Catheter Angiography in Carotid Disease: Systematic Review with ☸SAIMSARA.

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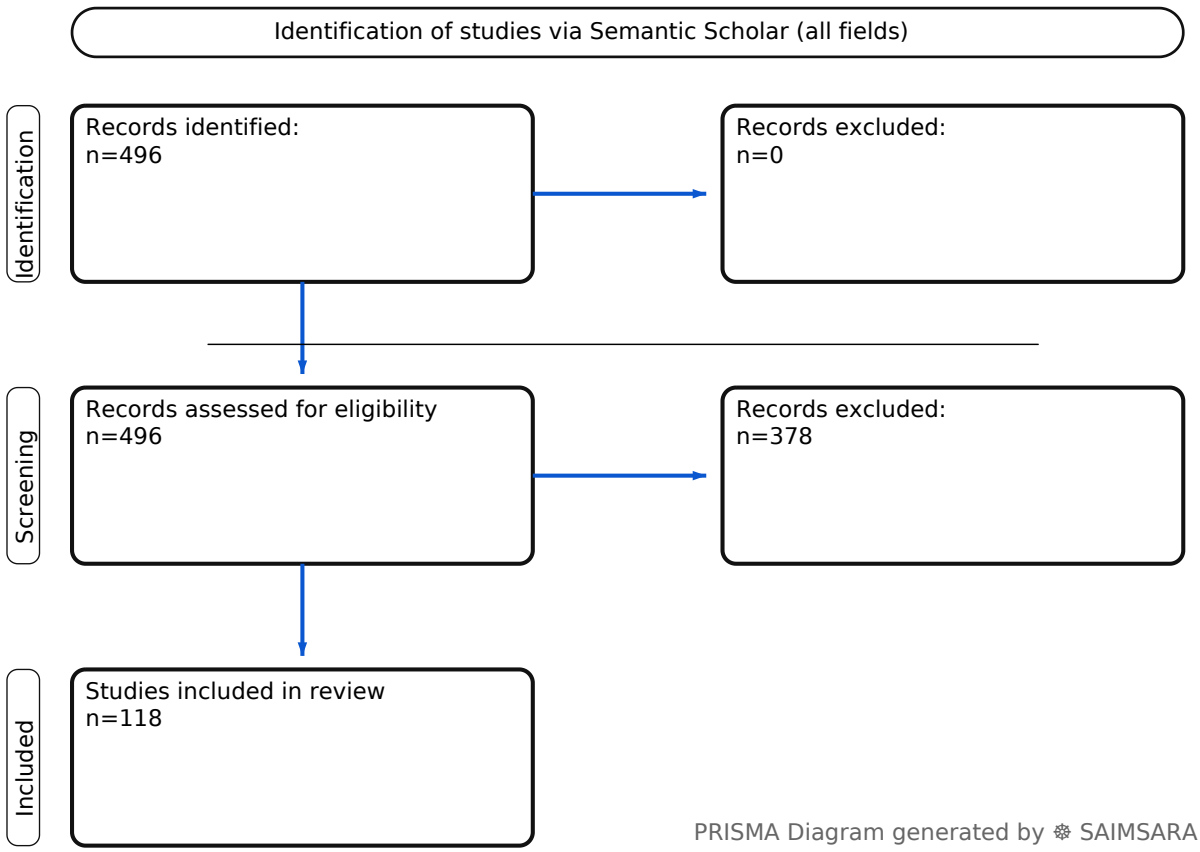
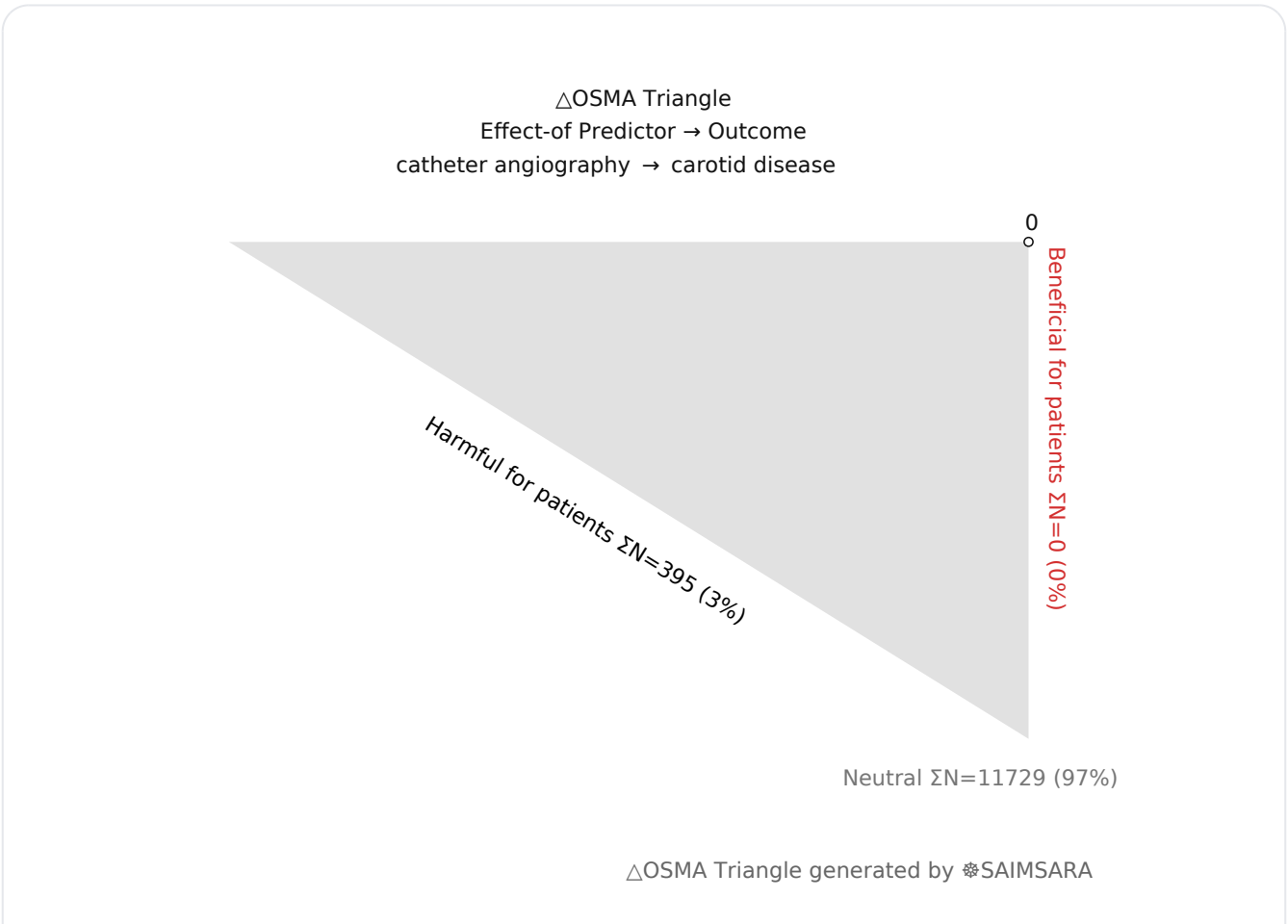
Abstract: Systematic review with multilayer AI research agent: keyword normalization, retrieval & structuring, and paper synthesis (see SAIMSARA About section for details). The review utilises 118 studies with 12124 total participants (naïve ΣN). Catheter-based angiography (DSA) frequently leads to a re-evaluation of non-invasive findings and changes in treatment plans for carotid disease, with discrepancies in stenosis severity or treatment plans ranging from 19% to 40%. This highlights its definitive role in refining diagnoses and guiding interventions, particularly for symptomatic patients. The generalizability of these findings is limited by the prevalence of retrospective designs and small sample sizes. The most significant limitation affecting certainty is the Heterogeneous Populations, which impedes direct comparisons and broad applicability. For clinicians, this underscores the continued importance of considering catheter angiography for definitive assessment in cases of symptomatic carotid disease or discordant non-invasive imaging results.

