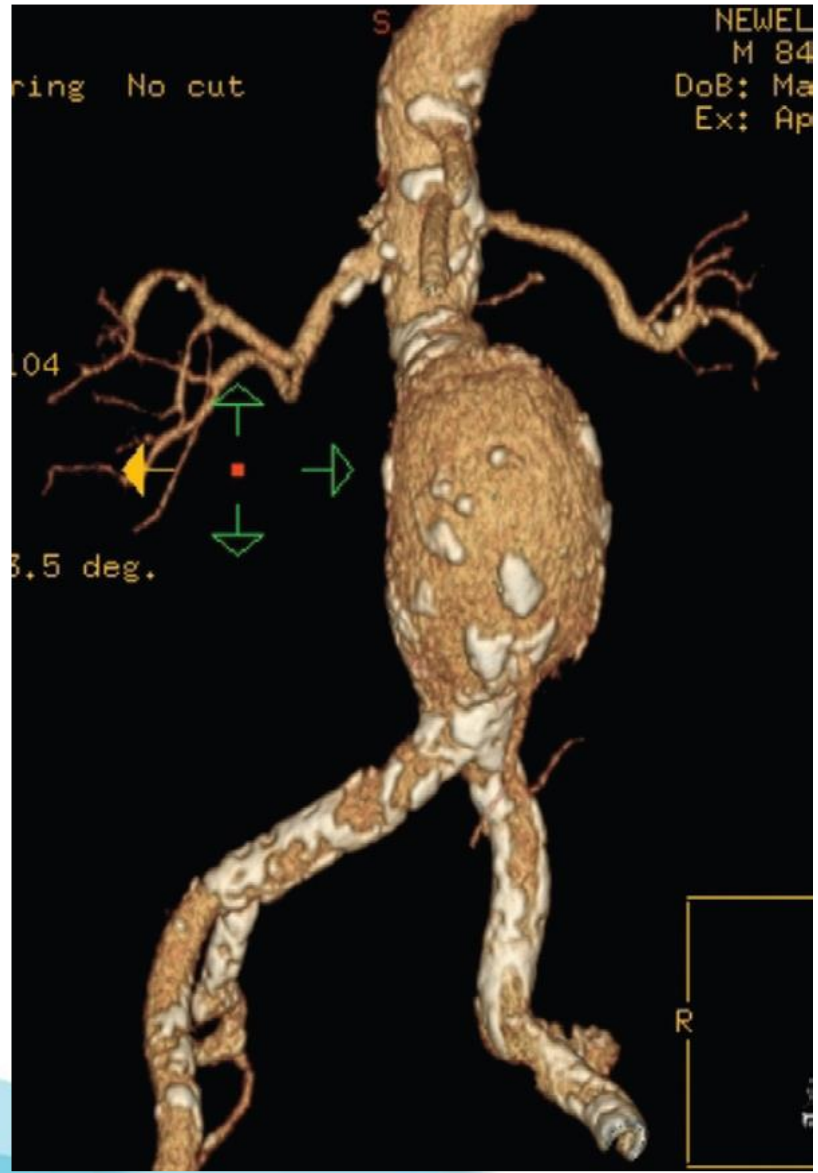
2025 제 17차 전공의 연수교육

Techniques and Complications of Endovascular Aortic repair

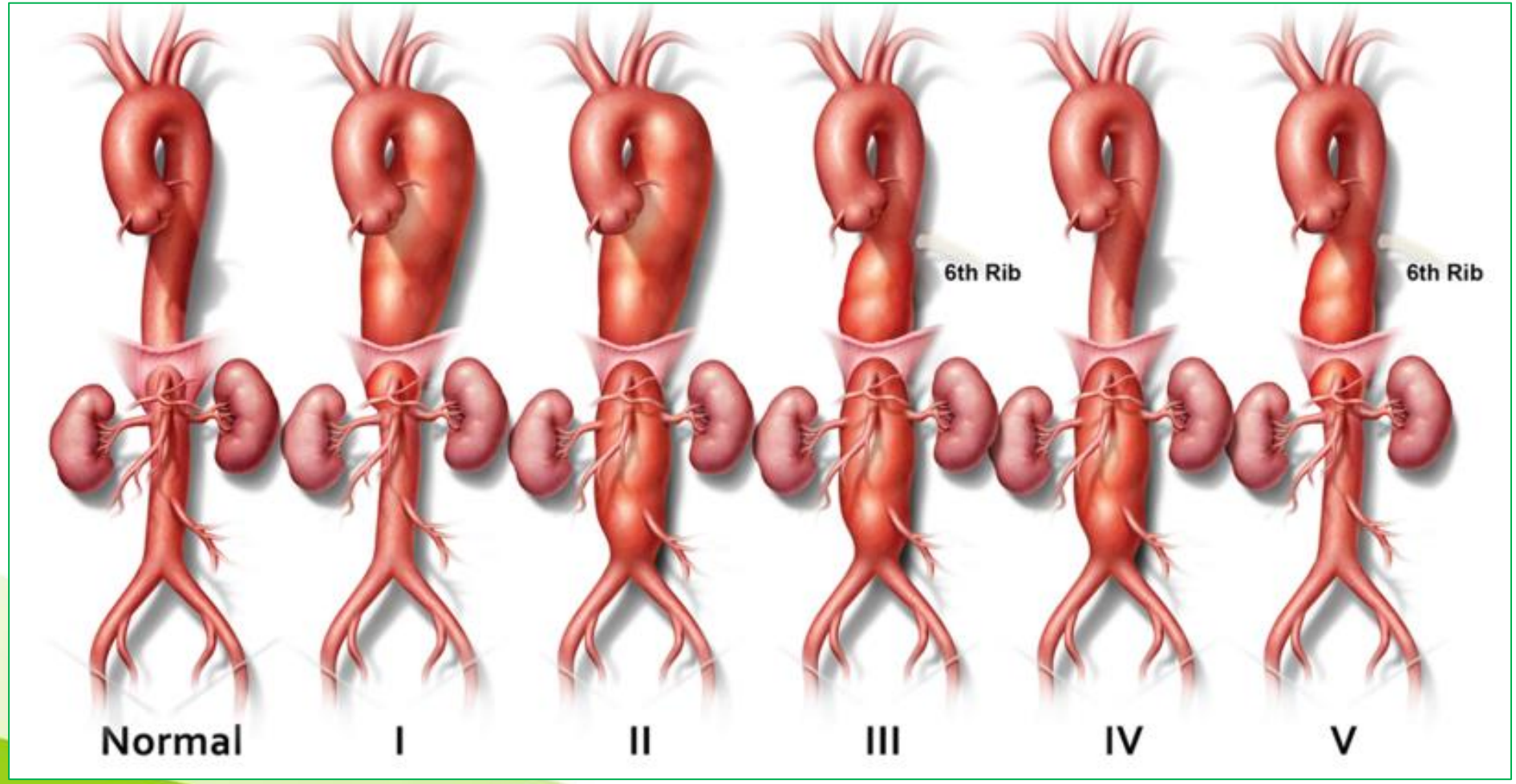
Seokbeom Hong, M.D.

Department of Thoracic and Cardiovascular Surgery,
Seoul St. Mary's Hospital
College of Medicine, The Catholic University of Korea

Aortic aneurysm

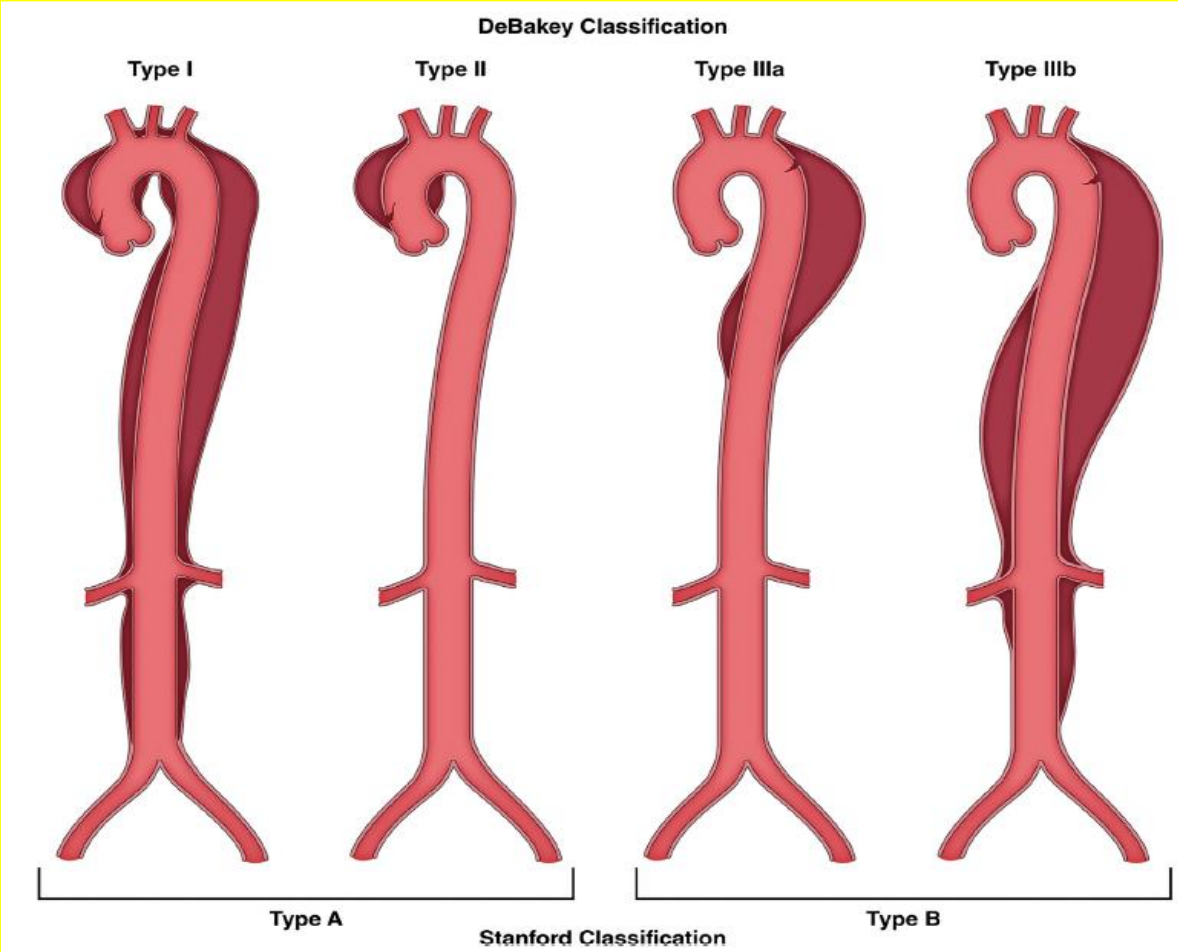


TAAA Crawford type

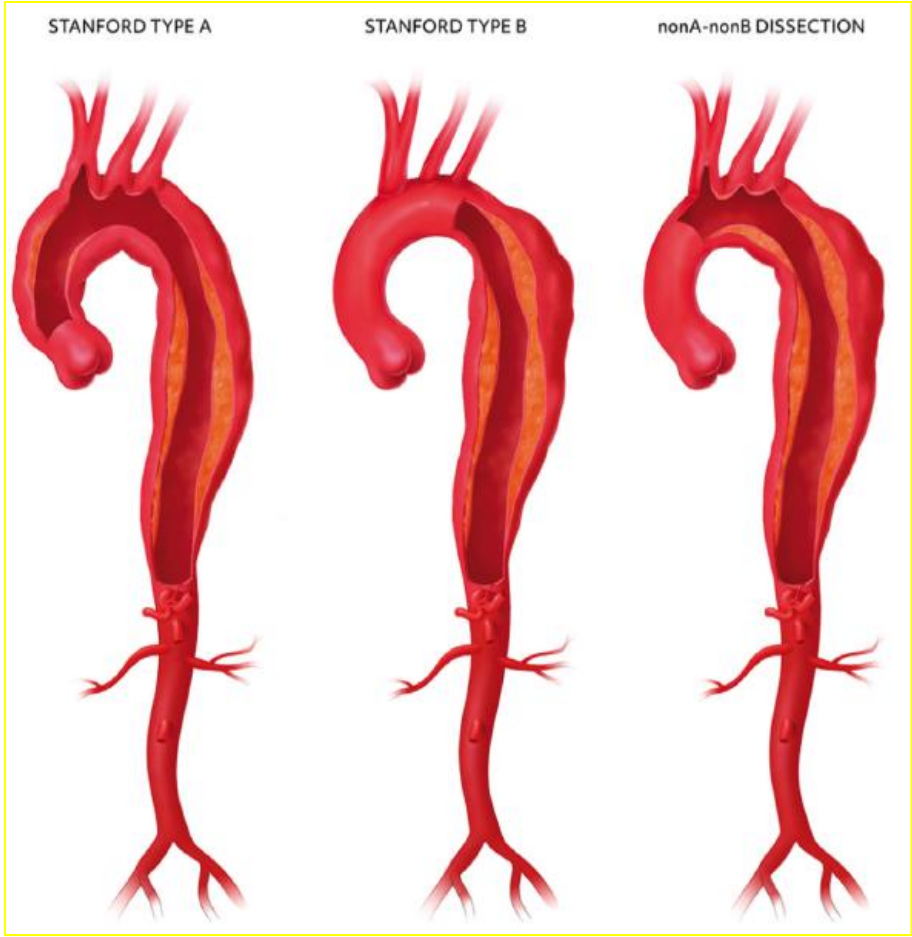


Estrera AL. Annals of Surgery, 2015

Classification of Acute Aortic dissection

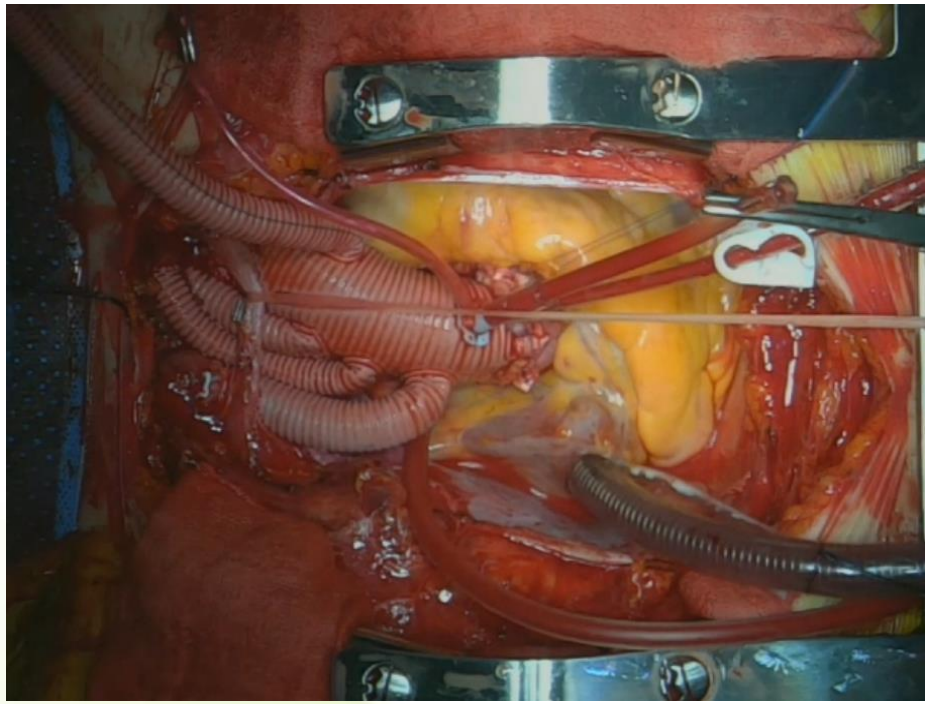


- *ACC/AHA 2022 Guideline*

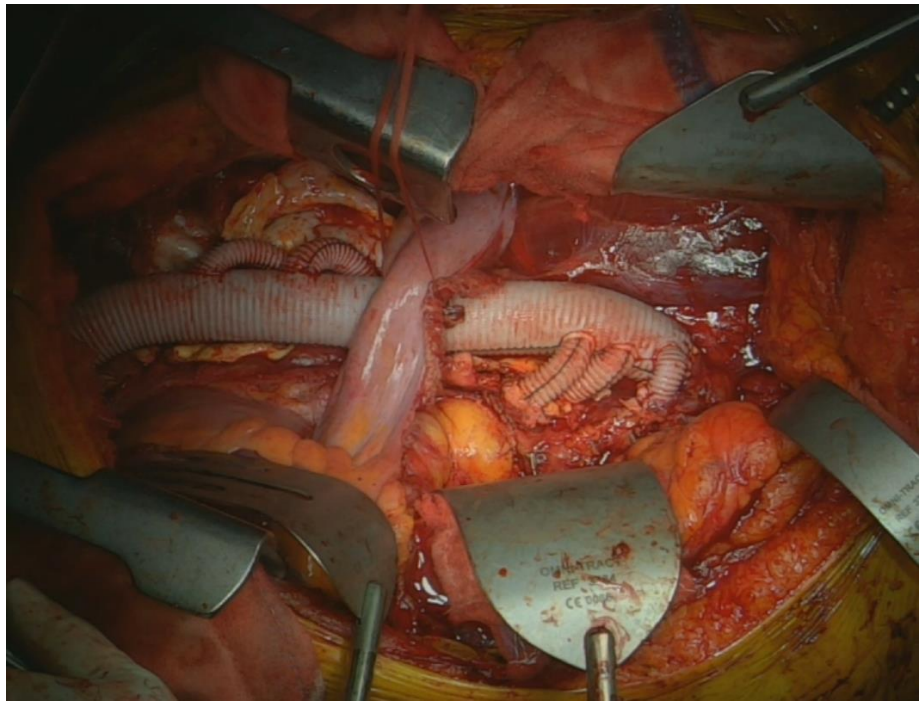


- *EACTS/STS 2024 Guideline*

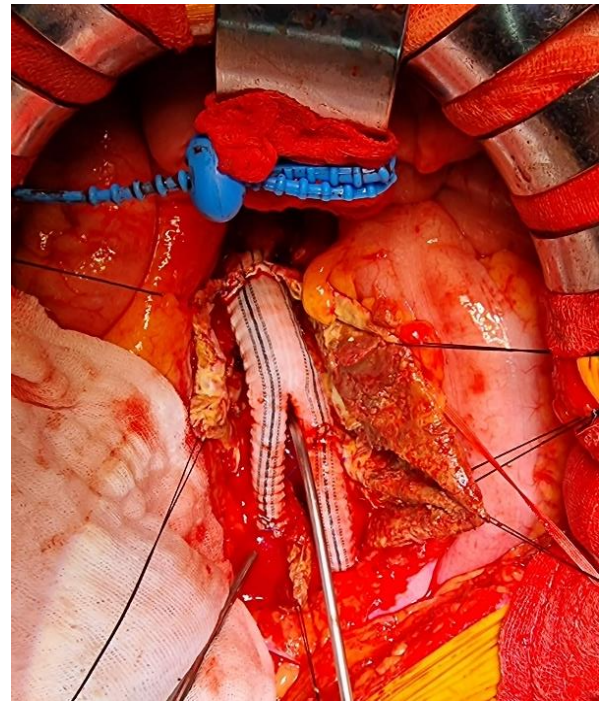
Aortic Disease Open surgical repair



Total arch replacement
In ATAAD or TAA



Open TAAA repair



Open AAA repair

1st Endovascular repair in AAA (1991)

Transfemoral Intraluminal Graft Implantation for Abdominal Aortic Aneurysms

J.C. Parodi, MD*, J.C. Palmaz, MD†, H.D. Barone, PhD, *Buenos Aires, Argentina, and San Antonio, Texas*

This study reports on animal experimentation and initial clinical trials exploring the feasibility of exclusion of an abdominal aortic aneurysm by placement of an intraluminal, stent-anchored, Dacron prosthetic graft using retrograde cannulation of the common femoral artery under local or regional anesthesia. Experiments showed that when a balloon-expandable stent was sutured to the partially overlapping ends of a tubular, knitted Dacron graft, friction seals were created which fixed the ends of the graft to the vessel wall. This excludes the aneurysm from circulation and allows normal flow through the graft lumen. Initial treatment in five patients with serious co-morbidities is described. Each patient had an individually tailored balloon diameter and diameter and length of their Dacron graft. Standard stents were used and the diameter of the stent-graft was determined by sonography, computed tomography, and arteriography. In three of them a cephalic stent was used without a distal stent. In two other patients both ends of the Dacron tubular stent were attached to stents using a one-third stent overlap. In these latter two, once the proximal neck of the aneurysm was reached, the sheath was withdrawn and the cephalic balloon inflated with a saline/contrast solution. The catheter was gently removed caudally towards the arterial entry site in the groin to keep tension on the graft, and the second balloon inflated so as to deploy the second stent. Four of the five patients had heparin reversal at the end of the procedure. We are encouraged by this early experience, but believe that further developments and more clinical trials are needed before this technique becomes widely used. (*Ann Vasc Surg* 1991;*5*:491–499).

