Clinical Research

One-Year Outcome of Postoperative Stroke and Nerve Injury After Supraclavicular Revascularization of The Left Subclavian Artery for Proximal Landing Zone Extension in Thoracic Endovascular Aortic Repair

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Objective: To assess the outcome of stroke and nerve injury after supraclavicular revascularization of the left subclavian artery for proximal landing zone extension in thoracic endovascular aortic repair (TEVAR).
Methods: Retrospective analysis of all patients undergoing left-sided carotid-subclavian bypass (CSB) and subclavian-carotid transposition (SCT) with simultaneous or staged TEVAR between January 2010 and June 2019. Endpoints were perioperative cerebrovascular events and nerve injuries, patency and re-intervention due to the debranching, and mortality at 30 days and during follow-up.
Results: Forty-eight patients (median age 66 years, 81 % male) had 25 (52%) CSB and 23 (48%) SCT. TEVAR was performed simultaneously in 39 (81%) patients, 11 (23%) of them in an emergent setting. There were 7 (15%) re-interventions within 30 days: 3 due to local hematoma, one for bypass occlusion, 2 for stenosis (of which one was not confirmed intraoperatively), and one after initially abandoned SCT with subsequent CSB on the next day. 30-day mortality was 2%; 1 patient died on the first postoperative day after emergency coronary artery bypass surgery and multiorgan failure. 4 (8%) patients suffered postoperative strokes; 3 occurred after simultaneous emergency procedures and none was fatal. There were 9 (19%) left neck nerve injuries in 8 patients, 5 patients had SCT and 3 CSB. During a median follow-up of 37.5 months (IQR 23-83) with a Follow-up Index of 0.77, there were no reinterventions or occlusions, and no graft infections. Primary patency was 90% and primary assisted patency 98% during follow-up. 8 patients died during follow-up, all of them with patent cervical debranching.
Conclusion: Supraclavicular LSA revascularization for proximal landing zone extension in TEVAR is safe with an acceptable rate of early re-interventions. There is higher risk for perioperative stroke during concomitant emergency LSA revascularization and TEVAR. Left neck nerve injuries are common complications but resolve completely in vast majority of the cases during first postoperative year. During follow-up, excellent patency could be expected.

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INTRODUCTION

Thoracic endovascular aortic repair (TEVAR) has become the first line therapy for different descending thoracic aortic pathologies.[1,2] In 40% of patients requiring TEVAR, the aortic pathology extends near the left subclavian artery (LSA).[3] To attain an adequate proximal landing zone for the stent-graft, coverage of the LSA origin is mandatory in these cases.

LSA coverage without revascularization prior to or during TEVAR significantly increases the 30-day risk for stroke (up to 25%) and upper extremity ischemia (up to 15%).[4] The Society for Vascular Surgery has suggested routine preoperative LSA revascularization in patients undergoing elective TEVAR where proximal sealing requires LSA coverage, despite a very low level of evidence (GRADE 2, level C).[5] The LSA is most frequently revascularized via a supraclavicular access performing carotid-subclavian bypass (CSB) or subclavian to carotid transposition (SCT). In most patients, both techniques are equally acceptable options for elective LSA revascularization, with excellent perioperative patency.[4] In an emergency setting, LSA revascularization should be individualized based on anatomy, urgency and availability of surgical expertise.[5]

Different rates of perioperative stroke and nerve injury have been reported after LSA revascularization in the context of TEVAR. While stroke rates vary between 2–9%, the rate of phrenic nerve injury may be as high as 25%.[4,6-10] Little data exists on the outcome of these neurological complications and patient's disability or recovery at one year or later after LSA revascularization. The aim of this study was to assess perioperative cerebrovascular events and nerve injuries and their outcome after supraclavicular revascularization of the LSA for proximal landing zone extension in TEVAR, focusing on patient's disability and recovery during follow-up.

MATERIAL AND METHOD

This is a retrospective observational cohort study from a single tertiary referral center. We included all patients between January 2010 and June 2019 who underwent elective or urgent supraclavicular LSA revascularization for proximal landing zone extension performed prior, simultaneously or subsequently to TEVAR with coverage of the LSA origin for the treatment of descending aortic pathologies. Patients with supraclavicular LSA revascularization procedures due to peripheral arterial disease of the upper limb with arm ischemia or subclavian steal syndrome as well as all patients who had refused informed consent were excluded. (Fig. 1) The local ethics committee approved the study (Ref. 2019-01071).

