Rotational Thrombectomy: Systematic Review with ☸SAIMSARA.

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Abstract: This paper aims to systematically review the current landscape of rotational thrombectomy, synthesizing its technical success, patency rates, safety profiles, and applications across various vascular pathologies, and to identify key research gaps and future directions. The review utilises 60 studies with 2410 total participants (naïve ΣN). The median 12-month primary patency rate for rotational thrombectomy across various vascular beds was 65%, with a range from 53.8% to 92.3%, demonstrating its variable but often effective role in restoring and maintaining vascular patency. This technique is broadly applicable across arterial, venous, and dialysis access occlusions, offering significant clinical benefits such as high technical success rates and a potential reduction in post-thrombotic syndrome. However, the reliance on heterogeneous study designs and varied patient populations represents the single limitation that most affects the certainty and generalizability of these findings. Clinicians should consider rotational thrombectomy as a valuable tool, often in conjunction with adjunctive therapies, for a wide range of thrombotic conditions, while acknowledging the need for further robust comparative research.

Keywords: Rotational Thrombectomy; Mechanical Thrombectomy; Vascular Occlusion; Deep Vein Thrombosis; Peripheral Artery Disease

Review Stats

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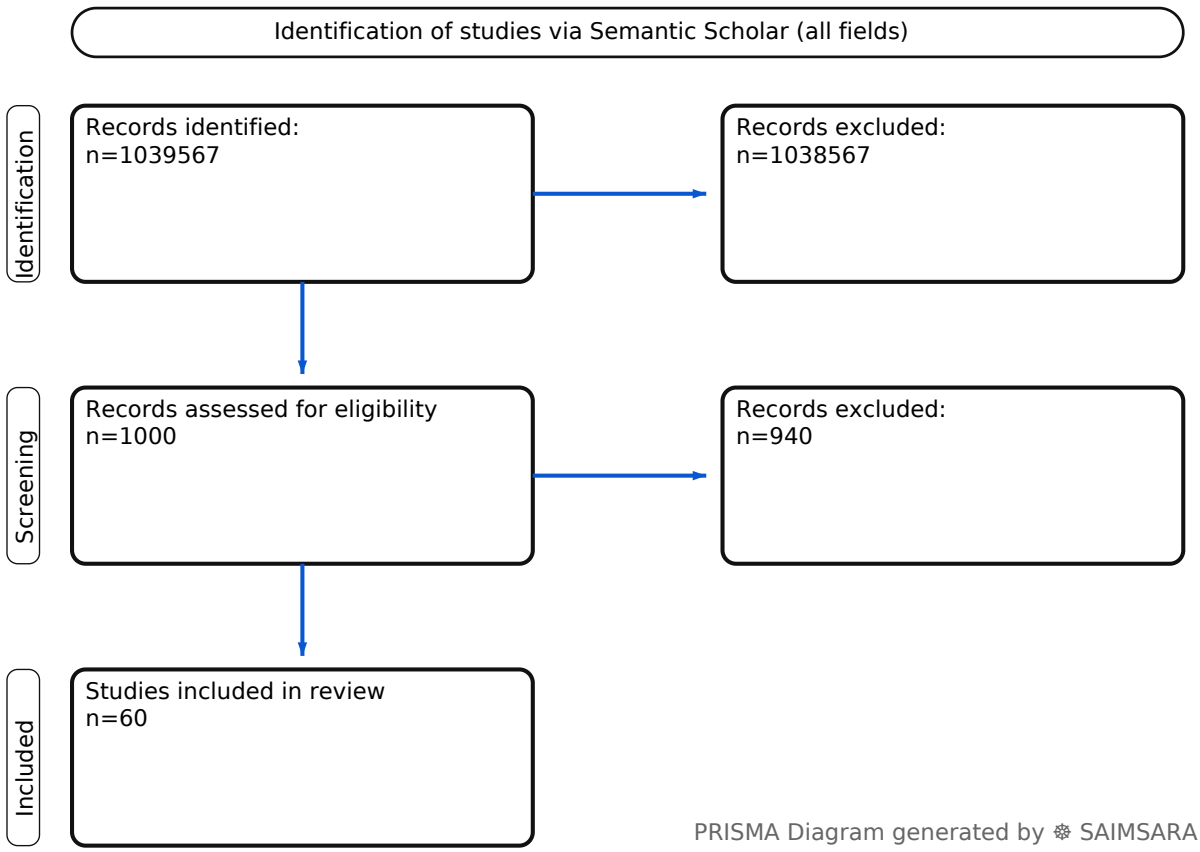
- Included original Abstracts/Papers: 60
- Total study participants (naïve ΣN): 2410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Records excluded:
n=1038567
Screening
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Records excluded:
n=940
Included
Studies included in review
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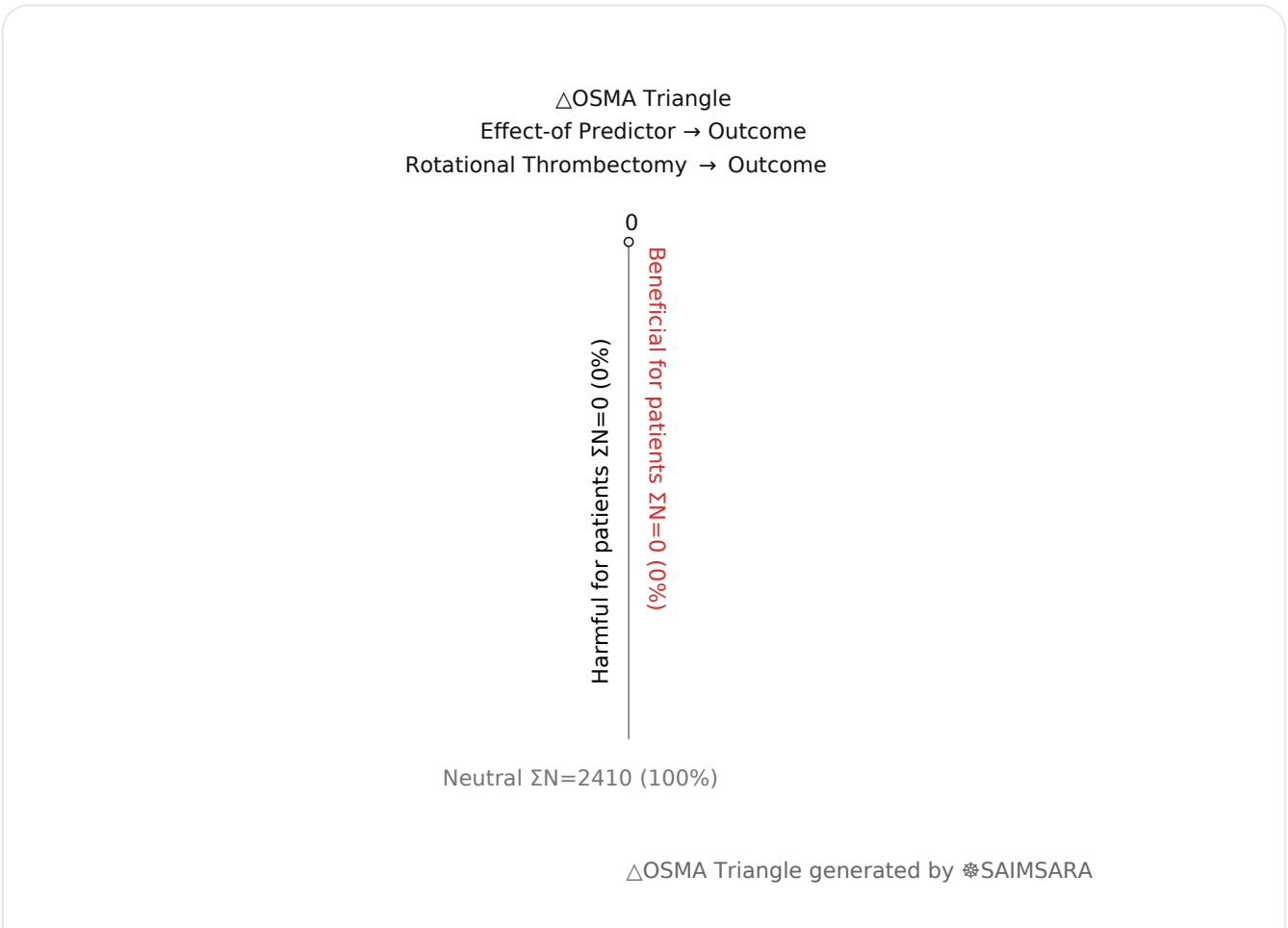
PRISMA Diagram generated by ☸ SAIMSARA


