INSELSPITAL
UNIVERSITÄTSSPITAL BERN
HÔPITAL UNIVERSITAIRE DE BERNE

How to manage the left subclavian and left vertebral artery during TEVAR

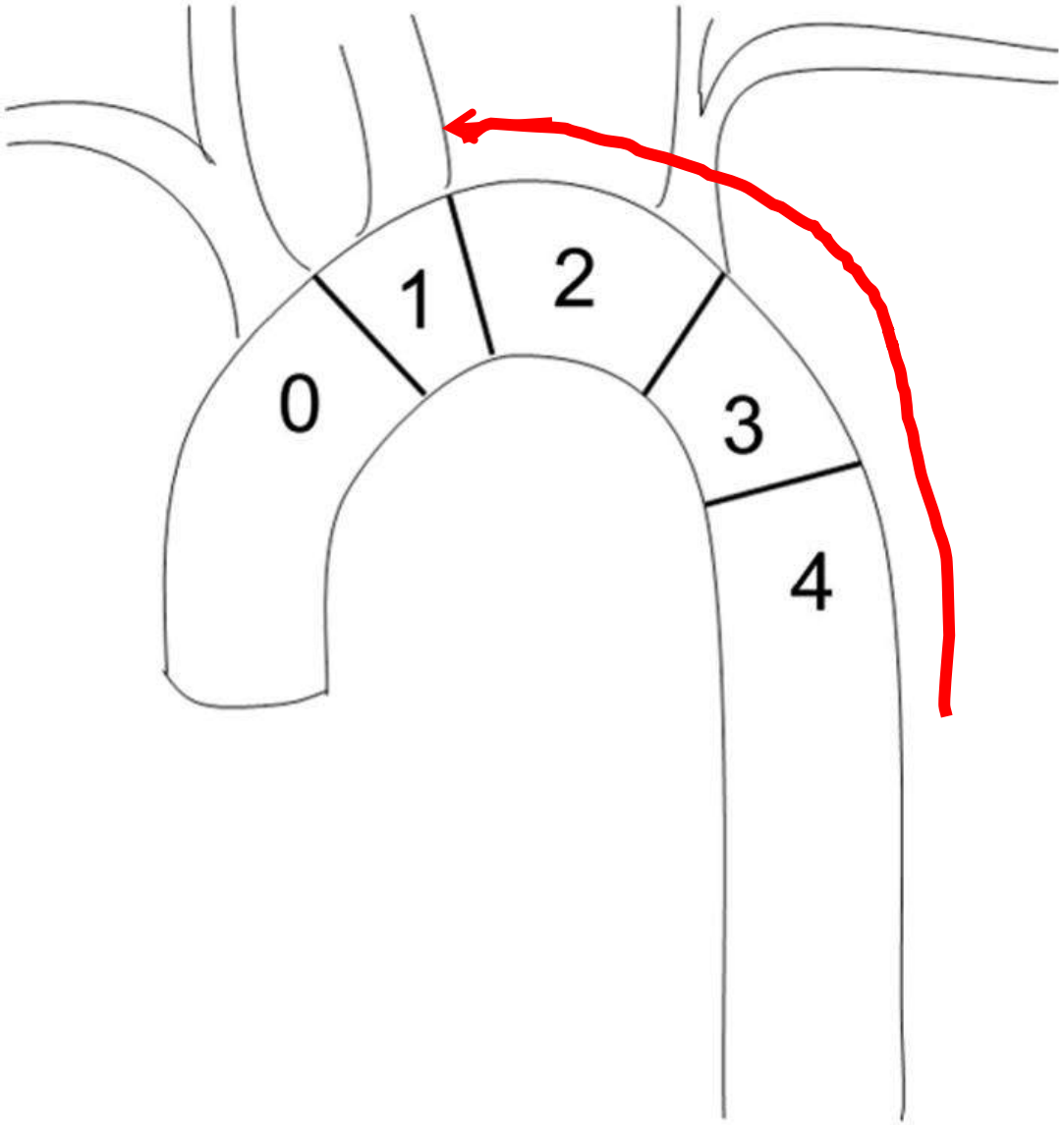
Jürg Schmidli
Chief of Vascular Surgery
Inselspital

Dept Cardiovascular Surgery, Bern, Switzerland

Disclosure

No Disclosures

Pathologies involving aortic segment 2, 3 and 4



Lee et al. Ann Thorac Surg. 2011

Introduction

- ✓ Up 40% of patients undergoing TEVAR have pathology that extends near the left subclavian artery (LSA) [1)]
- ✓ dominant left vertebral artery (60% of patients)
- ✓ previous left internal mammary coronary artery bypass graft
- ✓ distal right vertebral segment is absent

- ✓ Prospective randomized trials directly comparing a **selective** strategy of LSA revascularization and **routine** LSA revascularization as well as other techniques of neuroprotection are unavailable and are needed.

[1)]Freezor et al., J Endovasc Ther 2007;14:568-73.

Neurologic injury with TEVAR

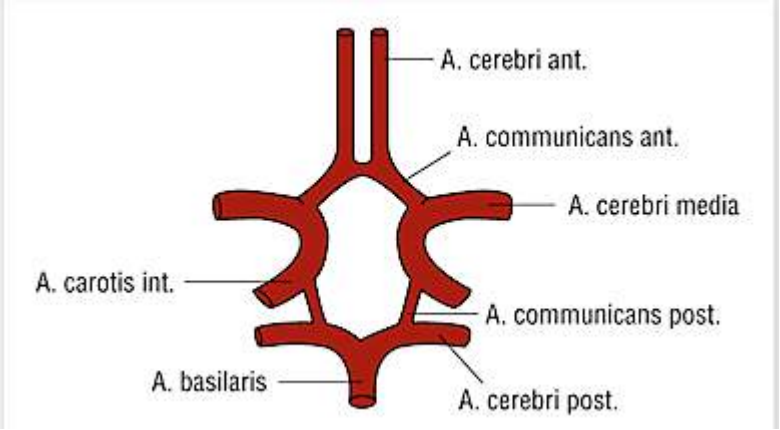
Multifactorial

Stroke may be caused by

(1) systemic factors such as hypotension, hypertension, and anticoagulation
(2) intracranial changes related to edema, cerebrospinal fluid drainage, or contrast/drug infusion
(3) embolization of air, atheroma, or thrombus from the device or manipulation of devices within the aortic arch
(4) interruption of forward blood flow from injury or coverage of arch vessels.

Imaging Assessment before TEVAR with intended covarage of the LSA

- ✓ CTA or MRA of thoracoabdominal aorta
- ✓ MRA of supraaortic and intracranial vessels
  - ✓ Completeness of the Willisii circulus
- ✓ US of supraaortic vessels



Ultrasound studies

After complete overstenting

- Complete reversed flow in ipsilateral vertebral artery in 70% of pts.
- Alternating flow profile in 25% of pts.
- Systolic deceleration: only few pts.