Baseline characteristics, peri- and postoperative data were extracted from the patients' medical records. All patients were followed at 6 months and one year after surgery and yearly thereafter, including a clinical examination, duplex ultrasound and/or computed tomography (CT) or magnetic resonance imaging (MRI) angiography. Follow-up information was obtained from the records of these visits and through an additional telephone survey with patients and/or relatives as well as their general practitioners by the end of July, 2020.

LSA REVASCULARIZATION

In case the proximal landing zone is shorter than 20mm we usually extend it by performing simultaneous LSA revascularization and TEVAR. In an urgent or emergency setting a LSA coverage without its revascularization was left at discretion of the treating vascular surgeon, depending on severity of the aortic pathology. Urgent setting was defined as TEVAR +/- LSA revascularization within 24h and emergency setting within 12h after admission, Both CSB and SCT were performed in supine position with the head turned slightly to the right via a supraclavicular incision. A single shot cefazolin was administered preoperatively. Before clamping, 100 IU of unfractioned heparin per kilogram body weight were administered. Cerebral perfusion was monitored with near infrared spectroscopy (NIRS).

For SCT, we dissected between the 2 heads of the sternocleidomastoid muscle. Division of the omohyoid muscle was at the surgeon's discretion. The left common carotid artery (LCCA) was dissected and reflected medially, whereas the internal jugular vein and the vagus nerve were reflected laterally. The thoracic duct was only ligated if it interfered with further dissection. The LSA was dissected and carefully clamped proximally to the vertebral artery using a Satinsky clamp, as the recurrent laryngeal nerve might be at risk in this area. We usually did not transect the artery completely, but partially and started oversewing it with continuous monofilament suture, reinforced by teflon pledgets. Once half of the stump was secured, the rest of the artery was transected and oversewn. End-to-side anastomosis of the LSA to the posterolateral side of the LCCA completed the procedure.

For CSB, we dissected the LCCA laterally to the clavicular head of the sternocleidomastoid muscle. Both the internal jugular vein and the vagus nerve were medialized. The LSA was dissected laterally of the anterior scalenus muscle after mobilization of the scalenus fat pad, where the brachial plexus and the phrenic nerve are at risk. In order not to jeopardize the phrenic nerve we did not divide the anterior scalenus muscle if not necessary. We used a prosthetic conduit [expanded polytetrafluoroethylene (ePTFE) or polyethylene

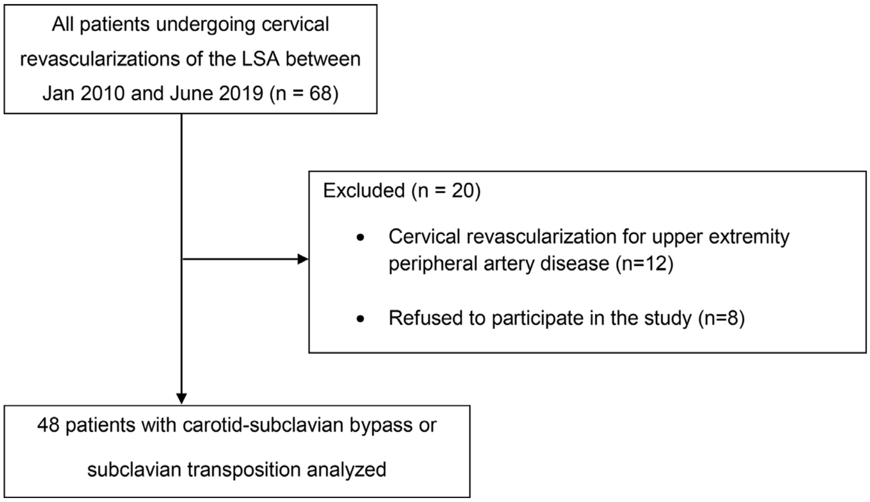


Fig. 1. Flow diagram outlining the Inclusion and exclusion criteria.

terephthalate Dacron)] and performed first the distal end-to-side anastomosis to the LSA and afterwards the proximal one to the LCCA. The LSA was then occluded at the origin using a vascular plug deployed under fluoroscopy via brachial access.

