ESVS CONSENSUS STATEMENT

European Society for Vascular Surgery (ESVS) 2025 Clinical Practice Consensus Statement on Ascending Thoracic Endovascular Aortic Repair

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WHAT THIS PAPER ADDS

This paper provides an expert consensus on the use of ascending thoracic endovascular aortic repair (aTEVAR) for the treatment of ascending thoracic aortic diseases, including recommendations on patient selection, procedural strategies, and post-operative management. By addressing key topics such as landing zones, stent graft sizing, risk assessment, and adjunctive procedures, this document aims to guide clinical practice, improve patient outcomes, and enhance procedural safety. Additionally, the paper identifies gaps in current evidence, highlighting areas for future research to refine the role of aTEVAR in managing ascending thoracic aortic pathologies.

Objective: Diseases of the ascending thoracic aorta, including type A aortic dissection, type A intramural haematoma, fusiform aneurysm, pseudoaneurysms, and penetrating aortic ulcer, pose significant management challenges due to the complex anatomy and high pressure haemodynamics of the ascending aorta. While open surgical repair is the gold standard, efforts to improve access to therapy and reduce invasiveness have driven interest in thoracic endovascular aortic repair adapted for the ascending aorta (aTEVAR). However, the lack of evidence has led to variability in patient selection, procedural approaches, and outcomes. This consensus document aims to provide recommendations on the use of aTEVAR for the treatment of ascending thoracic aortic diseases.

Methods: Pre-defined criteria were applied to develop the most relevant clinical questions, and a systematic literature review was performed. Consensus statements were developed using a nominal group technique, including structured Delphi type methodology involving two online meetings, followed by three survey rounds and a final in person meeting of the multidisciplinary panel of experts.

Results: The consensus document provides aTEVAR recommendations in relation to topics including patient selection, risk stratification, procedural planning (e.g., landing zones and stent graft sizing), intra-operative strategies, and post-operative management. The document also highlights gaps in evidence and identifies areas requiring further research.

Conclusion: This document provides expert consensus based guidance on aTEVAR as a treatment option for selected patients with ascending thoracic aortic diseases, particularly those at high surgical risk. By providing standardised recommendations and emphasising multidisciplinary care, the document aims to reduce variability in clinical practice, enhance procedural safety, and improve patient outcomes. Future research should focus on optimisation of procedural techniques, device specific data, long term outcomes, improving patient selection, and direct comparison of aTEVAR with matched cohorts undergoing open repair.

[†] Jonathan R. Boyle, Nuno Dias, Barend Mees, Tim Resch, and Christopher P. Twine monitored the development of this consensus document on behalf of the ESVS Guidelines Steering Committee and reviewed the different drafts of the document.

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INTRODUCTION

Diseases of the ascending aorta, including type aortic A dissections (TAADs) and type A intramural haematoma (IMH), fusiform aneurysm, pseudoaneurysms, and penetrating aortic ulcer (PAU), are routinely treated by open surgical repair via median sternotomy; this is historically the gold standard for these conditions.[1,2] However, in elderly patients or those with significant comorbidities, the morbidity and mortality rates associated with open repair have driven the exploration of alternative approaches, including thoracic endovascular aortic repair adapted for the ascending aorta (aTEVAR).[3,4]

The ascending aorta poses unique difficulties for endovascular interventions, including the difference in length of the inner (shorter) and outer (longer) wall, the proximity to critical structures, such as the coronary arteries, aortic valve, and supra-aortic arch vessels, and the dynamic forces generated by greater pulsatile flow than other segments of the aorta.[5,6] These challenges are compounded by the lack of dedicated stent grafts for this segment, with most procedures relying on off label use of devices designed for the descending aorta or arch.[3,7] Despite these limitations, advances in imaging technology, procedural techniques, and device innovation have enabled aTEVAR to emerge as a feasible option for selected high risk patients (Fig. 1).[8]

Given the expanding use of aTEVAR, there remains a need for consensus on its role in treating ascending aortic diseases. The lack of standardised patient selection criteria, procedural strategies, and long term outcome data has resulted in variability in clinical practice.[3] Additionally, integrating aTEVAR into the broader context of hybrid approaches and open repair requires careful consideration.

This expert consensus document aims to provide comprehensive guidance on treating ascending aortic diseases, integrating current evidence with expert opinion. It addresses the indications for aTEVAR, patient selection, procedural approaches, and post-operative management in the light of the role of open surgery and hybrid techniques. By establishing statements, this document aims to standardise practice, improve patient outcomes, and define the role of aTEVAR within the evolving landscape of ascending aortic treatment.

METHODS

The methods follow those agreed by the European Society for Vascular Surgery (ESVS) Guidelines Steering Committee.[9] Definitions of the classes of recommendations and levels of evidence are those proposed by the recent ESVS grading system (Tables 1 and 2).[9]

Terminology

The Consensus Writing Committee (CWC) used the definition of attachment zones provided in the reporting standards for thoracic endovascular aortic repair, commonly referred to as Ishimaru zones in the aortic arch, as well as the modification proposed by Roselli *et al.* to differentiate the aortic root from the proximal and distal segments of the ascending aorta (Fig. 2).[10,11] For the anatomical characteristics of the aortic arch, the classification of type I, type II, and type III aortic arch configurations was used.[2] These three types are based on the position of the brachiocephalic trunk in relation to the aortic arch.

Regarding specific descriptors for arch configurations such as gothic arch, steep arch angulation, and aortic arch radius, a common basis for establishing a meaningful definition could not be identified. As a result, the use of these terms to describe specific morphologies remains subjective.

Categorisation of tears in the ascending aorta was defined as primary entry tear, most proximal entry tear, most distal tear, and communications between laminae. The use of other terms, such as multiple entry tear, was avoided for a better clarification.

The phases of aortic dissection were defined as hyperacute ($<$ 24 hours), acute (1 — 14 days), subacute (15 — 90 days), or chronic ($>$ 90 days).[1,2,12]

The type of aortic dissection was defined by a modified Stanford classification system, based on the European Association for Cardio-Thoracic Surgery (EACTS) and the ESVS.[1,12–14] A TAAD involves dissection of the ascending aorta, regardless of the location of the proximal entry tear. A type B aortic dissection involves an entry tear more distal than the left subclavian artery and distal involvement of the descending aorta, and a non-A non-B aortic dissection refers to a dissection with an entry tear in the aortic arch and or more distal, with arch dissection, but without involvement of the ascending aorta.

Ascending aortic aneurysm was defined as a dilation of the ascending aorta $>$ 45 mm, following the EACTS and Society of Thoracic Surgeons (STS) guidelines.[1] In the case of a true aneurysm, all three layers of the arterial wall are involved.[1] For a pseudoaneurysm, the peri-arterial tissues are involved. Aneurysms can also be classified by shape: fusiform (symmetrical, spindle shaped dilation) or saccular (asymmetrical, sac like outpouching).

