The Egyptian Journal of Hospital Medicine (July 2025) Vol. 100, Page 4503-4508

Left Subclavian Artery To Left Common Carotid Artery Bypass for TEVAR, Does It Make Difference?

[1]Ahmed Hatem Onsi , [1]Ahmed Labib Dokhan, [2]Saeed Abd Elaziz Badr , [1]Mohamed Ahmed El-Hag Aly, [1]Mohamed Mordy Bakoush
[1]Cardiothoracic Surgery Department , Menoufia University , Egypt
[2]Cardiothoracic and Aortic Surgery Department , Cairo University, Egypt
Corresponding author: Ahmed Hatem Onsi**, Email:** doctoronsi3@gmail.com, **Phone:** +201008816919

ABSTRACT

Background: Thoracic endovascular aortic repair (TEVAR) is often accompanied with subclavian artery revascularization. The short-term results of individuals undergoing carotid to subclavian artery bypass in this clinical context, however, are not well documented.

Objectives: This study aimed to compare the left subclavian artery to the left common carotid artery bypass for TEVAR.

Methods: 21 patients with different etiologies of aortic pathologies underwent left subclavian artery (LSA) revascularization through cervical -sub clavicular incisions using 8 Fr Dacron graft and TEVAR either simultaneously or as a staged operation. Demographic data, operative procedures, and postoperative data were gathered.

Results: 18 patient were males and 3 were females with mean age of 57 ± 12 years. 12 patients with hypertension. Main pathology was aortic dissection 12 patients, 5 patients had aortic aneurysm with mean aortic diameter of 5.37 ± 1.7 mm penetrating ulcer or intramural hematoma were the least, only 4 patients. Mean operative time 3.6 ±1.2 hours. TEVAR was done either simultaneously in 9 cases or as staged procedure in 12 cases. Only 2 cases of post-operative stroke with no evidence of spinal cord ischemia only one case with postoperative bleeding, but no spinal cord or peripheral nerve injury, no chylous leak and no hematoma. We had only 2 cases of superficial wound infection treated conservatively. Postoperative ICU stay was about 86.1 ± 50 hrs and total hospital stay was about 8.9 ± 2.9 days .

Conclusion: When used in conjunction with TEVAR, carotid-subclavian bypass surgery for subclavian artery revascularization was safe, advantageous, and dramatically reduced the risk of stroke after TEVAR.

Keywords: Aorta, Endovascular procedures, Revascularization, Subclavian artery.

INTRODUCTION

Diseases of the aorta are relatively rare, and their natural progression is not well understood. Many affected individuals remain without symptoms, while others may present with sudden, severe, and potentially fatal complications. Such conditions include degenerative aneurysms as well as acute aortic syndromes, such as penetrating ulcers, intramural hematomas, and aortic dissections **[1]**.

Despite advancements in techniques and growing surgical experience, treatment of aortic diseases continues to carry considerable risks, including mortality, the need for reintervention, and neurological complications. To address these challenges, hybrid aortic arch repair was developed as a mean to streamline the procedure and enhance patient outcomes [2].

Over the years, conventional open aortic arch surgery has demonstrated reductions in mortality and neurological risks, however a subset of patients remains unsuitable for open repair because of significant comorbidities and high-risk factors such as advanced age, frailty, or a history of prior cardiac surgery **[3, 4]**.

The primary benefit of TEVAR in managing aortic disease lies in its ability to reduce perioperative illness and death, whether performed electively or in emergency situations, particularly among elderly and fragile patients. However, TEVAR is more complex than it may appear, requiring careful and detailed anatomical evaluation of the aortic pathology **[5, 6]**.

Hybrid arch repair is performed by initially debranching the arch vessels, followed by the placement of a stent graft within the native aorta. This approach was first introduced by **Czerny *et al.*** [7] and, with growing expertise and technical refinement, has been associated with improved success rates and a reduction in neurological complications [8]. Despite these advances, the aortic arch still represents the most proximal boundary for endovascular management of aortic diseases **[9]**.

A surgical technique called arch vascular debranching is used to make a secure landing space for stent deployment. According to Ishimaru's classification, there are several choices for debranching arch vessels, including partial or complete debranching, depending on the features of the sick arch **[10, 11]** .

