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SUMMARY

ORIGINAL ARTICLE

SURGICAL ANATOMY OF THE MITRAL VALVE

Mitral valve relationship with the circumflex artery and its surgical implications

ABSTRACT

Introduction: The gold standard for mitral valve disease is surgical treatment, for which it is essential to have a deep understanding of its anatomy. Our work aims to specify the relationships of the mitral annulus with the circumflex artery and define areas of proximity and greater risk of compromise during mitral interventions.

Material and methods: A descriptive, observational, cross-sectional study was conducted, in which 39 hearts from adult cadavers fixed in formaldehyde solution were dissected. From an atrial view of the mitral valve, taking the mitral annulus as a reference, several measurements were taken using Carpentier´s classification of the sectors of the posterior mitral valve (P1, P2, and P3). Distance 1: from the anterolateral commissure to the circumflex artery. Distance 2: from the middle third of P1 to the artery. Distance 3: from P2 to the artery. Distance 4: from P3 to the artery.

Results: The global mean of distance 1 was 8.38 mm, of distance 2 was 8.16 mm, of distance 3 was 7.09 mm, and of distance 4 was 7.97 mm. We found no statistically significant differences according to coronary dominance.

Conclusion: The area of highest risk of injury to the circumflex artery concerning to the mitral annulus corresponds to the P2 sector of the posterior mitral leaflet. Left dominance and codominance would be associated with a greater risk.

Key words: *Mitral Valve; Coronary Vessels; Cardiac Surgical Procedures.*

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INTRODUCTION

Valvular heart disease is responsible for 10-20% of cardiac surgeries in the US [1].

The repair of injuries is considered with increasing precociousness due to advances in surgical techniques and the development of percutaneous techniques. The aforementioned has resulted in the relief of symptoms and the preservation of ventricular function, thus improving patients' survival and quality of life [2-4].

The mitral valve (MV) can be affected by stenosis or regurgitation. About mitral stenosis, in most cases, it is of rheumatic origin and, therefore, nowadays rare [4].

Mitral regurgitation can be divided into two major causes: functional or secondary and primary or organic. An imbalance between the closing and anchoring forces, secondary to alterations in the geometry of the left ventricle, produces functional or secondary regurgitation. The initial cause is at the valve level in primary or organic regurgitation. It can be due to various diseases that directly affect the components of the MV (leaflets, chordae tendinous, papillary muscles). Until a few decades ago, its most common cause was rheumatic fever. Nowadays, the most common etiology is degenerative, associated with myxoid degeneration [4,5].

The gold standard for the treatment of MV disease is surgical treatment. Endovascular devices are mainly applied to patients with secondary mitral regurgitation who do not benefit from surgical treatment and/or present prohibitive surgical risk or are inoperable [2,3,5].

It is, therefore, essential to have a deep understanding of the anatomy of the MV and its relationships with the atrioventricular (AV) node, the circumflex artery, and the great cardiac vein.

Our work aims to specify the relationships of the mitral annulus with the circumflex artery and define areas of proximity and greater risk of injury during mitral interventions.

MATERIALS AND METHODS

A descriptive, observational cross-sectional anatomical study was conducted, and 39 hearts from adult cadavers of both sexes were fixed in a formaldehyde solution to be used. The average age of the donors was 55 to 65 years, and they did not present cardiovascular disease, being excluded those that presented it.

The chest was approached by bilateral paramedian lateral thoracotomy, and posteriorly the cardiopulmonary block was removed. Both pulmonary pedicles and the great supracardiac vessels were dissected. An inverted "T" pericardiotomy was performed at the same time, and the intrapericardial pulmonary veins, the vena cava, and supra-aortic vessels were sectioned, releasing the heart.

Once the heart was released, the left atrium (LA) was approached by a vertical left atriotomy at the level of the posterior wall of the LA, with a lateral extension of the commissures towards the pulmonary veins. Subsequently, the lower lateral incision was extended parallel to the mitral annulus. In this way, better exposure of the atrial face of the MV was achieved.

The circumflex artery (CxA), its course through the coronary sulcus, and its collateral branches were identified.

From an atrial view of the MV and taking the mitral annulus as the measurement site, the anterolateral commissure and the sectors of the posterior MV P1, P2, and P3 according to the Carpentier classification (*Figure 1*) were chosen as measurement sites [6].

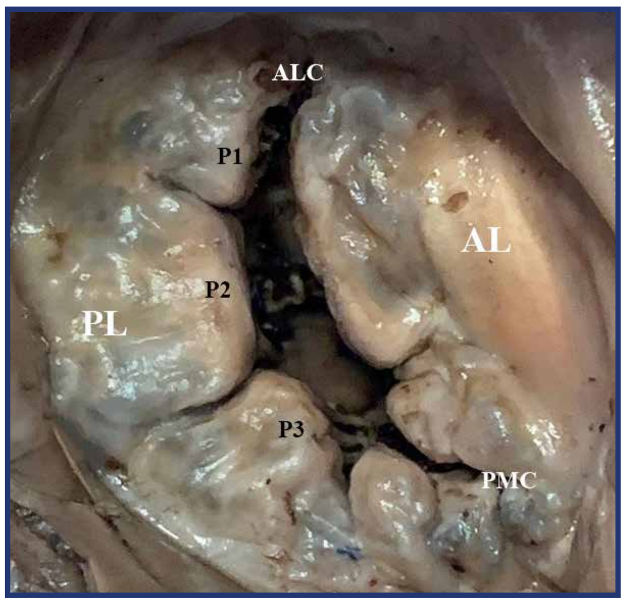

FIGURE 1. Atrial view of the mitral valve in a cadaveric piece. AL: Anterior leaflet, PL: Posterior leaflet, ALC: Anterolateral commissure, PMC: Posteromedial commissure, P1: Lateral portion of the posterior leaflet, P2: Middle portion of the posterior leaflet, P3: Medial portion of the posterior leaflet, CxA: Circumflex coronary artery, CS: Coronary sinus.

Posteriorly, the following measurements were made: from the anterolateral commissure to the CxA (distance 1); from the middle third of P1 to the CxA (distance 2); from the middle third of P2 to the CxA (distance 3) and finally the distance from the middle third of P3 to the CxA (distance 4) (*Figures 1 and 2*).

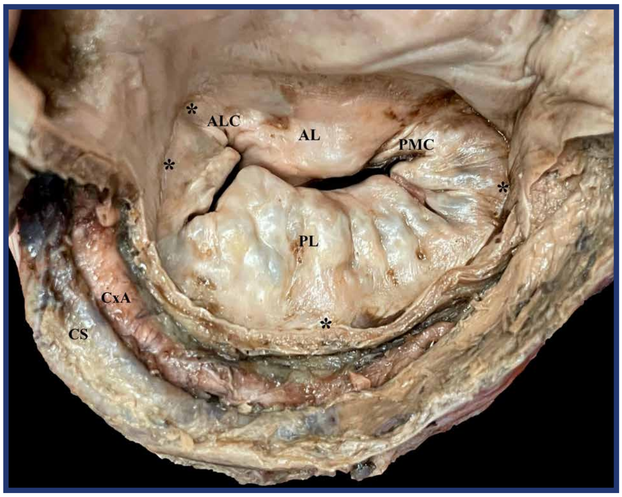

FIGURE 2. Atrial view of the mitral valve in cadaveric piece with a pattern of right dominance. AL: Anterior Anleaflet, PL: Posterior leaflet, ALC: Anterolateral commissure, PMC: Posteromedial commissure, CxA: Circumflex coronary artery, CS: Coronary sinus. Asterisks indicate the points of measure between the annulus to the circumflex coronary artery.

Cardiac dominance was defined according to which coronary artery originated the posterior descending artery. In some right-dominant hearts, measuring the artery in relation to P2 and P3 was impossible.

All measurements were made with a millimeter numerical caliper and by the same observer.

Continuous variables were expressed as a mean, range (minimum-maximum), and standard deviation (SD). Categorical variables were expressed as absolute numbers and percentages. Distances were compared in cadavers with left and right cardiac dominance using the Mann-Whitney U test, and a value of $p < 0.05$ was considered significant.

RESULTS

Of the 39 dissected hearts, 33 presented right coronary dominance (85%), five left coronary dominance (13%), and one codominance (2%).

The global mean of distance 1 (D1) was 8.38 mm, that of distance 2 (D2) was 8.16 mm, that of distance 3 (D3) was 7.09 mm, and that of distance 4 (D4) was 7.97 mm (*Table 1*).

In right-dominant hearts, the mean D1 was 8.32 mm (range 1-16 mm); that of D2 was 8.25 mm (range 2-15 mm); that of D3 was 7.41 mm (range 4-18 mm); and that of D4 was 8.63 mm (range 3-15 mm).

In the case of right-dominant hearts in which it was possible to measure D3 and D4, the CxA reached the lower face of the left ventricle, originating a posteroventricular branch for the lower face.

In left-dominant hearts, the mean D1 was 9.40 mm (range 3-11.5 mm); that of D2 was 7.60 mm (range 2-11 mm); that of D3 was 5.20 mm (range 2.5-11 mm); and that of D4 was 6.75 mm (range 3-13 mm).

In the only case of codominance, the mean of D1 was 5.5 mm; that of D2 was 8 mm; that of D3 was 9.5 mm; and that of D4 was 5 mm.

We found no statistically significant differences between hearts with right and left coronary dominance (*Table 2*).

DISCUSSION

The mitral annulus is part of the central fibrous skeleton of the heart and acquires essential relationships with the AV node, the CxA, and the great cardiac vein. The precise anatomical knowledge of these relationships is of enormous hierarchy during the intervention of the MV in order to reduce complications. The MV is formed by the anterior and posterior leaflets. The posterior veil adheres to the mitral fibromuscular annulus at the base, filling ⅔ of it. It is divided by two clefts defined in three festoons called P1, P2, and P3 from lateral to medial. The anterior veil occupies ⅓ of the annulus; and is divided into 3 festoons called A1, A2 and A3, corresponding to festoons 1, 2, and 3 of the posterior leaflet [(6)]. The CxA runs in the left atrioventricular or coronary groove, closely related to the mitral annulus. In its course, it is accompanied by the great cardiac vein.

