EVAR Endoleak: Systematic Review with ☸SAIMSARA.

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Abstract: This paper aims to systematically review and synthesize findings from the provided structured extraction summary to characterize the landscape of endoleaks after EVAR, including their incidence, associated factors, detection methods, and management approaches. The review utilises 273 studies with 112315 total participants (naïve ΣN). The overall incidence of endoleaks after EVAR, when reported as a percentage of patients, ranged from 10% to 54%, with a median incidence of 21.27%. This highlights endoleaks as a significant and common complication requiring ongoing attention. The heterogeneous study designs, particularly the prevalence of retrospective cohorts and case reports, most affects the certainty of findings and their generalizability. Clinicians should consider prophylactic embolization for high-risk patients and utilize advanced imaging modalities for precise detection. Future research should prioritize large-scale, prospective studies with standardized reporting to enhance the evidence base for optimal endoleak management.

Keywords: Endovascular Aortic Repair; Endoleak; Type II Endoleak; CT Angiography; Aneurysm Sac; Reintervention; Sac Embolization; Abdominal Aortic Aneurysm; Diagnostic Imaging; Endograft

Review Stats

- Generated: 2026-02-13 21:43:47 CET
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- Scope: All fields
- Keyword Gate: Fuzzy (≥60% of required terms, minimum 2 terms matched in title/abstract)
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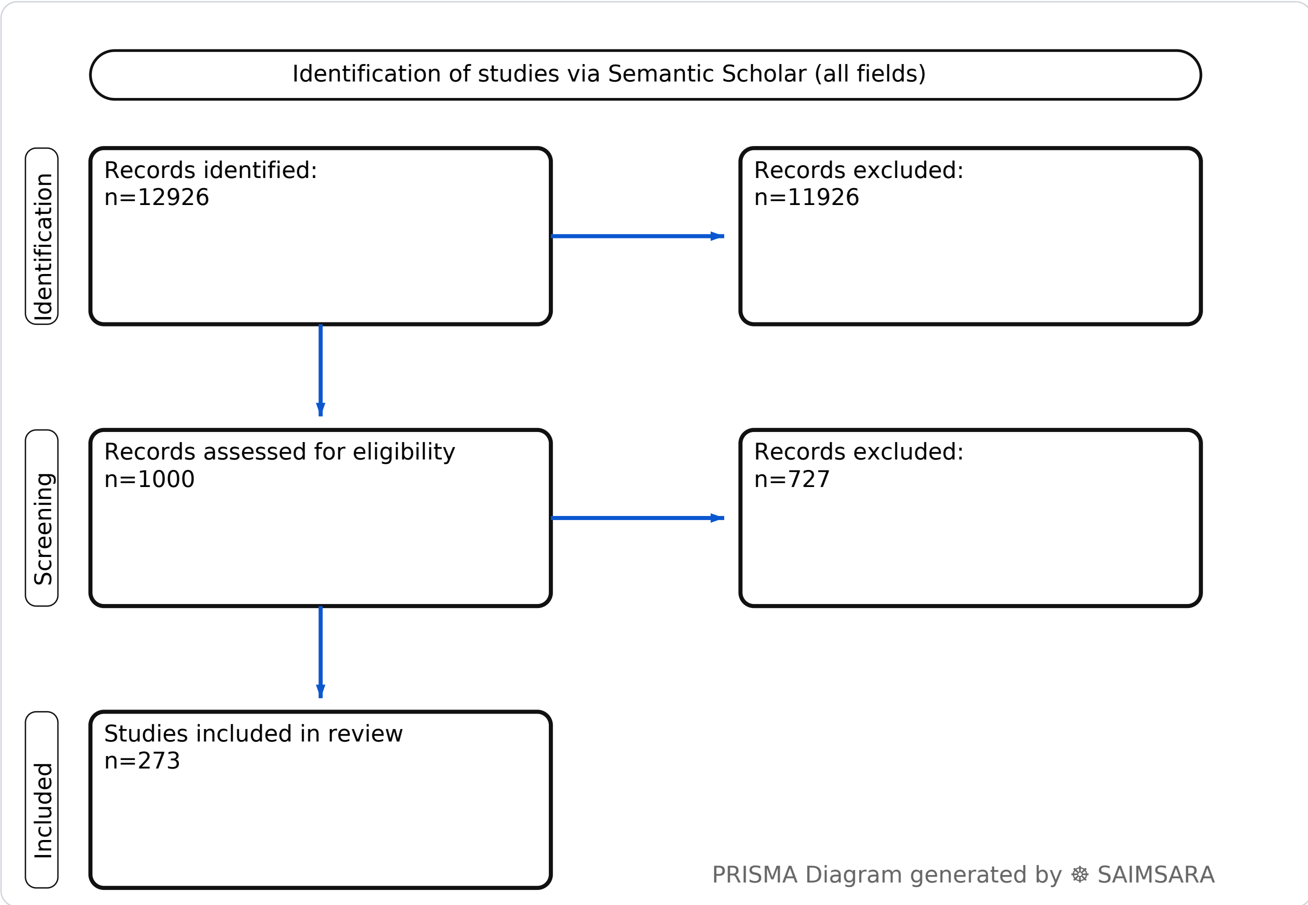
- Downloaded Abstracts/Papers: 1000
- Included original Abstracts/Papers: 273
- Total study participants (naïve ΣN): 112315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Records excluded:
n=11926
Screening
Records assessed for eligibility
n=1000
Records excluded:
n=727
Included
Studies included in review
n=273
PRISMA Diagram generated by ☸ SAIMSARA


