Intentional coverage of the left subclavian artery during endovascular repair of traumatic descending thoracic aortic transection

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Objective: **This single-center, prospective study aimed to investigate the technical success and outcome of intentional coverage of the left subclavian artery (LSA) in patients undergoing thoracic endovascular aortic repair (TEVAR) for traumatic rupture of the aortic isthmus at a tertiary care medical center.**

Methods: **From January 2005 to June 2011, patients who presented with traumatic aortic transection underwent TEVAR with coverage of the LSA when the distance between the artery and the rupture was <2 cm. At 12, 24, and 72 hours postoperatively, clinical and neurologic evaluation including transcranial Doppler insonation of the brachial artery was performed. A decrease in peak systolic velocity (PSV) >60% with respect to the contralateral one was considered relevant. Functional status of the left arm was evaluated using a provocative test. Thoracoabdominal computerized tomographic angiography was performed postoperatively at 3-, 6-, and 12-month follow-up.**

Results: **Thirty-one patients (mean age 35 years) underwent emergency TEVAR for traumatic aortic transection with intentional LSA coverage during the study period. In four cases (12.9%) coverage was partial. Two patients (6.4%) died during the postoperative period due to associated lesions. No signs of vertebrobasilar insufficiency, stroke, or paraplegia were observed in any of the patients. Nine patients (36%) had severe arm claudication (ischemic pain within 60 seconds of beginning arm exercise and decrease of PSV between 50% and 60%). Risk factors for the condition were left vertebral artery diameter <3 mm ($P < .0001$). A significant correlation was found between the degree of PSV reduction and left arm symptoms ($P < .0001$). There was an improvement in ischemic arm symptoms ($P < .0001$) during mean follow-up of 36 months (range, 6-65 months), with only one patient (4.2%) presenting with severe claudication. Freedom from reintervention at 48 months was 93.5%. No signs of endoleaks or graft migrations were detected on computerized tomographic angiography control scans.**

Conclusions: **Coverage of the LSA during TEVAR for traumatic aortic injuries appears to be a feasible, safe method for extending the endograft landing zone without increasing the risk of paraplegia, stroke, or left arm ischemia. Left vertebral artery diameter can be used to identify patients at risk for postoperative left arm ischemia. (J Vasc Surg 2013;57:684-90.)**

Traumatic transection of the thoracic aorta is a catastrophic condition with a mortality rate at the scene ranging from 75% to 90%.[1] The prognosis of patients who survive the initial insult remains poor, with a mortality rate of 30% during the first 6 hours and 50% within 24 hours of the event.[2] In order of frequency, ruptures involve the aortic isthmus (70%-90%), ascending aorta, aortic arch, and distal descending aorta.[3] Despite significant advances in critical care medicine and surgical techniques, morbidity and mortality after open repair (OR) continue to be high, with a 30-day mortality rate ranging from 10% to 30% and the paraplegia rate ranging from 3% to 25%.[4,5]

Beginning with Semba et al[6] in 1997, thoracic endovascular aortic repair (TEVAR) has been found to be a safe, effective alternative to OR.[7] A recent meta-analysis of retrospective cohort studies found that TEVAR is associated with a lower postoperative mortality rate and ischemic spinal cord complication rate with respect to OR.[8] Several technical/physical variables such as aortic diameter and arch angulation in young patients and access artery size must be taken into consideration when endovascular repair is being contemplated, with special attention given to the landing zone. A landing zone of at least 1.5 cm usually is recommended to achieve a reliable seal, but the surgeon is often faced with a challenge because aortic rupture frequently involves the isthmus, which is located 1 to 2 cm below the left subclavian artery (LSA) at the inner aortic curve. This implies covering the ostium of the LSA to secure a proximal seal of the endograft, and complications such as acute left arm ischemia and posterior stroke are possible consequences.[9,10] There is also a theoretical risk of paraplegia due to reduction in perfusion of the radicular and the supreme intercostal arteries, which supply blood to the spinal cord tissue.[10]

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The aim of this single-center, prospective study was to investigate the outcome of intentional coverage of the LSA in patients undergoing TEVAR for traumatic rupture of the thoracic aorta.