PAU is an ulceration of the aortic wall that penetrates the intima and progresses into the media layer.[1] IMH is the accumulation of blood within the media of the aortic wall without an intimal tear. Only type A IMH, involving the ascending aorta, was considered in this document.[1]

Consensus process

The pre-specified ESVS consensus statement framework was used in the process of creating this consensus document.[9] Two systematic reviews were written to support the statements in this consensus document with appropriate recommendations.[3,4] The first systematic review was written with a focus on a tubular stent graft confined to the

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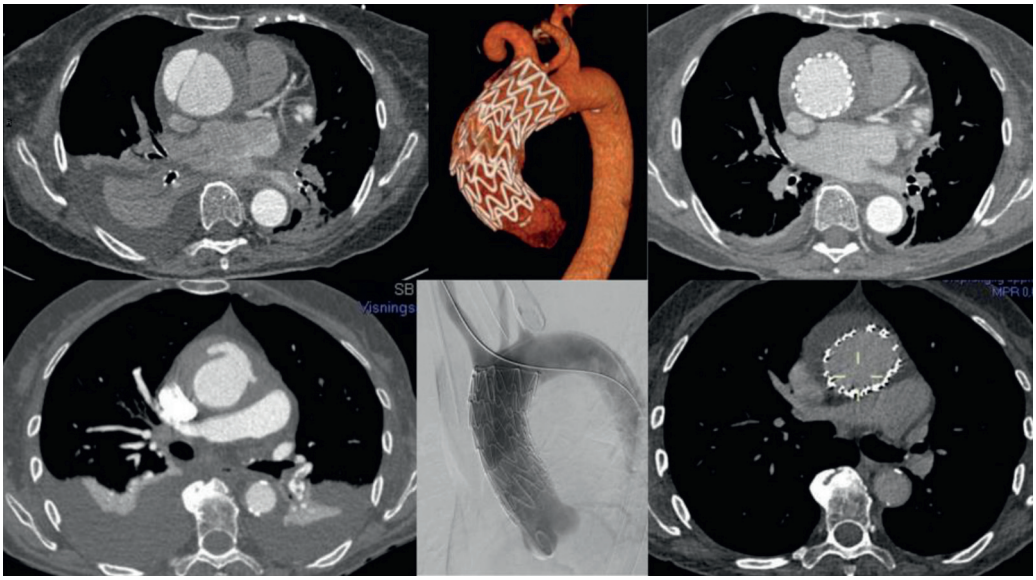

Figure 1. Example of ascending thoracic endovascular aortic repair without supra-aortic trunk treatment, used to treat a type A aortic dissection (top) and an intramural haematoma evolving to dissection (bottom).

ascending aorta, between the sinotubular junction and the brachiocephalic trunk, regardless of disease treated.[3] The second systematic review included diseases originating in the ascending aorta, treated endovascularly, irrespective of the stent graft's distal landing zone, which may extend into the aortic arch and need additional treatment such as branches, fenestrations, surgical bypasses, etc.[4]

The modified Delphi process included three rounds of anonymous surveys. After each round, participants received anonymised feedback summarising the group's responses, highlighting areas of agreement and disagreement. To complement the surveys, an online meeting was convened after each round to discuss the outcomes and to address topics where consensus had not yet been reached. These discussions provided an opportunity to explore divergent viewpoints and clarify areas of uncertainty, fostering convergence in subsequent rounds. A nominal group technique was used as required during online or face to face discussions.

Following the third and final survey round, an in person meeting was convened with the entire expert panel to conduct an in depth discussion on each statement, its recommendation, and the level of evidence. During this meeting, participants collaboratively reviewed and refined the wording of the statements, ensuring clarity, precision, and consensus on every item.

The CWC served as the expert panel for the modified Delphi consensus process, consisting of six vascular surgeons and two cardiothoracic surgeons. No additional experts were consulted in the modified Delphi consensus process, thereby ensuring that the consensus reflected the collective expertise of the authors directly involved in the surgical management of these conditions. Pre-defined criteria were applied to define consensus,

Table 1. Classes of Recommendations

Class	Definition	
I	**Evidence and/or general agreement that a given treatment or procedure is beneficial, useful, effective**	**is recommended**, (is indicated, should, is effective)
II	**Conflicting evidence and/or divergence of opinion about the usefulness/efficacy about the given treatment or procedure.**	
IIa	**Weight of evidence/opinion is in favour of usefulness/efficacy**	**should be considered**, (is reasonable, can be useful, is probably recommended/indicated)
IIb	**Usefulness/efficacy is less well established by evidence/opinion**	**may be considered**, (may/might be considered reasonable, effectiveness is unclear/uncertain)
III	**Evidence or general agreement that a given treatment or procedure is not useful/effective and in some cases may be harmful**	
IIIa	**The given treatment or procedure is not necessarily useful or effective**	**is not recommended,** (is not indicated, should not be done)
IIIb	**The give treatment or procedure may be dangerous or harmful to patients**	**Is not recommended,** (it is not indicated, should not be done)

Table 2. Levels of Evidence

Level of Evidence A	Data derived from multiple randomised trials or meta-analyses of randomised trials
Level of Evidence B	Data derived from a single randomised trial, large non-randomised studies or a meta-analysis of non-randomised studies
Level of Evidence C	Consensus opinion of experts and/or small studies, retrospective studies, registries

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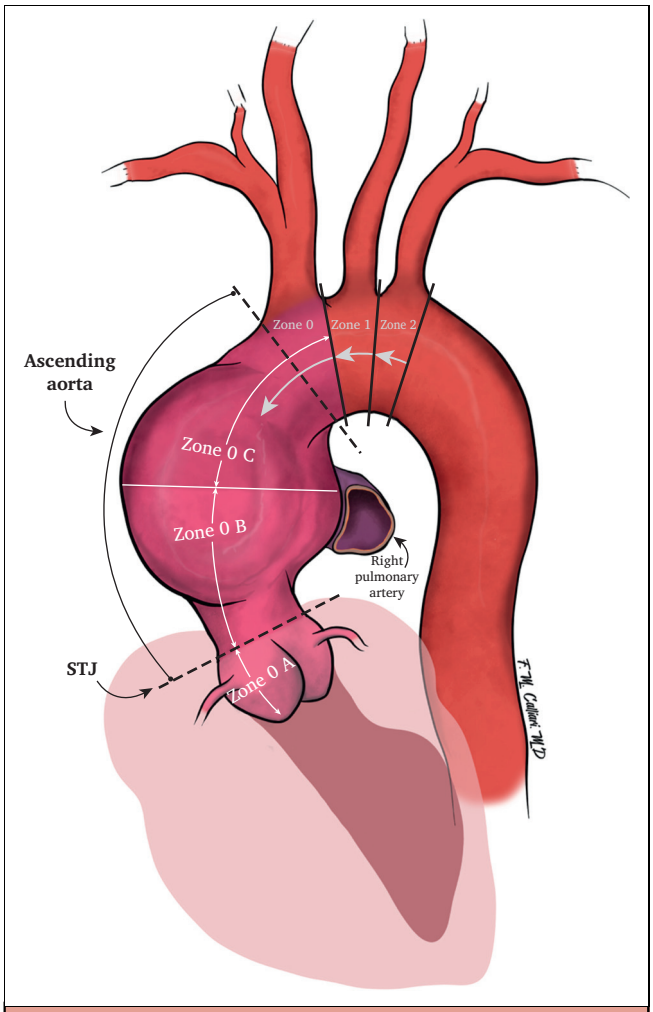

Figure 2. Schematic image of the ascending aorta with the modified Ishimaru zones. STJ = sinotubular junction.

typically requiring a specific level of agreement (e.g., $\geq$ 75% of experts rating an item as agree or strongly agree).

The outcomes of the modified Delphi process formed the base of these consensus guidelines, which aim to provide informed evidence and widely accepted statements. Areas where consensus was not reached are explicitly highlighted, reflecting the complexity of the issues and the need for further investigation.

In line with the ESVS consensus development framework, the AGREE II checklist was completed to ensure methodological rigour and transparency in the preparation of this document.[15] The completed checklist is provided as a supplementary file for reference (Supplementary Table S1).

