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Artificial intelligence for CT and CT angiography analysis of the thoracic and abdominal aorta: a task-based systematic review of segmentation, measurement and detection applications. Protocol (retrospective registration)

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ADMINISTRATIVE INFORMATION

Support - No external funding was received for this review.

Review Stage at time of this submission - Completed but not published; manuscript submitted for publication and under peer review. Retrospective registration: the protocol records the methods as conducted. The review was not registered prospectively.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 1 November 2026 and was last updated on 1 November 2026.

INTRODUCTION

Review question / Objective To synthesise the evidence on artificial intelligence (AI) applications to computed tomography (CT) and CT angiography (CTA) of the thoracic and abdominal aorta, organised by primary task: (1) segmentation of the aorta and its compartments, (2) geometric measurement (diameters, volumes, landmarks, planning parameters), and (3) detection or classification of aortic disease. For each task, the review describes the targets, AI methods, validation designs, reference standards and reported performance, and appraises methodological quality with task-specific frameworks. Population: patients undergoing CT or CTA of the thoracic and/or abdominal aorta, in any clinical condition (aneurysm, dissection, acute aortic syndrome, post-operative surveillance) and in normal anatomy. Index test: an AI model trained or applied to CT/CTA images producing an anatomical output. Comparator/reference: manual or expert-adjudicated segmentation, measurement or diagnosis, or expert-reader assessment of the model output. Outcomes: task-specific performance metrics. Study designs: original studies of any design.

Rationale CT and CTA are central to the assessment of aortic aneurysm and dissection, but manual segmentation and geometric analysis are time-consuming and operator-dependent. AI applications to aortic CT have expanded rapidly, yet existing reviews are confined to a single pathology or a single task, or are narrative. A task-based synthesis across the whole thoracoabdominal aorta is needed to map where the evidence is concentrated, how models were validated, and how far reported technical performance is supported by evidence of transportability and clinical benefit.

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Condition being studied Diseases of the thoracic and abdominal aorta assessed with CT/CTA: abdominal aortic aneurysm, thoracic aortic aneurysm or dilatation, aortic dissection and acute aortic syndrome (including intramural haematoma and penetrating ulcer), post-operative states after open or endovascular repair (EVAR, FEVAR, TEVAR) including endoleak, and normal aortic anatomy.

METHODS

Search strategy PubMed/MEDLINE and Europe PMC were searched on 5 September 2026 for records published from 1 January 2015. Both strings combined three concept blocks with AND: artificial intelligence (artificial intelligence, machine learning, deep learning, neural network, convolutional, U-Net, radiomic*, automated/automatic segmentation), aorta (aortic aneurysm, aortic dissection, aortic diseases, aort*, endoleak, EVAR, TEVAR, stent graft), and computed tomography (computed tomography angiography, CT, CTA). No task block was used, so that predictive models were retrieved and excluded at screening. No language filter was applied in PubMed/MEDLINE; the Europe PMC search was restricted to English. IEEE Xplore was evaluated and not searched because its predominantly conference-proceedings content would not justify the screening burden. Database searching was supplemented by backward and forward citation searching of the included studies and of previous reviews on the topic. Full search strings are reported in the manuscript's Supplementary Table S1.

Participant or population Patients undergoing CT or CTA of the thoracic and/or abdominal aorta, in any clinical condition and in normal anatomy, in pre-operative and post-operative settings. Both clinical cohorts and methodological studies based on public datasets were eligible, with no restriction on sample size.

Intervention Index test: an AI model (machine learning or deep learning) trained or applied to CT or CTA images, producing an anatomical output defined as segmentation, geometric measurement, or spatially localised detection or classification. Models developed in the study, adapted models, and commercial or open-source software applied without training were all eligible.

Comparator Reference standard: manual or expert-adjudicated segmentation, measurement or diagnosis (including same-session contrast-enhanced CT for detection on non-contrast CT, and the original radiology report where used by the authors), or an expert-reader assessment of the model output with an ordinal or metric scale. Where available, comparison with human readers (radiologists) was also extracted.

Study designs to be included Original studies of any design: retrospective and prospective clinical studies, methodological studies on public datasets, challenge reports, and prospective clinical evaluations. Excluded: reviews, editorials, letters, corrections, conference abstracts, preprints of published articles and redundant publications.