METHODS

A prospective study was carried out between January 2005 and December 2010 at the Vascular and Endovascular Surgery Department of the University of Padua Medical Center to analyze the outcome of intentional LSA coverage during emergency TEVAR for traumatic aortic injury. The study's primary end points were left arm ischemia, stroke, and paraplegia rate. Secondary end points included postprocedural complications, such as endoleaks, graft migration, and mortality rate.

Study design. All patients who presented to the emergency room of our hospital center with suspected traumatic aortic injury were immediately transferred to the radiology department, where emergency thoracoabdominal computerized tomography angiography (CTA) was performed to confirm aortic trauma and to detect the presence of other concomitant injuries. Based on imaging, aortic lesions were classified into four grades according to the classification proposed by Azizzadeh et al.[11] In accordance with the protocol, patients with grade I and II lesions were treated medically (Table I). The scans of patients with grade III and IV lesions were elaborated using the OsiriX software (www.osirix-viewer.com) to ascertain aortic diameter and length, information needed to determine the size of the thoracic endograft to be implanted. Indications for covering the LSA ostium are listed in Table II.

The endograft were oversized approximately 10% to 15%. All TEVARs were performed in an operating room equipped with a mobile C-arm (Euroampli, Alien; Eurocolumbus, Milan, Italy) and a carbon fiber operating table. Valiant thoracic endografts (Medtronic Vascular Inc, Santa Rosa, Calif) were used. The procedures were performed with patients under general anesthesia. Invasive right radial artery and standard cuff left humeral artery pressure recordings were used. Vascular access for endograft deployment was obtained through the right common femoral artery surgically exposed or through an iliac polytetrafluoroethylene (PTFE) conduit if the femoral vessel was unsuitable. A marked pigtail catheter was introduced through a left percutaneous femoral access using a 5F introducer sheath. To reduce arch manipulation by the endograft, an angiogram was usually performed to mark the origin of the left common carotid artery, and the endograft was advanced in the aortic arch without exceeding that mark. The roadmap was used for accurate deployment of the endograft. The entire procedure was performed without systemic heparinization to prevent bleeding from other organ lesions; the entry site was flushed with heparin solution (10 UI/mL) to prevent clot formation. A routine completion angiogram was performed to confirm rupture exclusion. In case of endoleak, the endograft was molded using a compliant balloon without ballooning the edges to avoid the risk of anterograde or retrograde dissection.

Table I. Classification system of traumatic aortic injury as proposed by Azizzadeh et al[11]

Grade	*Description*	*Study population, No. (%)*
I	Intimal tear	3 (8.1%)
II	Intramural hematoma	2 (5.4%)
III	Pseudoaneurysm	22 (59.4%)
IV	Rupture	10 (27.1%)

Table II. Indications for covering the ostium of the left subclavian artery (*LSA*) during thoracic endovascular aneurysm repair (TEVAR) for emergency aortic transection

Distance between rupture site and LSA ostium <2 cm
Distance between rupture site and sharpest bend of descending thoracic aorta <1.5 cm

Upon awakening, patients were evaluated by a neurologist to identify any sign of stroke and/or vertebrobasilar insufficiency. Postoperative CTA was performed 48 hours later.

Left arm evaluation. Complete clinical evaluation of the left arm, including examination of the hand and capillary nail refill test, temperature evaluation, pulse palpation, and bilateral brachial blood pressure measurements, was performed in all patients immediately after the procedure and 12, 24, and 72 hours later. At those times and at discharge, Doppler insonation of the brachial forearm arteries at the wrist was performed. A monophasic spectral Doppler waveform with >60% decrease in peak systolic velocity (PSV) with respect to the contralateral vessel was considered relevant.