Aims of the document

The statements in this document were structured using the PICO (Population, Intervention, Comparison, Outcome) framework, which formed the basis of each section. This expert consensus document aims to provide comprehensive guidance on the treatment of ascending aortic diseases by integrating current evidence with expert opinion. It seeks to define the role of aT-EVAR alongside open surgery and hybrid techniques, offering statements on indications, patient selection, procedural strategies, and post-operative management. By establishing consensus based recommendations, the document aims to standardise clinical practice, improve patient outcomes, and support the safe and effective implementation of aT-EVAR in selected cases.

SYSTEMATIC REVIEW SUMMARY

The full systematic reviews are published elsewhere, and the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were followed for both.[16] The first systematic review, "Outcomes of endovascular repair confined to the ascending thoracic aorta: a systematic review and meta-analysis",[3] included 94 studies (19 cohort studies, 75 case reports or series) reporting on 259 patients (57.8% male). The mean age was 69.1 years (95% confidence interval [CI] 65.0 — 73.1). The most common indications for aT-EVAR were TAAD (43.6%), pseudoaneurysm (38.6%), and PAU (3.9%). The in hospital mortality rate was 7.3% (95% CI 4.7 — 11.2), 30 day mortality rate 7.7% (95% CI 5.1 — 11.6), and overall mortality rate 17.0% (95% CI 12.9 — 22.0) at a mean follow up of 19.6 (95% CI 12.5 — 24.6) months. The re-operation rate was 13.1% (95% CI 9.5 — 17.8). The in hospital and 30 day mortality rates for TAAD were 12.4% (95% CI 7.5 — 19.7) (n = 14) and 13.3% (95% CI 8.2 — 20.8) (n = 15), respectively, and for pseudoaneurysm 4.0% (95% CI 1.6 — 9.8) (n = 4) and 4.0% (95% CI 1.6 — 9.8) (n = 4), respectively. Intra- and post-operative complications were reported in 38 and 88 cases, with 24 and 27 endoleaks reported, respectively. The rate of post-operative stroke was 5.0%.

The second systematic review, "Endovascular repair of diseases originating in the ascending thoracic aorta: a systematic review and meta-analysis",[4] included 21 studies (all cohort studies including more than five patients, excluding case reports or series with fewer than five patients) reporting on a total of 312 patients (60.9% male). The mean age was 67.6 years (95% CI 66.5 — 68.7). The most commonly treated diseases of the ascending aorta were acute TAAD (35.9%), chronic TAAD (21.2%), and pseudoaneurysm (19.2%). The in hospital, 30 day, and follow up mortality rates were 9.0% (95% CI 6.0 — 12.7), 9.3% (95% CI 6.3 — 13.1), and 19.6% (95% CI 15.3 — 24.4), respectively, at 21.2 (95% CI 18.8 — 23.5) months. Subgroup analyses showed in hospital and follow up mortality rates for TAAD of 9.8% (95% CI 5.9 — 15.0) and 18.0% (95% CI 12.7 — 24.3); for PAU 9.0% (95% CI 1.9 — 24.3) and 15.2% (95% CI 5.1 — 31.9); and for pseudoaneurysm 2.8% (95% CI 1.0 — 13.9) and 13.3% (95% CI 5.9—4.6), respectively. Intra-operative and post-operative complications were reported in 43 and 148 cases, with endoleaks occurring in 14 and 36 cases, respectively. The rate of post-operative stroke was 8.7%.

CONSENSUS RECOMMENDATIONS

Organisation of care

For organisation of care, multidisciplinary management in specialised centres is compared with non-specialised care, aiming to improve patient safety, procedural success, and outcomes.

PICO: For patients with ascending thoracic aortic diseases, does care in specialised centres improve outcomes compared with non-specialised care?

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PICO: Which conditions and facilities must be present in aortic centres using aT-EVAR?

PICO: What is the best follow up for patients after aT-EVAR for ascending aortic diseases?

As a novel and evolving intervention, aT-EVAR requires cautious and structured implementation. The adoption of new endovascular techniques in the past has demonstrated that premature or widespread use without sufficient long term data can lead to unforeseen complications and sub-optimal outcomes. To minimise these risks, aT-EVAR should be introduced within highly specialised centres with appropriate multidisciplinary expertise and rigorous clinical oversight, ideally supported by prospective data collection and structured follow up.

While this consensus document does not recommend a specific evaluation framework, structured models such as the IDEAL framework provide guidance for the stepwise development, evaluation, and integration of innovative procedures.[17] Ongoing research, transparent reporting, and collaboration across centres will be essential to ensure the safe and effective development of aT-EVAR in clinical practice.

The management of ascending aortic diseases requires a multidisciplinary approach, with an aortic team closely involved from initial diagnosis to treatment and long term follow up.[1,2,12,14,18] This team should be led by experts in cardiac and vascular surgery, working in collaboration with anaesthetics, cardiology, radiology, and genetics. A key advantage of having surgery as the leading specialty is the ability of surgeons to correlate radiographic findings with their clinical experience, allowing for a more informed decision when determining the treatment strategy, as well as their capability to manage possible complications, including the need for conversion when necessary.

The CWC recommends centralising the care of ascending aortic diseases in specialised centres. Such centres should provide the full spectrum of treatment options, with expertise in open cardiac surgery, cardiac catheterisation, transcatheter valve replacement, and open or endovascular aortic procedures, ensuring comprehensive care under one umbrella. The availability of a hybrid operating room is essential to facilitate advanced intra-operative imaging and to enable the safe execution of complex surgical and endovascular interventions. A hybrid operating room has been associated with improved technical success and has suggested better long term outcomes in complex endovascular aneurysm repair (EVAR), branched EVAR, and fenestrated EVAR procedures, and in conventional treatment of TAAD.[19,20] Trade offs in imaging capabilities should be minimised, as high quality imaging is fundamental to delivering reliable and effective treatment.

Specialised centres must also establish streamlined pathways for emergency care, ensuring 24/7 availability, efficient transportation and transfer systems, and rapid activation of the multidisciplinary team.

Finally, structured surveillance of all patients is critical, both for those being monitored prior to reaching treatment thresholds and for those who have undergone intervention. This serves not only as a means of quality control, but also to identify and address potential complications or the progression of aortic disease in untreated proximal or distal segments. The interval between follow up examinations should be considered on a case by case basis, preferably similar to the follow up of complex endovascular aortic interventions.[1,2,14,21] However, in patients who are no longer fit for further intervention, continued follow up may not be necessary. The decision to stop follow up should be made through shared decision making within the multidisciplinary team, considering the patient's overall prognosis and quality of life.

This exception does not alter the general recommendation for lifelong follow up in patients who remain candidates for future interventions but ensures that surveillance strategies remain patient centred.

Consensus statements	Class	Level of evidence
1. Patients with ascending aortic diseases considered for aT-EVAR are recommended to be evaluated by a multidisciplinary team.	I	C
2. It is recommended that aortic centres performing aT-EVAR have access to open cardiac and open and endovascular aortic surgical expertise.	I	C
3. aT-EVAR is recommended to be performed in a hybrid operating room.	I	C
4. Lifelong clinical follow up and serial cross sectional imaging is recommended after aT-EVAR, for patient safety and data collection.	I	C

Risk scores

For risk scores, the use of quantifiable tools like EuroSCORE II is evaluated against clinical judgement alone to enhance surgical risk assessment.

PICO: For patients considered for aT-EVAR, do risk scores improve risk assessment compared with no formal tools?

