Type B Aortic Dissection: Systematic Review with ☸SAIMSARA.

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Abstract: The aim of this paper is to systematically review and synthesize the current literature on type B aortic dissection, extracting and structuring key findings to identify predominant research themes, significant numerical results, clinical implications, and future research directions. The review utilises 382 studies with 89251 total participants (naïve ΣN). Research on type B aortic dissection spans a broad spectrum, from identifying critical prognostic factors like maximal aortic diameter, false lumen dynamics, and aortic arch morphology, to evaluating the efficacy and complications of various treatment strategies. Endovascular repair (TEVAR) has emerged as a cornerstone, demonstrating superior false lumen thrombosis compared to medical therapy, though its long-term mortality benefit for uncomplicated cases remains debated. Computational modeling and advanced imaging techniques are increasingly providing patient-specific hemodynamic insights and aiding in surgical planning. Despite advancements, the variability in reported mortality (median 6.4%, range 2-13.9%) highlights the complexity of this condition. A key limitation is the prevalence of retrospective studies, which necessitates future prospective, multi-center trials. Clinically, careful risk stratification using anatomical and inflammatory markers, coupled with personalized treatment approaches, is crucial to improve patient outcomes.

Keywords: Type B aortic dissection; False lumen; Thoracic endovascular aortic repair; Aortic remodeling; Computational fluid dynamics; 4D Flow MRI; False lumen thrombosis; Hemodynamics; Acute aortic dissection; Prognosis

