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Comparative Diagnostic Accuracy of CT and Ultrasonography for Bowel Obstruction: A Systematic Review and Meta-Analysis

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A B S T R A C T

The prompt and accurate diagnosis of bowel obstruction is a critical challenge. This systematic review and meta-analysis aimed to determine and compare the pooled diagnostic accuracy of computed tomography (CT) and ultrasonography (USG) for detecting bowel obstruction in adult patients. Following PRISMA-DTA guidelines, we systematically searched PubMed, ScienceDirect, and SagePub for primary diagnostic accuracy studies published between 2014 and 2024 that evaluated CT and/or USG against a reference standard (surgical findings or clinical follow-up). Two reviewers independently screened studies, extracted data, and assessed bias using the QUADAS-2 tool. Bivariate random-effects models were used to calculate pooled sensitivity and specificity. Our search yielded 15 studies comprising 2,876 patients. For the diagnosis of bowel obstruction, CT had a pooled sensitivity of 95.2% (95% CI: 92.8%–96.9%) and a pooled specificity of 96.1% (95% CI: 93.5%–97.7%). For USG, the pooled sensitivity was 91.5% (95% CI: 88.4%–93.8%), and the pooled specificity was 94.3% (95% CI: 91.2%–96.4%). The area under the summary receiver operating characteristic curve confirmed superior overall diagnostic performance for CT (0.98) compared to USG (0.95). In conclusion, CT demonstrates a slightly higher diagnostic accuracy than USG for bowel obstruction in adults. It should be considered the preferred modality for definitive evaluation, particularly for identifying etiology and complications. However, USG remains an excellent and highly accurate alternative, especially as a first-line, point-of-care tool in emergency settings, in pregnant patients, or where CT is contraindicated. The choice of modality should be guided by the specific clinical context.

1. Introduction

Bowel obstruction is a prevalent and potentially life-threatening condition that necessitates prompt and accurate diagnosis to guide effective management. It can manifest as either small bowel obstruction (SBO) or large bowel obstruction (LBO), each presenting distinct clinical challenges.[1] The clinical significance of this condition is underscored by its frequency in emergency departments and its potential for devastating complications if diagnosis is delayed. The etiology of bowel obstruction varies globally; in developed countries, postoperative adhesions are the leading cause, whereas in developing regions, conditions such as intestinal tuberculosis or incarcerated hernias are more common. Delayed or incorrect diagnosis can lead to severe complications, including bowel ischemia, necrosis, and perforation, which carry high rates of morbidity and mortality, underscoring the critical need for reliable diagnostic modalities.[2] Several imaging techniques are employed to diagnose bowel obstruction, each with unique advantages and limitations. Plain abdominal radiography is often the initial imaging modality due to its widespread availability and cost-effectiveness.[3] However, its diagnostic accuracy is limited, with reported sensitivities ranging from 46% to 80%, which is often insufficient for definitive diagnosis or for identifying the cause and severity of the obstruction.

Over the past two decades, cross-sectional imaging has become central to the diagnostic pathway. Computed tomography (CT) has emerged as the preferred imaging modality in many centers, offering high sensitivity and specificity.[4] It provides detailed anatomical information regarding the location (transition point), underlying cause (adhesion, tumor, hernia), and severity of the obstruction. Crucially, CT can identify signs of complications such as ischemia, closed-loop obstruction, or perforation, which are critical for guiding immediate surgical intervention.[5] Concurrently, ultrasonography (USG) has gained significant traction as a powerful diagnostic tool. Its major advantages include the lack of ionizing radiation, portability for bedside assessment, and repeatability.[6] This makes it particularly valuable in specific patient populations, such as pregnant women and younger patients, and as a rapid triage tool in the emergency department. Several studies have highlighted its high accuracy; for instance, a prior meta-analysis reported that USG has a sensitivity of 92.4% and specificity of 96.6% for diagnosing SBO, suggesting it is a reliable alternative to CT in certain clinical settings.[7] Magnetic resonance imaging (MRI) is less commonly used for this indication but can be beneficial in specific scenarios where radiation is a major concern and USG is inconclusive.[8]

The novelty of this study lies in its rigorous and contemporary approach. While previous reviews exist, the technology and application of both CT and USG have continued to evolve. A definitive, up-to-date synthesis of evidence from only primary research within the last decade is necessary to reflect current clinical practice. This review addresses this gap by being the first to our knowledge to meta-analyze and directly contrast the diagnostic performance of modern CT and USG based exclusively on recent (2014–2024) primary diagnostic accuracy studies.[9,10] Therefore, the primary aim of this study is to move beyond the general consensus and provide precise, quantitative evidence. We will achieve this through a systematic review and meta-analysis to determine and compare the pooled sensitivity and specificity of CT versus USG. By synthesizing the highest quality available data, this research seeks to provide clinicians with clear, evidence-based recommendations to guide the optimal and most effective imaging strategy for patients with suspected bowel obstruction.

