Diagnostics of Abdominal Aortic Aneurysm: Systematic Review with ☸SAIMSARA.

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Abstract: The aim of this systematic review is to comprehensively analyze and synthesize the current diagnostic methodologies for abdominal aortic aneurysm, drawing exclusively from a structured extraction of recent scientific literature. The review utilises 216 studies with 51365 total participants (naïve ΣN). For opportunistic AAA detection in CT using AI, a review found a mean sensitivity of 95% (95% CI 100–87%), a mean specificity of 96.6% (95% CI 100–75.7%), and a mean accuracy of 95.2% (95% CI 100–54.5%). The diagnostic landscape for abdominal aortic aneurysm is characterized by a blend of established imaging modalities, rapidly advancing AI applications, and a burgeoning field of molecular biomarkers. While traditional ultrasound and CT remain foundational, newer technologies and biomarkers offer enhanced precision and less invasiveness. However, the significant heterogeneity across studies, particularly in methodologies and populations, remains the most impactful limitation affecting the certainty and generalizability of findings. Future research should prioritize large-scale validation of AI algorithms and standardized assessment of novel biomarkers to translate these promising advances into improved clinical practice.

Keywords: Abdominal aortic aneurysm; Diagnostic imaging; Artificial intelligence; Biomarkers; Ultrasound; Computed tomography; Aneurysm progression; Non-alcoholic fatty liver disease; Theranostic nanozyme; Inflammatory aneurysm