After partial overstenting

- No pathologic changes detected

E. Weigang, Mainz, VISAR 2007

Editor's Choice — Incidence of Stroke Following Thoracic Endovascular Aortic Repair for Descending Aortic Aneurysm: A Systematic Review of the Literature with Meta-analysis☆

Eur J Vasc Endovasc Surg (2017) 53, 176-184

R.S. von Allmen [a,*], B. Gahl [b], J.T. Powell [c]

10 studies

2594 patients

pooled **prevalence for stroke** 4.1% (95% CI 2.9e5.5)

LSA uncovered

pooled stroke incidence **3.2%** (95% CI 1.0e6.5)

Silent Cerebral Ischemia After Thoracic Endovascular Aortic Repair: A Neuroimaging Study

- ✓ 19 patients
- ✓ TEVAR, 8 with coverage of LSA
- ✓ In 63% new foci of restricted diffusion
- ✓ Overstenting of the left subclavian artery **not associated with lateralization of lesions to one side**

Kahlert et al. Ann Thorac Surg 2014;98:53–8)

Expected symptoms after LSA coverage

Neurologic symptoms

- Vertebrobasilar insufficiency
  Subclavian steal syndrome
  dizziness

Left arm hypoperfusion

- Ischemia
- Rest pain
- Claudiaction

Reported symptoms after LSA coverage

Neurological signs

- ✓ Vertebrobasilar insufficiency (24%) Si et al. Ann Vasc Surg 2014;28:851-9
  - ✓ Subclavian steal syndrome
  - ✓ Posterior cerebral strokes
  - ✓ Cerebellar infarction
  - ✓ Impaired binocular vision
  - ✓ TIA with speech disorders
- ✓ Paraplegia/paraparesis

Left arm hypoperfusion

- ✓Ischemia
- ✓Rest pain
- ✓Claudiaction

The effect of left subclavian artery coverage on morbidity and mortality in patients undergoing endovascular thoracic aortic interventions: a systematic review and meta-analysis.

- ✓ 6% arm ischemia
- ✓ 4% spinal cord ischemia
- ✓ 2% vertebrobasilar ischemia
- ✓ 5% anterior circulation stroke
- ✓ 6% death

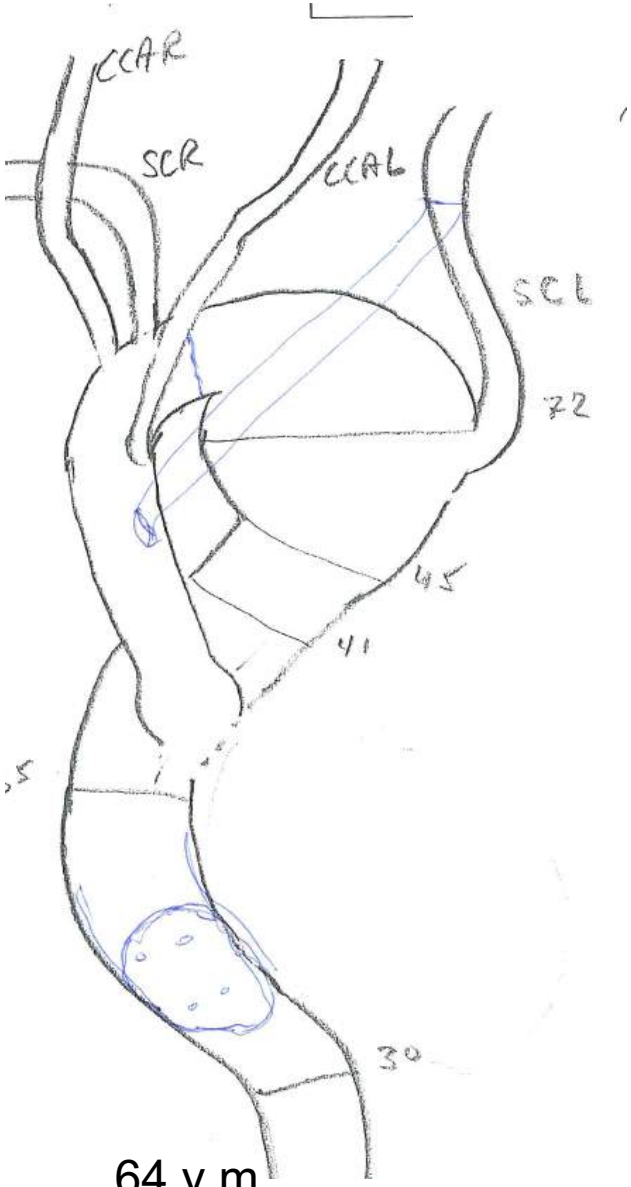
Risk of coverage

- ✓ increase in the risk of **paraplegia** (odds ratio [OR], **2.69**; 95% confidence interval [CI] 0.75-9.68)
- ✓ anterior circulation **stroke** (OR, **2.58**; 95% CI, 0.82-8.09)
- ✓ **Arm ischemia** (OR, **47.7**; 95% CI, 9.9-229.3)
- ✓ **Vertebrobasilar ischemia** (OR, **10.8**; 95% CI, 3.17-36.7)