△OSMA Triangle
Effect-of Predictor → Outcome
Rotational Thrombectomy → Outcome
0
Harmful for patients ΣN=0 (0%)
Beneficial for patients ΣN=0 (0%)
Neutral ΣN=2410 (100%)
△OSMA Triangle generated by ☸SAIMSARA

Outcome-Sentiment Meta-Analysis (OSMA): *(LLM-only)*
Frame: Effect-of Predictor → Outcome • *Source*: Semantic Scholar
Outcome: Outcome Typical timepoints: 12-mo, 1-mo. Reported metrics: %, CI, p.
Common endpoints: Common endpoints: complications, patency, occlusion.
Predictor: Rotational Thrombectomy — exposure/predictor. Typical comparator: balloon maceration for, stenting, 3d rotational angiography, local thrombolysis or a….

- **1) Beneficial for patients** — Outcome with Rotational Thrombectomy — — — ΣN=0
- **2) Harmful for patients** — Outcome with Rotational Thrombectomy — — — ΣN=0
- **3) No clear effect** — Outcome with Rotational Thrombectomy — [1], [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], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60] — ΣN=2410

1) Introduction

Rotational thrombectomy (RT) represents a significant advancement in the endovascular management of thrombotic occlusions across various vascular beds. This minimally invasive technique utilizes specialized catheters to mechanically fragment and remove thrombus, aiming to restore blood flow and prevent long-term complications. Its application has expanded from peripheral arterial disease to venous thromboses, dialysis access occlusions, and even cerebrovascular events. This paper synthesizes current evidence on the efficacy, safety, and emerging applications of rotational thrombectomy, drawing insights from a diverse body of literature.

2) Aim

This paper aims to systematically review the current landscape of rotational thrombectomy, synthesizing its technical success, patency rates, safety profiles, and applications across various vascular pathologies, and to identify key research gaps and future directions.

3) Methods

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

- **Bias:** The majority of studies identified were of mixed or retrospective design, with several case series and a few prospective studies. This prevalence of retrospective designs

introduces potential for selection bias and confounding, limiting the overall certainty and generalizability of the findings. Smaller sample sizes in many studies further contribute to this limitation.

4) Results

4.1 Study characteristics:

The included studies predominantly featured mixed study designs, combining retrospective and prospective elements, with a notable number of purely retrospective analyses and case series. Populations varied widely, encompassing patients with symptomatic venous stent occlusions, thrombosed arteriovenous fistulas or grafts, total vascular occlusions of the lower extremity, acute/subacute deep vein thrombosis (DVT), acute ischemic stroke, and acute lower limb ischemia. Follow-up periods ranged from short-term (3 months) to longer-term (12 months, 18 months, or even 9 years in a case report), with several studies not specifying follow-up duration.

4.2 Main numerical result aligned to the query:

Across various vascular beds including lower extremity arterial occlusions, femoropopliteal arteries, iliofemoral deep vein thrombosis, and arteriovenous fistulas/grafts, the 12-month primary patency rates for rotational thrombectomy procedures ranged from 53.8% to 92.3% [4, 6, 21, 28, 30, 32, 34]. The median 12-month primary patency rate observed in these studies was 65%. This heterogeneity reflects the diverse patient populations, vascular anatomies, and specific devices employed in different clinical scenarios.

