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Thoracic aortic aneurysm surgery in a third level single center. Five years experience

Cirugía del aneurisma de aorta torácica en un centro hospitalario de tercer nivel. Experiencia de cinco años

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ABSTRACT

Introduction: aortic aneurysms and acute aortic syndrome are the two most frequent entities within the thoracic aortic pathology that require surgical intervention. The indication for aneurysm is elective, while acute aortic syndrome is an emergency. **Objective:** to describe the current state of surgical treatment of patients with aortic aneurysm in a third level single center from January 2016 to December 2020. **Material and methods:** this is a descriptive cross-sectional study to identify demographic characteristics, risk factors, clinical presentation, imaging, perioperative variables, morbidity and mortality. **Results:** eighty patients were included, 39 with the diagnosis of thoracic aortic aneurysm and 41 with the diagnosis of thoracic acute aortic syndrome. Within the group of aneurysms, 34 (87%) were men and 5 (13%) women. The predominant symptom was dyspnea. Severe acute aortic regurgitation was present in 70% of cases, and bicuspid aortic valve present in 23%. The most frequent location was at the level of the root and ascending aorta in 51% of patients. The most frequently performed surgical procedure was the composite graft implantation with the Bentall technique. Early mortality was 15% and morbidity of 45%. **Conclusions:** aortic aneurysm is an entity that must be treated in third level units. A multidisciplinary team trained in thoracic aortic surgery is required to reduce morbidity and mortality and achieve international standards in terms of results.

Keywords: aortic surgery, bentall procedure, thoracic aortic aneurysm.

RESUMEN

Introducción: *los aneurismas de la aorta y síndrome aórtico agudo constituyen las dos entidades más frecuentes dentro de la patología de aorta torácica que requieren de una intervención quirúrgica. La indicación del aneurisma es electiva, mientras que el síndrome aórtico agudo es una urgencia.* ***Objetivo:*** *describir el estado actual del tratamiento quirúrgico de los pacientes con aneurisma de aorta torácica en un centro hospitalario de tercer nivel, de enero de 2016 a diciembre de 2020.* ***Material y métodos:*** *se trata de un estudio descriptivo para identificar las características demográficas, factores de riesgo, presentación clínica, de imagen, variables perioperatorias, morbilidad y mortalidad.* ***Resultados:*** *se identificaron 80 pacientes, 39 con diagnóstico de aneurisma de aorta torácica y 41 con síndrome aórtico agudo torácico. Dentro de los aneurismas, 34 (87%) fueron hombres y 5 (13%) mujeres. El síntoma predominante fue la disnea. La insuficiencia aórtica aguda severa estuvo presente en 70% de los casos, y válvula aórtica bivalva se identificó en 23%. La localización más frecuente fue a nivel de la raíz y aorta ascendente en 51% de los pacientes. El procedimiento quirúrgico más frecuentemente realizado fue el implante de tubo valvulado con técnica de Bentall. La mortalidad temprana fue de 15%, y la morbilidad de 45%.* ***Conclusiones:*** *el aneurisma aórtico es una entidad que debe ser atendida en unidades de tercer nivel. Se requiere de un equipo multidisciplinario capacitado en cirugía de aorta torácica para disminuir la morbimortalidad y alcanzar los estándares internacionales en cuanto a resultados.*

Palabras clave: *cirugía aórtica, procedimiento de Bentall, aneurisma de aorta torácica.*

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Pathology of the aorta includes different diseases such as aortic aneurysms, acute aortic syndrome, congenital anomalies and traumatic pathology.[1] The most serious complication is aortic dissection or rupture. Ruptures are usually fatal; symptoms include severe chest pain with low blood pressure or signs of shock. Patients with aortic dissection experience severe chest pain that is acute in onset and described as a tearing sensation.[2]

In 1968 Bentall and Bono described a technique to replace the ascending aorta and the aortic valve with a tubular graft containing a valve prosthesis with reimplantation of the coronary arteries, this technique being the technique of choice today.[3] In 1993 Sarsam and Yacoub described aortic root remodeling with aortic valve preservation.[4]

