Aortic Aneurysms: Definition, Epidemiology and Natural History

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Arno von Ristow and Bernardo Massière

Discipline of Vascular and Endovascular Surgery of the Post Graduate School of Medicine of the Pontifical Catholic University of Rio de Janeiro; CENTERVASC-Rio—Center for Vascular Research, Prevention, Diagnosis and Treatment. Rio de Janeiro, RJ.

Rupture and death! *Galenus*, 18 centuries ago, described with clearness of mind this fatidic association, the natural evolution of the pseudoaneuryms that he observed in the wounded gladiators under his care in Pergamon and later in the Coliseum of Rome [1]. The rupture of an aortic aneurysm (AA) is the dreadful final event of the evolution of this potentially lethal disease. Although AA can present with other complications, as compression of adjacent structures and peripheral embolism, the potential of catastrophic rupture is the crucial end of its the natural history [2–5].

Aortic Aneurysms: Definition and Brief Classification

Aneurysm is a term derived from the ancient Greek, meaning "a widening". An aneurysms is defined by a permanent localized dilatation of an artery, having at least a 50 % increase over the expected normal diameter. Smaller arterial dilatations are termed ectasias [6]. True aneurysms involve the three layers of the artery—intima, media and adventitia. Pseudo aneurysms do not involve all layers, but are due to rupture of the arterial wall and formation of a perivascular hematoma. In this chapter, we will limit our discussion to the Aneurysms of the Abdominal Aorta (AAA), by far the most frequent of all the aneurysms of the aorta.

Aortic Aneurysms: Epidemiology

The prevalence of AAA is increasing. This is due to three main factors: the progressive increase of life expectancy, the accuracy of the diagnostic methods and the awareness of doctors regarding this disease as well as the benefits of its treatment. The later, has prompted many physicians to request abdominal ultrasound exams of their patients, mainly elderly white men, the most affected by the problem [7]. In fact, AAA is a disease of elderly white men, occurring 3 times more than in black men of the same age [8]. The incidence increases progressively after the

A. von Ristow (✉)
Department of Vascular and Endovascular Surgery, CENTERVASC-Rio, National Academy of Medicine—Brazil, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil
e-mail: drarno@centervasc.com.br

B. Massière
Department of Vascular and Endovascular Surgery, CENTERVASC-Rio, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil

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fifth decade and, in our material, with more than 2000 AAA treated, men outnumber women in a ratio of 7:1. The likelihood to develop a AAA varies broadly in the literature, ranging from 3 to 117 per 100,000 person-years; this broad variation is due to the diversity of the individuals screened [9].

The importance of AAA can be measured by the high mortality its rupture determines. It is the 13th cause of death in the USA in men over 65 years, and the 10th in the same group in Canada [10, 11]. Parallel to the increase of the aging population, the mortality due to rupture of AAA also increases, as demonstrated by many authors, as Fowkes et al. in 1959—404 deaths in England and Wales, and in 1984—7259! [12] In the late decades, great interest has been aroused to determined the real prevalence of AAA. So, with that objective, autopsy and especially abdominal ultrasound population screening studies have been conducted. Bengston et al. published what is probably the landmark of the autopsy studies in 1993, reporting the prevalence of AAA in Malmö (Sweden), those days with a population of 230,000 (45,838 autopsies performed between 1858 and 1986). In the period of 1971–1986 they identified 215 ruptures (155 men and 60 women). Of these, 91 died at home, 63 in the hospital without treatment and, of the 69 that were operated on, 33 died to. In the same time frame, they have operated electively on another 130 cases [13]. Several population screening studies were conducted after the seminal publication by Colin et al.—The Oxford Study. In that study, 426 men with age between 65 and 64 years were screened for AAA by abdominal ultrasound: an incidence of 5.4 % was detected [14]. Bonamigo published a meta analysis of ten studies, including his one and found a percentage that varied from 1.7 to 10.7 %, depending on the population studied [7]. It is clear that there are population subgroups that have increased risk of AAA, patients with coronary artery disease, those with peripheral arterial occlusive disease, mainly those with carotid artery involvement and amputees. Old age is an independent predictor [8, 9]. History of smoking is very prevalent, being the risk factor most strongly associated with AAA [7–9]. Last but not least, heredity has an important role: relatives of patients with AAA present a higher incidence of the disease than other individuals without history of the disease in their families. The first paper addressing the subject, was published by Tilson and Seashore in 1984, later confirmed by others, in several countries [15]. Johansen and Koepsell estimated that first-order relatives have a 12-fold increased risk for developing a AAA themselves [16]. In Brazil, Barbosa et al. confirmed the disease in 25 % male relatives and in 4.6 % of female, both of first-order relatives [17]. It seems that tobacco abuse has a triggering effect in developing aneurysms in these subjects.