In both, SCT and CSB, mean blood pressure was elevated by at least 20 mmHg during clamping of the LCCA and the perfusion was always first restored to the arm and then to the brain after extensive flushing to avoid cerebral embolization.

PRIMARY ENDPOINTS

Primary endpoints were perioperative cerebrovascular events and nerve injuries including patient recovery from these events and disability during the first postoperative year. Cerebrovascular events were differentiated in transient ischemic attacks (TIA) with a complete resolution of neurologic symptoms < 24 hours, and strokes as defined by the American Stroke Association.[11] All cerebrovascular events were confirmed by a neurologist and correlated with radiological findings (CT or MRI).

Recurrent laryngeal nerve palsy was usually confirmed by indirect laryngoscopy performed by an otolaryngologist. However, postoperative new onset of hoarseness without further investigation by laryngoscopy was also considered recurrent laryngeal nerve palsy. Phrenic nerve palsy was confirmed by fluoroscopic assessment of the diaphragm motor function (sniff test). Horner's syndrome was a clinical diagnosis with the typical triad of ptosis, miosis and enophtalmus.

SECONDARY ENDPOINTS

Secondary endpoints were mortality, re-intervention associated with LSA revascularization and patency within 30 days and during follow-up.

STATISTICAL ANALYSIS

Data are presented as median values and range for continuous variables, and by absolute numbers and percentages for categorical variables. For survival and primary patency, we used Kaplan-Meier analyses. Follow-up was assessed using the Follow-up Index.[12] Statistical analyses were performed using SPSS Statistics 26.0.0.0 (IBM, Armonk NY, USA).

RESULTS

Forty-eight patients (81% male) with a median age of 66 years (range 36-84) were analyzed (Fig. 1). Demographic parameters and comorbidities are presented in Table I. 25 (52%) patients underwent CSB and 23 (48%) SCT. The underlying aortic pathologies and perioperative parameters are listed in Table II. TEVAR was performed in an urgent or emergency setting in 11 patients (23%).

One patient underwent bilateral SCT because of an aberrant right subclavian artery with a Kommerell's diverticulum at the level of the descending aorta. The right-sided SCT was not included in this analysis. In 39 patients (81%) LSA revascularization was performed simultaneously with TEVAR, in 4 (8%) prior to TEVAR and in 5 (10%) after TEVAR. All 5 patients with LSA revascularization after TEVAR had emergency

Table 1. Baseline characteristics

	N
Total number of patients	48 (100%)
Age (years, median, range)	66 (36-84)
Male	39 (81%)
Hypertension	41 (85%)
Coronary artery disease	25 (52%)
Hyperlipidaemia	24 (50%)
Smoking	38 (79%)
COPD	15 (31%)
Diabetes	5 (10%)
Chronic kidney disease*	15 (31%)
Dialysis	2 (4%)
Body mass index (kg/m^2, mean ± SD)	28 ± 5
Peripheral artery disease	5 (10%)
Previous stroke	1 (2%)
Previous neck surgery	0 (0%)

SD, standard deviation; COPD, chronic obstructive pulmonary disease
*mild loss (or more) of kidney function (GFR <60 ml/min) according to the KDIGO 2017 Clinical Practice Guidelines

procedures with partial/complete coverage of the LSA. In these patients, delayed supraclavicular LSA revascularization became necessary due to spinal cord ischemia (1), acute arm ischemia (1), subclavian steal syndrome (2) and the need for proximal extension to treat a type Ia endoleak, requiring landing in zone 2 (1). The patient with spinal cord ischemia additionally received a cerebrospinal fluid drainage and recovered completely prior discharge.

PRIMARY ENDPOINTS

Four patients (8%) suffered perioperative strokes, none of them were fatal and 3 occurred after an emergency procedure. 1 patient had no symptoms at discharge and 2 recovered completely after 2 and 5 months, respectively. The fourth patient partially recovered after one month but died after 3 months of pneumonia. All strokes were caused by emboli and with multiple ischemic zones both supra- and infratentorial as well as right- and left-sided. (Table III)

There were 9 (19%) left neck nerve injuries in 8 patients. 5 patients underwent SCT and 3 CSB. Of 4 patients with left recurrent laryngeal nerve palsy with hoarseness, 2 were confirmed with laryngoscopy and 2 refused to have one.