The aorta is an artery that arises from the left ventricle until its division at the level of the lower edge of the fourth lumbar vertebra, it is divided by the diaphragm into the thoracic and abdominal aorta. The thoracic aorta consists of four main segments: aortic root, ascending aorta, aortic arch, and descending aorta. The ascending aorta has an average length of 5 to 7 cm. Classically, its initial part is considered the aortic root, which is histologically different.[5] The aortic root represents a fibrous and complex structure, which by definition extends from the aortic annulus to the sinotubular junction, it is a short segment of around 2-3 cm in length, which consists of three components: the cusps, the sinuses of Valsalva and the intercalated triangles, in other literature the ostia of the coronary arteries are also included.[6,7] The aortic arch is the continuation of the ascending aorta, a structure outside the pericardium, below the lower half of the sternal manubrium, with a normal curvature to the left until the fourth thoracic vertebra to continue as the component descending thoracic aorta.

The normal diameter of the aorta depends on the age, sex and height of the individual. An aneurysm is an increase in diameter 1.5 times normal. In addition to its conduit function, it participates in the control of systemic vascular resistance and heart rate, as well as Windkessel (second pump) function. It has a diameter that does not exceed 40 mm in healthy adults (upper limit is 40 mm in men and 34 mm in women).[8]

The most common location for thoracic aortic aneurysms is in the aortic root and ascending aorta, they can also occur in the descending thoracic aorta and less frequently in the aortic arch. 70% involve the aortic root and/or ascending aorta, 40% affect the descending thoracic aorta, 10% affect the aortic arch, and 10% affect the thoracoabdominal aorta. The most common cause of thoracic aortic aneurysms is a cystic degenerative process of the media, where the elastic fibers of the wall degenerate, weakening it, causing aneurysmal dilation. This phenomenon occurs around 60-70 years of age. Smoking and systemic high blood pressure are also associated with aneurysm formation. In young patients it may have a genetic origin. These include connective tissue disorders such as Marfan, Loeys-Dietz and Ehlers-Danlos syndrome, or familial thoracic aortic aneurysm syndrome.[2,9]

The average growth rate of an aneurysm is 0.1 cm per year. Diameter is the main predictor of aortic rupture or dissection. Follow-up imaging studies are usually performed every six months and then annually. The annual risk of rupture or dissection of thoracic aortic aneurysms is approximately 2% for those with a diameter < 5 cm, 3% for 5-5.9 cm, and 7% for those > 6 cm. The growth rate is significantly higher for ascending aortic aneurysms. The definitive diagnosis requires an angiotomography or magnetic resonance angiography with the use of intravenous contrast material, an imaging technique that allows 3D reconstructions, obtaining an accurate diagnosis and thus a surgical/endovascular plan. Once a thoracic aortic aneurysm is detected, it requires abdominal imaging.[10]

Thoracic aortic aneurysm is an entity that is usually diagnosed incidentally, with complications occurring in many cases as the first manifestation, bringing with it a high fatality rate. In high-risk individuals who have conditions such as Marfan syndrome, other collagenopathies, bicuspid aortic valve, intracranial aneurysms, aortic arch anomalies, renal cyst, abdominal aneurysm, temporal arteritis and a positive family history for aortic aneurysms, the use of tomography is indicated.[11,12]

The guidelines of the American College of Cardiology, American Heart Association, Society of Thoracic Surgery & American Association for Thoracic Surgery recommends repair of all symptomatic aneurysms. On the contrary, in asymptomatic patients, elective surgery is recommended for aneurysms with a diameter > 5.5 cm. The risk of rupture is higher with lower diameters in patients with certain genetic disorders. Surgical intervention is recommended when it reaches 4.5 cm in diameter for patients with Marfan syndrome and 4.0 cm for Loeys-Dietz syndrome. For patients with a bicuspid aortic valve, surgery is recommended for aortic diameters > 5.5 cm, but intervention at 5 cm may be recommended in patients with a family history of dissection or who grew rapidly. In aneurysms of the descending aorta, the threshold for intervention is about 6 cm. For any patient with a growth rate greater than 0.5 cm per year, intervention is recommended since there is an increased risk of rupture.[8,11,12]