Aortic Aneurysms: Natural History

In the past, when there was no effective diagnosis and treatment for AAA, the observation of the natural history of the disease was based in clinical observation of the patients. Many presented growth of the aneurysm, with progressive expansion and finally rupture, leading to death. Commonly, rupture and death occurred before any evident symptoms. Although AAA can present many complications in their evolution, listed in Table 2.1, rupture is the crucial one in the natural history of this disease.

In parallel, many patients with AAA died of other causes associated with old age, mainly from cardiovascular or other degenerative diseases, as cancer or renal insufficiency [18].

Despite the fact that the exact etiology of AAA is unclear, extensive and well conducted epidemiological studies, some cited above, clarified much about its evolution. It is a disease in ascension in all western world. Ultrasound studies in a large number of individuals in the age of

Table 2.1 Complications of abdominal aortic aneurysms

Rupture
Embolization (macro and micro)
Inflammatory aneurysm
Acute thrombosis
Adjacent venous, ureteral and intestinal compression
Rupture into adjacent organs (digestive tract, more commonly to the duodenum, vena cava)
Infection

higher prevalence of aneurysmal aortic degeneration, allowed a clear view of the pathology, formerly based only in *post mortem* evaluations [4, 5]. Being rupture the most dreadful complication, it seems logical that it is the most studied in the natural history of AAA, and form the base if this Chapter.

In 1950, Estes et al. published a classical paper on the natural history of AAA: rupture was the *causa mortis* of 63 % of the 102 patients followed up for 5 years. Survival at 5 years was only 18.9 %, contrasting with the life expectancy of 79.1 % of the matched population! [19] Important publications followed, confirming this findings, in clinical research and autopsy studies [7–9, 11, 13, 18]. A percentage of rupture of 27.7 % in non operated cases was reported by Gore and Hirst in 1973, stressing the importance of the diameter of the AAA in this final event: 9.5 % of small AAA's (less than 5 cm in diameter) ruptured; in medium size (5–7 cm), the rate was 36 % and in large ones, with more than 7 cm in cross section—76 %! [20] Darling et al., in 473 autopsies of patient who passed away due to AAA rupture, stressed that small aneurysms, with less than 4 cm in diameter, could rupture too, in a rate of 9.5 % of the cases [21]. Another Swedish study, by Glimacker et al., detected a rate rupture of 2.5 % for AAA with less than 5 cm in diameter, in contrast with those with more than that size, who had a rupture rate of 28 %! We must observe that in all these studies, the aorta was not pressurized [22]. Silva et al. were the first to measure the diameter of pressurized the aortas in necropsy evaluation. They pressurized the specimens at 80 mmHg, in patients that died from ruptured AAA and found that none ruptured with less than 5 cm in diameter [23]. This study also confirmed the finding of others, that the fusiform shape of the AAA is associated with a higher risk of rupture than the spherical form. The numbers were too small to establish a clear relation with the saccular form, thought to be the most prone to rupture [23]. Interestingly, as it was formerly believed, they confirmed the findings of other investigators that the presence of thrombus did not prevent rupture, but rather facilitated it, since thrombi were found next to the rupture site in 80 % of the specimens, maybe acting as precipitating factor through the enzymatic activation contained in viable macrophages inside the thrombus [23]. A subgroup that deserves special attention are women: their native aortas have generally smaller size and are prone to rupture with smaller diameters than in men, being considered at risk with diameters of more than 2.5 times their original diameter.