In the present work, 85% of the hearts presented right dominance, 13% left dominance, and 2% codominance. Pessa et al. (2004) described the following relative frequencies for 85 hearts fixed with formaldehyde: 81.7% for right dominance, 16.37% for codominance, and 2.35% for left dominance [(7)]. Likewise, using preoperative CT angiography, Caruso et al. (2020) found that for a total of 95 hearts, right dominance in 80% of cases, codominance in 11%, and left dominance in 9% [(8)]. For the frequencies of right dominance, the findings are similar. In contrast, Pessa and Caruso described codominance as more frequent than left dominance.

Virmani et al. (1982), in a study that included 15 cadaveric hearts, recorded in an anteroposterior plane, lateral to the left appendage, average distances of 8.4 mm (6.0-11.5 mm) for right dominance, 4.1 mm (3.0-6.5 mm) for left dominance and 5.5 mm (4.5-7.5 mm) for codominance [(9)]. These results are similar to those recorded in the present work, observing that the shortest distance between the CxA and the mitral annulus is found in left dominance.

Pessa et al. (2004) recorded the shortest distance between the anterolateral commissure and the CxA,

Distance*	N	Mean	Minimum	Maximum	SD
1 (mm)	39	8,385	1,00	16,00	4,3626
2 (mm)	38	8,158	2,00	15,00	3,4467
3 (mm)	28	7,089	2,50	18,00	3,4455
4 (mm)	17	7,971	3,00	15,00	4,0907

TABLE 1. Distance between the mitral annulus and the circumflex coronary artery. *Distance 1: distance of the anterolateral commissure to the circumflex artery (CxA). Distance 2: distance of the middle third of P1 to the CxA. Distance 3: distance of the middle third of P2 to the CxA. Distance 4: distance of the middle third of P3 to the CxA. SD: Standard deviation.

Distance*	Right dominance Mean (SD)	Left dominance Mean (SD)	P value
1 (mm)	8,39 (4,53)	9,40 (6,60)	0,501
2 (mm)	8,25 (3,41)	7,60 (4,39)	0,714
3 (mm)	7,41 (3,41)	5,20 (3,55)	0,129
4 (mm)	8,63 (4,17)	6,75 (4,35)	0,446

TABLE 2. Distance comparison between hearts with right and left dominance. *Distance 1: distance of the anterolateral commissure to the Circumflex Artery (CxA). Distance 2: distance of the middle third of P1 to the CxA. Distance 3: distance of the middle third of P2 to the CxA. Distance 4: distance of the middle third of P3 to the CxA. SD: Standard Deviation.

with an average value of 3.99 mm (± 1.86 mm) in right-dominant hearts, 3.56 mm (± 1.63 mm) in hearts with codominance, and 4.09 and 3.69 mm for the two hearts with left dominance [7]. These results differ from those analyzed in this work since the global distance measured at the level of the anterolateral commissure (distance 1) was the most significant observed: 8.38 mm (1-16 mm). The site with the shortest distance between the mitral annulus and the CxA was at the level of P2 (distance 3) with a global mean of 7.09 mm (range 2.5-18 mm), 7.41 mm (range 4-18 mm) for right dominance, 5.20 mm (range 2.5-11 mm) for left dominance, and the only case of codominance was 9.5 mm. In any case, Pessa et al. (2004) propose that the iatrogenic susceptibility of the CxA is unrelated to the dominance pattern.

Caruso et al. (2020) found that the smallest distance between the mitral annulus and the CxA was zone 1, defined as the distance between the anterolateral commissure and the midpoint of the scallop P1, corresponding to a global average of 5.49 mm (± 3.13 mm), 5.9 mm (± 3.2 mm) for right dominance, 3 mm (± 2.1 mm) for left dominance, and 4.6 mm (± 2.3 mm) for codominance [8]. However, it should be mentioned that the authors mentioned above clarify that the differences found in in the dominance pattern were not significant.

Ghersin et al. (2013) studied the relationships of the coronary vessels for the mitral and tricuspid annulus using computed tomography. In said study, they observed that the minimum distance from the mitral annulus to the CxA was 6.4 (± 2.1 mm). The cases that presented left cardiac dominance presented shorter distances compared to those that presented right cardiac dominance 4.3 mm (± 1.0 mm) vs. 6.5 mm (± 2.0 mm). In addition, they presented a higher percentage of cases in which the distance was less than 5 mm. Regarding the topography, they found that the initial and middle portion of the artery is the one with the greatest proximity to the mitral annulus, lateral to the left trigone, which corresponds to the area of the anterolateral commissure (10). The findings mentioned above are comparable to ours in that the left-dominant hearts were the ones that indicated the shortest distance, but not about topography.

The iatrogenic compromise of the CxA is a rare complication, but with severe consequences of not performing an early diagnosis and treatment. There can be direct damage when sutures are passed through the mitral annulus or indirectly by pulling the tissues close to it, generating distortion or kinking of the artery. The location of the lesion is usually posterior to the anterolateral commissure and the first segments of the posterior leaflet (P1 and P2), and it is proposed that left cardiac dominance is a risk factor. For those above, a coronary angiography is recommended before any valve procedure in adults (11,12).

Ziadi et al. (2013) report the case of a CxA occlusion during a mitral plasty procedure. In this study, they refer to the fact that it occurs more frequently in patients with left dominance and codominance. In hearts with left dominance, the mean distance between the mitral annulus and the CxA was 4.1 mm (range 3-6.5mm), 5.5 mm (range 4.5-7.5mm) in codominance, and 8.4 mm (range 6-11.5 mm) in dominance right. In the said study, there is no reference to which sector of the posterior annulus is the one that is closest to it (13). The distances analyzed are consistent with the values found in our work.

Yavari et al. (2021) report the case of a patient who underwent mitral valve replacement due to severe mitral stenosis, which presented an inferior acute ST-elevation myocardial infarction in the immediate postoperative period. An emergency cineangiocoronariography showed an occlusion in the middle part of the CxA. The mechanisms of injury to the CxA after mitral valve replacement include: air embolism, compromise of the artery by a suture, coronary spasm, oversized prosthesis, excessive resection of valve tissue, and excessive proximity of the CxA to the mitral annulus, especially in hearts with left dominance (14).

Pettinari et al. (2015) describe the case of iatrogenic CxA lesion after mitral valve plasty. In this case, the CxA had an abnormal origin from the right coronary artery taking a close relationship to the aortic annulus and the anterior mitral annulus (15). It was compromised at the level of the anterior mitral ring, so when performing mitral surgery, cases with anomalous origins of the CxA should also be considered.

Husain et al. (2019) conducted a retrospective study on the incidence of iatrogenesis on CxA during mitral valve surgery in Saudi Arabia. Of 1706 patients who underwent mitral surgery between 2000 and 2016, 95 were evaluated by postoperative cineangiocoronariography for suspected CxA injury, and nine (0.5%) showed injury to the CxA. Of the nine cases, all occurred in valve replacement surgery but not mitral plasty (16). The distribution of these was similar for the coronary dominance pattern.

Arévalos et al. (2021) report the case of a patient who suffers an acute occlusion of the CxA after mitral valve plasty. In their analysis, as suggested by the bibliography, they mention that it is more frequent in left dominance and codominance, where the proximity of the CxA is more significant than the anterolateral commissure and the posterior mitral annulus (17).

Finally, we recognize as a limitation of our work that it was carried out on hearts fixed with formaldehyde. This method of cadaveric fixation dehydrates the tissues, which can determine alterations in the measurements concerning fresh tissues or living tissue. We must also consider that the measurements taken were only analyzed in the transverse plane, not making measurements between the annulus and the CxA in the vertical plane.

CONCLUSIONS

The anatomical knowledge of the MV and its relationships is essential to reduce complications during surgical and endovascular procedures.

The area of most significant risk of injury to the CxA in relation to the mitral annulus corresponds to the P2 sector of the posterior mitral leaflet (*Figure 3*).

Left dominance and codominance would associate a greater risk of vascular injury during surgical procedures on the MV.

Declarations
The authors declare no conflict of interest.

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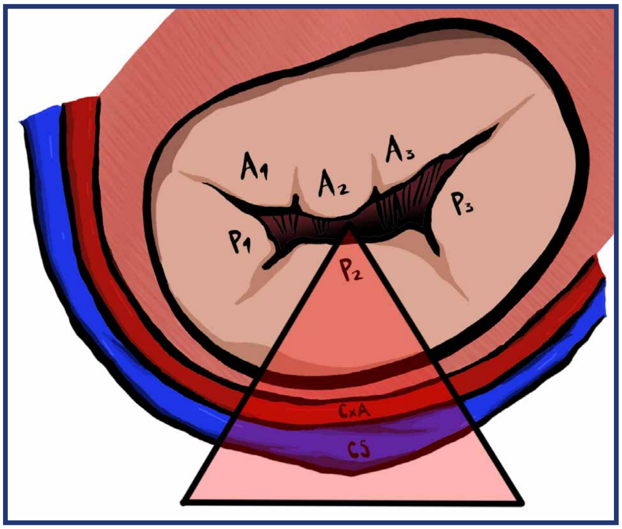

FIGURE 3. Schematic representation of the mitral valve (atrial view) in relation to the circumflex coronary artery and the coronary sinus. AL: Anterior leaflet, PL: Posterior leaflet, ALC: Anterolateral commissure, PMC: Posteromedial commissure, A1: Lateral portion of the anterior leaflet, A2: Middle portion of the anterior leaflet, A3: Medial portion of the anterior leaflet, P1: Lateral portion of the posterior leaflet, P2: Middle portion of the posterior leaflet, P3: Medial portion of the posterior leaflet, CxA: Circumflex coronary artery, CS: coronary sinus, Red zone shows the area with the most significant risk.

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ETHICAL STATEMENT

The authors declare having respected the ethical principles underpinning the research. Regarding informed consent, the corpses in which the dissections were performed were obtained from voluntary donors who expressed their consent in writing, freely and voluntarily, while alive. The Departamento de Anatomía, Facultad de Medicina, Universidad de la República, has these informed consents that enable said corpses to be used for teaching and research tasks.

SCIENTIFIC LETTER

CORONARY ENDARTERECTOMY: BENEFIT OR DETRIMENT TO MYOCARDIAL REVASCULARIZATION?