4.3 Topic synthesis:

- **Broad Efficacy Across Vascular Beds:** Rotational thrombectomy demonstrates high technical success rates, often exceeding 90% (e.g., 90.4% for lower extremity arterial occlusions [3], 100% for thrombosed hemodialysis accesses [4], 97% for refractory dialysis shunts [7], 100% for acute iliofemoral deep vein thrombosis [23]), in treating a wide array of thrombotic conditions, including arterial occlusions of the lower extremity [3, 21, 28, 34], venous occlusions such as iliofemoral DVT [9, 12, 23, 26, 30], superior mesenteric vein (SMV) thrombosis [31], and venous stent occlusions [1].
- **Patency Outcomes:** Short-term patency rates are generally high, with 90-day primary patency reported at 86.7% (95% CI: 71.0-100.0) for venous stent occlusions [1] and 1-month primary patency at 90% for acute lower limb ischemia [21]. Longer-term patency at 12 months varies by application, ranging from 53.8% for arteriovenous fistulas (AVFs) and grafts [32] to 92.3% for iliac and infrainguinal arterial occlusions [34].

- **Safety and Complication Profile:** While generally safe, procedures carry a risk of adverse events. Overall adverse events were 46.1% in one study of lower extremity occlusions, with rotational thrombectomy (RT)-associated complications at 7.1% [3]. Minor bleeding was reported at 17% for venous stent occlusions [1] and 32.4% for acute iliofemoral vein thrombosis [26]. Distal embolization rates ranged from 4.8% in femoropopliteal interventions [35] to 11% for periprocedural peripheral embolization (PPE) in femoropopliteal occlusions [6].
- **Device-Specific Performance:** Specific devices like the Cleaner XT/Vac system [4, 7, 32, 46, 47, 48], Rotarex/Rotarex®S [15, 22, 28, 33, 34, 37], and Aspirex®S [25, 30, 38] are frequently cited, demonstrating excellent clinical and technical success rates and good patency results for their respective indications.
- **Adjunctive Therapies and Imaging:** Rotational thrombectomy is often combined with other interventions such as angioplasty [1, 6], stent implantation [6, 8], or catheter-directed thrombolysis (CDT) [5, 9, 23, 26, 31, 42]. Advanced imaging techniques, including three-dimensional rotational angiography (3D-RA) [11] and contrast-enhanced cone beam computed tomography (CE-CBCT) [20], are shown to improve recanalization rates and visualization during mechanical thrombectomy for acute ischemic stroke.
- **Factors Influencing Outcomes:** Patient characteristics such as male sex (OR, 2.65; 95% CI, 1.098–6.410; p = .030) and poor distal runoff (OR, 2.94; 95% CI, 1.439–5.988; p = .003) are associated with higher rates of additional CDT in lower-limb ischemia [5]. Lesion length (>200 mm) and thrombus density (≤45 HU) are identified as risk factors for periprocedural peripheral embolization [6].
- **Emerging Applications and Specialized Contexts:** Beyond common peripheral indications, RT is utilized in acute ischemic stroke for middle cerebral artery M2 segment occlusions [11], acute superior mesenteric vein thrombosis [31], acute massive pulmonary embolism [27], and complex cases like limb graft occlusion after endovascular aneurysm repair (EVAR) [22] and post-Glenn shunt thrombosis [42]. It also plays a crucial role in dialysis access salvage [2, 4, 7, 32, 49].

5) Discussion

5.1 Principal finding:

The median 12-month primary patency rate for rotational thrombectomy across various vascular beds was 65%, with a range from 53.8% to 92.3% [4, 6, 21, 28, 30, 32, 34], indicating its variable but often effective role in restoring and maintaining vascular patency.

5.2 Clinical implications:

- **Versatile Treatment Option:** Rotational thrombectomy is a viable and often highly successful treatment for acute and chronic occlusions in diverse vascular territories, including arterial, venous, and dialysis access systems [3, 4, 7, 23, 30, 34].
- **Dialysis Access Salvage:** It offers a safe and effective option for restoring patency to thrombosed hemodialysis accesses, potentially providing longer primary patency compared to balloon maceration [2, 4, 7, 32].
- **Reduced Post-Thrombotic Syndrome:** For deep vein thrombosis, particularly in the iliofemoral segment, rotational thrombectomy can significantly improve pain and Villalta scores and prevent moderate to severe post-thrombotic syndrome [23, 30].
- **Adjunctive Therapy Integration:** Optimal outcomes often involve the concomitant use of angioplasty, stenting, or catheter-directed thrombolysis, tailoring the approach to specific lesion characteristics [1, 6, 9, 23, 26, 31].
- **Improved Neurovascular Recanalization:** Advanced imaging techniques like 3D rotational angiography and contrast-enhanced cone beam CT can enhance recanalization rates and procedural efficacy in acute ischemic stroke [11, 20].