Quantifiable surgical risk scores play a role in assessing the surgical risk or level of fitness of patients with ascending thoracic aortic diseases. Several tools are commonly used to estimate overall surgical risk. Options for these patients include, but are not limited to: EuroSCORE II, STS risk calculator, TEM classification, and GERAADA score (for TAAD).[22–25] These scores each have their specific uses and may be considered for daily practice based on their applicability and ease of use by the clinician to assist in the decision making process. However, none of them have been specifically validated for use in aT-EVAR. The CWC does not endorse a specific cutoff value for the decision to treat using either open surgery or endovascular surgery, or to decide on conservative management, best medical therapy, follow up with serial imaging, or a palliative course of action. While the risk scores can be a useful general guide, they should not be the sole determinant in decision making. Expert clinical judgement remains central

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in selecting the appropriate treatment strategy for patients with ascending aortic diseases.

Consensus statement	Class	Level of evidence
5. In addition to clinical judgement, quantifiable surgical risk scores may be considered for the assessment of patient surgical risk and or fitness.	IIb	C

Diagnosis and assessment

In the EACTS/STS, American Heart Association/American College of Cardiology, and other aortic guidelines, the sections on diagnostic work up and imaging outline the recommended modalities and criteria for diagnosing ascending aortic diseases, emphasising the critical role of imaging techniques such as (gated) computed tomography angiography, magnetic resonance imaging, and echocardiography.[1,2,14,21,26] They also provide standardised thresholds for aortic diameters and classifications, like modified Ishimaru zones, to describe the extent of the disease. Readers seeking detailed protocols and criteria for diagnosing and assessing ascending aortic diseases will find these guidelines a valuable resource, with focus areas structured within their diagnostic sections.

Patient selection and diseases to treat

Patient selection and diseases to treat focus on aT-EVAR for PAUs, pseudoaneurysms, and dissections, comparing outcomes with open surgery or medical management.

PICO: In patients with ascending aortic pathologies, does aT-EVAR improve survival and reduce morbidity compared with traditional options?

Based on the available literature and the expert opinion of the CWC, aT-EVAR is a viable treatment option for ascending aortic diseases, such as PAU, pseudoaneurysms, and both acute and chronic TAAD, in both elective and emergency settings.[3,4]

Ascending PAUs (Fig. 3A) are rare but carry risks of rupture or progression to dissection if left untreated.[27–29] aT-EVAR offers a less invasive alternative, particularly for high risk patients who are unsuitable for open surgery. Short term aT-EVAR outcomes in PAUs are comparable with those for descending aortic diseases, with a mortality rate of 15.2% at a mean follow up ± standard deviation of 21.2 ± 20.3 months.[4] Its utility in acute settings underscores its value as a lifesaving option.

Pseudoaneurysms of the ascending aorta (Fig. 3B) often result from previous surgery, trauma, or infection, and may present with a risk of rupture. aT-EVAR has demonstrated favourable short term results, with in hospital and 30 day mortality rates as low as 2.8%[4] and 4.0%,[3] similar to those associated with open repair. These outcomes make it an appealing option, particularly for patients with limited physiological reserves or multiple previous operations. Additionally, the use of custom modified stent grafts and multicomponent modular systems enhances aT-EVAR's adaptability to complex anatomies.

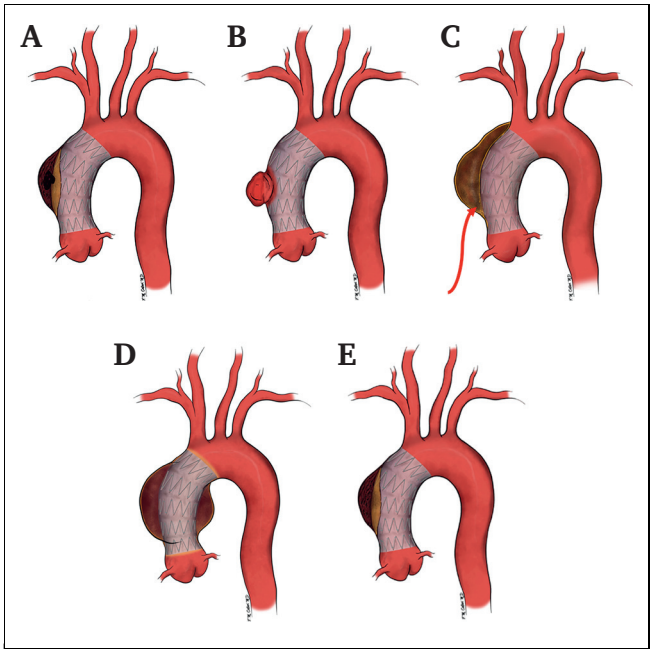

Figure 3. Different ascending aortic diseases treated with ascending thoracic endovascular aortic repair: (A) penetrating aortic ulcer of the ascending aorta; (B) pseudoaneurysm of the ascending aorta; (C) type A aortic dissection, with a red arrow pointing at the entry tear in the ascending aorta; (D) fusiform aneurysm of the ascending aorta; and (E) intramural haematoma of the ascending aorta.

In chronic TAAD, progressive false lumen expansion or aneurysm degeneration frequently necessitate intervention. aT-EVAR offers a less invasive means of excluding the false lumen and stabilising the aorta, with lower reported mortality rates than medical management. In anatomically suitable cases, aT-EVAR provides a low risk alternative to open repair, reducing associated risks while offering the potential for effective stabilisation.

Acute TAADs (Fig. 3C) remain a surgical emergency, with a high mortality rate if untreated. While open repair remains the gold standard, aT-EVAR has shown promising results for patients unfit for surgery due to frailty or comorbidities. Reported in hospital and 30 day mortality rates are 9.8% and 10.3%, respectively,[4] and 12.4% and 13.3%, respectively.[3] These highlight its potential as a lifesaving option for carefully selected high risk cases with highly selected anatomies, particularly in situations where rapid intervention is required.

The versatility of aT-EVAR across elective and emergency settings makes it a potential treatment approach. Elective procedures allow for thorough planning and anatomical assessment, optimising outcomes. In emergencies, the rapid deployment of aT-EVAR has been effective in stabilising patients with life threatening conditions such as rupture or haemodynamic instability.

Fusiform aneurysms of the ascending aorta (Fig. 3D) are generally managed surgically due to their rupture risk and challenging anatomical location near the coronary arteries and aortic valve. However, aT-EVAR may be suitable for select cases with favourable proximal and distal landing zones and minimal aortic angulation, enabling secure stent graft deployment.

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Type A IMH (Fig. 3E), a life threatening condition, requires urgent intervention in cases of pericardial effusion, progression, or complications such as impending rupture or aortic dilation. While data on aT-EVAR for IMH are limited, stent grafts provide a promising option for excluding the pathological segment and preventing progression. Successful outcomes depend on anatomical suitability, particularly adequate proximal and distal landing zones, minimally covering up the ulcer like projection, and sufficient ascending aortic length for secure graft placement.

While the aim of aT-EVAR is to offer a less invasive treatment option for selected patients with ascending aortic pathology, it is equally important to acknowledge that not all patients will benefit from intervention, even if anatomically feasible. In cases of advanced age, significant comorbidities, severe frailty, or limited life expectancy, the risks of a procedure, whether open or endovascular, may outweigh the potential benefits. Additionally, some pathologies such as small PAUs and limited IMHs have been observed to remodel or remain stable over many years in other sections of the aorta. Therefore, in patients who are otherwise fit for intervention and have a good life expectancy, surveillance with serial imaging may also represent an appropriate management strategy.

There are currently no validated criteria or risk thresholds to definitively guide when conservative, surgical, or endovascular management should be preferred; decisions regarding non-intervention must therefore be made on an individual basis. The absence of high quality data in this context reinforces the importance of clinical judgement and multidisciplinary team evaluation in determining when a strategy of serial imaging, symptom monitoring, or palliative care is more appropriate than active intervention.