Keywords: Catheter Angiography; Carotid Artery Disease; Digital Subtraction Angiography

Review Stats

- Generated: 2026-02-03 12:42:02 CET
- Plan: Pro (expanded craft tokens; source: Semantic Scholar)
- Source: Semantic Scholar
- Scope: All fields
- Keyword Gate: Fuzzy (≥60% of required terms, minimum 2 terms matched in title/abstract)
- Total Abstracts/Papers: 496
- Downloaded Abstracts/Papers: 496
- Included original Abstracts/Papers: 118
- Total study participants (naïve ΣN): 12124


Identification of studies via Semantic Scholar (all fields)
Identification
Records identified:
n=496
Records excluded:
n=0
Screening
Records assessed for eligibility
n=496
Records excluded:
n=378
Included
Studies included in review
n=118
PRISMA Diagram generated by ☸ SAIMSARA


△OSMA Triangle
Effect-of Predictor → Outcome
catheter angiography → carotid disease
0
Beneficial for patients ΣN=0 (0%)
Harmful for patients ΣN=395 (3%)
Neutral ΣN=11729 (97%)
△OSMA Triangle generated by ☸SAIMSARA

Outcome-Sentiment Meta-Analysis (OSMA): *(LLM-only)*
Frame: Effect-of Predictor → Outcome • *Source*: Semantic Scholar
Outcome: carotid disease Typical timepoints: peri/post-op, 3-day. Reported metrics: %, CI, p.
Common endpoints: Common endpoints: occlusion, complications, functional.
Predictor: catheter angiography — exposure/predictor. Doses/units seen: 20 mg, 10 mg. Typical comparator: conventional catheters in, control, controls, duplex sonography assessments.…

- **1) Beneficial for patients** — carotid disease with catheter angiography — — — ΣN=0
- **2) Harmful for patients** — carotid disease with catheter angiography — [39] — ΣN=395
- **3) No clear effect** — carotid disease with catheter angiography — [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], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [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] — ΣN=11729

1) Introduction

Catheter angiography, particularly digital subtraction angiography (DSA), serves as a critical diagnostic and interventional tool in the evaluation and management of carotid artery disease. While non-invasive imaging modalities have gained widespread use, the precision and definitive nature of catheter-based angiography remain indispensable for confirming diagnoses, guiding therapeutic decisions, and assessing complex cerebrovascular conditions. This paper synthesizes current evidence on the application, utility, and implications of catheter angiography in the context of carotid pathology, drawing from a diverse range of studies.

2) Aim

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

3) Methods

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

- **Bias:** The body of evidence reviewed is predominantly retrospective [1, 2, 4, 7, 22, 23, 24, 32, 33, 37, 47, 50, 60, 70, 72, 103, 107, 110, 115, 117], including numerous case reports and case series [6, 14, 16, 19, 22, 25, 26, 27, 29, 43, 44, 46, 49, 51, 52, 53, 54, 55, 57, 58, 59, 75, 82, 84, 85, 88, 90, 92, 96, 97, 99, 100, 101, 102, 104, 105, 106, 108, 112, 113, 114, 116, 118]. This introduces inherent selection bias and limits generalizability, particularly given the frequent lack of specified study design or directionality in many entries. Sample sizes are often small, with many single-patient case studies, and consistent long-term follow-up is not uniformly reported.

4) Results

4.1 **Study characteristics:** The reviewed studies encompass retrospective analyses, cohort studies, cross-sectional investigations, and numerous case reports/series. Populations range from symptomatic patients referred for carotid disease evaluation [1, 2], patients with concomitant coronary artery disease (CAD) [3, 7, 35, 36, 39, 41, 42, 45, 87], individuals with Moyamoya disease [23, 24, 26, 27, 28, 55, 59, 62, 90], and healthy controls or disease-free arteries [4, 78]. Animal models (swine, rabbit, rat, canine) were also utilized for technical development and stroke modeling [17, 31, 61, 76, 80, 91, 93, 98]. Follow-up periods varied widely, from immediate post-procedure assessment to several months or years in specific case studies, but were frequently unspecified or absent for larger cohorts.