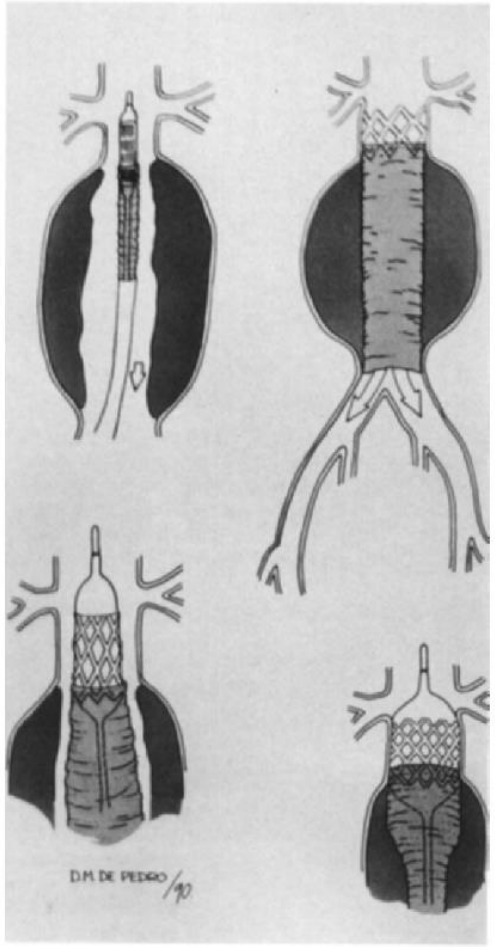


Fig. 2. Intraluminal exclusion of artificial aneurysm by implanting Dacron tubular grafts by transfemoral route. Balloon expandable tents anchor graft to aortic wall.

1st Endovascular repair in DTAA (1994)

The New England
Journal of Medicine

Volume 331 DECEMBER 29, 1994 Number 26

TRANSLUMINAL PLACEMENT OF ENDOVASCULAR STENT–GRAFTS FOR THE TREATMENT OF DESCENDING THORACIC AORTIC ANEURYSMS

MICHAEL D. DAKE, M.D., D. CRAIG MILLER, M.D., CHARLES P. SEMBA, M.D., R. SCOTT MITCHELL, M.D., PHILIP J. WALKER, M.B., B.S., AND ROBERT P. LIDDELL, B.A.

Abstract *Background.* The usual treatment for thoracic aortic aneurysms is surgical replacement with a prosthetic graft, but the associated morbidity and mortality are considerable. We studied the use of transluminally placed endovascular stent–graft devices as an alternative to surgical repair.

Methods. We evaluated the feasibility, safety, and effectiveness of transluminally placed stent–grafts to treat descending thoracic aortic aneurysms in 13 patients over a 24-month period. Atherosclerotic, anastomotic, and post-traumatic true or false aneurysms and aortic dissections were treated. The mean diameter of the aneurysms was 6.1 cm (range, 5 to 8). The endovascular stent–grafts were custom-designed for each patient and were constructed of self-expanding stainless-steel stents covered with woven Dacron grafts.

Results. Endovascular placement of the stent–graft prosthesis was successful in all patients. There was complete thrombosis of the thoracic aortic aneurysm surrounding the stent–graft in 12 patients, and partial thrombosis in 1. Two patients initially had small, residual patent proximal tracts into the aneurysm sac, but both tracts thrombosed within two months after the procedure. In four patients, two prostheses were required to bridge the aneurysm adequately. There have been no deaths or instances of paraplegia, stroke, distal embolization, or infection during an average follow-up of 11.6 months. One patient with an extensive chronic aortic dissection required open surgical graft replacement four months later because of progressive dilatation of the arch.

Conclusions. These preliminary results demonstrate that endovascular stent–graft repair is safe in highly selected patients with descending thoracic aortic aneurysms. This new method of treatment will, however, require careful long-term evaluation. (N Engl J Med 1994; 331:1729-34.)

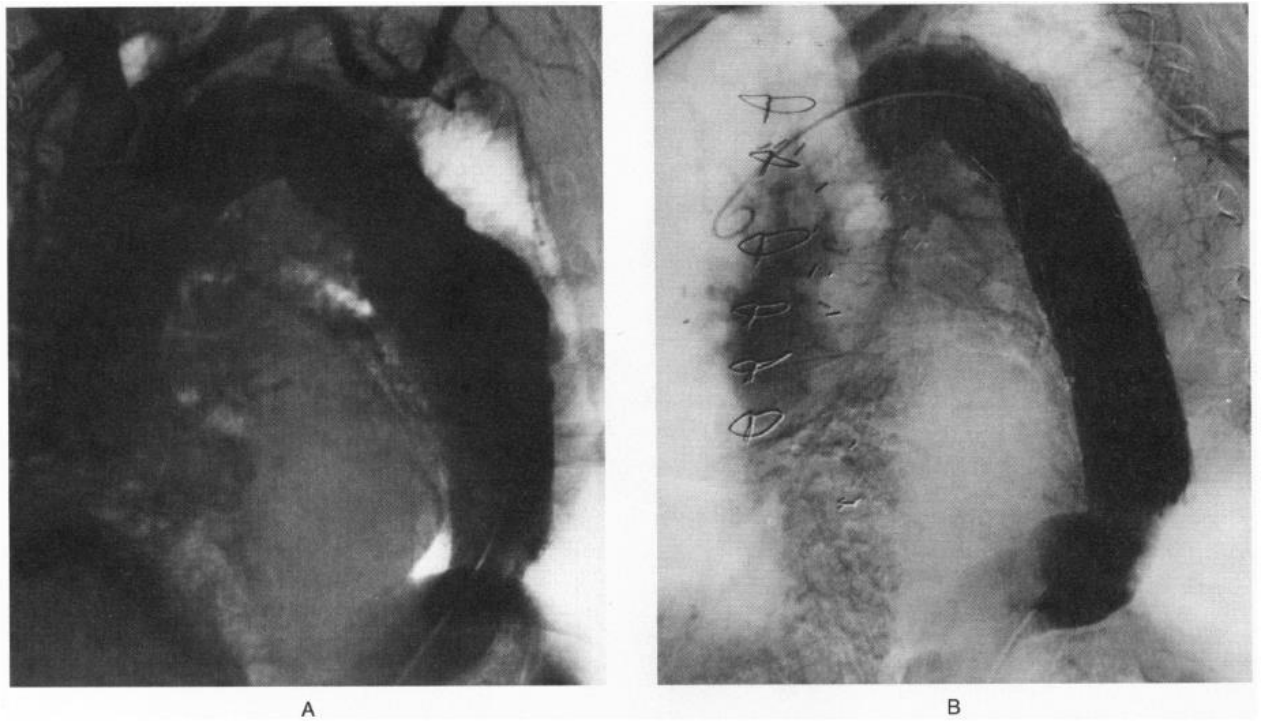


Figure 2. Left Anterior Oblique Views of the Aorta in a 71-Year-Old Woman (Patient 5) with Back Pain and an Abnormal Chest Radiograph Who Had Previously Undergone Coronary-Artery Bypass Grafting.

Before the placement of the stent–graft, an aortogram (Panel A) shows a long, atherosclerotic aneurysm of the descending thoracic aorta associated with an irregular lumen. After the procedure, an arteriogram (Panel B) shows good flow of contrast medium through the device, with no leakage into the surrounding aneurysm.

Medtronic AneuRx First FDA approved for EVAR , 1999

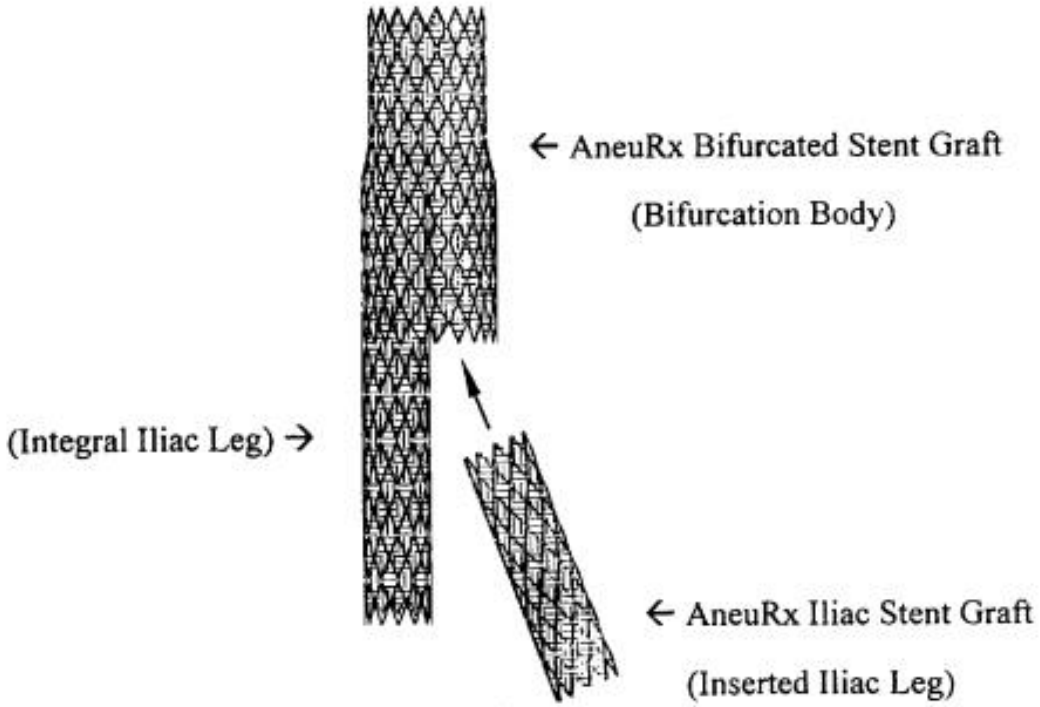


Figure 1: AneuRx Bifurcated and Iliac Stent Grafts

Medtronic

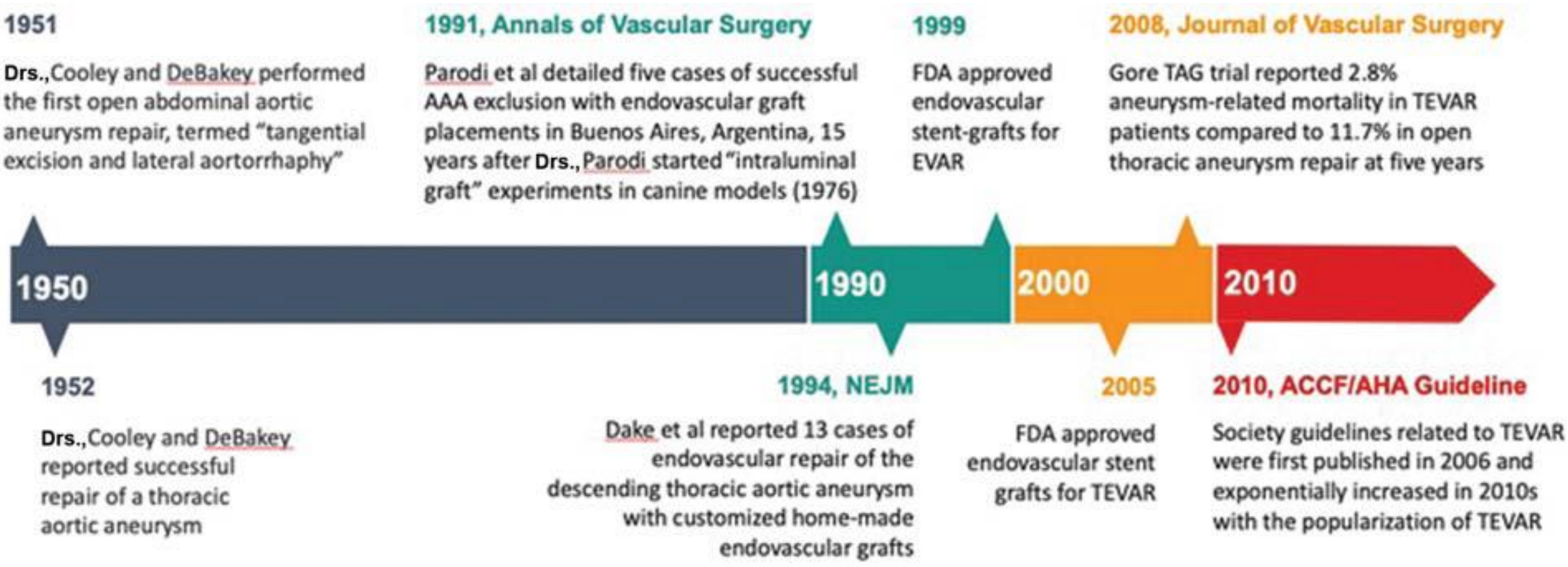
GORE TAG device, First FDA approval for TEVAR, 2005

CONFORMABLE

GORE TAG®

THORACIC
ENDOPROSTHESIS

Timeline of the History of Endovascular Aortic repair



Chen SW, Lee KB, Napolitano MA, Murillo-Berlioz AE, Sattah AP, Sarin S, et al. Complications and management of the thoracic endovascular aortic repair. Aorta. (2020) 8:49–58. doi: 10.1055/s-0040-1714089

EACTS/STS Guidelines for Aortic disease 2024

AORTIC DISEASE CLINICAL PRACTICE GUIDELINE

EACTS/STS Guidelines for Diagnosing and Treating Acute and Chronic Syndromes of the Aortic Organ

Authors/Task Force Members: Martin Czerny[1,2,*] (Co-Chairperson) (Germany), Martin Grabenwöger[3,4,*] (Co-Chairperson) (Austria), Tim Berger[1,2] (Task Force Coordinator), Victor Aboyans[5,6] (France), Alessandro Della Corte[7,8] (Italy), Edward P. Chen[9] (USA), Nimesh D. Desai[10] (USA), Julia Dumfarth[11] (Austria), John A. Elefteriades[12] (USA), Christian D. Etz[13] (Germany), Karen M. Kim[14] (USA), Maximilian Kreibich[1,2] (Germany), Mario Lescan[15] (Germany), Luca Di Marco[16] (Italy), Andreas Martens[17,18] (Germany), Carlos A. Mestres[19] (South Africa), Milan Milojevic[20] (Serbia), Christoph A. Nienaber[21,22] (UK), Gabriele Piffaretti[23] (Italy), Ourania Preventza[24] (USA), Eduard Quintana[25] (Spain), Bartosz Rylski[1,2] (Germany), Christopher L. Schlett[2,26] (Germany), Florian Schoenhoff[27] (Switzerland), Santi Trimarchi[28] (Italy), and Konstantinos Tsagakis[29] (Germany), EACTS/STS Scientific Document Group

TEM Aortic dissection Classification

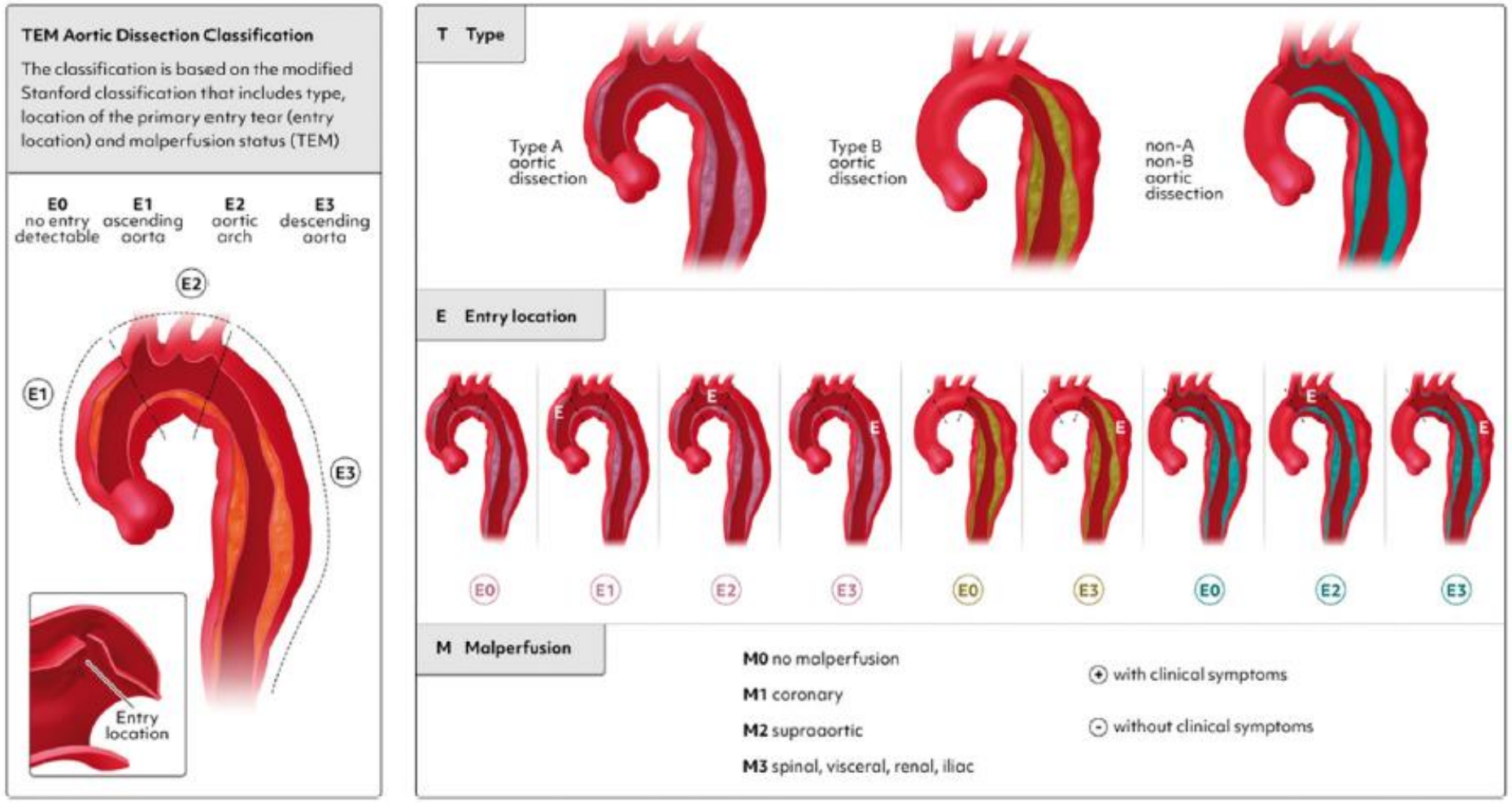


FIGURE 6 Type, entry, malperfusion classification for acute aortic dissection. (TEM, type, entry, malperfusion.)