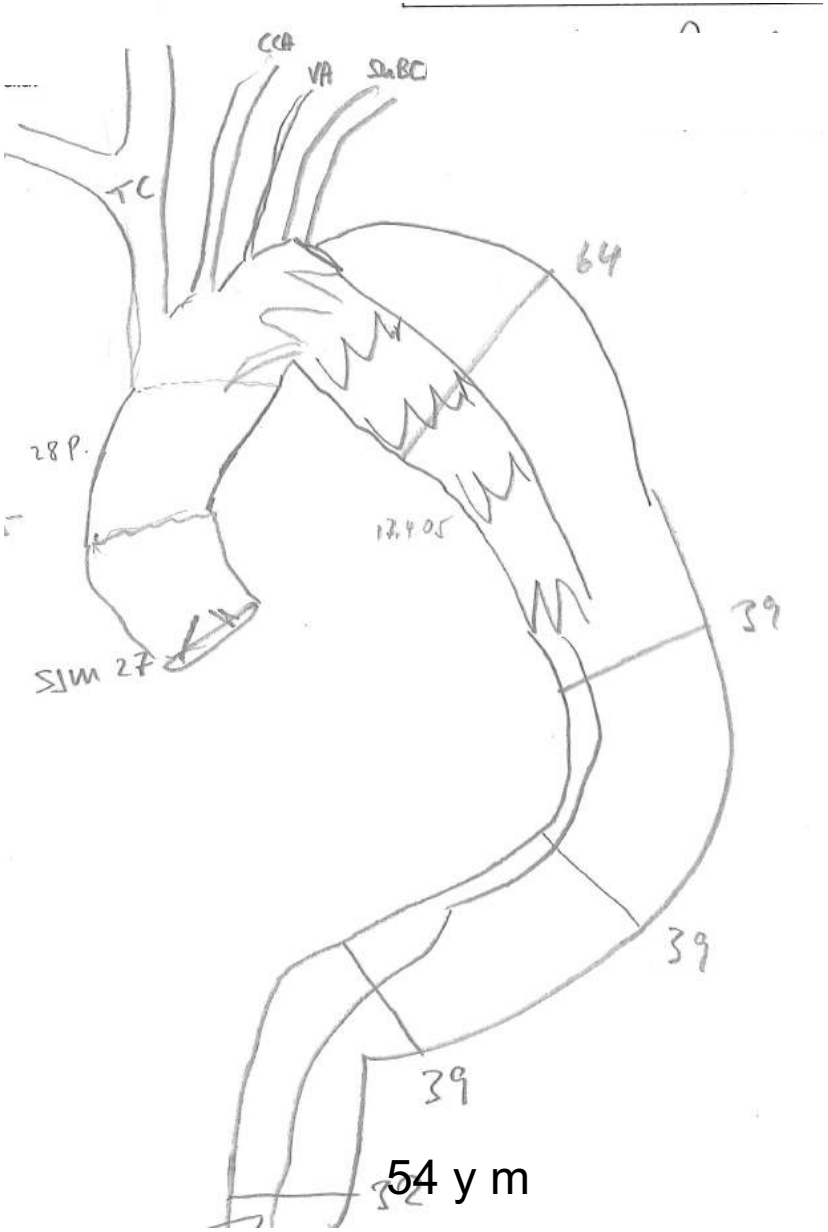
Risk of revascularisation

- ✓ Incidence of **phrenic nerve injury** as a complication of primary revascularization was **4.40**% (95% CI, 1.60%- 12.20%)
- ✓ no association with death, myocardial infarction, or transient ischemic attack.

Rizvi et al. J Vasc Surg 2009;50:1159-69


CCAR
SCR
CCAL
SCL
72
45
41
30

64 y m


CCA
VA
SIMBC
TC
64
28P.
39
SIM 27
39
39

54 y m

Management of the left subclavian artery and neurologic complications after thoracic endovascular aortic repair

Benjamin O. Patterson, PhD, MRCS,[a] Peter J. Holt, PhD, FRCS,[a] Christoph Nienaber, MD,[b] Ronald M. Fairman, MD,[c] Robin H. Heijmen, MD, PhD,[d] and Matt M. Thompson, MD, FRCS,[a]
London, United Kingdom; Rostock, Germany; Philadelphia, Pa; and Nieuwegein, The Net

- ✓ MOTHER Registry
- ✓ 1002 patients
- ✓ Overall Stroke 2.2%
- ✓ Coverage
- ✓ 11%
- ✓ revasc indipendently associated with stroke (odds **3.5**; 95% confidence interval [CI], 1.7-7.1)
- ✓ specifically in the **posterior territory** (OR, **11.7**; 95% CI, 2.5-54.6)
- ✓ And previous cerebrovascular accident (OR, **7.1**; 95% CI, 2.2-23.1)
- ✓ But not SCI

Prior revascularization appears to protect against posterior circulation territory stroke

Editor's Choice — Incidence of Stroke Following Thoracic Endovascular Aortic Repair for Descending Aortic Aneurysm: A Systematic Review of the Literature with Meta-analysis☆

Eur J Vasc Endovasc Surg (2017) 53, 176-184

R.S. von Allmen [a,*], B. Gahl [b], J.T. Powell [c]

10 studies

2594 patients

pooled **prevalence for stroke** 4.1% (95% CI

LSA uncovered

p

L

po **5.3%** (95% CI 2.6-8.6)

LSA covered without revascularization

Pooled stroke incidence **8.0%** (95% CI 4.1-2.9)

Conclusion
Stroke incidence is an important morbidity after TEVAR, and probably increases if the LSA is covered during the procedure, particularly in those without revascularisation.

Left subclavian artery revascularization in zone 2 thoracic endovascular aortic repair is associated with lower stroke risk across all aortic diseases

Rhiannon J. Bradshaw, BA, S. Sadie Ahanchi, MD, Obie Powell, MD, Sebastian Larion, MD, Colin Brandt, MD, Michael C. Soult, MD, *and* Jean M. Panneton, MD, *Norfolk, Va*

- ✓ 96 Patients
- ✓ 54 with revascularization (laser fenestration
- ✓ 30d **stroke** rate **overall**
- ✓ 30
- ✓

1.9% (p=.02)

0% (p=.11)

Our study suggests that coverage of the LSA without revascularization increases the risk of stroke and possibly SCI.

J Vasc Surg 2017;65:1270-9

Opinion leaders: LSA revascularization before TEVAR

I do it in every patient !

Carotid-subclavian bypass and subclavian-carotid transposition in the thoracic endovascular aortic repair era

Arin L. Madenci, MPH,[a] C. Keith Ozaki, MD,[b] Michael Belkin, MD,[b] and James T. McPhee, MD,[c]
Ann Arbor, Mich; and Boston, Mass

Carotid-Subclavian Bypass or Subclavian-Carotid Trsp in patients **with TEVAR or without (isolated reconstruction)**

- ✓ 30-day postoperative cerebrovascular accident (CVA) or death (CVA/D)
- ✓ Overall stroke, mortality, and combined CVA/D rates were for all 3.5% (n [31), 3.3% (n [29), and 5.8% (n [51), respectively
- ✓ Surgical approach did not affect outcome
- ✓ **CVA/D rate was 10.2% (n [9) for revascularization in conjunction with TEVAR** and 5.3% (n [42) for isolated reconstruction (P [.06).

Intentional left subclavian artery coverage during thoracic endovascular aortic repair for traumatic aortic injury

Cameron L. McBride, BS, Joseph J. Dubose, MD, Charles C. Miller III, PhD, Alexa P. Perlick, Kristofer M. Charlton-Ouw, MD, Anthony L. Estrera, MD, Hazim J. Safi, MD, and Ali Azizzadeh, MD, *Houston, Tex*