4.2 **Main numerical result aligned to the query:** Catheter-based angiography (DSA) frequently leads to a re-evaluation of non-invasive findings and changes in treatment plans for carotid disease. Discrepancies in stenosis severity or treatment plans between non-invasive imaging and conventional catheter angiography ranged from 19% to 40% [1, 2]. Specifically, 19% of patients referred based on non-invasive imaging for ipsilateral carotid stenosis >50% or occlusion were found to have non-significant stenosis (<50%) on DSA [1]. In another cohort, 40% of symptomatic patients referred for intervention based on non-invasive imaging had a change in their treatment plan following conventional catheter angiography, with 40% of those referred for moderate to severe stenosis ultimately not found to have significant stenosis [2].

4.3 **Topic synthesis:**

- **Diagnostic Superiority Over Non-Invasive Imaging:** Catheter angiography (DSA) frequently alters initial diagnoses from non-invasive imaging, with discrepancies in stenosis severity or treatment plans ranging from 19% to 40% [1, 2].

- **Evaluation of Carotid Occlusion and String Sign:** DSA is crucial for evaluating suspected carotid occlusions, successfully identifying "string signs" and enabling stenting in 28-32% of such cases [1, 2].
- **Association with Coronary Artery Disease:** Significant carotid artery disease is prevalent in patients with coronary artery disease, found in 25.5-38.6% of patients undergoing coronary angiography [3, 39], and a 62% correlation between the two conditions has been observed [7].
- **Technical Innovations and Access Routes:** Advances include handmade S-shaped catheters reducing procedural time and contrast volume [7], a "New Carotid Catheter" for transradial angiography [8], and specialized femoral S carotid catheters achieving 95% selective imaging success with 3.8% minor complications [33]. Alternative access routes like transbrachial [13] and common carotid artery access [49, 96] are employed for challenging cases.
- **Diagnosis and Management of Moyamoya Disease:** Catheter angiography is the diagnostic method of choice for Moyamoya disease, visualizing characteristic vascular networks and occlusions [26, 27, 55, 59, 62, 90], and is used to assess bypass function [23] and vessel wall thickness [28].
- **Assessment of Carotid Webs and Hemodynamic Disruption:** DSA time-density curve analysis reveals that carotid webs produce greater local hemodynamic disruption, characterized by flow stasis, than mild/moderate atherosclerotic lesions [11], and intravascular ultrasound (IVUS) can characterize these webs [44].
- **Safety and Complications of Procedures:** Diagnostic DSA is generally safe with low complication rates, such as 0.4% asymptomatic femoral artery dissections and 0.3% groin hematomas [37]. However, procedures can lead to complications like contrast-induced encephalopathy (CIE) [60] or, rarely, stroke [95].

5) Discussion

5.1 **Principal finding:** The principal finding is that catheter-based angiography significantly impacts the diagnosis and treatment planning for carotid disease, with discrepancies in stenosis severity or treatment plans ranging from 19% to 40% compared to non-invasive imaging [1, 2]. This underscores its definitive role in patient management.

5.2 **Clinical implications:**

- **Definitive Diagnosis:** Catheter angiography (DSA) is essential for definitive diagnosis of symptomatic carotid disease, particularly when non-invasive imaging is inconclusive or contradictory, preventing unnecessary interventions or identifying treatable lesions [1, 2].

- **Re-evaluation of Stenosis:** Clinicians should consider DSA for re-evaluating patients with suspected moderate to severe carotid stenosis based on non-invasive methods, as a significant proportion (up to 40%) may not have significant stenosis requiring intervention [2, 47].
- **Management of Occlusions and Complex Conditions:** DSA is crucial for identifying "string signs" in suspected carotid occlusions, enabling revascularization [1, 2], and for diagnosing complex conditions like Moyamoya disease, fibromuscular dysplasia (FMD), and carotid webs [26, 62, 86, 90].
- **Concomitant Disease Screening:** Given the high prevalence of carotid artery disease in patients with coronary artery disease (25.5-38.6%) [3, 39], screening for carotid pathology during coronary angiography may be beneficial for identifying at-risk patients [87].
- **Procedural Optimization:** The use of specialized catheters and tailored access routes can improve the safety and efficacy of carotid angiography, reducing procedural time, contrast volume, and complications, especially in patients with challenging anatomy or absent peripheral access [7, 33, 49].