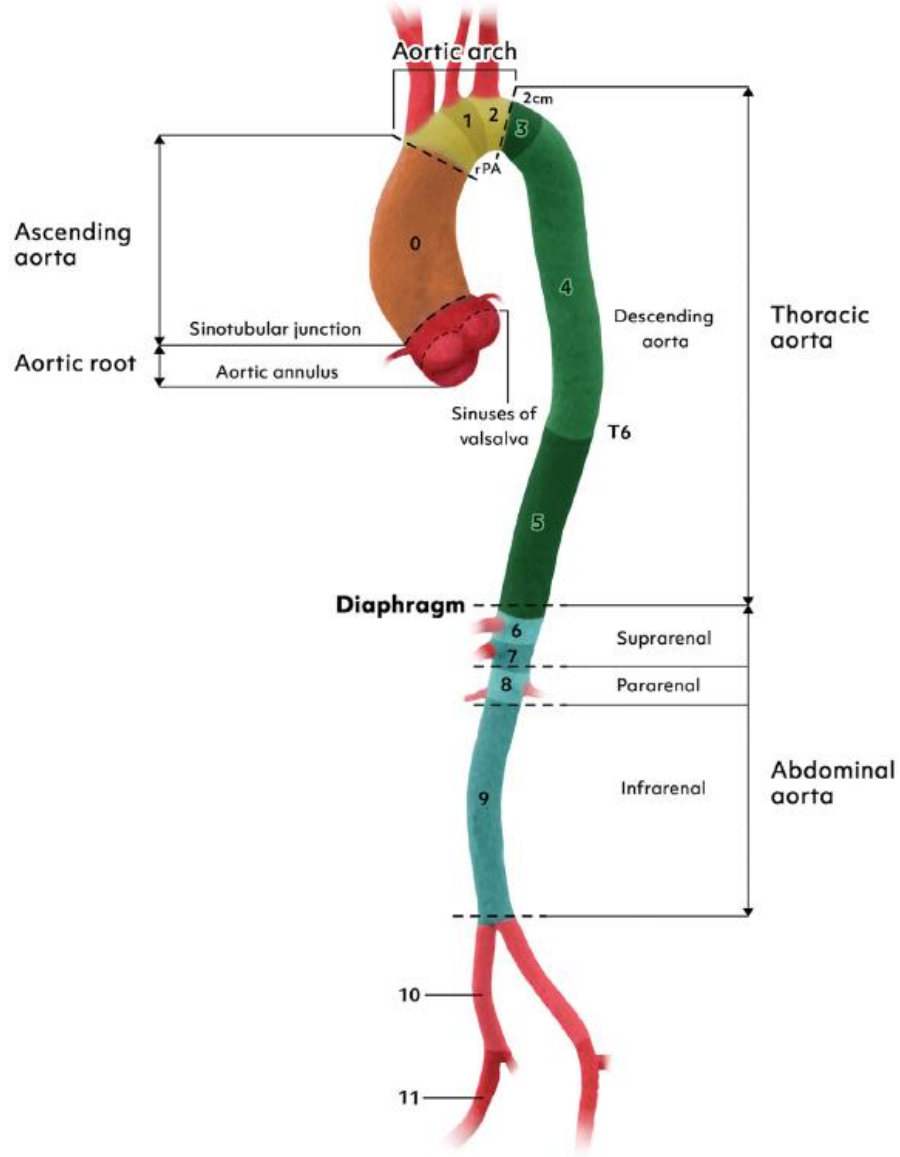


FIGURE 3 Aortic segments based on Ishimaru zones.

Aortic Team and Hybrid OR for Endovascular repair

AORTIC TEAMS AND HEALTHCARE IMPLICATIONS

RECOMMENDATION TABLE 3 Aortic Teams and Healthcare Implications

Recommendations	Class[a]	Level[b]	Ref[c]
Shared decision-making for the optimal treatment of aortic pathologies by a multidisciplinary aortic team is recommended.	I	C	-
In patients with multisegmental aortic disease, treatment is recommended in aortic centers providing open and endovascular cardiac and vascular surgery on site.	I	C	-
Transfer to an aortic center should be considered for patients with complex aortic pathologies.	IIa	B	105-118
For endovascular aortic procedures, a hybrid operating room, including an integrated imaging system, is recommended.	I	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References.

Acute Aortic dissection

RECOMMENDATION TABLE 5 Acute Aortic Diseases: Type A Aortic Dissection

Recommendations	Class[a]	Level[b]	Ref[c]
Initiation of emergency surgery is recommended in patients presenting with acute type A aortic dissection.	I	B	211, 212
A tear-oriented approach with exclusion or resection of the primary entry tear in the ascending aorta and arch is recommended.	I	B	213, 214
Inspection and coverage of communications between lumina in the proximal descending aorta may be considered in specialized centers for prognostic reasons.	IIb	C	-
Despite preoperative neurologic dysfunction or nonhemorrhagic stroke, open repair should be considered.	IIa	B	215-217
In case of clinical and imaging evidence of visceral malperfusion, revascularization may be considered prior to aortic repair.	IIb	C	-
Antegrade systemic perfusion via axillary or direct aortic cannulation should be considered.	IIa	B	218, 219
An open distal anastomosis during lower body hypothermic circulatory arrest is recommended.	I	B	220, 221

[a]Class of recommendation; [b]Level of evidence; [c]References.

RECOMMENDATION TABLE 6 Acute Aortic Diseases: Non-A Non-B Aortic Dissection

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with complicated non-A non-B aortic dissection with arch entry tear, repair via the FET technique should be considered.	IIa	C	-
In patients with anatomical feasibility to cover the primary entry tear, a stent graft implantation may be considered.	IIb	C	-

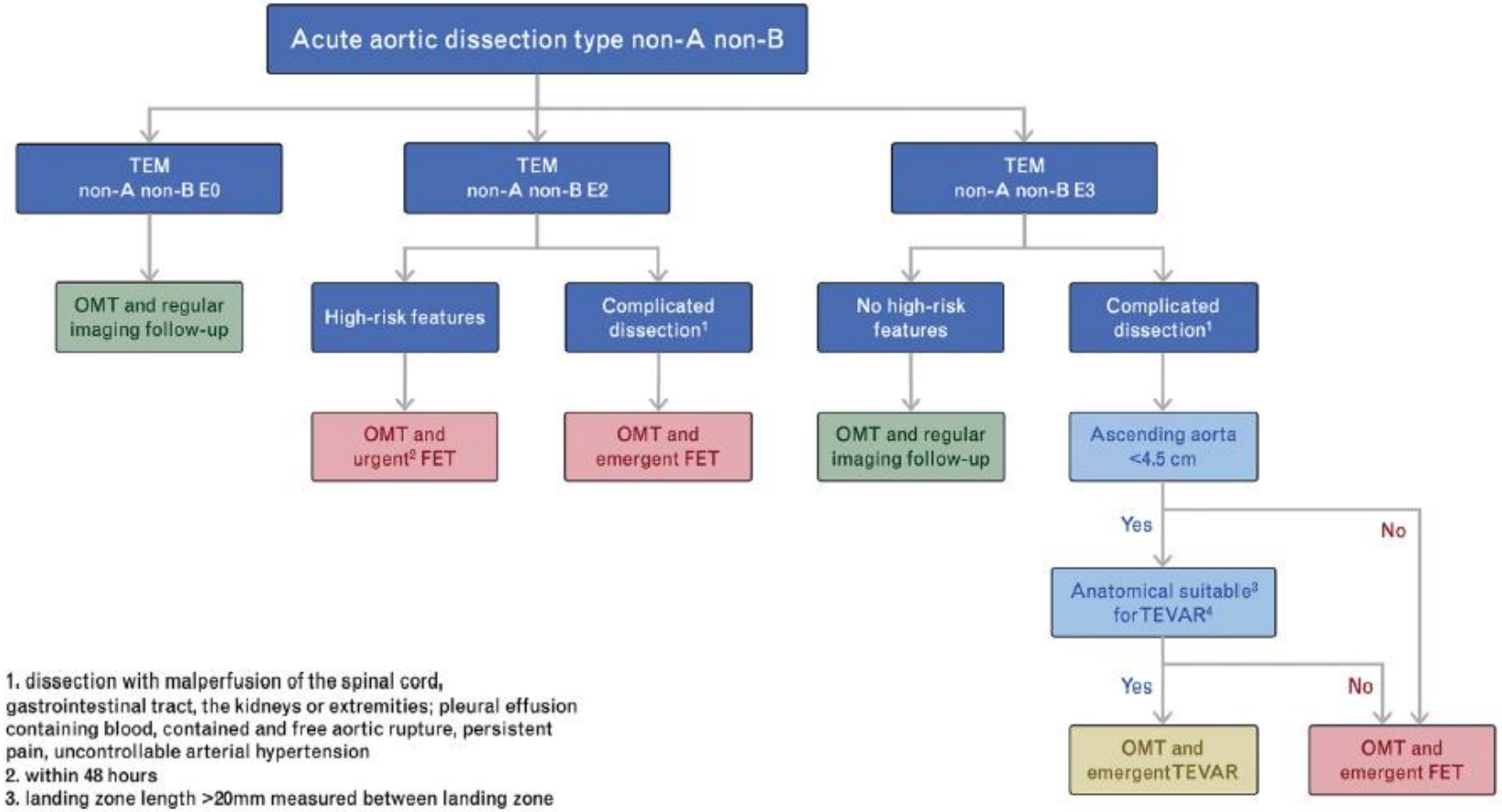
[a]Class of recommendation; [b]Level of evidence; [c]References. FET, frozen elephant trunk.

RECOMMENDATION TABLE 7 Acute Aortic Diseases: Type B Aortic Dissection

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with complicated acute type B aortic dissection and suitable anatomy, TEVAR is recommended.	I	B	249-253
In patients with acute complicated type B aortic dissection with unsuitable anatomy for TEVAR, FET repair should be considered.	IIa	B	254, 255
In acute type B aortic dissection with high-risk features, TEVAR should be considered in the subacute phase.	IIa	C	-
In patients with acute type B aortic dissection without high-risk features, optimal medical therapy, close monitoring and follow-up is recommended for emerging high-risk features.	I	B	256, 257

[a]Class of recommendation; [b]Level of evidence; [c]References. FET, frozen elephant trunk; TEVAR, thoracic endovascular aortic repair.

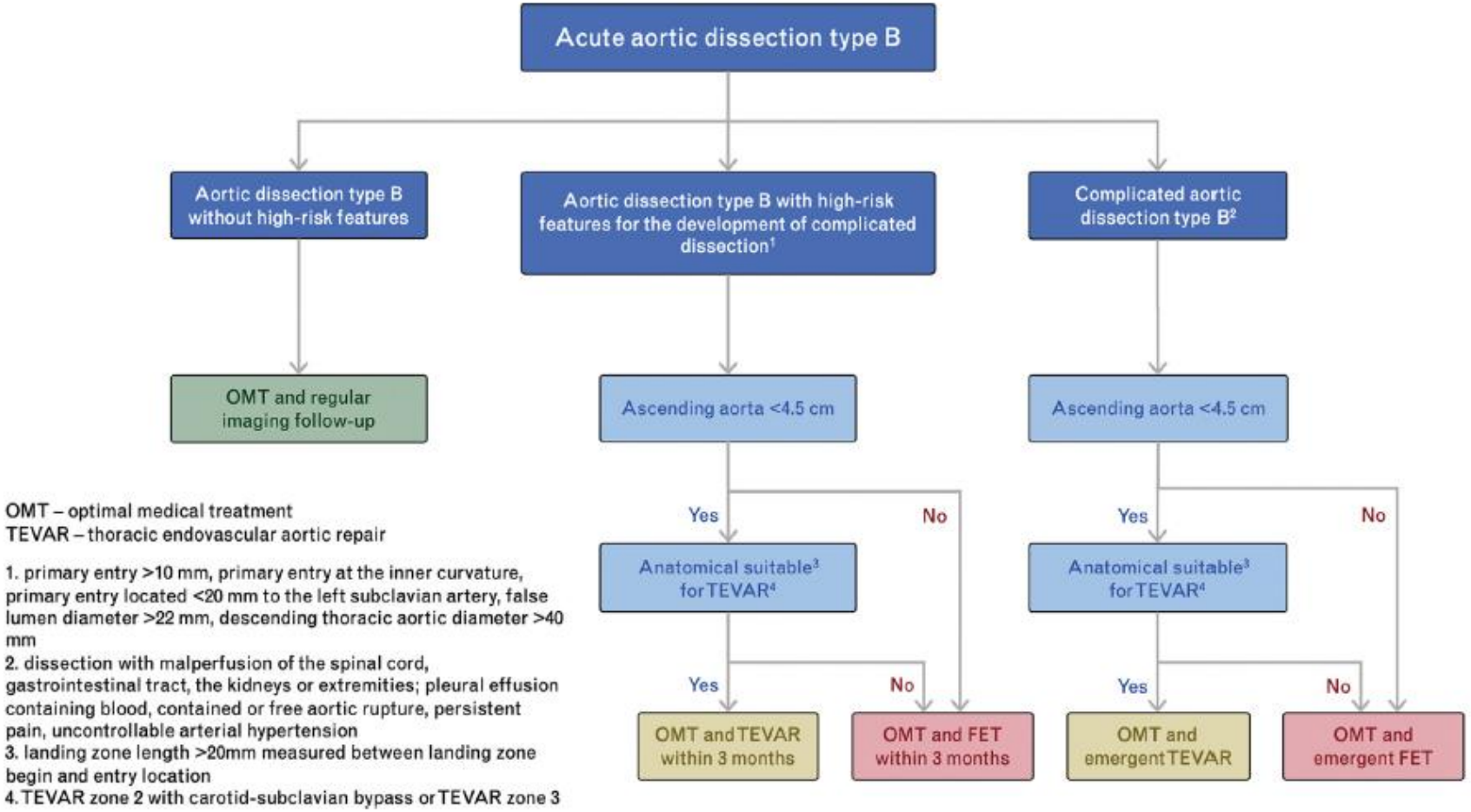
Acute non-A non-B Aortic dissection



1. dissection with malperfusion of the spinal cord, gastrointestinal tract, the kidneys or extremities; pleural effusion containing blood, contained and free aortic rupture, persistent pain, uncontrollable arterial hypertension
2. within 48 hours
3. landing zone length >20mm measured between landing zone begin and entry location
4. TEVAR zone 2 with carotid-subclavian bypass or TEVAR zone 3

FIGURE 12 Treatment strategy for non-A non-B aortic dissection. (E0, no entry visible; E2, arch entry; E3, descending entry; FET, frozen elephant trunk; LSA, left subclavian artery; OMT, optimal medical therapy; TEM, type, entry, malperfusion; TEVAR, thoracic endovascular aortic repair.)

Acute Type B Aortic dissection



OMT – optimal medical treatment
TEVAR – thoracic endovascular aortic repair

1. primary entry >10 mm, primary entry at the inner curvature, primary entry located <20 mm to the left subclavian artery, false lumen diameter >22 mm, descending thoracic aortic diameter >40 mm
2. dissection with malperfusion of the spinal cord, gastrointestinal tract, the kidneys or extremities; pleural effusion containing blood, contained or free aortic rupture, persistent pain, uncontrollable arterial hypertension
3. landing zone length >20mm measured between landing zone begin and entry location
4. TEVAR zone 2 with carotid-subclavian bypass or TEVAR zone 3

FIGURE 13 Treatment strategy for type B aortic dissection. (FET, frozen elephant trunk; LSA, left subclavian artery; TEM, type, entry, malperfusion.)

High risk features for late complications

TABLE 3 High-Risk Features in Acute Type B Aortic Dissection

Morphologic Criteria
Primary entry >10 mm[261,264]
Primary entry at the inner curvature[264]
Primary entry located <20 mm in relation to the left subclavian artery[261]
False lumen diameter >22 mm[264,265]
Descending thoracic aortic diameter >40 mm[261,264]
High systolic antegrade flow volume in the false lumen with significant diastolic retrograde flow assessed by MRI[263]
Clinical Criteria
Persistent pain[266,267]
Uncontrollable HTA[266,267]

HTA, hypertension arterialis; MRI, magnetic resonance imaging.