Retrospective experience in 12 cases of diffuse coronary artery disease

ABSTRACT

Cardiovascular disease is the leading cause of death worldwide. In the same sense, coronary artery bypass graft (CABG) surgery is one of the most frequently performed cardiac surgery procedures worldwide. In clinical practice, myocardial revascularization can be followed by a procedure called endarterectomy to reinforce the sanitation of the vessel with decreased flow and improved irrigation. However, there is sufficient evidence in the medical literature that reports serious adverse events due to the application of endarterectomy, the most feared complication being the perioperative infarction itself, which is why it has fallen into disuse. This work aims to disseminate our experience regarding coronary endarterectomy to be valued as an intervention tool within a complex spectrum like diffuse coronary disease.

Key words: *Diffuse coronary artery disease, Coronary endarterectomy, Antiplatelet, Antithrombotic, Myocardial infarction.*

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INTRODUCTION

Cardiovascular disease is the leading cause of death worldwide. In 2019, according to the World Health Organization, ischemic heart disease was the leading cause of death, responsible for 16% of all deaths (8.9 million). In second place was stroke, which accounted for 11% of all deaths.

Thus, coronary artery bypass grafting is one of the most frequently performed cardiac surgery procedures worldwide, although it is often insufficient to restore blood flow. In medical practice, myocardial revascularization may be followed by a procedure called coronary endarterectomy (CE), which reinforces the healing of the vessel with diminished flow and improves blood supply. However, sufficient evidence in the medical literature reports serious adverse events from the application of CE, the most feared complication being perioperative infarction, which is why it has fallen into disuse, so much so that the 2021 guidelines for myocardial revascularization proposed by ACC/AHA/SCAI do not mention this procedure.

This work aims to disseminate the experience of our surgical team regarding the application of CE in situations of myocardial revascularization within a complex spectrum, such as diffuse coronary artery disease. The series of cases studied represents 6% of the patients revascularized over four years, with favorable results.

CE is a surgical procedure for removing cholesterol material or plaque from the tunica intima that obstructs the lumen of a vessel. Bailey and collaborators in 1957 [1] described its application in humans with successful results.

This procedure can be performed open or closed. Open endarterectomy involves:

- Incising the coronary artery along the stenosis,
- Sectioning the atheroma proximally, and
- Carefully plaque dissection, including the extensions in the coronary side branches.

The vessel is then closed using an autologous saphenous vein or mammary artery patch. On the other hand, a closed endarterectomy is performed through a small arteriotomy over the coronary, followed by gentle traction to remove the atheroma [2].

There are controversies regarding the efficiency of CE based on the aggression to the vascular endothelium due to the "erosion" inherent to the technique, which leads to a higher rate of perioperative events when compared to isolated myocardial revascularization. Thus, CE has been limited to situations of advanced vascular disease. On the other hand, the satisfactory short- and long-term results described after CEA could be attributed to improved surgical techniques, careful perioperative management, and effective antithrombotic therapy after the operation [3].

In this article, we present the experience obtained in 12 cases of coronary endarterectomy in patients with a history of diffuse coronary artery disease.

METHODOLOGY

A retrospective study from July 2018 to August 2022 of a multidisciplinary group of surgical professionals who performed 193 myocardial revascularizations and, on 12 occasions (6.22%), CE was also performed.

The patients had a history of hypertension (HT), diabetes mellitus (DM), and smoking (SMK)/ ex-smoking (EX-SMK). Table 1 summarizes the demographic and clinical characteristics of the patients.

Characteristics	N (12)	Percentage (%)
Gender		
Male	10	83
Mujer	2	17
Age (years)		
40-50	1	8,3
51-60	1	8,3
61-70	6	50
71-80	3	25
81-90	1	8,3
Affected vessels		
Anterior descending	9	74,7
Intermediate	1	8,3
Right	2	17
Extracorporeal circulation		
Yes	10	83
No	2	17
Bypasses (n)		
2	2	16,7
3	9	75
4	1	8,3
Comorbidities		
HT	12	100
DBT	11	91,6
SMK	6	50
EX-SMK	6	50
Perioperative infarction rate		
No	11	91,6
Yes	1	8,4

TABLE 1. Summary of the demographic and clinical characteristics of the patients. **Notes:** HT: hypertension; DBT: diabetes mellitus; SMK: smoking; EX-SMK: ex-smoking.

Patients with a history of diffuse coronary artery disease who had not received any previous revascularization procedure were included in this study (inclusion criteria). Patients with a history of diffuse coronary artery disease who had undergone a previous procedure to revascularize their coronary tree were excluded.

The procedure was always performed on a single main vessel; on nine occasions on the anterior descending coronary artery (AD) with subsequent anastomosis of an arterial graft (left internal mammary artery), on two occasions on the right coronary artery (RCA) and, only once, on an intermediate branch, performing anastomosis of a venous graft to form a coronary artery bypass graft. In all cases of endarterectomy, the closed technique was chosen (*Figures 1A, 1B and 2*).

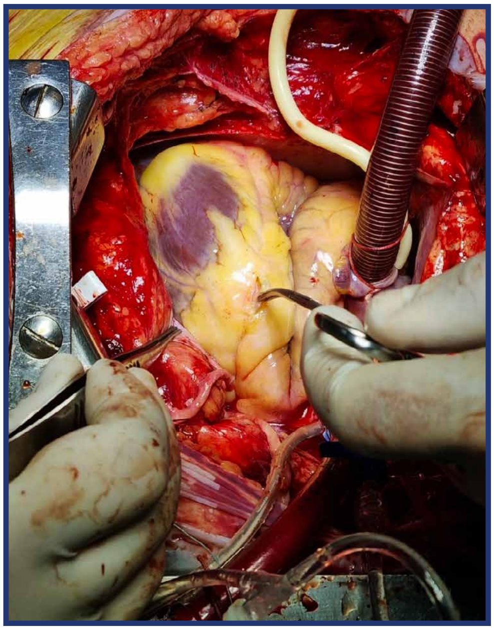

FIGURE 1A. Coronary opening.

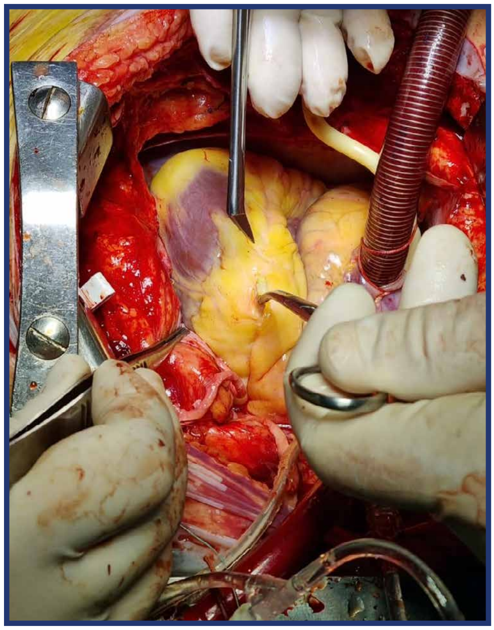

FIGURE 1B. Atheromatous core clamping

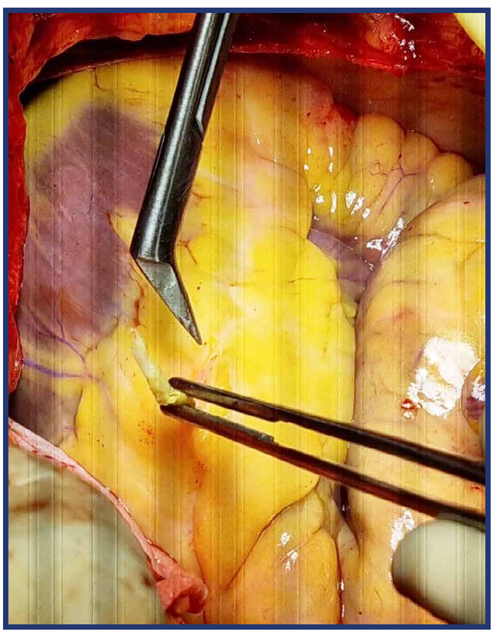

FIGURE 2. Complete distal removal of the atheromatous core over the anterior descending artery

In 10 cases, it was performed under extracorporeal circulation (ECC) plus cardiac arrest. In 2 cases, it was performed without extracorporeal circulation pump support, and in these cases, the endarterectomized vessel was the DA artery. In 9 cases, 3 bridges were performed, in 2 cases, 2 bridges were performed, and in 1 case, 4 bridges were performed. All the procedures performed were planned.

One case developed perioperative infarction within 24 hours after myocardial revascularization, evidenced by ST-segment elevation from V1 to V5 and positive qualitative troponins with subclinical signs. Antithrombotic therapy was not installed in this case because it was considered a risk factor. In the remaining 11 cases, no electrocardiogram recordings of myocardial infarction were obtained during hospitalization.

The pharmacological strategy used to maintain vessel patency was always the same. Initiation 24 hours after the procedure, using an antiplatelet agent (acetylsalicylic acid 100 mg/day) and a subcutaneous dose of low molecular weight heparin (enoxaparin) in an anticoagulant dose every 12 hours. After discharge from the hospital, oral medication (acenocoumarol) was continued for 3-6 months with hematological controls.

Postoperative controls were performed at 7 and 14 days with electrocardiography. The shortest in-hospital stay was 4 days, and the longest was 7 days.

DISCUSSION

The increase in life expectancy of the population added to the characteristics of modern life (such as a sedentary lifestyle and intake of a diet rich in high-calorie ultra-processed products). The higher incidence of chronic diseases (such as diabetes mellitus, hypertension, or inflammatory diseases) means that medical teams must be trained to respond to more significant challenges. The vascular system in this type of patient is modified by the deposit of atheromatous material obstructing the lumen. In diabetic patients, it is common to find multiple deposits at short distances within a vessel, resembling a "string of pearls". Functional and complete revascularization in these cases involves more than a bypass performance; therefore, we consider the complementary application of CE.

It is of fundamental importance to understand that the procedure involves mechanical damage to the vascular surface, with alteration of the integrity of the endothelium and its functions, which could include the possibility of embolization of detached atheromatous material [(2)] and thus an increased tendency to de novo thrombogenesis.

Several studies, including two meta-analyses evaluating more than 50,000 patients, have compared clinical outcomes after CE and coronary artery bypass grafting (CABG) interventions (CE + CABG vs. CABG alone). The results show that CE + CABG had significantly higher 30-day mortality and perioperative and postoperative heart failure mortality rates. However, long-term survival was comparable between the two types of interventions, [(2)] which came to support the selective use of CE + CABG in diffuse coronary artery disease where the distal vessel is unsuitable for CABG alone. Another published study reported that the CE + CABG procedure had a higher incidence of mortality and, in addition, postoperative renal failure [(2)].