Review Stats

- Generated: 2026-02-13 00:28:23 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)
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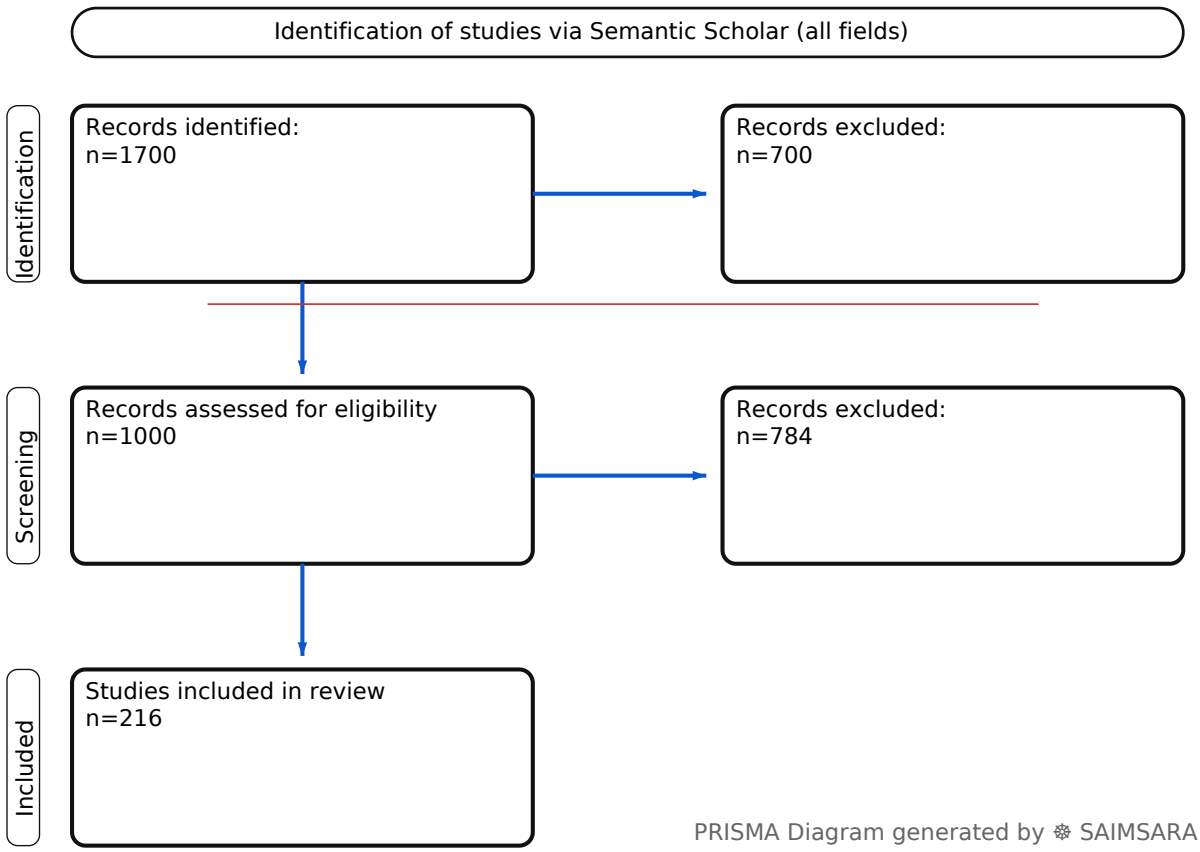
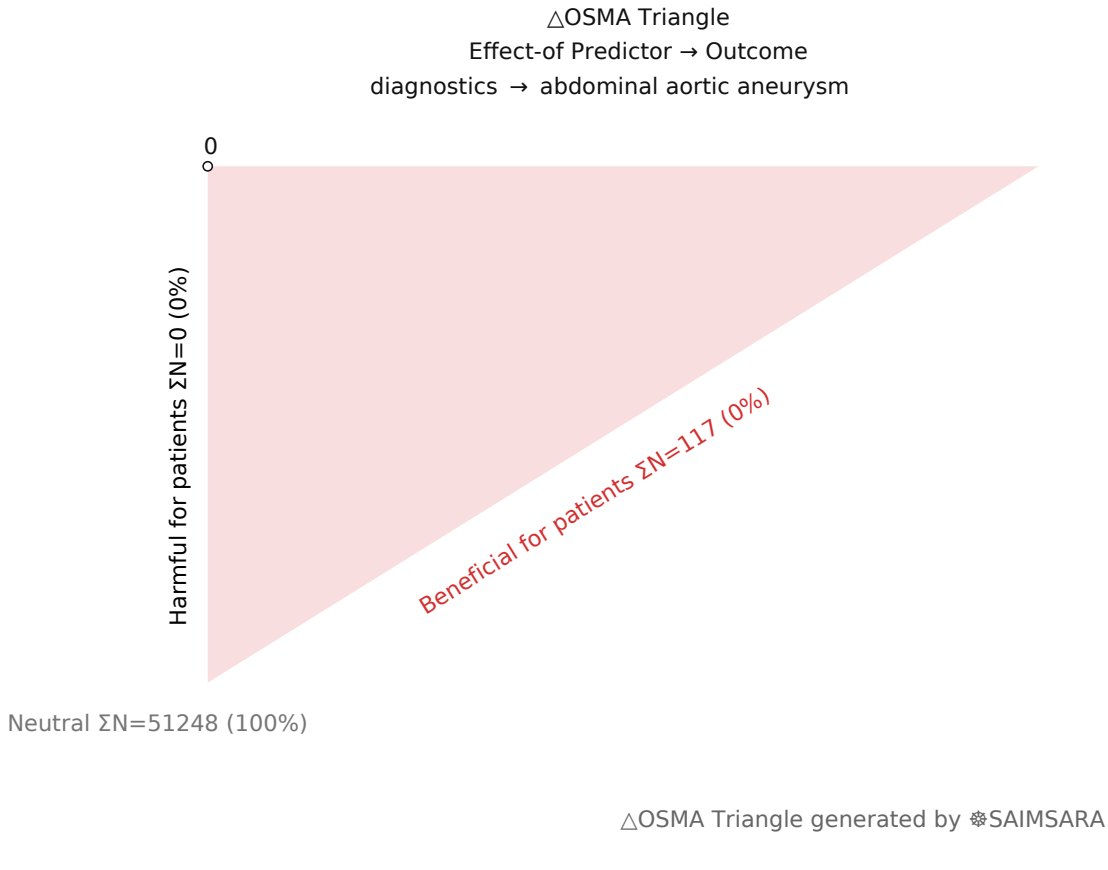
- Downloaded Abstracts/Papers: 1000
- Included original Abstracts/Papers: 216
- Total study participants (naïve ΣN): 51365



PRISMA Diagram generated by ☸ SAIMSARA



Neutral ΣN=51248 (100%)

△OSMA Triangle generated by ☸SAIMSARA

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

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

Outcome: abdominal aortic aneurysm Typical timepoints: 50-y, 12-mo. Reported metrics: %, CI, p.

