ARTIGO DE REVISÃO
ASCENDING THORACIC AORTIC ANEURYSM: UPDATE ON DEFINITION, INDICATIONS FOR SURGICAL TREATMENT AND NEW EXTERNAL COATING TECHNIQUES

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ABSTRACT
Aortic aneurysm is a pathology that corresponds to a permanent increase of more than 1.5 times the normal range in the diameter of the aorta, which leads to complications such as acute aortic syndromes (aortic dissection and rupture) that have very high mortality rates. Through the methodology of narrative literature review in databases such as PubMed, it can be summarized that the main risk factors for the development of this pathology are age, sex, pregnancy, hypertension, atherosclerosis, and genetic and infectious conditions. Furthermore, approximately 95% of cases of aortic aneurysms are asymptomatic, resulting in incidental findings on imaging tests, such as computed tomography angiography. This is the preferred method for evaluating the aorta due to its ability to capture high-resolution, three-dimensional images quickly. After diagnosis, international guidelines recommend surgical treatment for ascending aortic aneurysms when dilation measures 50 mm, or growth of the aortic root, from 5 mm in one year to 3 mm in two consecutive years. Therefore, it is up to the team of surgeons to decide which technique is best, among the conventional techniques of Bentall-De Bono, Tirone-David, Yacoub, and Robiscek, for example. In addition to current plating techniques with customized external supports for the aortic root (PEARS). Therefore, it is concluded that knowledge of the different aspects of this pathology broadens the horizons of which interventions, which subjects, and the advantages and disadvantages of such actions in treating these aneurysmal patients.

Keywords: Aortic aneurysm; Cardiovascular Surgery; External supports of the aorta.

RESUMO
O aneurisma da aorta é uma patologia que corresponde a um aumento permanente superior a 1,5 vezes o valor normal do diâmetro da aorta, o que leva a complicações como síndromes aórticas agudas (dissecção e ruptura aórtica) que apresentam taxas de mortalidade muito elevadas. Através da metodologia de revisão narrativa da literatura em bases de dados como PubMed, pode-se resumir que os principais fatores de risco para o desenvolvimento desta patologia são idade, sexo, gravidez, hipertensão, aterosclerose e condições genéticas e infecciosas. Além disso, aproximadamente 95% dos casos de aneurismas de aorta são assintomáticos, resultando em achados incidentais em exames de imagem, como a angiotomografia computadorizada. Este é o método preferido para avaliar a aorta devido à sua capacidade de capturar rapidamente imagens tridimensionais de alta resolução. Após o diagnóstico, as diretrizes internacionais recomendam o tratamento cirúrgico dos aneurismas da aorta ascendente quando a dilatação mede 50 mm, ou o crescimento da raiz da aorta, de 5 mm em um ano para 3 mm em dois anos consecutivos. Portanto, cabe à equipe de cirurgiões decidir qual técnica é a melhor, dentre as técnicas convencionais de Bentall-De Bono, Tirone-David, Yacoub e Robiscek, por exemplo. Além das técnicas atuais de chapeamento com suportes externos customizados para raiz da aorta (PEARS). Conclui-se, portanto, que o conhecimento dos diferentes aspectos desta patologia amplia os horizontes de quais intervenções, quais sujeitos, e as vantagens e desvantagens de tais ações no tratamento desses pacientes aneurismáticos.

Palavras-chave: Aneurisma de aorta; Cirurgia Cardiovascular; Suportes externos da aorta.

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INTRODUCTION

Aortic aneurysm is a pathology, generally asymptomatic, that corresponds to a permanent increase of more than 1.5 times the normal range in the diameter of the aorta, implying a greater risk of lacerations and hemorrhages in its wall due to its weakening.[1]

Thoracic aortic aneurysm (TAA) is less common than abdominal aortic aneurysm. However, it is clinically just as important, as it can lead to complications, such as acute aortic syndromes (aortic dissection and rupture), which have very high mortality rates. The main risk factors for the development of TAA are age, sex, pregnancy, hypertension, atherosclerosis, genetic and infectious conditions.[2]

The diagnosis of this pathology presents complexities, mainly due to the high proportion of asymptomatic cases, which corresponds to approximately 95%. However, even with the risk of sudden death, the diagnosis is given incidentally when imaging tests are requested for other illnesses.[3]