5.3 **Research implications / key gaps:**

- **Standardized Stenosis Criteria:** Research is needed to establish universally accepted and harmonized criteria for carotid artery stenosis across different imaging modalities to reduce diagnostic discrepancies [21, 47].
- **Comparative Catheter Efficacy:** Future studies should prospectively compare the effectiveness, safety, and long-term outcomes of different catheter designs (e.g., S-shaped, New Carotid Catheter, Femoral S) and access routes (transradial, transfemoral, common carotid) in diverse patient populations [7, 8, 33].
- **Cost-Effectiveness of DSA:** A comprehensive analysis of the cost-effectiveness of catheter-based angiography for specific indications, especially in cases of cervical internal carotid artery occlusion, is warranted [12].
- **Integration of Advanced Imaging:** Further investigation into the complementary role and integration of advanced non-invasive techniques like 4D-flow magnetic resonance imaging (MRI), contrast-enhanced ultrasound (CEUS), and arterial spin labeling (ASL) MRI with DSA is needed to optimize diagnostic pathways [9, 15, 24].
- **Longitudinal Outcomes Post-DSA:** Long-term follow-up studies are required to assess the clinical impact of treatment decisions made based on DSA findings, particularly for revascularization procedures in complex carotid pathologies [14, 50].

5.4 **Limitations:**

- **Retrospective Study Designs** — The majority of studies are retrospective, introducing selection bias and limiting the ability to establish causality or generalizability across diverse patient cohorts.
- **Heterogeneous Populations** — The included studies feature a wide range of patient populations, from symptomatic carotid disease to Moyamoya and coronary artery disease, making direct comparisons and pooled analyses challenging.
- **Lack of Long-Term Follow-up** — Many studies, particularly case reports, lack long-term follow-up, which limits the assessment of sustained treatment efficacy and long-term safety outcomes.
- **Small Sample Sizes** — Numerous findings are derived from small cohorts or single-patient case reports, which restricts the statistical power and generalizability of the reported results.
- **Varied Diagnostic Criteria** — Inconsistent diagnostic criteria for carotid stenosis across studies and between non-invasive and invasive modalities contribute to heterogeneity and make direct comparisons difficult.

5.5 **Future directions:**

- **Prospective Comparative Studies** — Conduct large-scale prospective studies comparing DSA with advanced non-invasive imaging for various carotid pathologies.
- **Standardized Diagnostic Protocols** — Develop and validate standardized diagnostic protocols for carotid stenosis using multimodal imaging approaches.
- **Longitudinal Outcome Tracking** — Implement long-term registries to track clinical outcomes following DSA-guided interventions for carotid disease.
- **Advanced Imaging Integration** — Investigate the optimal integration of emerging imaging technologies (e.g., 4D-flow MRI, CEUS) into diagnostic algorithms for carotid disease.
- **Cost-Effectiveness Analyses** — Perform comprehensive cost-effectiveness analyses to guide appropriate utilization of catheter angiography in carotid disease management.

6) Conclusion

Catheter-based angiography (DSA) frequently leads to a re-evaluation of non-invasive findings and changes in treatment plans for carotid disease, with discrepancies in stenosis severity or treatment plans ranging from 19% to 40% [1, 2]. This highlights its definitive role in refining diagnoses and guiding interventions, particularly for symptomatic patients. The generalizability of these findings is limited by the prevalence of retrospective designs and small sample sizes. The most significant

limitation affecting certainty is the **Heterogeneous Populations**, which impedes direct comparisons and broad applicability. For clinicians, this underscores the continued importance of considering catheter angiography for definitive assessment in cases of symptomatic carotid disease or discordant non-invasive imaging results.