Table 2. Perioperative characteristics

	N
Clinical presentation (aortic pathology)	
elective	37 (77%)
rupture/symptomatic	11 (23%)
Underlying aortic pathology*	
dissection	16 (34%)
aneurysm	29 (61%)
PAU/IMH	22 (47%)
blunt traumatic aortic lesion	6 (13%)
Subclavian transposition	23 (48%)
Carotid-subclavian bypass	25 (52%)
6 mm ePTFE graft	7 (15%)
8 mm ePTFE graft	14 (29%)
8 mm Dacron graft	4 (8%)
Operation time (inkl. TEVAR), (minutes, median, range)	243 (80-526)
Clamping time of the LCCA (minutes, median, range)	15 (9-85)
Clamping time of the LSA (minutes, median, range)	31 (7-65)
Blood loss (ml, median, range)	400 (80-2200)
Autotransfusion from cell saver (ml, median, range)	212 (86-1108)
Cervical revascularization	
staged: prior to TEVAR	4 (8%)
simultaneously with TEVAR	39 (81%)
staged: after TEVAR	5 (10%)

PAU, penetrating aortic ulcer; IMH, intramural hematoma; PTFE, polytetrafluoroethylene; TEVAR, thoracic endovascular aortic repair; LCCA, left common carotid artery; LSA, left subclavian artery
*some patients had two or more pathologies; Percentages may not total 100 due to rounding

Table 3. Cerebrovascular events after supraclavicular LSA revascularization and TEVAR

Index procedure	Symptoms	Imaging	Symptoms at discharge	Follow-up
Elective, simultaneous CSB and TEVAR	Slight dysarthria, left leg proximal motoric impairment and arm ataxia, right leg paralysis	MRI: Multiple left-sided supra- and infratentorial and cerebellar emboli	Yes, residual stand and gait ataxia	Neurorehabilitation for 1 month, partially resolved, died after 3 months of pneumonia
Emergency TEVAR, staged CSB & chimney stent LCCA on day 1 post TEVAR	Balance and gait disturbance, ataxia lower extremities	MRI: multiple subacute right ischemia zones (cerebellar, precentral gyrus, pontine, precuneus)	None	No late neurological problems
Emergency, simultaneous SCT and TEVAR	Left hemiparesis (predominantly of the arm), facial nerve palsy	CT: subacute ischemia in the right precentral gyrus	Yes, significant improvement, leg M4-M5, arm M3, fingers M1	Completely resolved after 2 months
Emergency, simultaneous CSB and TEVAR	Right hemiparesis (predominantly of the leg)	CT: left-sided subacute temporooccipital ischemia	Yes, significant improvement, leg M3-M4	Completely resolved after 5 months

CSB, carotid-subclavian bypass; SCT, subclavian to carotid transposition; CT, computed tomography; TEVAR, thoracic endovascular aortic repair; LCCA, left common carotid artery; MRI, magnetic resonance imaging

1 patient was treated with a silicone injection into the left vocal cord 3 months later and had significant improvement after 18 months. 2 patients had complete recovery after 6 and 11 months, respectively, and one was lost to follow-up. Phrenic nerve palsy occurred in 2 patients and was confirmed by fluoroscopy in both. One of them died 6 weeks after surgery due to a non-aortic cause and the other one had persistent but asymptomatic phrenic nerve palsy at 12 months. 3 patients presented with left-sided Horner's syndrome, most likely due to damage to fibers of the inferior cervical sympathetic ganglion. All 3 resolved completely after 1 week, 1 month and 6 months, respectively. Left neck nerve injury outcomes are listed in Table IV.

SECONDARY ENDPOINTS

Thirty-day mortality was 2% (1/48) with 1 patient dying on the first postoperative day. This patient was referred to our center due to a pseudoaneurysm of the LSA after iatrogenic subclavian puncture for implantation of a hemodialysis catheter, suffering severe tracheal compression because of the huge mediastinal pseudoaneurysm. After CSB and TEVAR the patient had a cardiac arrest and was resuscitated. Immediate coronarography revealed severe coronary artery disease. Emergent aortocoronary bypass was performed. After transferring the patient to the ICU, she developed bilateral acute-on-chronic limb ischemia. CT angiography revealed a completely thrombosed aorto-iliac segment, early thrombosis of the CSB and one aortocoronary bypass. A severe coagulation disorder was postulated and palliative therapy initiated.