Consensus statements	Class	Level of evidence
6. aT-EVAR should be considered a treatment option for ascending penetrating aortic ulcer, pseudoaneurysm, and chronic and acute type A aortic dissection in patients with suitable anatomy, in the elective and acute setting.	IIa	C
7. aT-EVAR may be considered in fusiform aneurysm and type A intramural haematoma in highly selected patients with suitable anatomy.	IIb	C

Landing zones

Landing zones emphasises tailoring zones to specific anatomy and disease, aiming to reduce complications such as endoleaks.

PICO: Does tailored landing zone selection reduce complications compared with non-specific planning?

The required proximal and distal landing zones during aT-EVAR should be tailored to the specific disease entity and anatomical features, including the measurements along the inner and outer curvatures of the aorta to account for the anatomical variation and curvature of the ascending aorta.

TAADs, which constituted 43.6% of cases in one review,[3] often present with short landing zones near the sinotubular junction, risking coronary coverage. By contrast, pseudoaneurysms (38.6%)[3] typically allow for more stable landing zones. The ascending aorta's short length (typically < 10 cm between the sinotubular junction and brachiocephalic trunk), the difference in length between the inner and outer curvature, dynamic properties, and proximity to critical structures create significant challenges. Improper landing zone selection can lead to complications, such as type Ia endoleaks (10.4%),[4] highlighting the importance of disease specific planning.

For acute TAAD, the CWC proposes that a proximal landing zone > 1 cm proximal to the entry tear may be considered when the anatomy and clinical condition permit. The frequent proximity of entry tears to the sinotubular junction limits sealing options. However, since the primary goal of treatment in acute TAAD is the closure of the primary entry tear, a landing zone of 1 cm may be sufficient, provided there is adequate apposition along the rest of the stent graft. The apposition of the stent along the aortic wall is expected to contribute to stability and reduce the risk of migration.[4] Many of these patients are high risk surgical candidates due to age or comorbidities, underscoring the need for precise planning and highly accurate device delivery to avoid conversion to open surgery, reported to be required in 2.3 — 6% of cases.[3,4]

For chronic TAAD, the CWC proposes that a proximal landing zone of at least 2 cm may be considered, to account for the increased rigidity and altered haemodynamics of fibrotic and remodelled aortic walls. Longer landing zones reduce risks such as type Ia endoleak and migration of the stent graft. In hospital mortality for these patients ranges from 9.8% to 12.4%.[3,4]

For patients with PAUs or pseudoaneurysms, the CWC proposes that proximal and distal landing zones of at least 2 cm may be considered to ensure stable sealing. PAUs are often focal lesions, while pseudoaneurysms typically result from previous surgical intervention or trauma, providing favourable anatomical features for securing extensions.[3]

Consensus statements	Class	Level of evidence
8. The required proximal and distal landing zone during aT-EVAR is recommended to be determined by the specific disease entity and anatomical features.	I	C
9. A proximal landing zone > 1 cm may be considered in patients with acute type A aortic dissections treated with aT-EVAR, considering anatomy, surgical risk, and clinical condition.	IIb	C
10. A proximal landing zone of at least 2 cm may be considered in patients with chronic type A aortic dissections treated with aT-EVAR, considering anatomy, surgical risk, and clinical condition.	IIb	C
11. A proximal and distal landing zone of at least 2 cm may be considered in patients with penetrating aortic ulcer or pseudoaneurysm treated with aT-EVAR.	IIb	C

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Oversizing

For oversizing, tailoring stent graft sizing (10 — 30%) is explored to minimise risks including migration and endoleaks.

PICO: Does stent graft oversizing within 10 — 30% reduce procedural risks compared with no standard approach?

The expert opinion of the CWC is that stent graft oversizing of 10 — 30% should be considered in aT-EVAR and must be tailored to the disease, anatomy, and stent graft properties. The unique challenges of the ascending aorta, including its distensibility, extensibility, and dynamic motion during the cardiac cycle, require careful consideration. Acute TAADs, with fragile aortic walls, often necessitate conservative oversizing to avoid rupture, whereas chronic dissections and pseudoaneurysms benefit from greater oversizing to ensure stability and reduce the risk of migration or sealing failure. However, when a pseudoaneurysm is located in an *in situ* surgical graft, too much oversizing should also be avoided, as this could result in stent graft infolding.

Proper planning within the recommended range is critical to minimise complications, such as type Ia endoleaks, which occur in up to 10.4% of cases.[4] Tailoring oversizing to the specific clinical scenario enhances durability and procedural success while mitigating risks associated with both undersizing and oversizing.

Consensus statement	Class	Level of evidence
12. Stent graft oversizing of 10 — 30% should be considered based on the specific disease entity, anatomical features, and stent graft features.	IIa	C

Number of stents

Number of stents evaluates maximum overlap (> 3 cm) between stents to prevent type III endoleaks.

PICO: Does greater overlap between stents reduce complications compared with minimum overlap?

The CWC recommends an overlap of at least 3 cm between two stent grafts during aT-EVAR to reduce the risk of type III endoleaks, with the goal of achieving as much overlap as anatomically and technically feasible. This overlap is especially critical in the ascending aorta, where dynamic forces and anatomical complexities heighten the risk of graft instability.

Early results from the ARISE trial, in which a specific ascending aortic stent graft is under evaluation, demonstrate the feasibility of using two dedicated ascending stent grafts with > 3 cm overlap, enabling the first graft to secure the proximal seal and the second to establish a durable distal landing zone.[8,30] This strategy effectively addresses complex anatomies, but is limited by the restricted availability of these specialised stent grafts, necessitating alternative approaches in most cases while these devices remain investigational.

For some stent grafts designed for treating aortic arch lesions, in which the manufacturer includes a minimum overlap length in the instructions for use, the instructions for use recommendation may be followed.

When anatomical conditions allow, a single stent graft could be the correct option, as it eliminates the risk of type III endoleaks. Abdominal cuffs are discouraged in the ascending aorta due to their limited capacity for adequate overlap, increasing the likelihood of sealing failures. For cases requiring multiple stents, sufficient overlap (> 3 cm) provides stability and reliable sealing in challenging scenarios.

Consensus statement	Class	Level of evidence
13. It is recommended to have maximal overlap (> 3 cm) between two stent grafts to avoid type III endoleaks.	I	C

Supra-aortic trunks

In supra-aortic trunks (SATs), advanced techniques like fenestrated and branched stent grafts are assessed for maintaining perfusion and improving distal seals.

PICO: Does incorporation of SATs improve outcomes compared with limiting treatment to the ascending aorta?

SAT incorporation should be carefully considered in order to achieve a proper distal landing zone during aT-EVAR (Fig. 4). When anatomy permits, a single tubular stent graft confined to the ascending aorta is preferred due to its simplicity, reduced procedural complexity, and lower risk of complications. However, when the distal ascending aorta cannot provide an adequate seal, such as in cases where the disease extends into the aortic arch, SAT incorporation becomes essential.

In these situations, extending into the arch using techniques like surgical debranching, fenestrations, branches, physician modified, or scalloped stent grafts are effective. These methods ensure a secure distal seal while maintaining perfusion to critical SATs. By addressing anatomical limitations, these techniques reduce the risk of complications, such as type IB endoleaks, and enhance the durability of the repair.

For more detailed guidance on the inclusion of SATs or extension of treatment into the aortic arch, readers are referred to the ESVS/EACTS consensus document on the management of aortic arch pathologies, where these aspects are addressed in greater depth, providing specific recommendations that complement the broader focus of this consensus on endovascular treatment of ascending aortic disease.[14]

Consensus statement	Class	Level of evidence
14. Supra-aortic trunk management should be considered in order to create an adequate distal landing zone during aT-EVAR.	IIa	C

Adjunctive procedures

Adjunctive procedures such as transoesophageal echocardiography (TOE) and intravascular ultrasound (IVUS) are compared with procedures without imaging aids for enhanced safety and positioning.