The pathophysiology of aneurysm is multifactorial, involving several conditions of loss of cellular functions, genetic involvement, and inflammation, among others.[4] It will trigger the involvement of the ascending aorta, which may result in a dissection of the thoracic aorta. This condition is influenced by the dimensions of this vessel, taking into account (1) dilation, in which the diameter of the aorta is in the range of 50 mm to 55 mm, this being a reference value for surgical repair, and (2) the longitudinal enlargement of this artery, which has its value doubled in this situation and can be added as a predictor of potential risk for surgical interventions.[5]

Therefore, this article aims to describe the general aspects of Ascending Aortic Aneurysm, addressing in a succinct and updated way the key elements linked to the definition, pathophysiology, epidemiology, diagnosis, and criteria to indicate surgical correction treatment, and surgical techniques—furthermore, new modalities of covering this aneurysm.

METHODS

A narrative review of the literature was carried out to synthesize the different aspects of aortic aneurysm, from definitions to surgical treatment. The included articles were obtained through the following databases: PubMed, Scientific Electronic Library Online (SciELO), and Virtual Health Library (VHL). The descriptors used were Aortic aneurysm, Definition, Epidemiology, Pathophysiology, Diagnosis, Treatments, Surgery, and external coating of the aorta. The inclusion criteria were Language (Portuguese, English, and Spanish), Availability (full text), and all articles and books. The selected articles were read and summarized in the following topics.
RESULTS AND DISCUSSION

Pathophysiology

The pathophysiology of aneurysm is multifactorial, involving conditions of loss of smooth muscle cells in the media layer, genetic factors, destruction of elastin and collagen, inflammatory responses, and neovascularization \[4\].

Regarding the disarray of vascular smooth muscle cells, it is known that TGF-β and Smads proteins are related to TAA, in addition to the high concentration of microRNA-21, significant in the proliferation and apoptosis of these cells \[6\].

The TAA can be classified as syndromic and non-syndromic, and these two classes have different development. Syndromic TAA is related to manifestations of other systems and organs in addition to the aorta. It is better described as being, in general, associated with a dysfunction in the extracellular matrix, medial smooth muscle cells, or TGF-β signaling, being seen in diseases such as Marfan Syndrome, Loeys-Dietz Syndrome, and Ehlers-Danlos Syndrome. Meanwhile, non-syndromic TAA is only related to the involvement of the aorta and may or may not have a hereditary association, being related to genetic mechanisms, such as the expression of genes with variable penetration, which play an essential role in the contraction of vascular smooth muscles \[7\].

Among the primary genes that play a role in the contraction of vascular smooth muscles and are related to TAA, we can mention: the ACTA2 gene, which encodes the specific α-actin of smooth muscle cells, this gene being the target of the most common mutation linked to family TAA; the MYLK gene, which, when mutated, reduces the activity of myosin light chain kinase, impairing the aorta’s ability to contract, since this kinase has a regulatory function responsible for increasing the activity of myosin II ATPase, allowing a fine control of blood pressure; The MYH11 gene, which encodes the smooth muscle myosin heavy chain, and, when mutated, deregulates smooth muscle cell contraction; the PRKG1 gene, which encodes the cGMP-dependent protein kinase (PKG-1), which regulates the phosphatase responsible for dephosphorylating the regulatory light chain and, when mutated, has a gain of function that structurally alters the isoform related to muscle cells smooth and does not allow its inhibitory domain to act, relaxing these cells \[8\].

In this pathology, the predominant change is cystic necrosis of the medial aortic layer, which occurs due to elastic fiber fragmentation, loss of smooth muscle cells, and accumulations of proteoglycans in the extracellular matrix. According to Laplace’s law, there is a directly proportional relationship between the dilation of the aorta and the degree of stress on the wall of this artery. Thus, with the increase in necrosis in the tunica media, there is an increase in the diameter of the aorta and, consequently, risks related to this reality, such as the development of necessary clinical conditions, for example, rupture of the aortic wall \[9\].
Within the development of this aneurysm, there is the knowledge that its formation is not just a degenerative condition but originates in changes occurring in the intracellular and extracellular environment. In this pathology, there is a change in the role of the extracellular matrix, which causes changes in the complete integrity of the structure of the ascending aorta due to the relationship between genetic changes in specific proteins, such as Lisl oxidase, which has the function of reticulating collagen and elastin, and the development of ascending thoracic aortic aneurysm. Such protein genetic modifications are also related to the presence of mutated smooth muscle cells, which encourages the precarious performance of such cells in terms of their contractile role in the smooth muscle and thus facilitates a predisposition to thoracic aortic aneurysm due to the precarious performance of such muscles in the structural support of the wall of the ascending aorta\textsuperscript{[10]}.  