5.3 Research implications / key gaps:

- **Prospective Comparative Studies:** Further prospective, randomized controlled trials are needed to directly compare rotational thrombectomy with other thrombectomy techniques or conservative management in specific vascular beds [2, 17, 29].
- **Standardized Outcome Reporting:** A lack of consistent reporting for primary patency, secondary patency, and complication rates across studies hinders robust meta-analysis and direct comparison of efficacy [3, 4, 6, 21, 28, 30, 32, 34].
- **Long-Term Patency Data:** While 12-month data is available for some applications, longer-term follow-up beyond 1-2 years is often lacking, especially for newer devices and specific patient cohorts [1, 3, 4, 6, 21, 28, 30, 32, 34].
- **Optimal Adjunctive Strategies:** Research is needed to define the optimal combination and timing of rotational thrombectomy with adjunctive therapies (e.g., drug-eluting balloons, stenting, thrombolysis) for different thrombus characteristics and vascular locations [5, 6, 8, 9, 23, 26, 31].
- **Predictors of Success and Complications:** Further investigation into patient-specific factors, lesion characteristics (e.g., thrombus density, lesion length), and imaging biomarkers that predict procedural success, patency, or complications like distal embolization is warranted [5, 6, 24, 35, 36, 52].

5.4 Limitations:

- **Heterogeneous Study Designs** — The reliance on mixed and retrospective study designs limits the ability to establish definitive causality and introduces potential for selection bias.
- **Varied Patient Populations** — The diverse patient populations and vascular beds studied make it challenging to generalize findings across all applications of rotational thrombectomy.
- **Inconsistent Outcome Metrics** — Different definitions and reporting periods for patency, success rates, and complications across studies impede direct quantitative comparisons.
- **Small Sample Sizes** — Many studies, particularly case series and early experiences, involve small sample sizes, which limits the statistical power and generalizability of their results.
- **Lack of Direct Comparators** — A scarcity of head-to-head comparisons between rotational thrombectomy and alternative treatments for specific indications makes it difficult to ascertain its relative superiority.

5.5 Future directions:

- **Prospective Comparative Trials** — Conduct large-scale prospective, randomized controlled trials comparing rotational thrombectomy to other standard treatments for specific indications.
- **Standardized Outcome Metrics** — Develop and adopt standardized definitions and reporting guidelines for technical success, patency, and complication rates in rotational thrombectomy studies.
- **Long-Term Follow-Up Studies** — Implement studies with extended follow-up periods (e.g., >2 years) to assess the durability and long-term clinical impact of rotational thrombectomy across various applications.
- **Advanced Imaging Integration** — Investigate the routine integration of advanced imaging modalities like CE-CBCT and 3D-RA to optimize procedural guidance and outcomes in complex cases.
- **Device-Specific Efficacy Benchmarks** — Establish benchmarks for efficacy and safety for individual rotational thrombectomy devices in specific vascular beds to guide clinical decision-making.

6) Conclusion

The median 12-month primary patency rate for rotational thrombectomy across various vascular beds was 65%, with a range from 53.8% to 92.3% [4, 6, 21, 28, 30, 32, 34], demonstrating its

variable but often effective role in restoring and maintaining vascular patency. This technique is broadly applicable across arterial, venous, and dialysis access occlusions, offering significant clinical benefits such as high technical success rates and a potential reduction in post-thrombotic syndrome. However, the reliance on heterogeneous study designs and varied patient populations represents the single limitation that most affects the certainty and generalizability of these findings. Clinicians should consider rotational thrombectomy as a valuable tool, often in conjunction with adjunctive therapies, for a wide range of thrombotic conditions, while acknowledging the need for further robust comparative research.

