Abdominal Aortic Aneurysm and Ultrasound: Systematic Review with ☸SAIMSARA.

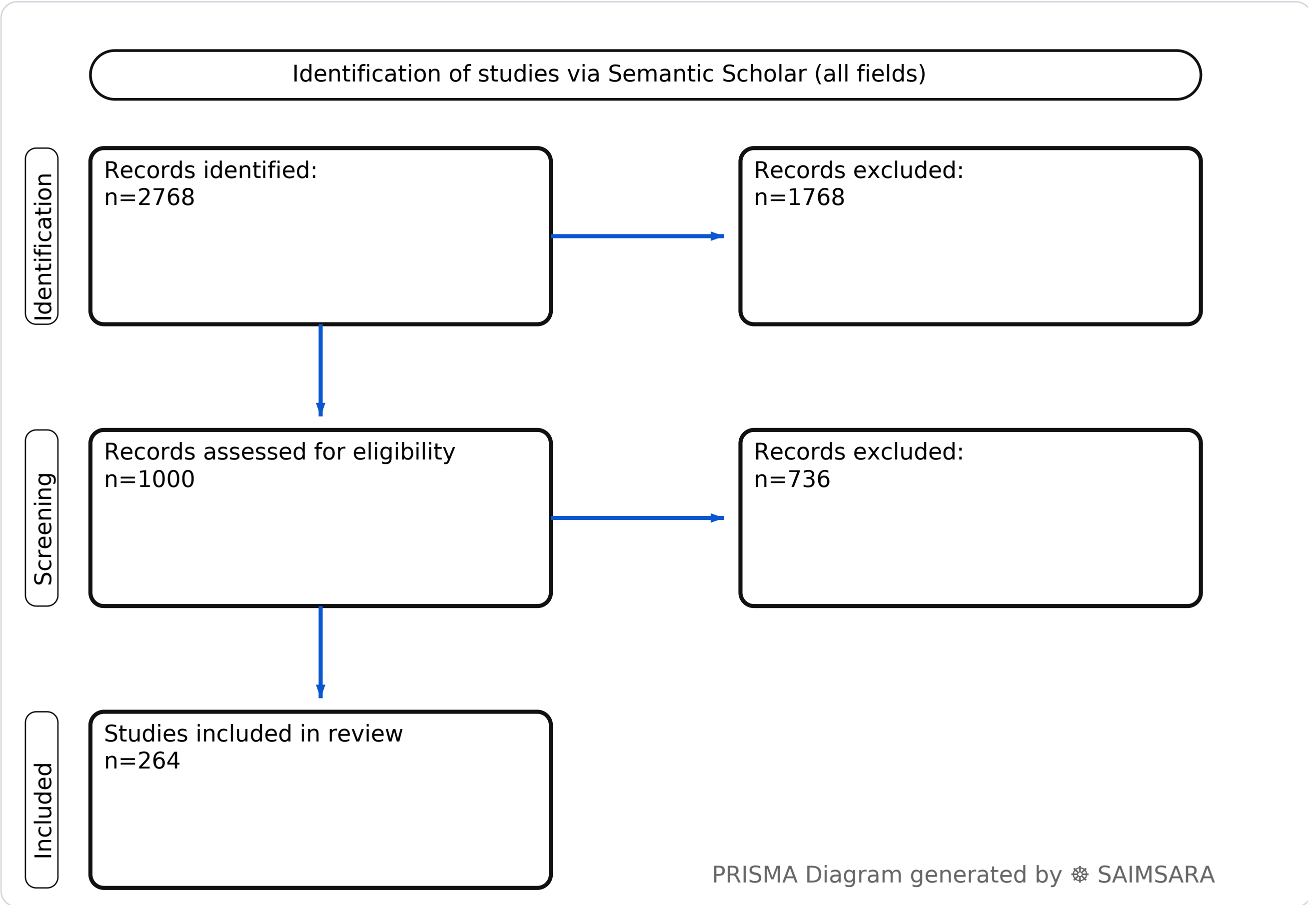
saimsara.com • Download PDF • URL

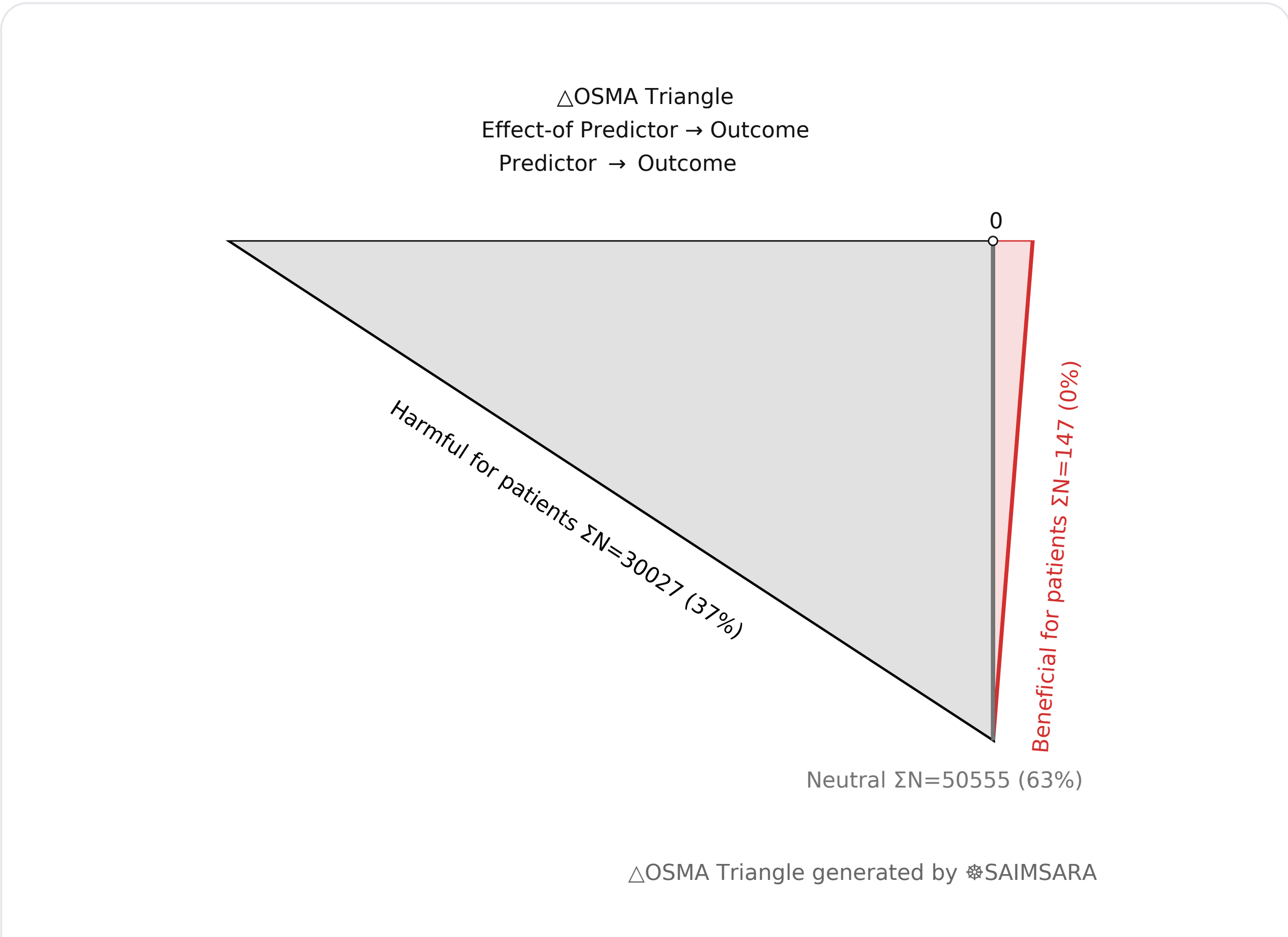
Abstract: The aim of this paper is to synthesize current evidence on the role of ultrasound in the assessment and management of abdominal aortic aneurysms. The review utilises 264 studies with 80729 total participants (naïve ΣN). For endoleak detection following endovascular abdominal aortic aneurysm repair (EVAR), ultrasound-based methods demonstrate a median sensitivity of 91.5% and a median specificity of 96.15%, with accuracy ranging from 60% to 97%. These findings underscore ultrasound's critical role in AAA management, from population screening and growth monitoring to post-EVAR surveillance. However, the inherent operator dependence of ultrasound remains a significant limitation affecting the certainty and generalizability of results. Future efforts should focus on developing standardized protocols and integrating AI-assisted diagnostics to further enhance the reliability and widespread utility of ultrasound in abdominal aortic aneurysm care.