A provocative test using a rubber squeeze ball was performed to evaluate exertional arm pain. Patients were instructed to squeeze a rubber ball with their left hand once every second for 3 minutes. An electronic clock provided the rhythm. Claudication was considered severe if the test was interrupted because of onset of ischemic pain within 1 minute, moderate if pain onset occurred between 1 to 2 minutes, and absent if pain onset occurred after more than 2 minutes. The test was performed upon awakening and before discharge.

Preoperative CTA scans were reviewed to examine the association between vertebral artery anatomy and onset of posterior ischemic symptoms and/or left arm ischemia using the following protocol: (1) The vertebral artery diameter was estimated by taking three different measurements at each side, and the mean value was used for further analysis. (2) Measurements in the first segment of the vertebral artery were taken between its origin and the transverse foramen of the fifth or sixth cervical vertebra. (3) The vertebral artery was considered dominant when the diameter difference was >2 mm.[12] (4) The artery was considered an atretic vertebral artery when its diameter was <2 mm.[13]

Follow-up. The CTA scans were performed 3, 6, and 12 months postoperatively and annually thereafter in uneventful cases. Follow-up measures were adjusted accordingly in complicated cases.

Clinical examination, Doppler ultrasound, and provocative test were performed 3, 6, and 12 months postoperatively and yearly thereafter to evaluate left arm function. Patients were asked to complete a questionnaire (Appendix, online only) about left arm function during daily activities at each postoperative control. Patients were instructed to rate each item using a scoring system between 0 and 6. A score between 0 and 2 indicated that the function being considered was unsatisfactory, a score of 3 to 4 indicated that the function considered was satisfactory, and a score of 5 to 6 indicated that there was no impairment in that function.

Neurologic examination was also performed during each follow-up control to evaluate signs of vertebrobasilar insufficiency

Definitions and statistics. Technical, functional, and clinical outcomes were defined according to the published criteria for endovascular aortic aneurysm repair.[14]

Results are given as median (standard deviation [SD] or range) for quantitative variables and as count and percentage for categorical data. Left vertebral artery diameter and PSV at baseline and during follow-up controls were compared across symptom categories using the Kruskal-Wallis test, which was followed, in the event of a statistically significant result, by the Dunn test or the Wilcoxon rank sum test. Changes in symptoms from baseline ratings were calculated using the Bhapkar test. Overall survival and freedom from LSA revascularization were calculated using Kaplan-Meier analysis. Significance was set at the 5% level. Analyses were performed using SAS 9.2 for Windows (SAS Institute, Cary, NC).

Table III. Patient characteristics

Demographic	
Male/female	28/3
Age, mean (range), years	35 (16-77)
Smoker	5
Hypertension	3
Chronic obstructive pulmonary disease	1
Preoperative	
Glasgow coma scale score, mean (range)	7 (3-15)
SBD at admittance, mean (SD), mm Hg	85.6 (8)
Grade III aortic lesion, No. (%)	22 (71)
Grade IV aortic lesion, No. (%)	9 (29)
Aortic diameter, mean (range)	28 (18-32)
Associated lesions, No. (%)	
Femoral fracture	11 (35)
Head trauma	9 (29)
Rib fracture	8 (26)
Arm fracture	7 (22)
Spleen rupture	5 (16)
Leg fracture	4 (13)
Vertebral fracture	2 (6)
Brachial plexus lesion	2 (6)
Hip fracture	1 (3)
Kidney rupture	1 (3)
Left ventricular papillary muscle rupture	1 (3)
Perioperative	
Endograft diameter, range, mm	22-34
Endograft length, range, cm	107-117
No. of endografts deployed per patient	1
Blood loss, mean (SD), mL	190 (72)
Primary clinical success	100%
Iliofemoral bypass, No. (%)	3 (10)
LSA coverage, No. (%)	27 (87)
Left arm ischemia, No. (%)	1 (3)
Mortality,[a] No. (%)	2 (8)

LSA, Left subclavian artery; *SBD,* systolic blood pressure; *SD,* standard deviation.

[a]Not procedure related.

