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Long-term Outcomes of Endovascular Repair of Acute Type B Aortic Dissection: A Systematic Review

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Abstract **Objectives:** To assess the long-term efficacy and safety of thoracic endovascular aortic repair (TEVAR) in the treatment of acute type B aortic dissection (ATBAD), emphasizing endpoints such as survival, re-intervention rates and complications throughout prolonged follow-up periods. **Methods:** An exhaustive search of the four databases yielded 1016 pertinent papers. Following the elimination of duplicates with the Rayyan QCRI and the assessment for relevance, 93 full-text publications were examined, with eight studies eventually satisfying the inclusion requirements. **Results:** Eight years of study on patients with ATBAD found a long-term mortality rate of 7.7% in uncomplicated cases and 78% in complicated cases, with a total mortality rate of 311 (10%). The post-operative complications and re-intervention rates varied. Preoperative inflammatory and lipid profiles are key predictors of mortality risk. **Conclusion:** TEVAR, a treatment for ATBAD, has shown potential long-term benefits. However, patient selection should be individualized based on risk factors and anatomical characteristics. Further research is needed to validate these findings, refine clinical guidelines and improve the safety and efficacy of TEVAR in diverse patient populations to ensure optimal treatment outcomes.

Key Words Aortic dissection, Type B, Endovascular repair, TEVAR durability, cardiovascular outcomes, Mortality, Long-term outcomes, Systematic review

INTRODUCTION

An entrance rip in the intimal layer of the aorta distal to the left subclavian artery (LSA) is a common feature of Stanford Type-B Aortic Dissection (TBAD). The False Lumen (FL), which grows over time and may eventually burst, receives blood from the True Lumen (TL) [1]. Antegrade or retrograde propagation of this initial entry tear may cause malperfusion or ischemia of the end organs as well as static blockage of the branch artery. A more frequent mechanism for malperfusion is dynamic obstruction, which is caused by the movable intimomedial dissection flap intermittently blocking a branch artery [2]. TBAD is a potentially fatal illness with a high morbidity rate of approximately 3 per 100,000 individuals [3]. TBAD can be divided into subgroups according to the duration and existence of problems. Co-TBAD, or complicated TBAD is characterized by specific symptoms at presentation that are linked to increased morbidity and mortality. End-organ malperfusion and aortic rupture are the two main side effects. TBAD is categorized as a simple TBAD (un-TBAD) if there is no rupture or malperfusion. TBAD can be categorized as acute (less than 15 days after symptom onset), subacute (15-90 days after symptom onset), or chronic (>90 days after symptom onset) based on the time of onset [1]. Currently, standard therapies for ATBAD include TEVAR and the best medical care [4]. TEVAR has emerged as a valuable option for managing Type B aortic dissections, particularly in patients with complications such as rupture risk, uncontrolled pain, malperfusion (reduced blood flow to vital organs), or aneurysmal growth in the affected area [4]. Compared to traditional open surgical

repair, TEVAR offers multiple advantages, including shorter recovery times, reduced risk of operative complications and less physiological stress on the patient. Open surgery typically requires thoracotomy (large chest incision) and is associated with longer hospital stay and higher morbidity, especially in older or medically fragile patients. TEVAR is minimally invasive and is associated with fewer post-procedural complications, lower mortality and shorter recovery times, making it a preferred option for high-risk patients or those with a complex anatomy that complicates open surgery [5].

Although TEVAR is increasingly used in the acute setting for TBAD, there is still limited clarity regarding its long-term outcomes, especially concerning survival rates, aortic remodeling, re-intervention rates and quality of life. As a relatively new intervention, understanding the durability and long-term efficacy of TEVAR in ATBAD is essential to guide clinical practice, optimize patient outcomes and refine the treatment guidelines. A systematic review is needed to consolidate evidence, address gaps and analyze TEVAR's role in long-term ATBAD management.

There is a consensus that swift and robust management of blood pressure using β-blockers and nitroprusside is crucial. However, they do not replace surgical or endovascular repairs.

As observed, these studies were limited to geographical areas of high socioeconomic status and, therefore, cannot represent the global population, as the procedure itself is not yet widely available.

