angiogenesis, and consequently increases the infiltration by inflammatory cells. Interleukin 6, Interleukin 8, Interleukin  $\gamma$  are also observed in the wall of the aneurysm. These cytokines have been accredited with disturbing the equilibrium between the synthesis and degradation of matrix proteins. Inflammatory blood diseases, for example Takayasu or Behcet's syndrome, predispose to the formation of aneurysms. In some cases, the inflammation is so severe that these cases are called inflammatory aneurysms [19].

Mechanical factors. Tensile forces which are exerted by blood pressure play an important role in the expansion of the aorta. They are particularly dangerous in the case of untreated or poorly treated hypertension. Mechanical trauma may be another factor, but it is mostly responsible for the formation of aneurysm or dissection [20].

Atherosclerosis. The significant factor tied to the formation of abdominal aortic aneurysms is atherosclerosis. This is due to a frequent location in the final section of the aorta, which correlates with the most common site of aneurysm occurrence because about 90% of them locates peripherally to the renal arteries. At the same time, abdominal aortic aneurysm almost always contains atherosclerotic plaque, however, its causal role has not been proven [21].

Smoking. Tobacco intake is the most recognized and broadly described independent risk

factor for AAA. It increases the risk among the current smokers, former smokers and people exposed to secondhand smoke.

However, it is pointed out that the elimination of smoking is of utmost importance for reducing the prevalence of AAA and its consequences in the population [21-24].

Age and sex. One of the most striking and consistent conclusions drawn from epidemiological studies is higher incidence of abdominal aortic aneurysm with age. It is difficult to determine the average age of onset because the majority of abdominal aortic aneurysms are asymptomatic. The rapid increase in the prevalence of the disease can be observed in people over 60 years of age and appears to be stabilizing above 80, unfortunately the age of the first diagnosis is dropping lately. The development of abdominal aortic aneurysm is much more common among men than among women [22, 25,26].

Diabetes. The research conducted by Smith et al. states that people with abdominal aortic aneurysm are less likely to suffer from diabetes than people who do not have AAA [22,25].

Taking into account all the factors, it can be concluded that the most common cause of abdominal aortic aneurysms, outside smoking, are advanced age, gender, hypertension, and lipid disorders. Genetic factors play a significant role in the pathogenesis as the rate of AAA heredity is about 70% [25].

*Disease among the population.*

The presence of an abdominal aortic aneurysm falls within the range from 3.2% to 4.6%. The results showed that the incidence of abdominal aortic aneurysm in Australia was higher than in America and Europe (Table1).

The total incidence in the Western countries was higher than in Asia. The incidence of AAA was higher among men than women. In addition, at the age of 65-74 years there is the highest percentage of patients from four age categories considered in the study. Aneurysms having a diameter of 30 to 39 mm occurred more frequently than aneurysms with a diameter of more than 40 mm [27].

**Table 1.** The incidence of abdominal aortic aneurysm in the elderly, taking into account various factors

Variables	Incidence	Lower limit	Upper limit
<b>Selected regions</b>			
North America	0.043	0.033	0.053
Europe	0.040	0.028	0.053
Australia	0.067	0.065	0.070
Asia	0.005	0.003	0.007
<b>Sex</b>			
Men	0.060	0.053	0.067
Women	0.016	0.012	0.019
<b>Age</b>			
55-64	0.013	0.012	0.015
65-74	0.028	0.027	0.029
75-84	0.012	0.011	0.013
>85	0.006	0.004	0.007
<b>Aneurysm diameter (mm)</b>			
30-39	0.033	0.028	0.039
40-49	0.007	0.004	0.010
>50	0.004	0.003	0.005

Source: Own study based on data [27].

*Statistics on deaths from abdominal aortic aneurysm in Polish population.*

The International Classification of Diseases ICD-10 includes different kinds of aortic aneurysms as shown in table 2 [28].

**Table 2.** Types of aortic aneurysm according to the International Classification of Diseases ICD-10

Aortic aneurysm	
ICD-10	I71
I71.0	Dissection of aorta [any part]
I71.1	Thoracic aortic aneurysm, ruptured
I71.2	Thoracic aortic aneurysm, without mention of rupture
I71.3	Abdominal aortic aneurysm, ruptured
I71.4	Abdominal aortic aneurysm, without mention of rupture
I71.5	Thoracoabdominal aortic aneurysm, ruptured
I71.6	Thoracoabdominal aortic aneurysm, without mention of rupture
I71.8	Aortic aneurysm of unspecified site, ruptured
I71.9	Aortic aneurysm of unspecified site, without mention of rupture

Table 3 shows the total number of deaths from abdominal aortic aneurysm mentioning both rupture and without mention of rupture. It can be concluded that the increase of deaths occurs at age

of 65-69 years, except 2010. The largest number of deaths occurs in the period of 75 to 79 years. The vast majority of deaths refers to ruptured abdominal aortic aneurysm. Internal bleeding during the rupture can lead to the death of patient [29].