References

SAIMSARA Session Index — session.json

Figure 1. Publication-year distribution of included originals

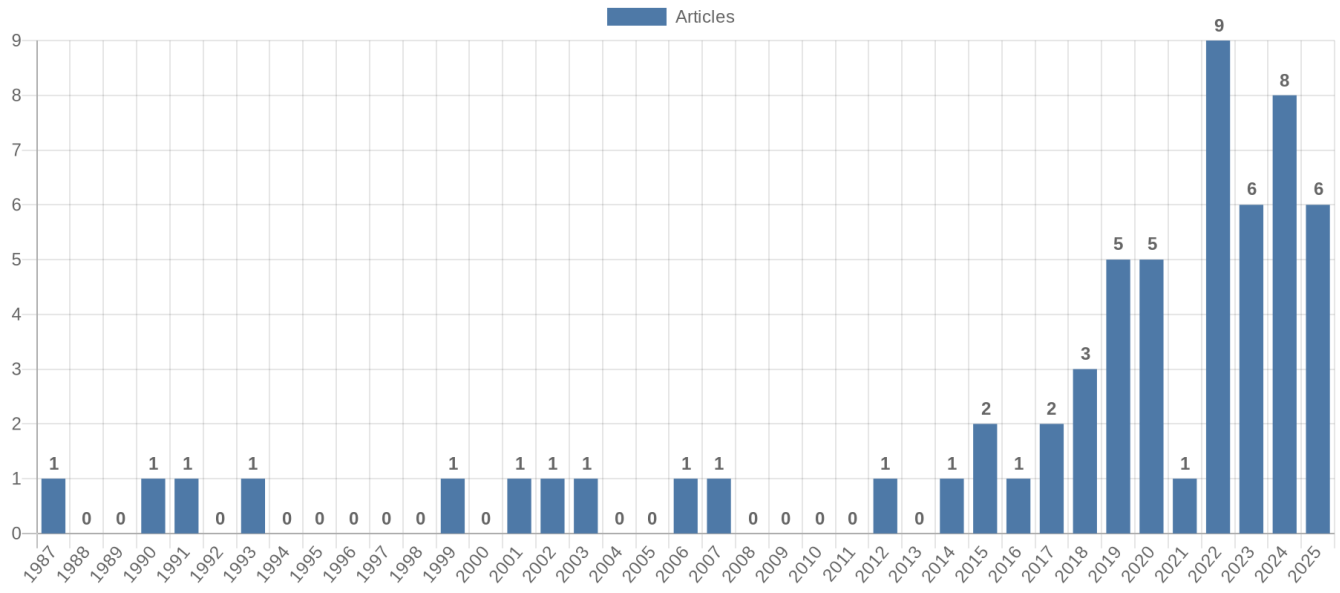


Figure 2. Study-design distribution of included originals