The presence of inflammation is an essential characteristic of this type of aneurysm, given studies that relate the degeneration, as mentioned earlier, to the increased production of reactive oxygen species and the systemic inflammatory response, exposed, for example, by the presence of T lymphocytes and macrophages in the blood from patients with this clinical picture of aortic degeneration. Such blood cells may result from the apotheosis of smooth muscle structures being degraded by the aneurysm. In recent studies, it was seen that, pathophysiological, ascending aortic aneurysm (AAA) is associated with the fibrinogen/albmin ratio (FAR), two proteins highly interconnected with cardiac and vascular pathological processes, which have their relationship as a predictor of inflammatory processes. High FAR has been identified as a risk factor for the progression of AAA, being specific and sensitive in predicting the severity of the disease and its clinical class\textsuperscript{[11]}.  

Finally, restricting the field of study to ascending thoracic aortic aneurysm (AAA), it is clear that this is a rare but highly fatal condition, with its dissection classified as Stanford type A\textsuperscript{[5]}. Epidemiologically, in studies that analyze a large sample of patients undergoing elective AAA surgery, a difference is shown in their clinical profile, with women, in general, being older and with a higher prevalence of other pathologies, such as COPD, hypertension, and renal failure, in addition to having larger aortic diameters\textsuperscript{[12]}.  

**Epidemiology**  
The Thoracic Aortic Aneurysm (TAA) epidemiology presents complexities, mainly due to the high proportion of asymptomatic cases, which corresponds to approximately 95% of the total. This implies that the detection of most TAA s remains limited to situations where they are accidentally identified. The classification of TAA s is carried out according to the segment of the aorta affected. Predominantly, those that affect the aortic root or its ascending portion are the most frequent, representing around
60% of occurrences. Next, we found TAAs of the descending portion of the aorta, with an incidence of 40%, followed by aneurysms of the aortic arch and thoracoabdominal aorta, each responsible for 10% of cases. Giant aneurysms can potentially affect multiple segments of the aorta.

In one study, the incidence of incidental diagnosis of arterial aneurysms was 2.2%, with ascending aortic aneurysms being 0.6%. In 4.4% of the 443 chest computed tomography scans, there was an incidental diagnosis of aneurysms. The majority of aneurysms affected males (60%), with a mean age of 81.5 years. Incidental diagnosis of aneurysms was more common in the thoracic aorta (ascending segment) and abdominal aorta. The average diameters found were 40 mm in the ascending aortic aneurysm, with respiratory symptoms as the main indication for performing a computed tomography associated with the incidental diagnosis of aneurysms.

At the national level, the underreporting of these cases generates information of significant relevance regarding mortality in Brazil. In the period between 2017 and 2021, there was a total of approximately 36 thousand deaths attributed to the ICD I71 classifications, which includes aneurysms and aortic dissections. In a more restricted approach to regional analysis, specifically in the state of Ceará, it is possible to observe 1207 individuals who lost their lives due to the same CID coding in the mentioned time interval. In this more delimited geographical context, the health macro-region corresponding to Fortaleza stands out and is mainly responsible for this mortality rate.

Studies indicate that patients with ascending aortic aneurysms without the involvement of other parts of the aorta, without diseases with genetic predispositions, without surgical follow-up, or under 16 years of age, had a mean age of 57 years, 75.6% being male, size average of ascending aortic aneurysms of 42.6 mm, with an estimated annual aneurysm growth rate of 0.61 mm/year, a linearized mortality rate of 1.99% per patient-year, and a linearized rate of composite outcome of all-cause mortality, aortic dissection and aortic rupture of 2.16% per patient-year. In conclusion, from the analysis of the study in question, the growth rate of AAA is slow and has implications for the interval of imaging follow-up.