Four patients required re-intervention concerning the LSA revascularization. One patient had an intraoperative local LCCA dissection after clamping and the transposition had to be abandoned. Transection of the LCCA with resection of the dissected segment resolved the acute problem and the LSA was left oversewn. The next day the patient developed acute arm ischemia due to a new dissection of the LSA. A carotid-axillary-bypass was performed. Intraoperatively, the LCCA dissected again with thrombotic occlusion. Finally, the LCCA was replaced by an ePTFE interposition graft and the axillary ePTFE bypass graft was reimplanted. One patient experienced sudden bypass occlusion with acute arm ischemia on the sixth postoperative day and was immediately reoperated. Thrombectomy and shortening of the bypass with new distal anastomosis resolved the ischemia and the arm recovered completely. One SCT was converted into a CSB on the first postoperative day due to a kinked LCCA with stenosis of the proximal LSA and occlusion of the left vertebral artery. Additional chimney stenting in the proximal LCCA was necessary in this case. The fourth patients had stenosis at the level of

Table 4. Left neck nerve injuries outcome

Procedure	Affected Nerve	Confirmed by	Symptoms at discharge	Follow-up
CSB	LRLN	Laryngoscopy	Persistent, improving	Recovered after 11 months
CSB	LPN	Fluoroscopic sniff test	Persistent, asymptomatic	Permanent & asymptomatic after 12 months
SCT	LPSCh	Horner's syndrome	Recovered after 1 week	Recovered during follow-up
SCT	LPSCh	Horner's syndrome	Persistent	Recovered after 1 month
SCT	LRLN	Laryngoscopy	Persistent	Treated with silicone injection after 3 months; significant improvement after 18 months
CSB	LPN	Fluoroscopic sniff test	Persistent	Unknown (death 6 weeks after surgery due to non-aortic cause)
SCT	LRLN	Refused laryngoscopy	Persistent	Unknown (lost to follow-up)
SCT	LPSCh + LRLN	Horner's syndrome / hoarseness (refused laryngoscopy)	Persistent, improving	Recovered after 6 months

CSB, carotid-subclavian bypass; SCT, subclavian to carotid transposition; LRLN, left recurrent laryngeal nerve; LPN, left phrenic nerve; LPSCh, left paravertebral sympathetic chain

Table 5. Early postoperative reintervention after supraclavicular LSA revascularization

Index procedure	Complication	Reintervention	Last-Follow up
CSB and TEVAR, LSA plug occlusion	Day 6: CSB occlusion with consecutive arm ischemia	Thrombectomy & shortening of the graft, fenestration of LSA dissection (found intraoperatively)	After 37 months bypass open, no reintervention
CSB and TEVAR, LSA plug occlusion	Day 2: suspected stenosis at the level of the distal anastomosis in CT scan	Intraoperatively no stenosis	After 32 months bypass open, no reintervention
CST and TEVAR	Day 0: dissection of the LCCA and LSA, Transposition abandoned	Bypass extension to the axillary artery, resection and T-shaped reconstruction of the LCCA	After 46 months bypass open, no reintervention
SCT and TEVAR	Day 1: CT scan revealed kinked LCCA with stenosis of the proximal LSA, occlusion of the left vertebral artery	Conversion from CST into CSB and additional chimney stent in the LCCA	After 101 months bypass open, no reintervention

CSB, carotid-subclavian bypass; SCT, subclavian to carotid transposition; TEVAR thoracic endovascular aortic repair; LSA, left subclavian artery; LCCA, left common carotid artery