Acute IMH

RECOMMENDATION TABLE 8 Acute Aortic Diseases: Type A Intramural Hematoma

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with acute type A IMH with complications or high-risk features, emergency surgery is recommended.	I	B	283, 287-290
Optimal medical therapies and serial imaging may be considered in patients with type A IMH in the absence of high-risk features.	IIb	C	-
In selected patients with acute type A IMH without high-risk features but a tear in the descending aorta, TEVAR may be considered in addition to OMT in specialized centers.	IIb	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References. IMH, intramural hematoma; OMT, optimal medical therapies; TEVAR, thoracic endovascular aortic repair.

RECOMMENDATION TABLE 9 Acute Aortic Diseases: Type B Intramural Hematoma

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with acute complicated type B IMH, urgent aortic repair is recommended.	I	B	305
In patients with acute type B IMH with high-risk features, TEVAR should be considered if the patient is anatomically suitable.	IIa	C	-

TABLE 4 High-Risk Features in Intramural Hematomas

Age >70 years[293,294]
Initial aortic diameter >45 mm[293,295]
Mean aortic diameter growth rate ≥5 mm/year[296]
Wall thickness of involved segment ≥10 mm[297]
Pleural effusion based on Hounsfield units[298,299]
Presence of aortic ulcer or ulcer-like projection[294,300]

Penetrating Atherosclerotic Ulcer

RECOMMENDATION TABLE 10 Acute Aortic Diseases: Penetrating Atherosclerotic Ulcer

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with PAUs in the ascending aorta and the presence of IMH or rupture, urgent aortic repair is recommended.	I	B	289
In patients with high-risk PAUs located in the distal arch or descending aorta, TEVAR should be considered if anatomically suitable.	IIa	B	310
In patients with high-risk PAUs located in the distal arch or descending aorta unsuitable for TEVAR, open surgical repair should be considered after careful evaluation of operative risk.	IIa	B	311

[a]Class of recommendation; [b]Level of evidence; [c]References. IMH, intramural hematoma; PAU, penetrating aortic ulceration; TEVAR, thoracic endovascular aortic repair.

TABLE 5 High-Risk Features in a Penetrating Atherosclerotic Ulcer

Morphologic Criteria
Pleural effusion based on Hounsfield units[313,314]
Prescence of IMH[313,314]
Large initial PAU depth (>10 mm) and diameter (>20 mm) or high growth rate size[313]
Clinical Criteria
Persistent pain despite medical treatment[313,315-317]

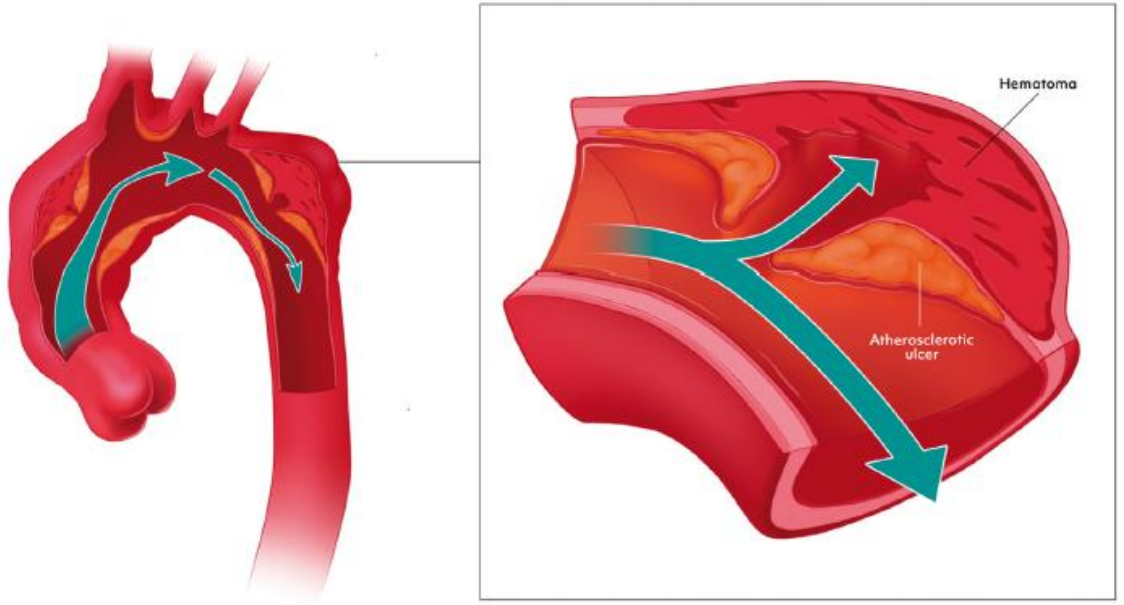


FIGURE 14 Penetrating atherosclerotic ulcer.

Blunt traumatic Aortic injury

RECOMMENDATION TABLE 11 Acute Aortic Diseases: Blunt Traumatic Aortic Injury

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with BTAI grade I, nonoperative management, including close follow-up imaging, is recommended.	I	C	-
In patients with BTAI grade II and high-risk imaging features, TEVAR should be considered.	IIa	C	-
In patients with BTAI grade II without high-risk imaging features, nonoperative management and close follow-up imaging may be considered.	IIb	C	-
In patients with BTAI grades III-IV and suitable anatomy, TEVAR is recommended.	I	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References. BTAI, blunt thoracic aortic injury; TEVAR, thoracic endovascular aortic repair.

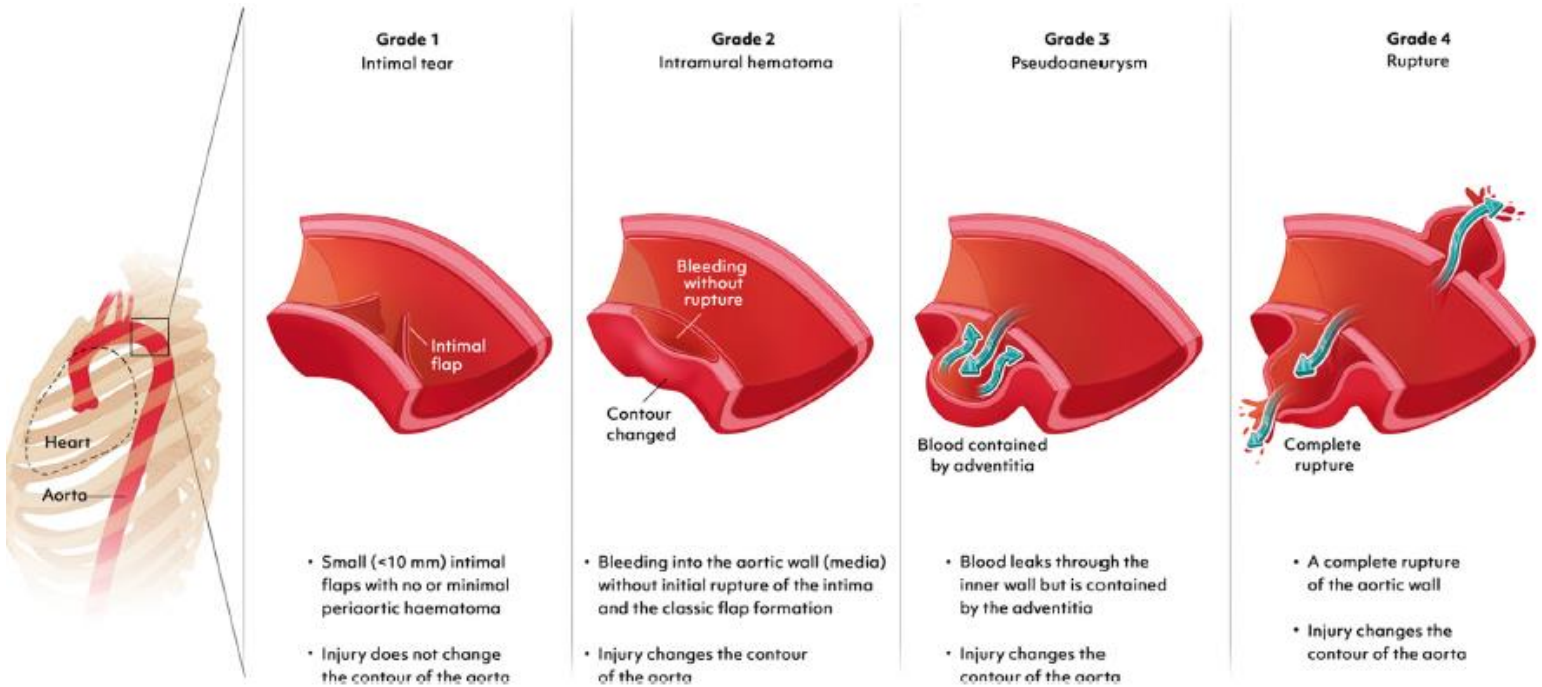


FIGURE 15 Classification of blunt traumatic aortic injury.

Aortic arch disease

RECOMMENDATION TABLE 14 Chronic Aortic Diseases: Aortic Arch

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with symptomatic aortic arch pathologies, aortic arch repair is recommended irrespective of diameter.	I	C	-
In patients with asymptomatic isolated aortic arch aneurysms ≥55 mm, aortic repair should be considered.	IIa	B	97
In patients with arch pathologies and diseased aortic segments distal to zone 2, FET repair should be considered.	IIa	B	311, 356-358
In patients with an indication for aortic repair unsuitable for open surgery, hybrid or endovascular aortic repair may be considered.	IIb	C	-
Hybrid or endovascular aortic repair is recommended to be performed in experienced centers with an adequate volume of both open and endovascular aortic repairs.	I	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References. FET, frozen elephant trunk.

RECOMMENDATION TABLE 15 Chronic Aortic Diseases: Chronic Aortic Dissection

Recommendations	Class[a]	Level[b]	Ref[c]
Intervention is recommended in patients with chronic aortic dissection at a maximum aortic diameter of ≥55 mm without involvement of the ascending aorta.	I	B	362, 363
In patients with HTAD with chronic aortic dissection, intervention at diameters <55 mm should be considered if the multidisciplinary aortic team makes the decision depending on the genotype, growth rate, family history and other individual patient risk factors.	IIa	C	-
In patients with dSINE, treatment is recommended to prevent diameter progression.	I	C	-
Intervention at >50 mm should be considered in patients with chronic aortic dissection if the treatment includes a multistep procedure, such as arch replacement with FET followed by TEVAR.	IIa	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References. dSINE, distal stent graft-induced new entry; FET, frozen elephant trunk; HTAD, heritable thoracic aortic disease; TEVAR, thoracic endovascular aortic repair.

Aortic arch disease

RECOMMENDATION TABLE 23 Ascending Aorta With or Without Proximal Arch

Recommendations	Class[a]	Level[b]	Ref[c]
In ascending aortic surgery, supracommissural isolated ascending aorta replacement is recommended in patients without adjunct aortic root and aortic arch dilatation.	I	B	571, 572, 574
It is recommended that in any open proximal thoracic aortic operation, ascending/hemiarch replacement has to be extensive, and short ascending grafts should be avoided to prevent disease progression and to anticipate a future endovascular modular distal extension.	I	C	-
In ascending aortic surgery with a diameter larger than 45 mm of the proximal aortic arch, hemiarch or more extensive aortic arch replacement may be considered.	IIb	B	575

RECOMMENDATION TABLE 24 Therapeutic Options: Aortic Arch

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with an intended one-stage aortic arch treatment, the FET technique should be considered.	IIa	B	576-581
Aortic arch replacement, including the creation of a sufficient landing zone, is recommended in the treatment of multisegmental aneurysms of the thoracic aorta in order to facilitate the further downstream repair.	I	C	-
When performing the frozen and conventional elephant trunk techniques, a distal anastomosis in arch zone 2 should be considered.	IIa	C	-
In the case of an elephant trunk implant, the polyester trunk component should be considered to be accessible in zone 4.	IIa	C	-
Hybrid procedures may be considered for aortic arch repair.	IIb	C	-
In any TEVAR involving zone 2, left subclavian artery revascularization is recommended to reduce the risk of neurologic complications such as stroke and spinal cord ischemia.	I	B	582-584

[a]Class of recommendation; [b]Level of evidence; [c]References. FET, frozen elephant trunk; TEVAR, thoracic endovascular aortic repair.

Endovascular Total Aortic arch repair

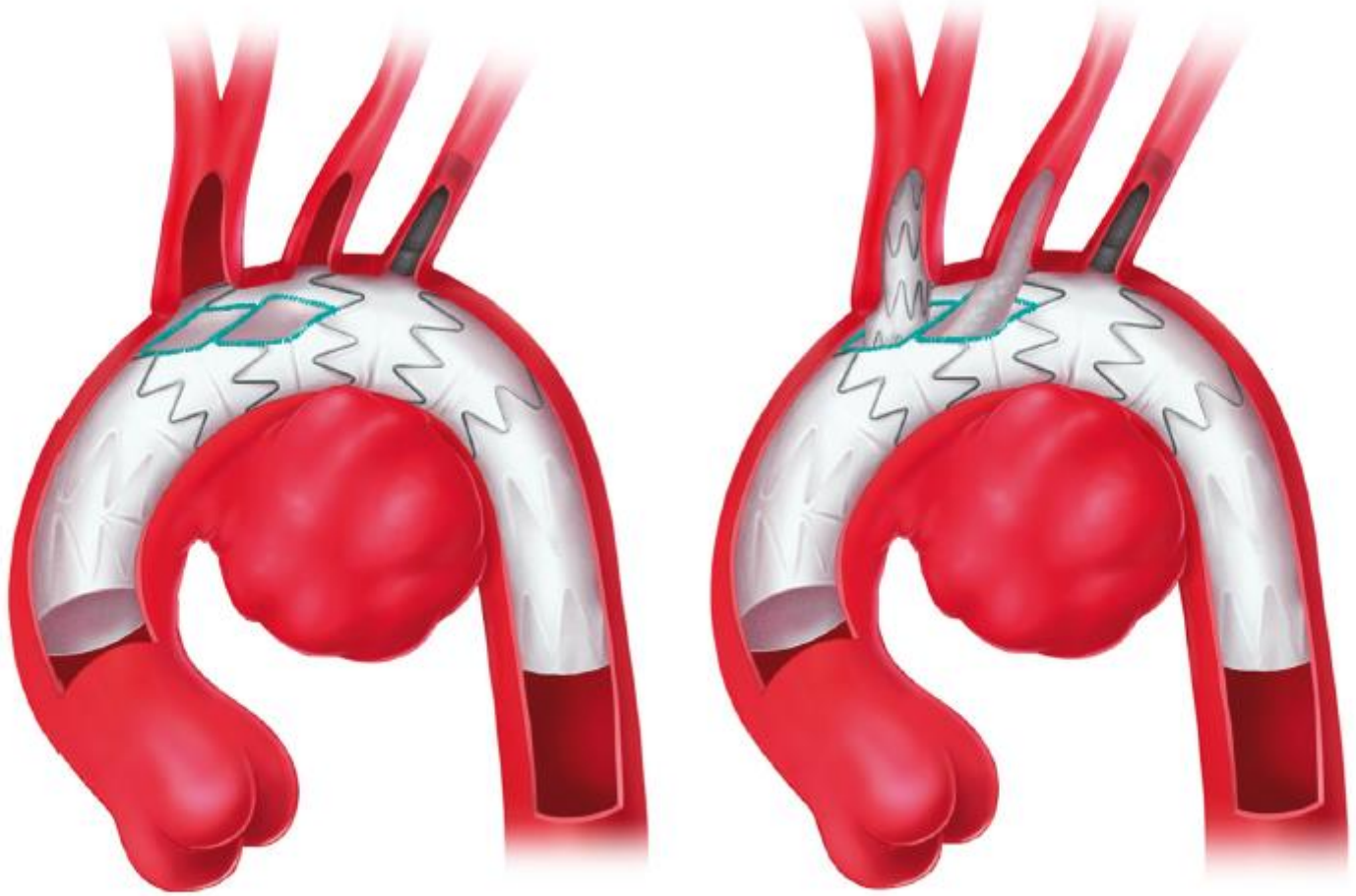


FIGURE 25 Branched endovascular total aortic arch repair.

Descending Thoracic Aorta

RECOMMENDATION TABLE 25 Therapeutic Options: Descending Aorta

Recommendations	Class[a]	Level[b]	Ref[c]
In patients undergoing endovascular aortic repair with suitable femoral artery anatomy, ultrasound-guided percutaneous access is recommended.	I	B	600
TEVAR is recommended as the first-choice therapy for acute complicated descending aortic syndromes.	I	B	601, 602
If LSA-to-LCCA bypass/transposition or double transposition cannot create a sufficient proximal landing zone, the FET technique should be considered.	IIa	C	-
If concomitant valvular or coronary disease requiring treatment is present together with acute and chronic thoracic aortic pathology involving the aortic arch, the FET technique should be considered.	IIa	B	247, 254
Stent-graft oversizing in degenerative/atherosclerotic aneurysms or PAUs should be considered <15-20% of the proximal and distal landing zone diameters.	I	C	-
Stent-graft oversizing in acute aortic dissection/IMH should be considered <10% of the proximal landing zone diameter.	I	C	-
It should be considered that the landing zone diameter should not exceed 38 mm in diameter.	IIa	B	603
It should be considered that the proximal landing zone length be at least 25 mm.	IIa	C	-
It should be considered that the distal landing zone length be at least 25 mm.	IIa	C	-
In TEVAR for type B aortic dissection, distal tapering for the prevention of dSINE should be considered according to the TL diameter.	IIa	C	-
The PETTICOAT technique should be considered in acute aortic dissections as a distal adjunct to TEVAR in case adequate true lumen decompression cannot be established by TEVAR alone.	IIa	B	604-606
The STABILISE technique may be considered in particular scenarios but preferably under controlled study conditions.	IIb	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References. dSINE, distal stent graft-induced new entry; FET, frozen elephant trunk; IMH, intramular hematoma; LCCA, left common carotid artery; LSA, left subclavian artery; PAU, penetrating atherosclerotic ulcer; PETTICOAT, Provisional Extension To Induce Complete Attachment; STABILISE, Stent-Assisted Balloon-Induced Intimal Disruption and Relamination in Aortic Dissection Repair; TL, true lumen; TEVAR, thoracic endovascular aortic repair.