Review Stats

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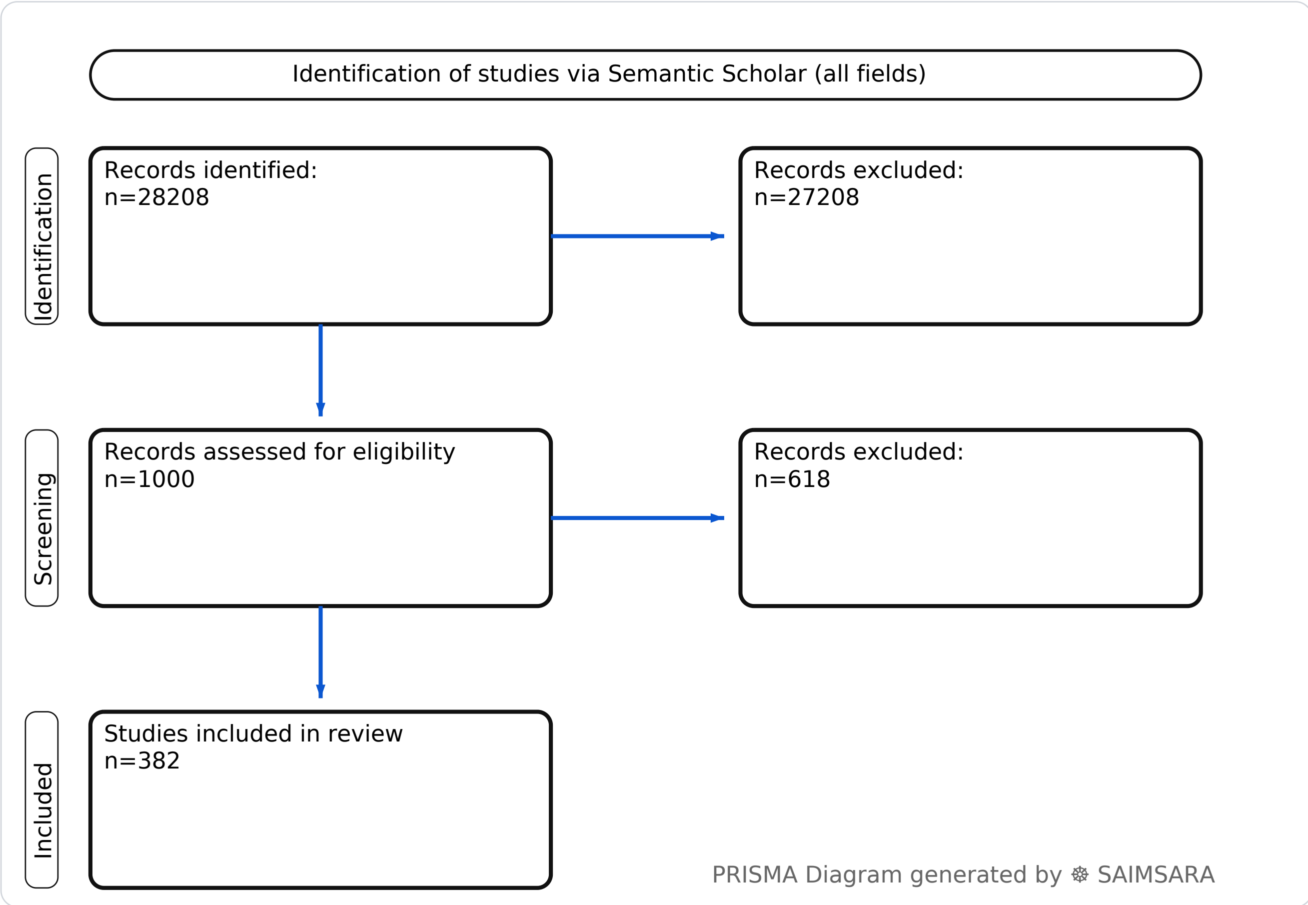
- Total study participants (naïve ΣN): 89251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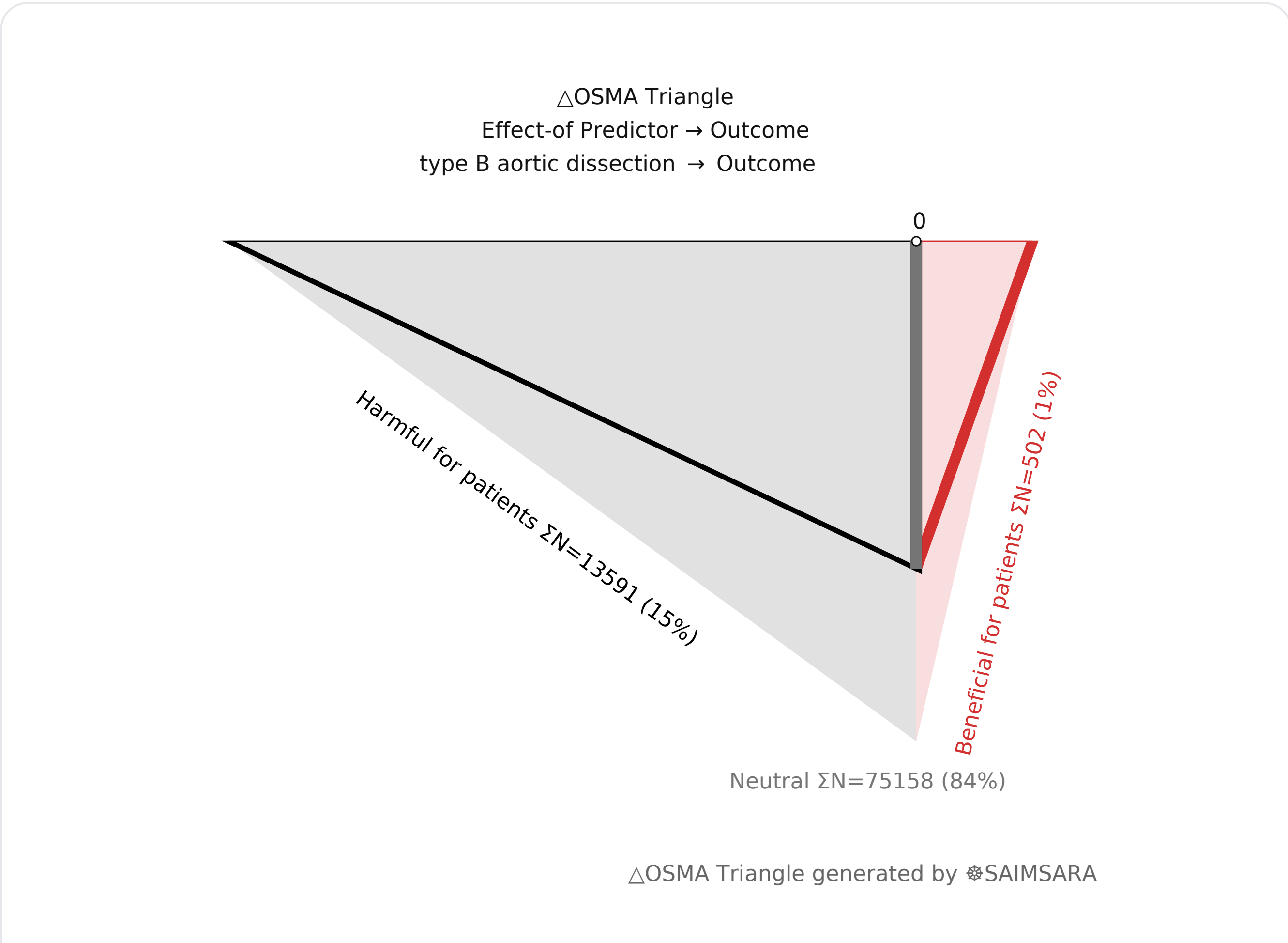
PRISMA Diagram generated by ☸ SAIMSARA


△OSMA Triangle
Effect-of Predictor → Outcome
type B aortic dissection → Outcome
0
Harmful for patients ΣN=13591 (15%)
Beneficial for patients ΣN=502 (1%)
Neutral ΣN=75158 (84%)
△OSMA Triangle generated by ☸SAIMSARA

Outcome-Sentiment Meta-Analysis (OSMA): *(LLM-only)*

Frame: Effect-of Predictor → Outcome • *Source*: Semantic Scholar

Outcome: Outcome Typical timepoints: peri/post-op, 30-day. Reported metrics: %, CI, p.

Common endpoints: Common endpoints: mortality, complications, survival.

Predictor: type B aortic dissection — exposure/predictor. Routes seen: iv. Typical comparator: a rigid model, manual methods, control, optimal medical therapy….