In our material, observing and following up more than 3000 patients with AAA in 35 years, we never observed ruptures in asymptomatic patients with diameter smaller than 5 cm. We stress the point that those patients were asymptomatic, bearers of fusiform or spherical degenerative aneurysms. Symptomatic aneurysms, as well as saccular and aneurysms of other etiologies are exceptions and must be individually addressed.

It is current belief that biochemical alterations within the aneurysm produce weakening of the arterial wall; histological and anatomical features predispose their localization and the hemodynamic effect contributes to the arterial widening. This last fact explains the relevance of the diameter, as well as the morphology, in the natural history of these dilations [23].

Inheritance has an outmost importance in the dilatation of the aorta. Members of the same family of a patient operated on for AAA have a 10 times chance of developing an aortic aneurysms, when compared to someone who never has a case in his relatives [13, 24]. Bengston et al. observed that in male children of patients operated on for AAA, the probability of developing an aneurysm is 30 and 4 % in women. Several other publications come to the same conclusions [24, 25]. The publication already quoted of Johansen and Koepsell evaluated 250 relatives of patients operated on for AAA and found aneurysms in 19.2 %; in 250 individuals of same age and gender in the general population, the incidence was 2.4 % [16].

The concentration of AAA in members of the same family has driven many investigators to investigate the genetic importance of the disease. Powell et al. proposed that abnormalities in the long chromatid arm of human chromosome 16 are responsible for the familial tendency to

develop the disease [25]. Gene expression leading to abnormalities in the content and structure of elastin and collagen in the arterial wall was reported as early as 1992 [26]. A thorough review was published by Tilson et al. [27]. In 2015, only in the English literature, there are more than 1000 publications linking AAA to genetics and of course, inheritance. Certainly in the future we will be able to identify individuals at risk of developing AAA and even other aneurysms. Currently, we must screen relatives of AAA bearers, because it is in this group that the diagnosis of the problem is more frequent [18].

Patients with AAA, independent of their size, have a reduced life expectancy, in comparison with individuals matched for age [26, 28]. Someone with a AAA has a yearly 7 % chance of dying, of many causes [28]. The data regarding larger aneurysms are even worse, and have already been addressed in this Chapter. The impact of the diagnosis of AAA usually is enormous for the patient. The majority presents anxiety and fear or rupture, with profound implications in their quality of life. Although the medical literature does not have precise reports of this impact, this fact is confirmed in our daily practice. The current knowledge of the natural history of AAA allows a sincere and ethical counseling about the best management of each individual patient. Albeit being nowadays a curable disease by surgery, in most cases with small AAA, a conservative approach is the best management, until size, shape or complications will change it [29]. Regular evaluations, especially with abdominal ultrasound, are fundamental.

In operated patients, the most frequent *causa mortis* are circulatory degenerative diseases, specially of the coronary and cerebral circulations [30]. Surgery is able to cure aneurysms, although not aneurismal disease. A small percentage of treated patients will develop new aneurysms proximal and/or distal to the treated segments, along their lives. These dilatations, the para anastomotic or para endoprothetic aneurysms can present a new risk of rupture or other complications. As this occurs generally many years after the initial treatment, it is uncommon the need of treatment of this situation [31].

The Role of Population Screening, Based on the Natural History of AAA

The majority of the patients that die from AAA rupture did not had previous knowledge of their disease. Despite all advances, even in developed countries more patients die of rupture AAA than are operated electively [32]. Moreover, studies relying on necropsy findings have reported that between 75 and 85 % of individuals with aneurysms died of other diseases, in particular from cardiovascular disorders [18, 21, 23, 28]. Although surgical management eliminates the rupture probability in most of the treated patients, a large contingent of individuals with small aneurysms do not need to endure a surgical procedure, because many aneurysms remain stable or grow very slowly [22, 23].