Objectives

This systematic review aims to:

- Evaluate the long-term efficacy and safety of TEVAR in managing ATBAD
- Focus on outcomes such as survival, re-intervention rates and complications over extended follow-up periods
- Clarify the durability and impact of TEVAR in ATBAD
- Guide future clinical practice and optimize patient's outcome
- State the deficiency in the availability of such knowledge

METHODS

Search strategy

This systematic review followed the PRISMA and GATHER criteria. A thorough search was performed to identify relevant papers describing the long-term efficacy and safety of TEVAR for the management of ATBAD. The reviewers searched four electronic databases: PubMed, the Cochrane Library, Web of Science and SCOPUS. Studies published between 2021-2024 were considered in this meta-analysis. We uploaded all titles and abstracts found through computerized searches in Rayyan and eliminated duplicates. The texts of all studies that satisfied the inclusion criteria based on the title or abstract were collected for full assessment. Two reviewers reviewed the appropriateness of the extracted papers and corrected any contradictions through conversation.

Study population-selection

The Population, Intervention, Comparison and Outcome (PICO) elements were utilized as inclusion criteria for our review: (i) Population: Patients diagnosed with ATBAD; (ii) Intervention: TEVAR; (iii) Comparator: Alternative therapies, if applicable and (iv) Outcome: Long-term outcomes. Only the primary studies on the treatment of ATBAD using TEVAR were included.

Data retrieval

Two reviewers extracted data from papers that fulfilled the inclusion criteria in a uniform and standardized manner. The following information was obtained and documented: (i) First author, (ii) Year of publication, (iii) Study design, (iv) Number of participants, (v) Age, (vi) Sex, (vii) Follow-up duration (in years), (viii) Condition (complicated/uncomplicated), (ix) Mortality rate, (x) Complication rate, (xi) Re-intervention rate and (xii) Main outcomes (Table 1).

Quality review

We employed the ROBINS-I methodology to assess the risk of bias, as it facilitates a comprehensive evaluation of confounding variables, which is crucial because of the prevalence of bias from omitted factors in studies within this domain. The ROBINS-I method is designed to assess non-randomized studies and is applicable to cohort designs in which subjects subjected to different staffing levels are observed over time. Two reviewers independently evaluated the risk of bias for each paper and discrepancies were reconciled through group discussions [6] (Table 2).

RESULTS

The designated search strategy produced 1016 publications (Figure 1). Following the elimination of duplicates (n = 566), 450 trials were assessed based on their titles and abstracts. Of these, 357 did not meet the eligibility criteria, resulting in 93 full-text articles for thorough review. Four records were discovered through a citation search, leading to the inclusion of 89 records in the review. Ultimately, eight met the eligibility requirements for evidence synthesis analysis, all of which were retrospective cohorts [8-15].

Sociodemographic and clinical outcomes

We included eight studies with a total of 3108 ATBAD patients and the majority were males 2472 (79.5%). Five

Table 1: Outcome measures of the included studies

Study ID	Study design	Country	Sociodemographic	Condition	Follow-up (years)	Mortality	Complications	Re-intervention	Main outcomes
Xie *et al.*, [8]	Retrospective cohort	China	N = 637 Mean age: 54.5 Males: 554 (86.9%)	Uncomplicated	4	55 (8.6%)	NM	NM	The preoperative monocyte to high-density lipoprotein ratio was found to be independently linked to both short- and long-term mortality.
Liang *et al.*, [9]	Retrospective cohort	China	N = 27 Mean age: 63.7 Males: 25 (92.5%)	Complicated	5	21 (78%)	NM	NM	In the group of ATBAD patients with a single kind of malignant tumor, TEVAR increases the 5-year overall and aortic disease-free survival rates.
Torrent *et al.*, [10]	Retrospective cohort	USA	N = 688 Mean age: 60.7 Males: 438 (63.7%)	Uncomplicated	1	53 (7.7%)	144 (20.9%)	64 (9.3%)	Neither mortality nor post-operative complications seem to be independently predicted by the time of TEVAR for UATBAD.
Du *et al.*, [11]	Retrospective cohort	China	N = 463 Mean age: 53.4 Males: 392 (84.6%)	Uncomplicated	5	26 (5.6%)	127 (27.4%)	27 (5.8%)	The therapeutic approach and risk factors for AD-related events and mortality are well documented, and TEVAR is a potential treatment for patients with ATBAD.
Rychla *et al.*, [12]	Retrospective cohort	Switzerland	N = 57 Mean age: 69 Males: 42 (73.7%)	Complicated	5	20 (38.5%)	0	10 (19.2%)	More conservative oversizing may reduce up to 50% of aortic-related incidents.
Li *et al.*, [13]	Retrospective cohort	China	N = 463 Mean age: 59.8 Males: 394 (85%)	Complicated	5	66 (14.3%)	93 (20%)	25 (5.4%)	In patients with acute or subacute TBAD having TEVAR, CAD was linked to worse short- and long-term results.
Tang *et al.*, [14]	Retrospective cohort	China	N = 567 Mean age: 53.6 Males: 489 (86.2%)	Uncomplicated	5	46 (9.9%)	46 (9.9%)	46 (9.9%)	A dissection length of more than 150 mm was a risk factor for TBAD patient mortality and TEVAR treatment could lower the long-term mortality of TBAD patients.
Beck *et al.*, [15]	Retrospective cohort	USA	N = 206 Mean age: 60.2 Males: 138 (66.9%)	Uncomplicated	5	24 (11.7%)	28 (13.6%)	14 (6.8%)	TEVAR is a possible treatment for patients with ATBAD and the therapeutic method and risk factors for AD-related events and mortality are well established.

