

**Gustaw Wójcik^{1,3}, Jolanta Piskorz², Teresa Stawińska¹,
Barbara Sokółowska⁴, Włodzimierz Bulikowski¹**

¹ Department of Rehabilitation, Physiotherapy and Balneotherapy, Medical University of Lublin.

² Anaesthesiology and Intensive Care Unit - Zofia Tarnowska from the Zamoyskis
Provincial Hospital in Tarnobrzeg.

³ Department of Imaging Diagnosis - Zofia Tarnowska from the Zamoyskis
Provincial Hospital in Tarnobrzeg.

⁴ Health Institute - State School of Higher Education in Biała Podlaska

Diagnostic methods used in detecting aortic aneurysm

Metody diagnostyczne stosowane w wykrywaniu tętniaków aorty

Summary

In highly industrialised countries diseases of the circulatory system are at the top of the list of civilizational diseases. Among them one of the most important health problems are degenerations of artery vessels leading to aneurysms. Higher blood pressure and local weakening of vessel walls fosters its pathological dilation. A dilation by 50% with respect to the correct diameter of the aorta bears the name of aneurysm. Due to their shape aneurysms are divided into fusiform aneurysms and saccular aneurysms. Majority of them are detected by accident when performing an abdominal or chest ultrasound. If there is a problem with estimating the diameter of the aneurysm, it is recommended that a CAT scan using a radiocontrast agent or a magnetic resonance be performed. Medicals include ultrasound, X-ray of the abdominal cavity, and, if in doubt, CAT scan and magnetic resonance.

Key words: aortic aneurysm, imaging diagnosis, medical examination

Streszczenie

W krajach wysoko uprzemysłowionych choroby układu krążenia znajdują się w czołówce chorób cywilizacyjnych. Wśród nich jednym z ważniejszych problemów zdrowotnych są zwyrodnienia naczyń tętniczych prowadzące do powstawania tętniaków. Wzrost ciśnienia krwi i miejscowe osłabienie ściany naczynia sprzyja jej patologicznemu poszerzeniu. Powiększenie o 50% w stosunku do prawidłowej średnicy aorty nosi nazwę tętniaka. Ze względu na kształt tętniaki dzieli się na wrzecionowate i workowate. Większość z nich jest wykrywana przypadkowo, przy okazji wykonywania badania USG jamy brzusznej czy klatki piersiowej. W przypadkach trudności w ocenie średnicy tętniaka zaleca się wykonanie TK z użyciem środka cieniującego lub MR. Do badań kontrolnych zalicza się wykonanie USG, przeglądowego rtg jamy brzusznej, a w wątpliwych przypadkach TK i MR.

Słowa kluczowe: tętniak aorty, diagnostyka obrazowa, badanie przedmiotowe

Introduction

Aortic aneurysms belong to relatively frequent diseases which may pose a serious hazard to one's health and life. Aneurysm is a local, incorrect dilation of the light of the aorta by at least 50% with respect to the healthy aorta. Aortic aneurysms occur in the thoracic or abdominal part of the body, or may occur simultaneously in both parts, creating a thoracic abdominal aneurysm. Due to their shape aneurysms are divided into fusiform aneurysms and saccular aneurysms. The frequency of occurrence of this pathology increases as the population gets older. They occur nine times more frequently in men than women, especially in tobacco smokers [Kuivaniemi, Elmore 2012]. Aortic aneurysms usually affect elderly people but are also observed in younger persons. Undetected and not treated, they may be a cause of numerous complications and even death.

Early identification of patients at risk of aortic aneurysm is very important since it makes it possible to start treatment before clinical symptoms of degeneration of the aorta become visible. A clear growth in the rate of detection of aortic aneurysms can be observed in recent years. Maybe this is associated with an ever better access to diagnostic tests and with better knowledge of the medical personnel itself concerning the possibilities, sensitivity and ways of using various examination methods which may contribute to the detection of pathologies of the vessels.

The basic problem associated with the treatment of patients in which aortic aneurysms have been detected is determination of the best moment when a surgery should be performed. The death rate in planned surgeries ranges between 1 and 10%, and in emergency surgeries it reaches even 75%. These disproportions show how important it is to detect them early and then to monitor the pace of dilation of aneurysms.