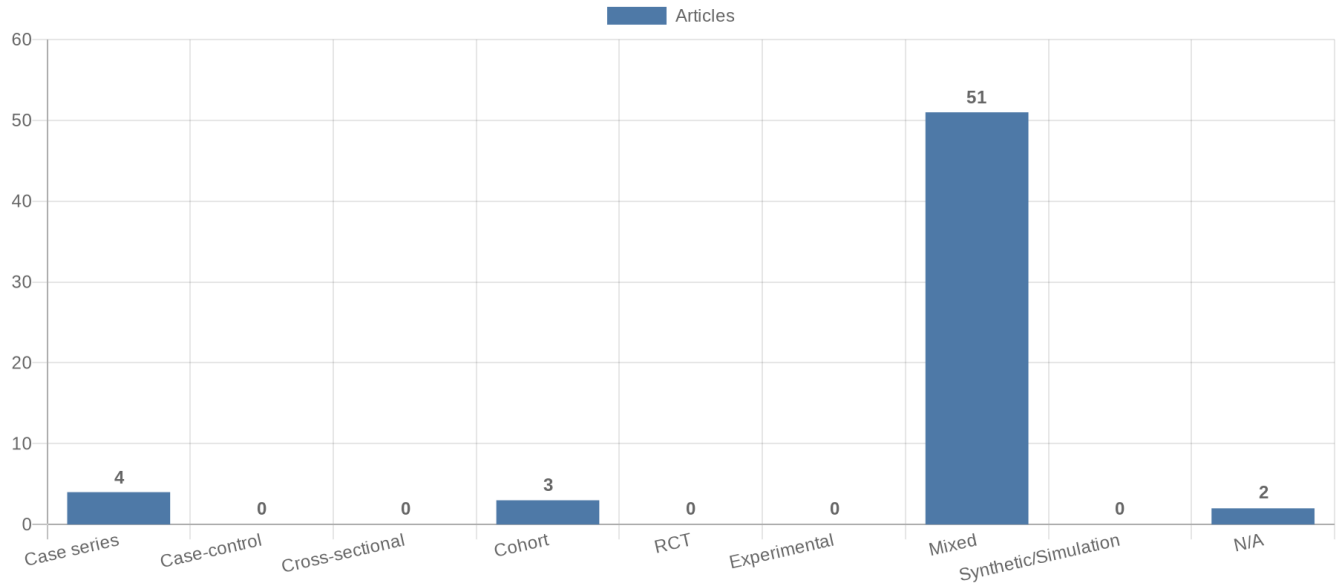


Figure 3. Study-type (directionality) distribution of included originals

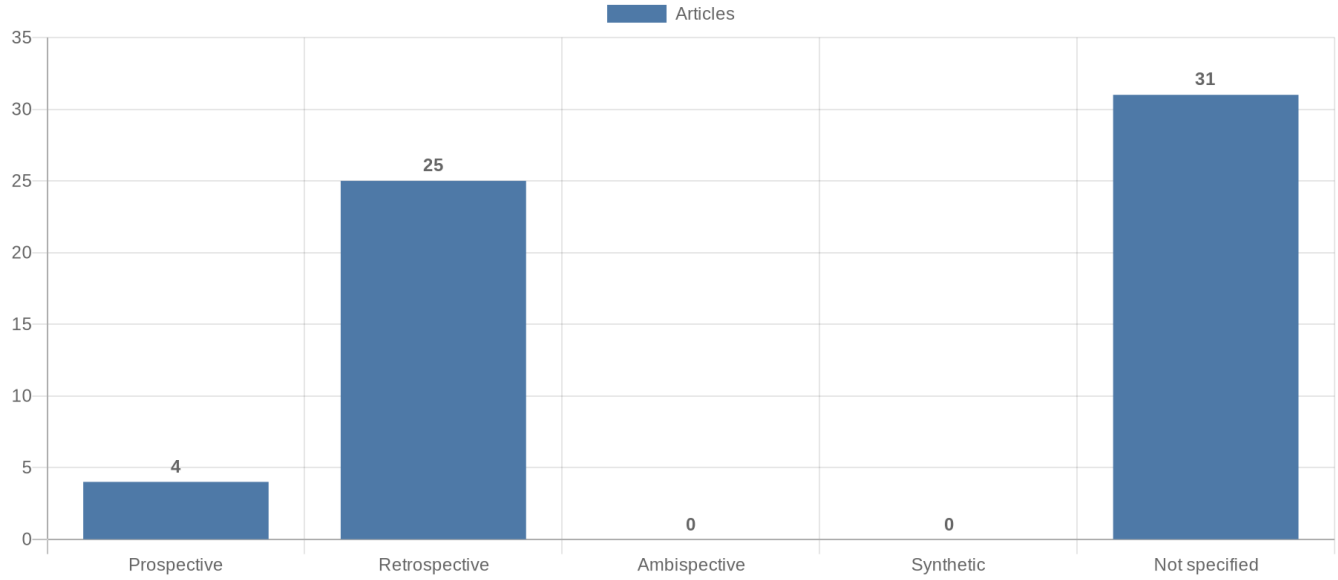


Figure 4. Main extracted research topics