Numerous problems, including spinal cord ischemia, left arm ischemia, and posterior circulation stroke, might result from LSA occlusion during TEVAR. This is caused by the coronary circulation in patients who had a left internal mammary artery (LIMA) bypass graft, the posterior cerebral circulation via the left vertebral artery, and the left subclavian artery (LSCA), which is the primary arterial supply to the left upper extremity. Additionally, it supports spinal cord perfusion by supplying branches to the anterior and posterior spinal arteries' higher regions **[12]**.

Nevertheless, covering the LSCA during TEVAR is generally well tolerated in most patients due to the presence of collateral circulation from various sources, such as the vertebral arteries, the left internal thoracic (mammary) artery, and the circle of Willis. Although

Received: 02/05/2025
Accepted: 04/07/2025

complications related to LSCA coverage are relatively uncommon, current evidence increasingly supports a strategy of selective revascularization based on individual risk factors for post-coverage ischemia **[13, 14]**. It is estimated that approximately 25%–40% of TEVAR procedures require extension into zone 2 to achieve an adequate landing zone [15, 16].

TEVAR is often associated with subclavian artery revascularization. The short-term results of individuals undergoing subclavian to carotid artery bypass in this clinical context, however, are not well documented.

PATIENTS AND METHODS

A prospective study involved 21 patients with different types of aortic pathologies at Cardiothoracic Department, Dar El Foud hospital, Kaser El Aini University Hospitals and Faculty of Medicine, Menoufia University Hospitals who were candidate for debranching of Lt SCA toleft common carotid artery (Lt CCA) and TEVAR.

Inclusion criteria: Patients with different types of aortic pathologies who were candidate for debranching of Lt SCA to Lt CCA and TEVAR.

Exclusion criteria: Open surgical repair. Other types of debranching. Debranching for arterial occlusive diseases of carotid arteries.

Operative data: The debranching of Lt SCA to Lt CCA done via cervical and sub-clavicular incisions with using an 8 Fr. tube graft. TEVAR was done subsequently either simultaneously or as staged surgery after LSA bypassing.

Frist, we did a vertical cervical incision parallel to posterior border of sternomastoid muscle, then dissection of subcutaneous and platysma muscle till carotid sheath. Longitudinal opening of the carotid sheath with carful identification of its all contents; left common carotid artery (LCCA), left internal jugular vein (IJV) and left vagus nerve with care not to harm or do any excess traction over any one of these contents especially vagus nerve to avoid post operative recurrent nerve injury. After identification of LCCA, we directed to sub-clavicular incision, which was done one fingerbreadth blow middle clavicle with carful dissection till LSA isolation with great care to avoid injury of brachial plexus or phrenic nerve. We used an 8 Fr. Tube graft for by passing, which passed blow the clavicle. Frist, we did subclavian anastomosis using proline 6/0 continuous running sutures, after heparin administration. Then LCCA anastomosis was done. Checking hemostasis after removal of the clamps with distal clamp over distal part of LCCA was the last one to be removed to minimize risk of air embolism.