The French surgeon Ambroise Paré first described the rupture of a thoracic aortic aneurysm. He said that aneurysms that occur within internal parts are incurable. Concept that has changed for seven decades.[13] In a review of the literature from 1946 to 2017, 20 studies were included with 8,800 patients with a diagnosis of ascending aortic aneurysm, with a mean age of 57 years, the mean diameter of the aneurysm during the

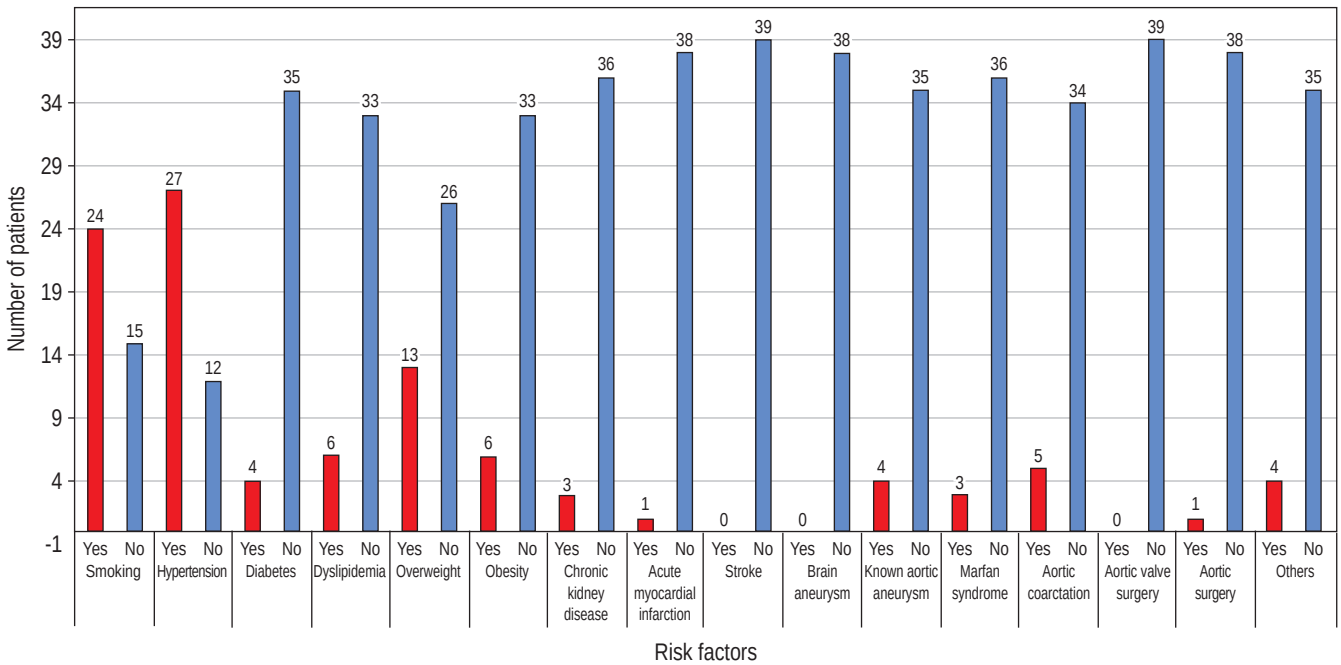

Figure 1: Risk factors in patients undergoing surgery for thoracic aortic aneurysm.

registry was 42 mm, with an elective surgery rate of 13.8% during a mean follow-up of 4.2 years.[14]

Replacement of the dilated segment with a valved tube used to be the standard treatment for patients with aortic root/ascending aorta aneurysm. However, in the last three decades, procedures have been developed whereby the aneurysm is replaced with a Dacron graft preserving the aortic valve, with good results in experienced centers.