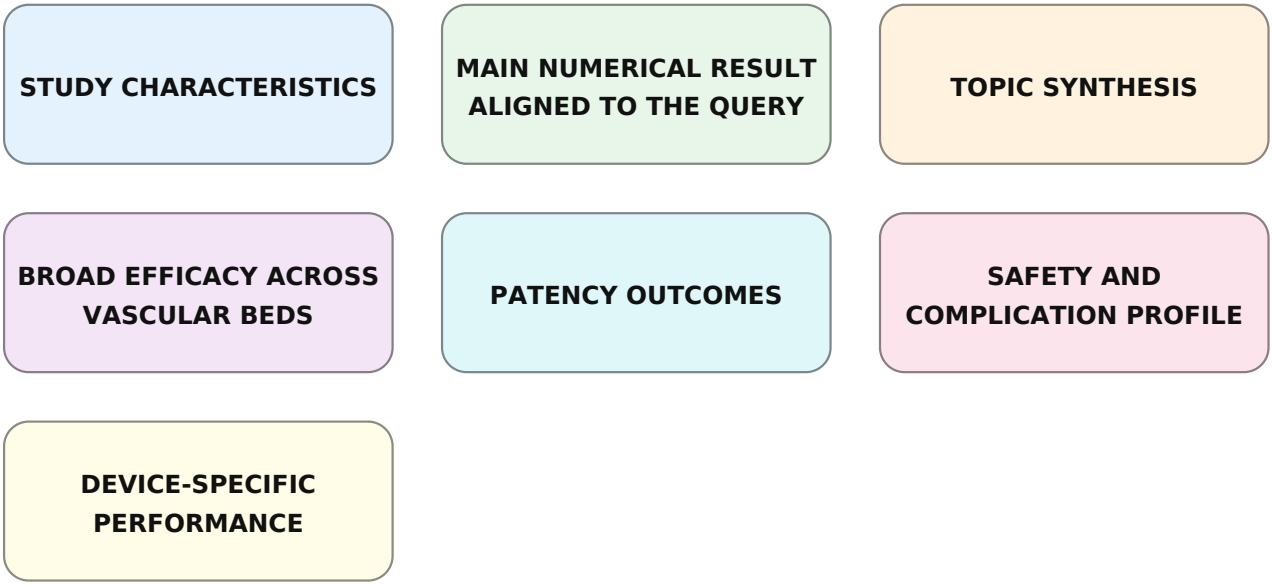


Figure 5. Limitations of current studies (topics)

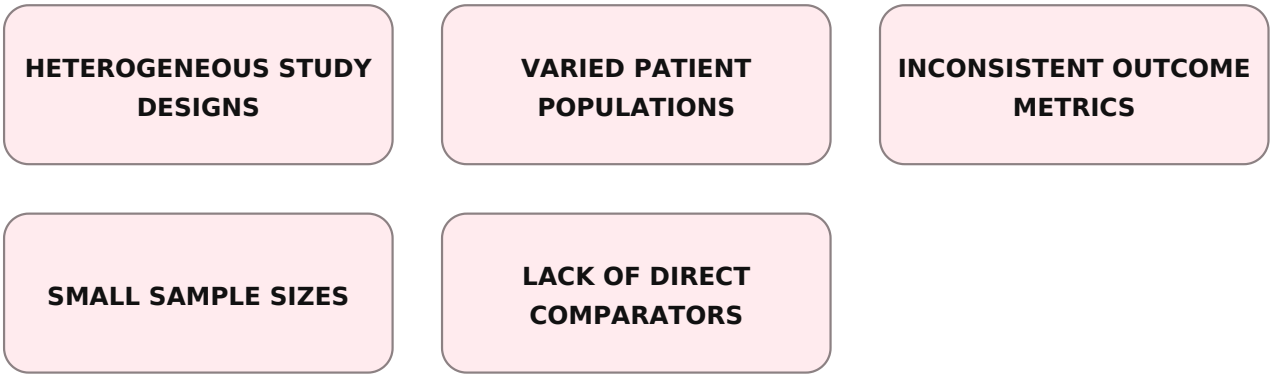


Figure 6. Future research directions (topics)