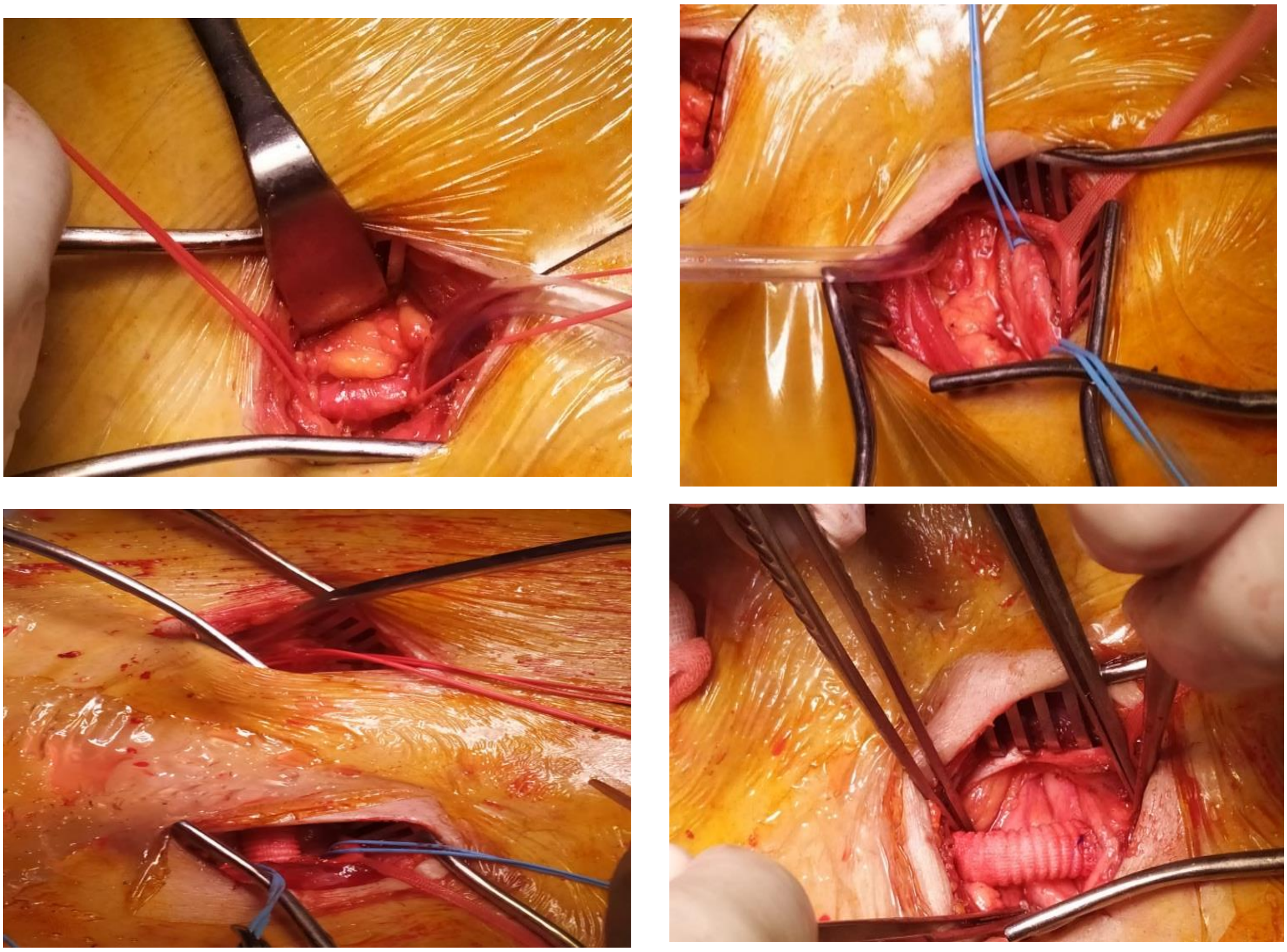

Fig: Cervical and subclavicular incisions for LSA -LCCA bypass

Ethical Approval: Before the study began, all participants provided written informed consents, which had been approved by The Local Ethical Research Committee of the Faculty of Medicine, Menoufia University. Institutional Review Board clearance was also secured. The research adhered to recognized ethical guidelines, following the principles of the Declaration of Helsinki and its subsequent revisions.

Statistical analysis of the data

The data were analyzed using IBM SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages, while continuous variables were tested for normality using the Kolmogorov-Smirnov test and summarized as range, mean, standard deviation, median, and interquartile range (IQR). A p-value ≤ 0.05 was considered statistically significant.

RESULTS

Table (1): Distribution of the studied cases according to different demographic premasters (n= 21)

	No.	**%**
Male	18	85.7
Female	3	14.2
Age (years)		
Mean ± SD.	57.8 ± 12.26	
HTN	12	57.14 %
CKD	3	14.2 %
DM	5	23.8 %
CT disorder	5	23.8 %
Previous stroke	4	19 %
Cardiac (IHD)	3	14.2 %

Table (2): Distribution of the studied cases according to aortic pathology (n= 21)

Aortic pathology	No.	%
Aortic Dissection	12	57.1 %
Dissecting aneurysm	5	23.8 %
Penetrating ulcer\ intramural hematoma	4	19 %
Acute or chronic		
Acute	8	38.09 %
Chronic	13	61.9 %
Aortic arch diameter (pre)		
Mean ± SD.	5.37 ± 1.7	
Median (IQR)	5.60(4.80 – 6.0)	