The standard treatment has been replaced with a composite graft (the most commonly used conduit is a Dacron graft containing a mechanical valve). An alternative is valve-sparing surgery.[15] Aortic valve-sparing surgery includes reimplantation of the aortic valve performed with a tubular graft or with a custom graft to recreate the coronary sinuses. While aortic remodeling is performed with a Dacron tube adapted to recreate the coronary sinuses, suturing the tube to the sinuses and aortic ring. Both procedures have been shown to be effective, as long as there is adequate patient selection and the center has surgical experience.[16] Price et al. included 165 patients with Marfan syndrome and aortic root aneurysm 98 underwent aortic valve-preserving surgery (69 reimplantations and 29 remodeling) and 67 underwent the Bentall procedure. There were no in-hospital deaths, 10-year survival was 90.5% in the Bentall procedure and 96.3% in valve-sparing surgery.[17] In a retrospective study, Zhang et al. included 135 patients with Marfan syndrome; they were divided into four groups: David, Bentall surgery, proximal and distal arch surgery with endovascular prosthesis. After 15 years there were no deaths in the David Procedure group, while the 15-year survival rate for patients in the Bentall group was 73 + 13.5% and 71 + 13.9% for patients in the Bentall group and arch surgery. Therefore, it was determined that it had more benefits and a higher long-term survival rate.[18] Aortic root replacement surgery with David valve preservation was studied from 1993 to 2009 by Escobar et al, in 233 patients (40% of them with Marfan syndrome). Survival at 5 and 10 years was 98 and 93% respectively. Free of reoperation in 92% at 10 years (three reoperations were aortic valve replacement due to structural deterioration). The absence of structural deterioration of the valve at 10 years was 96%.[19] At our institution, Ramírez et al. reported from 1999 to 2003, 39 patients with thoracic aortic aneurysm undergoing surgical treatment. Of the 39 patients who underwent surgery, 16 (41%) had a secondary aortic aneurysm with dissection and 23 (59%) had aneurysm only. Of the 16 with dissection, 15 (87.5%) had type A dissection and two (12.5%) had type B dissection. 12 patients had Marfan syndrome. In 35 patients (88.7%) the aneurysm was located in the ascending aorta, 1 in the aortic arch and 3 (7.77%) in the descending aorta. With an early overall mortality of 7% and a postoperative morbidity of 68.9%.[20] In the world, aortic pathology is relatively common, occupying an important place in morbidity and mortality in the United States, Japan and Asian countries. Its care requires human, economic and infrastructure resources. In Mexico there are no adequate statistics, since it is an underdiagnosed pathology as it is a silent disease in many cases, only until the different complications already known are established.[21]

MATERIAL AND METHODS

A descriptive study was carried out which studied the demographic characteristics, risk factors, clinical presentation, findings in non-invasive imaging studies, mortality and morbidity of patients with a diagnosis of thoracic aortic aneurysm who required surgical treatment in our institution. Data collection was carried out retrospectively directly from the clinical records.

RESULTS

In the study period, from January 2016 to December 2020 at our institution, 80 patients were identified, 39 with the diagnosis of thoracic aortic aneurysm and 41 with the diagnosis of acute aortic syndrome (39 with dissection, 1 hematoma and 1 perforating ulcer). Within the aneurysm group, 34 (87%) were men and 5 (13%) women. The minimum age found was 21 years, maximum 85 years, median 54, and average 53 years.

Regarding the risk factors found in this series, the most relevant were high blood pressure and smoking; however, diabetes, overweight, obesity, stroke, known aortic aneurysm, Marfan syndrome and aortic coarctation were also present, but frequently lower than the first two *(Figure 1)*.