References

SAIMSARA Session Index — session.json

Figure 1. Publication-year distribution of included originals

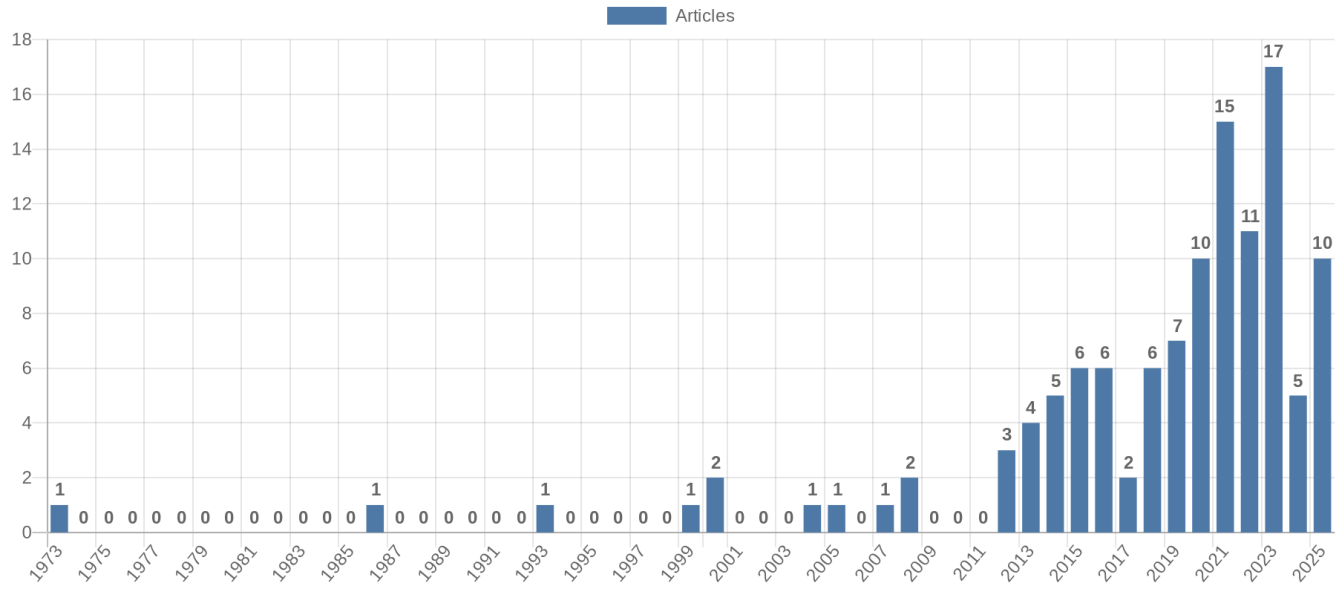


Figure 2. Study-design distribution of included originals

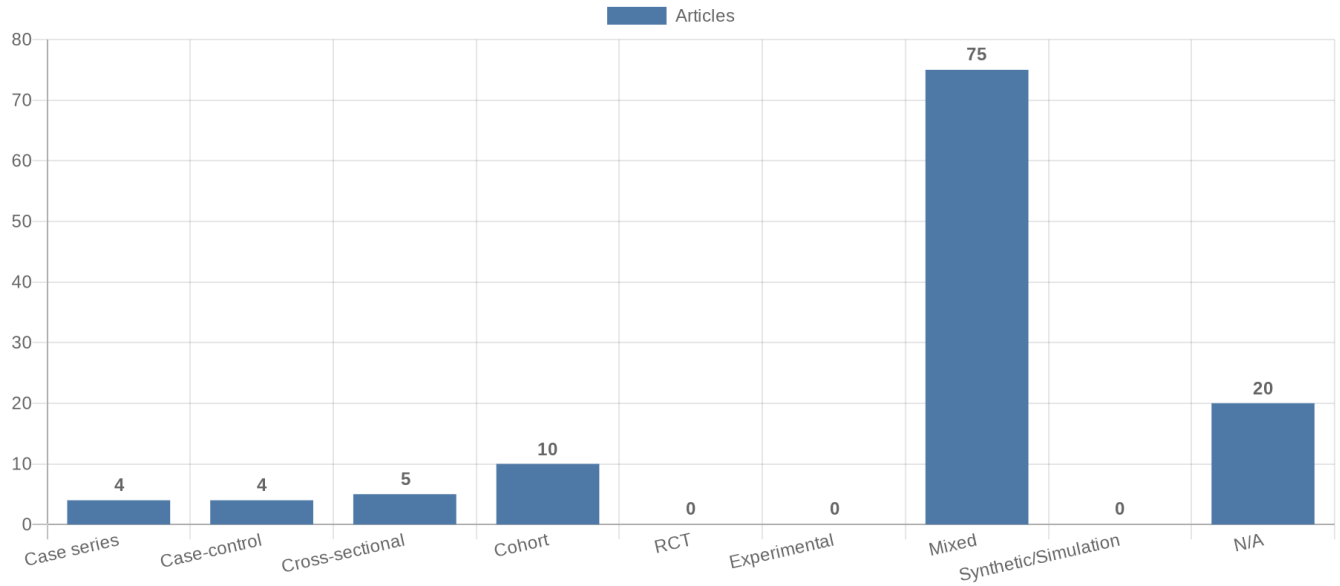