RESULTS

Forty-one patients presented to the emergency room with suspected traumatic rupture of the thoracic aorta during the study period. All underwent emergency CTA that in four cases (9.7%) showed no sign of thoracic aorta lesions. Aortic lesions were classified as grade I and II in five cases (15.6%); these were treated medically according to protocol. Those data were not included in this study. One patient (3.1%) who presented with a type IV rupture died in the radiologic department immediately after CTA.

Thirty-one patients (28 males and three females; mean age 35 years; range, 16-77 years) diagnosed with a traumatic rupture of the thoracic aorta (caused by an automobile accident in 16, a motorcycle accident in 14, and a bike accident in one) were considered eligible for this study. At admittance to the emergency room, mean systolic blood pressure was 75.6 (8) mm Hg with a Glasgow coma scale score of 7 (range, 3-15). Associated traumatic lesions are listed in Table III. The CTA scan showed a grade III aortic lesion in 22 patients (70.9%) and a grade IV lesion in nine (29.1%), with aortic diameter ranging from 18 to 32 mm (Fig 1, *A*).

In three cases (9.7%), a retroperitoneal iliac approach was used for thoracic endovascular aortic repair access. Mean endograft diameter was 28 mm (range, 22-34 mm). Because all of the lesions were focal, a single graft was sufficient. Mean intraoperative blood loss was 190 (72) mL, mean amount of contrast dye infused was 98 (23) mL, and mean fluoroscopy time was 13 (5) minutes. In five cases (16.1%), balloon angioplasty of the endograft was required because of type IA endoleaks. Completion angiography using multiple projections showed successful exclusion of the transection in all of these cases.

In 27 cases (87.1%), the LSA was successfully covered with some residual flow detected by completion angiography. In four cases (12.9%), the LSA was partially covered, and there was direct inflow from the aortic arch that persisted throughout the postoperative period, as confirmed by Doppler ultrasound. Two of these patients died during the early postoperative period, one due to severe head trauma with brain exposure and the other due to acute left ventricular failure linked to papillary muscle rupture. The overall early mortality rate was 6.4%. There were two nonfatal pulmonary complications and two wound and urinary tract infections.

Postoperative CTA at 48 hours showed complete exclusion of the aortic transection in all cases and no signs