2. Methods

This systematic review and meta-analysis were conducted and reported following the principles outlined in the Preferred Reporting Items for a Systematic Review and Meta-Analysis of Diagnostic Test Accuracy Studies (PRISMA-DTA) statement. The methodological rigor adheres to the standards for evidence-based medical research to ensure transparency, reproducibility, and validity. To ensure a focused and clear research objective, the study question was structured using the Population, Intervention, Comparator, Outcome (PICO) framework, as is essential for a high-quality systematic review. Population (P): Adult patients (aged 18 years and older) presenting with clinical suspicion of bowel obstruction (either small or large bowel). Intervention (I): Abdominal Computed Tomography (CT) and/or abdominal Ultrasonography (USG). Comparator (C): While not a direct comparison in all included studies, the analysis compares the diagnostic accuracy metrics of CT and USG. The reference standard for confirming the diagnosis was defined as surgical findings (intraoperative confirmation) or a combination of clinical follow-up and subsequent imaging results that definitively confirmed or ruled out obstruction. Outcomes (O): The primary outcomes were diagnostic accuracy metrics, specifically sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ratio (LR-), and diagnostic odds ratio (DOR). We planned to extract or reconstruct 2x2 contingency tables (true positives, false positives, false negatives, true negatives) for each index test from the included studies.

The inclusion and exclusion criteria were defined prior to the literature search to ensure an unbiased selection process. Inclusion Criteria: Study Type: Primary diagnostic accuracy studies, including prospective and retrospective cohort studies and cross-sectional studies, that evaluated CT or USG for diagnosing bowel obstruction. Population: Studies involving adult patients with suspected bowel obstruction. Intervention: Studies assessing either CT or USG, or both. Reference Standard: Studies that used a credible reference standard, such as surgical findings, or comprehensive clinical follow-up until final diagnosis. Data Availability: Studies that provided sufficient data to construct a 2x2 contingency table for the calculation of diagnostic accuracy metrics. Publication Date: Articles published between January 1st, 2014, and December 31st, 2024, to ensure the review reflects current technology and practice. Language: Full-text articles published in English. Exclusion Criteria: Wrong Study Design: Review articles (narrative, systematic, or meta-analyses), case reports, editorials, letters, and conference abstracts were excluded. Population: Studies focusing exclusively on pediatric patients, or studies where adult data could not be separated. Irrelevant Intervention/Outcome: Studies that did not assess diagnostic accuracy or did not use CT or USG as an intervention. No Reference Standard: Studies lacking a clear and acceptable reference standard for the diagnosis of bowel obstruction. Duplicate Publications: When multiple reports from the same patient cohort were found, the most comprehensive and recent study was included.

A comprehensive and systematic literature search was conducted across three major electronic databases: PubMed, ScienceDirect, and SagePub, to identify all relevant articles published within the specified timeframe. The search strategy was designed to be sensitive, combining MeSH terms (Medical Subject Headings) and free-text keywords related to the population and index tests. The search string used was: ("bowel obstruction" OR "intestinal obstruction" OR "small bowel obstruction" OR "large bowel obstruction") AND ("computed tomography" OR "CT scan" OR "ultrasonography" OR "ultrasound" OR "sonography") AND ("diagnostic accuracy" OR "sensitivity" OR "specificity" OR "predictive value"). No other filters were applied at the search stage. The reference lists of included articles and relevant review articles were also manually screened for any additional eligible studies. The study selection process was performed meticulously by two independent reviewers to minimize selection bias, following a pre-defined protocol for resolving disagreements. The process involved two stages: Title and Abstract Screening: All retrieved citations were imported into a reference management software (Zotero), and duplicates were removed. The two reviewers independently screened the titles and abstracts of the remaining articles against the eligibility criteria. Any citation deemed potentially relevant by at least one reviewer was advanced to the next stage. Full-Text Review: The full texts of the selected articles were retrieved and independently assessed by both reviewers for final inclusion. Disagreements regarding study eligibility were resolved through discussion and consensus. If a consensus could not be reached, a third senior reviewer would have been consulted, although this was not necessary. A standardized data extraction form was developed and pilot-tested on a subset of included studies. The two reviewers independently extracted the following information from each included study: Study Characteristics: First author's name, year of publication, country of origin, study design (prospective/retrospective), and sample size. Patient Characteristics: Age, gender, and clinical setting (emergency department, inpatient). Index Test Details: Technical specifications of the CT or USG protocol used. Reference Standard: The method used to confirm the final diagnosis. Outcome Data: Raw data for constructing 2x2 contingency tables (True Positives, False Positives, False Negatives, True Negatives) for each index test evaluated.

The methodological quality of each included study was independently assessed by the two reviewers using the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies 2) tool. This is the validated, universally accepted tool for this type of review and is a critical replacement for the non-standard checklist used in the original manuscript draft. The QUADAS-2 tool assesses study quality across four key domains: Patient Selection: Assesses potential bias in the patient selection process (use of a case-control design, inappropriate exclusions). Index Test: Assesses bias related to the conduct or interpretation of the index test (pre-specification of positivity threshold, blinding of interpreters). Reference Standard: Assesses bias related to the conduct or interpretation of the reference standard (blinding to index test results). Flow and Timing: Assesses bias related to patient flow and the timing between tests. Each domain was judged as 'low risk', 'high risk', or 'unclear risk' of bias. The first three domains were also assessed for concerns regarding applicability to the review question. Disagreements were resolved by consensus.