Table (3): Distribution of the studied cases according to operation time (n= 51)

Time of surgery	No.	%
Operative time (hours)		
Mean ± SD.	3.60 ± 1.27	
Median (IQR)	3.30(3.0 – 4.0)	

Table (4): Distribution of the studied cases according to aortic TEVAR (n= 51)

TEVAR	No.	%
Sequential	9	42.8 %
Staged	12	57.2 %

Table (5): Distribution of the studied cases according to complication (n= 21)

Complication	No.	%
Stroke	2	9.5 %
Spinal cord, nerve injury	0	0.0
Limb ischemia, chyle leak	0	0.0
Access complication (type)	0	0.0
Reopening for bleeding	1	4.7 %
Surgical re intervention	1	4.7 %

Table (6): Distribution of the studied cases according to ICU (n= 21)

ICU	No.	%
Stay in ICU (hours)		
Mean ± SD.	86.10 ± 50.12	

Table (7): Distribution of the studied cases according to ward (n= 21)

Ward	**No.**	**%**
Wound complication		
No		
Superficial infection	2	9.5 %
Total Stay in Ward (Days)		
Min. – Max.	4.0 – 17.0	
Mean ± SD.	8.98 ± 2.92	
Median (IQR)	10.0(6.0 – 10.50)	

18 patient (65%) were males and 3 were females with mean age 57 ± 12 years. 12 patients (57.4%) with hypertension. 3 patients (14.2%) had CKD, 5 DM (23.8%), 5 had (23.8%) connective tissue disorders,4 (19%) has previous stroke, 3 patients (14.2%) with IHD **.**

The main pathology was aortic dissection 12 patients (57.4%), 5 patients had (23.8%) aortic aneurysm with mean aortic diameter 5.37 ± 1.7. penetrating ulcer or intramural hematoma were the least, only 4 patients (19%). 8 patients (38.09%) had acute presentation while 13 (61.9%) were chronic. The mean aortic arch diameter was 5.37 ± 1.7 cm **.**

The mean operative time was 3.60 ± 1.27 hr. with mean ICU stay 86.10 ± 50.12hr. TEVAR after debranching was done in a sequential manner in 9 patients (42.8 %), and in a staged manner in 12 patients (57.2%) **.** There was no Spinal cord or peripheral nerve injury, no Limb ischemia, no chyle leak, or Access complication. Only 2 cases (9.5%) of post-operative stroke. One case of postoperative bleeding that needed re-exploration (4.7%).

Only 2 cases (9.55) had superficial wound infection. The mean hospital stay in ward was 4.0 – 17.0 days.

DISCUSSION

Diseases affecting the aorta are relatively rare, and their natural progression remains poorly understood. Many patients either show no clinical symptoms or present only when a severe, life-threatening complication occurs. Surgical or endovascular treatment of aortic arch disorders continues to be associated with considerable risks, including high rates of mortality, repeat interventions, and neurological injury. Management of these conditions is technically demanding and represents a major challenge for cardiovascular surgeons. The hybrid arch repair technique involves first rerouting (debranching) the arch vessels, followed by the placement of a stent-graft within the native aorta. The main advantage of TEVAR in aortic arch intervention is decreased perioperative morbidity and mortality either in elective or emergency cases specially in elderly frail patients. LSCA revascularization is needed to improve the outcome without increase in perioperative morbidity or mortality. [15]