- **1) Beneficial for patients** — Outcome with type B aortic dissection — [127] — ΣN=502
- **2) Harmful for patients** — Outcome with type B aortic dissection — [1], [28], [34], [35], [38], [40], [41], [43], [45], [50], [60], [62], [183], [189], [190], [191], [192], [194], [229], [233], [234], [235], [236], [241], [272], [273], [276], [278], [280], [284], [285], [288], [289], [290], [294], [296], [298], [352], [370] — ΣN=13591
- **3) No clear effect** — Outcome with type B aortic dissection — [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [29], [30], [31], [32], [33], [36], [37], [39], [42], [44], [46], [47], [48], [49], [51], [52], [53], [54], [55], [56], [57], [58], [59], [61], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [99], [100], [101], [102], [103], [104], [105], [106], [107], [108], [109], [110], [111], [112], [113], [114], [115], [116], [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [128], [129], [130], [131], [132], [133], [134], [135], [136], [137], [138], [139], [140], [141], [142], [143], [144], [145], [146], [147], [148], [149], [150], [151], [152], [153], [154], [155], [156], [157], [158], [159], [160], [161], [162], [163], [164], [165], [166], [167], [168], [169], [170], [171], [172], [173], [174], [175], [176], [177], [178], [179], [180], [181], [182], [184], [185], [186], [187], [188], [193], [195], [196], [197], [198], [199], [200], [201], [202], [203], [204], [205], [206], [207], [208], [209], [210], [211], [212], [213], [214], [215], [216], [217], [218], [219], [220], [221], [222], [223], [224], [225], [226], [227], [228], [230], [231], [232], [237], [238], [239], [240], [242], [243], [244], [245], [246], [247], [248], [249], [250], [251], [252], [253], [254], [255], [256], [257], [258], [259], [260], [261], [262], [263], [264], [265], [266], [267], [268], [269], [270], [271], [274], [275], [277], [279], [281], [282], [283], [286], [287], [291], [292], [293], [295], [297], [299], [300], [301], [302], [303], [304], [305], [306], [307], [308], [309], [310], [311], [312], [313], [314], [315], [316], [317], [318], [319], [320], [321], [322], [323], [324], [325], [326], [327], [328], [329], [330], [331], [332], [333], [334], [335], [336], [337], [338], [339], [340], [341], [342], [343], [344], [345], [346], [347], [348], [349], [350], [351], [353], [354], [355], [356], [357], [358], [359],

[360], [361], [362], [363], [364], [365], [366], [367], [368], [369], [371], [372], [373], [374], [375], [376], [377], [378], [379], [380], [381], [382] — ΣN=75158

1) Introduction

Type B aortic dissection (TBAD), characterized by an intimal tear distal to the left subclavian artery, represents a significant cardiovascular emergency with diverse clinical presentations and outcomes. The management of TBAD has evolved considerably, encompassing medical, endovascular, and open surgical strategies. Understanding the intricate interplay of anatomical, hemodynamic, and patient-specific factors is crucial for accurate diagnosis, risk stratification, and optimizing therapeutic interventions to improve patient prognosis and long-term aortic remodeling. This paper synthesizes current research on TBAD, highlighting key findings across diagnostic, prognostic, and therapeutic domains.

2) Aim

The aim of this paper is to systematically review and synthesize the current literature on type B aortic dissection, extracting and structuring key findings to identify predominant research themes, significant numerical results, clinical implications, and future research directions.

3) Methods

Systematic review with multilayer AI research agent: keyword normalization, retrieval & structuring, and paper synthesis (see SAIMSARA About section for details).

- **Bias:** Qualitatively inferred from study design fields. Retrospective cohort studies and mixed-design studies are prevalent, introducing potential selection and recall biases. Synthetic/simulation studies provide mechanistic insights but require clinical validation. Lack of specified directionality in some mixed studies limits definitive causal inference.

4) Results

4.1 Study characteristics

The included studies predominantly comprised retrospective cohort analyses, mixed-design investigations combining retrospective data with other methodologies, and numerous synthetic/simulation studies focusing on computational fluid dynamics (CFD) and biomechanical modeling. Patient populations were primarily Chinese or general adult cohorts with acute or chronic type B aortic dissection, with some studies focusing on specific subgroups such as Marfan syndrome patients or octogenarians. Follow-up periods varied widely, from in-hospital outcomes to long-term surveillance spanning up to 13 years.

4.2 Main numerical result aligned to the query

Across various studies, the in-hospital or 30-day mortality rate for type B aortic dissection patients, encompassing both medically and endovascularly managed cases, showed a median of 6.4% [322]. Reported rates ranged from 2% [302] to 13.9% [352], reflecting heterogeneity in patient cohorts, complication status, and treatment strategies.