PETTICOAT/ STABILISE technique

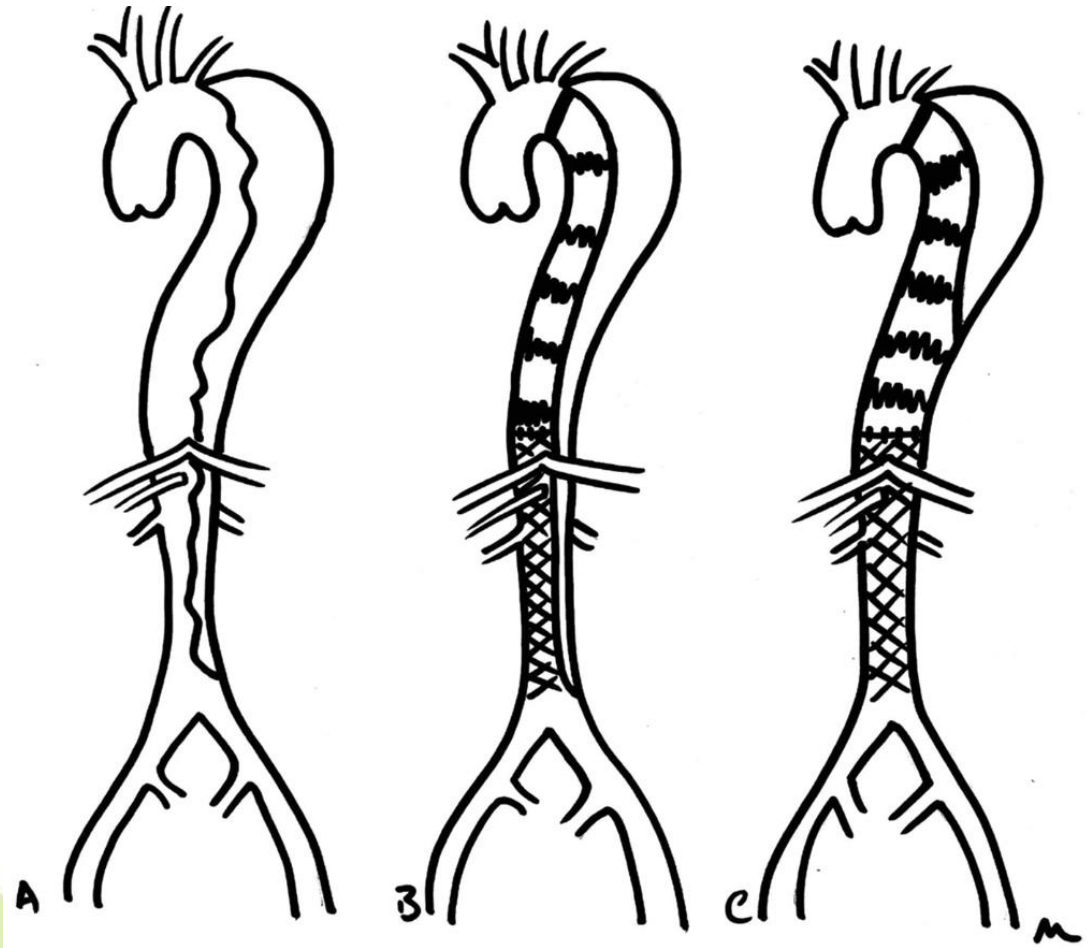


Figure 1 Schematic representation of the STABILISE technique. (A) Type B aortic dissection with compression of the true lumen (TL) by the false lumen (FL). (B) Residual flow in the false lumen after implantation of the proximal endoprosthesis and bare metal stent (PETTICOAT technique). (C) Intimal re-apposition after ballooning of the distal endoprosthesis and stent with obliteration of the false lumen (STABILISE technique).

Thoraco-abdominal Aortic Aneurysm

RECOMMENDATION TABLE 26 Therapeutic Options: Thoracoabdominal Aorta

Recommendations	Class[a]	Level[b]	Ref[c]
For patients with low-to-moderate perioperative risk, open repair as well as endovascular treatment of pararenal and TAAA should be considered.	IIa	C	-
For patients unfit for open repair, a B/FEVAR procedure should be considered the first-line treatment.	IIa	B	631, 632
A hybrid approach may be considered for patients unfit for open repair and anatomically unsuitable for a B/FEVAR procedure.	IIb	C	-
A "distal-shifting" strategy may be considered in any TAAA to reduce left lung manipulation to a minimum.	IIb	C	-
For patients at high risk for SCI undergoing endovascular treatment of type I, II, III or V thoracoabdominal aortic aneurysms, a staged TEVAR–B/FEVAR approach should be considered.	IIa	C	-
In open TAAA repair, proximal clamping before the full establishment of CPB to avoid retrograde embolization of parietal thrombi should be considered.	IIa	C	-
In patients undergoing open descending or thoracoabdominal aorta repair, cryoablation of multiple intercostal spaces (temporary nerve blockage) may be considered for pain control as an adjuvant strategy.	IIb	C	-
Left heart bypass or partial femoral–femoral bypass for open thoracoabdominal aorta repair should be considered based on surgical and institutional experience.	IIa	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References. B/FEVAR, branched and/or fenestrated endovascular aortic repair; CPB, cardiopulmonary bypass; SCI, spinal cord injury; TAAA, thoracoabdominal aortic aneurysm; TEVAR, thoracic endovascular aortic repair.

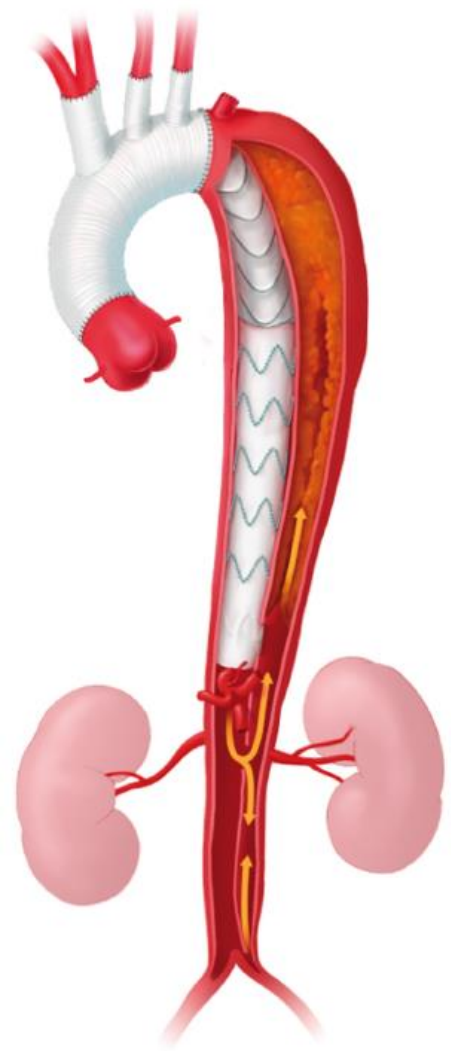


FIGURE 27 Frozen elephant trunk implant followed by distal thoracic endovascular aortic repair extension for distal shifting.

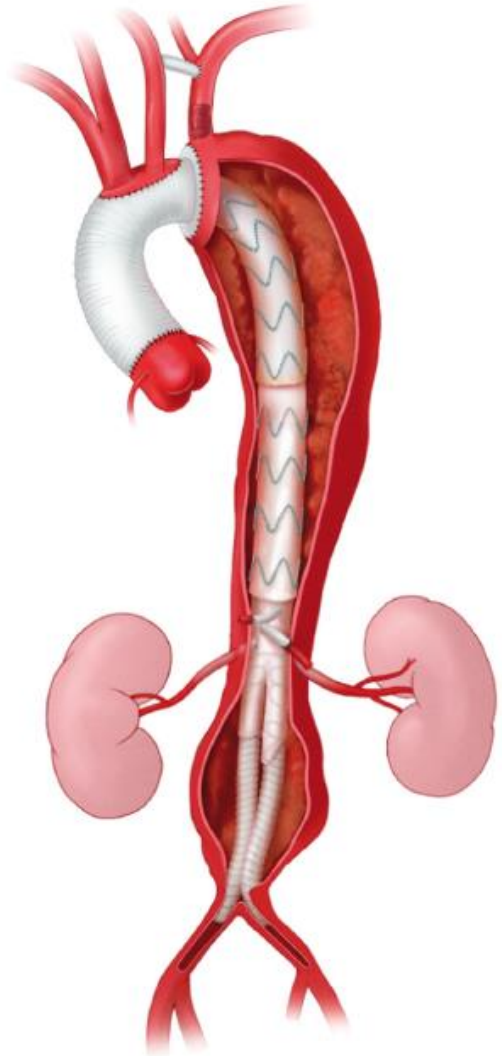


FIGURE 31 Complete endovascular treatment of the descending thoracic and abdominal aorta.

Infrarenal aortic aneurysm

RECOMMENDATION TABLE 27 Therapeutic Options: Infrarenal Aorta

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with complicated PAU, dissection or intramural hematoma and in patients with mycotic aneurysm and pseudoaneurysm in the abdominal aorta, repair is recommended.	I	C	-
In patients with complicated PAU, dissection intramural hematoma, or pseudoaneurysm with suitable anatomy of the abdominal aorta, endovascular repair should be considered as the first option.	IIa	C	-
In patients with intact AAA with suitable anatomy for either open or EVAR, a shared decision-making process for each approach, including life expectancy, is recommended.	I	C	-
In patients with long life expectancy, open AAA repair should be considered the preferred treatment modality.	IIa	B	651-654
In patients with suitable anatomy and reasonable life expectancy, endovascular AAA repair should be considered the preferred treatment modality.	IIa	B	651-654
In patients with ruptured AAA undergoing endovascular treatment, a bifurcated device should be considered as preferable over an aorta-uni-iliac device if anatomically suitable.	IIa	C	-
Tubular EVAR without an iliac bifurcation stent graft implant is not recommended.	III	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References. AAA, abdominal aortic aneurysm; EVAR, endovascular aortic repair; PAU, penetrating aortic ulcer.

Postoperative management

RECOMMENDATION TABLE 35 Intensive Care Unit Postoperative Management of Patients Undergoing Aortic Surgery

Recommendations	Class[a]	Level[b]	Ref[c]
The enhanced recovery after surgery concept is recommended in stable patients undergoing aortic repair.	I	C	-
Normothermia is recommended in the early postoperative phase.	I	C	-
The femoral artery should be considered as preferred for arterial pressure monitoring postoperatively.	IIa	C	-

RECOMMENDATION TABLE 35 Continued

Recommendations	Class[a]	Level[b]	Ref[c]
Close monitoring of lactate levels as a surrogate for postoperative malperfusion is recommended.	I	C	-
Point-of-care monitoring, in addition to regular laboratory coagulation parameters, should be considered in the early postoperative phase after open aortic repair.	IIa	B	921, 922
Rescue protocols for postoperative SCI after aortic arch surgery procedures that include CSF drainage and blood pressure elevation are recommended.	I	C	-
Immediate CSF drainage in patients with new onset of paraplegia after TEVAR or open TAAA replacement is recommended.	I	C	-
For patients with ILT after FET procedures, therapeutic anticoagulation is recommended.	I	C	-
Early TEVAR extension may be considered in patients with ILT after a FET implant.	IIb	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References. CSF, cerebrospinal fluid; FET, frozen elephant trunk; ILT, intraluminal thrombi; SCI, spinal cord injury; TAAA, thoracoabdominal aortic aneurysm; TEVAR, thoracic endovascular aortic repair.

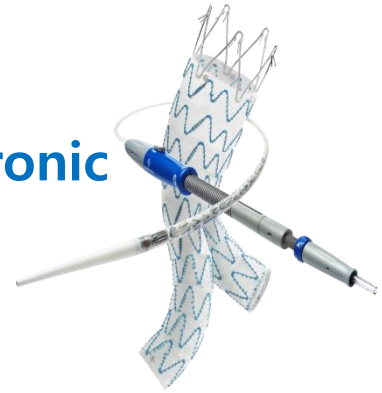
Indications of Endovascular aortic repair

- Acute Aortic Syndrome
  - Acute Complicated Type B Aortic Dissection
  - High risk Uncomplicated type B Aortic dissection (Subacute phase)
  - High risk Penetrating Aortic Ulcer or Intramural Hematoma
  - Blunt Traumatic Aortic Injury
- Aortic Aneurysm (Arch, Descending thoracic aorta)
- Thoraco-abdominal Aortic Aneurysm
- Abdominal Aortic aneurysm

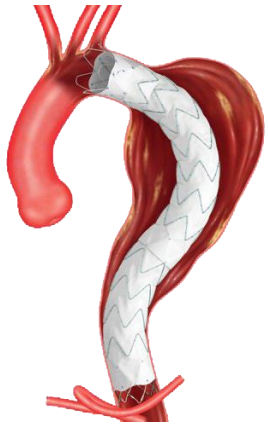
Stent Grafts available in Korea, 2025

Medtronic

Valiant™



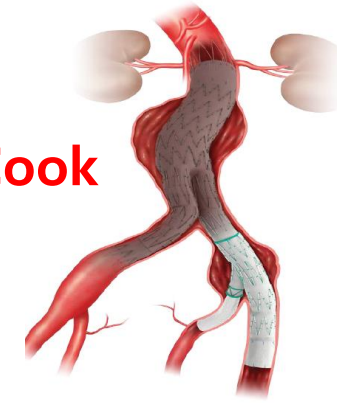
Endurant IIs™



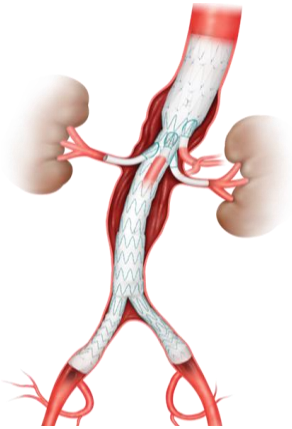
Zenith TX2™

Cook

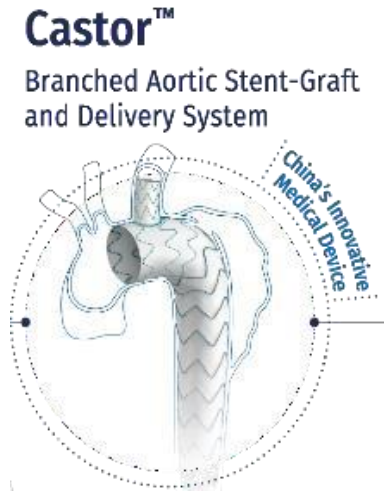
Flex™



IBD™



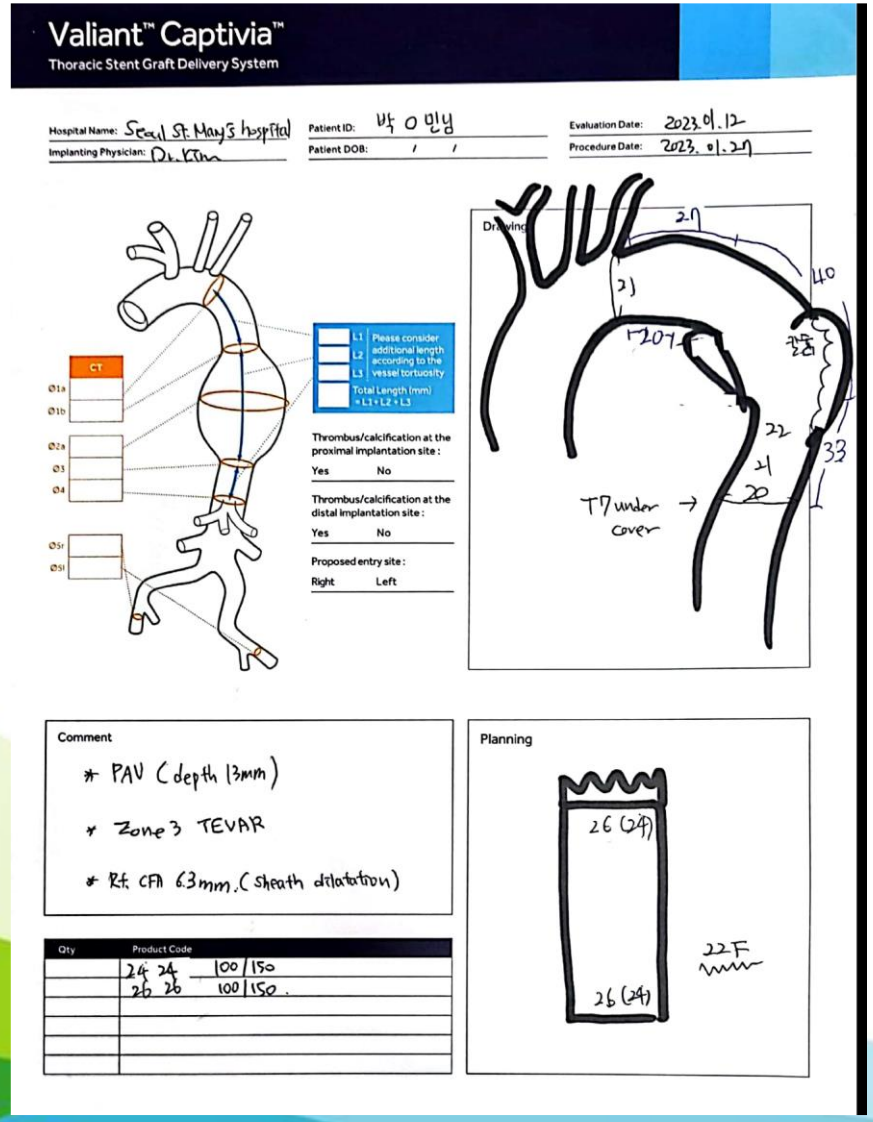
T-branch



Stent Grafts available in Korea, 2025

Category	Company	Product	Key Features
TEVAR	Medtronic	Valiant Captivia™	Widely adopted standard device with over a decade of global experience
	Cook Medical	Zenith TX2™	Proven long-term durability Low profile system
	S&G Biotech	SEAL Thoracic	Low-profile (15,18,21 Fr) system; optimized for small and tortuous acces s custom-made option available
EVAR	Medtronic	Endurant II / IIs™	One of the most widely used EVAR systems globally; suitable for short neck and challenging access anatomies
	Cook Medical	Zenith Flex™ Branch™	Reliable long-term outcomes; Offer Iliac branch device system
	Endovastec™	Minos™	14 Fr ultra-low profile delivery; modular design; suitable for narrow or tortuous iliac access
	S&G Biotech	SEAL NOVUS	Domestic low-profile EVAR with custom-made capability
Branched / Co mplex	Cook Medical	T-Branch™	Off-the-shelf 4-branch stent graft for TAAA; recently introduced in Korea ; enables endovascular repair in extensive Aortic disease
	Endovastec™	Castor™	Unibody single-branch TEVAR designed for LSA preservation; practical so lution for Zone 2 deployment

Basic Techniques of TEVAR


Valiant™ Captivia™
Thoracic Stent Graft Delivery System

Hospital Name: Seoul St. Mary's hospital
Implanting Physician: Dr. Kim
Patient ID: 박 O 민성
Patient DOB: / /
Evaluation Date: 2023.01.12
Procedure Date: 2023. 01. 29

CT
Ø1a
Ø1b
Ø2a
Ø3
Ø4
Ø5r
Ø5l

L1 Please consider additional length according to the vessel tortuosity
L2
L3
Total Length (mm) = L1+L2+L3

Thrombus/calcification at the proximal implantation site : Yes No
Thrombus/calcification at the distal implantation site : Yes No
Proposed entry site : Right Left

Drawing
21
40
21
T20
22
33
T7 under cover
20

Comment
* PAU (depth 13mm)
* Zone 3 TEVAR
* Rt. CFA 6.3mm. (sheath dilatation)

Planning
26 (24)
22F
26 (24)

Qty	Product Code	
24 24		100 / 150
26 26		100 / 150

Graft sizing

- Aneurysm : 15~25% oversizing
- **Dissection** : 0~10% oversizing

TEVAR Grafts available Sizes

TABLE 2. CURRENTLY AVAILABLE, FDA-APPROVED STENT GRAFTS FOR TREATMENT OF THORACIC AORTIC PATHOLOGY			
Product Name (Manufacturer)	Available Graft Sizes (mm)	Proximal Neck Diameter (mm)	Sheath/Introduction System Diameter (F)
TAG conformable thoracic endoprosthesis (Gore & Associates)	21–45	16–42	18–24 (inner diameter; sheath required)
The RelayPlus system (Bolton Medical, Inc.)	22–46	19–42	22–26 (outer diameter)
Valiant thoracic stent graft (Medtronic)	22–46	18–42	22–25 (outer diameter)
Zenith Alpha thoracic device (Cook Medical)	24–46	20–42	16–20 (inner diameter)
Abbreviations: FDA, US Food and Drug Administration.			