Common endpoints: Common endpoints: complications, mortality, functional.

Predictor: diagnostics — exposure/predictor. Doses/units seen: 0.675 mg, 1.5 l, 110 mg. Routes seen: oral. Typical comparator: clinical imaging techniques, ct for abdominal aortic, controls and correlated with, pad patients after adjusting….

- **1) Beneficial for patients** — abdominal aortic aneurysm with diagnostics — [113] — ΣN=117
- **2) Harmful for patients** — abdominal aortic aneurysm with diagnostics — — — ΣN=0
- **3) No clear effect** — abdominal aortic aneurysm with diagnostics — [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], [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], [114], [115], [116], [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [127], [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], [183], [184], [185], [186], [187], [188], [189], [190], [191], [192], [193], [194], [195], [196], [197], [198], [199], [200], [201], [202], [203], [204], [205], [206], [207], [208], [209], [210], [211], [212], [213], [214], [215], [216] — ΣN=51248

1) Introduction

Abdominal aortic aneurysm (AAA) represents a critical cardiovascular condition characterized by localized dilatation of the abdominal aorta, posing a significant risk of rupture if left undiagnosed and untreated. Early and accurate diagnosis is paramount for effective management, risk stratification, and improved patient outcomes. The landscape of AAA diagnostics is rapidly evolving, encompassing

traditional imaging modalities, advanced computational analyses, and emerging molecular biomarkers. This paper synthesizes current research on the diverse diagnostic approaches for AAA, highlighting advancements and identifying key areas for future investigation.

2) Aim

The aim of this systematic review is to comprehensively analyze and synthesize the current diagnostic methodologies for abdominal aortic aneurysm, drawing exclusively from a structured extraction of recent scientific literature.

3) 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 qualitative heterogeneity in design, ranging from mixed-methods and retrospective cohorts to case series and synthetic/simulation studies. Sample sizes vary widely, from single case reports to thousands of patients, and follow-up periods are often unspecified or short. This variability, coupled with the absence of explicit randomization in many studies, suggests a potential for selection and reporting biases. Furthermore, the focus on pioneering technologies and specific biomarkers in several studies may introduce publication bias towards positive or novel findings.

4) Results

4.1 Study characteristics: The reviewed literature comprises a diverse array of study designs, including mixed-methods, retrospective and prospective cohorts, case series, and synthetic/simulation studies. Populations range from rat models and 3D-printed aneurysm models to healthy adult subjects, specific patient cohorts (e.g., those with peripheral artery disease, Behçet's disease, or undergoing EVAR), and general populations undergoing screening. Follow-up periods, when specified, typically range from a few months to several years, with some studies having no follow-up.

4.2 Main numerical result aligned to the query:

For opportunistic AAA detection in CT using AI, a review found a mean sensitivity of 95% (95% CI 100–87%), a mean specificity of 96.6% (95% CI 100–75.7%), and a mean accuracy of 95.2% (95% CI 100–54.5%) [1]. Separately, a deep learning-based segmentation pipeline for computed tomography angiography (CTA) demonstrated 97% accuracy, 98% sensitivity, and 96% specificity for AAA screening [44]. In the context of initial AAA detection, point-of-care ultrasound (POCUS) by nonradiologist physicians showed high diagnostic performance with 98% sensitivity and 99%

specificity [194], and emergency ultrasound by emergency physicians achieved 100% sensitivity (95% CI: 87-100) and 91% specificity (95% CI: 90.8-99.8) [121].