The aim of this paper is to present diagnostic methods, thanks to which aortic aneurysms may be detected before they are confirmed by clinical symptoms.

Symptoms and diagnosis of aortic aneurysms

Usually dilation of aortic aneurysms is spread over time and gives no symptoms. It happens that the first symptom is a dramatic course of aortic dissection. Aneurysms of thoracic aorta may be a cause of chest pains, aortic insufficiency, and, in consequence, a cause of heart failure. Aneurysms of thoracic aorta may cause dysphonia as a result of constriction of the recurrent laryngeal nerve, recurrent bronchitis, cough, dyspnoea, haemoptysis, dysphagia, may also be the cause of superior vena cava syndrome [Elefteriades, 2008].

A pulsating tumour in the abdomen could be felt using a palpation in almost every patient suffering from aortic aneurysm [Botta and co-authors, 1983]. Dilation of the aneurysm may cause pain in the lumbosacral area, similar to sciatica. Other symptoms include pain in the abdomen, radiating down to thighs, urinary bladder and inguinal region. Growing aneurysms hardly ever constrict the inferior vena cava or one of the iliac veins, causing tumefaction of the lower limbs. They sporadically constrict the ureter, causing albuminuria or haematuria. Symptoms which make it possible to detect the aortic pathology early do not appear in all patients and are characteristic only for 5-10% of subjects [Elefteriades, 2008].

Aneurysms grow faster the bigger they are. Their growth disturbingly increases the risk of rupturing, especially in patients with hypertension and chronic obliterative lung disease. A frequent symptom of rupturing of an aneurysm is sudden pain in the lumbar region, radiating towards the abdomen and the crotch. A haematoma of the scrotum and/or around the anus is a typical symptom of rupture of the aneurysm as a result of blood seeping into the retroperitoneal space. These symptoms occur several and even a dozen hours after retroperitoneal rupture. When the pressure in the tight retroperitoneal space exceeds the pressure in the aorta, autotamponade occurs and pain usually alleviates or even recedes [Woźniak, Noszczyk 2000]. Aneurysms may also rupture into the peritoneal cavity. The subject has a strong stomach ache then, and symptoms of a hypovolemic shock appear several minutes later. There are also aortic ruptures into the duodenum, whose symptoms include massive bleeding from the digestive system. Ruptures of the aneurysm into the inferior vena cava as a complication of a vein implant are rare [Botta and co-authors, 1983].

As for inflammatory aneurysms, one may observe an excessive thickening of the aortic wall with an inflammatory infiltration into the surrounding tissues. A symptom is pain in the abdomen, higher body temperature, high ESR, increased leucocytosis. The concentration of urea and creatinine in the blood may also increase. Additionally, swelling in the pelvic and lower limb area may be observed in the subjects. Nausea and emesis often occur [Cencora, 1994; Michalak 1993]. Mycotic aneurysms, caused by staphylococci or salmonella, are ever more rare. Subjects with mycotic aneurysms may have symptoms typical of symptomatic aneurysm, high fever and increased leucocytosis often occur. Embolizing aneurysms may be observed in unique cases. They are rare (1-3%). They may cause limb ischaemia, and when thrombi clod the light of the aorta in the toes, they are a cause of sudden pain in the toes, which turn grey or navy blue.

Some authors point to co-existence of abdominal aneurysms and hernia, which may be associated with the pathology of the connective tissue [Woźniak and Noszczyk 2000].

A physical examination constitutes the basic diagnostic tool. The abdomen and limbs should be palpated carefully in subjects in whom an aortic aneurysm is suspected. This makes it possible to detect pulsating areas and lack of pulse in the circumference. Palpation does not increase the risk of an aneurysm rupturing [Lederle and Simel 1999]. The palpating method is rather effective, nonetheless, its value diminishes in case of obese patients.

Aortic aneurysms are frequently detected by accident while performing examinations for other diseases. Approx. 15% of aortic aneurysms is detected during radiological examinations. Radiological assessment of aortic aneurysms is based on non-invasive methods such as medical X-ray imaging, classical or transesophageal echocardiography (TEE), CAT scan or magnetic resonance as well as invasive methods such as: aortography or digital subtraction angiography [Całka, 2000].