Table 2: Risk of bias assessment using ROBINS-I

Study ID	Bias due to confounding	Bias in the selection of participants into	Bias in the classification of interventions	Bias due to deviations from the intended interval	Bias due to missing data	Bias in the measurement of outcomes	Bias in the selection of reported result	Overall bias
Xie *et al.*, [8]	Mod	Mod	Low	Low	Low	Low	Low	Low
Liang *et al.*, [9]	Low	Low	Low	Low	Low	Mod	Low	Low
Torrent *et al.*, [10]	Low	Mod	Low	Low	Low	Low	Low	Low
Du *et al.*, [11]	Mod	Low	Low	Low	Low	Low	Low	Low
Rychla *et al.*, [12]	Mod	Mod	Low	Low	Low	Low	Mod	Moderate
Li *et al.*, [13]	Mod	Mod	Low	Low	Mod	Low	Mod	Moderate
Tang *et al.*, [14]	Crit	Low	Crit	Low	Mod	Mod	Low	Critical
Beck *et al.*, [15]	Crit	Low	Low	Low	Low	Mod	Low	Critical

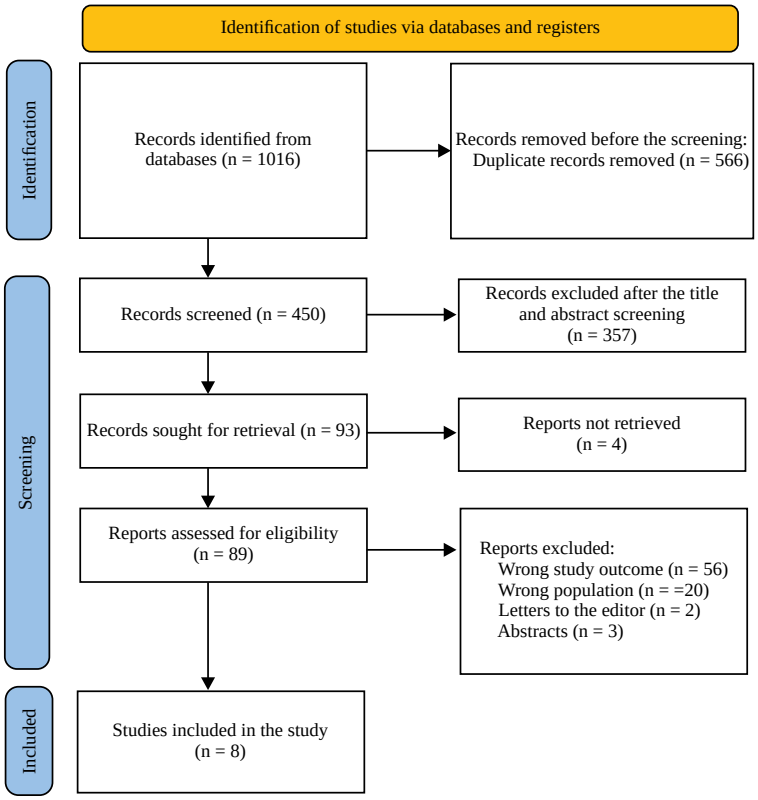

Figure 1: PRISMA flowchart [7]

studies were conducted in China [8, 9,11,13,14], two in the USA [10,15] and one in Switzerland [12]. The follow-up durations in these studies ranged from one to five years. Only three studies included patients with complicated ATBAD [8,12,13] and the remaining included uncomplicated cases.
The long-term mortality rate after TEVAR for ATBAD ranged from 7.7% [10] in uncomplicated cases to 78% [9] in complicated cases, with a total mortality rate of 311 (10%). The incidence of post-operative complications ranged from 0 [12] to 27.4% [11]. Moreover, the re-intervention rate ranges from 5.4% [13] to 19.2% [12].