Anatomic Considerations

- Aortic Arch
  - Arch size(<40mm), Angulation(<60°), Healthy landing zone (>2.5cm)
- Access vessels
  - The femoral and iliac A. should be carefully assessed Small diameter (<7mm) or Heavy calcification
  - Alternative approaches; Iliac conduit, Axillary artery
- Head vessels
  - Carotid artery and Circle of willis condition, especially in Zone 0~2 TEVAR
- Intercostal Arteries and iliac arteries, especially Long segment coverage

Preparations…

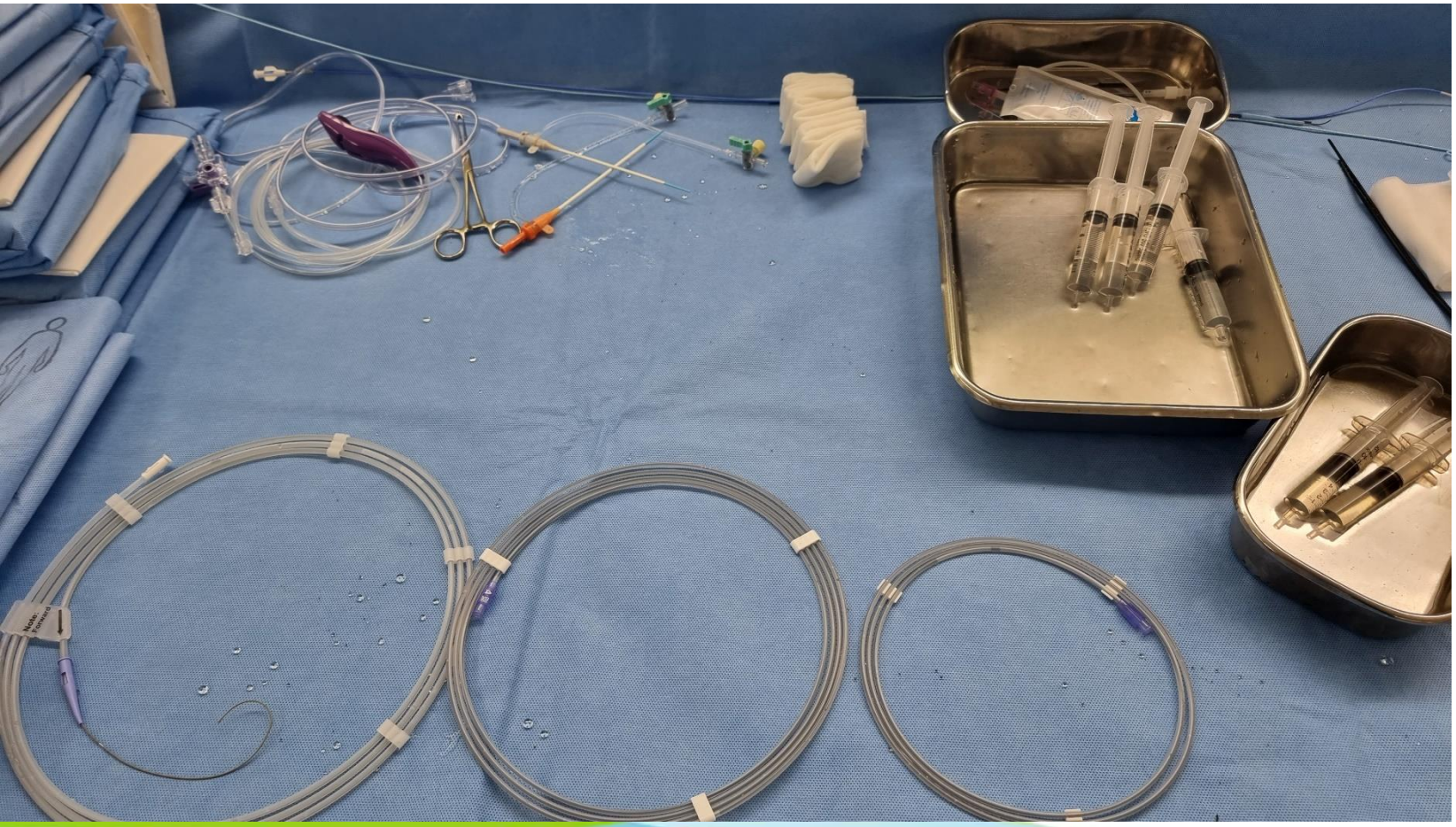
- Angiography-room(fluoroscopy), hybrid OR, Angio C-arm
- Injector (hand injection X)
- Wires, catheters, sheaths…
- Main device
- Heparin injection(ACT >300sec, 100unit/kg)

Hybrid OR

Anethesia & Vascular access

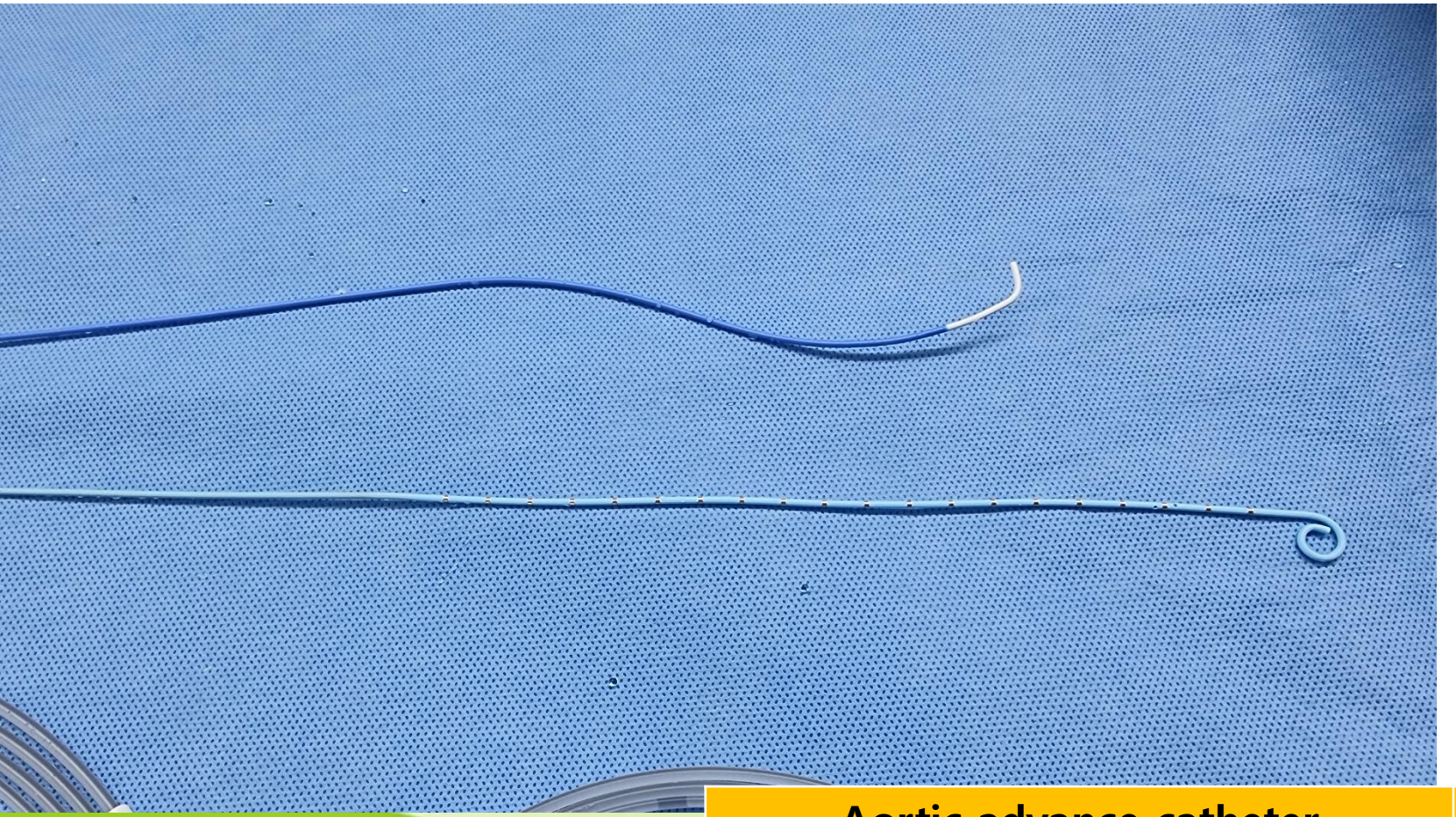
- General or local anesthesia
- Percutaneous using closing device
- Open vascular access (femoral artey, calcified vessels…)

Wires and sheaths…



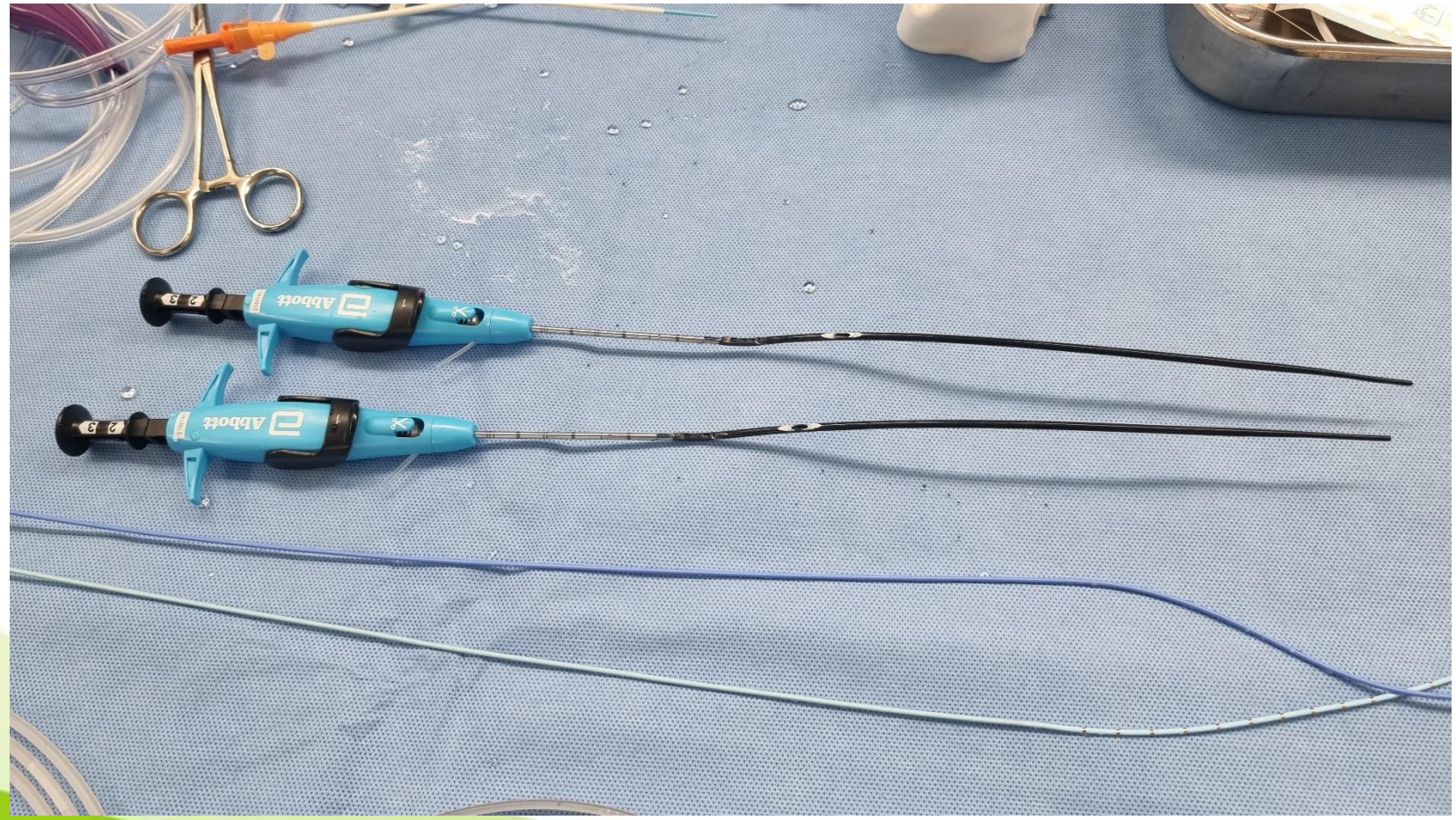
Lunderquist Wire Guides 201Cm이상 (William Cook Europe)	0.35''*260 Cm	1	EA
Micropuncture Push-Plus Introducer Set Nitinol 4.0Fr*10Cm MPIS-401-NT-SST (Cook Medical)	Nitinol 4.0Fr*10C m	1	EA
Performa Catheter All Size (Merit Medical)	JR*4.0*5F r	1	EA
Radifocus Guide Wire 200Cm미만 (Terumo)	035*150*3 *A	1	EA
Radifocus Guide Wire 200Cm이상 (Terumo)	035*260*3 *A	1	EA
Radifocus Introducer II All Size,4Fr~8Fr/7Cm,10Cm (Terumo Corporation)	5Fr, 10Cm, A type	1	EA
Radifocus Introducer II All Size,4Fr~8Fr/7Cm,10Cm (Terumo Corporation)	7Fr, 10Cm, A type	1	EA

Catheters…



Aortic advance catheter	David, Jerkin catheter
Angiographic catheter	Pigtail

Closing device



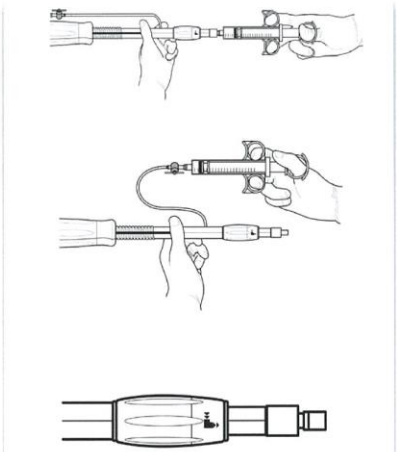
Hydrophilic coating activation and flushing

Captivia Delivery System Preparation

Flush the guidewire lumen with heparinized saline via the luer connector.

Flush the graft cover using a syringe with heparinized saline solution via the sideport.

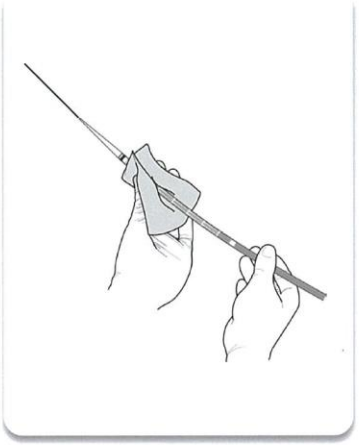
Verify that the tip capture release handle is in its locked position. In its locked position, the handle should be forward and ***not*** be able to rotate clockwise.



Caution: Do not grip the tip capture release handle during flushing of the delivery system as this may cause unlocking of the tip capture release handle.