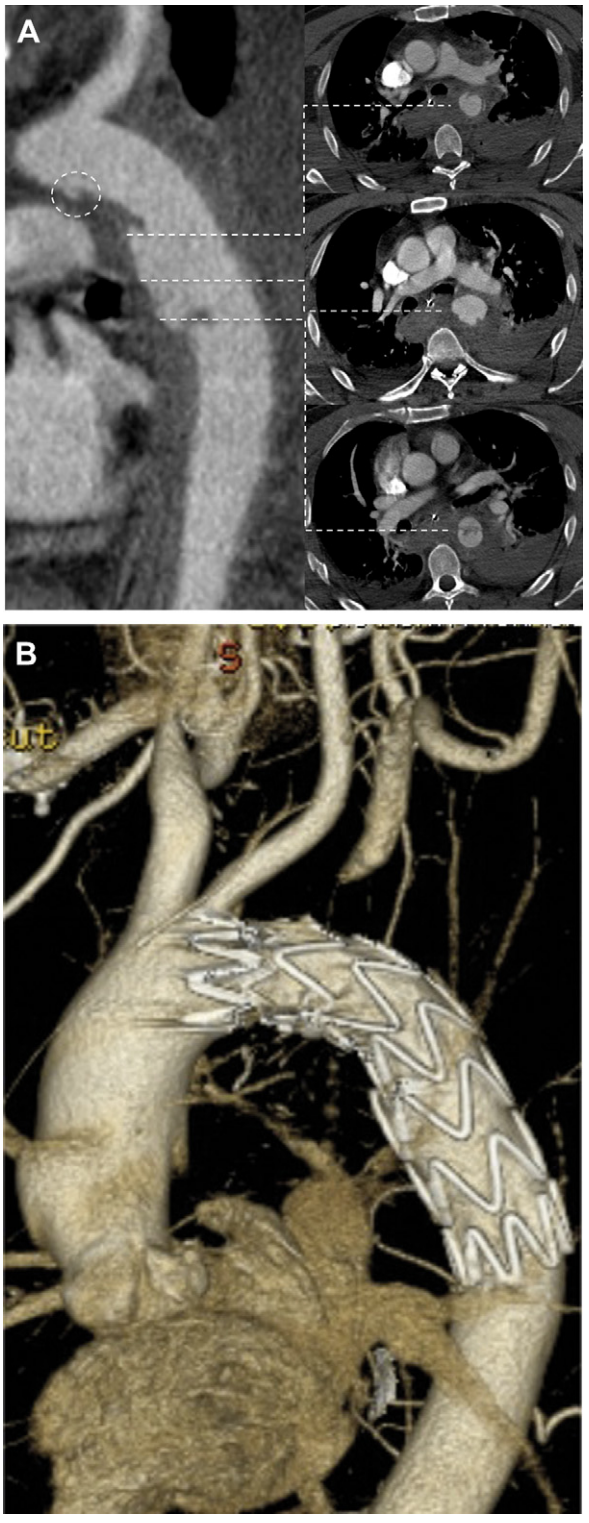

Fig 1. Preoperative computed tomographic angiograms (CTAs) showing a grade IV traumatic aortic transection (*white circles* indicates lesion's extension near origin of left subclavian artery [LSA]; **A**) treated with an endovascular repair covering the origin of the LSA **(B)**.

of endoleaks, with apposition of the endograft within a few centimeters of the LSA (Fig 1, *B*).

On the third postoperative day, one patient (3.7%) with a Glasgow coma scale score of 11 developed a brachial artery thrombosis with acute onset of forearm ischemia. Because the LSA originated close to the left common carotid artery, it was marked with a 0.035-inch hydrophilic guidewire inserted through the brachial access using a 4F introducer sheath. Arterial compression and an elastic bandage maintained for 24 hours probably were responsible for the thrombosis. Doppler ultrasound examination detected PSV reduction of 71% and 65% at 12 and 24 hours, respectively, in the absence of signs of acute ischemia. The next Doppler examination detected brachial artery thrombosis with acute-onset ischemia. A carotid-to-subclavian bypass using an 8-mm e-PTFE graft with thrombectomy of the brachial artery was performed.

Clinical evaluation and Doppler ultrasound examinations showed no sign of left arm ischemia in the other patients. Mean reduction in PSV in the left brachial artery was 34% ± 15% with respect to the contralateral vessel after 24 hours, and that value remained constant at subsequent evaluations. There was inverted vertebral artery flow and a pressure gradient between the right and left arms ≥20 mm Hg (range, 20-28 mm Hg) not detected preoperatively in all these patients.

The provocative test performed upon awakening detected severe claudication in eight patients (32%), moderate claudication in nine (36%), and no claudication in eight (32%). The test could not be performed in one patient who presented with concomitant fracture of the left humerus and lesions of the brachial plexus. The test was repeated at discharge (mean 18 days; range, 12-26 days), and a significant improvement ($P < .0001$) was noted. Three patients (12%) presented with severe claudication, seven (28%) with moderate claudication, and 15 (60%) with no signs of claudication (Fig 2).

A significant, noteworthy correlation between the percentage of PSV reduction and the results of the provocative test ($P < .0001$) was found. Patients with >50% reduction of PSV presented with severe claudication, those with a reduction between 30% and 50% had moderate claudication, and those with <30% reduction had no signs of claudication (Fig 2).

Mean diameter of the left vertebral artery was 3.69 (0.43) mm, whereas that of the right vertebral artery was 3.51 (0.44) mm. The difference between diameters was not significant ($P = .15$). No hypoplastic vertebral arteries were observed. The left vertebral artery was dominant in 11 patients (44%), the right vertebral artery was dominant in six (24%), and the vessels were symmetric in eight (32%). Mean diameter of the dominant artery (3.96 [0.41] mm) was significantly wider with respect to the nondominant one (3.28 [0.41] mm; $P < .001$).