△OSMA Triangle
Effect-of Predictor → Outcome
evar → endoleak
0
Harmful for patients ΣN=83064 (74%)
Beneficial for patients ΣN=1650 (1%)
Neutral ΣN=27601 (25%)
△OSMA Triangle generated by ☸SAIMSARA

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

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

Outcome: endoleak Typical timepoints: 1-y, 30-day. Reported metrics: %, CI, p.

Common endpoints: Common endpoints: complications, recurrence, mortality.

Predictor: evar — exposure/predictor. Routes seen: oral. Typical comparator: dsa, the endurant ii endograft, twist-vibe, evar without embolization....

- **1) Beneficial for patients** — endoleak with evar — [66], [74], [81], [85], [86], [242], [248], [258], [266] — ΣN=1650
- **2) Harmful for patients** — endoleak with evar — [1], [10], [11], [15], [27], [67], [83], [91], [92], [96], [100], [102], [103], [109], [110], [111], [112], [113], [114], [120], [121], [126], [128], [129], [132], [134], [135], [136], [138], [140], [141], [142], [144], [145], [152], [154], [156], [157], [159], [160], [161], [162], [163], [164], [165], [166], [168], [172], [177], [181], [200], [206], [207], [210], [212], [216], [218], [220], [223], [224], [231], [232], [233], [234], [236], [240], [245], [247], [251], [252], [254], [255], [256], [259], [260], [262], [263], [264], [265], [267], [268], [269] — ΣN=83064
- **3) No clear effect** — endoleak with evar — [2], [3], [4], [5], [6], [7], [8], [9], [12], [13], [14], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [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], [61], [62], [63], [64], [65], [68], [69], [70], [71], [72], [73], [75], [76], [77], [78], [79], [80], [82], [84], [87], [88], [89], [90], [93], [94], [95], [97], [98], [99], [101], [104], [105], [106], [107], [108], [115], [116], [117], [118], [119], [122], [123], [124], [125], [127], [130], [131], [133], [137], [139], [143], [146], [147], [148], [149], [150], [151], [153], [155], [158], [167], [169], [170], [171], [173], [174], [175], [176], [178], [179], [180], [182], [183], [184], [185], [186], [187], [188], [189], [190], [191], [192], [193], [194], [195], [196], [197], [198], [199], [201], [202], [203], [204], [205], [208], [209], [211], [213], [214], [215], [217], [219], [221], [222], [225], [226], [227], [228], [229], [230], [235], [237], [238], [239], [241], [243], [244], [246], [249], [250], [253], [257], [261], [270], [271], [272], [273] — ΣN=27601

Introduction

Endovascular aneurysm repair (EVAR) has become a cornerstone in the management of abdominal aortic aneurysms (AAAs), offering a less invasive alternative to open surgical repair. Despite its advantages, EVAR is associated with specific complications, most notably endoleaks. An endoleak refers to persistent blood flow into the aneurysm sac outside the endograft, which can compromise the repair and lead to aneurysm growth or rupture. The detection, classification, and management of endoleaks are critical for ensuring the long-term success of EVAR and necessitate diligent post-procedural surveillance. This paper synthesizes current evidence on the incidence, risk factors, diagnostic modalities, and treatment strategies for endoleaks following EVAR.