In the clinical presentation of patients with aneurysm, the most frequent symptoms were dyspnea and chest pain. *(Table 1)*. The dimensions and frequency measurements of the aortic annulus, root, sinotubular junction, and ascending aorta are represented in *Table 2*. The involvement of the aortic valve was present in the thoracic aortic aneurysm, finding in our series the predominance of lesions due to severe aortic insufficiency (74%), as well as bicuspid aortic valve (23%) *(Table 3)*. According to the location of the aneurysm, the most frequent presentation is in both the root and ascending (51%) *(Figure 2)*. The score most used to calculate surgical risk in our unit is the EuroScore II, in this series a minimum of 0.5, maximum of 19.6, median of 2.68, mode 1.27, mean 3.78 and SD 3.86 were calculated.

In relation to the most frequent location of the thoracic aortic aneurysm, the most frequently performed surgical procedure is the implantation of a composite graft with the Bentall technique in all cases. Additionally, two patients underwent myocardial revascularization surgery and four underwent packing. None underwent any surgical intervention in a second surgical stage during hospitalization, regardless of the unpacking procedure *(Figure 3)*. The most used type of cardioplegia was intracellular Bretschneider in 92% of cases, the degree of moderate hypothermia in 82% of cases and the most frequent rhythm after aortic unclamping was ventricular fibrillation with 51% *(Table 4)*. Regarding the operative variables of cardiopulmonary bypass, aortic clamping, bleeding, transfusion of blood products and cell recovery, they are reported in *Table 5*. A total of six deaths were identified (early mortality of 15.3%), two were intraoperative deaths and four were postoperative deaths. Five in the composite graft group (mortality 19.2% in the group), one of a composite graft with debranching, no deaths were identified in the root-preserving aortic valve surgery group or in the supracoronary graft. In this series, 16 patients presented some postsurgical complication (morbidity of 45.6%). The most frequent complications were related to bleeding greater than usual and its reintervention, as well as

Table 1: Symptoms in thoracic aortic aneurysm.

Symptoms	Number of patients	%
Asymptomatic	4	10
Chest pain	17	44
Abdominal pain	1	3
Low back pain	1	3
Dyspnoea	27	69
Nausea/Vomiting	0	0
Cough	3	8
Syncope	2	5
Dysphonia	0	0
Dizziness/Vertigo	3	8
Dysphagia	0	0
Shock state	0	0
Others	0	0

Table 2: Measurements of the aortic annulus and ascending aorta in patients with thoracic aortic aneurysm.

	N	Minimum	Maximum	Median	Mode	Mean	SD
Aortic ring	39	17	38	25	26	25.59	4.27
Aortic root	39	20	81	49	43	52.13	14.11
STJ	35	29	85	45	48	48.74	14.88
Ascending aorta	38	27	83	52	70	53.92	15.68

SD = standard deviation. STJ = sinotubular junction.

Table 3: Aortic valve disease in thoracic aortic aneurysm.

		Number of patients	%
Aortic stenosis	No stenosis	30	77
	Mild	1	3
	Moderate	1	3
	Severe	7	18
Aortic insufficiency	Without insufficiency	1	3
	Mild	6	15
	Moderate	2	5
	Severe	30	77
Bivalve aorta	Yes	9	23
	No	29	74

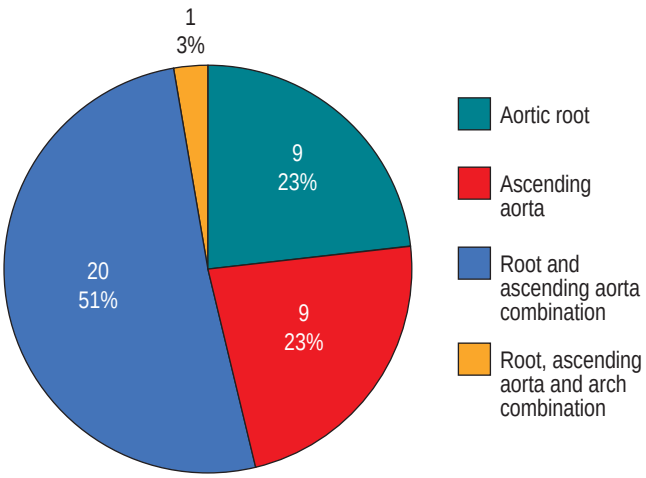

Figure 2: Location of thoracic aortic aneurysm

pneumonia *(Figure 4)*. Regarding the days of hospital stay in surgery for thoracic aortic aneurysm, we have found an average of 16.15 ± 8.8 days *(Table 6)*.