Our study included 21 patients diagnosed with different aortic pathologies and all were indicated for TEVAR with LSCA revascularization. 18 patient (65%) were males and 3 were females with mean age 57 ± 12 years. Peri operative demographic data showed 12 patients (57.4%) with hypertension. The main pathology was aortic dissection 12 patients (57.4%), 5 patients had (23.8%) aortic aneurysm with mean aortic diameter 5.37 ± 1.7 mm. Penetrating ulcer or intramural hematoma were the least, only 4 patients (19%). Our demographic characteristics are generally consistent with those reported in the literature regarding patient age, underlying aortic conditions, and associated risk factors. In the study by **Rhiannon *et al*.** [15], the mean patients' age was 59 ± 15.9 years, with males representing 61.5% of the cohort. Hypertension was present in 88% of cases. The distribution of aortic pathologies included acute aortic dissections in 25 patients (24%), chronic dissections with aneurysmal changes in 22 cases (22%), making the overall proportion of dissections 46%. Primary aortic aneurysms accounted for 21 patients (21%), penetrating aortic ulcers and intramural hematomas were seen in 17 cases (27.7%), while traumatic aortic injuries were reported in 11 patients [16]. Also **Lee *et al.*** [16] in their study reported that mean age was 62 ±15 years. Incidence of hypertension was 83%. The main pathology was aortic dissection (37.4%) and aortic aneurysm (53.8%).

In our study LSCA by pass was done via cervical-sub clavicular approach with mean operative time 3.6 ± 1.2 hour. In case of simultaneous TEVAR we addressed right femoral artery exposure after completion of by pass and administration of protamine before we transferred to Cath room, which was near by our operating room. Many different techniques wereused foe LSA by pass like conduit graft, as we did or translocation to LCCA, or LASER fenestration.

Teng Lee *et al.* [16] reported their study the approach they did which was quite different with us. They did the revascularization through single supra clavicular incision and by passing LSCA to LCCA with 8 Fr Dacron graft. They had higher incidence in injuring the phrenic nerve as the manipulation and cutting of scalenus anterior in this approach. Others used translocation technique as Cina's systematic review of more than 1000 patients showed that subclavian artery translocation to LCCA is safe and effective method [15]. The following TEVAR done either simultaneously in 9 cases (57.4%) or as stagged procedure in 12 cases (42.6%). In all our cases we planned for the sequence of by passing and operatively, according CT study**.** **Rhiannon *et al.*** [15] usually did the two procedures in sequence 45% with only 10 % as a staged manner, this was for their revascularized group [17]. The indication of LSCA by passing may be preoperative as functioning LIMA graft, Lt dialysis shunt, vertebrobasilar insufficiency or intraoperative as sudden Lt arm ischemia proved by absent arterial wave of Lt invasive arterial line or damped O_2 saturation curve or it may be post operative in a lesser incidence as post operative limb ischemia.

We had only 2 cases of post operative stroke (9.5%) with no evidence of spinal cord ischemia. In comparison of our results with **Rhiannon *et al.*** [15] in their study, post operative stroke was 7.8 %. Also it was nearby of **Chung *et al*.** [17] study, which showed a stroke rate of 8.6%. Another study done by **Contrella *et al.*** [18] demonstrated a 9.5% higher risk of stroke in patients without LCA revascularization than in a different group with LSA by pass.

The mechanism of protection against embolic strokes is less known, but it is certain that surgically passing LSA should prevent ischemic strokes by preserving and obtaining maximal brain perfusion uninterrupted. Post-operative stroke may be caused by retrograde emboli or excessive manipulation. CSF denials were not something we used frequently. Only one case with post operative bleeding, managed by reoperation and controlling bleeder. But no spinal cord or peripheral nerve injury, no chylous leak, no hematoma, with mean post operative drainage 124.6 ±45 ml. **Voigt *et al.*** [13] to find out short-term outcome after LSA to LCCA bypass, they found 25% of patients with phrenic nerve injury, this was examined by serial post operative X-Ray studies. Although most of patient showed improvement with follow up especially with mild injury, but 20% of the affected patient needed intervention. We think that this is due to the preferred surgical approach as we used sun clavicular approach one fingerbreadth blow middle third of the clavicle but **Voigt *et al.*** [13] used supraclavicular medial approach with cutting of scalenus anterior muscle. Another nerve problem was post-operative recurrent nerve injury secondary to vagal nerve injury at carotid sheath. We tend to avoid injury of vagus nerve and avoid its excess manipulation.

We had only 2 cases of superficial wound infection that treated conservatively. Post operative ICU stay was about 86.1 ± 50 hours and total hospital stay was about 8.9 ± 2.9 days.

CONCLUSION

The hybrid repair was established by debranching of arch vessels first, then stent-graft deployment in the native aorta that showed increased technical success and experience, with decreased incidence of neurological complication. LSA occlusion during TEVAR is associated with higher incidence of stroke and other complications so its revascularization is beneficial without increase in peri-operative morbidity or mortality.