82 Patients
32 LSA covered

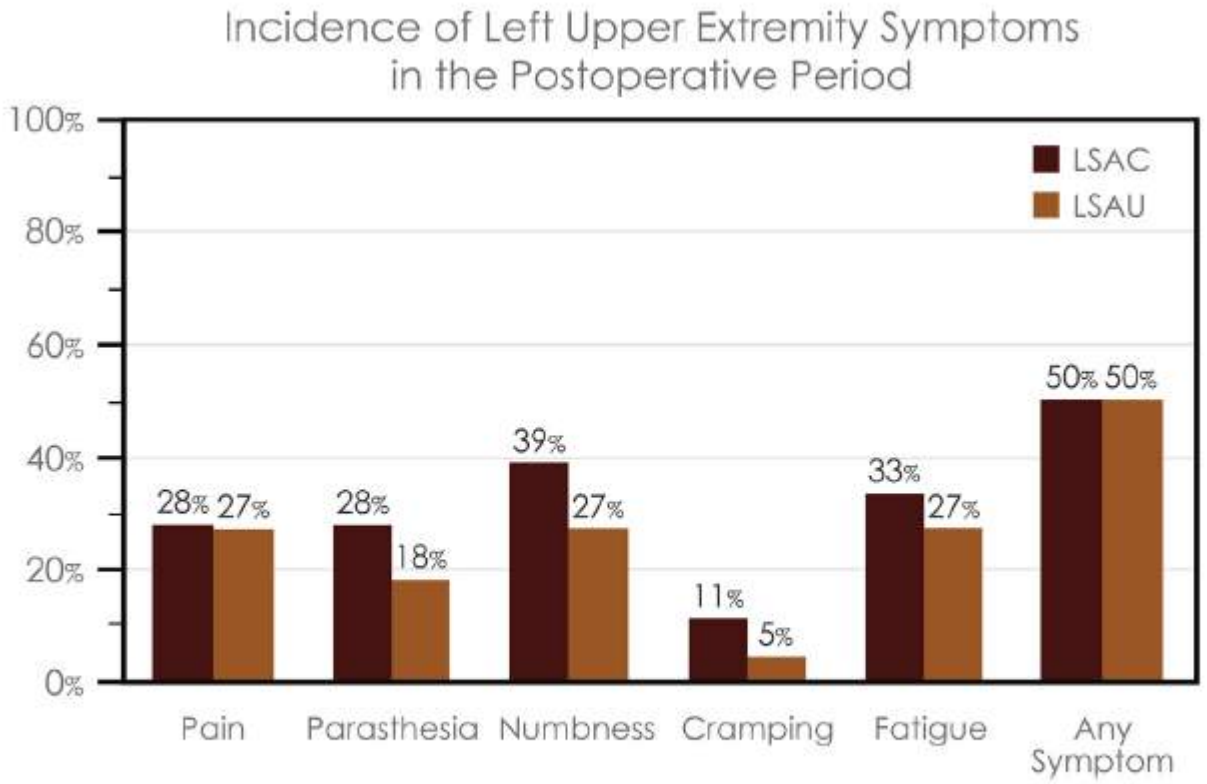


Fig 3. Incidence of left upper extremity symptoms in the postoperative period. *LSAC*, Left subclavian artery covered; *LSAU*, left subclavian artery uncovered.

JOURNAL OF ENDOVASCULAR THERAPY
An official publication of the International Society of Endovascular Specialists
A SAGE Publication

Meta-analysis of Left Subclavian Artery Coverage With and Without Revascularization in Thoracic Endovascular Aortic Repair

Journal of Endovascular Therapy
2016, Vol. 23(4) 634–641

DOI: 10.1177/1526602816651417
www.jevt.org
SAGE

Shahin Hajibandeh, MBChB[1], Shahab Hajibandeh, MBChB[1],
Stavros A. Antoniou, MD, PhD, FEBS[2], Francesco Torella, MD, FRCS[1],
and George A. Antoniou, MD, PhD, MSc, FEBVS[3]

No difference

- ✓ 5 st
- ✓ 1161
- ✓ 444 r … without
- ✓ Stroke rate, SCI rate and death rate not significantly different

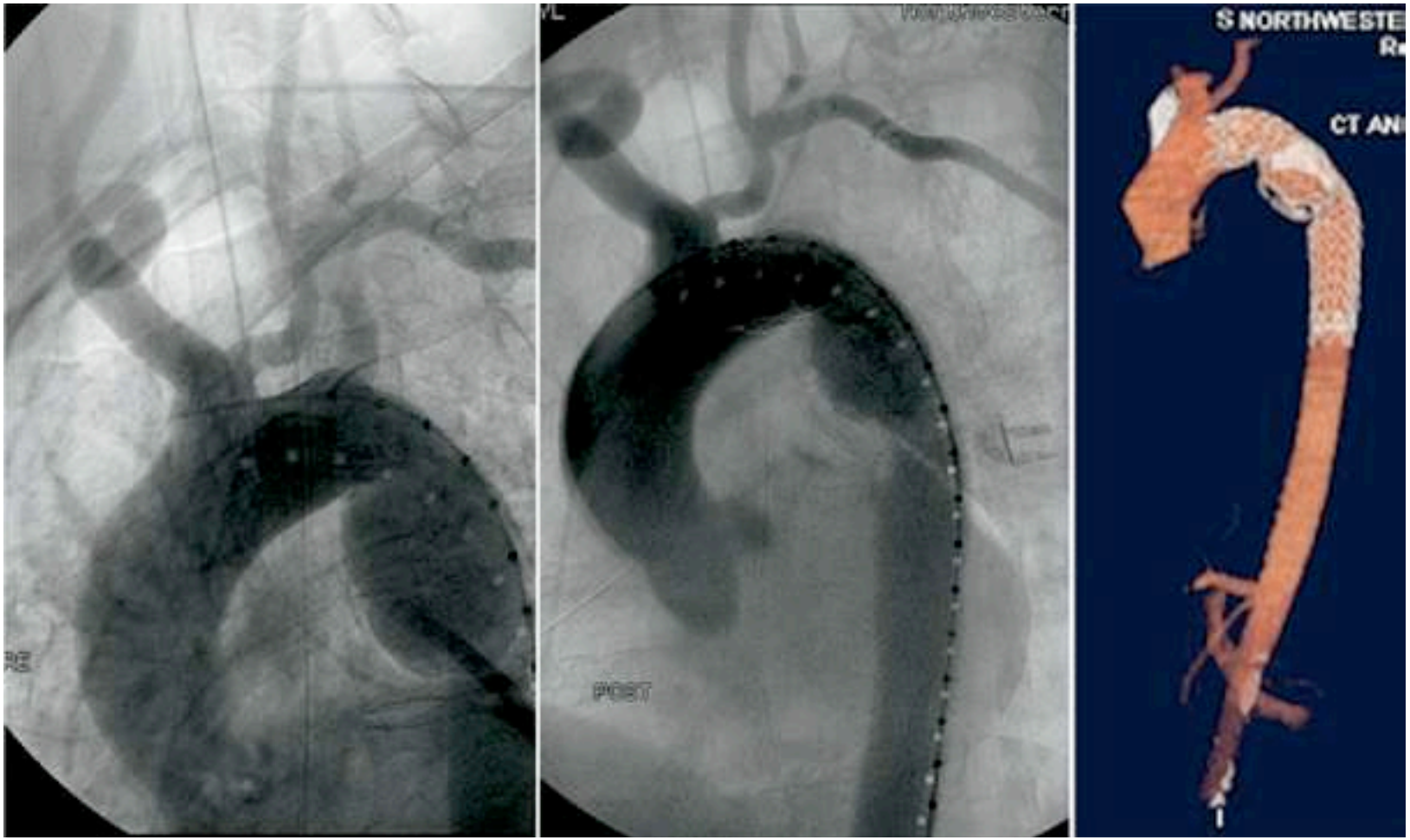
JEVT 2016, Vol. 23(4) 634–641

LSA repair techniques

- ✓ Carotid-subclavian Bypass
- ✓ Subclavian-carotid transposition
  - lateral approach
  - medial approach