On a chest X-ray thoracic aneurysms may give an image of a limited tumorous mass in a projection of the mediastinum, which may even lead to the top of the lung [Meier and co-authors, 1993]. They may also take on a form of a mediastinal enlargement or result in an image of double aortic arch. Characteristics which make it possible to detect aneurysms on an X-ray image include excessive calcification of the aortic walls and its curvilinear regression.

Urography – by performing an X-ray examination with an intravenous radiocontrast agent it may be possible to detect a blockage of the urethra and its displacement caused by dilating aneurysm.

In some cases of particularly complicated anatomy of the vessels and in the event of a planned surgery, an invasive method such as arteriography may prove necessary. Arteriography is a radiological examination consisting in imaging the light of the aortic vessel after introduction of contrast material through a catheter inserted into an artery. The aim of this method is to assess anomalies taking place in the vessels being examined. Should an aneurysm be detected, it makes it possible to determine its anatomical structure but not its size or diameter.

When small, aneurysms usually do not cause any pain. They are frequently detected during routine examinations, during ultrasound examination of the abdominal cavity or during diagnosis of other diseases. Screening ultrasound examinations show that abdominal aortic aneurysms occur at 4.4% of people aged between 40 and 75, however, they are detected 3 to 8 times more often in men than women. An ultrasound examination shows a dilation of the vessel with calcifications in the wall and with the presence of thrombi in its light.

An excellent examination of the abdominal aortic aneurysms is the B-mode ultrasound, which is a part of the Duplex ultrasound or real-time ultrasound examination. They do not pose a risk for the patient and are the least expensive examination. The accuracy of the Duplex ultrasound examination depends on the skills of the examining person, especially in detecting small abdominal aortic aneurysms [Ellis and co-authors, 1991]. Turbulent blood flow dominates in the Doppler mode. An ultrasound examination is recommended because it is a non-invasive, inexpensive and commonly available method.

In case of preliminary diagnosis as well as for the purpose of monitoring the development of the aneurysm, the preferred imaging methods, the so-called “gold standard”, are currently a CAT scan and magnetic resonance. A multi-detector row spiral CT with a radiocontrast agent is a method of a relatively low invasiveness in comparison to arteriography and a very sensitive method of diagnosing aneurysms [Rubin and co-authors, 2000]. Computed tomography is used mainly in pre-operative classification of aneurysms, whose aim is to measure the maximum lateral size and to assess the relation of the aneurysm to the surrounding anatomical structures. When performing endovascular surgeries it is extremely important to precisely measure the diameter and length of the aneurysm neck. Potential curvatures and presence of thrombi in the light of the aorta as well as the presence of curvatures and arcuations in hip arteries are examined. 3D reconstructions are used ever more frequently in computed tomography with radiocontrast agents since they facilitate the process of qualifying patients for endovascular techniques or open surgeries [Broeders and Blankenstein 1999].

Computed tomography is the most effective method of detecting ruptures of aneurysms, while indicating the presence of a fluid collection on the aorta.

A computed tomography examination has a high diagnostic value but due to the use of X-rays and large volumes of radiocontrast agents, it poses a certain burden to the health of the patients. In this case an alternative is a magnetic resonance examination. Unfortunately this method is also burdened by certain flaws, the largest one being

a longer duration of the examination in comparison to a computed tomography. However, continuous development of technology makes it possible to obtain ever better images of vessels in magnetic resonance, including images of kidney arteries. It should be assumed that continuous development of technology will increase the future usefulness of magnetic resonance in diagnosing aneurysms and that the precision of the images obtained using this method will be similar to that obtained in spiral computed tomography [Ludman and co-authors, 2000].

As regards examinations of blood vessels using magnetic resonance, we are talking about magnetic resonance angiography (angio-MR or MRA). Blood vessels may be imaged with or without the use of radiocontrast agents. One of the methods where no radiocontrast agent is used is time-of-flight (TOF) angiography. This method makes it possible to reduce the signal of stationary tissues while simultaneously strengthening the signal from inflowing blood. However, in case of slow blood flows as well as in case of large thrombi, this technique is burdened by flaws associated with changes in the intensity of the signal. In this technique it is difficult to differentiate between turbulent and laminar flow.