4.3 Topic synthesis:

- **Artificial Intelligence in Imaging:** AI for opportunistic AAA detection in CT shows high mean sensitivity (95%) and specificity (96.6%) [1], with deep learning segmentation achieving 97% accuracy for CTA screening [44]. Datasets for AI training are being developed [2].
- **Ultrasound Modalities:** Point-of-care ultrasound (POCUS) is highly sensitive (100%) and specific (91–99%) for AAA detection [121, 194], and can identify inflammatory AAAs with 100% sensitivity and 98.7% specificity [7]. Superb Microvascular Imaging (SMI) and contrast-enhanced ultrasound (CEUS) show comparable accuracy (95.9%) to CTA for detecting type II endoleaks after EVAR [10, 149].
- **Computed Tomography (CT) and Magnetic Resonance Angiography (MRA):** CTA is the most common diagnostic method for asymptomatic AAAs (81.2%) [23], while multiphasic multidetector CT angiography is the initial choice for aortic fistulas [159]. Dynamic radial MRA demonstrated superior diagnostic performance for detecting type II endoleaks (AUC 0.97) compared to CTA (AUC 0.66) in patients with inconclusive CTA findings [93].
- **Novel Imaging Techniques:** Infrared thermography (IRT) and cardiac thermal pulse (CTP) evaluation are proposed for earlier AAA detection [27, 35]. SPECT imaging tools using functionalized radiolabeled polysaccharide microparticles show potential for AAA diagnosis [129, 133]. A Non-Invasive Vision-Based System (NIVBS) achieved 98.56% accuracy for AAA wall deformation analysis [4].
- **Biomarkers for AAA Diagnosis and Progression:**
- **Genetic/Molecular:** MiR-15a [16], miR-3154 [18], LINC00265 [80], FOS [30, 36], G0S2 [45], POU2AF1 [73], ETS1 and ITPR3 [22], and six macrophage-related hub genes [40] show diagnostic potential. Circulating cell-free DNA (cfDNA) levels are elevated in AAA patients [17].
- **Protein/Peptide:** D-dimer is a reliable biomarker for predicting AAA in patients with peripheral artery disease (PAD) (sensitivity 76.9%, specificity 84.9% at 0.675 mg/L) [29]. A combination of heme and heme oxygenase-1 (HO-1) with interleukin-6 (IL-6) improved diagnostic potential (AUC 0.87, sensitivity 80%, specificity 79%) [37]. Circulating CCL20 is a highly sensitive biomarker for AAA (AUC 0.768) [54]. Profilin 1 (PFN1) and complement factor D (CFD) are potential blood biomarkers, with their combination improving diagnostic performance [92].
- **Inflammatory Markers:** CXCL8 is upregulated in AAA [19]. Calprotectin levels are threefold higher in AAA patients [119]. Neutrophil counts and NLR show good diagnostic performance

for differentiating ruptured from unruptured AAAs (neutrophils AUC 0.847) [97].

- **Risk Factors and Progression Predictors:** Non-alcoholic fatty liver disease (NAFLD) is an independent predictor of AAA progression (HR 4.28) and improves diagnostic efficacy when combined with maximal diameter (AUC 0.857) [13]. Initial diameter and intraluminal thrombus are prognostic factors for aneurysm expansion [41]. Elevated circulating monocyte subsets predict aneurysm progression [84].
- **Specific AAA Types and Complications:** Brucella-induced AAAs are rare, diagnosed by serology and imaging [5]. Inflammatory AAAs can be identified by ultrasound [7]. Aorto-duodenal fistulas are rare but severe complications, diagnosed by CT with oral contrast [25] or multiphasic CT angiography [159].
- **Theranostic Approaches:** A theranostic nanozyme targets AAA sites, mitigates expansion, and enables noninvasive diagnostic monitoring via urinalysis in rat models [3]. Gold nanoparticles (GNPs) conjugated with an elastin antibody show promise as a micro-CT imaging tool [53].

5) Discussion

5.1 Principal finding: The integration of artificial intelligence (AI) into computed tomography (CT) imaging demonstrates a high diagnostic capability for abdominal aortic aneurysm (AAA), with a reported mean sensitivity of 95% and mean specificity of 96.6% for opportunistic detection [1]. This highlights the significant potential of advanced computational methods in identifying AAA.