Aim

This paper aims to systematically review and synthesize findings from the provided structured extraction summary to characterize the landscape of endoleaks after EVAR, including their incidence, associated factors, detection methods, and management approaches.

Methods

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

- **Bias:** The included studies exhibit a qualitative inference of bias due to the prevalence of retrospective designs and case reports, which may introduce selection bias and limit generalizability. While some prospective cohort studies and randomized controlled trials (RCTs) are present, the overall evidence base is heterogeneous, with varying follow-up periods and patient populations.

Results

4.1 Study characteristics

The included studies comprise a mixed array of designs, predominantly retrospective cohort studies and case series, with some prospective cohorts and randomized controlled trials (RCTs). Populations generally consist of patients undergoing EVAR for abdominal aortic aneurysms, with some studies focusing on specific anatomical challenges or endograft types. Follow-up periods vary significantly, ranging from immediate post-operative assessment to up to 15.8 years, with many studies reporting mid-term outcomes.

4.2 Main numerical result aligned to the query

The overall incidence of endoleaks after EVAR, when reported as a percentage of patients, ranged from 10% [162] to 54% [4], with a median incidence of 21.27% [80]. This wide range reflects heterogeneity in study populations, follow-up durations, and diagnostic methodologies.

4.3 Topic synthesis

- **Endoleak Incidence and Types:** Endoleaks are a common complication, with overall incidence ranging from 10% to 54% [4, 80, 162]. Type II endoleaks (T2ELs) are the most frequently observed, accounting for 62% of complications in some cohorts [256] and being present in 27.5% of patients in others [32]. Type I endoleaks (T1ELs), including type Ia and Ib, and type III endoleaks (T3ELs) are also reported, with T3ELs occurring in 0.37% during index hospitalization and 0.7% during follow-up [163].
- **Risk Factors for Endoleak Development:** Hostile neck anatomy, characterized by short length (<15mm), large diameter (>28mm), or severe angulation (≥45-60°), is consistently identified as a significant risk factor for type Ia endoleaks [52, 98, 103, 112, 141, 177, 207, 210, 213, 218, 272]. Other factors include age, smoking, inferior mesenteric artery (IMA) diameter (especially >2.5mm), and the number of patent lumbar arteries [5, 76, 78]. Increased thrombus density [4, 70] and extracellular matrix dysregulation (e.g., proMMP-9) [57] are also implicated.
- **Impact of Endograft Choice:** Specific endograft devices show varying endoleak rates; for example, the Zenith endograft was associated with higher rates of type I and II endoleaks and reinterventions compared to the Endurant II [10]. The AFX device iterations were linked to a significantly higher risk of type III endoleaks (11.6%) at 5 years compared to non-AFX devices (5.7%) [200].
- **Detection and Diagnostic Modalities:** Computed Tomography Angiography (CTA) is a standard method [2, 7, 16, 19, 34, 39, 58, 60, 117, 171, 173, 176, 202, 214], with advanced techniques like dynamic CTA (d-CTA) [7, 214, 244], dual-energy CTA (DECTA) [16, 58, 176, 198], and 4D-CT [56] offering improved detection and characterization. Contrast-enhanced ultrasound (CEUS) demonstrates high sensitivity (91.5-100%) and specificity (93-100%) for T2EL detection, comparable or superior to CTA [6, 55, 87, 88, 116, 167, 184, 188, 189, 201, 226]. Other promising modalities include Superb Micro-vascular Imaging (SMI) [6, 55, 61], B-Flow ultrasound [25, 87], and various MRI techniques (4D-flow, QISS-MRA, unenhanced MRI) [115, 119, 192, 217, 241, 246].
- **Artificial Intelligence in Endoleak Detection:** Machine learning and deep learning algorithms show high accuracy (89-95%) in detecting endoleaks on CTA, with potential for clinical use [20, 39, 60, 99, 107, 118, 199, 209].
- **Prophylactic Strategies:** Preemptive embolization of collateral arteries (IMA and lumbar arteries) during EVAR is effective in preventing T2ELs, with reported incidence reductions (e.g., 17.3% vs 34.5%) [21, 26, 53, 64, 68, 108, 133, 193, 225]. Fibrin glue sac filling also shows promise in preventing short-term T2ELs and promoting aneurysm sac shrinkage [22].
- **Endoleak Management and Reintervention:** Reintervention rates for endoleaks vary, with 7.8% overall in one large cohort [1] and 13% for complications requiring reintervention in another [256]. Persistent T2ELs are associated with aneurysm sac expansion and often require intervention, including embolization (transarterial, direct sac puncture, EVOH, Onyx,

coils, AneuFix) [11, 15, 27, 29, 31, 37, 49, 50, 71, 72, 73, 75, 79, 82, 84, 95, 97, 106, 142, 146, 178, 196]. Open surgical conversion is a last-resort for refractory endoleaks, especially T2ELs causing sac enlargement, with endoleaks being the most common indication (50-75%) [11, 15, 83, 106, 135, 145, 161, 180, 240].