Keywords: Abdominal Aortic Aneurysm; Ultrasound Imaging; AAA Screening; AAA Surveillance; Aneurysm Measurement; 3D Ultrasound; Endovascular Aortic Repair; Endoleak Detection; Point-of-Care Ultrasound; Aneurysm Growth

Review Stats

- Generated: 2026-02-13 07:30:42 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: 2768
- Downloaded Abstracts/Papers: 1000
- Included original Abstracts/Papers: 264
- Total study participants (naïve ΣN): 80729


Identification of studies via Semantic Scholar (all fields)
Identification
Records identified:
n=2768
Records excluded:
n=1768
Screening
Records assessed for eligibility
n=1000
Records excluded:
n=736
Included
Studies included in review
n=264
PRISMA Diagram generated by ☸ SAIMSARA


△OSMA Triangle
Effect-of Predictor → Outcome
Predictor → Outcome
0
Harmful for patients ΣN=30027 (37%)
Beneficial for patients ΣN=147 (0%)
Neutral ΣN=50555 (63%)
△OSMA Triangle generated by ☸SAIMSARA

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

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

Outcome: Outcome Typical timepoints: 3-day, 2-day. Reported metrics: %, CI, p.

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

Predictor: Predictor — exposure/predictor. Typical comparator: conventional segmentation, ct angiography in detecting, computed tomography, color doppler flow imaging....

- **1) Beneficial for patients** — Outcome with Predictor — [41], [47], [48], [219] — ΣN=147
- **2) Harmful for patients** — Outcome with Predictor — [25], [26], [42], [45], [49], [52], [66], [69], [71], [209], [212], [245], [246] — ΣN=30027
- **3) No clear effect** — Outcome with Predictor — [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [43], [44], [46], [50], [51], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [67], [68], [70], [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], [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], [210], [211], [213], [214], [215], [216], [217], [218], [220], [221], [222], [223], [224], [225], [226], [227], [228], [229], [230], [231], [232], [233], [234], [235], [236], [237], [238], [239], [240], [241], [242], [243], [244], [247], [248], [249], [250], [251], [252], [253], [254], [255], [256], [257], [258], [259], [260], [261], [262], [263], [264] — ΣN=50555

1) Introduction

Abdominal aortic aneurysm (AAA) is a localized dilatation of the abdominal aorta, representing a significant public health concern due to its potential for rupture and associated high mortality. Early detection and continuous surveillance are critical for effective management. Ultrasound, a noninvasive and widely accessible imaging modality, has emerged as a cornerstone in the screening, diagnosis, and post-interventional follow-up of AAAs. This paper systematically synthesizes recent research on the application of ultrasound in AAA, covering its utility in prevalence studies, growth monitoring, advanced imaging techniques, and surveillance after endovascular repair.

2) Aim

The aim of this paper is to synthesize current evidence on the role of ultrasound in the assessment and management of abdominal aortic aneurysms.

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. Cohort studies and mixed designs (often retrospective) are prevalent, introducing potential for selection and information bias. Experimental studies, particularly in animal models, are subject to translational limitations. Randomized controlled trials (RCTs) are less common but provide stronger evidence for screening efficacy and intervention impact. Many studies lack explicit reporting of study type directionality, sample size, or specific statistical methods, limiting a comprehensive assessment of internal validity.

4) Results

4.1 Study characteristics:

The evidence base primarily comprises cohort studies (both prospective and retrospective), mixed-design studies, and experimental/synthetic studies, often utilizing animal models or simulations. Populations range from general community screenings in elderly males and high-risk women to specific patient cohorts such as those with coronary artery disease, peripheral arterial disease, or post-endovascular aneurysm repair (EVAR). Follow-up periods, when specified, vary from short-term (e.g., 28 days in animal models) to long-term surveillance spanning up to 10 years in human cohorts.

4.2 Main numerical result aligned to the query:

For endoleak detection following endovascular abdominal aortic aneurysm repair (EVAR), ultrasound-based methods demonstrate high diagnostic performance. The median sensitivity for endoleak detection is 91.5% [169], with reported values ranging from 27% [151] to 100% [40, 151]. The median specificity is 96.15% [30], with values ranging from 92% [17] to 100% [40, 169]. Accuracy for endoleak detection ranges from 60% [151] to 97% [151, 169]. These figures highlight the significant, though variable, efficacy of ultrasound in post-EVAR surveillance.