Consent for publication: Not relevant.
Data availability: The datasets generated and/or analyzed in this study can be obtained from the corresponding author upon reasonable request.
Competing interests: The authors reported no conflicts of interest.
Funding: This research did not receive any financial support.

REFERENCES

1. **Cheng S (2016):** Aortic arch pathologies–incidence and natural history. Gefässchirurgie, 21 (4): 212-6.
2. **Singh S, Pupovac S, Assi R *et al.* (2022):** Comprehensive review of hybrid aortic arch repair with focus on zone 0 TEVAR and our institutional experience. Frontiers in Cardiovascular Medicine, 9: 991824.
3. **Englum B, He X, Gulack B *et al.* (2017):** Hypothermia and cerebral protection strategies in aortic arch surgery: a comparative effectiveness analysis from the STS Adult Cardiac Surgery Database. European journal of cardio-thoracic surgery, 52 (3): 492-8.
4. **Harky A, Bashir M, Antoniou A *et al.* (2019):** Open aortic arch surgery: the gold standard method. Indian Journal of Thoracic and Cardiovascular Surgery, 35 (2): 130-5.
5. **Bhamidipati C, Irvine J, Hagspiel K *et al.* (2012):** Hybrid repair of aortic arch aneurysm. Annals of Vascular Surgery, 26 (3): 420-e1.
6. **Faure E, Canaud L, Marty-Ané C *et al.* (2016):** Hybrid aortic arch repair for dissecting aneurysm. The Journal of thoracic and cardiovascular surgery, 152 (1): 162-8.
7. **Czerny M, Schmidli J, Carrel T *et al.* (2013):** Hybrid aortic arch repair. Annals of cardiothoracic surgery, 2 (3): 372.
8. **Bünger C, Kische S, Liebold A *et al* (2013):** Hybrid aortic arch repair for complicated type B aortic dissection. Journal of Vascular Surgery, 58 (6): 1490-6.
9. **Spear R, Clough R, Fabre D *et al.* (2017):** Total endovascular treatment of aortic arch disease using an arch endograft with 3 inner branches. Journal of Endovascular Therapy, 24 (4): 534-8.
10. **Pérez M, Coto J, del Castro Madrazo J *et al.* (2017):** Debranching aortic surgery. Journal of Thoracic Disease, 9 (6): S465.
11. **Bosse C, Kölbel T, Mougin J *et al.* (2020):** Off-the-shelf multibranched endograft for total endovascular repair of the aortic arch. Journal of vascular surgery, 72 (3): 805-11.
12. **Ramdon A, Patel R, Hnath J *et al.* (2020):** Chimney stent graft for left subclavian artery preservation during thoracic endograft placement. Journal of vascular surgery, 71 (3): 758-66.
13. **Voigt S, Bishawi M, Ranney D *et al.* (2019):** Outcomes of carotid-subclavian bypass performed in the setting of thoracic endovascular aortic repair. Journal of Vascular Surgery, 69 (3): 701-9.
14. **Brusa J, Lutz E, Schoenhoff F *et al.* (2022):** 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. Annals of Vascular Surgery, 83: 265-74.
15. **Bradshaw R, Ahanchi S, Powell O *et al.* (2017):** Left subclavian artery revascularization in zone 2 thoracic endovascular aortic repair is associated with lower stroke risk across all aortic diseases. Journal of vascular surgery, 65 (5): 1270-9.
16. **Lee T, Andersen N, Williams J *et al.* (2011):** Results with a selective revascularization strategy for left subclavian artery coverage during thoracic endovascular aortic repair. The Annals of thoracic surgery, 92 (1): 97-103.
17. **Cinà C, Safar H, Laganà A et al. (2002):** Subclavian carotid transposition and bypass grafting: consecutive cohort study and systematic review. Journal of vascular surgery, 35 (3): 422-9.
18. **Contrella B, Sabri S, Tracci M et al. (2015):** Outcomes of coverage of the left subclavian artery during endovascular repair of the thoracic aorta. Journal of Vascular and Interventional Radiology,26 (11): 1609-14.