The impact of this high mortality in the rational for the screening studies, especially in populations with high prevalence of AAA. In 1988, we have proposed what today is unanimously accepted: to screen all male population over 60 years. Those days, that proposal was regarded as exaggerated or unnecessary [33]. The individuals at high risk of developing a AAA are well identified: those with aneurysms in other sites, men in the sixth and seventh decade of life, relatives of patients with AAA and patients with coronary, cerebrovascular or peripheral arterial obstructive disease. Current or previous smokers and hypertensive patients that that fit into the above categories have an even higher chance of bearing a AAA. In these groups, despite the economical difficulties found in developing countries like Brazil, screening is needed.

The natural history of AAA may be influenced by several factors, such as diameter, rate of expansion, morphology–geometry, mechanical properties of the arterial wall, enzymatic activity, arterial hypertension, chronic obstructive pulmonary disease, genetic propensity, recent laparotomy and use of certain medications [2, 3, 23]. In 2016, we know that most AAA are asymptomatic until they rupture; usually, only patients with abdominal or lumbar pain have their AAA diagnosed without screening; in practice, almost half

of the AAA have a evolution to rupture; by the current methods of emergency treatment, only one of every five patients that ruptures, survives. In contrast, mortality for AAA treatment, especially by the endovascular method, can be lower than 2 %. We also know that patients that survive treatment have a life expectancy only slightly lower than individuals of their age. Prevention of rupture, which prevents all the other complications as well, is the only effective way of treatment.

As everything in Medicine, we must take into account individual variations, clinical evidences and all the accumulated knowledge, that points to a diameter of 5 cm as a flow divider between living with, or risking to die as a consequence of a AAA.