PICO: Does using adjunctive imaging improve safety compared with no additional imaging?

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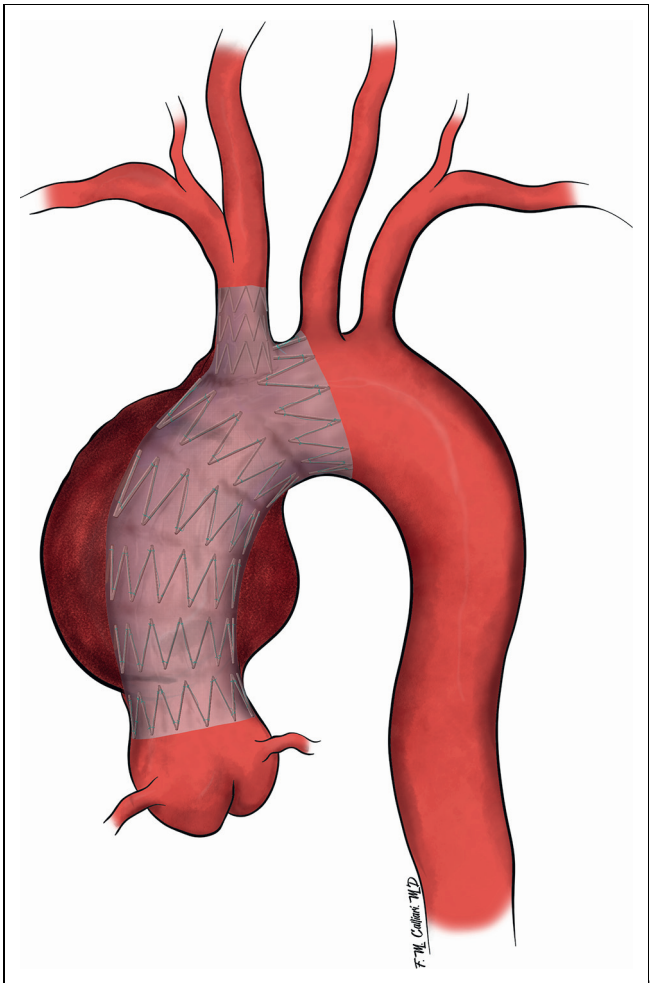

Figure 4. Treatment of an ascending aneurysm with extension of the stent graft into the aortic arch.

TOE may be considered an adjunctive imaging option during aT-EVAR, offering real time visualisation of the aorta, improved device positioning, and better monitoring of anaesthesia, volume status, and cardiac output. However, it often needs to be removed during endograft deployment to ensure optimal visualisation. While not essential for every procedure, TOE provides valuable insights that complement other imaging modalities, such as fluoroscopy and IVUS, and is particularly valuable when planning to cross the aortic valve. IVUS offers detailed intraluminal views of aortic morphology and stent graft apposition, while cerebral protection devices may potentially reduce embolic risks when the arch is involved.

Consensus statement	Class	Level of evidence
15. Transoesophageal echocardiography may be considered as an adjunctive imaging option during aT-EVAR.	IIb	C

Access sites

Access sites evaluates femoral access against alternatives like the left subclavian artery or left ventricular apex for reducing vascular complications.

PICO: Does femoral access reduce complications compared with alternative routes?

The femoral artery is the preferred access site for aT-EVAR procedures due to its accessibility, reduced invasiveness, and compatibility with most stent graft delivery systems. It is used in approximately 85%[3,4] of cases in the literature, providing a reliable and straightforward route for stent graft delivery with a lower risk of vascular complications compared with alternative access sites.

When femoral access is not feasible, the left ventricular apex or supra-aortic vessels may be considered as alternative routes. Access through the supra-aortic vessels, such as the axillary or carotid arteries, is effective for patients with severe peripheral vascular disease or extensive atherosclerosis in the femoral or iliac arteries. Another reason for choosing supra-aortic access has been reported in the literature. In cases where abdominal stent grafts or cuffs were used, the ascending aorta could not be reached via the femoral route, necessitating supra-aortic access. Access using the SAT has been performed in approximately 15% of cases.[3] The left ventricular apex, accessed via a minithoracotomy, is useful for patients with challenging iliac or femoral anatomy, offering precise control of stent graft placement. This approach has been used in approximately 9 — 13%[3,4] of cases. When reviewing guidelines for transcatheter aortic valve replacement (TAVR), there is a clear preference for transfemoral access.[31,32] The use of transapical access has largely been abandoned in favour of transfemoral access.[33] In cases where transfemoral access is not an option, SAT access is considered preferable in TAVR. Extrapolating from this, SAT access may also be favoured over transapical access for aT-EVAR in cases where the femoral artery is inaccessible.

Pre-operative imaging of the access vessels is essential for procedure planning, regardless of whether transfemoral or SAT access is anticipated. Detailed evaluation of vessel diameter, calcification, tortuosity, and previous interventions allows the operating team to assess the feasibility and safety of the chosen access route, anticipate challenges, and selecting appropriate devices.

Consensus statements	Class	Level of evidence
16. The femoral artery should be considered as the preferred access site for aT-EVAR procedures.	IIa	C
17. The supra-aortic vessels and left ventricular apex may be considered as alternative access routes in patients undergoing aT-EVAR.	IIb	C

Pacing methods

Pacing methods evaluates rapid ventricular pacing against alternative cardiac output control techniques.

PICO: Does rapid ventricular pacing improve procedural outcomes compared with alternative methods of cardiac output control during aT-EVAR?

Rapid ventricular pacing may be considered as the preferred method for managing cardiac output during aT-EVAR when

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necessary, as it effectively reduces aortic motion and stabilises the aorta for precise stent graft deployment. By temporarily decreasing cardiac output, it minimises pulsatile forces that could complicate stent placement. This technique ensures proper graft alignment and reduces the risk of complications such as acute migration or endoleaks.

This approach was the most reported method for cardiac output control in the available literature, being used in 38.1% of cases.[4] Additionally, it was identified by the CWC as the most applied method during the consensus process. However, no high level evidence currently supports the superiority of rapid ventricular pacing over alternative techniques. Specific stent grafts designed for the ascending aorta may eliminate the need for cardiac output management.[8] These advanced systems feature innovative deployment mechanisms that allow controlled placement even in the dynamic ascending aorta, removing the necessity for rapid ventricular pacing in such cases.

When cardiac output control is required and rapid ventricular pacing is not feasible or appropriate, alternatives such as inferior vena cava balloon occlusion, Valsalva manoeuvre, cardiopulmonary bypass, mechanical induction of cardiac standstill, or the use of adenosine to induce transient asystole can be considered. While these methods offer varying degrees of aortic motion control, they are generally more invasive or less practical. The choice of cardiac output control strategy should be guided by the patient's condition, procedural complexity, resource availability, and surgeon and anaesthetist expertise, with rapid ventricular pacing remaining the preferred option in most cases.

Consensus statements	Class	Level of evidence
18. Cardiac output control should be considered during aT-EVAR.	IIa	C
19. Rapid ventricular pacing may be considered to be the preferred method for cardiac output control during aT-EVAR.	IIb	C

Anaesthesia

Anaesthesia evaluates general anaesthesia against alternatives.

PICO: Does general anaesthesia improve safety and procedural outcomes compared with alternative anaesthetic care in patients undergoing aT-EVAR?