DISCUSSION

Thoracic aortic aneurysm and acute thoracic aortic syndrome are two different entities of the thoracic aorta, both in clinical presentation and the state with which they enter the operating room. The surgical indication for aneurysm is elective, while acute aortic syndrome is an emergency. Both entities share the same surgical techniques for their resolution.

Ascending aortic aneurysms are generally an asymptomatic entity with catastrophic complications of rupture and dissection. Aortic diameter is currently the main variable for the risk of dissection and rupture. The diameter in a healthy adult does not exceed 40 mm (upper limit of 40 mm in men and 34 mm in women).[2,8]

In our group of only thoracic aortic aneurysms, we found asymptomatic 10% of cases, while the predominant symptom was dyspnea (69%), followed by chest pain (44%). In our center, the population studied with thoracic aortic aneurysm has a mean age of 53.41 ± 16.3 years, similar to that reported

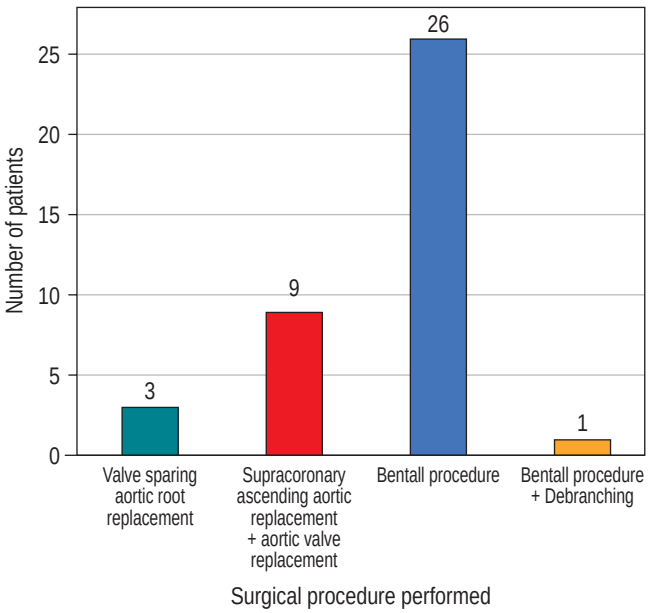

Figure 3: Type of surgical intervention in thoracic aortic aneurysm.

Table 4: Operative variables of cardioplegia, hypothermia and rhythm in patients undergoing surgery for thoracic aortic aneurysm.

		Number of patients	%
Type of Cardioplegia	Bretschneider	36	92
	St Thomas	3	8
	Of the nest	0	0
	Hematic	0	0
	Other	0	0
Degree of hypothermia	Mild	4	11
	Moderate	32	82
	Deep	3	7
Rhythm after aortic clamping	Sinus rythm	13	33
	AV block	4	10
	Atrial fibrillation	20	51
	Ventricular tachycardia	2	5
	Atrial fibrillation	0	0
	Other	0	0

Table 5: Operative variables of cardiopulmonary bypass (CBP), aortic clamping and use of blood products in patients undergoing surgery for thoracic aortic aneurysm.

	CBP (min)	Aortic clamping (min)	Bleeding (ml)	RBCC transfusion	FFP transfusion	PP transfusion	Cryoprecipitates transfusion	Autologous blood from Cell Saver (ml)
N Valid	39	39	38	39	39	39	39	39
N Lost	0	0	1	0	0	0	0	0
Minimum	83	58	210	0	0	0	0	0
Maximum	358	258	1,790	6	7	2	10	2,900
Mean	172.41	129.87	631.87	1.67	2.31	0.92	0.28	693.18
Median	148.00	122.00	537.50	1.00	2.00	1.00	0.00	613.00
SD	67.39	45.59	364.43	1.59	1.77	0.62	1.60	628.13

FFP = fresh frozen plasma. PP = plateletpheresis. RBCC = red blood cells concentrate. SD = standard deviation.