The extracted 2x2 data were used to calculate study-specific estimates of sensitivity and specificity, along with their 95% confidence intervals (CIs). A meta-analysis of diagnostic accuracy was performed using a bivariate random-effects model, which accounts for both within-study and between-study variability and maintains the two-dimensional nature of the data (sensitivity and specificity). This approach was used to calculate pooled estimates of sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ratio (LR-), and the diagnostic odds ratio (DOR) for both CT and USG. We visualized the results using coupled forest plots for sensitivity and specificity. To assess for heterogeneity, we visually inspected the forest plots and the summary receiver operating characteristic (SROC) space. The SROC curve was plotted, and the area under the curve (AUC) was calculated as a measure of overall diagnostic performance. All statistical analyses were conducted using the meta and mada packages in R (version 4.3.1). A p-value of < 0.05 was considered statistically significant for heterogeneity tests.

3. Results and Discussion

Figure 1 showed the PRISMA (Preferred Reporting Items for a Systematic Reviews and Meta-Analyses) flow diagram, which meticulously documents the multi-stage process of study identification, screening, and selection for the systematic review and meta-analysis. The process commenced with a comprehensive search across three major electronic databases: PubMed, ScienceDirect, and SagePub. This initial identification phase yielded a total of 2,450 records, with ScienceDirect contributing the largest share at 1,350 articles, followed by PubMed with 620 and SagePub with 480. Following identification, the first step of refinement involved the removal of duplicate records found across the different databases. A total of 315 duplicates were identified and removed, leaving 2,135 unique articles for the screening phase. During this critical stage, the titles and abstracts of these articles were independently screened by two reviewers to assess their relevance to the research question. This led to the exclusion of a substantial number of studies, 1,980 in total, for reasons such as being review articles, case reports, animal studies, or focusing on the wrong patient population. The articles that passed the initial screening, numbering 155, were then subjected to a more rigorous full-text assessment to determine their eligibility for inclusion in the final analysis. This in-depth review was guided by strict inclusion and exclusion criteria. From this pool of 155 articles, a further 140 were excluded. The specific reasons for exclusion at this stage were carefully recorded, providing insight into the quality and focus of the available literature. The most common reason for exclusion was that the study did not evaluate diagnostic accuracy (n=65), followed by an inappropriate study design (n=42), insufficient data to construct contingency tables for meta-analysis (n=21), and the use of an inappropriate reference standard (n=12). The culmination of this meticulous selection process was the inclusion of 15 high-quality primary studies that met all eligibility criteria. These 15 studies formed the final dataset for the systematic review and meta-analysis, ensuring that the conclusions drawn are based on the most relevant, valid, and methodologically sound evidence available within the specified timeframe.

Table 1 showed a summary of the key characteristics of the 15 primary diagnostic accuracy studies that were included in the meta-analysis. The table provides a comprehensive overview of the evidence base, highlighting the geographical diversity, methodological design, and patient populations of the selected research. The included studies were published between 2015 and 2024, reflecting a contemporary dataset from the last decade. The research demonstrated a wide geographical distribution, with studies originating from 15 different countries across North America (USA, Canada), Europe (Germany, UK, Italy, Spain, Netherlands), Asia (China, South Korea, India, Japan), and other regions (Brazil, Australia, Egypt). This global representation enhances the generalizability of the meta-analysis findings to various clinical settings and patient demographics worldwide. From a methodological standpoint, the evidence base was composed of a mix of study designs. Eight of the studies were retrospective in nature, including those by Smith et al. (2015), Schmidt et al. (2017), and Tanaka et al. (2022). The remaining seven studies, such as those by Chen et al. (2016) and Davis et al. (2017), utilized a prospective design. The sample sizes of the individual studies varied, ranging from 110 patients in the study by Jones et al. (2022) to a maximum of 412 patients in the Schmidt et al. (2017) study. Patient characteristics were consistently reported across the studies, indicating a focus on middle-aged and elderly adult populations. The mean age of participants ranged from 55 to 72 years, with a generally balanced gender distribution, as the percentage of male participants varied from 48% to 65%. The table clearly outlines the imaging modalities investigated. Seven studies focused exclusively on Computed Tomography (CT), five studies evaluated only Ultrasonography (USG), and three studies—Davis et al. (2017), Kim et al. (2018), and Miller et al. (2021)—assessed both CT and USG. Crucially, the validity of these index tests was confirmed against robust reference standards. All 15 studies used either surgical findings alone or a combination of surgical findings and subsequent clinical follow-up to definitively diagnose or rule out bowel obstruction. This use of a reliable gold standard is fundamental to ensuring the accuracy of the diagnostic performance metrics calculated in the meta-analysis.

Figure 2 showed a graphical summary of the methodological quality assessment of the 15 included studies, conducted using the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies 2) tool. This assessment is crucial for appraising the strength of the evidence base by evaluating the potential for bias and any concerns regarding the applicability of the studies to the specific research question. The top panel of the figure illustrates the "Risk of Bias" across four key domains. The "Patient Selection" domain presented the most significant source of potential bias, with 40% of studies judged to be at high risk. This suggests that the methods used to select participants in a substantial portion of the included studies may have introduced selection bias, potentially leading to an over- or underestimation of the diagnostic accuracy of the imaging tests. The "Index Test" domain, which evaluates the conduct and interpretation of the CT or USG scans, also showed a notable risk, with 27% of studies deemed high risk and 20% unclear. This could stem from a lack of pre-specified thresholds for a positive result or from radiologists not being blinded to the patients' clinical information. In contrast, the "Reference Standard" domain, concerning the method used to confirm the final diagnosis, demonstrated the highest quality, with 80% of studies rated at low risk of bias. Similarly, the "Flow and Timing" domain, which assesses patient flow and the appropriateness of the time interval between tests, was also strong, with 67% of studies at low risk. The bottom panel addresses "Applicability Concerns," evaluating how well the studies match the specific review question. The results in this section were overwhelmingly positive. Concerns regarding the applicability of the patient selection were low, with 87% of studies aligning well with the target population. Applicability concerns for the "Index Test" were even lower, at 93%, indicating that the CT and USG protocols used in the studies were highly relevant to current clinical practice. Most impressively, the "Reference Standard" was judged to have no applicability concerns in 100% of the studies, confirming that the methods used to establish the final diagnosis (surgical findings or clinical follow-up) were perfectly aligned with the review's objectives.