Many of these studies use antiplatelet and/or anticoagulant therapies during the postoperative period after the intervention; however, there is no unified criterion for using antiplatelet or anti-inflammatory therapy [(4)]. Published pharmacological therapy is mainly based on acetylsalicylic acid, clopidogrel, and unfractionated heparin [(5,6)]. Some authors evaluated intraoperative or perioperative myocardial infarction by persistent electrocardiographic changes compatible with myocardial infarction, such as new Q waves, loss of R wave progression, or new atrioventricular conduction defects associated with elevated cardiac enzymes [(2)]. In our experience, one case of myocardial infarction was reported within 24 hours post-intervention, the reason for which could be found in the non-application of antithrombotic therapy due to the risk of hemorrhage due to the patient's baseline condition.

In this study, 6.22% of patients required CE + CABG to achieve complete myocardial revascularization. Within this group, all patients had diabetes mellitus, HT, and had been or were nicotine smokers (TB-EXTBQ), all factors that predispose to coronary artery disease and condition to high morbi-mortality rates. In patients with diffuse coronary artery disease, CE can be considered a good complement to achieving complete revascularization. From our point of view and experience, we believe that case selection for the performance of the procedure, careful planning and technical management employed during the removal of the atheroma core, and the implementation of antiplatelet and anticoagulant drug therapy are of vital importance for success in the postoperative period.

CONCLUSION

The selected group of patients met standard criteria for applying the CE procedure (such as advanced coronary artery disease with hypertension) and conditions complicating heart disease (such as diabetes and hyperlipidemia). Then we performed CE + CABG surgery to favor tissue revascularization and to make it last longer. Only one case of myocardial infarction was reported; no strokes or death following the procedure were reported.

Declarations
The authors declare no conflict of interest.

LIMITATIONS OF THE STUDY

No analysis of graft patency was performed, and no tests were performed to evaluate cardiovascular functionality after a year of the study. The N of the study is low.

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SCIENTIFIC LETTER

SURGICAL AND ENDOVASCULAR TREATMENT IN THE ASSOCIATION OF BILATERAL POPLITEAL ANEURYSM AND ABDOMINAL AORTIC ANEURYSM

ABSTRACT

The association of popliteal aneurysms (PAs) with other aneurysms of the arterial tree is very frequent. Although PAs are an infrequent entity, the popliteal artery is the second most frequent location of arterial aneurysms.

In this paper we present the case of a patient with right lower limb ischemia as a result of a thrombosed popliteal aneurysm associated to contralateral popliteal aneurysm and aortic aneurysm. The case was resolved with a combination of surgical revascularization in the lower limbs and EVAR.

Key words: *Abdominal aortic aneurysm; Popliteal artery aneurysm; Combined surgery.*

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INTRODUCTION

The association of popliteal aneurysms with other aneurysms of the arterial tree is very frequently reported in the literature, reaching 62% in some series [1]. Although this is broadly acknowledged in the literature [2,3,4], the most common location (femoral vs. aortic), is under discussion. In any case, in patients with a popliteal aneurysm, the presence of other lesions should be ruled out at the time of consultation and during subsequent follow-up with Doppler ultrasound or CT angiography directed to the sites reported as most frequent.

In 1953, Gifford published the experience of the Mayo Clinic [2]; this series of 69 patients with 100 popliteal aneurysms shows the main characteristics of this disease: frequent in hypertensive men, high incidence of bilaterality, association with aneurysms in other territories and what is most important, a 46-month- follow-up in asymptomatic patients shows that 29% of cases develop ischemic complications, and 11% lose their limb.

In 1963, Edmunds reviewed the experience of the Massachusetts General Hospital, concluding that vascular reconstruction with the saphenous vein, associated with the exclusion of the aneurysm is the treatment with the best results [5].

Popliteal aneurysms (PA) are a rare entity, however, the popliteal artery represents the second most frequent location of arterial aneurysms [6].

Although the diameter that determines indication for surgery or expectant management is not well established, aneurysms are classified into SPAAs (small popliteal artery aneurysms), i.e. those less than or equal to 20mm and PAAs (popliteal artery aneurysms), i.e. those greater than 20mm. However, since the most frequent complication is thrombosis, conventional surgery is considered in PAAs with aneurysmal exclusion and the creation of a bypass with the saphenous vein if possible [7].

The indication for surgery in PAAs is typically based on the appearance of symptoms, while for asymptomatic PAAs the parameter used to establish the surgical indication is the diameter, the same as for AAAs. However, unlike the latter, in which there is a firm and proven association between diameter and risk of rupture, in PAAs the appearance of symptoms and complications is not linked to aneurysmal diameter, which explains the lack of consensus in the management of asymptomatic PAAs [8].

We present a case report with right lower limb ischemia due to thrombosed popliteal aneurysm associated with contralateral popliteal aneurysm and aortic aneurysm (*Figures1-2*) with resolution by combined surgical revascularization techniques in the lower limbs and EVAR.

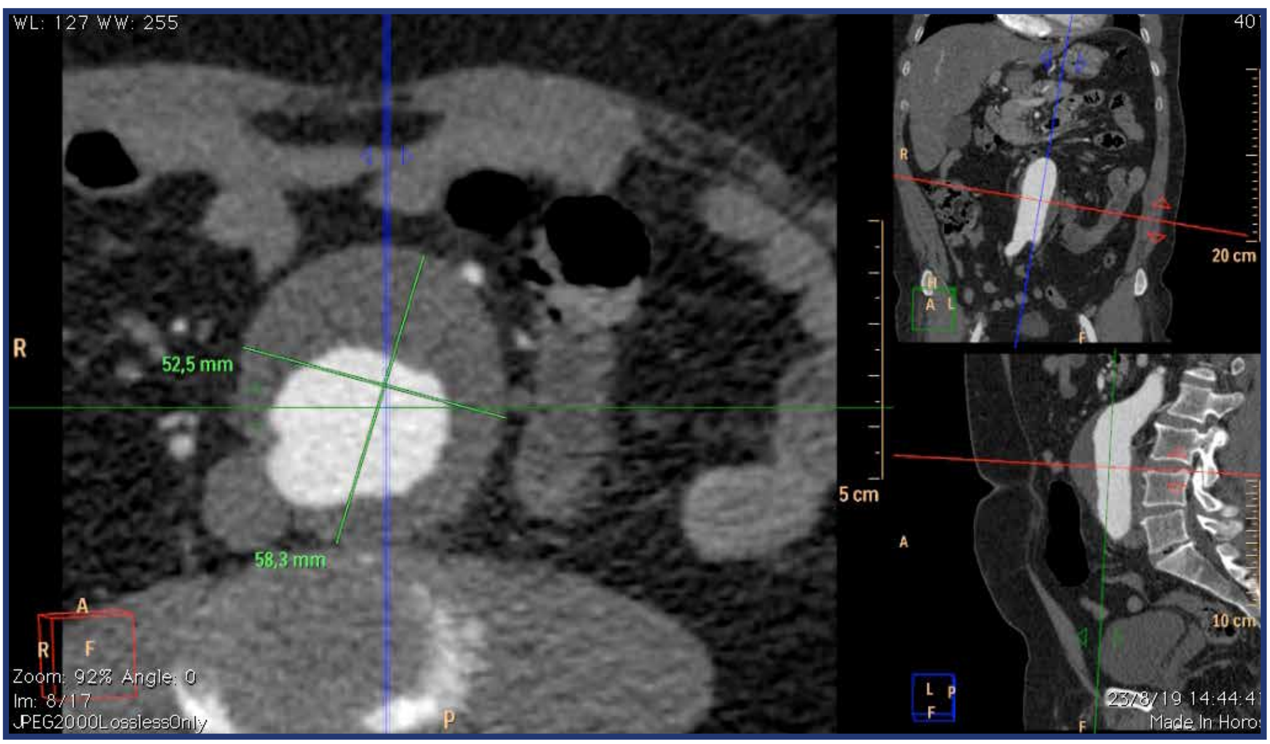

FIGURE 1. Aortic measurement

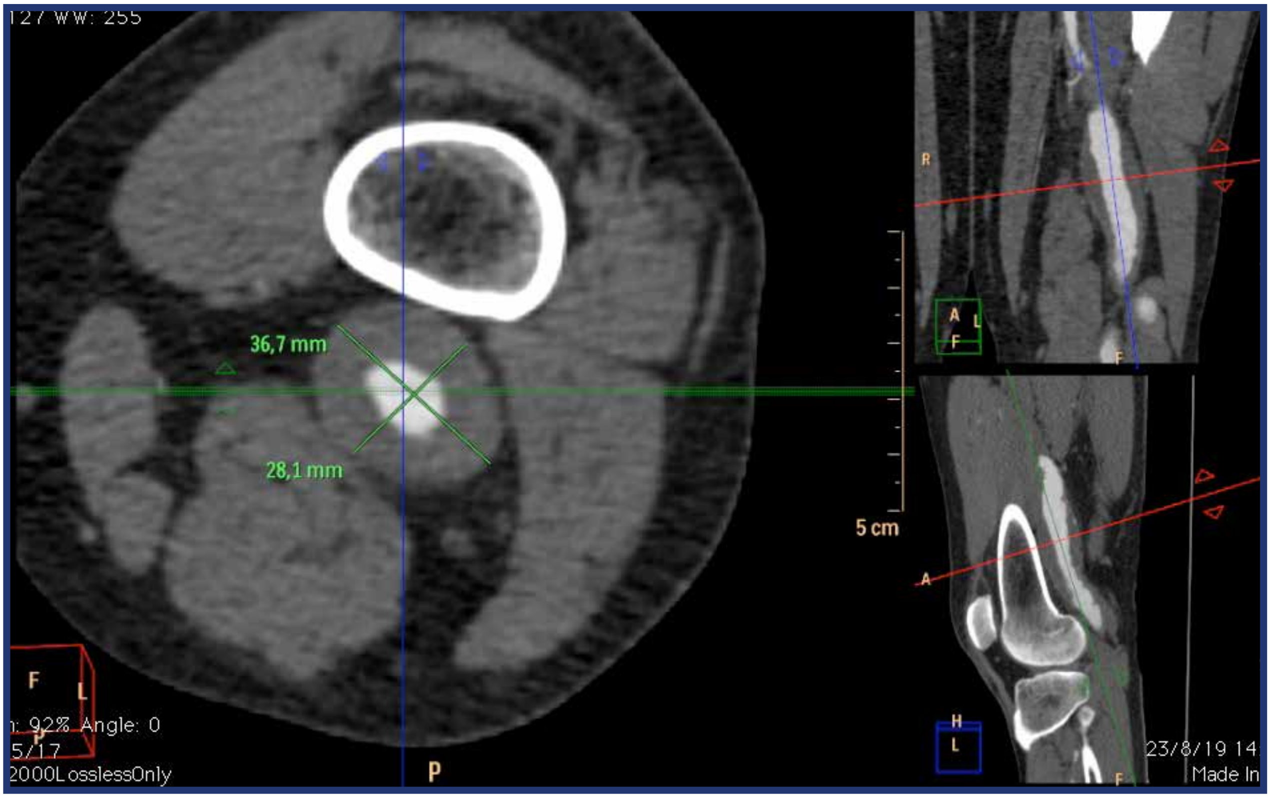

FIGURE 2. Measurement of left popliteal aneurysm.