Technique for subclavian to carotid transposition,tips, and tricks

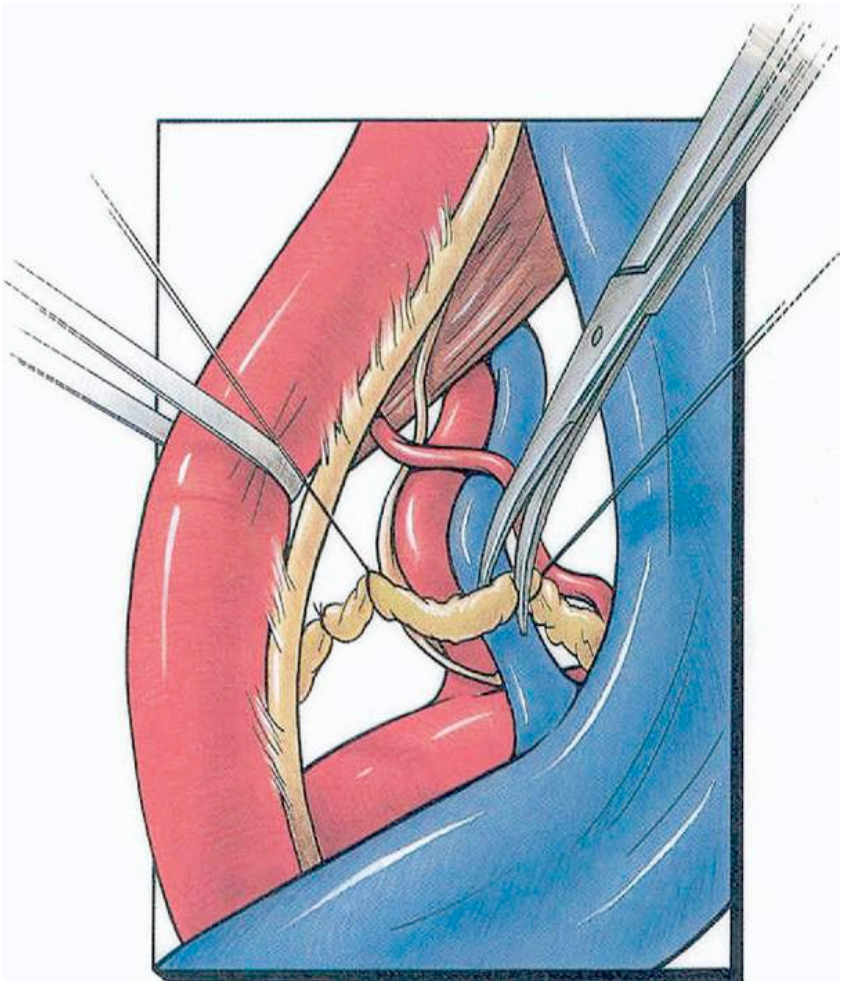
Mark D. Morasch, MD, Chicago, Ill

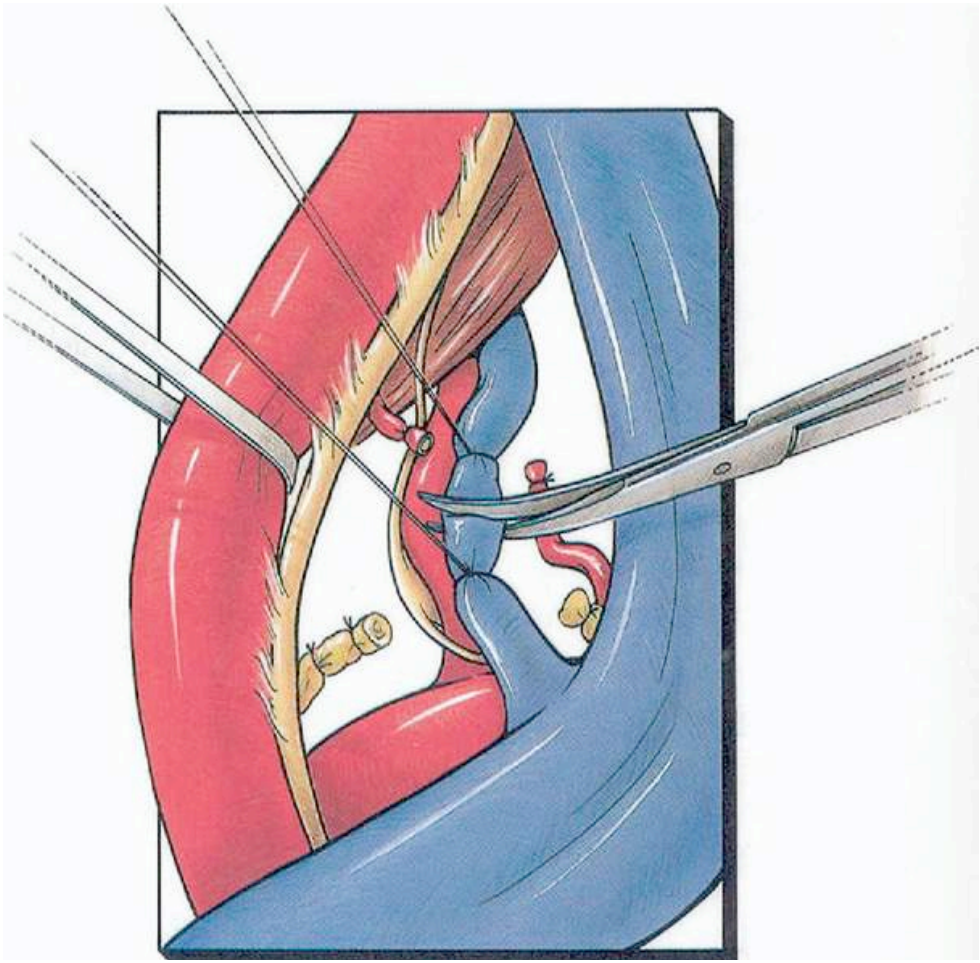


J Vasc Surg 2009;49:251-4.

J Vasc Surg 2009;49:251-4.