Figure 3. Study-type (directionality) distribution of included originals

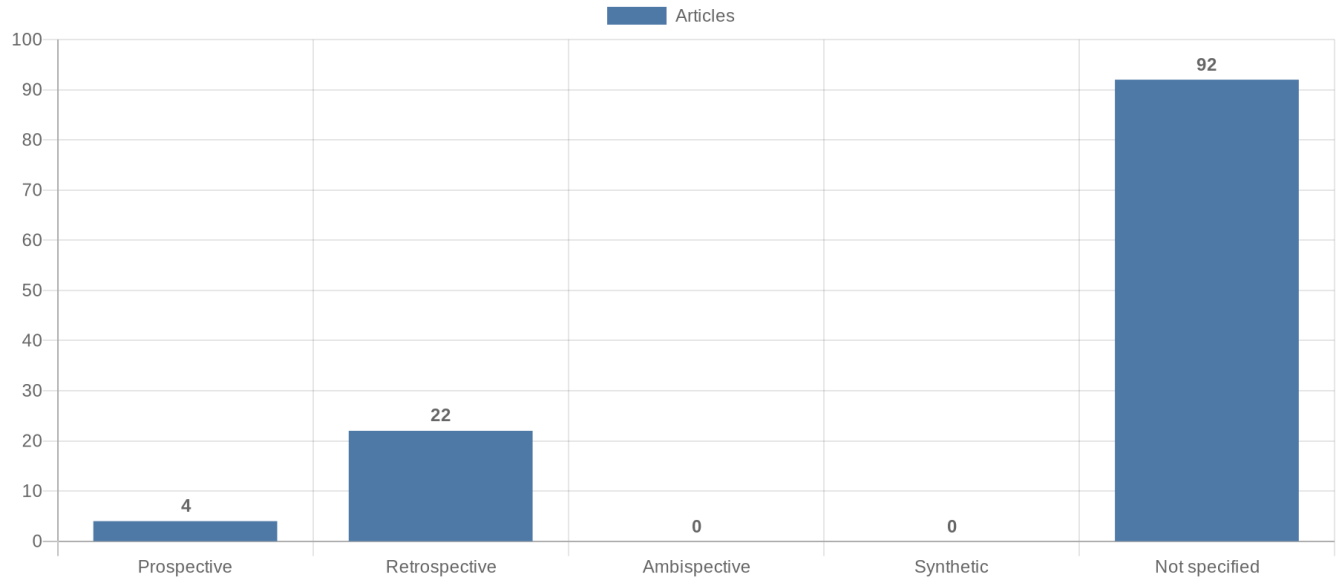


Figure 4. Main extracted research topics

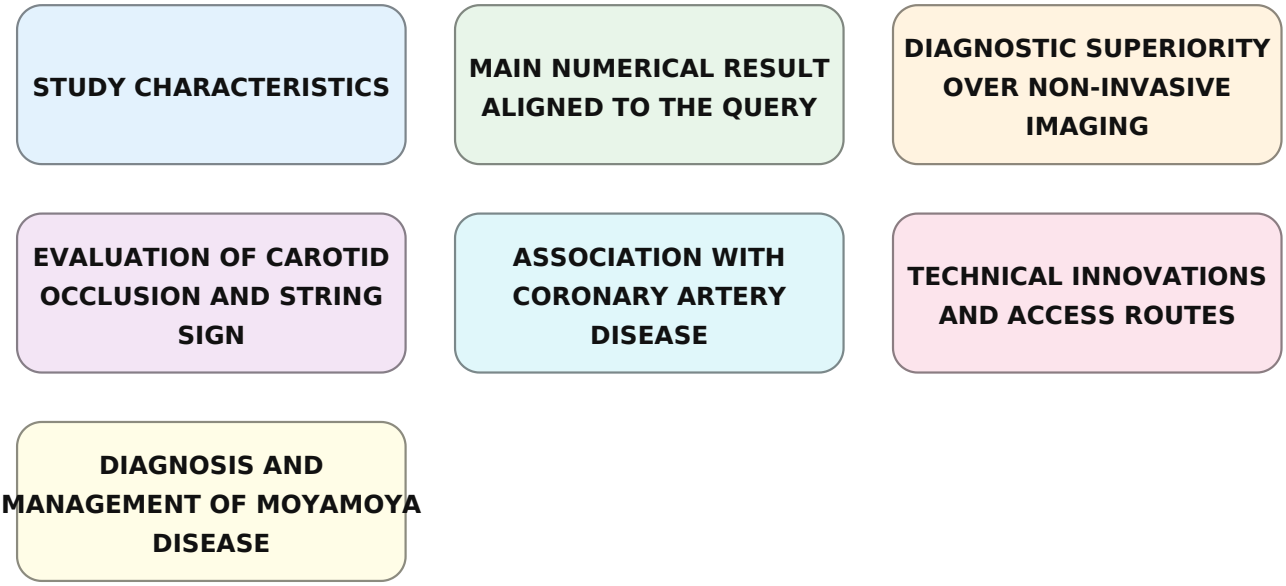


Figure 5. Limitations of current studies (topics)

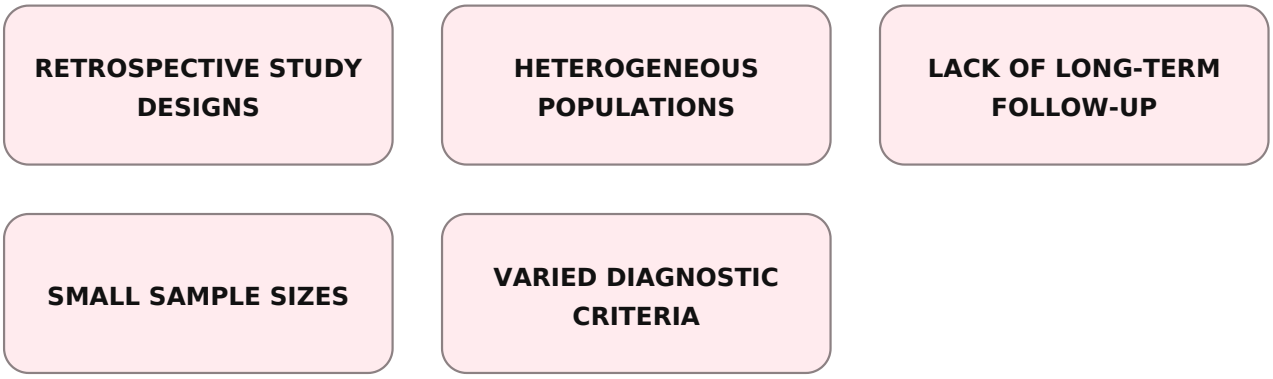


Figure 6. Future research directions (topics)

STANDARDIZED STENOSIS CRITERIA

COMPARATIVE CATHETER EFFICACY

COST-EFFECTIVENESS OF DSA

INTEGRATION OF ADVANCED IMAGING

LONGITUDINAL OUTCOMES POST-DSA

PROSPECTIVE COMPARATIVE STUDIES

STANDARDIZED DIAGNOSTIC PROTOCOLS