4.3 Topic synthesis

- **Mortality and Prognostic Factors:** Maximal aortic diameter showed a J-curve relationship with in-hospital mortality (OR=1.06, 95% CI 1.03-1.10) [1]. Uncontrolled hypertension and a dissecting aorta diameter >4.75 cm were independent predictors of early mortality [191]. High blood pressure variability (BPV) was an independent predictor of aorta-related death [296]. The triglyceride/high-density lipoprotein cholesterol (TG/HDL-c) ratio positively correlated with in-hospital mortality (OR=2.08, 95% CI 1.32-3.27) [28].
- **Aortic Morphology and Geometry:** Increased aortic arch tortuosity and angulation, along with a type III arch configuration, were identified as independent geometric factors associated with acute type B aortic dissection (aTBAD) [30, 32, 34, 35]. The distance of the primary intimal tear from the left subclavian artery (LSA) was an independent predictor of aortic growth rate [13, 69]. Preoperative aortic arch angulation predicted a postoperative bird-beak configuration after TEVAR, with a cut-off angle of 59.15° [40].
- **False Lumen Dynamics and Thrombosis:** False lumen ejection fraction (FLEF) and false lumen relative pressure (FL ΔP_{max}) derived from 4D flow CMR independently correlated with aortic growth rate ($r=0.78$, $p=0.003$ for FLEF) [5, 13]. Failure of complete false lumen thrombosis and an aortic diameter ≥5.5 cm were identified as independent risk factors for adverse aortic events (AAEs) in chronic type B AD treated with TEVAR [25]. Partial false lumen thrombosis was also independently associated with late adverse events and long-term mortality [52, 289].
- **Endovascular Repair (TEVAR) Outcomes:** Thoracic endovascular aortic repair (TEVAR) for acute uncomplicated type B AD provided superior false lumen thrombosis compared to optimal medical therapy (OMT) [22]. However, initial TEVAR for acute uncomplicated type B AD (uTBAD) was not associated with improved mortality or reduced hospitalizations over 5 years in older adults, although a sensitivity analysis showed lower mortality in the first year [9]. TEVAR performed at ≥15 days post-onset was independently associated with lower in-hospital/30-day mortality and improved 1-year survival (OR=0.38, P=.0388) [187].

- **TEVAR Complications and Management:** Left subclavian artery (LSCA) coverage, diabetes mellitus, and general anesthesia were identified as independent predictors of stroke after TEVAR (OR=5.920, 95% CI: 2.077–16.878 for LSCA coverage) [11]. Secondary aortic intervention (SAI) after TEVAR for type B AD was common (27% overall rate) [232]. Cocaine users undergoing TEVAR had higher rates of endoleaks and reinterventions [60].
- **Adjunctive Endovascular Techniques:** The PETTICOAT technique for aortic dissection may promote aortic remodeling and reduce aorta-related adverse events compared to conventional TEVAR (8% vs 54%, $p<0.001$) [276], though it does not prevent long-term aneurysmal degeneration [24]. Left subclavian artery (LSA) revascularization using a Castor single-branched stent-graft during TEVAR reduced the incidence of stroke and left arm ischemia compared to LSA coverage [26, 188].
- **Surgical and Hybrid Approaches:** The frozen elephant trunk (FET) technique was a safe and feasible approach for chronic type B and non-A non-B aortic dissection, showing favorable long-term outcomes and freedom from reintervention (79.3% at 7 years) [46, 186, 249]. Hybrid repair of the aortic arch and proximal descending thoracic aorta was technically feasible for acute type B AD, with acceptable short-term mortality [318].
- **Computational Modeling and Hemodynamics:** Oscillatory shear and helicity were highly sensitive to inlet velocity distribution and flow volume throughout the false lumen (FL), indicating that the choice of inlet velocity profile may greatly affect the future clinical value of simulations [2]. Inclusion of minor aortic branches in patient-specific flow simulations improved agreement with 4D-flow MRI velocities and affected time-averaged wall shear stress (TAWSS) and transmural pressure (60-75% differences in metrics) [3]. Wall compliance and flap motion in integrated fluid-structure interaction (FSI) and thrombosis models influenced the progression of false lumen thrombosis (FLT), with the FSI model predicting a 25% larger thrombus volume compared to a rigid model [8].
- **Imaging and Segmentation:** A three-dimensional deep convolutional neural network (CNN) accurately and stably segmented and measured the diameter of type B AD from CT angiographic images, significantly reducing measurement time compared to manual methods (21.7 ± 1.1 vs. 82.5 ± 16.1 minutes, $p < 0.001$) [19]. An automated segmentation pipeline using machine learning accurately identified true and false lumina on CT angiograms, enabling derivation of morphologic parameters [23].
- **Inflammation and Biomarkers:** Elevated preoperative neutrophil-to-lymphocyte ratio (NLR) was an independent predictive factor of early adverse events within 2 years after TEVAR in uncomplicated type B AD patients (HR per SD, 1.98, 95% CI, 1.14–3.44; $P = 0.015$) [38]. NLR and fibrinogen (FIB) showed diagnostic value with high specificity for type B AD (AUC of 0.836 for NLR, 0.756 for FIB) [41].
- **Patient-Specific Considerations:** Women affected with type B acute aortic dissection were older and had more intramural hematoma, but no male-female differences in

management, early or late death, or morbidity were found after multivariable adjustment [15, 189]. In contemporary Marfan syndrome cohorts, type B dissections were more common than type A and occurred at traditional nonsurgical thresholds, with a high risk for re-interventions [192, 235, 370]. Pregnancy-related aortic dissection included 55% type B cases, often without a dilated descending aorta [358].