Another study used the institutional computed tomography database to characterize the growth rate of ascending thoracic aortic aneurysms in a non-referred population. It analyzed 21,325 computed tomography scans performed at the institution from 2013 to 2016 on patients aged between 50 and 85. Five hundred sixty patients with aortic dilation > 40 mm were identified, of whom 207 had follow-up intervals > 6 months and were followed in the study. The median initial aneurysm size was 43 mm, and the median growth rate was 0.13 mm/year. Although some patients’ ascending thoracic aortic aneurysms may grow at about 1 mm/
year, this is not the predominant pattern in an unrefereed population and may overestimate the overall growth rate, as the study suggested [16].

**IMAGE DIAGNOSIS**

Computed tomography angiography (CTA) is the preferred method for evaluating the aorta due to its ability to quickly capture high-resolution, three-dimensional images, encompassing the region of the aorta and surrounding structures and utilizing contrast to improve visualization. CTA synchronized with the electrocardiogram (EKG) reduces motion artifacts by aligning with the cardiac cycle, although it involves higher doses of radiation; however, dual-source technology can reduce the need for EKG triggering and decrease radiation exposure. Additionally, nuclear magnetic resonance (NMR) offers 3D images with excellent contrast of soft tissues, quantifying anatomical and functional aspects without ionizing radiation. Both techniques have their advantages, thus contributing to a comprehensive assessment of the conditions of the aorta [17].

Ultrasound (US) techniques have a more limited field of view compared to computed tomography (CT) and magnetic resonance imaging (MRI). Although it cannot penetrate bone or gas/air, ultrasound provides functional information with high temporal resolution. Microbubble contrast is used for contrast-enhanced ultrasound (CE US), allowing the detection of endoleaks during endovascular aortic surgery. Both transesophageal echocardiography (TEE) and transthoracic echocardiography (TTE) can be performed at the bedside, providing images of the aorta and its main branches. Intravascular ultrasound is invasive and dynamic, allowing the detection of thrombosis in false lumens. Acute dissections require effective and safe surgical and perfusion strategies to evaluate aortic arch disease for emergency repair. CTA and duplex ultrasound of the carotid arteries provide sufficient information for planning and treatment [17].

Non-invasive imaging techniques, exemplified by cardiovascular computed tomography (CCT) and cardiovascular magnetic resonance (CMR), are accurate and safe for diagnosing and monitoring cardiovascular diseases. As knowledge about cardiovascular disorders advances and new therapeutic approaches become available, the need for detailed information and precise measurements about the stage of these diseases has become essential in determining the most appropriate treatment for each patient. CMR allows a precise analysis of the heart chambers, myocardium, and large vessels such as the aorta. The capacity for contraction can be assessed by identifying areas with scars and quantifying the viability of cardiac muscle tissue and blood flow in the myocardium during periods of stress and rest, enabling the calculation of the coronary flow reserve (RFC) [18].
CMR and CBT techniques have been widely used to achieve earlier and more accurate diagnoses, aiming to select more appropriate therapies according to the information provided by these non-invasive methods. Combining CMR and CBT can evaluate practically all relevant aspects of most heart diseases. CMR and CBT play essential roles in the detailed characterization of cardiovascular diseases. Accurate identification of the advanced profile of the disease, the clinical presentation of the syndrome, and, in some cases, genetic information establishes the basis for choosing the most effective personalized therapeutic approach in cardiovascular diseases.

High-quality aortic imaging plays a crucial role in managing and diagnosing patients with thoracic aortic aneurysms. Computed tomography angiography and magnetic resonance angiography are the most commonly used techniques for the diagnosis and imaging monitoring of thoracic aortic aneurysms, and each technique has unique advantages and limitations that must be weighed when deciding on a patient-specific application, according to the flowchart in table 1.

| Recommendation 7: Preoperative assessment of aortic arch pathologies with CT angiography is recommended as the first line imaging modality. | Class I | Level C |
| Recommendation 8: Assessment of patency and morphology of the circle of Willis is recommended where treatment involves the aortic arch. | Class I | Level C |
| Recommendation 9: Assessment of the extracranial supra-aortic vessels down to the level of the femoral artery bifurcation is recommended where treatment involves the aortic arch. | Class I | Level C |

Extracted from CZERNY et al. 2019 [17].

**Indications for surgical treatment of ascending aortic aeurysm – when to operate?**

The most current guidelines for treating ascending aortic aneurysm (AAA) recommend surgery mainly based on assessing maximum diameter. As described in the European Guideline for Cardiovascular Surgery, the indication for surgery varies depending on the patient's condition. In cases of Marfan syndrome, surgery is recommended for patients with a maximum aortic diameter equal to or greater than 50 mm. In contrast, for patients with a bicuspid aortic valve (BAV), the limit is 55 mm [20].