5.2 Clinical implications:

- **Enhanced Screening:** Point-of-care ultrasound (POCUS) offers a highly sensitive (98-100%) and specific (91-99%) non-invasive tool for early AAA detection, suitable for routine screening by non-radiologist physicians, potentially reducing the need for further costly tests [121, 194, 188].
- **Improved Endoleak Surveillance:** Superb Microvascular Imaging (SMI) and contrast-enhanced ultrasound (CEUS) provide accurate, less invasive, and less expensive alternatives to CTA for detecting type II endoleaks after EVAR, improving post-operative monitoring [10, 149].
- **Risk Stratification:** Biomarkers like D-dimer (sensitivity 76.9%, specificity 84.9%) [29], combined heme and HO-1 with IL-6 (AUC 0.87) [37], and elevated monocyte subsets [84] can aid in predicting AAA presence and progression, guiding patient management.
- **Differential Diagnosis:** Advanced imaging (e.g., PET/CT) can differentiate between mycotic and inflammatory AAAs with higher accuracy than CE-CT (AUC 0.81 vs 0.63) [102], crucial for targeted treatment.

- **Acute Presentations:** Prompt CT imaging is vital for diagnosing ruptured AAAs [113, 170] and complications like aorto-duodenal fistulas [25, 205], enabling timely intervention in life-threatening scenarios.

5.3 Research implications / key gaps:

- **AI Algorithm Validation:** Further large-scale, prospective studies are needed to validate the high sensitivity and specificity of AI algorithms for opportunistic AAA detection in diverse clinical settings and populations [1].
- **Novel Biomarker Efficacy:** Research should focus on standardizing diagnostic thresholds and validating the clinical utility of emerging biomarkers (e.g., miR-15a, CXCL8, PFN1, CFD) in larger cohorts to improve early detection and risk prediction [16, 19, 92].
- **Theranostic Nanozyme Development:** Further preclinical and clinical development is required to translate promising theranostic nanozymes from rat models to human application for noninvasive diagnostic monitoring and therapeutic intervention [3].
- **Advanced Imaging Integration:** Studies are needed to assess the cost-effectiveness and workflow integration of novel imaging techniques like Infrared Thermography (IRT) and SPECT imaging tools in routine clinical practice for AAA detection and monitoring [27, 133].
- **Standardized Screening Protocols:** Comparative effectiveness research is needed to determine optimal screening protocols, considering patient-specific metrics, cost, radiation exposure, and the integration of various diagnostic modalities for high-risk populations [75, 123].

5.4 Limitations:

- **Study Heterogeneity** — The wide variety of study designs, populations, and outcome metrics limits direct comparison and synthesis of results.
- **Small Sample Sizes** — Many studies, particularly those on novel biomarkers or specific AAA types, involve small sample sizes, affecting the generalizability of their findings.
- **Lack of Standardization** — Inconsistent measurement methods and diagnostic criteria across studies, especially for ultrasound, complicate the interpretation of reported sensitivities and specificities.
- **Validation Needs** — Several promising diagnostic tools and biomarkers require further independent validation in larger, more diverse cohorts before clinical implementation.
- **Limited Follow-up** — Short or unspecified follow-up periods in some studies restrict the ability to assess long-term diagnostic accuracy or prognostic value.

5.5 Future directions:

- **AI Algorithm Validation** — Conduct large-scale, multicenter trials to validate AI algorithms for AAA detection.
- **Biomarker Panel Development** — Investigate combined biomarker panels for enhanced diagnostic and prognostic accuracy.
- **Theranostic Agent Translation** — Advance preclinical theranostic nanozyme research to human clinical trials.
- **Advanced Imaging Integration** — Evaluate the clinical impact and cost-effectiveness of novel imaging techniques.
- **Personalized Screening Strategies** — Develop risk-stratified, personalized AAA screening protocols based on combined diagnostics.

6) Conclusion

For opportunistic AAA detection in CT using AI, a review found a mean sensitivity of 95% (95% CI 100–87%), a mean specificity of 96.6% (95% CI 100–75.7%), and a mean accuracy of 95.2% (95% CI 100–54.5%) [1]. The diagnostic landscape for abdominal aortic aneurysm is characterized by a blend of established imaging modalities, rapidly advancing AI applications, and a burgeoning field of molecular biomarkers. While traditional ultrasound and CT remain foundational, newer technologies and biomarkers offer enhanced precision and less invasiveness. However, the significant heterogeneity across studies, particularly in methodologies and populations, remains the most impactful limitation affecting the certainty and generalizability of findings. Future research should prioritize large-scale validation of AI algorithms and standardized assessment of novel biomarkers to translate these promising advances into improved clinical practice.