- **Natural History and Medical Management:** Medically managed uncomplicated subacute type B AD in octogenarians had excellent outcomes, with similar freedom from aorta-related death compared to younger patients, and less surgical intervention [59]. Optimal medical therapy (OMT) for acute uncomplicated type B AD (auTBAD) was associated with a 35% failure rate [22]. Antihypertensive medication adherence was identified as an important consideration in the management of chronic type B AD [64].

5) Discussion

5.1 Principal finding

The median in-hospital or 30-day mortality rate for type B aortic dissection patients was found to be 6.4% [322], with a range from 2% to 13.9% across various studies, indicating a significant, albeit variable, immediate risk associated with this condition.

5.2 Clinical implications

- **Risk Stratification:** Patients presenting with uncontrolled hypertension, larger aortic diameters (>4.75 cm), high blood pressure variability, or elevated inflammatory markers (NLR, FIB) are at increased risk for adverse outcomes and require intensified monitoring and potentially earlier intervention [1, 28, 38, 41, 191, 296].
- **Imaging for Prognosis:** Advanced imaging techniques, particularly 4D flow CMR and automated CTA segmentation, are crucial for assessing false lumen dynamics (FLEF, FL ΔPmax), aortic growth, and false lumen thrombosis, which are key predictors of disease progression and adverse events [5, 13, 19, 23, 25].
- **Timing of Intervention:** For uncomplicated type B AD, delayed TEVAR (≥15 days) may be associated with lower early mortality and improved 1-year survival [187], while initial TEVAR in older, uncomplicated patients may not offer a 5-year mortality benefit compared to medical therapy [9].
- **Preventing Complications:** Careful management of the left subclavian artery (LSCA) during TEVAR, potentially through revascularization with branched stent-grafts, can reduce stroke risk [11, 26, 188]. Preoperative assessment of aortic arch angulation is important to anticipate and mitigate complications like bird-beak configuration [40].

- **Personalized Treatment:** Marfan syndrome patients with type B AD often present at smaller aortic diameters than traditional intervention thresholds and face a high risk of re-intervention, highlighting the need for individualized management strategies [192, 235, 370].

5.3 Research implications / key gaps

- **Optimal TEVAR Timing:** Further randomized controlled trials are needed to definitively establish the optimal timing of TEVAR for uncomplicated type B AD, particularly regarding long-term mortality and re-intervention rates across different age groups [9, 65, 187].
- **Hemodynamic-Guided Therapy:** Prospective studies are required to validate computational fluid dynamics (CFD) and fluid-structure interaction (FSI) models in predicting false lumen thrombosis and aortic remodeling, to guide personalized treatment decisions and stent-graft design [2, 3, 8, 14, 49, 282, 286].
- **Biomarker Validation:** Larger prospective cohort studies are necessary to validate the diagnostic and prognostic utility of inflammatory markers (NLR, FIB, monocytes) and other novel biomarkers (lysophosphatidylcholines, sphingolipids, type IV collagen exposure) for early detection and risk stratification in type B AD [38, 41, 43, 274, 353].
- **Long-term PETTICOAT Efficacy:** More comprehensive, long-term studies are needed to evaluate the effectiveness of the PETTICOAT technique in preventing aneurysmal degeneration and improving distal aortic remodeling, especially in comparison to conventional TEVAR [24, 195, 276].
- **Aortic Arch Morphology:** Research should explore the precise biomechanical implications of specific aortic arch configurations (e.g., type III, tortuosity) on dissection initiation and progression, and how these factors might inform preventive strategies or tailored endovascular device selection [30, 35, 40].

5.4 Limitations

- **Retrospective Bias** — Many studies are retrospective, limiting causal inference and introducing potential selection and reporting biases.
- **Heterogeneous Populations** — Patient cohorts vary widely in demographics, acute vs. chronic status, and complication profiles, making direct comparisons challenging.
- **Inconsistent Metrics** — Numerical outcomes, particularly mortality and complication rates, are reported with varying definitions and follow-up periods, hindering direct meta-analysis.

- **Simulation Validation** — Computational and experimental models, while providing valuable insights, require extensive clinical validation to ensure their applicability to real-world patient outcomes.
- **Geographic Focus** — A significant portion of the patient data originates from specific geographic regions (e.g., China), which may limit the generalizability of some findings to diverse global populations.

5.5 Future directions

- **Prospective Registry Development** — Establish large, international prospective registries to standardize data collection and follow-up for type B AD patients.
- **AI-Enhanced Risk Prediction** — Develop and validate AI models for personalized risk prediction, integrating imaging, hemodynamic, and biomarker data.
- **Advanced Imaging Protocols** — Standardize and optimize 4D flow MRI protocols to enhance its role in routine hemodynamic assessment and treatment planning.
- **Novel Device Innovation** — Design and test new endovascular devices that better conform to complex aortic anatomies and optimize false lumen remodeling.
- **Comparative Effectiveness Research** — Conduct randomized controlled trials comparing different TEVAR strategies (e.g., timing, stent-graft types) against optimal medical therapy for specific type B AD subgroups.