CASE REPORT

A 64-year-old patient with a history of arterial hypertension and dyslipidemia, referred from a community health care center due to rest pain in the right lower limb, with angiography compatible with occlusion of the right SFA and poor visualization of the distal vessels, associated with an aneurysm, left popliteal and aortic dilation. Vascular examination shows absence of distal pulses, paresthesia, temperature drop and palpable non-pulsatile mass in the right popliteal fossa. Peripheral pulses in the left limb were preserved, with a significant pulsatile mass in the popliteal fossa. Abdominal examination reveals a pulsatile periumbilical mass. Suspecting the association of multiple aneurysms, a CT scan was ordered confirming the diagnosis of a 58mm abdominal aortic aneurysm associated with a thrombosed right popliteal aneurysm and a left popliteal aneurysm with partial thrombosis greater than 36mm (*Figure 3*). Repair was carried out in three stages:

1st. stage: aorto-bi-iliac EVAR with self-expanding endoprosthesis EXCLUDER C3 (*Figure 4*); 2nd. stage: 13 days later, right anterior femoro-tibial bypass with inverted ipsilateral saphenous vein (*Figure 5*); 3rd. stage: 30 days after the first surgery, exclusion of left popliteal aneurysm and femoro-popliteal bypass with ipsilateral saphenous vein inverted from SFA to infrapatellar popliteal artery (*Figure 6*).

FIGURE 3. 3D image prior to surgery with visualization of aortic aneurysm, right popliteal occlusion and left popliteal aneurysm

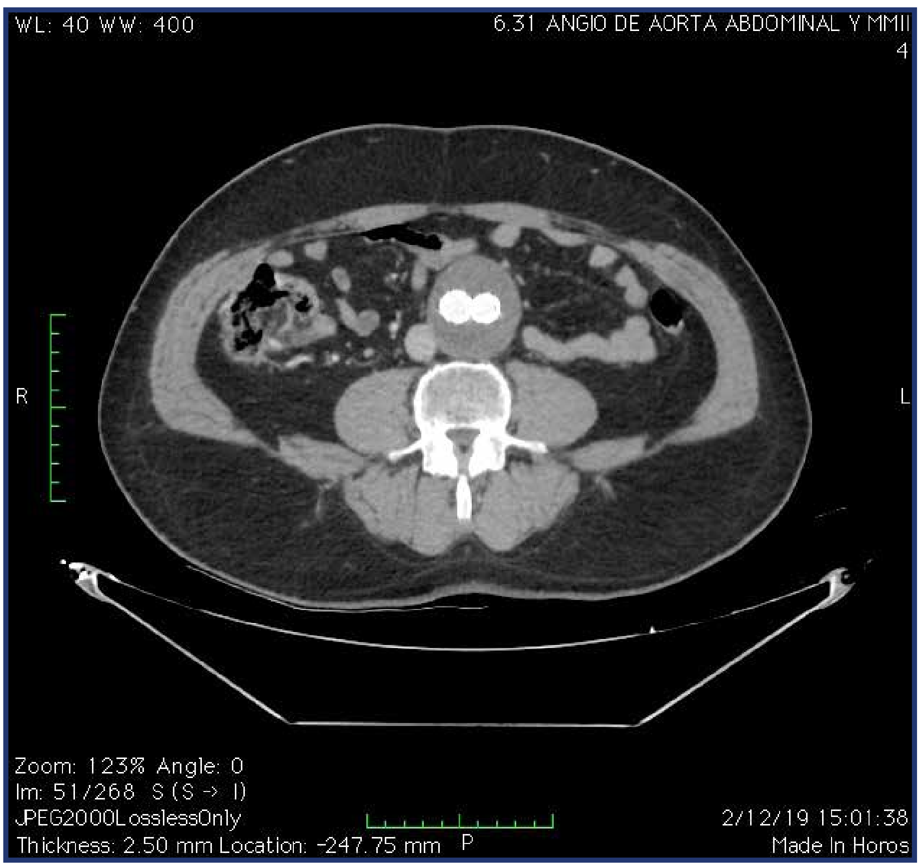

FIGURE 4. EVAR with EXCLUDER C3 endoprosthesis.

FIGURE 5. Right bypass to the anterior tibial artery.

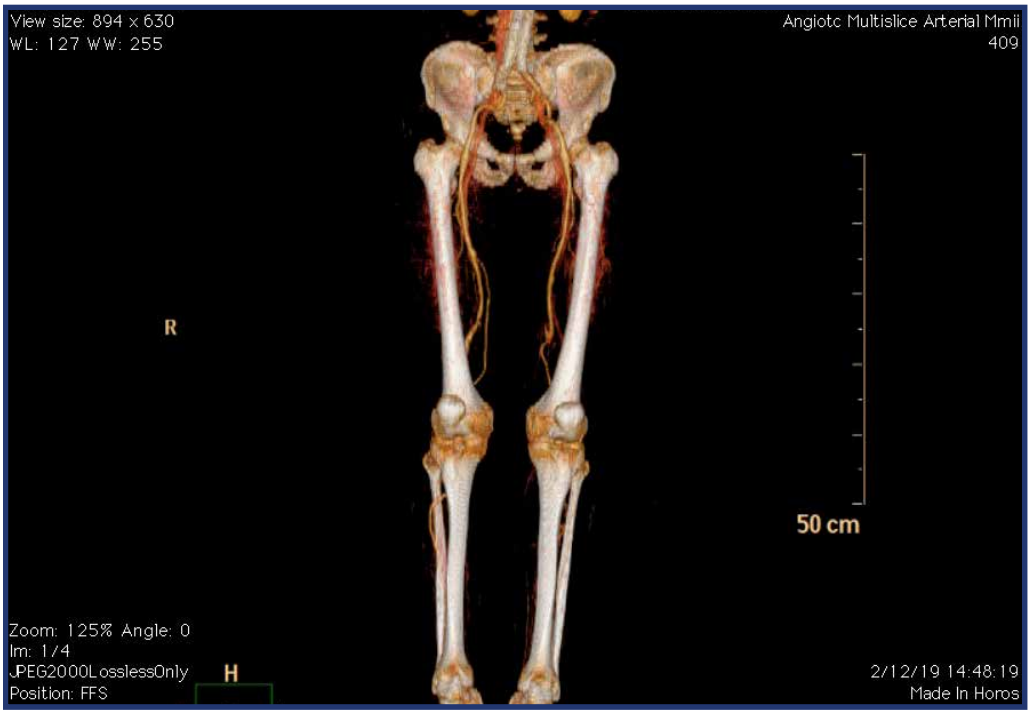

FIGURE 6. 3D image showing all procedures completed in stages

RESULTS

Favorable evolution with nosocomial stay of 3 to 7 days without complications in each procedure, with palpable bilateral pulse and resolution of symptoms of ischemia.

CONCLUSIONS

Due to the probability of association of aortic and popliteal aneurysms, it is necessary not only to achieve an accurate diagnosis but also to propose surgical strategies that eventually combine endovascular techniques with open surgery, prioritizing, if possible, the use of autologous tissue for revascularization.

Declarations

The authors declare no conflict of interest.

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SCIENTIFIC LETTER

RENO-CAVO BIOLOGICAL BYPASS WITH TUBULIZED BOVINE PATCH FOR NUTCRACKER SYNDROME

ABSTRACT

Nutcracker syndrome (NCS) is the set of symptoms resulting from compression of the left renal vein. A 19-year-old female patient with abdominal pain is approached. In the physical examination, we found pain in the left flank and left iliac fossa with abdominal palpation. Computed tomography and renal Doppler were performed and showed direct NCS signs. A reno-cavo bypass was performed with a tubulized bovine pericardium patch. NCS is a rare and underdiagnosed entity, and more follow-up data are needed to evaluate reno-cavo bypass in reducing symptoms and long-term complications.

Key words: *Pericardium; Bioprosthesis; Porcine Xenograft; Nutcracker syndrome; Venous bypass.*

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INTRODUCTION

Nutcracker syndrome (NCS) is the set of symptoms resulting from the compression of the left renal vein (LRV) with subsequent venous hypertension. The most commonly reported symptoms have been abdominal pain in the left flank, associated with microscopic and macroscopic hematuria. Due to the lack of evidence, there is no consensus on the optimal management of SCN. This lack of consensus can be attributed to several factors, including the rarity of SCN, lack of uniformity in patient symptomatology with an uncertain diagnosis, differing opinions on the optimal surgical approach, lack of consensus data on the durability and longevity of these different approaches, and the participation of many specialists in the care of these patients [(1)].

CLINICAL CASE

A 19-year-old female with no relevant personal history presented intense and intermittent abdominal pain in the left flank, radiating to the ipsilateral iliac fossa, resistant to analgesic treatment. Initially treated as nephritic colic, obstructive pathology of the urinary tract was ruled out after CT-urogram. For approximately one year, she was followed-up by the urology service with the diagnosis of recurrent urinary tract infection. Microhematuria was found in systematic urine tests with subsequent progression to macroscopic hematuria. The patient persisted without improvement of symptoms, despite analgesic treatment escalation. On physical examination, we found a non-distended abdomen with pain on palpation in the flank and left iliac fossa, with positive ipsilateral fist percussion. There was no evidence of alterations at the level of the genitalia related to pelvic congestion. CT scan and renal doppler were performed with direct signs of NCS [(7)].