Introducing and Positioning the Captivia Delivery System

During insertion of the delivery system, activate the hydrophilic coating by gently wiping the surface of the graft cover with saline saturated gauze



TEVAR procedure

- Both femoral artery access & wire Placement

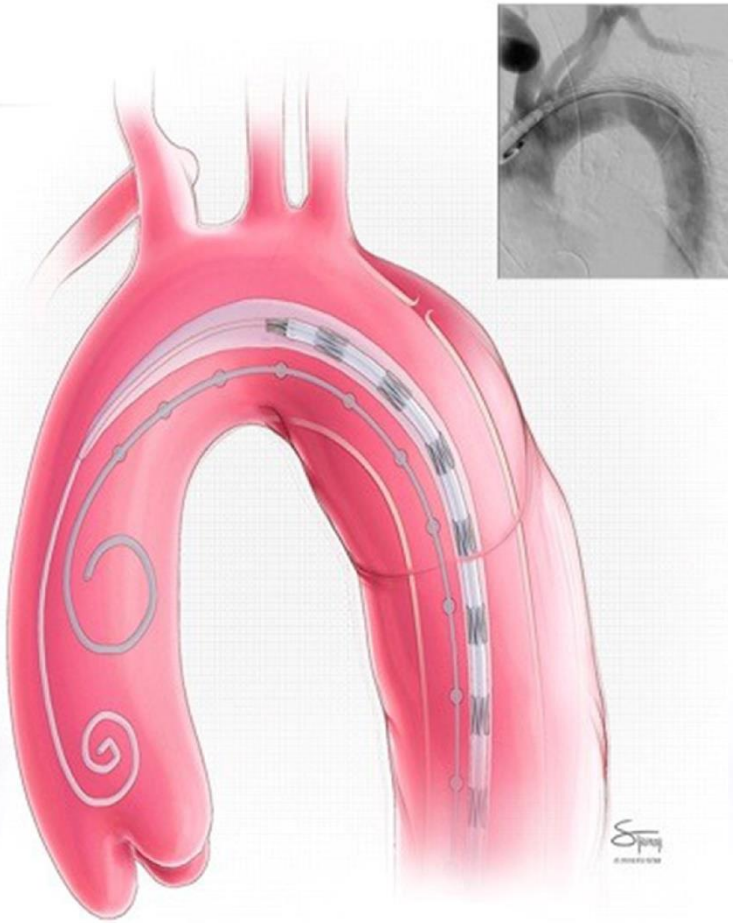
  ; One side → Pig tail , the other side → stiff wire for endograft advance

- Delivery of the Main Device and aortography
- Alignment of stent graft
- Device Deployment
- Completion Arteriography

Check Landing Zone precisely

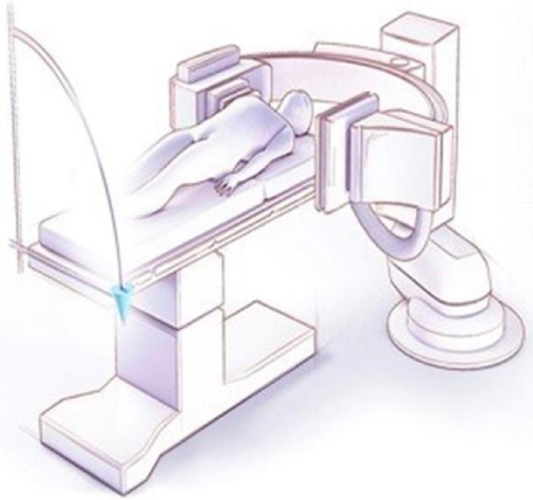
Proximal Landing Zone

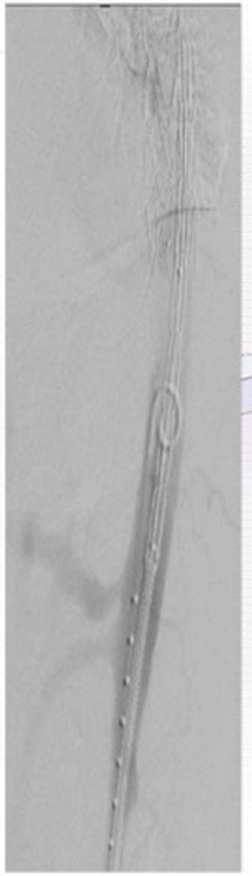
Position the image intensifier **LAO** for optimal imaging of aortic arch proximal landing zone

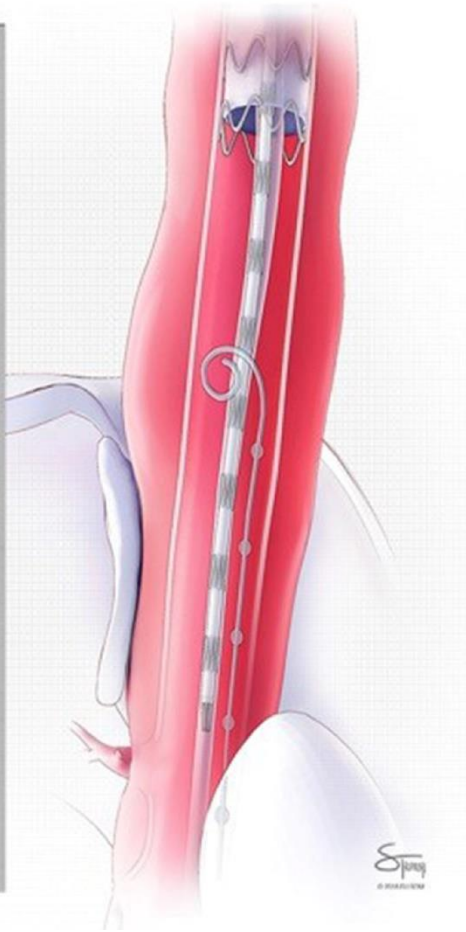


Distal Landing Zone

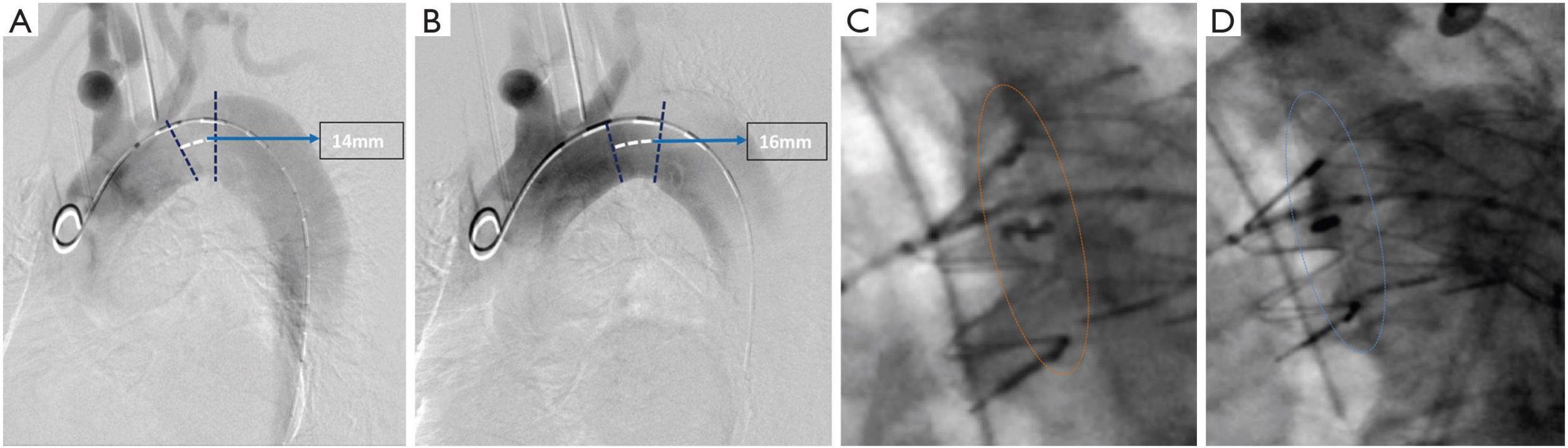
Position the image intensifier in **steep lateral** for optimal imaging of distal landing zone







Check Alignment of Stent Graft



Precise Deployement

Precise deployment

- Platinum-iridium Figur8 markers provide high visibility for accurate placement.
- Three-step deployment with tip capture release provides controlled deployment and precise placement in the thoracic aorta.

Step 1

Slow, controlled deployment for precise placement

Step 2

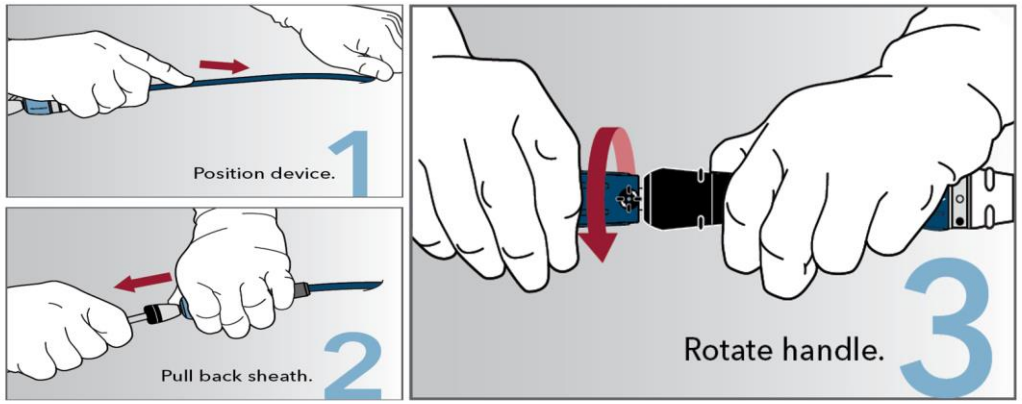
Quick deployment option, if desired

Step 3

Tip capture release

Medtronic Valiant
Rotation

2. Intuitive delivery system



COOK MEDICAL

Cook Zenith alpha
Pull back

Case Brief…

- 64 years old, Male
- C.C : Chest and back pain
- P.Hx : Prostate Cancer
- Diagnosis
  - ChemoTx. Induced HTN
  - Complicated Acute type B IMH

    (Persistent Pain, Refractory HTN although 2wks OMT)
- Plan : Zone 3 TEVAR

CT angiography (pre)

Case Video

Complications of Endovascular Aortic Repair

- Retrograde Type A Aortic dissection
- Spinal Cord Ischemia
- Stroke
- Renal failure
- Vascular access and device delivery injuries

- Endoleaks
- dSINE
- Migration
- Infection (Aorto-enteric, Aorto-pulmonary fistula)

Retrograde Type A Aortic dissection

Journal of the American Heart Association
Volume 6, Issue 9, September 2017
https://doi.org/10.1161/JAHA.116.004649

SYSTEMATIC REVIEW AND META-ANALYSIS

Retrograde Type A Aortic Dissection After Thoracic Endovascular Aortic Repair: A Systematic Review and Meta-Analysis

Yanqing Chen, MD†; Simeng Zhang, MD†; Lei Liu, MD†; Qingsheng Lu, MD; Tianyi Zhang, MD; Zaiping Jing, MD

- RTAD incidence was 2.5% and mortality was 37.1%
- Highest incidence in **Acute TBAD** post TEVAR (8.4% vs 3.0% in chronic)

Stent-graft oversizing in acute aortic dissection/IMH should be considered <10% of the proximal landing zone diameter.	I	C	-
It should be considered that the landing zone diameter should not exceed 38 mm in diameter.	IIa	B	603

Spinal Cord Ischemia (Paraplegia)

- *The most Devastating and Catastrophic complication*

- Prevention strategy
  - LSCA revascularization
  - Staged procedure in high risk pts
  - mABP > 90, sABP> 140
  - Pre-emptive CSF drainage

In any TEVAR involving zone 2, left subclavian artery revascularization is recommended to reduce the risk of neurologic complications such as stroke and spinal cord ischemia.	I	B	582-584

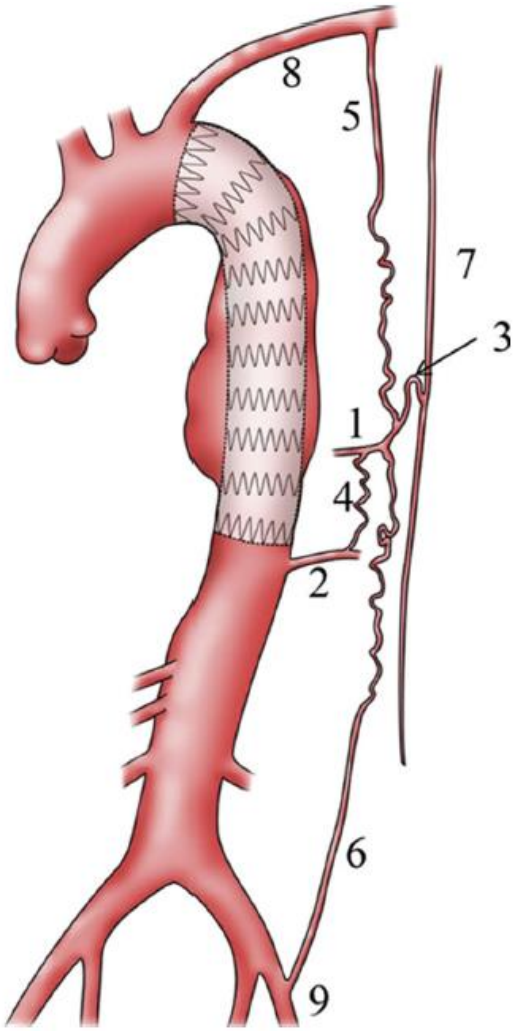
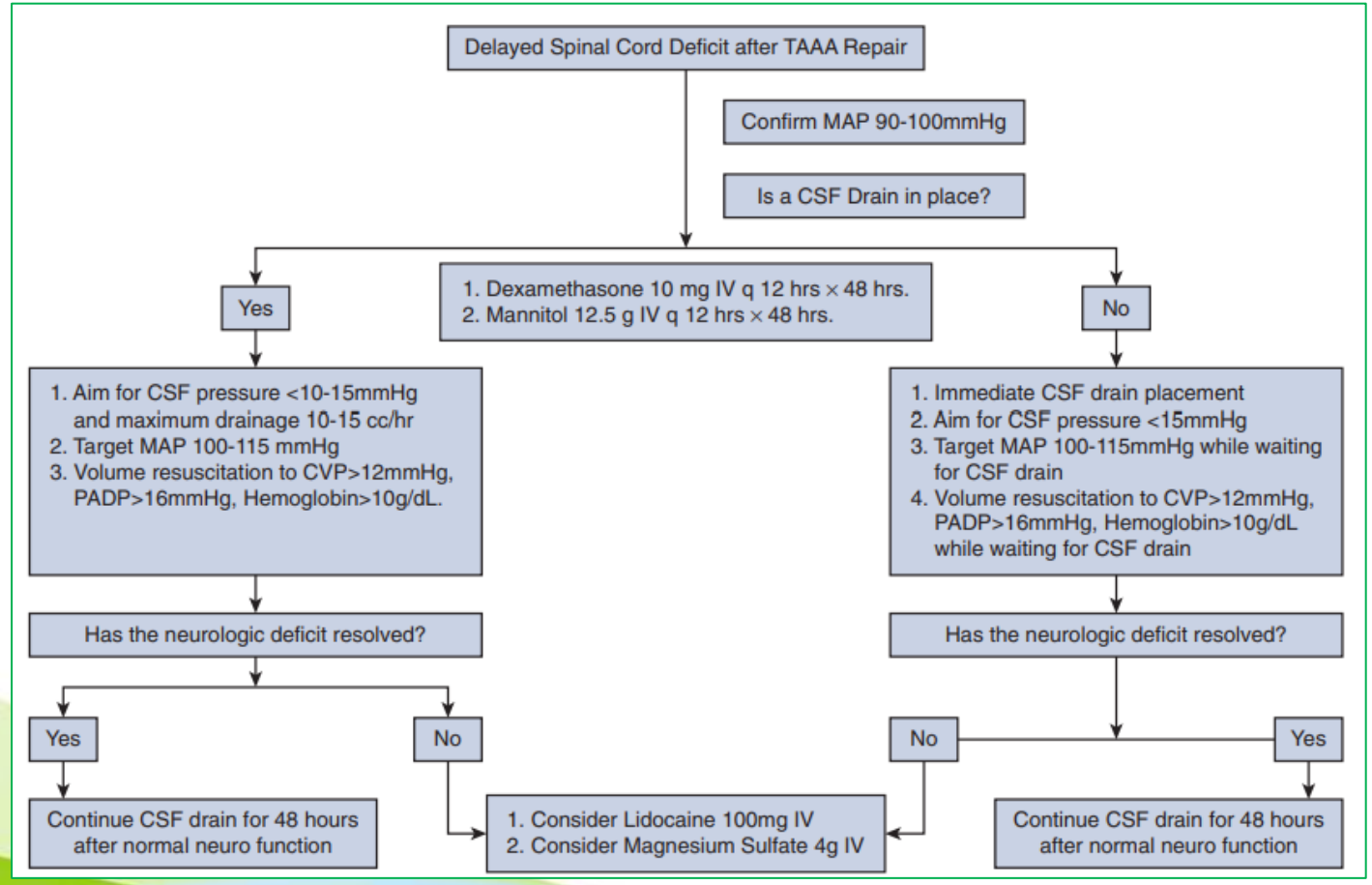


FIGURE 6. (1) A preoperatively detected segmental artery was occluded by a stent graph. Collateral supply to the (3) artery of Adamkiewicz and (7) anterior spinal artery: (2 and 4) intersegmental collateral, (5 and 8) branches of the left subclavian artery, and (6 and 9) deep circumflex iliac branch of left external iliac artery. Reproduced from Fukui and colleagues[166] with permission from European Society for Vascular Surgery.

Spinal Cord Ischemia (Paraplegia)

■Management algorithm



Chatterjee S, JTCVS, 2021

Stroke

Left Subclavian Arterial Coverage and Stroke During Thoracic Aortic Endografting: A Systematic Review

Waterford SD Ann Thorc Surg 2016; 101: 381-9.