References

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Figure 1. Publication-year distribution of included originals

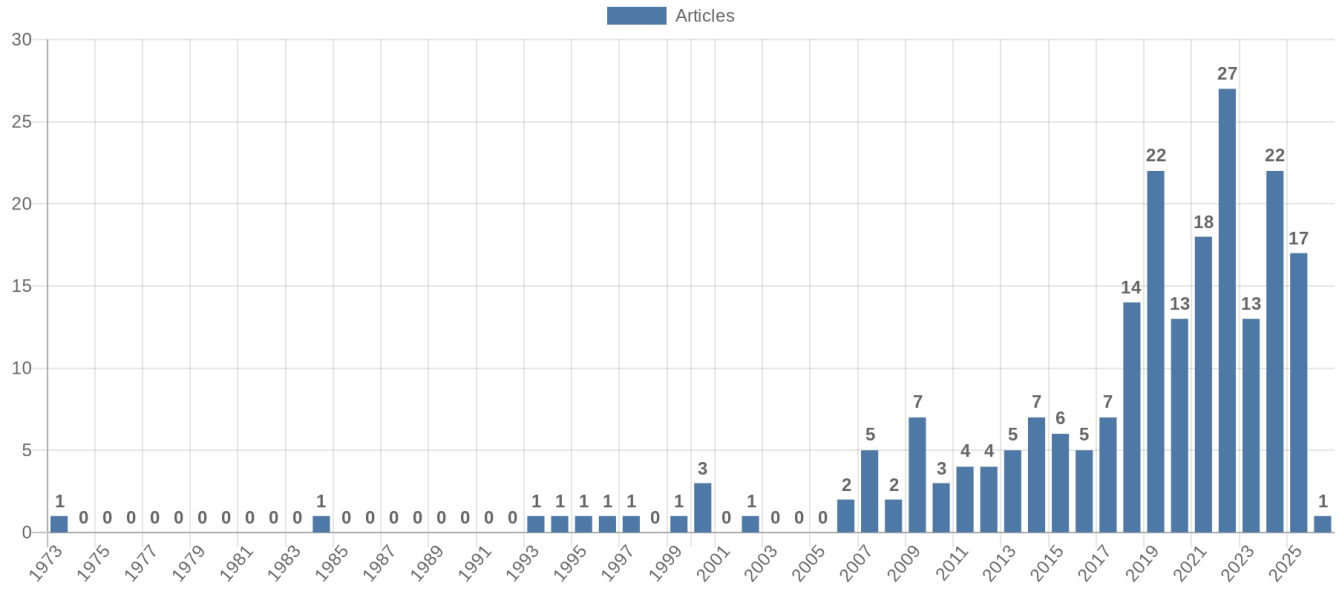

Figure 2. Study-design distribution of included originals