TREATMENT

Conservative management of SCN was chosen, with follow-up in outpatient consultations. This treatment was not effective, and the patient persisted with severe symptoms. The case was assessed in a multidisciplinary clinical discussion, where conservative treatment was ruled out due to poor evolution.

Open surgical intervention was performed, and a reno-cavo bypass with tubulized pericardium was executed (*Figures 1 and 2*). During the dissection, left ovarian and suprarenal veins could be seen without dilation, confirming the absence of alternative drainage of the renal vein, leaving the compressed segment in the aortomesenteric clamp as the only outflow route.

The patient was admitted to the ICU without needing ventilatory support or vasoactive drugs and on an absolute diet and total parenteral nutrition. After 24 hours, the patient was discharged from the ICU with admission to hospitalization. Analgesia was started with reasonable pain control. Ten days after the surgical procedure, and considering the improvement of the symptoms, medical discharge and subsequent control in outpatient clinics were indicated.

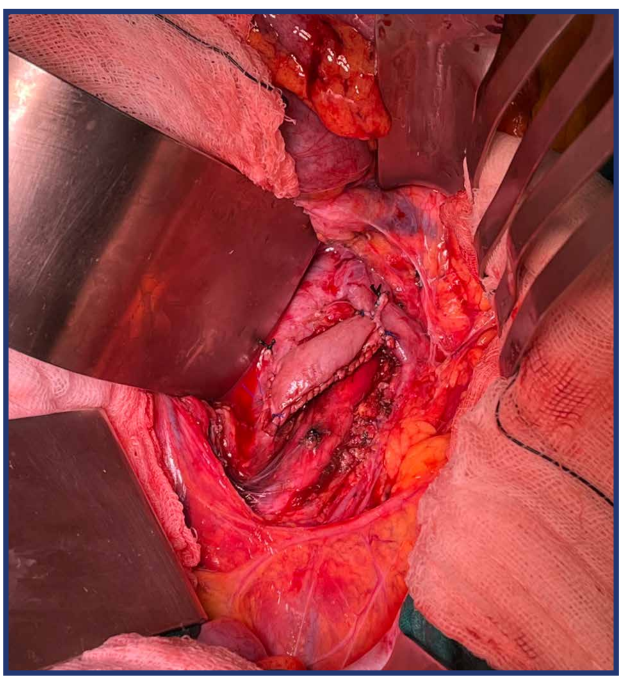

FIGURE 1. Reno-cavo bypass finished.

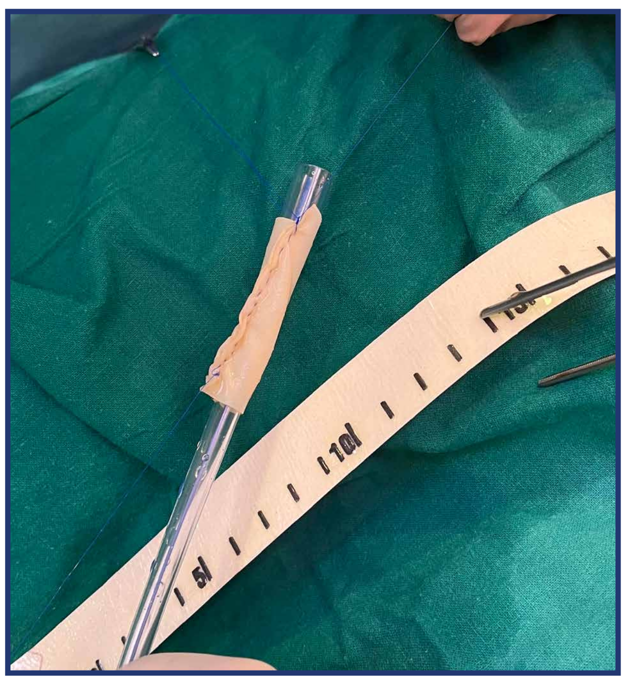

FIGURE 2. Tubulized bovine patch.

DISCUSSION

The compression of the IRV between the aorta and the superior mesenteric artery (SMA) was first described in 1950 by El Sadr and Mina [2], while Dr. Schepper described the nutcracker syndrome in 1972 [3].

The exact prevalence of SCN is unknown; it can be present at any time from childhood to adulthood, with a relatively high prevalence in young and middle-aged adults [4]. However, one study demonstrated an incidental 10.4% of SCN on abdominal computed tomography (CT) scans, with no difference in prevalence by gender [5].

There is a lack of agreement regarding the exact moment and type of treatment that should be used to treat these patients, as well as the choice of the optimal surgical technique [6]. In patients under 18, conservative treatment is recommended for weight gain and pain control [8]. In this clinical case, due to the age of the patient at the time of diagnosis (17 years), conservative management was indicated. Still, surgical treatment was decided as a result of the increased symptoms related to pain and hematuria [9]. We discussed the endovascular approach with stenttechnique, which could lead to severe complications, such as stent migration into the inferior vena cava or right ventricle [10-12]. In these terms, the patient's age when making the surgical decision (19 years) must also be considered since it is not close to the average age (26 years) shown in the studies that expose the endovascular treatment.

The most frequently reported procedure is a transposition of the IRV [13]; however, in this clinical case, a reno-cavo bypass was performed, with a tubulized bovine pericardium graft, with an improvement of the symptoms in the medium term. Due to the age of the patient, and the aesthetic considerations of a new incision, it was decided to omit the use of the saphenous vein as a therapeutic option for this case since it has been shown that the bovine pericardium offers similar results.

CONCLUSIONS

SCN is a rare and underdiagnosed entity that deserves more attention. In this case, IRV bypass with tubulized bovine pericardial bypass has given good short- and medium-term results. However, more follow-up data are needed to evaluate this technique in reducing symptoms and long-term complications.

Declarations

The authors declare no conflict of interest.

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OPINION ARTICLE

EXPECTATIONS FOR THE FUTURE OF CARDIOVASCULAR SURGERY

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Recently, I had the opportunity to watch a video, Surgical Correction of Dissecting Aneurysm of Ascending Aorta (Baylor College of Medicine, 1963), which made me reflect on the evolution of cardiovascular surgery in recent decades and, at the same time, on the future of our specialty.

This video shows an ascending aorta replacement procedure in a patient with an ascending aortic dissection, performed by Dr. M. E. De Bakey in 1963. I also invite you to compare the procedure in the video with what we can do six decades later. Although ancillary aspects of the procedure, such as cardioplegia, oxygenators, and sutures, among others, have evolved, the surgical technique itself, which at that time represented a disruptive innovation in treating this disease, has yet to evolve that much. What has evolved the most is the camera with which the intervention was recorded, a 16mm film camera, which has little to do with the digital cameras used today.

Nevertheless, let us look at those elements of the procedure that have evolved over the last 60 years. Today's sternal saws are a major advance over the Lebsche sternotome used in the video. From my point of view, myocardial protection, with new cardioplegic solutions that make it possible to perform interventions with the heart stopped, is the element that has evolved the most, the one that has had the most significant impact on results, and the one that has opened up the most possibilities for new treatments. Likewise, mechanical circulatory assistance for treating heart failure is another field in which we have seen significant progress. Otherwise, evolution has been limited, and the innovations introduced have merely served to improve or refine existing technologies or techniques.

Since 1963, two innovations that could be considered "disruptive" have emerged in the surgical treatment of cardiovascular disease: aortocoronary bypass and valve replacement and/or repair. Both have impacted the surgical treatment of coronary artery disease and valvular heart disease and made it possible to treat diseases for which, until then, there were no effective remedies. The advent of percutaneous coronary intervention, introduced by Andreas Gruentzig in 1976, was a significant breakthrough in the treatment of coronary artery disease. Since then, the technology has evolved fundamentally in two aspects: the stent construction material and the radial artery vascular approach. However, both the technique and the technology, as well as their

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surgical alternatives, have evolved little in the last two decades. Percutaneous treatment of valvular heart disease (without the need for extracorporeal circulation) represents another disruptive innovation in the treatment of cardiovascular disease. Disruptive innovations, although they may initially offer inferior results to those of traditional technologies, end up eliminating the latter. The similarity between the graph of trends in the number of TAVRs and aortic valve replacements in North America and the well-known graph of disruptive innovation (*Figures 1A and 1B*) is striking.

A technology, a manufacturer, or a specialty that does not reinvent itself ends up being replaced by others that are more innovative.

Let us see the case of Kodak, an undisputed leader in the printed photography market, which, although the initial leader in digital photography, disappeared because it needed to learn how to adapt to new market trends. Can cardiac surgery end up like Kodak? Are we destined to disappear as a specialty, to perish in the face of the avalanche of alternative percutaneous treatments to our surgical procedures?

Let us perform a SWOT analysis of our specialty to determine the position of cardiovascular surgery in the current "market".

Weaknesses: with honorable exceptions, and unlike our predecessors, today, we are not an innovative specialty, nor does a scientific spirit characterizes us. Most of the evidence published in cardiovascular surgery is retrospective and observational, and most of our research is clinical and focused on testing the safety or efficacy of established treatments. On the other hand, our treatments are not as profitable for manufacturers as percutaneous alternatives, and, therefore, manufacturers' R&D investment is primarily devoted to the latter. This means that the technology of percutaneous devices is advancing faster than that of surgical devices. As if this were not enough, manufacturers promote randomized trials that are sometimes designed to favor percutaneous devices (which give them more profit) over surgical devices.

Threats: the increase in the number of percutaneous treatments and the consequent decrease in the number of surgical treatments will result in fewer cases per center and less opportunity for training and development surgical skills, especially for newer surgeons. The cases referred to surgery will be the most complex or result from complications of percutaneous treatments. The combination of decreased opportunities for training and skill development, and the need to deal with higher-risk cases, will lead to increased mortality and complications, affecting the specialty's reputation. The best and brightest students will gravitate toward those specialties that are less demanding and offer innovative treatment alternatives.

Strengths: current surgical treatments are, in most cases, safe and effective and capable of treating diseases that, without these treatments, would be lethal. Some of these highly complex treatments require skills developed over years of experience. Cardiac surgeons acquire extensive knowledge of pathophysiology, natural history, and treatment of these diseases. Cardiovascular surgery has pioneered the development of registries and data analysis. This puts us in an advantageous position, allowing us to learn from our mistakes and improve our medical practice.