References

1. Galenus: on the natural faculties. Chicago, IL: Encyclopaedia Britannica; 1952 (Traduction of A. J. Brock, M.D.).
2. Ristow AV, Coelho RP. Aneurismas da Aorta Abdominal Rotos. In: Mesquita ET, editor. Emergências Clínico-Cardiológicas. Rio de Janeiro: Revinter; 2000. p. 381–95.
3. Ristow AV, Coelho RP, Cury JM, Pedron C. Aneurismas da Aorta Abdominal Rotos. In: Galvão-Alves J, editor. Emergências Clínicas. Rio de Janeiro: Rubio; 2007. p. 207–16.
4. Collin J, Araújo L, Walton J, Lindsell D. Oxford screening programme for abdominal aortic aneurysm in men aged 65 to 74 years. Lancet. 1988;10:613.
5. Bonamigo TP, Siqueira I, Bianco C. Rastreamento de aneurismas da aorta abdominal em uma população ambulatorial com risco para doença cardiovascular. Cir Vasc Angiol. 1993;9(Suppl):7–10.
6. Johnston KW, Rutherford RB, Tilson MD, Shah DH, Hollier L, Stanley JC. Suggested standards for reporting on abdominal aortic aneurysms. J Vasc Surg. 1981;13:452.
7. Bonamigo TP, Araújo FL, Siqueira I, Becker M. Epidemiologia dos aneurismas da aorta abdominal. In: Bonamigo TP, Ristow AV, editors. Aneurismas. Rio de Janeiro: DiLivros; 2000. p. 39–45.
8. Blanchard JF. Epidemiology of abdominal aortic aneurysms. Epidemiol Rev. 1999;21:207.
9. Wilmink AB, Quick CR. Epidemiology and potential for prevention of abdominal aortic aneurysms. Br J Surg. 1998;85:155.
10. Siqueira I, Bonamigo TP, Muller C, Martins F. Rastreamento de aneurismas da aorta abdominal em homens com mais de 65 anos. Cir Vasc Angiol. 1993;9:47–50.
11. Semenciew R, Morrison H, Wigle D, Cole W, Hill G. Recent trends in morbidity and mortality rates for abdominal aortic aneurysms. Revue Canadienne de Santé Publique. 1992;83:27–31.
12. Fawkes FGR, Macyntire CCA, Ruckerley CV. Increasing incidence of aortic aneurysms in England and Wales. Br Med J. 1989;298:33–5.
13. Bengston H, Bergqvist D. Ruptured abdominal aortic aneurysms: a population-based study. J Vasc Surg. 1993;18:74–9.
14. Colin J, Araújo FL, Lindsell D. Screening of abdominal aortic aneurysms. Lancet. 1989;26:736–40.
15. Tilson MD, Seashore MR. Fifty families with abdominal aortic aneurysms in two or more first-order relatives. Am J Surg. 1984;147:551–60.
16. Johansen K, Koepsell T. Familial tendency for abdominal aortic aneurysm. JAMA. 1986;256:1934–40.
17. Barbosa RD, Denardi MR, Rominii JR, Zorn WGW, Bellen BV. Rastreamento com ultrassonografia abdominal em irmãos com aneurismas da aorta abdominal. Cir Vasc Angiol. 1995;11:68–72.
18. Bonamigo TP, Ristow AV, Burihan E. História natural do aneurisma da aorta abdominal. In: Bonamigo TP, Ristow AV, editors. Aneurismas. Rio de Janeiro: DiLivros; 2000. p. 61–6.
19. Estes Jr JE. Abdominal aortic aneurysm: a study of one hundred and two cases. Circulation. 1950;2:258–65.
20. Gore I, Hirst AE. Atherosclerotic aneurysms of the abdominal aorta. A review. Prog Cardiovasc Dis. 1973;16:113–49.
21. Darling RC, Messina CR, Brewster DC, Ottinger LW. Autopsy study of unoperated abdominal aortic aneurysms: the case for early resection. Circulation. 1977;56:II161–6.
22. Glimaker H, Holmberg L, Elvin A, Nybacka O, Almgren B, Björck CG, et al. Natural history of patients with abdominal aortic aneurysm. Eur J Vasc Surg. 1990;5:125.
23. Silva ES, Rodrigues AJ, Tolosa EMC, Rodrigues CJ, Prado GVB, Nakamoto JC. Morphology and diameter of infrarenal aortic aneurysms: a prospective autopsy study. Cardiovasc Surg. 2000;8:526–32.
24. Bengtsson H, Nörrgard Ö, Ängqvist K, Ekberg O, Öberg L, Bergqvist D. Ultrassonography screening of abdominal aortic aneurysms among siblings of patients with abdominal aortic aneurysms. Br J Surg. 1989;76:589–93.
25. Powell JT, Bashir A, Dawson S, Vine N, Henney AM, Humphreys SE, et al. Genetic variation on chromosome 16 is associated with abdominal aortic aneurysm. Clin Sci. 1989;78:104–8.
26. Mesh CL, Baxter BT, Pearce WH, Chrisholm RL, McGee GS, Yao JS. Collagen and elastin gene expression in aortic aneurysm. Surgery. 1992;112:256–61.
27. Tilson III M, Kuivaniemi H, Upchurch GR (Eds). The abdominal aortic aneurysm: genetics, pathophysiology and molecular biology. Boston, MA: Blackwell; 2006, p. 411.
28. Gersh BJ, Rihal CS, Rooke TW, Ballard DJ. Evaluation and management of patients with both peripheral

vascular and coronary artery disease. J Am Coll Cardiol. 1991;18:203–7.
29. Ristow AV, Bonamigo TP, Santos MA, Sampaio MM, Palazzo JCC, Moll J. Aneurisma Aórtico. Uma doença curável. Ars Curandi Odontol. 1985;18:10–30.
30. Roger VL, Ballard DJ, Hallet JW, Osmundson PJ, Puetz PA, Gersh BJ. Influence of coronary artery disease on morbidity and mortality following abdominal aortic aneurysmectomy: a population base-study, 1971–87. J Am Coll Cardiol. 1989;14:1245–52.
31. Ristow AV, Vescovi A, Massière BV. The management of para anastomotic aortic and iliac aneurysms. In: Gloviczki P, editor. Mayo clinic advances and controversies in vascular medicine, vascular surgery and endovascular interventions. Torino: Minerva; 2011, p. 50–8.
32. Greenhalg RM, Fowkes FGR, Powell JT, Ruckley CV. When should the small asymptomatic aneurysm be operated upon? In: Greenhalg RM, editor. The cause and management of aneurysms. London: Saunders; 1990. p. 457–60.
33. Palazzo JCC, Ristow AV. Aneurismas da aorta abdominal: não são tão raros como imaginávamos… J Bras Med. 1988;55:129–37.