Another method used in magnetic resonance without radiocontrast agents is phase-contrast (PC) angiography in which maps of the blood flow are obtained, where the intensity depends on the blood velocity. This method significantly better reduces the signal of stationary tissues, and the images have a much better resolution. In PC angiography it is easy to distinguish a thrombus from a flowing blood.

Despite of quite good methods visualizing the vessels without radiocontrast agents, the most accurate examination is considered to be MR angiography with intravenous administration of paramagnetic contrast agent.

This MRA is completely non-invasive when using non-contrast methods since it uses a constant magnetic field and radio waves which are harmless to the human body. In MR examinations it takes a long time to gather data. The examination may last even 1 hour.

CAT scans and MR examinations are performed before planned surgeries for the purpose of precisely assessing the disturbed anatomical relationships of the aneurysm to the correctly functioning part of the vessel. It should be remembered that these examinations are definitely most expensive and bear a risk associated with Roentgen radiation and intravenous administration of a radiocontrast agent, which may result in anaphylactoid reaction. Anaphylactoid shock is a non-allergic, general, systemic reaction to exposure to a specific stimulus in a dosage tolerated by healthy persons. Immunological mechanisms do not participate in non-allergic reactions, that is why the shock may occur during the first exposure to the given radiocontrast agent, regardless of the quantity of the agent administered intravenously. Direct administration of the agent into the blood circulation causes immediate degranulation of mast cells and basophils and release of histamine. In case of radiocontrast agents administered parenterally, reactions may occur within a few seconds. Clinical symptoms differ in degree of severity and cover the skin, eyes, airways, alimentary tract, cardiovascular system and central nervous system [Korenblat and co-authors, 1999].

“EUS-guided angiography” is a method which constitutes a modern approach to diagnostic and therapeutic interventions in the vascular system. Initially this method was used in the diagnosis of oesophageal varices. Currently studies are being conducted

on using this method in the diagnosis and treatment of aortic aneurysms. This method requires administering a large volume of agent improving the contrast of the image since it makes it possible to shorten the time needed to visualise the vessel. The blood velocity in large vessels is associated with the administration of larger volumes of radiocontrast, which constitutes the main limitation of this diagnostic method [Priscilla 2007].

In the event of a suspicion of an inflammatory aneurysm, a scintigraphic examination is required since isotopic examinations are the best method of detecting hidden inflammatory foci. Scintigraphy is used ever more frequently in the diagnosis of inflammatory states occurring within the area of vascular prostheses and grafts. Marked leukocytes of the patient, which are a natural element of his immunological system and participate in the inflammatory processes taking place in the body, are used to conduct the examination. That is why in this examination one may observe a collection of the markers in areas affected by the inflammation. The flaw of this examination is the fact that the marked leukocytes are disseminated by blood and are naturally captured by some of the organs, especially by the liver and the spleen, which hinders the interpretation of the images.

Until now blood tests played a less important role in diagnosing acute abdominal aortic aneurysms. Weber and co-authors describe a 100% dependence of the growth of D-dimers in persons suspected of having an aortic aneurysm. The level of D-dimers in those cases exceeded 0.5 µg/ml in all persons who later underwent an emergency surgery of the abdominal aorta. The sensitivity of that test in this case is 100%, and its specificity reaches up to 68.6% [Weber and co-authors, 2003].

An increase in the level of C-reactive protein and lactate dehydrogenase can be observed in some patients. Also, there is an increase in the myosin heavy chain of the smooth muscle in an immunoenzymatic method, although this test is currently not in wide use. Suzuki and co-authors came to a conclusion that a negative D-dimer result may be useful in ruling out an acute aortic aneurysm [Suzuki and co-authors, 1996].

Carefully conducted physical examinations and appropriately matched imaging examinations allow for an early detection of aortic aneurysms and for an appropriately early surgical intervention.

Once diagnosed, aneurysms should be continuously monitored. The frequency of the check-ups should depend on the diameter of the aorta and the pace at which it is dilating.

Conclusions

Diagnosis of aortic aneurysms is constantly developing. Previous methods are being improved and new ones are being developed. Imaging diagnosis techniques presented in this paper, based on computed tomography and magnetic resonance, provide the most precious information about the anatomical conditions of the aneurysm, indicating the diameter of the lumen of the aorta, its external layer and size of the thrombus. These examinations are usually performed before planned surgical procedures as well as during follow-up examinations after grafting of vein implants. Considering the fact that the aforementioned examinations are one of the most expensive ones, diagnosis using these methods has certain limitations.