6) Conclusion

Research on type B aortic dissection spans a broad spectrum, from identifying critical prognostic factors like maximal aortic diameter, false lumen dynamics, and aortic arch morphology, to evaluating the efficacy and complications of various treatment strategies. Endovascular repair (TEVAR) has emerged as a cornerstone, demonstrating superior false lumen thrombosis compared to medical therapy, though its long-term mortality benefit for uncomplicated cases remains debated. Computational modeling and advanced imaging techniques are increasingly providing patient-specific hemodynamic insights and aiding in surgical planning. Despite advancements, the variability in reported mortality (median 6.4%, range 2-13.9%) highlights the complexity of this condition. A key limitation is the prevalence of retrospective studies, which necessitates future prospective, multi-center trials. Clinically, careful risk stratification using anatomical and inflammatory markers, coupled with personalized treatment approaches, is crucial to improve patient outcomes.

References

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Figure 1. Publication-year distribution of included originals

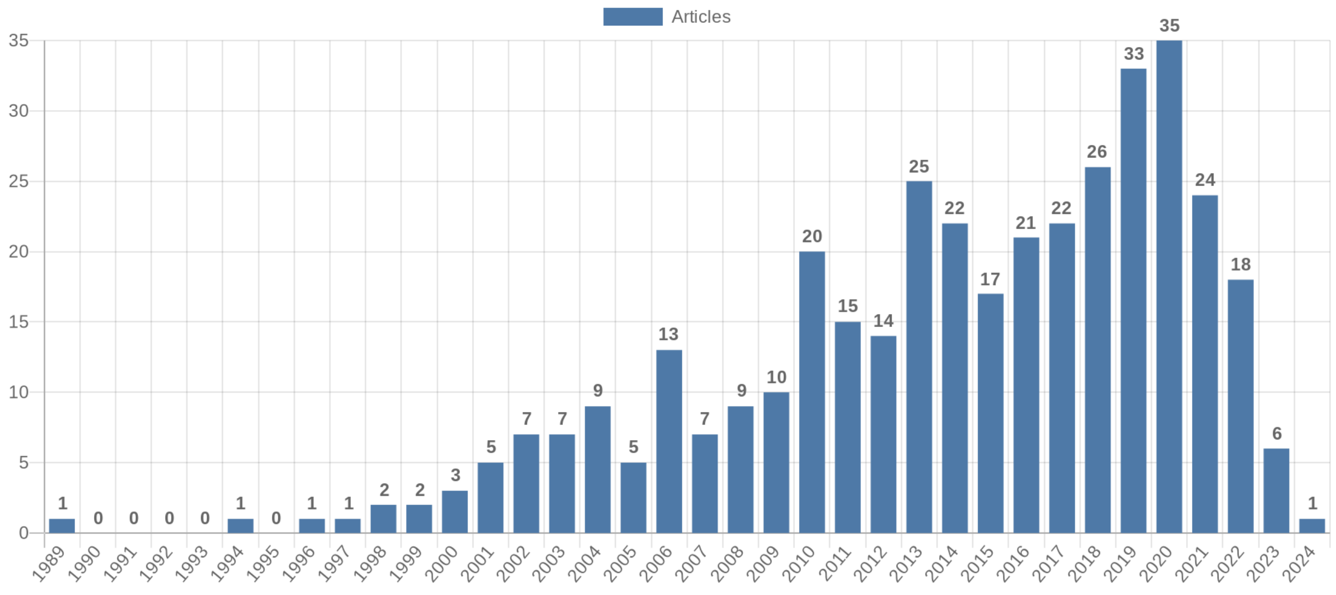


Figure 2. Study-design distribution of included originals

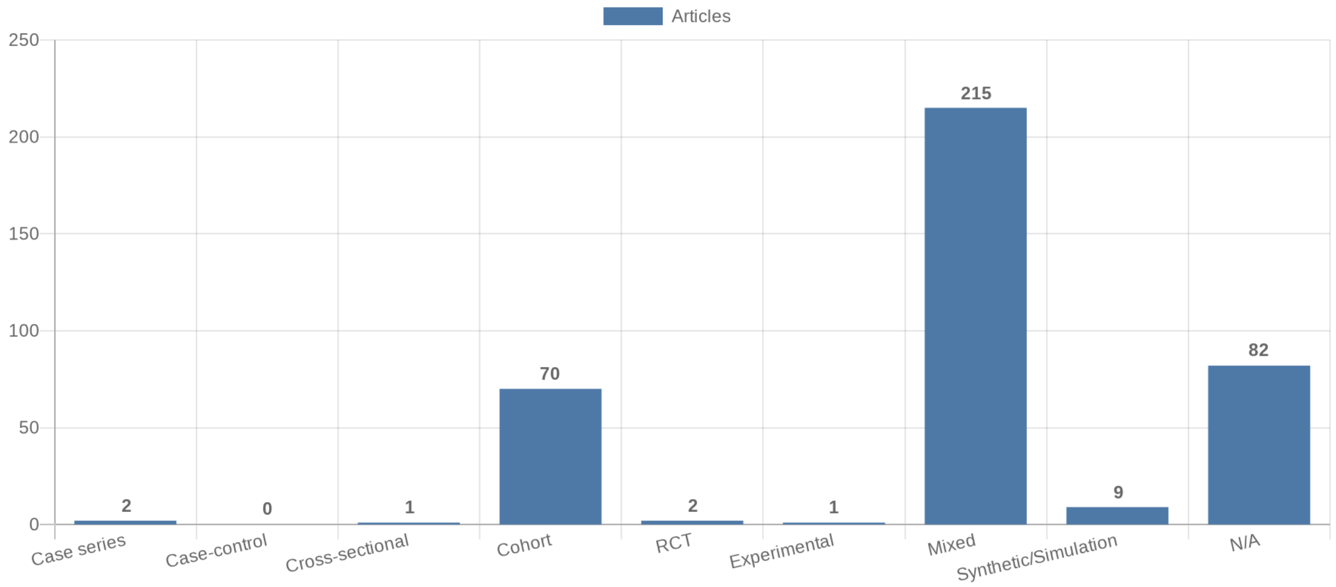


Figure 3. Study-type (directionality) distribution of included originals

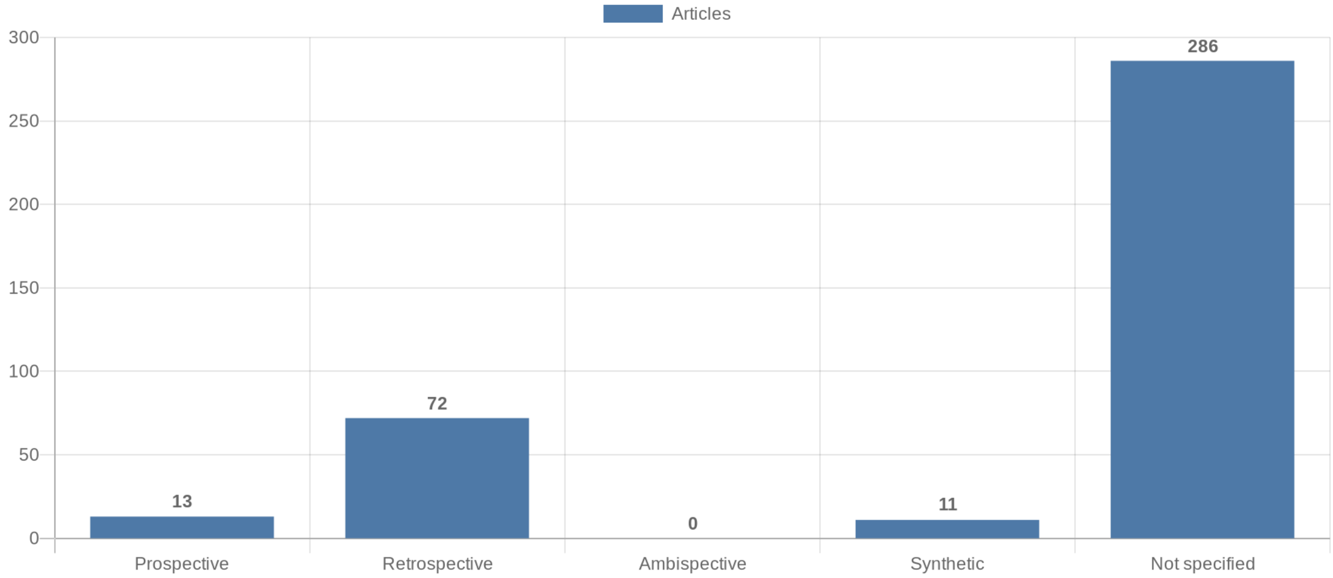


Figure 4. Main extracted research topics

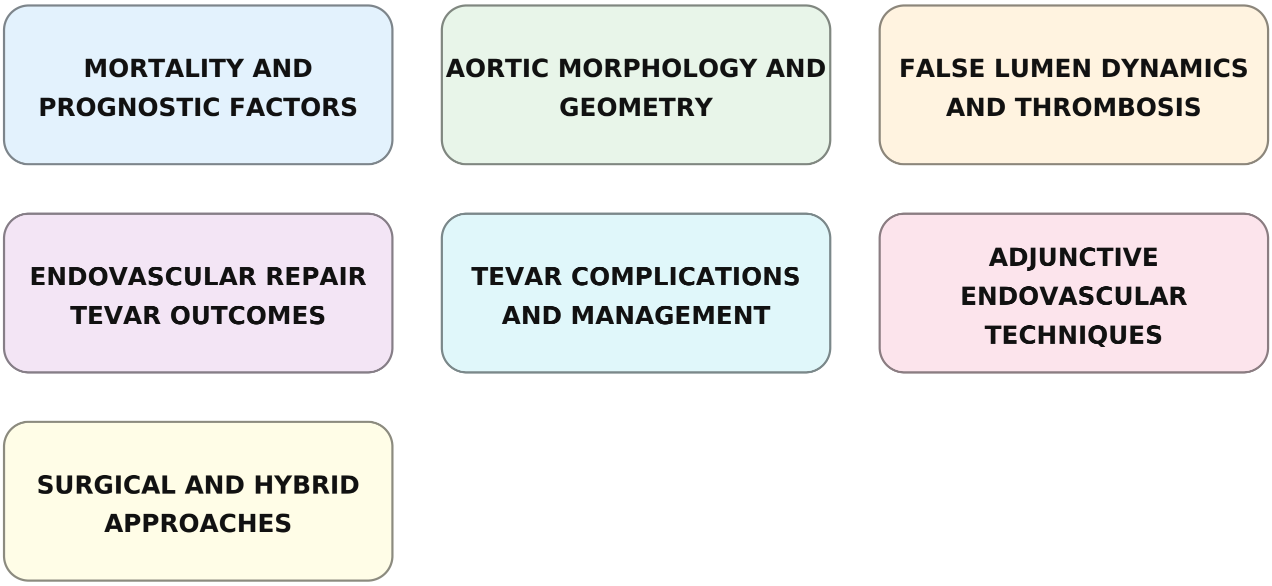


Figure 5. Limitations of current studies (topics)