4.3 Topic synthesis:

- **AAA Screening and Prevalence:** Ultrasound screening programs in various populations (e.g., men aged 65-74, high-risk women, patients with cardiopulmonary disease) report AAA prevalence ranging from 0.29% [6] to 10.8% [242]. Male gender, smoking, older age, and family history are consistently identified as significant risk factors [59, 93, 109, 193].
- **AAA Measurement and Growth Monitoring:** Ultrasound accurately measures AAA diameter, with point-of-care ultrasound (POCUS) showing comparable measurements to standard-of-care imaging (average difference -0.1 ± 0.3 cm, P = NS) [5]. Growth rates for AAAs measuring 4.5–4.9 cm average 0.3 cm/year [3], with overall rates ranging from 0.56 mm/year to 4.2 mm/year [165, 116].
- **Advanced Ultrasound Techniques:** Three-dimensional (3D) and four-dimensional (4D) ultrasound enable comprehensive volumetric assessment, strain analysis, and growth profiling, performing comparably to computed tomographic angiography (CTA) [15, 23, 29, 33, 60]. Contrast-enhanced ultrasound (CEUS) and Superb Micro-vascular Imaging (SMI) are highly effective for endoleak detection post-EVAR, with CEUS sensitivity up to 100% and specificity up to 100% [40, 151].
- **EVAR Surveillance and Endoleak Detection:** Duplex ultrasound (DUS), CEUS, and SMI are routinely used for post-EVAR surveillance, demonstrating high sensitivity (median 91.5%) and specificity (median 96.15%) for endoleak detection [169, 30]. These methods can reduce reliance on CTA by detecting and classifying endoleaks and monitoring sac size evolution [30, 68, 191].
- **AAA Pathogenesis and Therapeutic Interventions (Animal Models):** Ultrasound is crucial for monitoring AAA formation and progression in animal models, revealing insights into biomechanical changes and the efficacy of interventions such as metformin, cycloastragenol, and IL-10 in reducing aortic diameter or rupture rates [38, 43, 61, 118, 122, 156].
- **Emergency Diagnostics:** Point-of-care ultrasound (POCUS) performed by emergency physicians is a feasible, safe, and reliable tool for rapid diagnosis of ruptured AAAs, aortic dissection, and other vascular emergencies in the emergency department, with sensitivity up to 100% and specificity up to 91% [28, 75, 171, 174].
- **Operator Dependence and Standardization:** Variability in AAA measurements can be influenced by factors such as transducer pressure and observer experience [7, 11]. Standardized acquisition protocols and harmonization with CT readings can significantly improve accuracy and reproducibility of ultrasound measurements [9, 120].
- **Cost-Effectiveness of Screening:** Ultrasound screening programs for AAA, particularly in high-risk groups like older male smokers, have been shown to be cost-effective, leading to reduced AAA-related mortality and healthcare costs [65, 114].

- **AI and Automation in Ultrasound:** Deep learning (DL) approaches and robotic systems are being developed to automate AAA segmentation from 3D+t ultrasound images, showing improved performance compared to conventional methods and promising for enhancing screening and diagnosis [27, 62, 207].

5) Discussion

5.1 Principal finding:

Ultrasound-based methods, including conventional duplex ultrasound (DUS) and advanced techniques like contrast-enhanced ultrasound (CEUS) and superb micro-vascular imaging (SMI), demonstrate a median sensitivity of 91.5% [169] and a median specificity of 96.15% [30] for detecting endoleaks after endovascular aneurysm repair (EVAR), indicating their strong utility in post-procedural surveillance.

5.2 Clinical implications:

- **Enhanced Surveillance Post-EVAR:** CEUS and SMI offer highly accurate, radiation-free alternatives to CT angiography for detecting and classifying endoleaks, potentially reducing patient exposure to radiation and nephrotoxic contrast agents [68, 149, 169].
- **Streamlined AAA Follow-up:** Point-of-care ultrasound (POCUS) is an accurate method for following AAA diameter, which can improve patient follow-up and streamline care pathways, especially for small aneurysms requiring regular monitoring [5].
- **Targeted Screening Programs:** Ultrasound screening is feasible and cost-effective, particularly for high-risk populations such as men aged 65-74, those with coronary artery disease, or a family history of AAA, leading to early detection and reduced mortality [65, 93, 114].
- **Improved Emergency Diagnostics:** Emergency physicians can reliably use focused ultrasound to rapidly diagnose ruptured AAAs and aortic dissections, supporting timely clinical assessment and appropriate triage [28, 75].
- **Personalized Surveillance Intervals:** Diabetic status may influence AAA growth rate (e.g., reduction from 0.29 to 0.19 cm/year compared to non-diabetics), suggesting the potential for personalized surveillance intervals based on patient characteristics [3].