In patients with additional risk factors, such as family history, systemic hypertension, coarctation of the aorta, or increase in aortic diameter by 0.3 mm/year, a lower limit of 50 mm can be considered, also taking into account age, size of the body, comorbidities and type of surgery. In all cases, regardless of etiology, surgery is recommended for patients with a maximum aortic diameter of 55 mm or more. In patients with small body size, especially those with Turner Syndrome, it is relevant to consider an indexed...
aortic diameter of 27.5 mm/m² of body surface area as a criterion for surgical intervention [20].

The most updated guideline for aortic diseases, produced by the American College of Cardiology/American Heart Association, adjusted the indication for surgery in sporadic aneurysms of the aortic root and ascending aorta, reducing the intervention threshold from 55 mm to 50 mm. Aortic root growth is also considered, from 5 mm in one year or 3 mm in two consecutive years and 3 mm in one year for individuals with genetic predisposition or concomitant aggravating disease [21].

However, several studies reveal that the sole use of this criterion has proven ineffective on several occasions in identifying patients at high risk of aneurysm growth and rupture. Most ascending aortic dissections occur at sizes below the 55 mm limit currently recommended [22]. In one study, a method was proposed to calculate a set of characteristics locally that, in addition to the maximum diameter, aims to improve classification performance for assessing the risk of growth of ascending aortic aneurysms [23].

In addition to the diameter already considered in the guidelines, the ratio between the diameter and the length of the central line, the ratio between the length of the outer and inner lines, and the tortuosity of the ascending tract are analyzed. Six different classifiers were used and compared to predict patients who may present adverse and rapid evolution of AAA and demonstrate how these new local characteristics can complement the information currently provided only by diameter [23].

Regarding measurements related to the shape of the AAA, the tortuosity and asymmetry of the vessel are highly relevant in predicting rupture [24]. Regarding AAA, studies have demonstrated the importance of estimating the length of the ascending tract for decision-making regarding surgery. Aortic measurements were analyzed in three distinct groups of patients: healthy individuals (control group), patients with type A aortic dissection, and patients in the stage prior to aortic dissection. In the pre-dissection group, the mean diameter of the ascending portion was 39 mm. Only one of the 16 patients in this group had a measurement above this limit. There was also an aorta measuring 53 mm, close to this measurement, while the other 14 dissected aortas had diameters less than 50 mm. Furthermore, 75% of the dissected aortas had ascending diameters smaller than 55 mm. These findings indicate that measuring a diameter of 55 mm is not sufficient to identify patients at high risk of dissection [25].

A risk score was developed based on midline length and maximum aortic diameter. Based on the development of a scoring system, a score of 2 was assigned for ascending aorta diameters ≥ 55 mm and a score of 1 for diameters between 45 and 54 mm. Additionally, a complete ascending aorta centerline length from the beginning of the aortic valve to the brachiocephalic trunk of ≥ 120 mm received 1 point. A sum of at least 2 points would suggest a high-risk aortic configuration, which would justify considering preventive surgical intervention [26].
Furthermore, other researchers have shown that greater curvatures of the ascending aorta are related to greater forces exerted on the wall, explaining the potential effect of this factor on the risk of aortic dissection [26]. The risk of aneurysm rupture has also been assessed, considering indices derived from the relationship between the aortic diameter and the patient’s height or body surface. During the research, the prognostic capacity was examined by directly assessing the proportional dimensions of the aorta concerning height expressed through the aortic height index. This index was calculated by dividing the aorta diameter by the individual’s height. More giant aneurysms grew faster, observing that a 35 mm aorta grew 1.1 mm/year, while a 70 mm aorta grew 2.2 mm in one year [27].

Patients with reduced body dimensions require surgery as quickly as possible, as they have a higher aorta/body size ratio, which indicates an increased risk [22]. The aortic size index is a relationship between aortic diameter and body surface area (ASI). According to the study findings, individuals whose aortic size index varies between 2.75 and 4.25 cm/m² have a moderate risk, with an annual incidence of approximately 8%. On the other hand, for those with ASI above 4.25 cm/m², the annual rates of rupture, dissection, or death occur as high as 20% to 25% [28].