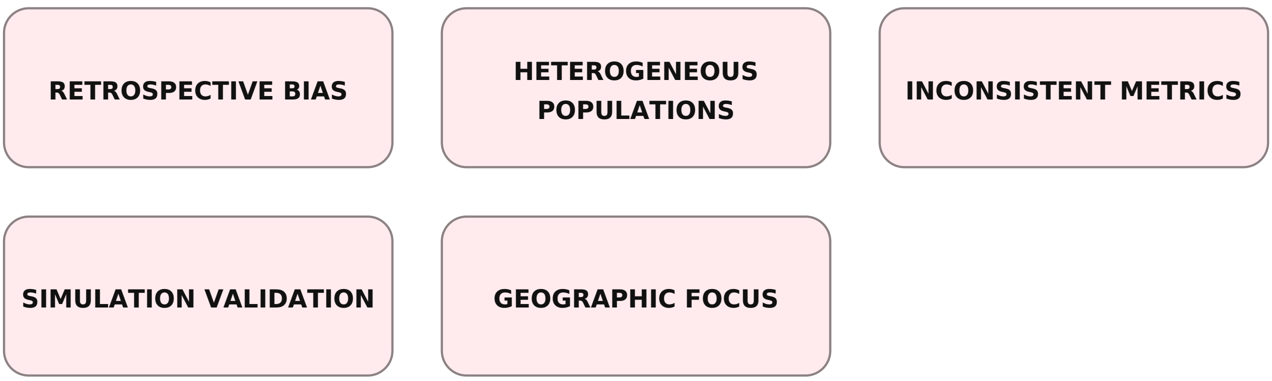
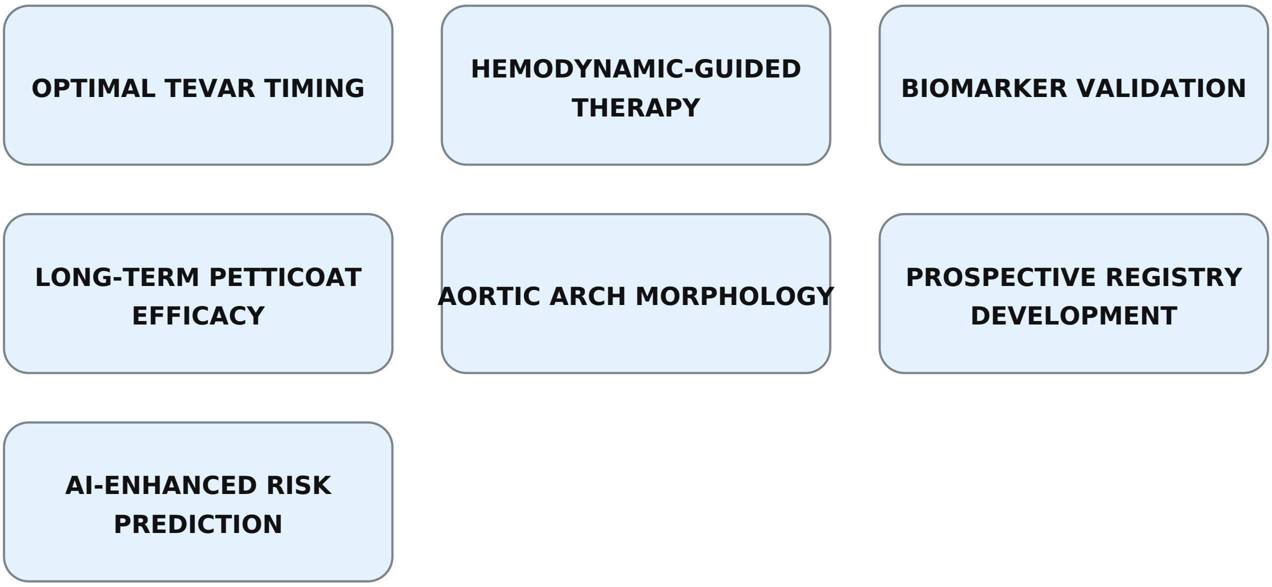


Figure 6. Future research directions (topics)


OPTIMAL TEVAR TIMING
HEMODYNAMIC-GUIDED THERAPY
BIOMARKER VALIDATION
LONG-TERM PETTICOAT EFFICACY
AORTIC ARCH MORPHOLOGY
PROSPECTIVE REGISTRY DEVELOPMENT
AI-ENHANCED RISK PREDICTION