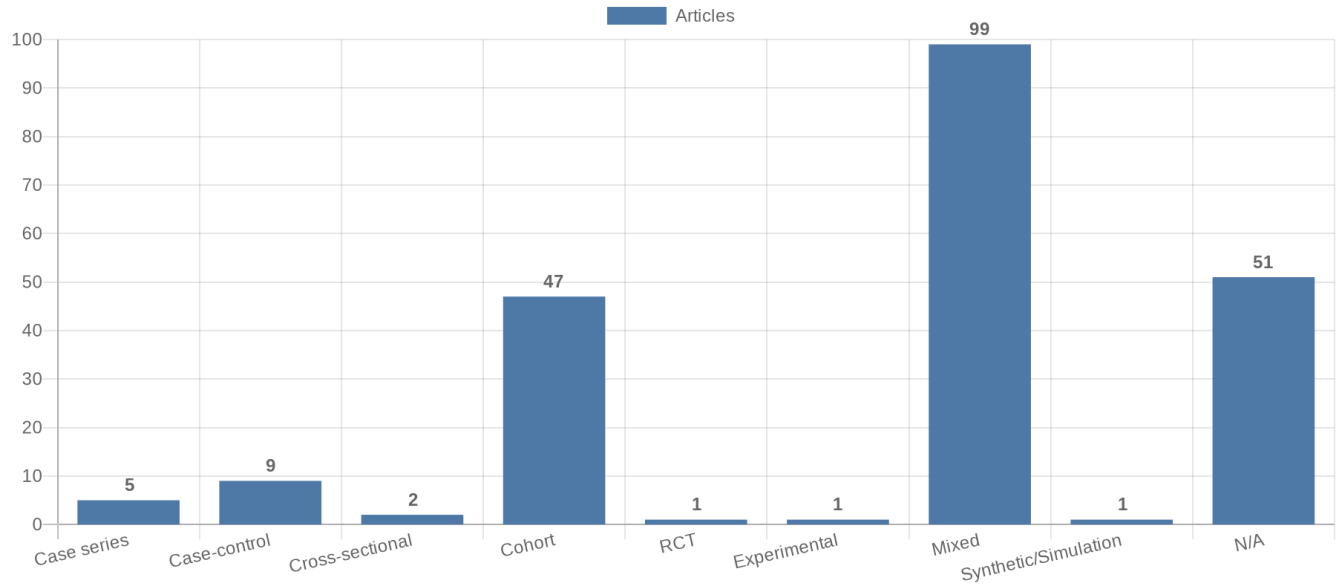

Figure 3. Study-type (directionality) distribution of included originals

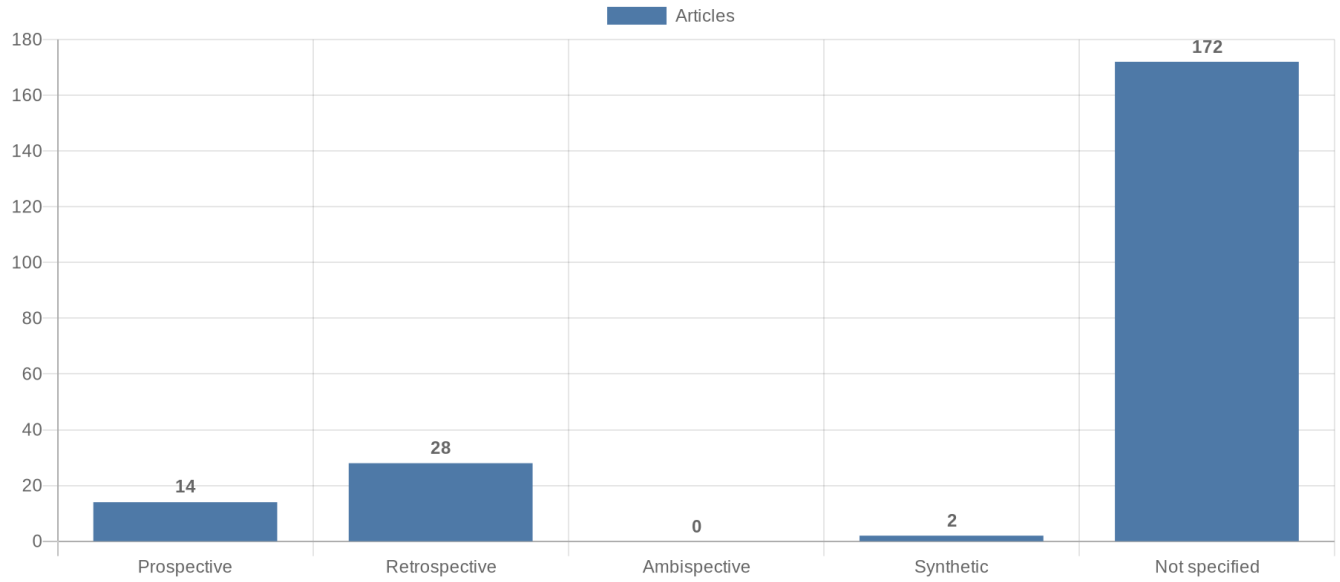