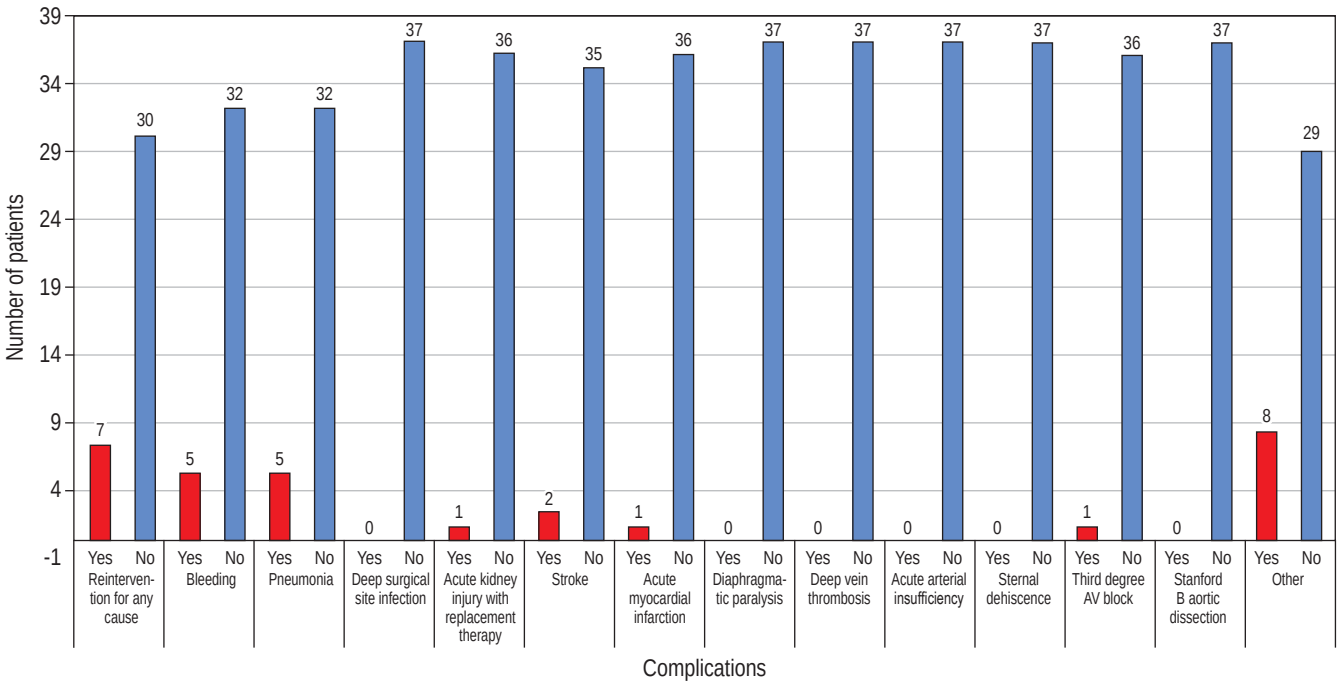

Figure 4: Complications in surgery for thoracic aortic aneurysm.

by Guo et al. in one review of 8,800 patients (mean age 57.75 ± 9.4 years) [14]. In our hospital, two decades ago, Ramírez et al. reported a younger age at presentation, with a mean of 47 years (range 2-78 years).[20]

The frequency of presentation with respect to sex was higher in men with 87% vs. women in 13%, a higher proportion than reported by Guo et al. (75.65% men),[14] being similar to what was reported by Ramírez et al. (82.05% men and 17.94% women).[20]

In our series of aortic aneurysms, we found a median diameter of the ascending aorta of 52 mm and a mean of 53.92 ± 15.68 mm. The mean size reported by Guo et al. at the time of registration was 42.6 mm (range 35.5-56 mm).[14] Ramírez et al. report a diameter of 6.5 to 15 cm (mean, 8 cm).[20] We observed a smaller aortic diameter at the time of the intervention after two decades in our institution.