5.3 Research implications / key gaps:

- **Standardized Measurement Protocols:** Further research is needed to establish universally adopted, harmonized ultrasound acquisition and measurement protocols to reduce inter-observer variability and ensure consistency across different clinical settings [7, 9].

- **Long-term Efficacy of Advanced US:** Prospective studies are required to evaluate the long-term clinical outcomes and cost-effectiveness of advanced ultrasound techniques (e.g., 3D/4D US, CEUS, SMI) as primary surveillance tools compared to CTA in diverse patient populations [15, 169].
- **Predictive Biomechanical Markers:** Studies should further investigate mechanical and geometrical parameters (e.g., wall strain, compliance, shear stress) derived from advanced ultrasound as predictors of AAA growth and rupture risk, aiming for improved risk stratification [33, 35, 42, 76].
- **Translational Research for Therapeutics:** More translational studies are needed to bridge findings from animal models (e.g., drug-containing microbubbles, specific molecular inhibitors) to human clinical trials, validating potential ultrasound-guided therapies for AAA progression [8, 38, 43, 118].
- **AI Integration and Validation:** Large-scale prospective studies are needed to validate the clinical utility and accuracy of deep learning models for automatic AAA segmentation and growth prediction across diverse patient demographics and ultrasound machine types [27, 207].

5.4 Limitations:

- **Heterogeneous Study Designs** — The variability in study designs (cohort, mixed, experimental) and methodological approaches limits the ability to perform robust meta-analyses or draw definitive pooled conclusions.
- **Inconsistent Reporting of Statistics** — Many studies lack detailed statistical reporting (e.g., sample sizes, complete confidence intervals, p-values), which hinders quantitative synthesis and comparison of results.
- **Operator Dependence of Ultrasound** — Ultrasound measurements can be highly operator-dependent, affecting reproducibility and accuracy, especially in complex cases or with less experienced personnel [7, 11, 159].
- **Lack of Direct Comparators** — While many studies compare ultrasound to CT, some lack a direct, gold-standard comparator or sufficient sample sizes to establish definitive equivalency for all applications.
- **Focus on Male Populations** — A significant portion of screening studies primarily targets male populations, potentially limiting the generalizability of prevalence and risk factor findings to women [6, 59, 93, 109].

5.5 Future directions:

- **Standardized Protocols Development** — Develop and implement international guidelines for ultrasound acquisition and measurement to minimize variability and improve inter-observer agreement.
- **AI-Assisted Diagnostics Integration** — Integrate validated deep learning algorithms into clinical ultrasound devices to enhance automatic segmentation and measurement accuracy, reducing operator dependence.
- **Longitudinal Outcome Studies** — Conduct large-scale, prospective longitudinal studies comparing advanced ultrasound techniques to CTA for long-term AAA surveillance and post-EVAR outcomes.
- **Novel Biomarkers Validation** — Validate biomechanical parameters (e.g., wall strain, compliance) derived from 3D/4D ultrasound as independent predictors of AAA rupture risk in human cohorts.
- **Point-of-Care Training Programs** — Expand and standardize training programs for point-of-care ultrasound (POCUS) in emergency and primary care settings to improve early diagnosis and triage of AAA.

6) Conclusion

For endoleak detection following endovascular abdominal aortic aneurysm repair (EVAR), ultrasound-based methods demonstrate a median sensitivity of 91.5% [169] and a median specificity of 96.15% [30], with accuracy ranging from 60% [151] to 97% [151, 169]. These findings underscore ultrasound's critical role in AAA management, from population screening and growth monitoring to post-EVAR surveillance. However, the inherent operator dependence of ultrasound remains a significant limitation affecting the certainty and generalizability of results. Future efforts should focus on developing standardized protocols and integrating AI-assisted diagnostics to further enhance the reliability and widespread utility of ultrasound in abdominal aortic aneurysm care.