No association was observed between vertebral artery dominance and degree of postoperative left arm claudication or PSV reduction in the left brachial artery. A

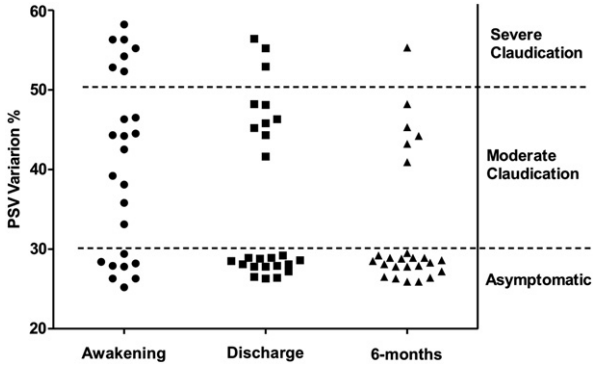

Fig 2. Relationship between percent of peak systolic velocity (PSV) decrease measured by ultrasound Doppler in the left brachial artery with respect to the contralateral and the grade of left arm claudication. If the decrease was >50%, patients had severe claudication; if the decrease was between 30% and 50%, patients had mild claudication; and if the decrease was <30%, patients were asymptomatic ($P < .0001$). The grade of left arm claudication improved significantly during follow-up ($P < .0001$).

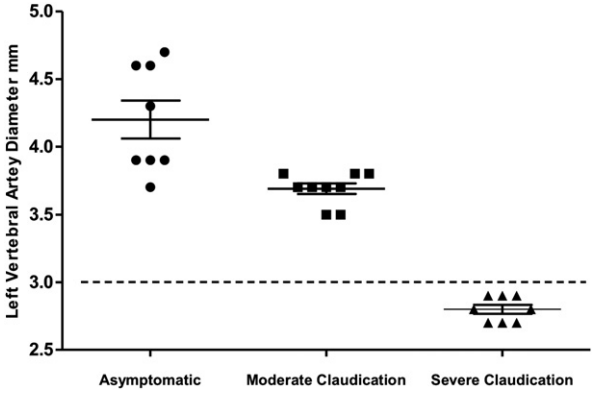

Fig 3. Relationship between left vertebral artery diameter and grade of left arm claudication ($P < .0001$). *Lines* represent mean left vertebral diameter with standard deviation (⊥). *PSV,* Peak systolic velocity.

significant correlation was found between left vertebral artery diameter and the degree of postoperative left arm claudication. Patients whose left vertebral artery diameter was <3 mm had severe claudication ($P < .0001$; Fig 3).

No cases of paraplegia or of vertebrobasilar insufficiency were noted.

Follow-up. The technical, functional, and clinical success rate of the procedure during the follow-up period (mean 36 months; range, 6-65 months) was 100%, and the CTA control scans showed patency of all endografts without signs of endoleaks or graft migration.

One patient (4%) who had a concomitant left humerus fracture and omolateral brachial plexus lesions required adjunctive orthopedic repair. In that case, the LSA was revascularized through a carotid subclavian bypass using an 8-mm e-PTFE graft before an orthopedic procedure was performed to ensure adequate blood supply to the left arm.

Five patients (20%), who had given a rating of 5 to 6 indicating no limitation in normal activities on all of the items on the questionnaire during follow-up, had moderate claudication with PSV reduction between 30% and 40% with respect the contralateral brachial vessel. Surgical revascularization of the LSA was not considered in any of these cases. Nineteen patients (76%) showed no signs of pain during the provocative test and gave a rating of 6 for all of the items on the questionnaire. Freedom from LSA revascularization at 48-month follow-up estimated by Kaplan-Meier analysis (intention to treat) was 93.5%, and the patency rate of reconstructions performed during the follow-up period was 100% (Fig 4).