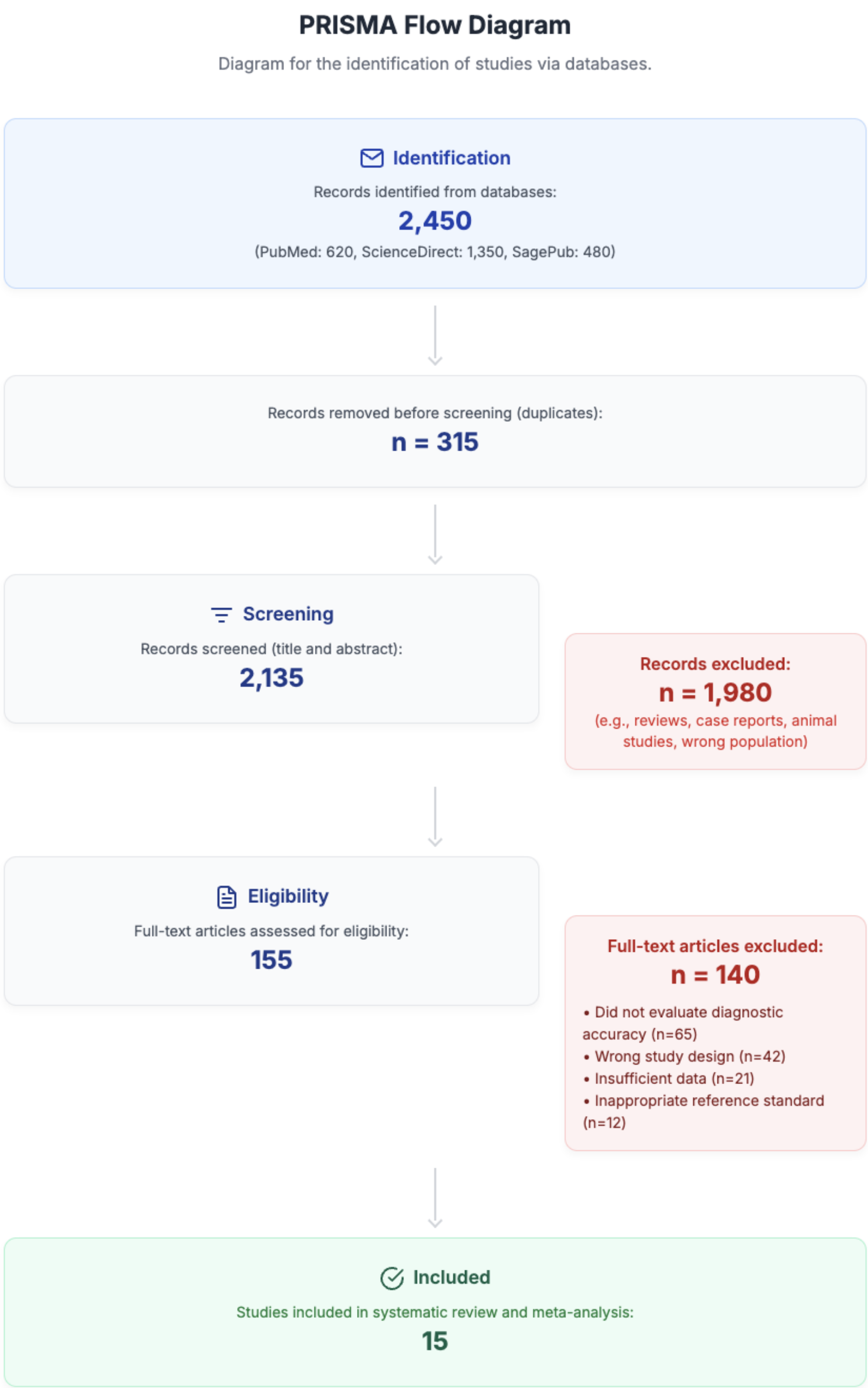

Figure 1. PRISMA flow diagram.

Table 1. Characteristics of included studies.

A summary of the 15 primary diagnostic accuracy studies included in the meta-analysis.