Eligibility criteria Inclusion (all three required): (1) an AI model trained or applied to CT or CTA images; (2) an anatomical output (segmentation, geometric measurement, or spatially localised detection/classification); (3) quantitative evaluation of model performance against a reference standard (manual or expert-adjudicated segmentation, measurement or diagnosis, or expert-reader assessment with an ordinal or metric scale). Exclusion: models predicting a future event (growth, rupture, post-operative outcome) rather than characterising the current examination; studies confined to the aortic valve, root, annulus or coarctation; non-aortic vascular districts; modalities other than CT, or hybrid modalities in which CT was not the substrate of the analysis; radiomic or feature-based analyses without an anatomical output; AI not operating on the image (clinical-variable models, natural-language processing of reports); image reconstruction, image quality, radiation dose or contrast-medium optimisation; quantification of vascular calcification only; surrogate models of computational simulation; studies without any model-performance endpoint. Date limit: published from 1 January 2015. Language: no filter in PubMed/MEDLINE; English in Europe PMC.

Information sources PubMed/MEDLINE; Europe PMC (including preprints); backward and forward citation searching of included studies and of previous reviews. No trial registers, grey literature sources or author contacts.

Main outcome(s) Task-specific performance of the AI model against the reference standard: for segmentation, overlap metrics (Dice similarity coefficient, Jaccard/IoU) and distance metrics (Hausdorff distance, surface distance) for the primary structure; for measurement, agreement statistics for the main measurand (bias with limits of agreement, mean absolute error, intraclass correlation, correlation coefficient); for detection/classification, sensitivity, specificity and area under

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the ROC curve at the stated unit of analysis, on internal and external test sets.

Additional outcome(s) Study characteristics (country and centres, design, sample size and data split, CT technique and contrast use, aortic segment, pathology and operative status); AI method and model provenance (developed, adapted, commercial, mixed); validation design (internal only; geographically external; temporally or otherwise independent same-centre cohort; independent evaluation of a pre-trained commercial or open-source tool; independence not established); comparison with human readers; workflow time against a comparator; processing failures.

Data management Records were exported from both databases, deduplicated (cross-database duplicates and preprint versions of published articles), and screened in a record register. Data were extracted into three task-specific forms sharing a common backbone, with extraction conventions and closed term lists defined a priori. Extraction was performed by one reviewer with the support of an AI-assisted research platform (Elicit) and every value was verified against the full text by a second reviewer; discrepancies were resolved by discussion. Extraction tables are provided as supplementary material with the manuscript.

Quality assessment / Risk of bias analysis Appraisal was matched to the primary task and performed by two reviewers in consensus. Detection/classification studies: QUADAS-2, supplemented by the QUADAS-AI items on data partitioning, leakage and external testing; overall risk of bias judged low when all domains were at low risk, high when at least one domain was at high risk, and unclear otherwise; applicability concerns recorded separately. Segmentation and measurement studies, for which no validated risk-of-bias tool exists: descriptive appraisal informed by the CLAIM 2024 checklist, rating three areas (reference standard and data; validation and generalisability; reporting and reproducibility) as no concern, concern or critical concern, and assigning a limitation tier by a fixed rule: higher if any area carried a critical concern; lower if no critical concern, an external or independent test was reported and the reference was established by at least two readers or with documented inter-reader variability; moderate otherwise. Tiers are descriptive and relative to the included literature, not risk-of-bias judgements.

Strategy of data synthesis Synthesis without meta-analysis, reported following the SWiM guideline, because of heterogeneity in targets, metrics and reference standards. Results are synthesised narratively and in structured tables, separately for each task, with rows grouped by pathology and operative status. The primary metric of each task is summarised as the unweighted median and range across studies reporting it, computed within groups of comparable targets (anatomical compartment, measurand, target condition and unit of analysis) rather than across all studies; studies reporting only multi-class means, non-convertible metrics or no quantitative agreement are described separately and excluded from the aggregate distributions. Medians are descriptive and serve to locate the evidence, not to rank models.

Subgroup analysis Descriptive stratified summaries of the headline statistics of each task by sample size (≤200 vs >200 patients or scans for segmentation and measurement; ≤500 vs >500 for detection), by validation design (external test reported or not; for measurement, model developed in the study vs commercial or open-source software applied) and, for detection, by CT technique (non-contrast vs contrast-enhanced). Studies are additionally grouped by aortic segment, pathology and operative status.

Sensitivity analysis None planned or performed (descriptive synthesis without meta-analysis).

Language restriction No language filter in PubMed/MEDLINE; Europe PMC restricted to English.

Country(ies) involved Italy.

Other relevant information This is a retrospective registration of a completed review, submitted for publication; the protocol describes the methods as conducted. The explicit decision rules for the CLAIM-informed limitation tiers, the descriptive stratified summaries and the cross-tabulation of validation design by task were specified after data extraction and are post hoc; they are descriptive and do not alter the eligibility criteria, the search or the primary synthesis.

Keywords artificial intelligence; deep learning; computed tomography angiography; aorta; abdominal aortic aneurysm; aortic dissection; image segmentation; systematic review.

Dissemination plans Publication in a peer-reviewed journal (manuscript submitted), with full extraction and appraisal tables as supplementary material.

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Contributions of each author

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