A study carried out by a group of Canadian researchers found that three hemodynamic measurements (aortic stiffness, central arterial pressure, and pulsatile arterial load) present results superior to the conventional standard of care for making medical decisions related to aneurysm size, especially about the prediction of its future expansion [29].

This discovery simplifies clinical assessment, making the results more applicable in medical practice. Furthermore, when analyzing interaction terms, researchers observed that specific aortic hemodynamic measurements may better predict aneurysm growth in specific demographic groups, considering factors such as gender, age, or cause of the aneurysm [30].

The characteristics associated with thoracic aortic aneurysm may be helpful in early identification of this condition. These features include the presence of a bicuspid aortic valve, giant cell arteritis, family history of aortic aneurysms, positive palm test result, intracranial aneurysm, anomalous aortic arch, abdominal aortic aneurysm, and simple renal cysts [22, 30].

Several alternative approaches have been proposed to estimate the risk of dissection in patients with borderline dilation of the thoracic aorta. These approaches include measuring alternative dimensions of the aorta, such as length and size in indices, and assessing biomechanical properties of the aorta, such as Young's modulus of elasticity, compliance, distensibility, and wall shear stress, and velocity of the aorta. Pulse wave. Other approaches involve analyzing energy loss, genotyping, and integrating all this information with patient phenotypes, such as hernias, BAV (bicuspid aortic valve), aortic arch variants, and thumbstick testing [22].
The offer of aortic root replacement depends on the dimensions of the aorta, the growth rate, and the presence or absence of a history of dissection in the Family. The surgical approach for the treatment of ascending aortic dilation and aneurysm in cases of aortopathy associated with BAV is well defined in treatment guidelines but still needs more specificities. The ascending aorta is the most common site of aneurysm formation in BAV. A vascular graft could be used in cases of simple extravascular involvement of the ascending aorta, especially for elderly individuals or patients at high risk for radical procedures.

From January 2015 to December 2018, a group of Chinese researchers performed a retrospective review of 119 patients with BAV. It dilated the ascending aorta, which underwent aortic valve replacement in conjunction with ascending aortic surgery. A mild to moderately dilated ascending aorta was found to be between 40 mm and 45 mm in size on computed tomography. Among these patients, 49 underwent an extravascular wrapping of the ascending aorta with a vascular graft procedure, while the other 70 patients underwent ascending aortic replacement.

The research results found that the extravascular procedure is considered a safe and practical method, applicable to a specific group of individuals with aortas without significant calcification and moderate expansion (< 45 mm). The wrap strategy decreased the death rate in the early postoperative period compared to the radical approach of ascending aorta replacement (1.51%). Notably, no mortality is associated with the aorta, either immediately after the procedure or in later stages.

In this procedure, a Dacron graft was used. The parameters that determined the size, length, and cutout of this material were the following: the maximum diameter of the aneurysmal dilatation, the integrity of the aortic wall, the length of the lesser curvature and the greater curvature, as well as the diameter close to the brachiocephalic trunk. The product of the diameter of this region and the tortuosity provided an approximate estimate of the post-wrap circumference of the ascending aorta, which was duly marked.

Current surgical treatment for ascending aortic aneurysm

Repair of thoracic aneurysms was first performed in the 1950s, and since then, surgical techniques have evolved with remarkable survival rates, especially in elective operations. The open surgical approach is used for the treatment of ascending aortic aneurysm with median sternotomy using cardiopulmonary bypass, often requiring aortic root replacement and reimplantation of the coronary arteries, as is performed in the Bentall-De Bono, Tirone-David, and Yacoub and de Robiscek, for example.
The Bentall-De Bono surgery was designed in 1968 by Hugh Bentall and Antony De Bono, who described this technique for the combined treatment of diseases of the aortic valve and the ascending aorta segment, using a valved tube in which the aortic valves were reimplanted. Coronary artery ostia is becoming the procedure of choice for such diseases [36].

The technique consists of median sternotomy with extracorporeal circulation through cannulation of the right atrium and the segment of the ascending aorta proximal to the brachiocephalic trunk or peripherally (femoral route or subclavian artery), depending on the surgical pathology to be treated. Then, moderate hypothermia (30°C–32°C), clamping of the ascending aorta, and cardiac arrest are performed with crystalloid solutions for cardioplegia. This is followed by transverse aortotomy, replacement of the native aortic valve, and fixation of the valved tubular graft, anastomosing proximally to the aortic ring. Finally, the coronary artery buttons are fixed to the graft, and its anastomosis is in the area close to the aortic clamp, as shown in Figure 1 [37].