General anaesthesia should be considered as the preferred method for aT-EVAR procedures owing to its advantages in safety, flexibility, and patient comfort. It provides optimal control over the patient's physiology and airway, ensuring stability during this technically demanding procedure. It also facilitates immediate conversion to open surgery if needed, which is particularly important in high risk cases where urgent intervention may be required. Additionally, general anaesthesia ensures that the patient remains immobile and comfortable, enabling the precision necessary for aT-EVAR.

In rare and specific situations, monitored anaesthetic care (local anaesthesia with sedation) may be a viable alternative, particularly for patients with significant contraindications to general anaesthesia, such as severe cardiac dysfunction or intolerance to anaesthetic agents. While monitored anaesthetic care can reduce physiological stress and avoid the complications associated with general anaesthesia, it is only appropriate for carefully selected patients and in straightforward cases. The choice of anaesthesia should be based on the patient's risk factors, procedural complexity, and the team's ability to manage emergencies. For most patients, however, general anaesthesia remains the preferred approach, ensuring the highest level of safety and procedural control.

Consensus statement	Class	Level of evidence
20. General anaesthesia should be considered the preferred method for most patients undergoing aT-EVAR.	IIa	C

Contraindications

Contraindications evaluates whether conditions such as prior coronary artery bypass graft (CABG), prior TAVR, infected aortic lesions, or significant thrombus or calcification in the aorta should preclude aT-EVAR.

PICO: In patients with prior cardiac interventions, infection, aortic thrombus, or calcification, can aT-EVAR be safely performed with appropriate planning compared with excluding these patients from intervention?

Previous CABG or TAVR, infected aortic lesions, and significant thrombus or calcifications in the arch are not absolute contraindications to aT-EVAR but require careful evaluation and tailored strategies.

For patients with prior CABG or TAVR, it is essential to account for the location and type of prior interventions. The position of bypass grafts or the design and placement of a TAVR device must be precisely evaluated to avoid complications such as coronary ischaemia and valve dysfunction during stent graft deployment. While these factors may necessitate procedural modifications, they may not preclude the use of aT-EVAR.

Infected aortic lesions may be considered for aT-EVAR in controlled scenarios, such as infections caused by bacteria responsive to antibiotic therapy or as a bridge to improve clinical status (see the next section). However, deploying a stent graft into an active, uncontrolled infection, particularly in the presence of purulence, carries a high risk of graft failure and persistent infection.

Significant thrombus or calcifications in the aortic arch pose additional risks, including embolisation or incomplete sealing. Alternative access to the femoral artery might be an option to avoid the aortic arch in cases where the treatment is limited to only the ascending aorta. While thrombus or calcification in the ascending aorta is exceedingly rare, it can be a concern if located within the proximal or distal sealing zones of the stent graft. The presence of significant thrombus in these areas may increase the risk of embolisation, incomplete apposition, or endoleaks, potentially

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compromising procedural success. Careful pre-operative imaging and planning are essential to assess the extent and stability of any thrombus or calcification. If deemed significant, alternative strategies, including adjusting landing zones or reconsidering patient selection, should be evaluated. The determination of significant thrombus or calcification should be made on a case by case basis, guided by detailed imaging and clinical judgement. The treating physician must weigh these risks against the potential benefits of aT-EVAR, adapting the approach to the patient's specific anatomy and clinical condition.

While each of these conditions demands extra caution, with meticulous planning and adaptation, aT-EVAR remains a viable option for appropriately selected high risk patients.

Consensus statement	Class	Level of evidence
21. aT-EVAR may be considered despite previous coronary artery bypass grafting, transcatheter aortic valve replacement, active infections, or significant thrombus and or calcifications, if anatomically suitable.	IIb	C

Bridge to open procedure

Bridge to open procedure evaluates the use of aT-EVAR as a temporary stabilising measure in high risk or emergency settings to enable delayed definitive open repair once the patient is stabilised or better optimised.

PICO: In high risk or unstable patients with ascending aortic pathology, does aT-EVAR as a bridge to open surgery improve outcomes compared with immediate open repair or no intervention?

aT-EVAR may be considered a bridge to definitive open surgical treatment in emergency settings, offering a stabilising option for patients who are haemodynamically unstable or at high immediate surgical risk. This approach can be particularly valuable in scenarios such as infected aortic lesions or acute aortic syndromes, where immediate definitive repair may not be feasible.

For infected lesion cases, aT-EVAR can help control bleeding or stabilise the aorta, allowing time for infection management with targeted antibiotic therapy. This temporary measure is most appropriate in controlled infections caused by bacteria responsive to treatment, providing a pathway to definitive surgical or endovascular repair once the infection is better controlled. However, care must be taken to avoid deploying stent grafts in actively infected fields filled with purulence, as this can lead to persistent infection or graft failure.

In other emergency scenarios, such as rupture of the ascending aorta, aT-EVAR can rapidly stabilise the patient by securing the damaged segment, reducing the risk of catastrophic events. In these instances, the procedure serves as an initial lifesaving intervention, with the intent to perform definitive repair, either open or endovascular, once the patient's condition has stabilised. This staged approach allows for better pre-operative planning and optimisation, improving overall outcomes.

While there are no data on the long term durability of aT-EVAR, its role as a temporary solution to bridge high risk patients to definitive treatment has been effective in selected cases. In ten patients who were unfit for open surgery at the time of the first surgery, open surgery was performed after stabilisation with aT-EVAR.[3,4] Careful patient selection and timing of follow up intervention are critical to the success of this staged management strategy.

Consensus statement	Class	Level of evidence
22. aT-EVAR may be considered as a bridge to definitive open surgical treatment in the emergency setting.	IIb	C

Endoleaks

Endoleaks evaluates the need for re-intervention *vs*. conservative management following the detection of endoleaks after aT-EVAR.

PICO: In patients with endoleaks following aT-EVAR, does re-intervention improve outcomes compared with conservative management with imaging surveillance?

Direct endoleaks (type Ia, Ib, III) following aT-EVAR should be considered for re-intervention, considering the patient's surgical risk, anatomy, and clinical condition (Fig. 5). These complications, which compromise the seal or graft integrity, require careful assessment to determine the best course of action.

Re-intervention needs to be approached with caution, particularly in the ascending aorta, where the anatomy and high pressures make intervention challenging. Ballooning in this region, especially in dissection cases, can result in catastrophic complications, including rupture, distal stent graft migration, or worsening of the dissection, making it a last resort option. Decisions should be made judiciously, ensuring that intervention is necessary and carries an acceptable risk.

In small or low flow endoleak cases observed during completion angiography or discharge computed tomography, conservative management is often appropriate. Monitoring the lesion with serial computed tomography angiography scans allows time to observe whether it resolves spontaneously, which, according to the CWC, is common. This approach reduces the risk of unnecessary intervention, while ensuring that any progression is detected early for timely action.

Endoleaks observed during follow up may need more immediate treatment. When required, the approach should be tailored to the patient's anatomy and specific circumstances, such as extending the sealing zone or addressing structural issues with the stent graft. Each decision must carefully weigh the benefits of intervention against the potential risks, particularly in the delicate and dynamic environment of the ascending aorta. Adjunctive ballooning or additional stent grafting may be better tolerated in elective situations than acute dissections.