The risk factors for thoracic aortic aneurysm described in the literature and found in our unit are systemic arterial hypertension (69%) and smoking (62%). Other factors such as overweight/obesity (19 cases), dyslipidemia (six cases), Marfan syndrome (three cases), aortic coarctation (five cases) and chronic kidney disease (three cases) are present, but

with better frequency. Although Marfan syndrome is highly associated with aneurysm and aortic dissection, in our unit, taking both entities into account, we have nine cases reported. Ramírez et al. reported that 41% (16 cases) had high blood pressure, 53% (21 cases) had smoking, and 30% (12 cases) had Marfan syndrome.[20]

In our series of ascending aortic aneurysms, we found greater aortic annuloectasia with a median diameter of the aortic annulus of 25 mm and mean of 25.59 ± 4.27 mm associated with severe insufficiency in 77% of patients and bicuspid aortic valve in 23%.

According to previously reported in the literature, thoracic aortic aneurysms are more frequent at the level of the aortic root and ascending aorta.[2] In our series, we found that 51% involve both the ascending aorta and the aortic root, followed by involvement of only the aortic root in 23% and isolated ascending aorta in 23%. Ramírez et al. report the ascending aorta as the most frequent site of aneurysm location in 88.7%.[20]

In our unit, the most used surgical technique for thoracic aortic aneurysm is the Bentall procedure compared to what happens worldwide where aortic root replacement surgery with preservation of the aortic valve is performed more frequently even in patients with Marfan syndrome with a 10-year survival of 90.5% for Bentall and 96.3 % for aortic valve-sparing surgery.[17]

The most commonly used type of cardioplegia in our unit is Bretschneider's intracellular cardioplegia. The cardioplegia used in large series is not specified. Also the most frequent exit rhythm is ventricular fibrillation in 51% of cases and the most used type of hypothermia is moderate hypothermia in 82% of cases.

Circulatory arrest with and without cerebral perfusion has been used in this type of procedure. However, in our unit, it was only reported on one occasion without determining whether or not cerebral perfusion existed and the duration thereof.

Table 6: Days of hospital stay in patients undergoing surgery for thoracic aortic aneurysm.

	Days of cardiac surgery ICU stay	Days of hospital stay	Total days of stay
Minimum	3	2	7
Maximum	27	36	44
Median	5	8	15
Mode	4	6	15
Mean	7.33	9.09	16.15
SD	5.38	6.67	8.8

ICU = Intensive Care Unit. SD = standard deviation.

In our series, a morbidity of 45.6% was identified, the most frequent being bleeding, as well as pneumonia. Ramírez et al. reported a morbidity of 72.9%, the main one also being bleeding greater than usual.[20]

In the thoracic aortic aneurysm group, we have a median stay in cardiac surgery intensive care unit of five days and an average of 7.3 ± 5.38 days, a median stay in hospital of 8 days and a mean of 9.09 ± 6.67 days, a median total stay of 15 days and a half days 16.5 ± 8.8 days. Ramírez et al. report an average stay in cardiac surgery intensive care unit of 6.7 days (range of 2 - 46 days) and an average hospital stay of 14.4 days (range of 6-64 days).[20]

We can conclude that aortic aneurysm is a disease of the aorta that, although rare, has high clinical relevance due to its high morbidity and mortality and should be treated in a tertiary care unit. A multidisciplinary team trained in thoracic aortic surgery is required to reduce morbidity and mortality and achieve international standards in terms of results. This will allow standardization of the surgical technique, perfusion management, myocardial protection methods, and perioperative management for greater experience of the surgical, anesthetic and medical team.

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