**Table 3.** The number of deaths from AAA I71.3, I71.4 in a given year, according to age

ICD-10	Age								
	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-95	≥95
<b>2005</b>									
I71.3	26	44	107	129	144	104	36	15	5
I71.4	14	16	35	38	55	39	12	4	1
<b>2006</b>									
I71.3	48	50	85	150	160	126	47	21	1
I71.4	6	13	30	51	39	36	22	3	-
<b>2007</b>									
I71.3	57	57	83	121	154	137	39	12	5
I71.4	7	16	23	45	47	34	16	5	1
<b>2008</b>									
I71.3	52	68	95	129	166	140	66	11	8
I71.4	9	17	26	41	37	34	18	3	3
<b>2009</b>									
I71.3	44	55	98	121	157	115	64	13	2
I71.4	17	15	29	37	45	40	20	4	1
<b>2010</b>									
I71.3	33	78	73	148	157	114	76	17	7
I71.4	9	8	17	30	40	41	11	6	-
<b>2011</b>									
I71.3	45	77	93	137	151	138	93	13	3
I71.4	9	12	18	22	39	28	15	5	1
<b>2012</b>									
I71.3	44	94	96	119	149	126	102	22	3
I71.4	5	16	20	23	35	30	18	7	-
<b>2013</b>									
I71.3	34	70	96	124	152	141	106	29	5
I71.4	3	15	21	31	25	29	16	6	4

Source: Own study based on data from the Central Statistical Office.

Figure 1 shows the distribution of the number of deaths from AAA among both sexes in the years 2003-2013. During these years that are included in the analysis, it can be seen that there are significantly more deaths among men.



**Fig. 1.** The average number of deaths from abdominal aortic aneurysm. Source: Own calculations based on data from the Central Statistical Office

*Statistics on the prevalence of abdominal aortic aneurysm around the world.*

Despite the constant advances in diagnosis and treatment, mortality due to rupture of aneurysms remains high. This disease affects society residing in developed countries and is the result of correlation of various factors, both environmental and genetic. In the United States, abdominal aortic aneurysm is one of 20 diseases associated with the highest mortality. Unfortunately, the number of cases of AAA rupture has not changed for the last 20 years, representing 3-5% of annual deaths in people aged over 65 years. This is due to often asymptomatic course of the disease. The diagnosis occurs most frequently at the moment of rupture or during the autopsy of the patient. According to the population studies, even 66% of patients die before operation due to the rupture of abdominal aortic aneurysm, another 41-48% die during the emergency operation [30].

Observing the prevalence comparison of abdominal aortic aneurysm in the world from 1990 to 2010 it can be said that in 1990, AAA prevalence rate per 100 thousand people ranged from 8.43 for people aged 40-44 years to 2.42 in people aged 75-79 years. In 2010 it was respectively 7.88 in the age group 40-44 years and 2.27 in the group age 75-79 years. The incidence in the developed countries is higher than in developing countries. The annual incidence in 1990 was on average 0.89 in the age of 40-44 years and 179.08 at the age of 75-79 years. Adequately, in 2010 it was 0.83 in the age group 40-44 years and 164.57 in the age group 75-79

years. The highest rate in 1990 was in regions with high income per capita, ie. Australia - 382.65 / 100 thousand and North America- 300.59 / 100 thousand (Table 4).

**Table 4.** The prevalence of abdominal aortic aneurysm around the world in 1990, 2005, 2010 per 100 thousand people

Region	Year		
	1990	2005	2010
Australia	382.65	318.83	310.27
North America	300.59	260.62	256.10
Asia	262.04	255.90	252.67
Oceania	257.67	281.21	280.10
South America	210.50	226.20	222.24
Africa	185.89	200.27	202.66
Europe	225.33	219.00	210.46

Source: Own study based on data [31].

In 2010, Australia was ranked at the top despite continuing drop in the prevalence of AAA in the population. The increase in incidence was observed in Oceania, South America and Asia. Despite the fact that in the last 20 years the global incidence of abdominal aortic aneurysm has decreased, further monitoring and activities that have a positive impact on the prevention of aortic related diseases is advisable [31,32].

**CONCLUSIONS**

Abdominal aortic aneurysm is a growing threat to public health, however, research carried out recently give progressively more answers to the questions concerning pathogenesis of abdominal aortic aneurysm, people affected, and factors influencing the development of the disease. Understanding the pathophysiology gives hope that therapeutic and pharmacological interventions can change the natural course of the disease and improve methods of treatment. Understanding the factors associated with the development of the AAA will simplify the identification of individuals at high risk and will help in creation of the appropriate secondary prevention means.

The occurrence of an abdominal aortic aneurysm in the areas tested falls within the range from 3.2% to 4.6%. Analysis of the results indicates that the incidence of abdominal aortic aneurysm in Australia is higher than in America and Europe. The total incidence in Western countries is higher than in Asia. AAA incidence in men is higher than in women. In addition, at the age of 65-74 years there is the highest percentage of patients from four age categories considered in the study. Aneurysms having a diameter of 30 to 39 mm were diagnosed more often than aneurysms with a diameter of more than 40 mm.

Smoking is a proven risk factor for atherosclerosis, which quadruples the risk of an aneurysm. Over the past 20 years, the number of abdominal aortic aneurysms has increased. This is due to increased detection by various diagnostic methods and population aging. During abdomen diagnostic tests for other diseases aneurysms are often accidentally detected. The vast majority of aneurysms are asymptomatic until they rupture. These changes are usually small in size and do not require immediate surgical intervention. However, they may enlarge later, carrying the risk of rupture, therefore systematic monitoring of the disease is of paramount importance.

### Conflicts of interest

There are no conflicts of interest.

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