No signs of vertebrobasilar insufficiency were noted.

DISCUSSION

Characterized by lower short-term mortality, morbidity, and spinal cord ischemia rates,[15] TEVAR for traumatic thoracic aortic rupture is a less invasive procedure with respect to open surgery. Short-term results are, in fact, promising, although concerns have been advanced with regard to long-term durability.

The landing zone is essential to the technical success of TEVAR and to good long-term results. A landing zone of at least 1.5 cm is generally required to ensure seal reliability. This could create a challenge to the surgeon because the rupture site is frequently located at the aortic isthmus, generally just 1 to 2 cm away from the LSA or from the sharpest bend of the descending thoracic aorta. Placing an endograft in that area could result in stent graft failure, graft migration, or the need for an adjunctive procedure.[7,16] To prevent these complications and to provide a secure sealing zone, the endograft should be deployed in the landing zone.[2]

Covering the LSA is not without consequences because there is less blood supplying the left arm and the vertebral artery, which plays a critical role in irrigating the posterior cerebral lobe, the cerebellum, and the spinal cord. Until now there have been conflicting data in the literature with regard to intentional LSA coverage, and there is no consensus on the management of LSA for traumatic aortic injury.[17-20] A recent systematic review of the literature reported a higher prevalence of left arm ischemia and stroke after LSA coverage,[9] but these findings are considered questionable, largely because all the studies were retrospective and were not designed for that specific topic.[20]

This study is the first prospective study specifically designed to investigate the outcome of LSA coverage used to treat traumatic lesion of the thoracic aorta. The data concerning the patients studied indicate that LSA coverage is a safe procedure associated with a 93.5% overall freedom from revascularization at 48 months. As already reported, LSA revascularization can be safely delayed and performed when necessary with excellent technical results.[17]

In the patient sample studied, the incidence of left arm ischemia after LSA coverage was very low, and the vertebral artery seemed to be able to ensure adequate perfusion to the arm. The compensatory mechanism seemed to increase

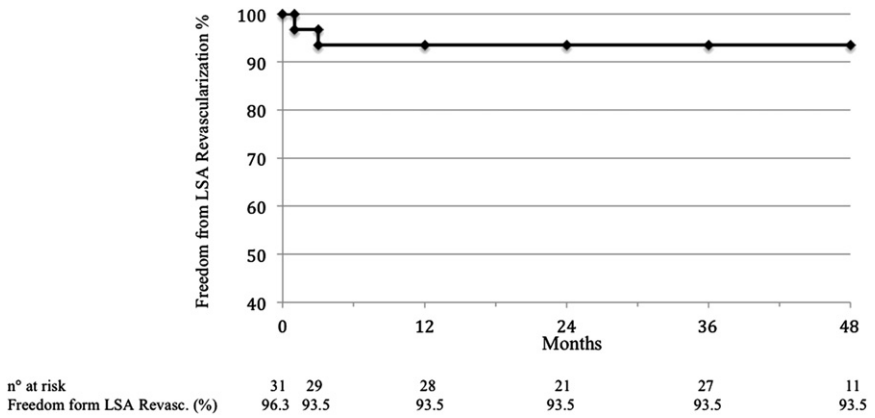

Fig 4. Kaplan-Meyer analysis showing freedom from left subclavian artery (*LSA*) revascularization of 93.5% at 48 months.

in the days after LSA coverage, as confirmed by the provocative test. Results of the first test performed immediately upon awakening indicated that there was a comparable distribution of ratings (severe, mild, or no claudication), whereas the test performed before discharge showed that the majority of patients (60%) had no claudication. During follow-up the percentage rose to 76%. Only one patient, who refused to consider further treatment and who nevertheless gave a rating of 5 to 6 (no impairment) on the questionnaire, presented persistent severe left arm claudication ($P < .0001$).