Ultrasound examinations are least expensive diagnostic methods but their accuracy is not as precise as that of computed tomography and magnetic resonance.

Urography, as an examination using a radiocontrast agent, may be just as useful in diagnosing aneurysms as a chest X-ray. These are least invasive examinations but they show only indirect symptoms of aneurysms, without the possibility to make any measurements.

The most invasive examinations are aortography and digital subtraction angiography since they are associated with introduction of contrast material through a catheter inserted directly into an artery.

Blood tests are becoming promising as regards diagnosis of aneurysms. Increase in D-dimers, C-reactive protein and lactate dehydrogenase is not specific enough to be able to conclude the presence of aneurysms on their basis. Meanwhile, a negative D-dimer result may be useful in ruling out an acute aortic aneurysm.

Bibliography

1. Botta G. C. et al. Abdominal aortic aneurysms. *J. Cardiovasc. Surg.*, 1983,24 , 484.
2. Broeders I.A., Blankenstein J.D. Preoperative imaging of the aortoiliac anatomy in endovascular aneurysm surgery. *Semin Vasc Surg.* 1999;12:306-14.
3. Całka K., Bojarski B., Jaźwiec P. and co-authors: Tętniak rozwarstwiający aorty piersiowej z krwawieniem do jamy opłucnej. *Przegl. Lek.* 2000; 57:1.
4. Cencora A., Morawiecki T., Szumilak A. W sprawie po operacjach zapalnych tętniaków aorty brzusznej w ostrej fazie choroby. *Pol. Przegl. Chir.*, 1994, 66, 598
5. Elefteriades J. A. Thoracic aortic aneurysm: Reading the enemy's playbook. *Curr Probl Cardiol*, 2008; 33: 203-277.
6. Ellis M., Powell J.T., Greenhalgh R.M. Limitations of ultrasonography in surveillance of small abdominal aortic aneurysms. *Br. Jour. Surg.*, 1991;78:614-6.
7. Korenblat P., Lundie M.J., Dankner R.E., et al. A retrospective study of epinephrine administration for anaphylaxis: how many doses are needed? *Allergy Asthma Proc.* 1999; 20: 383-386.
8. Kuivaniemi H; Elmore JR. Opportunities in abdominal aortic aneurysm research: epidemiology, genetics, and pathophysiology. *Ann Vasc Surg*, 2012; 26 (6): 862-70
9. Lederle FA, Simel DL. The rational clinical examination: does this patient have abdominal aortic aneurysm? *JAMA* 1999; 281:77-82.
10. Ludman C.N. et al. Feasibility of using dynamic contrast-enhanced magnetic resonance angiography as the sole imaging modality prior to endovascular repair of abdominal aortic aneurysms. *Eur J Vasc Endovasc Surg*, 2000;19:524-30.
11. Meier R., Marianacci E., Costello P. et al. 3D image reconstruction of right subclavian artery aneurysms. *J. Comput. Assist. Tomogr.* 1993; 17: 887-890.
12. Michalak J. and co-authors Wyniki leczenia tętniaków zapalnych jamy brzusznej. *Wiad. Lek.*, 1993,46, 384
13. Priscilla M. et al. EUS-guided angiography: a novel approach to diagnostic and therapeutic interventions in the vascular system. *Gastrointest End*, 2007; 66(3), 587-591.
14. Rubin G.D. et al. Cost identification of abdominal aortic aneurysm imaging by using time and motion analyses. *Radiology*, 2000;215:63-70.

15. Suzuki T, Katoh H, Watanabe M, et al. Novel biochemical diagnostic method for aortic dissection: results of a prospective study using an immunoassay of smooth muscle myosin heavy chain. *Circulation*, 1996; 93:1244-1249.
16. Weber T, Hogler S, Auer J, et al. D-dimer in Acute Aortic Dissection. *Chest*, 2003; 123(5) 1375-1378.
17. Woźniak W., Noszczyk W. Tętniak aorty brzusznej. *Przew Lek* 2000, 5: 48-51.

Number of signs with spaces: 23 263