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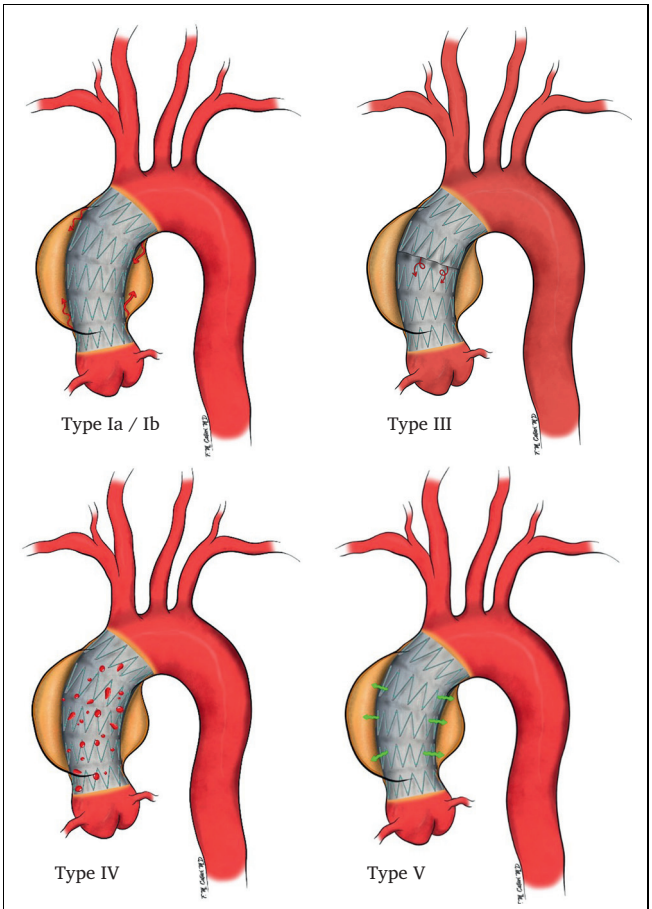

Figure 5. Types of endoleak after ascending thoracic endovascular aortic repair: Type I: Leak at the proximal(a) or distal(b) seal zones; Type III: Leak from graft fabric tear or modular disconnection; Type IV: Flow through graft wall due to porosity; Type V (Endotension): Continued sac expansion without visible leak. The arrows represent blood flow entering the area that has been covered by the stent.

Consensus statement	Class	Level of evidence
23. Direct endoleaks (IA, IB, III) after aT-EVAR should be considered for re-intervention, considering the surgical risk, anatomy, and clinical condition.	IIa	C

Flushing

Flushing evaluates whether pre-flushing the endograft system reduces the risk of cerebral air embolism and related complications compared with no or inadequate flushing techniques during aT-EVAR.

PICO: In patients undergoing aT-EVAR, does pre-flushing of the endograft system reduce the risk of cerebral embolism and procedural complications compared with no or inadequate flushing?

Pre-flushing of the endograft is a critical step in aT-EVAR to reduce the risk of cerebral air embolism, a potentially severe complication that can result in stroke or neurological deficits. Effective flushing removes air from the stent graft system, ensuring procedural safety by minimising embolisation risks.

The process must be executed carefully, with the operating surgeon directly performing or supervising the flushing to ensure that no air bubbles remain. For sheath constrained endografts, a combination of CO_2 flushing followed by saline is particularly effective, as CO_2 efficiently displaces air and is quickly absorbed into the bloodstream, while saline ensures complete clearance.[34] For sleeve constrained endografts, back bleeding is the recommended method, allowing natural egress of air through the delivery system.

In other cases, saline or heparinised solutions are commonly used and can adequately clear air when thoroughly applied. While blood flushing is an option, it requires precise handling to avoid clot formation. Regardless of the technique, careful inspection of the system during and after flushing is essential.

It is the opinion of the CWC that adapting the flushing approach to the endograft design and ensuring that it is performed thoroughly by the surgeon are ways of reducing the risk of complications.

Consensus statement	Class	Level of evidence
24. Pre-flushing of the endograft should be considered in patients undergoing aT-EVAR to decrease the risk of cerebral air emboli.	IIa	C

CONCLUSION

aT-EVAR represents an advance in the treatment of complex thoracic aortic diseases and has emerged as a viable option for highly selected patients with specific diseases. This consensus document underscores its potential role in managing conditions, such as PAUs, pseudoaneurysms, acute and chronic TAAD, and type A IMH, provided that patients meet precise anatomical and clinical criteria. The recommendations highlight the importance of meticulous patient selection, the use of advanced imaging modalities, and the necessity of performing the procedure in specialised centres equipped with multidisciplinary expertise. While aT-EVAR offers a less invasive alternative to traditional open surgery, its use must be carefully considered on a case by case basis, ensuring optimal outcomes, while minimising risks. This evolving therapeutic option adds a valuable dimension to the armamentarium for managing thoracic aortic diseases in the modern era.

RECOMMENDATIONS FOR FUTURE RESEARCH

Device specific evidence

A lack of commercially available stent grafts specifically designed for the ascending aorta has led to the off label use of devices intended for other aortic segments. The long term outcomes of such adaptations remain underexplored. There are limited data on the performance of newly developed and currently investigational devices, such as the Gore ASG, in diverse clinical scenarios and patient populations.

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Standardised protocols

There is no consensus on optimal pre-, intra-, and post-operative protocols for aT-EVAR. For example, guidelines for access site selection, graft sizing, and techniques to manage complications such as endoleaks are based on expert opinion rather than robust evidence.

Outcome data

Most studies on aT-EVAR report short and midterm outcomes, with a significant lack of data on long term durability, survival, and re-intervention rates. Outcomes for specific subgroups, such as patients with connective tissue disorders and those with heavily calcified or thrombotic aortas, are poorly characterised.

Complication management

There is limited evidence regarding the optimal management of complications such as type Ia endoleaks, stroke, and graft migration. The effectiveness and safety of various interventions, such as ballooning or additional stent graft placement, remain unclear.

Patient selection criteria

Clear, evidence based criteria for patient selection are lacking. This is particularly relevant for high risk groups, such as those with previous aortic surgery, complex aortic anatomy, or infections.

Role of adjunctive techniques

The effectiveness of adjunctive imaging modalities, such as TOE and IVUS, and the role of cerebral protection devices during aT-EVAR needs further investigation. The impact of techniques like rapid ventricular pacing and their necessity in modern procedures remains insufficiently studied.

Infections and aortic disease

There is limited evidence on the safety and effectiveness of aT-EVAR in patients with infected aortic lesions, particularly regarding the appropriate timing and use of stent grafts in the context of ongoing infection.

Real world data and trials

Most evidence comes from case series, retrospective studies, and small cohorts, with high heterogeneity and selection bias. Randomised controlled trials or large prospective registries specifically focusing on aT-EVAR are almost non-existent. Evidence comparing aT-EVAR with open surgical repair or medical management in specific conditions, such as TAADs or pseudoaneurysms, is sparse and may be difficult to perform due to the need for equipoise in patient profiles.

Impact of surgeon experience

The influence of surgeon experience and institutional volume on aT-EVAR outcomes is poorly documented, despite being a probable critical factor in procedural success.

CONFLICT OF INTEREST

S. Trimarchi is consultant and speaker for Medtronic Inc., WL Gore and Associates, and Terumo Aortic. M. Czerny is a consultant for Terumo Aortic, Medtronic, NEOS, and Endospan, received speaking honoraria from Cryolife Jotec and Bentley, and is a shareholder and co-founder of TEVAR Ltd. and Ascense Medical. S. Haulon has intellectual property in and is a consultant for Cook Medical and is consultant for Bentley InnoMed. J. van Herwaarden is or has been proctor or consultant for Gore Medical, Terumo Aortic, and Cook Medical. E. Roselli has a consulting, advisory, and speaking function for Artivion, Inc., Edward Lifesciences Corporation, Terumo Aortic, and WL Gore and Associates.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejvs.2025.05.023.

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