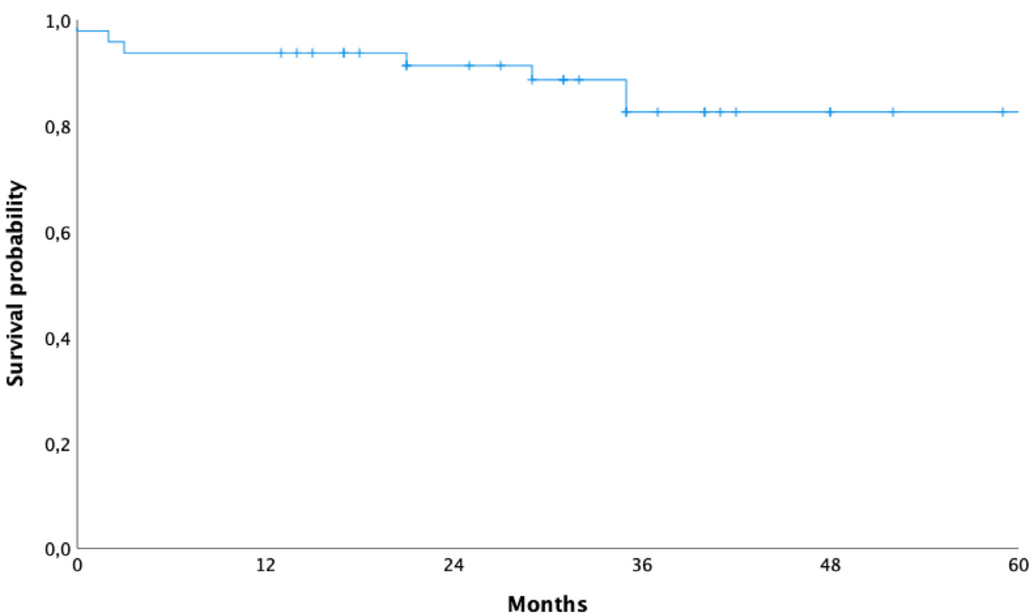
the distal anastomosis, which was not confirmed intraoperatively and was explained through the overhead position of the arms during postoperative CT scan. All 4 reconstructions associated with re-interventions remained patent during follow-up. (Table V)

There were 4 patients with postoperative hematomas, 3 of them requiring surgical evacuation. There were no graft infections. 1 patient with initially suspected hematoma had a putrid collection. The patient had known Takayasu arteritis and already suffered from pyoderma gangraenosum in the past. A vacuum assisted-therapy was initiated and secondary wound closure was achieved 8 days after the primary surgery. All microbiological biopsies remained negativ. There were no local lymphatic leaks, but one of 2 drained pneumothoraces turned out to be a chylothorax, which was self-limiting. All postoperative complications are listed in Table VI. 8 patients died after a median of 30 months (range 0-82). For the remaining patients, median follow-up was 38 months (range 12-83) with a Follow-up Index of 0.77. Estimated survival at 1, 2, and 5years was 94%, 91% and 83%, respectively (Fig. 2). There were no reinterventions or complications associated with the supraclavicular LSA revascularization, resulting in a primary patency of 90% and primary assisted patency of 98% after1, 2 and 5 years, respectively. (Fig.3)

Table 6. Postoperative complications

	N
Pneumonia/	4 (8%)
Stroke	4 (8%)
Myocardial infarction	1 (2%)
Atrial fibrillation	3 (6%)
Left neck nerve injury*	8 (17%)
paravertebral sympathetic chain	3 (6%)
phrenic nerve	2 (4%)
reccurent laryngeal nerve	4 (8%)
Re-intervention related to LSA revascularization	4 (8%)
Wound hematoma	
conservative treatment	1 (2%)
surgical revision	3 (6%)
All-cause 30-day mortality	1 (2%)

*one patient had simultaneous injury of the left paravertebral sympathetic chain and the left reccurent laryngeal nerve