- **Aneurysm Sac Dynamics:** Aneurysm sac shrinkage (≥10mm) after EVAR is associated with significantly fewer endoleaks and reinterventions [48, 101, 236]. Conversely, persistent endoleaks, particularly T2ELs, are linked to a lower probability of sac regression and increased risk of sac expansion [27, 32, 42, 144, 174, 185, 224].
- **Predictors of Aggressive Endoleaks:** Shortest apposition length (SAL) <10mm is a strong indicator for late type Ia endoleak [24, 28]. Unsharp T2EL delineation on pre-interventional CT predicts persistent endoleak and growth [95]. Machine learning algorithms can predict aggressive T2ELs leading to sac expansion [209].
- **Long-term Outcomes and Surveillance:** Lifelong surveillance is crucial due to the potential for late complications, including endoleaks and reinterventions [36, 48, 98, 187]. T2ELs are generally considered benign, not associated with increased mortality [1, 36], but persistent T2ELs can lead to sac expansion and necessitate reintervention [27, 31, 32, 71]. Type III endoleaks are associated with decreased 5-year survival [163].

Discussion

5.1 Principal finding

The overall incidence of endoleaks after EVAR, when reported as a percentage of patients, ranged from 10% [162] to 54% [4], with a median incidence of 21.27% [80], highlighting their common occurrence and the need for ongoing management.

5.2 Clinical implications

- **Personalized Surveillance:** Given the variability in endoleak types and their clinical significance, personalized surveillance strategies using a modular imaging algorithm are promising [87].
- **Prophylactic Interventions:** Preemptive embolization of collateral arteries (IMA, lumbar arteries) should be considered in high-risk patients to prevent type II endoleaks and subsequent sac enlargement [21, 26, 53, 68, 108, 133, 193, 225].
- **Advanced Imaging for Detection:** Clinicians should leverage advanced imaging techniques like dynamic CTA, CEUS, SMI, and MRI for accurate and radiation-reduced endoleak detection and characterization, especially for type II endoleaks [6, 7, 16, 19, 25, 55, 61, 87, 88, 115, 116, 119, 184, 186, 188, 189, 201, 214, 217, 241, 243, 244, 246].

- **Risk Stratification for Reintervention:** Patients with hostile neck anatomy, specific endograft types, or persistent endoleaks require closer monitoring and may necessitate earlier reintervention to prevent aneurysm expansion or rupture [10, 24, 28, 52, 98, 103, 112, 141, 156, 177, 200, 207, 210, 213, 218, 272].
- **Refractory Endoleak Management:** For refractory type II endoleaks leading to sac growth, aggressive treatment options, including direct sac puncture embolization or open surgical conversion, should be considered to achieve resolution [11, 15, 29, 97, 106].

5.3 Research implications / key gaps

- **Comparative Effectiveness of Embolization Techniques:** Further RCTs are needed to compare the long-term efficacy and safety of different embolization materials (e.g., Onyx vs. coils vs. novel polymers) and approaches (e.g., transarterial vs. direct sac puncture) for persistent type II endoleaks [82, 97, 146, 196, 197].
- **Standardized AI Integration:** Prospective studies are required to validate the clinical utility and establish standardized protocols for integrating AI/machine learning tools into routine post-EVAR surveillance workflows for endoleak detection and risk prediction [20, 39, 60, 99, 107, 118, 199, 209].
- **Predictive Biomarkers for Endoleak:** Research into novel biomarkers (e.g., specific peptide signatures in aortic wall, inflammatory markers) is needed to identify patients at high risk for endoleak development or progression, potentially enabling earlier, targeted interventions [57, 131, 136].
- **Long-term Outcomes of Novel Devices:** Continued long-term prospective studies are essential to assess the durability and endoleak rates of newer endograft designs and techniques (e.g., semi-branched grafts, EndoAnchors, CERIB, bell-bottom technique) in diverse anatomical settings [3, 86, 90, 91, 92, 148, 221, 250].
- **Impact of Anticoagulation on Endoleaks:** The effect of warfarin or other oral anticoagulation therapies on endoleak development and persistence after EVAR remains an area requiring further investigation [38, 182].