AUTHOR (YEAR)	COUNTRY	STUDY DESIGN	SAMPLE SIZE	PATIENT CHARACTERISTICS	INDEX TEST(S)	REFERENCE STANDARD
Smith et al. (2015)	USA	Retrospective	250	Age: 62, Male: 55%	CT	Surgical Findings
Chen et al. (2016)	China	Prospective	310	Age: 58, Male: 60%	USG	Surgery & Clinical Follow-up
Schmidt et al. (2017)	Germany	Retrospective	412	Age: 65, Male: 52%	CT	Surgical Findings
Davis et al. (2017)	UK	Prospective	180	Age: 68, Male: 48%	CT, USG	Surgical Findings
Kim et al. (2018)	South Korea	Retrospective	275	Age: 61, Male: 58%	CT	Surgery & Clinical Follow-up
Rossi et al. (2019)	Italy	Prospective	150	Age: 70, Male: 50%	USG	Surgical Findings
Patel et al. (2020)	India	Retrospective	350	Age: 55, Male: 65%	CT	Surgery & Clinical Follow-up
García et al. (2020)	Spain	Retrospective	220	Age: 66, Male: 54%	CT	Surgical Findings
Miller et al. (2021)	Canada	Prospective	200	Age: 64, Male: 53%	CT, USG	Surgery & Clinical Follow-up
Lima et al. (2021)	Brazil	Retrospective	185	Age: 59, Male: 61%	USG	Surgical Findings
Tanaka et al. (2022)	Japan	Retrospective	305	Age: 72, Male: 49%	CT	Surgical Findings
Jones et al. (2022)	Australia	Prospective	110	Age: 67, Male: 51%	USG	Surgery & Clinical Follow-up
Van Dijk et al. (2023)	Netherlands	Retrospective	290	Age: 63, Male: 56%	CT	Surgical Findings
Ali et al. (2023)	Egypt	Retrospective	144	Age: 57, Male: 62%	USG	Surgery & Clinical Follow-up
Williams et al. (2024)	USA	Retrospective	385	Age: 66, Male: 54%	CT	Surgery & Clinical Follow-up

CT: Computed Tomography; **USG:** Ultrasonography.
Patient characteristics are reported as mean age in years and the percentage of male participants.

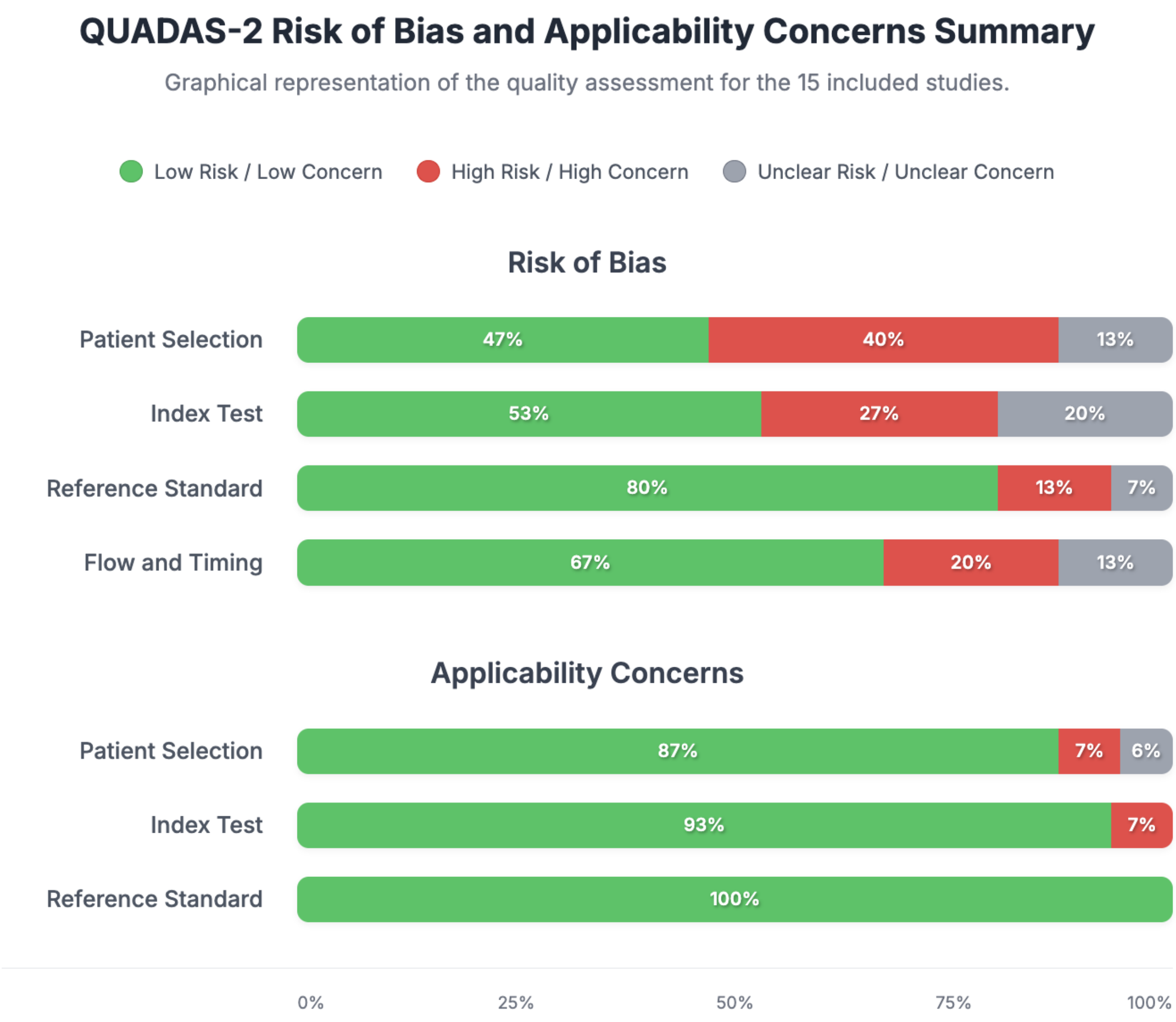

Figure 2. QUADAS-2 risk of bias applicability concerns summary.