In 1992, surgeons Tirone and Feindel observed that 30% to 50% of patients undergoing surgical treatment for aneurysms of the ascending aortic segment had standard aortic leaflets. Given this, the Tirone-David surgery proposes a new surgical correction technique in which the aortic valve is preserved and reimplanted in the aortic graft, avoiding a valve prosthesis implantation and its consequences. The technique follows the initial steps of Bentall-De Bono; however, there is no resection of the aortic valve, the aorta being resected circumferentially close to the sinuses of Valsalva, leaving a margin of 5 to 7 mm of aortic walls in continuity with the valve ring, with an equal margin left around the coronary ostia in preparation for their reimplantation and finishing this surgery in the same way as Bentall, as shown in Figure 2 [39, 40].
Another surgical technique that spares the aortic valve is the surgery proposed by Yacoub in 1993, which aims to improve the patient’s longevity free from complications related to valve prostheses (mechanical or biological). In this procedure, there is excision of the coronary ostia and resection of the aortic sinuses up to a 2 to 3-mm edge of the aortic wall (and complete resection of the aortic root) sutured with a tubular graft trimmed to produce tongue-shaped extensions, thus creating three new Valsalva breasts. This technique differs from Tirone-David in the internal fixation of the commissural pillars and aortic ring graft, as seen in Figure 3 [42, 43].

In addition to the techniques for replacing the segment of the ascending aorta and replacing or preserving the aortic valves, reduction Aortoplasty surgeries emerged, which were initially proposed in the 50s and 60s, but only at the end of the 70s were they refined by Francis Robicsek [44].

In this technique, an oval segment of the anterior wall of the ascending aorta is resected, and the remaining aortic tissue is then directly sutured in an attempt to maintain the aorta with a diameter of less than 35 mm. To prevent the
diseased and previously aneurysmal aortic tissue from dilating again, an external support is usually used to cover the aorta, such as a belt, preserving this new diameter, illustrated in Figure 4 [45, 46, 47].

Aortic sheathing, in turn, is a procedure used since the 1960s, initially using a polypropylene mesh. In the classically described approach, a tubular vascular prosthesis, with a predefined diameter and smaller than the diameter of the aneurysmal aorta, is sectioned, positioned to surround the aorta, and sutured externally in order to compress the aorta and prevent its dilation [48].

In another similar approach, instead of using a tubular prosthesis, a bovine pericardium plate is used, with a length defined by the assistant surgeon, and this plate surrounds the aorta like a belt, this plate being sutured externally also to fix the diameter of the tubular portion of the ascending aorta [47, 49, 50].

These approaches are technically more straightforward and can reduce CPB time as well as complications resulting from ascending aorta replacement [51]. In addition to maintaining the usual conformation of the aorta, allowing physiological helical blood flow through this artery, and keeping the endothelium and native aortic valve intact, with good results in the medium term [46, 47, 52, 53]. However, in more complex cases, with the involvement of the aortic root, these approaches cannot be applied directly since the commonly manufactured tubular prostheses do not adapt to the structure of the sinuses of Valsalva [54].

Seeking a simpler surgical alternative that would allow the treatment of AAAs involving the aortic root, Golesworthy, and collaborators conceived 2004 the development of a personalized external aortic root support (PEARS) [55]. In this approach, based on images obtained by computed tomography angiography and MRI, a replica of the aorta of a patient with Marfan syndrome was constructed, and a personalized prosthesis was manufactured to externally cover this aorta, with
the exact contours of the artery of the patient, Figure 5 [55, 56].

Since this initial approach, other groups have adopted the use of a PEARs with good clinical results, especially with the use of more porous mesh, which would avoid accumulation of liquid between the aorta and the external support, avoiding displacement of the latter and reducing the incidence of possible postoperative complications [31, 34, 56, 57].

CONCLUSION

Considering the various surgical techniques for correcting aortic aneurysms, this work ranged from conventional to more modern. In this way, by better understanding the pathophysiology, epidemiology, and available techniques, we can broaden our horizons on which intervention, which subjects, and the advantages and disadvantages of such an action in treating these aneurysmal patients.

REFERÊNCIAS

Ascending thoracic aortic aneurysm: update on definition, indications for surgical treatment


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