5.4 Limitations

- **Heterogeneous Study Designs** — The reliance on mixed study designs, particularly retrospective cohorts and case reports, limits the ability to draw definitive causal conclusions and introduces potential biases.

- **Varied Follow-up Durations** — Inconsistent follow-up periods across studies make it challenging to assess the true long-term incidence and natural history of endoleaks and the durability of interventions.
- **Inconsistent Reporting Metrics** — Lack of standardized reporting for endoleak incidence, reintervention rates, and sac dynamics across studies complicates direct comparisons and meta-analysis.
- **Limited Comparative Data** — Many studies focus on single interventions or device types, with fewer head-to-head comparisons of different management strategies or endograft platforms.
- **Lack of Patient-Reported Outcomes** — The summary primarily focuses on clinical and radiological outcomes, with limited information on patient-reported quality of life or symptom burden related to endoleaks.

5.5 Future directions

- **Standardized Reporting Guidelines** — Implement universal guidelines for reporting endoleak incidence, types, and outcomes to facilitate future meta-analyses.
- **Longitudinal Cohort Studies** — Conduct large, multicenter, prospective cohort studies with extended follow-up to track the natural history of all endoleak types.
- **Randomized Controlled Trials** — Design RCTs comparing different prophylactic and therapeutic interventions for endoleaks, particularly for persistent type II endoleaks.
- **AI-Powered Predictive Models** — Develop and validate AI models for early and accurate prediction of endoleak development and progression, integrating diverse clinical and imaging data.
- **Cost-Effectiveness Analyses** — Perform studies to evaluate the cost-effectiveness of various surveillance strategies and intervention thresholds for different endoleak types.

Conclusion

The overall incidence of endoleaks after EVAR, when reported as a percentage of patients, ranged from 10% [162] to 54% [4], with a median incidence of 21.27% [80]. This highlights endoleaks as a significant and common complication requiring ongoing attention. The heterogeneous study designs, particularly the prevalence of retrospective cohorts and case reports, most affects the certainty of findings and their generalizability. Clinicians should consider prophylactic embolization for high-risk patients and utilize advanced imaging modalities for precise detection. Future research should prioritize large-scale, prospective studies with standardized reporting to enhance the evidence base for optimal endoleak management.