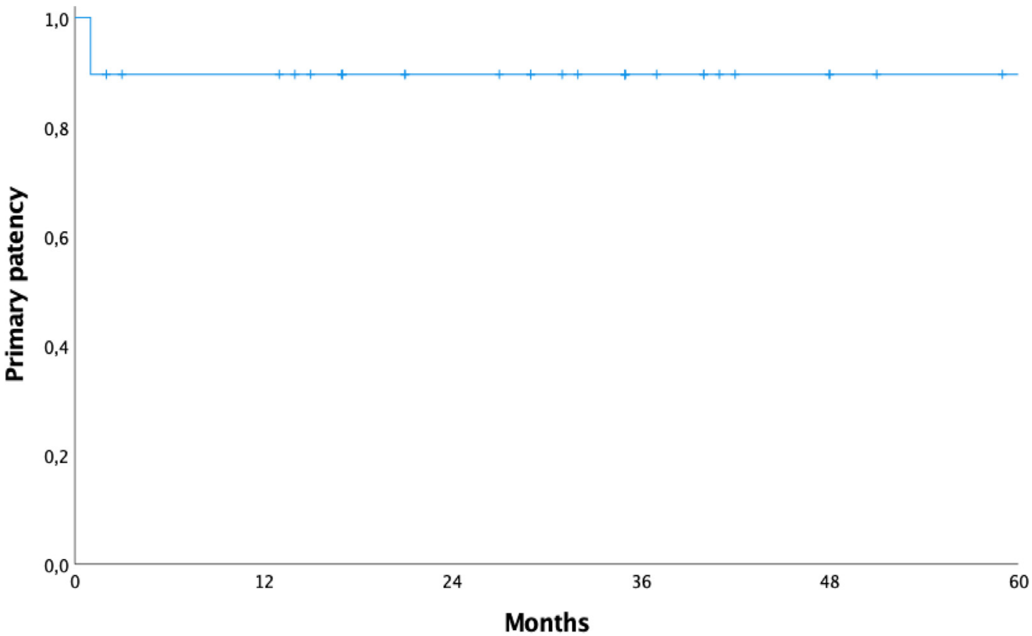


Time (months)	0	12	24	36	48	60
Patients at risk (quantity)	48	37	27	18	16	15
Survival estimate		0.937	0.913	0.887	0.825	0.766
Survival standard error		0.035	0.041	0.048	0.061	0.080

Fig. 2. Kaplan-Meier curve estimating overall survival probability.

DISCUSSION

Simultaneous or staged revascularization of the left subclavian artery for proximal landing zone extension in TEVAR is recommended to reduce the risk of stroke, spinal cord ischemia and left arm ischemia associated with aortic repair.[1,5] We report early and mid-term outcomes of patients who suffered stroke or left neck nerve injury after left-sided CSB or SCT for proximal landing zone extension in TEVAR. Our results show that complete recovery could be possible after stroke caused by emboli, of hoarseness caused by left-sided recurrent laryngeal nerve palsy and Horner's



Time (months)	0	12	24	36	48	60
Patients at risk (quantity)	48	37	27	18	16	15
Survival estimate		0.896	0.896	0.896	0.896	0.896
Survival standard error		0.044	0.044	0.044	0.044	0.044

Fig. 3. Kaplan-Meier curve estimating primary patency of the cervical reconstruction.

syndrome caused by temporary damage of left-sided inferior cervical sympathetic ganglion during first postoperative year. It seems, that the left-sided phrenic nerve palsy shows no improvement over time.

Supraclavicular revascularization by carotid-subclavian bypass or subclavian to carotid transposition is well-established technique for the treatment of occluded/stenotic prevertebral segments of the LSA.[6,13] Consequently, the same technique was adopted for LSA revascularization in TEVAR requiring proximal landing zone extension by LSA coverage. Cina's systematic review of more than 1000 patients undergoing CSB or SCT reported a very low mortality rate of 1%, but a 7% stroke rate and an 11% nerve injury rate.[13] Cina's systematic review did not analyze the strokes or the nerve injuries in details.

Left neck nerve injuries could be very disabling, especially if combined with stroke. Various studies report different rates of local neurological damage, but there is limited information about their recovery during follow-up. Konstantinou et al. reported 9.5% of local peripheral neurological damage of which 4.7% had left recurrent laryngeal nerve damage, 2.8% Horner's syndrome and 0.5% each of arm paresthesia, arm paresis and mild facial nerve paresis.[14] The incidence of peripheral nerve injury correlated strongly with type of debranching procedure (7.2% for CSB, 30% for SCT), thus making them to switch completely to CSB for LSA revascularization. Zamor et al found similarly higher rate of vocal cord paralysis 10.5% after SCT vs. 4.5% after CSB.[4] Of our 8 patients with left neck nerves injury, 3 had CSB and 5 SCT. Only one patient was discharged with completely resolved symptoms. At one year all followed-up patients with left recurrent laryngeal nerve damage or Horner's syndrome had significant improvement or complete recovery, but the phrenic nerve palsy remained. Voigt et al. reported high 30-day rate of patients with phrenic nerve palsy 25% (33/112), but didn't analyzed their recovery during follow-up. 9 of 15 left neck nerve injuries analyzed by van der Weijde et al. were persistent during follow-up.[15] Left neck nerve injuries are not life-threatening, but their persistence might extend patient's recovery and diminish their quality of life.