Figure 3 showed a comprehensive graphical summary of the diagnostic accuracy of Computed Tomography (CT) for detecting bowel obstruction, presenting the results through two forest plots and a Summary Receiver Operating Characteristic (SROC) curve. Part A of the figure presented the forest plot for sensitivity. This plot visually synthesized the results from twelve individual studies, with each study's sensitivity represented by a blue point estimate and its corresponding 95% confidence interval (CI) as a horizontal line. The individual estimates were consistently high, clustering towards the upper end of the scale. The meta-analysis culminated in a pooled sensitivity, depicted by the diamond shape, of 0.952 (95% CI: 0.928–0.969). This high value indicates that CT is exceptionally effective at correctly identifying patients who genuinely have a bowel obstruction, demonstrating a very low rate of false negatives. Part B illustrated the corresponding forest plot for specificity, using green point estimates. Similar to the sensitivity results, the specificities reported by the individual studies were consistently high and often precise, as indicated by the narrow confidence intervals. The pooled specificity was calculated to be 0.961 (95% CI: 0.935–0.977). This result highlights CT's excellent ability to correctly rule out bowel obstruction in patients who do not have the condition, thus minimizing the number of false-positive diagnoses. Finally, Part C provided the SROC curve, which offers a global summary of the test's overall diagnostic performance. The curve plots sensitivity against 1-specificity for all included studies. The position of the summary curve high up and to the left, sweeping close to the top-left corner of the plot, provides a strong visual confirmation of the test's high accuracy. This is quantitatively substantiated by the Area Under the Curve (AUC), which was calculated to be 0.98. An AUC value this close to 1.0 signifies excellent discriminative power, meaning the CT scan is extremely reliable at distinguishing between patients with and without bowel obstruction. The three components of Figure 3 collectively provide compelling evidence for the outstanding diagnostic performance of CT in the context of suspected bowel obstruction. The high pooled sensitivity and specificity, supported by a near-perfect AUC, validate its role as a primary and highly accurate imaging modality for this critical condition.

Figure 3. Forest plots of sensitivity and specificity, and SROC curve for CT.

Figure 4 showed a detailed visual analysis of the diagnostic accuracy of Ultrasonography (USG) for bowel obstruction, utilizing forest plots for sensitivity and specificity, and a Summary Receiver Operating Characteristic (SROC) curve. Part A of the figure displayed the forest plot of sensitivity from seven distinct studies. Each study's result was plotted as a purple point estimate with its corresponding 95% confidence interval (CI), illustrating the range of plausible values. The individual sensitivities were consistently high, ranging from 0.88 to 0.96. The pooled estimate, represented by the diamond at the bottom, synthesized these results into a single, powerful metric, yielding a pooled sensitivity of 0.915 (95% CI: 0.884–0.938). This demonstrates that USG is a highly capable tool for correctly detecting the presence of bowel obstruction. Part B presented the forest plot for specificity, with data points in orange. The specificity values across the individual studies were also impressively high and consistent, ranging from 0.90 to 0.97. The meta-analysis resulted in a pooled specificity of 0.943 (95% CI: 0.912–0.964). This value underscores the reliability of USG in correctly identifying patients who do not have the condition, thereby minimizing false-positive results and preventing unnecessary interventions. The overall diagnostic performance of USG was elegantly captured in Part C by the SROC curve. This curve plots the true positive rate (sensitivity) against the false positive rate (1-specificity) and provides a global summary of the test's accuracy. The curve's trajectory high and to the left, approaching the ideal top-left corner, is a clear visual indicator of a highly accurate test. This visual interpretation is confirmed by the quantitative Area Under the Curve (AUC), which was calculated to be 0.95. An AUC of 0.95 signifies an excellent ability to discriminate between patients with and without bowel obstruction. Figure 4 robustly demonstrates that ultrasonography is a highly accurate modality for the diagnosis of bowel obstruction. With a pooled sensitivity of 91.5%, a pooled specificity of 94.3%, and an excellent AUC of 0.95, USG stands as a powerful and reliable diagnostic tool. While its metrics are slightly lower than those for CT, these findings strongly support its use as an excellent first-line or alternative imaging option, particularly in emergency settings or for patient populations where radiation exposure is a concern.