Ligation and division of thoracic duct

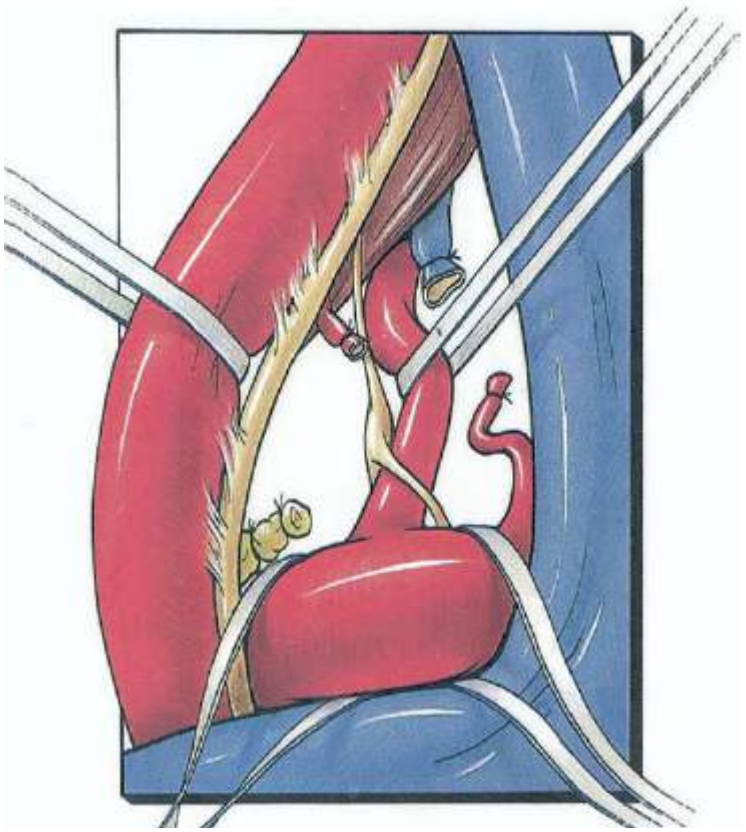


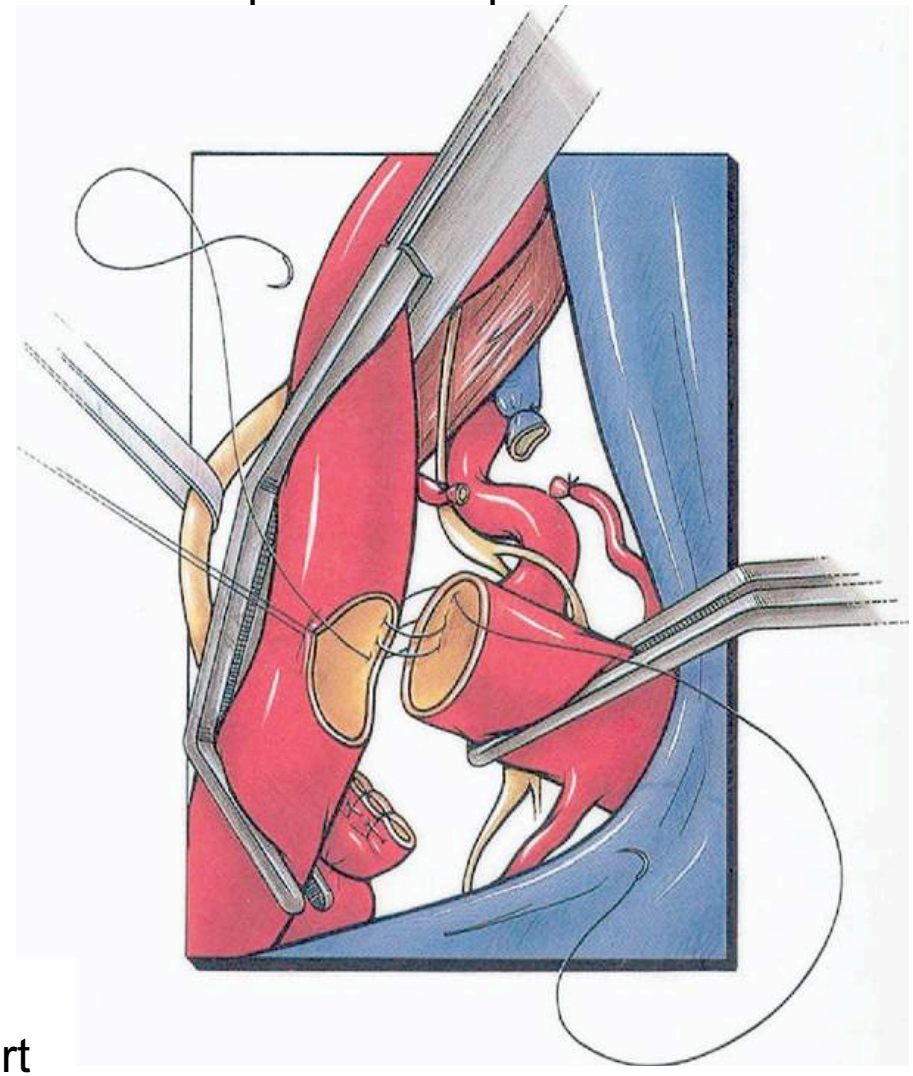


Ligation and division of the vertebral vein.

J Vasc Surg 2009;49:251-4.

Subclavian stump and transposition suture line.