A systematic review and meta-analysis by Huang at al. including almost 2600 patients revealed that LSA revascularization should be recommended for patients with LSA coverage in TEVAR.[16] The perioperative stroke and spinal cord ischemia rates of 5.4% and 4.7% rates were lower in patients with LSA revascularization vs. 6.7% and 7.8% in patients without LSA revascularization, respectively.[16] No data were available about the recovery from stroke or neck nerve injuries. Opposite to Huang et al, Hajibandeh's meta-analysis showed that LSA revascularization did not significantly reduce neurologic complications or mortality in patients undergoing TEVAR with coverage of the LSA origin.[17]

Similarly, Varkevisser et al. confirmed a higher risk for stroke of 5.2% in patients undergoing TEVAR with LSA coverage vs. 2.3% without LSA coverage, but found a higher stroke incidence when the LSA was concomitantly revascularized 7.5% vs. 4.4% without concomitant LSA revascularization.[18] Konstantinou et al recommended a staged approach, first with LSA revascularization and then TEVAR, after finding significantly higher 30-day mortality and stroke rate in single stage procedures.[14] All strokes in our group occurred after concomitant LSA revascularization during TEVAR, 3 of them in an emergency setting. There is no doubt that the LSA coverage increases the perioperative stroke risk, but it remains questionable, if simultaneous LSA revascularization reduces or increases the risk of periprocedural stroke during TEVAR.

Stroke during TEVAR with landing zone 2 would be expected to occur frequently in the left hemisphere or in the posterior vascular territory. Indeed, by analyzing all 48 strokes (48/1002, 4.8%) in the MOTHER registry, Patterson et al. found that the rate of posterior territory strokes was higher in the patients whose LSA was covered and not revascularized compared with those whose LSA was revascularized (3.8% vs. 0.7%).[7] However, strokes occurred in all vascular territories in those patients whose LSA was covered, regardless of revascularization status. Anterior circulation strokes were similar in both groups (2.8% vs. 2.2%).[7] All 4 patients with stroke in our group had distribution in both anterior and posterior vascular territory. 3 of them recovered completely and 1 partially, dying on pneumonia 3 months after LSA revascularization. In the MOTHER registry, 5 strokes were fatal and 30% (12/39) of the nonfatal had complete recovery.[7] During follow-up increased risk of death in patients who had a perioperative stroke and spinal cord injury could be expected.[7] Varkevisser et al. confirmed this as well: of the 33 TEVAR patients experiencing a perioperative stroke 8 (24%) died within 30 days.[18]

One patient (2%) died in-hospital and 8 during median follow-up of 3 years, and none of the LSA revascularizations in our series required re-intervention during follow-up. We report an overall survival rate of 94% and 83% and primary assisted patency rate of 98% after one and 5 years, respectively. Similar midterm outcomes of LSA revascularization in the setting of TEVAR after mean follow-up of 4 years were reported by Protack et al. with overall survival rates of 82% and 60%, and primary patency rates of 99.5% and 98.9% after one and 5 years, respectively.[19] Primary graft patency rate of 97% at 5 years for CSB was reported by Voigt et al. In our experience both CSB and SCT are equally acceptable LSA revascularization methods.

LIMITATIONS

This retrospective study has a small number of patients and only reports a single-centre experience. Additional 8 patients rejected to participate in this trial, thus leaving valuable data unanalysed. Analysis of stroke cause, especially in patients with simultaneous LSA revascularization and TEVAR remains difficult. Poor patient's compliance and unavailability to perform exams like laryngoscopy limits the objective hoarseness diagnose postoperatively. The improvement of all neurological disabilities at 1 year was based on clinical exam and patient's statement. No endovascular LSA revascularization techniques were assessed in this series.

CONCLUSION

Supraclavicular LSA revascularization for proximal landing zone extension in TEVAR is safe with an acceptable rate of early re-interventions. There is higher risk for perioperative stroke during simultaneous emergency LSA revascularization and TEVAR. Left neck nerve injuries are common complications but resolve completely in vast majority of the cases during first postoperative year. During follow-up, excellent patency could be expected.

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