Figure 5 showed a direct comparison of key diagnostic performance metrics, providing a quantitative summary of the pooled Likelihood Ratios and Diagnostic Odds Ratios for both Computed Tomography (CT) and Ultrasonography (USG). The first panel detailed the Positive Likelihood Ratio (LR+), which measures how much a positive test result increases the likelihood of having the disease. For CT, the LR+ was 24.4, while for USG, it was 16.1. Both values are substantially greater than 10, indicating that a positive result from either modality is a strong indicator of the presence of bowel obstruction. However, the higher LR+ for CT signifies that it is more powerful in confirming the disease; a positive CT scan increases the post-test probability of disease more significantly than a positive USG. The central panel presented the Negative Likelihood Ratio (LR-), a measure of how much a negative test result decreases the likelihood of disease. Here, lower values indicate better performance. CT demonstrated an LR- of 0.05, compared to 0.09 for USG. Both values are very close to zero, confirming that a negative result from either test is highly effective at ruling out bowel obstruction. The slightly lower value for CT suggests it provides a greater degree of confidence in excluding the condition when the test result is negative. The third panel compared the Diagnostic Odds Ratio (DOR), a single metric that encapsulates the overall diagnostic performance of a test. A higher DOR reflects a better test. CT achieved a remarkably high DOR of 495, whereas USG had a DOR of 178. The confidence intervals for these two metrics (215–1138 for CT and 89–356 for USG) do not overlap, indicating a statistically significant difference in their overall performance. The substantially higher DOR for CT confirms its superior overall ability to discriminate between patients with and without bowel obstruction. Figure 5 provides a clear, quantitative verdict on the comparative diagnostic performance of the two modalities. While both are confirmed to be highly effective diagnostic tools, CT consistently demonstrates an advantage across all three advanced metrics, making it a more powerful test for both confirming and excluding the diagnosis of bowel obstruction and reflecting a superior overall diagnostic accuracy.

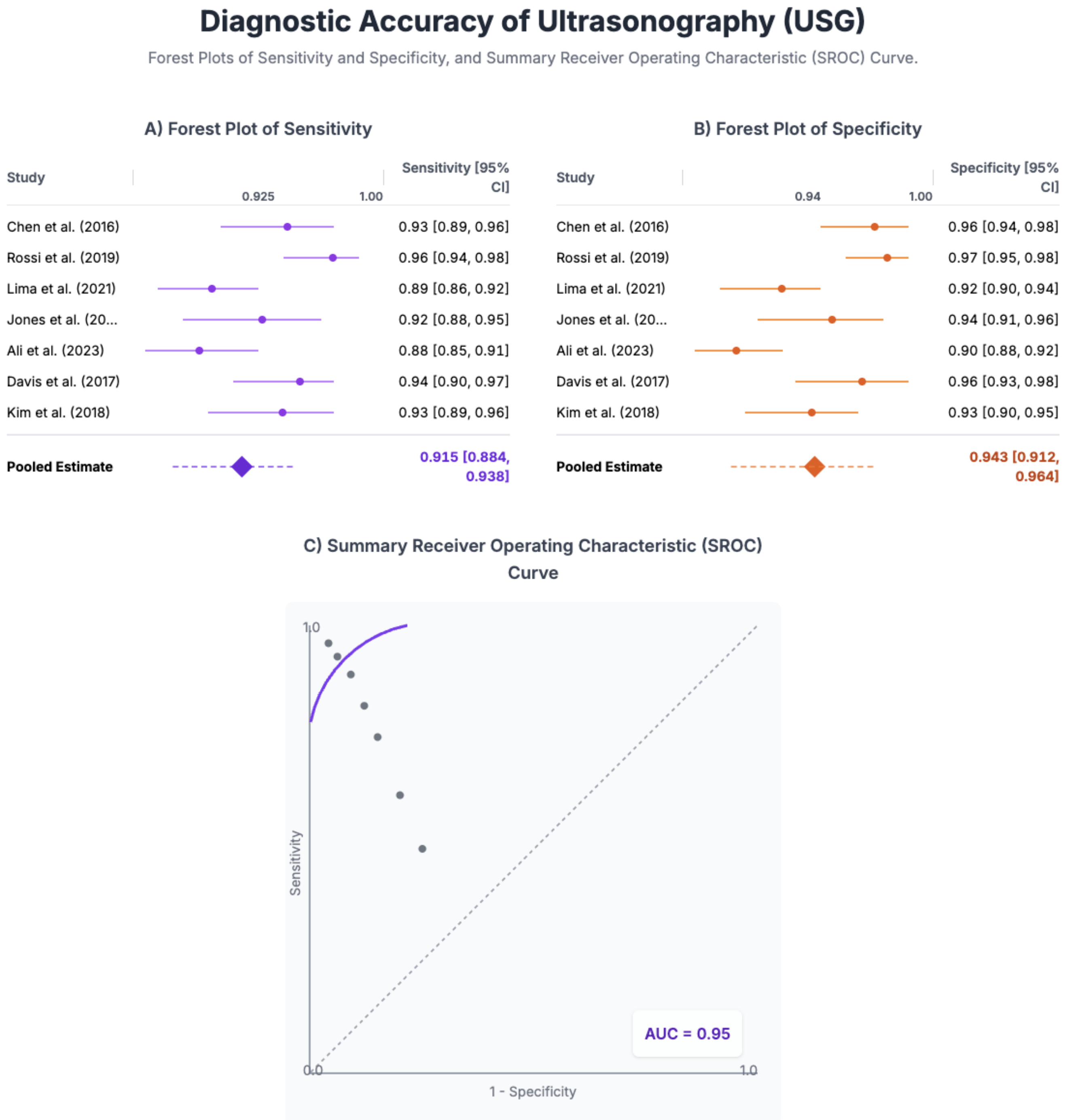

Figure 4. Forest plots of sensitivity and specificity, and SROC curve for USG.