References

SAIMSARA Session Index — session.json

Figure 1. Publication-year distribution of included originals

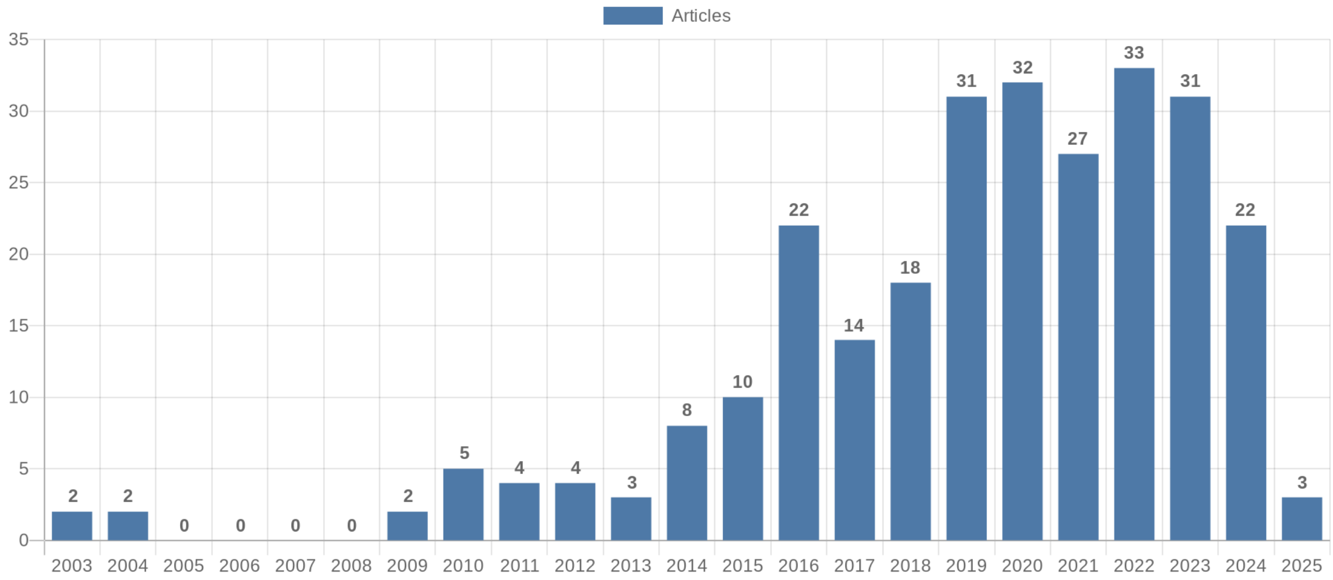


Figure 2. Study-design distribution of included originals

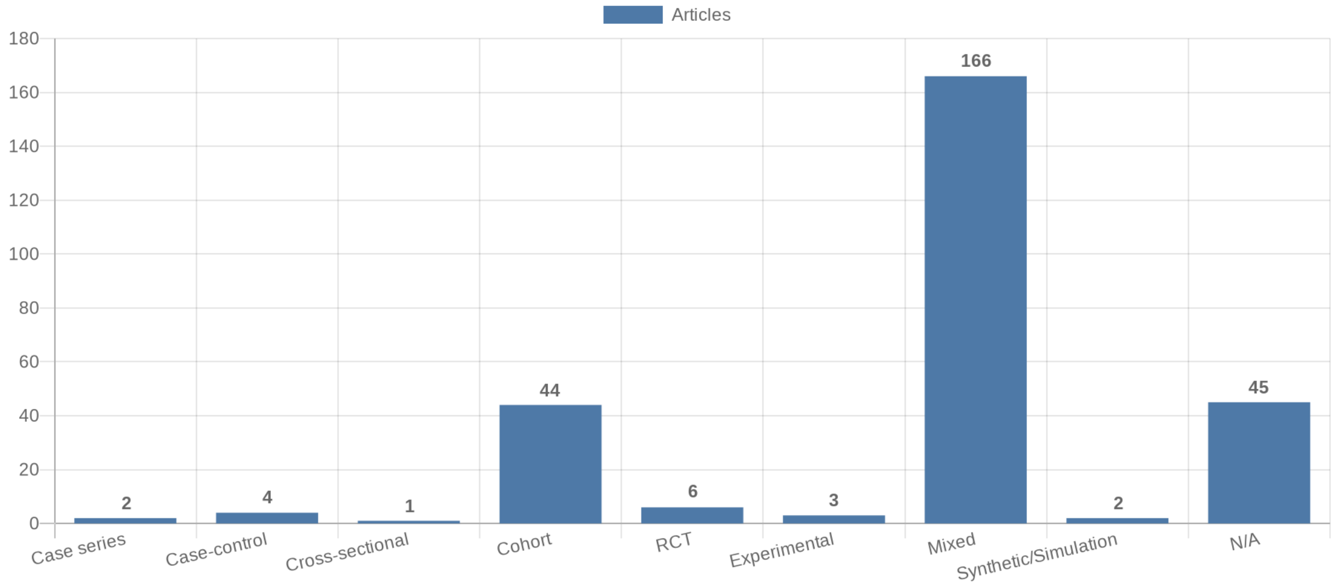