Figure 4. Main extracted research topics

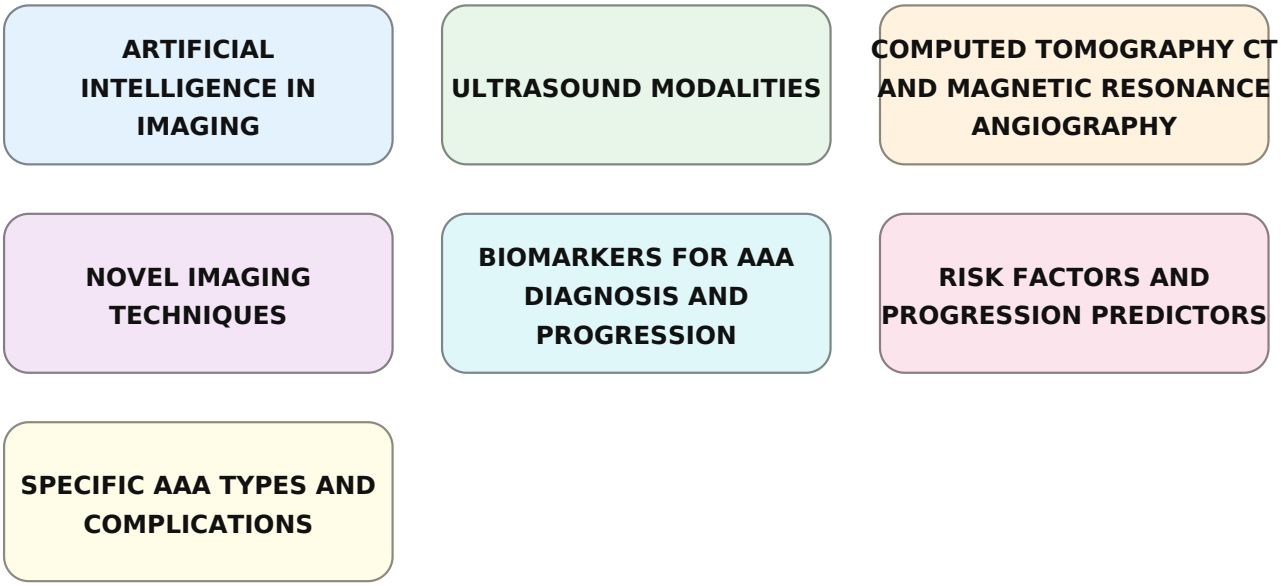

Figure 5. Limitations of current studies (topics)

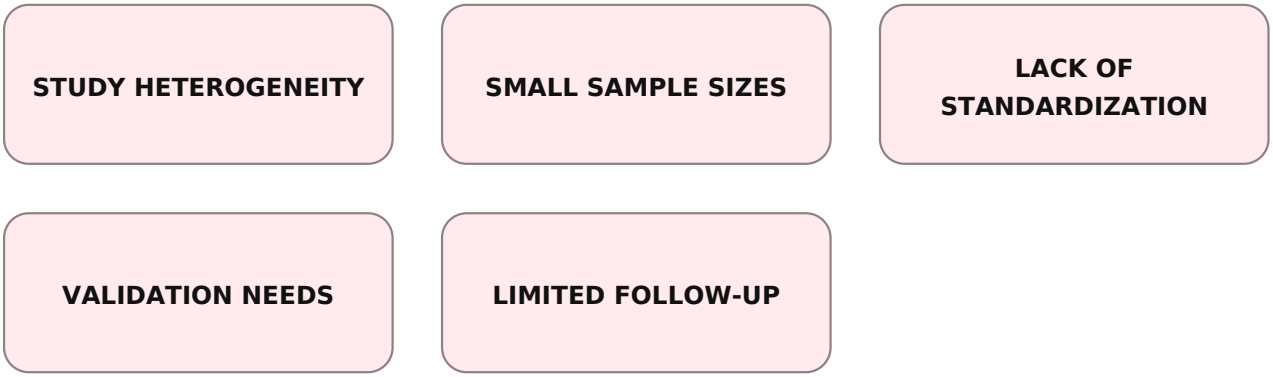

Figure 6. Future research directions (topics)