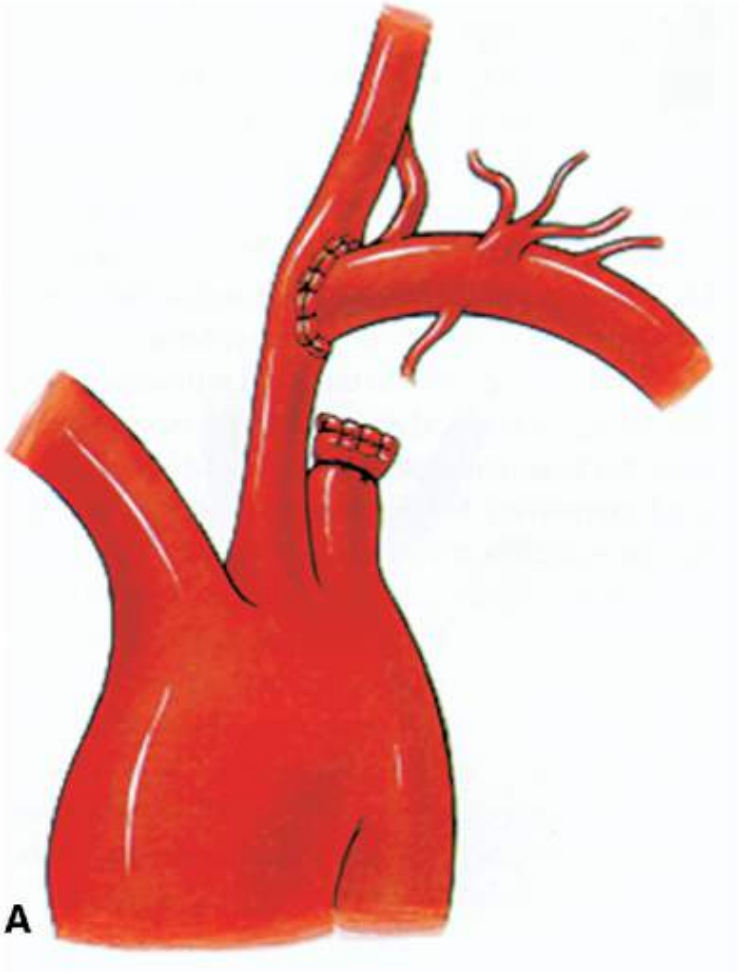




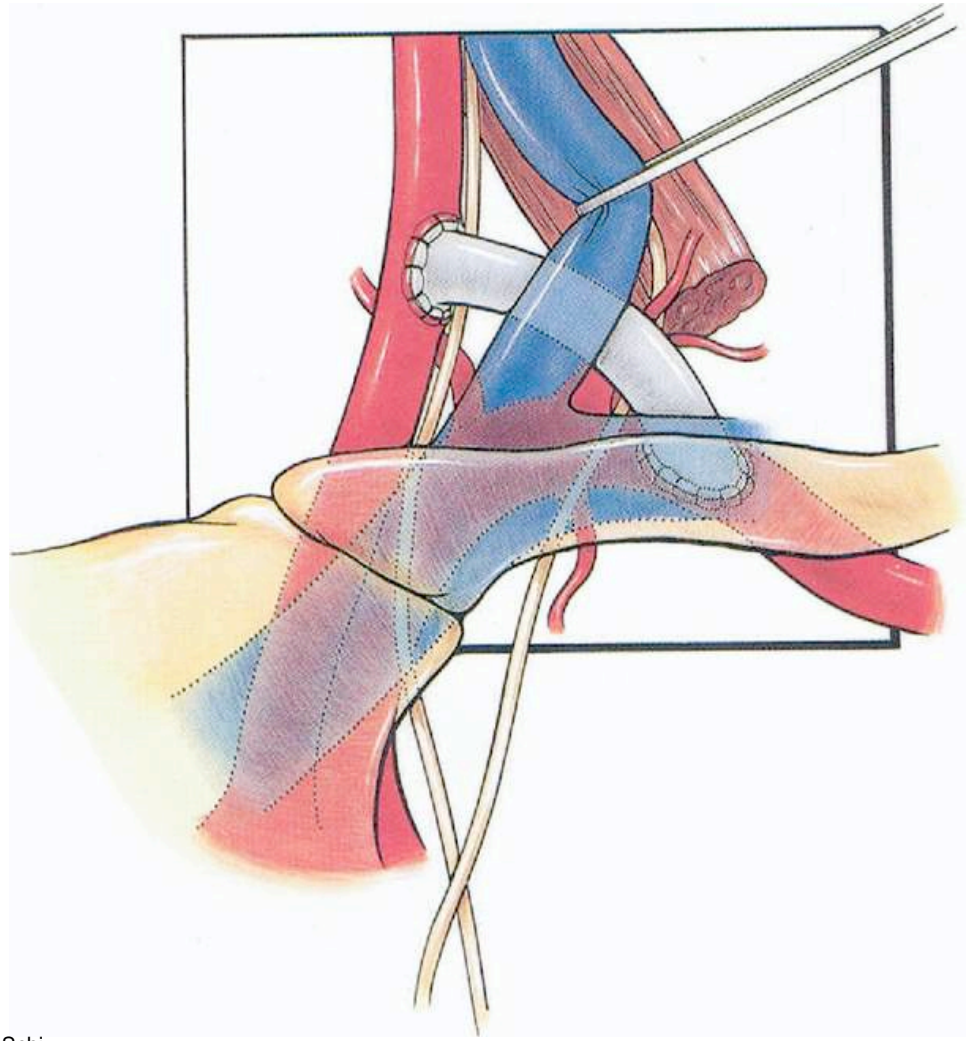
Mobilization of the subclavian artery
and its proximal branches, inf. Thyroid art

J Vasc Surg 2009;49:251-4.

Carotid to subclavian bypass



Completed transposition.

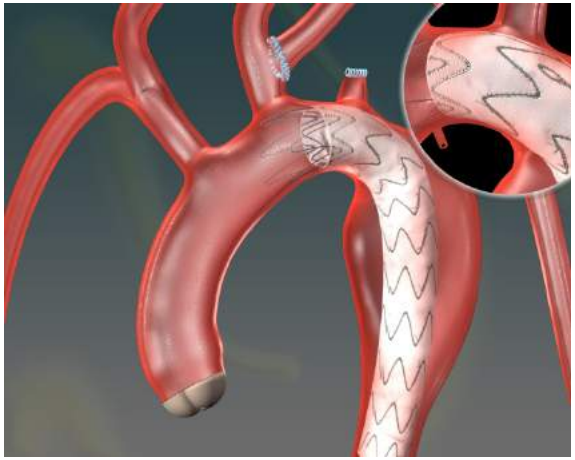


Results- subclavian transposition

n = 24

in-hospital mortality 0%

neurologic injury 0%



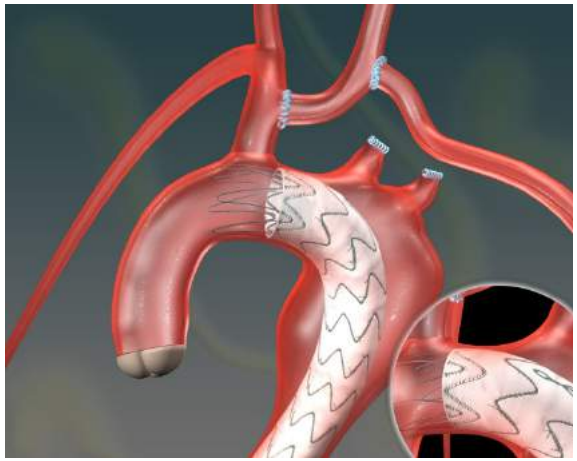
Gottardi et al. Ann Thorac Surg. 2008;86:1524-9

Results- double transposition

n = 40

in-hospital mortality 2.5%

neurologic injury 0%



Gottardi et al. Ann Thorac Surg. 2008;86:1524-9

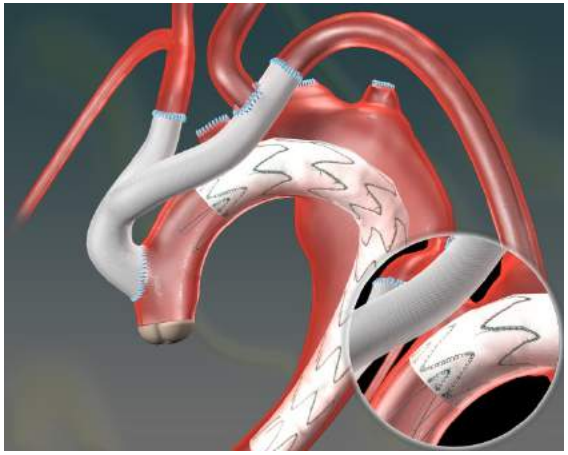
Results- total arch rerouting

n = 17

in-hospital mortality 17%

neurologic injury 5.8%

retrograde type A aortic dissection!!