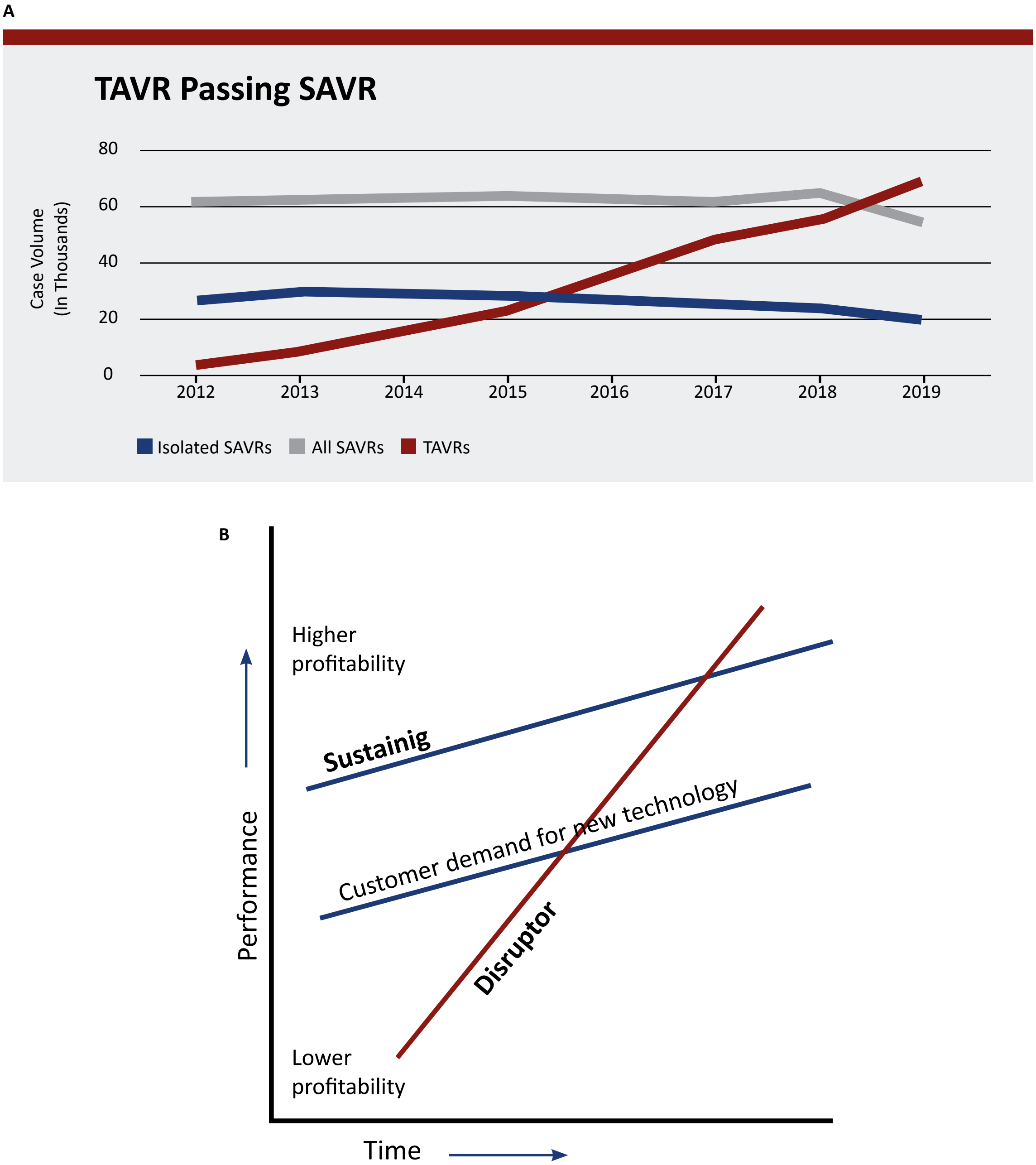
Opportunities: surgical experience and knowledge of anatomy and pathophysiology put the surgeon in an excellent position to acquire percutaneous skills. The development of minimally invasive techniques (including robots) improves patient acceptance of surgical treatments. Surgery may be the only therapeutic option in certain situations of complexity or complications of percutaneous treatments. Therapies such as transplantation cannot be approached percutaneously. On the other hand, there is much room for maneuvering to optimize the results of surgical treatments, putting the patient at the center of our activity.

It is not the strongest species that survive, but those that are best adapted to change. How can we adapt to permanent change?

How will technology evolve in the coming decades? Surgery, in general, has advanced more in the last 20 years than in the previous 100 years. As Raymond Kurzweil, expert systems and artificial intelligence technologist, points out, our intuition about the future is linear. However, the reality of information technology is exponential, making a profound difference. If I take 30 steps linearly, I get to 30. If I take 30 steps exponentially, I get to a billion. So it is not easy to understand what the future holds for us as a specialty.

Regardless of the above, the two fields with the most significant potential for development are percutaneous technologies and minimally invasive access, mainly robotics. A third field of development is that of composites for constructing valve prostheses that do not require anticoagulation and, at the same time, do not suffer from structural degeneration or bioengineering developments that allow the construction of biological scaffolds for

FIGURE 1A. Similarity between the graph of trends in the number of TAVRs and aortic valve replacements in North America. **1B.** Graph of disruptive innovation



From: 1A, https://www.sts.org/publications/sts-news/tavr-surges-past-surgery-us-avr-treatment-volume; **1B**, Gerber, A., Matthee, M. (2019) [9].

valve regeneration. These elements are relevant to the training of future surgeons. Undoubtedly, percutaneous techniques should be included in the curriculum of future training programs, as should specific training in minimally invasive and robotic access techniques. Scientific research should play a more relevant role in the training of future surgeons so that they can play a more critical role in the development of new forms of treatment. Xenotransplantation is an excellent example of the opportunities that are opening up in the future.

In this era of high expectations and "value"-centered medicine, outcomes in surgery take on a new dimension. "Value" in healthcare is measured by those patient-centered outcomes that are achieved, not by the volume of services provided. Perhaps this is where the future development of cardiac surgery should be based. It is worth recalling here the influential article by Michael E Porter [1], which sets out the principles by which "value" in health should be assessed. Outcomes for any medical condition can be organized into a three-level hierarchy in which the top level is usually the most important, and lower-level outcomes involve a progression of outcomes contingent on success at the higher levels. Each level of this hierarchy contains, in turn, two categories, each of which involves one or more distinct dimensions of outcomes.

Level 1 is the state of health achieved by therapeutic intervention. The first category in this level, survival, is undoubtedly the most relevant for most patients.

The second category in level 1 is the degree of health or recovery achieved. For example, in stable angina, this category refers to the absence of angina at maximum stress after myocardial revascularization surgery.

Level 2 outcomes are related to the recovery process. The first category of this level refers to the time required to recover and return to regular activity. This category can be divided into different phases: time to hospital discharge and time to return to work. This is critical for many patients, where percutaneous techniques outweigh surgical techniques.

The second category at level 2 is the futility of the care or treatment process regarding discomfort, need for reoperation, short-term complications, and possible errors and their consequences.

Level 3 refers to the maintenance of health status after treatment. The first category here is recurrences of the original disease or long-term complications, and the second category captures new health problems created as a consequence of treatment.

In the absence of disruptive innovations in surgery, the future of cardiac surgery lies in optimizing outcomes at all 3 levels:

Level 1. Category 1: in-hospital or short-term survival of standard procedures has declined significantly over the past decades and, in most cases, is similar to alternative percutaneous procedures. However, reducing the mortality of other more complex procedures or those that are less common is necessary. This should be a multidisciplinary effort involving both clinical cardiologists and specialists in cardiac imaging, anesthesiologists, and intensive care. Establishing treatment protocols and algorithms to unify the forms of action and reduce variability is an essential part of the process. Category 2: in general, cardiovascular surgery is very effective in the treatment of diseases, and, in most cases, patients reach an adequate level of health. They can lead an everyday life after recovery.

Level 2. Category 1: post-procedure recovery is the area with the most significant potential for improvement in cardiac surgery procedures. Minimally invasive procedures decrease pain and allow earlier ambulation, reducing hospital stay and recovery time. Enhanced Recovery after Surgery (ERAS) programs improve outcomes in cardiac surgery by accelerating post-surgical recovery [2]. The causes of asthenia or weakness after major surgery have not been studied; therefore, there are no interventions or treatments to alleviate it. The casual element may be related to the release of free radicals caused by surgical trauma [3]. The possibility of neutralizing these free radicals could also accelerate the recovery process [4]. Category 2: establishing treatment algorithms and protocols aimed at reducing process variability, improving the training of professionals in surgical safety issues, and recording adverse effects and their analysis are tools that contribute to reducing complications and errors [5,6]. Implementing actions aimed at reducing surgical site infections and those associated with orotracheal intubation are equally important in this section.

Level 3. Category 1: avoiding recurrences and the need for re-interventions is another of the objectives that should be considered. The improvement of valve repair techniques and progress in the knowledge of those factors that dictate the durability of the procedures are fundamental in this field. It is crucial to develop skills in different modes of treatment in order to be able to treat the patient in a personalized way that is targeted to the specific anatomy and pathophysiology. For example, the optimal selection of the types of arterial grafts available contributes to their long-term patency and freedom from recurrences. **Category 2:** the disadvantages derived from the use of valve prostheses, in terms of risk of endocarditis, degeneration, and complications associated with anticoagulation, can also be reduced using valve repair techniques. Developing durable prostheses that do not require anticoagulation treatment is a highly relevant field of research [7].

The sustainability of healthcare systems is everyone's responsibility and is an essential factor in the future of cardiovascular surgery. Historically, the value of medical care has always been defined as the intersection between the highest quality care available at the lowest possible cost. Those treatments that achieve the same results at a lower cost to healthcare systems should be prioritized over those with a higher economic cost. For example, valve repair offers advantages over percutaneous techniques in treating valvular heart disease.

The results of the techniques used in surgery seem to be related to a certain extent to the volume per surgeon and center and, therefore, to subspecialization. The complexity of surgical techniques has evolved significantly over the last 3 decades. Even for the most basic cardiac surgery (such as coronary artery bypass grafting), surgeons dedicated mainly to this technique are advocated to optimize results by applying multiarterial grafts and off-pump surgery [(8)]. Other techniques (such as complex aortic or mitral valve repair), complex aortic surgery, and the use of minimally invasive techniques also require subspecialization to optimize health outcomes and to be able to compete with percutaneous techniques that have so far always been inferior to surgical techniques in terms of medium- and long-term results.