The monocyte-to-high-density lipoprotein ratio has an independent predictive value for both short- and long-term mortality [8]. TEVAR enhances the 5-year survival and aortic disease-free rates in patients with a single malignant tumor, indicating its potential as a viable intervention for complex ATBAD [9].

Torrent *et al.* [10] noted that neither mortality nor post-operative complications were directly linked to the timing of TEVAR for uncomplicated ATBAD, potentially supporting a flexible intervention window [10,11,15]. Coronary Artery Disease (CAD) correlates with poorer short- and long-term outcomes in patients with ATBAD undergoing TEVAR, underlining CAD as a critical factor in the preoperative evaluation [13].

DISCUSSION

This review reported that the long-term mortality rate after TEVAR for ATBAD ranged from 7.7% [10] in uncomplicated cases to 78% [9] in complicated cases, with a total mortality rate of 311 (10%). Zhao *et al.* [16] reported that in a 1-year survival trial, the mortality rate in the acute stage group was significantly higher than that in the subacute stage group. The comparatively high death rate in the subacute phase suggests that the acute phase group has a greater long-term advantage than the subacute phase group for longer follow-up studies lasting three-five years [16]. Yang *et al.* [17] reported that, although there was no discernible difference in follow-up mortality between the two groups, this meta-analysis indicated that patients in the acute uncomplicated TBAD group had higher 30-day complications and 30-day mortality [17].

The incidence of post-operative complications ranged from 0 [12] to 27.4% [11]. Moreover, the re-intervention rate ranges from 5.4% [13] to 19.2% [12]. Zhao *et al.* [16] the perioperative complication ($p<0.0001$) and mortality ($p<0.0001$) rates in the acute group were more than twice as high as those in the subacute group, according to the OR values obtained by combining the results of each study regarding 30-day complications and mortality using the fixed-effects model [16]. Dissecting membranes are often

thinner and more delicate than normal, which may be the cause of the markedly elevated risk of problems during the acute period [18].

In the most recent follow-up trials, re-intervention was linked to excessive stent oversizing, significant aortic dilatation, anticoagulant therapy and bare-spring stent graft location in the proximal landing zone [19]. Re-intervention is typically managed endovascularly, saving patients from open surgical intervention, as demonstrated by several encouraging findings [20].

We found that the monocyte-to-high-density lipoprotein ratio has an independent predictive value for both short- and long-term mortality [8]. TEVAR enhances the 5-year survival and aortic disease-free rates in patients with a single malignant tumor, indicating its potential as a viable intervention for complex ATBAD [9]. Harky *et al.* [21] reported that for individuals who arrive with acute type B aortic dissection, endovascular treatment provides good perioperative results for up to five years [21]. CAD correlates with poorer short- and long-term outcomes in patients with ATBAD undergoing TEVAR, underlining CAD as a critical factor in preoperative evaluation [13].

These findings suggest a stratified approach to TEVAR in patients with ATBAD. For those with uncomplicated presentations, TEVAR offers substantial benefits, with relatively low mortality and complication rates. However, in complicated cases, clinicians should weigh the high mortality and re-intervention rates carefully, potentially considering alternative strategies or additional supportive measures to improve outcomes.

Strengths and limitations

This review consolidates the findings of several retrospective studies and offers a broad perspective on the long-term outcomes of TEVAR in ATBAD patients. By highlighting key risk factors, such as CAD, tumor presence and anatomical factors, our study underscores a more personalized approach to managing ATBAD, which could contribute to improved survival rates. Additionally, identifying the potential of specific biomarkers and anatomical parameters as predictors of outcomes provides a foundation for more nuanced preoperative assessment.

The primary limitation of these findings was the retrospective design of the included studies, which may have introduced bias and limited the generalizability of the results. The patient populations were also predominantly from specific geographic regions (China, the USA and Switzerland), which might restrict the applicability of the findings to a broader demographic population. Additionally, the lack of standardization in follow-up duration across studies presents challenges in making direct comparisons of outcomes.

CONCLUSIONS

TEVAR offers promising long-term benefits for patients with ATBAD, with survival rates influenced by factors such as CAD status, tumor presence, dissection length, and stent sizing. Although TEVAR appears beneficial, patient selection should be individualized based on specific risk factors and anatomical characteristics to optimize the treatment outcomes. Further prospective research is needed to validate these findings, refine the clinical guidelines, and enhance the safety and efficacy of TEVAR in diverse patient populations.

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