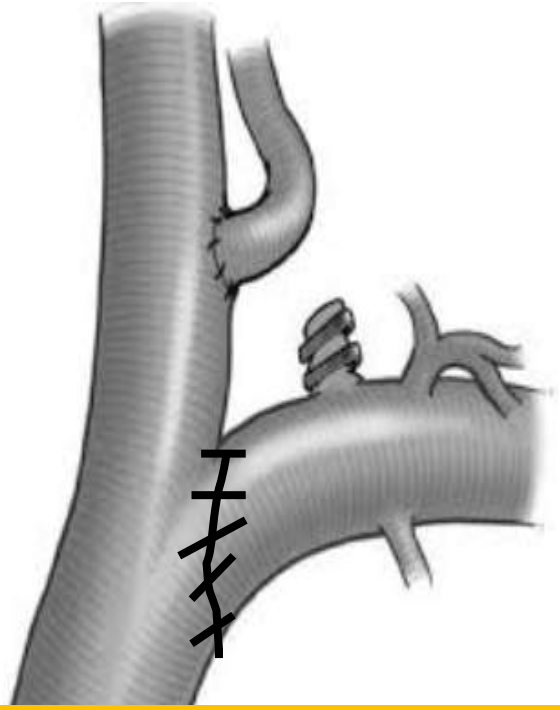


Gottardi et al. Ann Thorac Surg. **2008**;86:1524-9

Coverage of vertebral artery originating from the arch and LSA

J Vasc Surg 2009;49:251-4.

Completed transposition.



Surgical solution

Vertebral to carotid artery transposition by same exposure as for subcalvian to carotid artery transposition

Hybrid OR

SVS Practice Guidelines J Vasc Surg 2009;50:1155-8

Recommendation 1:

- In patients who need **elective TEVAR** where achievement of a proximal seal necessitates coverage of the left subclavian artery, we **suggest routine preoperative revascularization**, despite the very low-quality evidence (GRADE 2, level C)

Recommendation 2:

- In **selected patients** who have an **anatomy that compromises perfusion to critical organs**, **routine preoperative LSA revascularization** is **strongly recommended**, despite the very low-quality evidence (GRADE 1, level C)

Recommendation 3:

- In patients who need **urgent TEVAR** for life-threatening acute aortic syndromes where achievement of a proximal seal necessitates coverage of the left subclavian artery, **we suggest** that **revascularization should be individualized and addressed expectantly** on the basis of anatomy, urgency, and availability of surgical expertise (GRADE 2, level C).

ESVS descending aorta clinical practice guidelines

Eur J Vasc Endovasc Surg (2017) 53, 4-52

Recommendation 11	Class	Level of evidence	References
In elective thoracic endografting cases when it is planned to intentionally cover the left subclavian artery, in patients at risk of neurological complications, preventive left subclavian artery revascularisation should be considered	IIa	C	44

Recommendation 24			
In emergency ruptured descending thoracic aortic aneurysm in patients with a patent left mammary to coronary bypass or with a dominant or single left vertebral artery, left subclavian artery revascularisation should be performed prior to left subclavian artery coverage	I	C	49

LSA revascularization strongly recommended

- ✓ presence of a **patent left internal mammary artery** to coronary artery bypass graft
- ✓ termination of the left vertebral artery at the posterior inferior cerebellar artery or other discontinuity of the vertebrobasilar collaterals
- ✓ absent or diminutive or occluded right vertebral artery
- ✓ functioning arteriovenous **shunt** in the left arm
- ✓ prior infrarenal aortic repair with ligation of lumbar and middle sacral arteries
- ✓ planned long-segment (>20 cm) coverage of the descending thoracic aorta where critical intercostal arteries originate
- ✓ hypogastric artery occlusion
- ✓ presence of early aneurysmal changes that may require subsequent therapy involving the distal thoracic aorta.
- ✓ Left-handed professionals (e.g. piano player)

LSA revascularization not recommended

- ✓ **Emergency TEVAR (no sufficient time)**
  - **Type B aortic dissections with malperfusion**
  - **traumatic aortic transsection**
- ✓ **Anatomic variations preclued revascularization**
  - **Congenital anomalies such as aberrant arch anatomy**
  - **abnormalities of the LSA or vertebral**
- ✓ **Post radiation therapy**
- ✓ **Expertise is not available**

Management of the vertebral artery during thoracic endovascular aortic repair with coverage of the left subclavian artery

Jian Zhu*, Er-Ping Xi*, Shui-Bo Zhu, Gui-Lin Yin, Rong-Ping Wang, Yu Zhang

- ✓ 160 patients underwent LSA closure or partial coverage
- ✓ 94 patients with partial LSA coverage during TEVAR, no treatment was provided
- ✓ 66 patients with full LSA coverage during TEVAR, right carotid artery-left common carotid artery bypass surgery was performed before TEVAR
- ✓ 10 patients, without any treatment for the vertebral artery, showing reverse blood flow of the left vertebral artery after surgery.
- ✓ 4 patients: Left common carotid artery-LSA bypass surgery was performed before TEVAR
- ✓ 3 patients: right common carotid artery-left common carotid artery-LSA bypass
- ✓ 6 out of these 7 patients underwent proximal LSA ligation
- ✓ In 160 patients, postoperative recurrent laryngeal nerve injury occurred in one patient
- ✓ No death

J Thorac Dis 2017;9(5):1273-1280

Neurological complications after left subclavian artery coverage during thoracic endovascular aortic repair: A systematic review and meta-analysis

David G. Cooper, MS, FRCS, Stewart R. Walsh, MSc, MRCSEd, Umar Sadat, MRCS, Ayesha Noorani, MRCS, Paul D. Hayes, MD, FRCS, and Jonathan R. Boyle, MD, FRCS,
Cambridge, United Kingdom

Pooled odds ratios (POR) postoperative CVA and SCI.

- ✓ **CVA** without LSA coverage **without revasc** vs non-coverage (4.7% vs 2.7%; **POR, 2.28**; 95% confidence interval [CI], 1.28-4.09; P <.005)
- ✓ **CVA** in LSA **coverage after revascularization** vs non-coverage (4.1% vs 2.6%; **POR, 3.18**; 95% CI, 1.17-8.65; P < .02).
- ✓ The risk of **SCI** with LSA coverage **without revasc** vs non-coverage (2.8% vs 2.3%; **POR, 2.39**; 95% CI, 1.30-4.39; P < .005)
- ✓ **SCI** in LSA coverage **after revascularization** vs non-coverage (0.8% vs 2.7%; **POR, 1.69**; 95% CI, 0.56-5.15; P <.35).

J Vasc Surg 2009;49:1594-601