References

SAIMSARA Session Index — session.json

Figure 1. Publication-year distribution of included originals

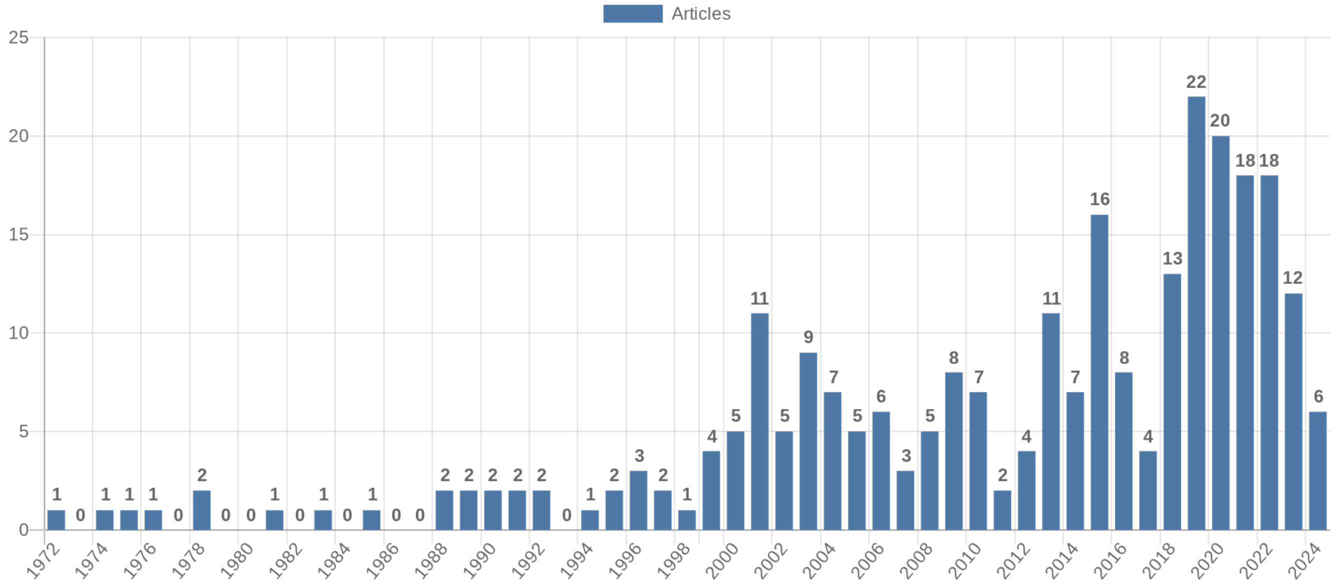


Figure 2. Study-design distribution of included originals

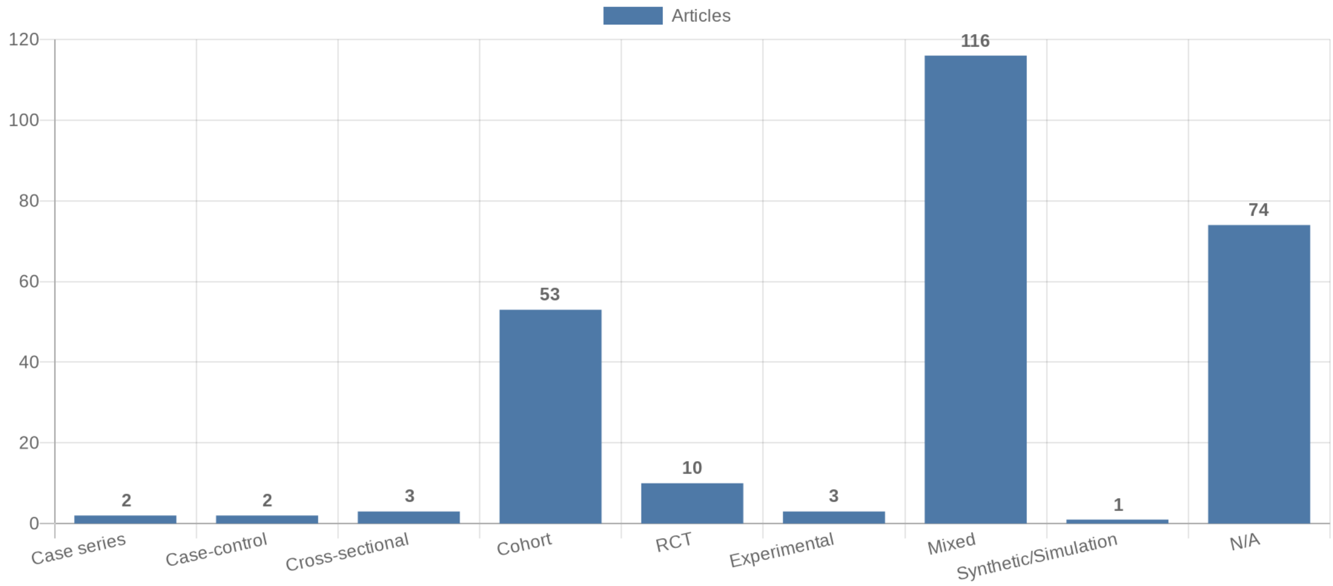