The future of cardiac surgery is bright if we know how to adapt to the development of new technologies and focus on offering a service centered on patient value. Therefore, we must not only train our residents in percutaneous and less aggressive techniques but also instill in them the concepts of value in health: safety of treatments, optimization of perioperative processes for rapid patient recovery, interventions with good lasting results and few complications, and which, in addition, can be performed at a lower economic cost.

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We hereby present comments on a selection of articles recently published in internationally acclaimed medical journals. We believe these papers deserve special attention due to the quality and importance of the conclusions reached by the studies. Our objective is to keep an open look on new aspects of scientific research or review articles that may, in turn, update aspects of our own medical specialty.

Also, the Editorial Committee will consider suggestions on recent articles that the readers think deserve to be commented in this section (revista@caccv.org.ar).

SPINAL CORD STIMULATION IN NON-SURGICAL CRITICAL ISCHEMIA OF THE LOWER LIMBS

G. S. PIEDADE, J. VESPER, ET AL. SPINAL CORD STIMULATION IN NON-RECONSTRUCTABLE CRITICAL LIMB ISCHEMIA: A RETROSPECTIVE STUDY OF 71 CASES.

Acta Neurochir (Wien). 2023; 165(4): 967-973.
Published online 2023 Jan 4. DOI: 10.1007/s00701-022-05448-8

Patients with critical peripheral arterial disease who receive primary treatment with vascular reconstruction (surgical or endovascular) have an estimated 30% risk of amputation and 25% of 1-year mortality. The need for amputation is much higher in people with diabetes.

Spinal cord stimulation (SCS) is a therapeutic option for critical peripheral arterial disease when vascular reconstruction is impossible or has failed. However, data on the efficacy of this type of treatment are dissonant. The mechanism of action of SCS still needs to be fully elucidated, and its method is estimated to be complex and multicausal; it has been reported to induce vasodilation in the peripheral microcirculation, antidromic activation of sensory fibers, and reduction of sympathetic tone.

Neurosurgeons from the universities of Wuppertal and Düsseldorf and vascular surgeons from the academic teaching hospital of the Ruhr University Bochum conducted a retrospective study of patients with this clinical situation in whom an SCS system was implanted in July 2010.

Those with active infection or a life expectancy of less than one year were excluded. Of the 72 patients included in the study, 35 were classified as inoperable, and 37 had previous unsuccessful or only partially successful vascular procedures. Twenty-one patients (29.2%) were classified as Fontaine stage III and the remaining 51 (70.8%) were classified as Fontaine stage IV. In addition, 19 cases were diabetic (26.4%), of which 2 were Fontaine III. An octopolar SCS was implanted in all cases. One of the patients died of myocardial infarction before pacing treatment could be started and was therefore not considered in the final statistics. Other minor complications were successfully treated and did not require discontinuation of treatment. Follow-up lasted from 1.6 to 39.6 months, with a mean of 17.1 months. At the last control, 42 patients (59.2%) were alive without major amputation; 23 (32.4%) were alive with amputation; of the six deceased, two had been amputated. The proportion of patients alive without amputation was highest in the Fontaine III (18 of 21 patients, 85.7%) and lowest in the Fontaine IV (24 of 50 patients, 48%). In the subgroup of the 19 patients with diabetes, of whom 17 were Fontaine IV, no deaths were recorded, and in 10 cases (52.6%), amputation was unnecessary.

The interpretation of these data is limited by their retrospective and uncontrolled nature, although the favorable results compared with similar results from previous studies. The authors conclude that SCS is an appropriate, safe, and effective method as an additional treatment in patients with no possibility of surgical reconstruction in critical ischemia and that the best results are observed in patients with Fontaine stage III.

VERTEBRAL ARTERY STENOSIS: A NARRATIVE REVIEW

BURLE V, PANJWANI A, MANDALANENI K, ET AL. (AUGUST 16, 2022). VERTEBRAL ARTERY STENOSIS: A NARRATIVE REVIEW.

Cureus 14(8): e28068.
[DOI 10.7759/cureus.28068](https://doi.org/10.7759/cureus.28068)

Burle et al. (St. George University School of Medicine, Clarksville, USA) review the anatomic, pathophysiologic, and therapeutic features of vertebral artery stenosis (VAS). They are responsible for 20% of subsequent ischemic cerebrovascular accidents (ICA). The causes of VAS, in addition to calcification and atherosclerotic lesions, are dissections, fibromuscular dysplasia, giant cell arteritis, neurofibromatosis, and bone compression. The most frequent symptoms are vertigo, vision disorders, nystagmus, dizziness, loss of consciousness, nausea, and ataxia. They can lead to stroke, infarction, vertebrobasilar insufficiency, and sudden death without diagnosis and treatment.

The vertebral artery is anatomically divided into four segments (V1-V4): the ostial segment (from its origin to the transverse foramen of the sixth cervical vertebra), the transverse segment (to the second vertebra), the suboccipital segment (until it crosses the dura mater) and the fourth or intracranial segment, which extends to its junction with the contralateral vertebral artery to form the basilar artery.

The authors review the causes of calcifications and atherosclerotic lesions in the extracranial segments.

Lesions caused by dissection are infrequent in the general population but are one of the leading causes of stroke in those under 45, with an incidence of 10-25%. They can be traumatic, associated with previous lesions, or spontaneous; the latter are seen more frequently in older adults. Possible causes include chiropractic maneuvers, spontaneous cranial movements, cervical trauma, oral contraceptives, and fibromuscular syndromes such as Ehlers-Danlos type IV and osteogenesis imperfecta type I. Dissections usually occur in segment V3 because of its proximity to the atlantoaxial joint, which is involved in the rotational movement of the head.

Fibromuscular dysplasia is a hereditary, non-atherosclerotic, non-inflammatory vascular condition that can affect any vessel and is the third most common cause of vertebral artery injury. It is caused by abnormal deposition of collagen fibers. It can affect the intimal, medial, or adventitial layers, with the medial layer being the most frequently involved, manifesting as alternating areas of dilatation and stenosis. The forms affecting the intimal or adventitial layers, which are less frequent, are stenotic.

Another rarer cause of AVS is giant cell arteritis, an autoimmune disorder that affects the vasculature by inflammation of the internal elastic membrane. Arteries with this granulomatous process, which in 75 to 100% of cases affects the vertebral arteries, present as thrombotic obstruction, necrosis, or stenosis. Neurofibromatosis type 1 is an autosomal dominant disorder affecting several tissues (brain, bones, and vessels) and can manifest as stenosis, occlusion, aneurysms, and arteriovenous fistulas, is also described.

External compressions can produce VAS at any point along its course, the most frequent site being the C1-C2 level. Primary causes include neck muscle hypertrophy, osteophytes, fibrous bands, idiopathic hyperostosis, cervical spondylosis, spondylolisthesis, herniated discs, and other mobility disorders and tumors. A particular case is the bow hunter's syndrome due to compression of the V3 segment, which typically occurs in cases of a dominant vertebral artery occluded by head rotation.

VAS can cause symptoms such as vertigo, ataxia, diplopia, speech disorders, bilateral hemianopsia, syncope, headaches, tinnitus, other neurological symptoms, and an increased risk of stroke or transient cerebral ischemia. The most severe symptoms are usually seen when the lesion is bilateral. The true incidence of VAS is unknown because of the large number of asymptomatic cases.

Subclavian steal syndrome is a special case of flow compromise resulting from injury to the subclavian artery in the vicinity of the origin of the vertebral artery, leading to a reversal of flow in the ipsilateral vertebral artery.

Because of its complex, tortuous, variable anatomy, with extracranial and cranial segments, VAS often offers difficulties in diagnosis. Doppler examination has low sensitivity compared to other noninvasive diagnostic methods, such as computed tomography and magnetic resonance imaging. Digital angiography is the most accurate method, although it is more invasive and risky.

In addition to preventing and treating risk factors common to other arteriopathies, it is suggested that patients with VAS due to atherosclerosis or compression receive antiplatelet medication. The WASID (warfarin-aspirin symptomatic intracranial disease) study concluded that warfarin would be more effective for stroke prevention in patients with symptomatic VAS.

In surgical treatment, the authors point out the technical difficulties, poor success, and complications of endarterectomy. Reconstructive surgeries have better results, especially when the involvement is proximal. Although surgical treatment of VAS has some degree of success, it is a technically challenging procedure with frequent postoperative complications and deaths. Direct surgery is performed less frequently because of advances in endovascular techniques. Currently, angioplasty-stenting of symptomatic VAS is considered a safe, durable, and effective method, and drug-eluting stents are preferred because of their lower restenosis rate.

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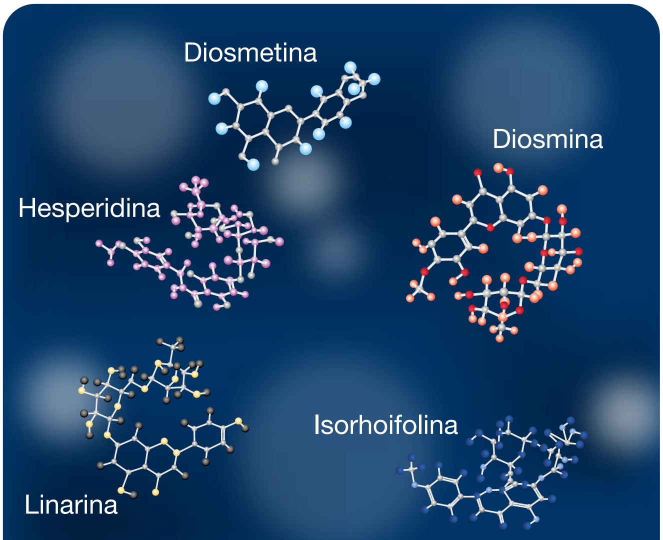

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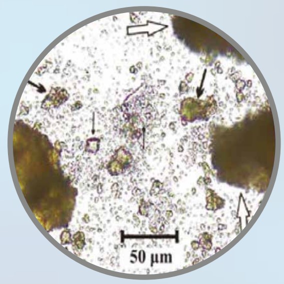

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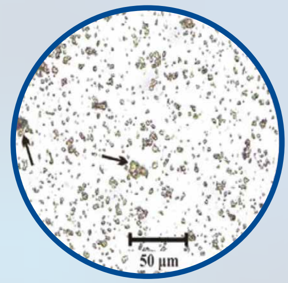

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