Figure 3. Study-type (directionality) distribution of included originals

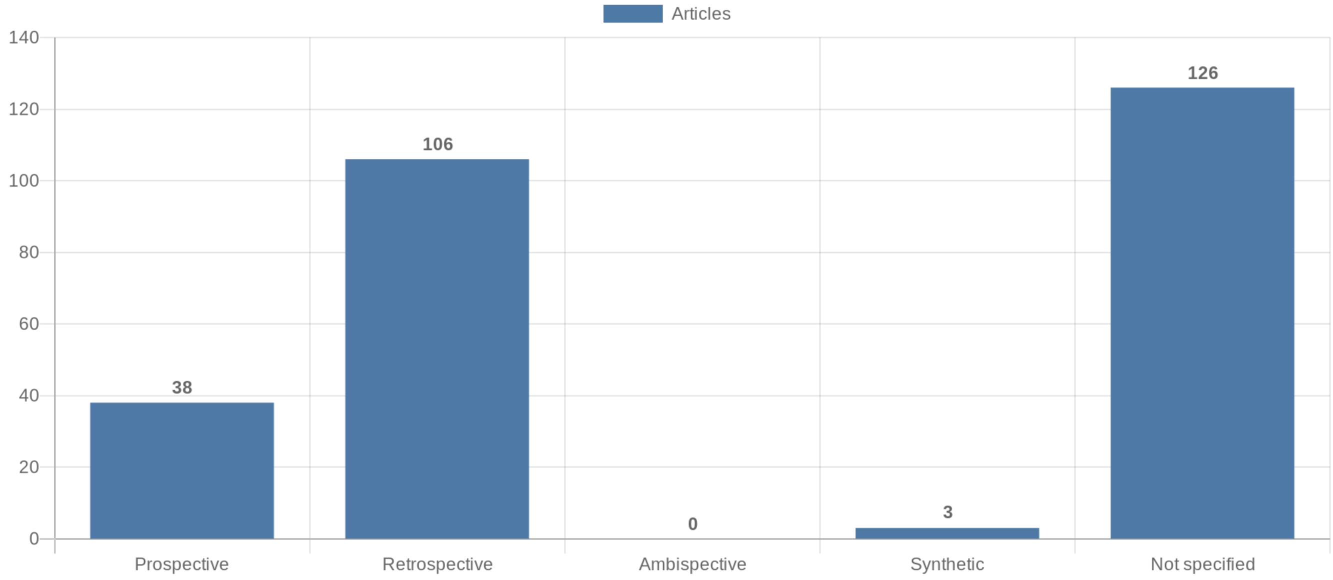


Figure 4. Main extracted research topics

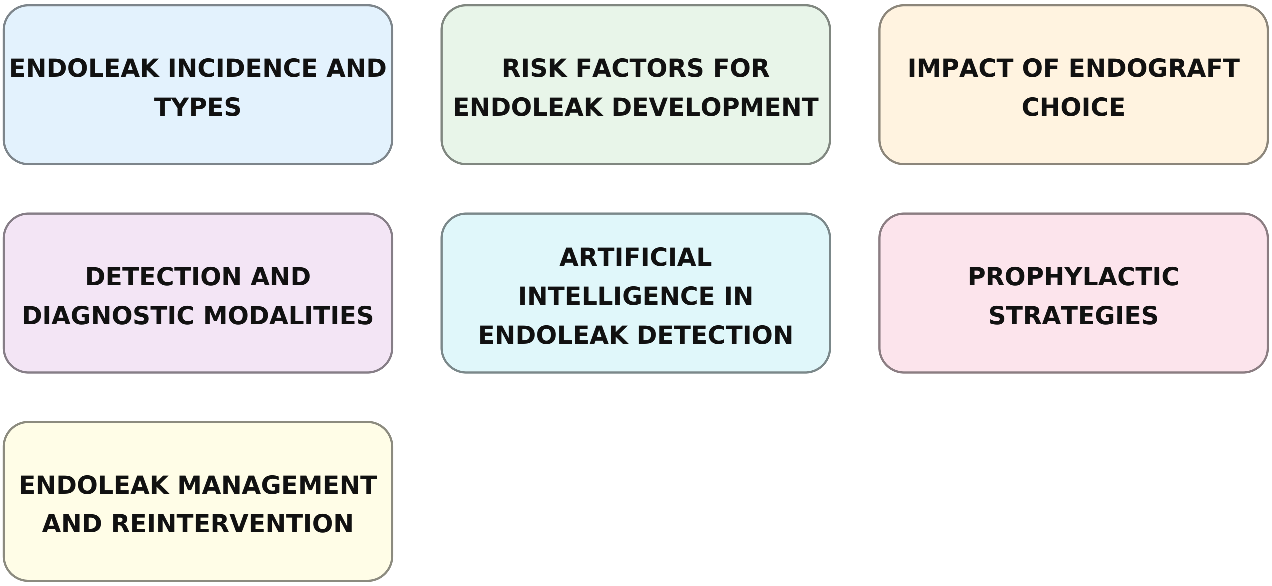


Figure 5. Limitations of current studies (topics)