CONCLUSIONS

The fact that the percentage of PSV reduction and the provocative test results were correlated is an important finding. Patients with >50% PSV reduction, in fact, also presented severe claudication. If patients had reduction between 30% and 50%, claudication was moderate, whereas those with <30% reduction had no symptoms. PSV reduction can then provide an objective criterion to evaluate upper arm ischemia, and this could be particularly useful if the patient is unconscious. Study results seem to suggest that PSV reduction >60% might be an indication to perform LSA revascularization. If the reduction is lower, revascularization does not seem to be necessary regardless of the degree of claudication or the questionnaire ratings. Further investigation is warranted to confirm these findings and to establish a cutoff value.

No association was observed between the degree of left arm claudication, PSV reduction, and vertebral artery dominance. The presence of a dominant or nondominant left vertebral artery does not seem to be a risk factor for LSA revascularization. A significant association, instead, emerged between left vertebral artery diameter and degree of postoperative left arm claudication: patients with diameter <3 mm developed severe claudication ($P < .0001$). This could be a parameter that preoperatively identifies patients at risk for postoperative arm ischemia and thus of LSA revascularization. Although a left hypoplastic vertebral artery may be associated with an increased risk of left arm ischemia, there were no cases in the sample studied. Recent studies have shown that the frequency of hypoplastic vertebral artery ranges between 1.9% and 2.3% in the healthy population, with a higher incidence on the right side (7.8% vs 2.8%).[13] The low incidence of this type of artery in the general population probably explains the results found in our sample.

Recent data have identified an increased risk of neurologic complications, cerebrovascular accidents, and spinal cord ischemia after LSA coverage.[21,22] This tendency was partially confirmed by a systematic review and meta-analysis carried out in 2009, which concluded that LSA coverage increased the risk of neurologic complications, although preemptive revascularization did not seem to offer any protection.[10] A heterogeneous etiology may be linked to these pathologies and not strictly related to LSA coverage. Our study results uncovered no cases of cerebrovascular accidents or spinal cord ischemia. This may be due to the fact that no patients with atretic or hypoplastic vertebral arteries, possibly associated with a higher risk of posterior ischemia, were found in our study sample. Another explanation could be linked to the fact that only a single endograft between 10.7 to 11.7 cm long was deployed in the upper portion of the thoracic aorta in the patients studied. Spinal cord ischemia is strongly associated with how much of the thoracic aorta and, more specifically, the distal thoracic segment near the origin of the Adamkiewicz artery is covered.[10]

This study presents some limitations. It is a single-center experience and not a control randomized comparative study. The study sample was relatively small, and follow-up was relatively short. Long-term studies are warranted to investigate the outcomes of LSA coverage and the durability of endovascular repair, particularly in young patients.

AUTHOR CONTRIBUTIONS

Conception and design: MA, PF
Analysis and interpretation: MA, SL

Data collection: CM, AD, SL
Writing the article: MA
Critical revision of the article: PF, MM
Final approval of the article: FG
Statistical analysis: CM, AF
Obtained funding: Not applicable
Overall responsibility: MA

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Additional material for this article may be found online at www.jvascsurg.org.

Appendix (online only)

Questionnaire

- **Work Activity**
  1. What kind of work do you perform?
  2. How important is, in your opinion, left arm strength in your everyday work?
     1 2 3 4 5 6
  3. How much strength of the left arm do you usually need in your everyday work?
     1 2 3 4 5 6
  4. Do you usually feel pain at the left arm during your work activity, and, if so, how much?
     Yes No
     1 2 3 4 5 6
  5. Do you perceive any limitation on your work activity that could be related to the left arm?
     Yes No
     1 2 3 4 5 6

- **Home Activities**
  1. How important, in your opinion, is left arm strength in your activity at home?
     1 2 3 4 5 6
  2. How much strength do you usually need in your activity at home?
     1 2 3 4 5 6
  3. Do you usually feel pain at the left arm during your activity at home, and, if so, how much?
     Yes No
     1 2 3 4 5 6
  4. Do you perceive any limitation on your home activity that could be related to the left arm?
     Yes No
     1 2 3 4 5 6