Figure 3. Study-type (directionality) distribution of included originals

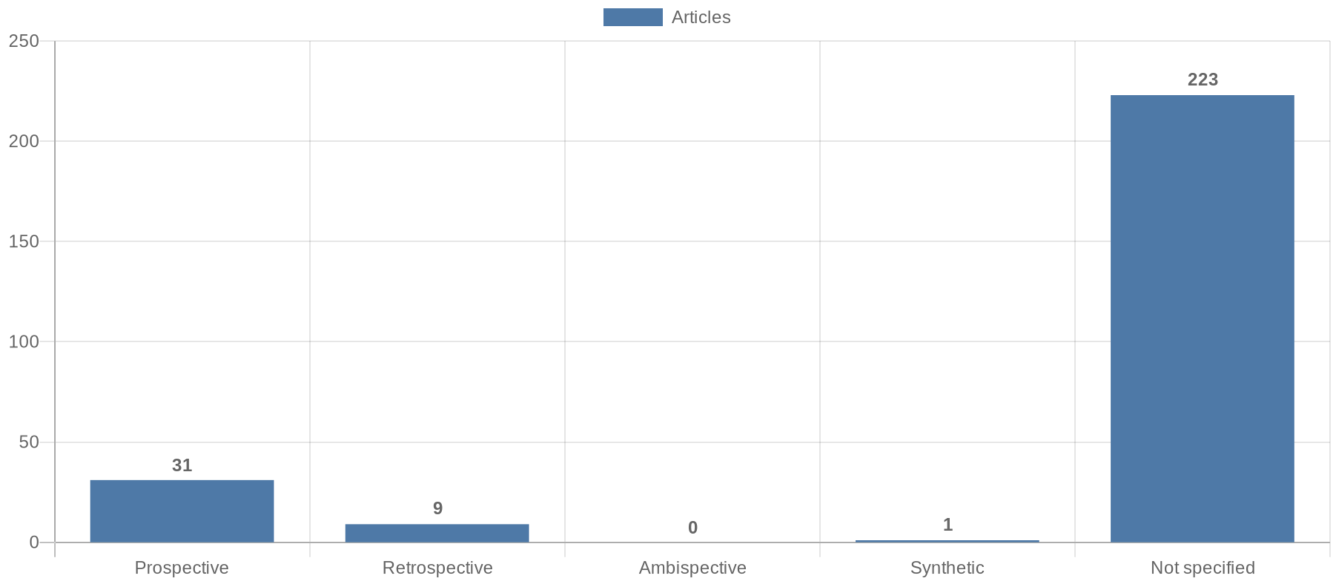


Figure 4. Main extracted research topics

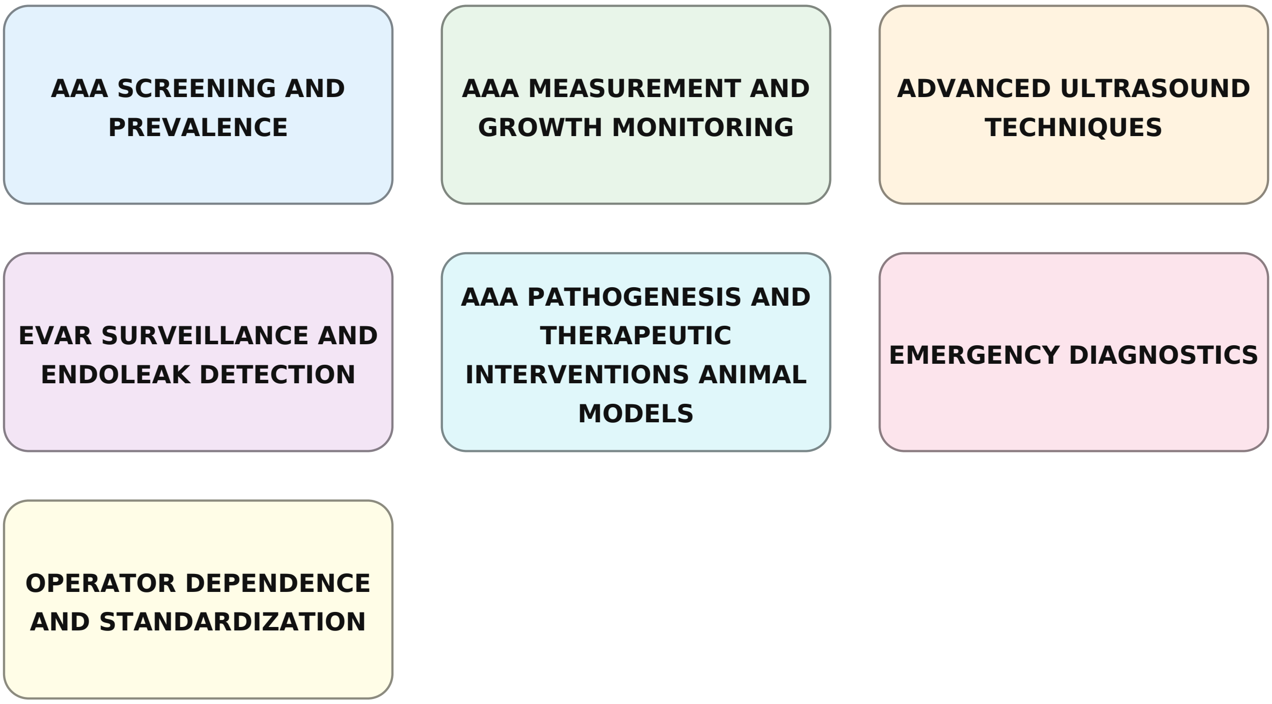


Figure 5. Limitations of current studies (topics)

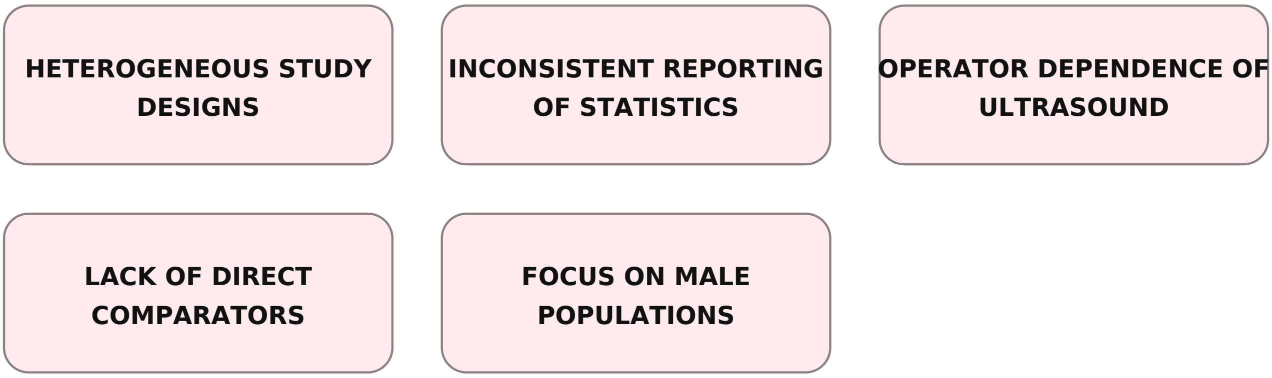


Figure 6. Future research directions (topics)

STANDARDIZED MEASUREMENT PROTOCOLS

LONG-TERM EFFICACY OF ADVANCED US

PREDICTIVE BIOMECHANICAL MARKERS

TRANSLATIONAL RESEARCH FOR THERAPEUTICS

AI INTEGRATION AND VALIDATION

STANDARDIZED PROTOCOLS DEVELOPMENT

AI-ASSISTED DIAGNOSTICS INTEGRATION