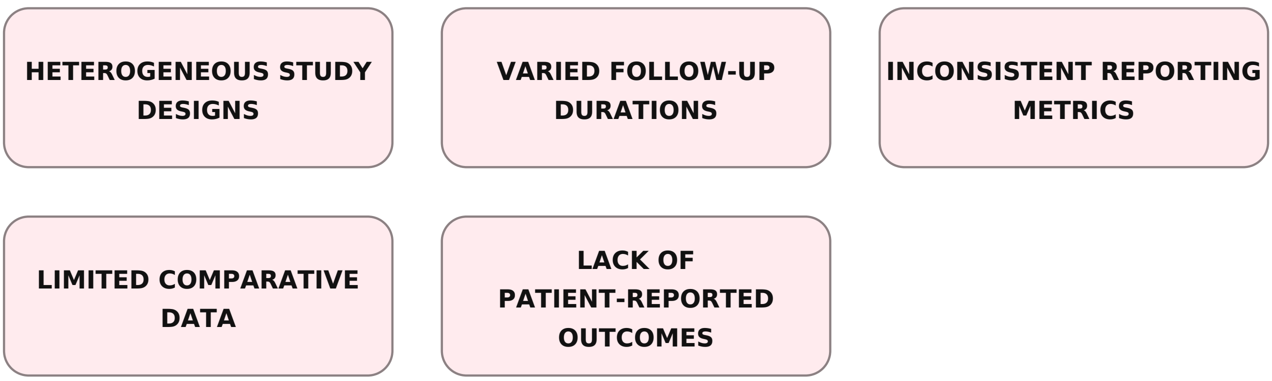
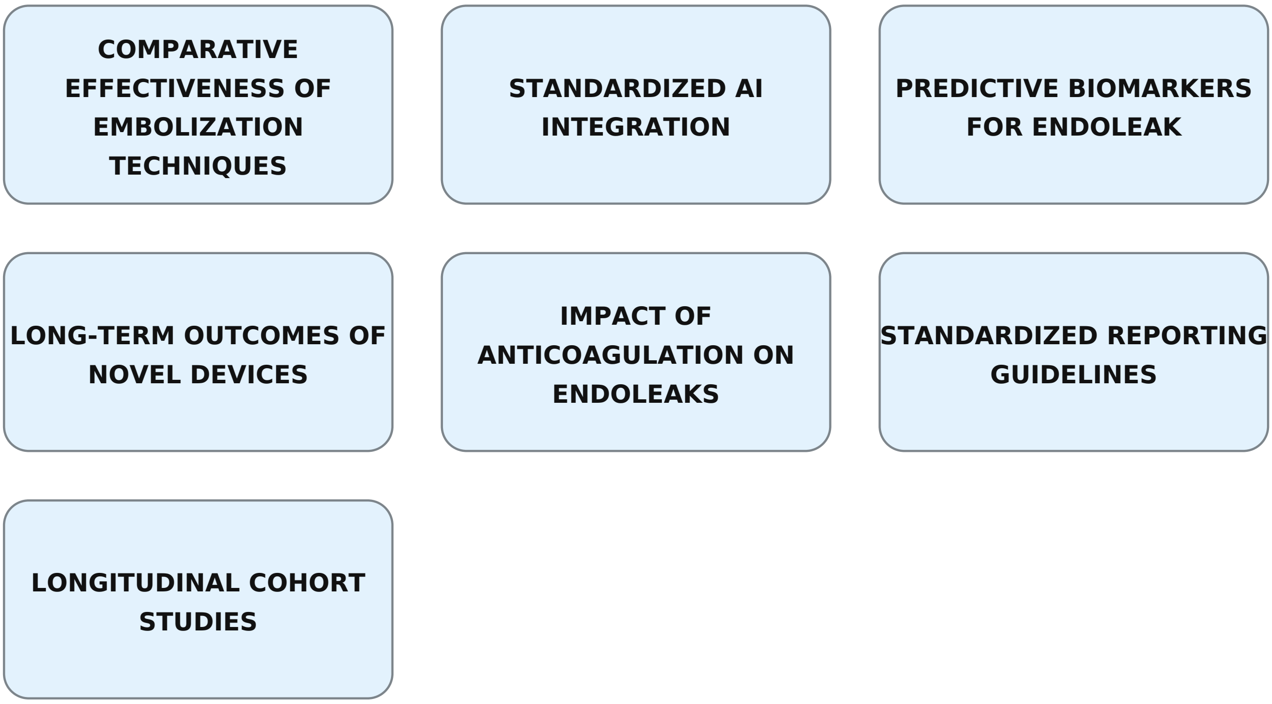


Figure 6. Future research directions (topics)


COMPARATIVE EFFECTIVENESS OF EMBOLIZATION TECHNIQUES
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LONGITUDINAL COHORT STUDIES