Stephen D. Waterford, MD, MS, Daisy Chou, MD, René Bombien, MD, PhD, Isil Uzun, MD, Aamir Shah, MD, and Ali Khoynezhad, MD, PhD

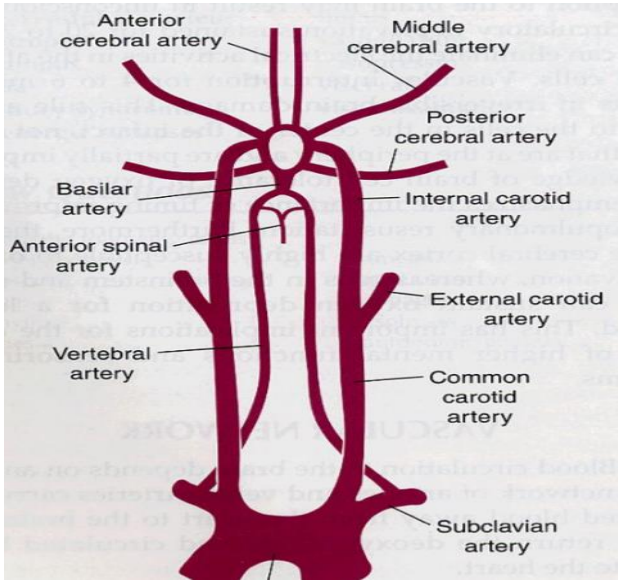
Department of Cardiovascular Surgery, Cedars-Sinai Medical Center, Los Angeles, California

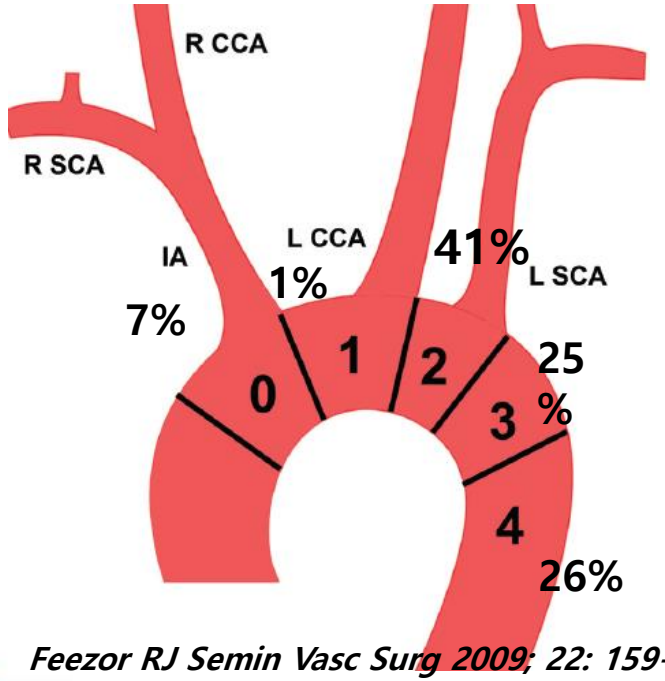
- Systematic review of 63 studies more than 3,000 patients
- Stroke rate (p=0.0657)
  - LSA coverage without revascularization 5.6% (46 of 824)
  - LSA coverage with revascularization 3.1% (13 of 413)

LSCA revascularization

- TEVAR require at least 2.5cm Landing zone
- About 40% required Zone 2 LSCA coverage
- Left subclavian Artery
  - Left upper extremity supply
  - **Posterior cerebral circulation (Vertebrobasilar system)**
    - **Via vertebral artery**
  - **Spinal circulation**
    - **Via vertebral to anterior spinal artery**
  - Coronary circulation in CABG pts
    - Left internal mammary artery

In any TEVAR involving zone 2, left subclavian artery revascularization is recommended to reduce the risk of neurologic complications such as stroke and spinal cord ischemia.	I	B	582-584





Feezor RJ Semin Vasc Surg 2009; 22: 159-164.

LSCA revascularization

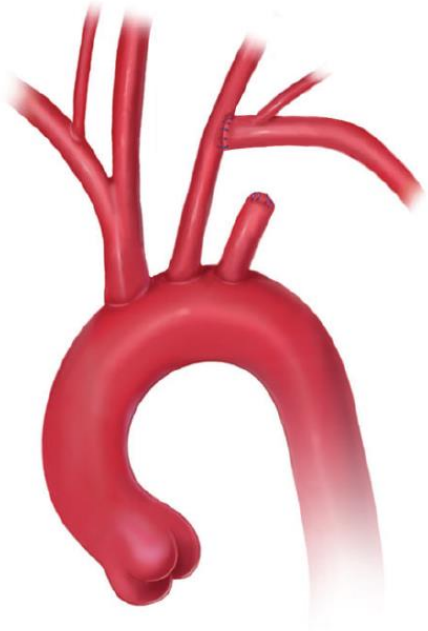
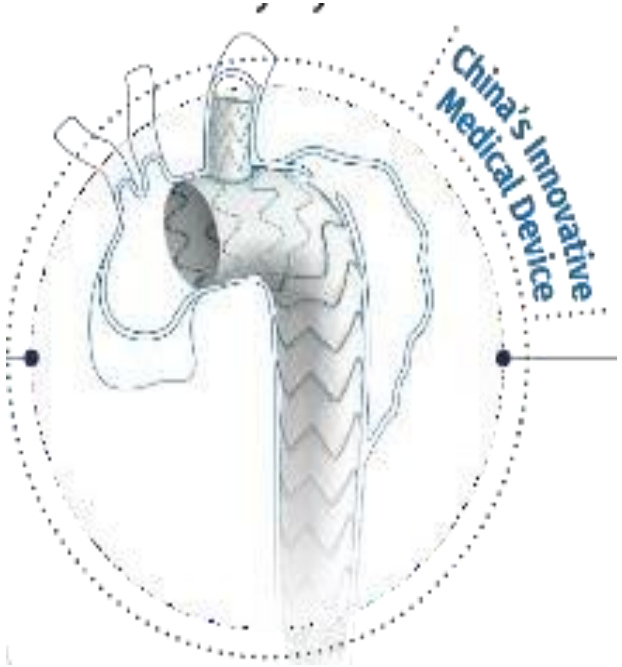


Figure 7: Subclavian-to-carotid transposition (printed with permission from © Emily McDougall Art).

Figure 8: Subclavian-to-carotid bypass and Amplatzer plug insertion in the proximal left subclavian artery (printed with permission from © Emily McDougall Art).

GORE® TAG® Thoracic Branch Endoprosthesis

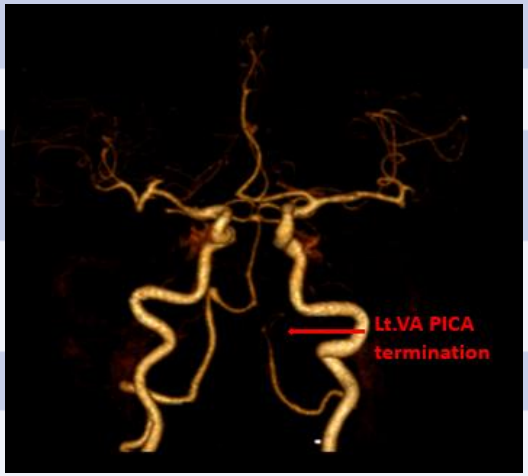


Endovastec Castor ®

LSCA revascularization

TABLE 2. Indications for left subclavian artery revascularization before zone 2 thoracic endovascular aortic repair

Society for Vascular Surgery Guidelines[179]	European Society for Vascular Surgery Guidelines[180]	Additional considerations[174]
Presence of left internal thoracic artery bypass graft	In patients at risk for neurologic complications	Left vertebral artery originating directly from the arch
Termination of left vertebral artery at posterior inferior cerebellar artery or other discontinuity of vertebrobasilar collaterals		
Functioning arteriovenous dialysis fistula in left arm		
Prior infrarenal aortic repair with occlusion 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		



Vascular access and device delivery injuries

- Iliac A. rupture
- Access site hematoma, bleeding, occlusion
- Femoral A. pseudoaneurysm
- Prevention
  - US guided access for Percutaneous procedure
  - Cut down or alternative access for unsuitable anatomy

Endoleaks

RECOMMENDATION TABLE 29 Therapeutic Options: Endoleaks

Recommendations	Class[a]	Level[b]	Ref[c]
Type I and type III endoleaks are regarded as treatment failures, and reintervention is recommended.	I	C	-
In the presence of a type II endoleak and aneurysm growth ≥10 mm, treatment should be considered in both thoracic and abdominal pathologies.	IIa	C	-
In the presence of a type V endoleak (endotension without depictable endoleak on standard follow-up imaging), treatment should be considered in both thoracic and abdominal pathologies.	IIa	C	-

[a]Class of recommendation; [b]Level of evidence; [c]References.

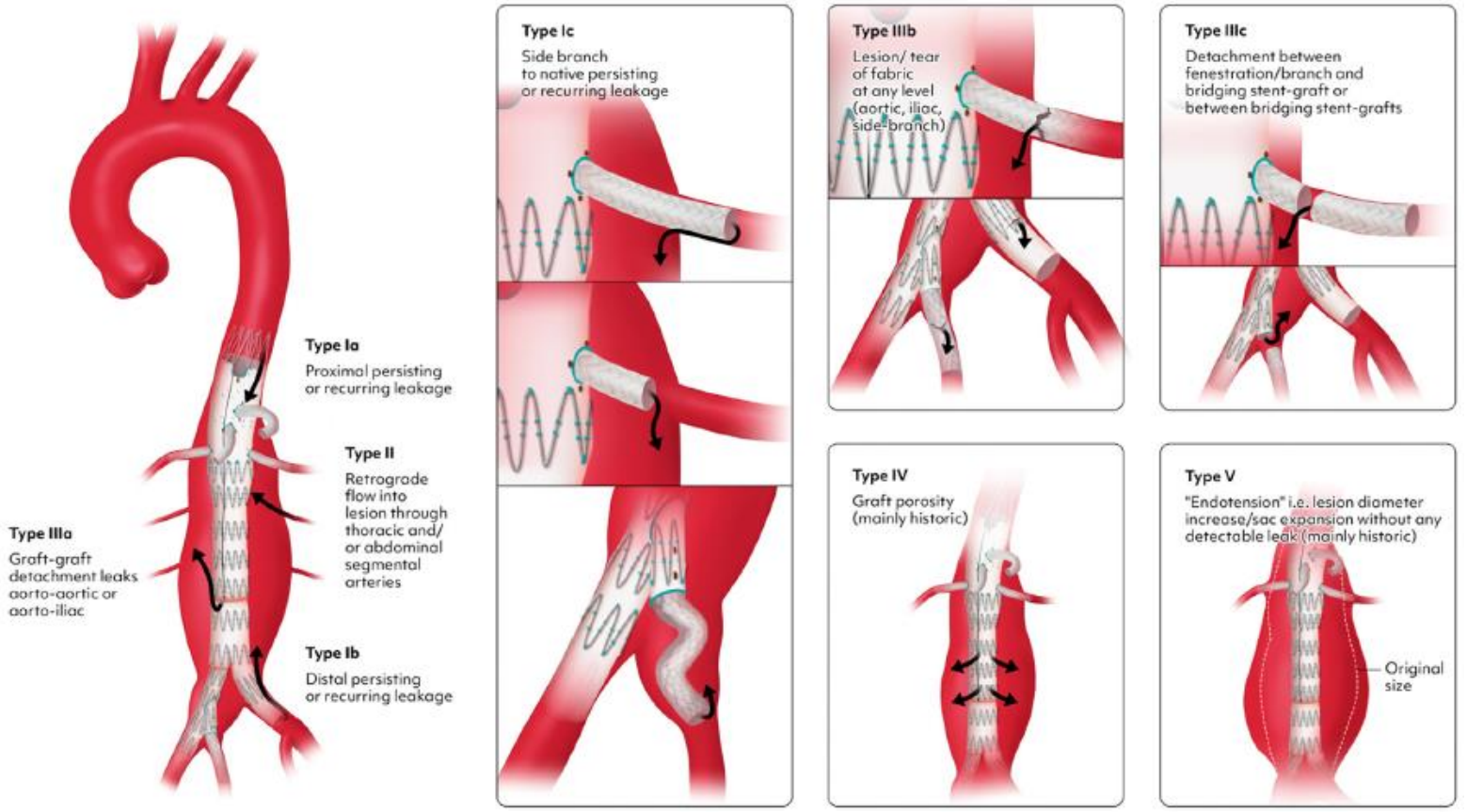


FIGURE 32 Classification of endoleaks.

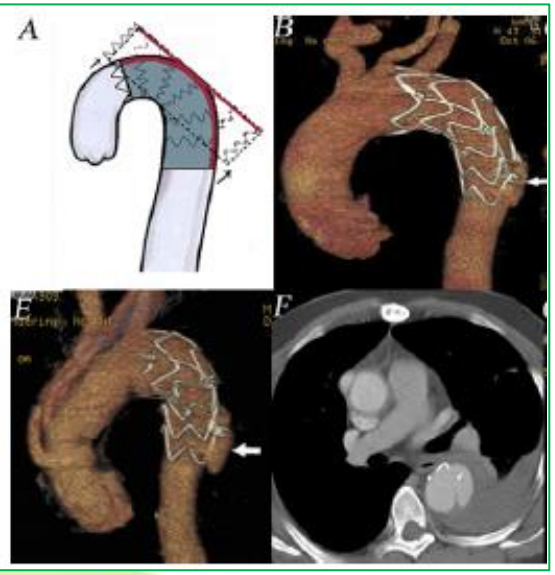
Distal Stent Induced New Entry (dSINE)

Stent graft-induced new entry after endovascular repair for Stanford type B aortic dissection

Zhihui Dong, MD,[a] Weiguo Fu, MD,[a] Yuqi Wang, MD,[a] Chunsheng Wang, MD,[b] Zhiping Yan, MD,[c] Daqiao Guo, MD,[a] Xin Xu, MD,[a] and Bin Chen, MD,[a] *Shanghai, China*

dSINE *- a new tear caused by the stent graft itself, excluding those created by natural disease progression or any iatrogenic injury from the endovascular manipulation*

- Incidence : 3 - 28%
- Onset interval : 12 - 36 month after TEVAR
- Asymptomatic, discovered on routine postoperative surveillance imaging

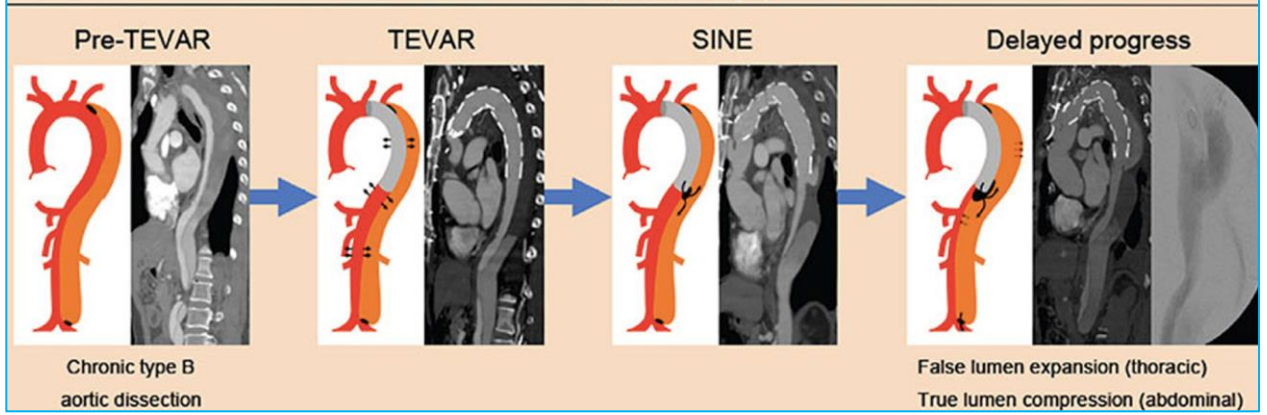


J Vasc Surg 2010;52:1450-8

The Impact of Distal Stent-Graft Induced New Entry on Aortic Remodeling of Chronic Type B Dissection

Chun-Yang Huang, Hung-Lung Hsu, Po-Ling Chen, I-Ming Chen, Chiao-Po Hsu, and Chun-Che Shih

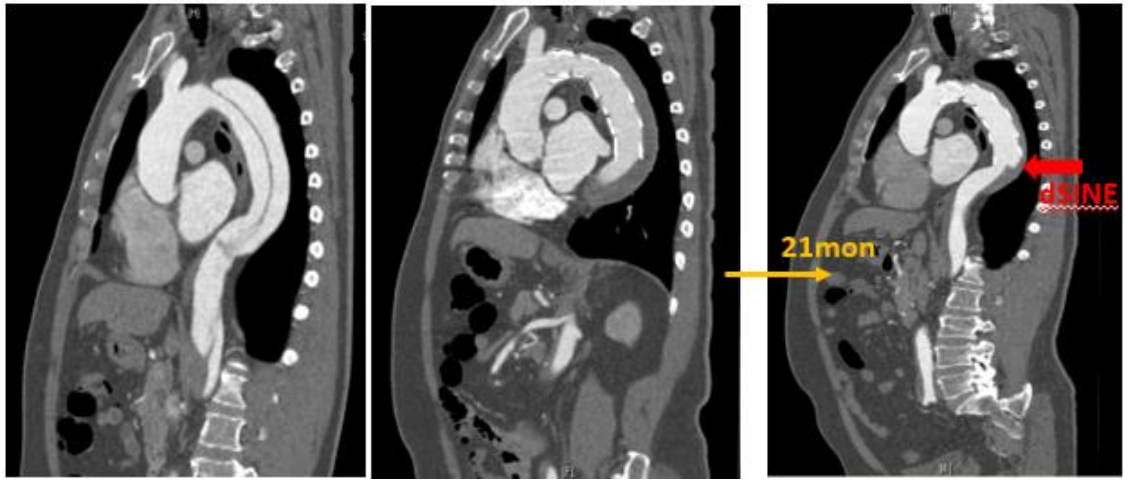
The Annals of Thoracic Surgery

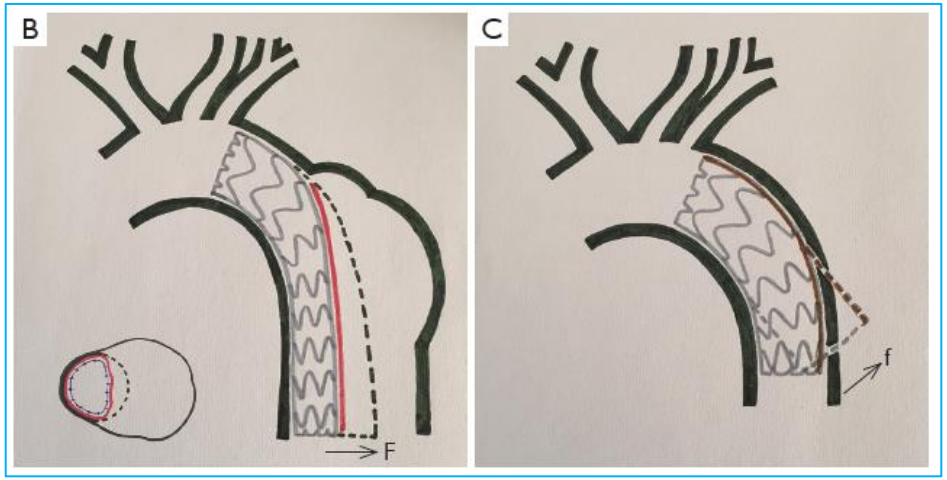


For CDIIIb, Occurrence of dSINE could significantly affect
"Abdominal TL compression & Thoracic FL reexpansion"

Ann Thorc Surg 2018;105;785-93

Distal Stent Induced New Entry (dSINE)





TEVAR for chronic dissection
Excessive oversizing of distal stent graft relative to smaller true lumen
Connective tissue disorder
Shorter length (<145 mm) stent grafts
Proximal to distal stent graft implantation sequence in chronic dissection

1. Fragile dissected intimal flap
2. Radial force
3. Springback force

Li Q, J Thorac Dis 2015

G.C. Hughes J Thorac Cardiovasc Surg 2019

Stent Graft Infection

- Aorto-esophageal fistula
- Aorto-Bronchial fistula
- Aorto-Duodenal fistula
- Total endograft extraction and arterial reconstruction anenteric or airway repair with flap coverage