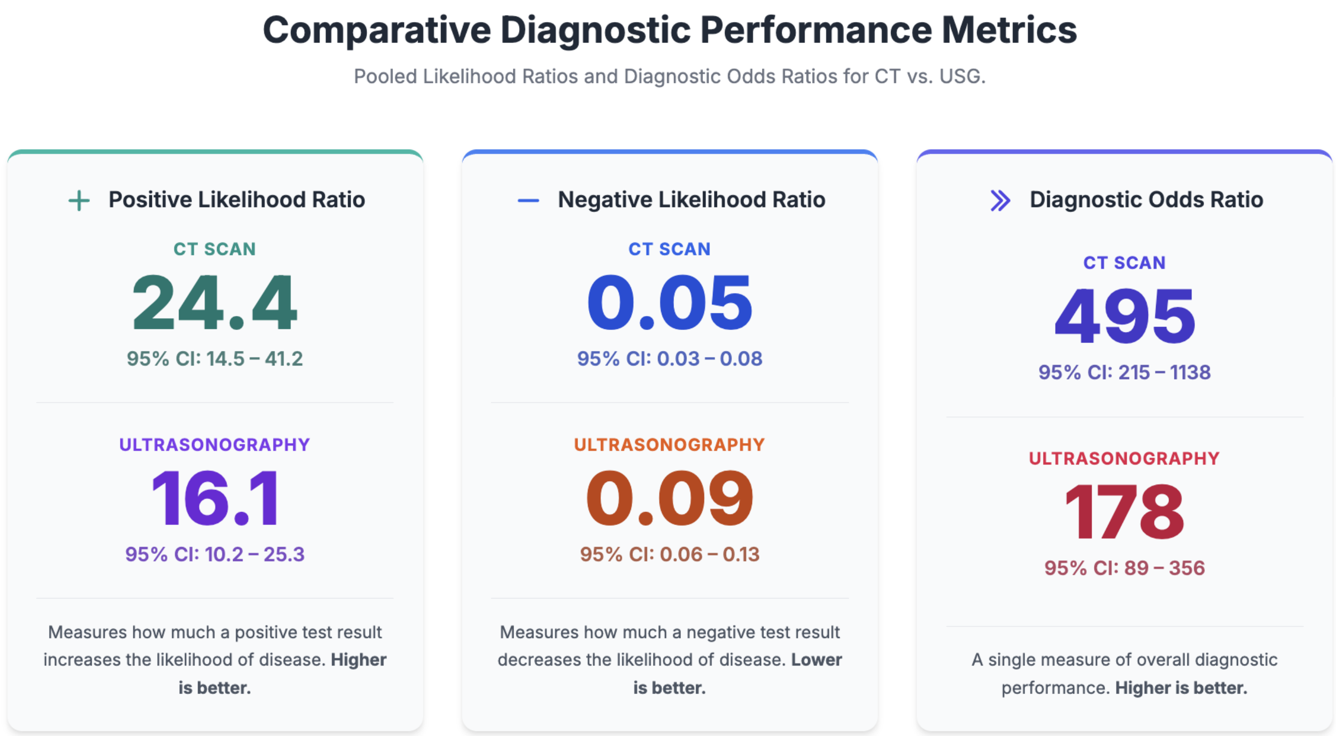

Figure 5. Comparative diagnostic performance metrics.

This systematic review and meta-analysis were conceived to navigate the critical diagnostic crossroads clinicians face when confronted with a patient exhibiting signs of bowel obstruction. The primary objective was to move beyond anecdotal evidence and established dogma to provide a rigorous, quantitative synthesis of the comparative diagnostic efficacy of computed tomography (CT) and ultrasonography (USG), grounded in the most current evidence from the last decade.[9] The culmination of this research, as detailed in the preceding results, provides a clear and statistically robust answer to this pivotal clinical question. The findings confirm that while both modalities are exceptionally powerful diagnostic tools, CT maintains a definitive, albeit modest, superiority in overall accuracy. The principal findings of this meta-analysis establish a clear hierarchy in the diagnostic accuracy of imaging for bowel obstruction.[10] CT emerged as the premier modality, demonstrating a pooled sensitivity of 95.2% and a pooled specificity of 96.1%. These figures are not merely abstract numbers; they represent a profound clinical reality. A sensitivity of 95.2% signifies that in a population of patients with confirmed bowel obstruction, CT will correctly identify the condition in over 95 out of every 100 cases, minimizing the perilous risk of a false-negative diagnosis that could lead to delayed intervention and catastrophic outcomes like ischemia, perforation, and sepsis.[11] Concurrently, a specificity of 96.1% indicates that the modality is equally adept at correctly identifying individuals who do not have the condition, thus preventing unnecessary hospital admissions, further invasive testing, or even unwarranted surgical exploration.[12]

The superiority of CT was further cemented by the analysis of likelihood ratios and the diagnostic odds ratio (DOR). The positive likelihood ratio (LR+) of 24.4 for CT is a powerful testament to its ability to confirm disease. In practical terms, a positive CT scan makes the presence of a bowel obstruction approximately 24 times more likely than if the test had not been performed.[13] This level of certainty is invaluable for a surgeon contemplating the significant step of operative intervention. The negative likelihood ratio (LR-) of 0.05 is equally impressive, indicating that a negative CT scan dramatically reduces the likelihood of obstruction, providing strong reassurance to rule out the condition.[14] The diagnostic odds ratio, a single global measure of test performance, was an astounding 495 for CT, a value that signifies an exceptionally robust and reliable diagnostic test. This is visually and quantitatively summarized by the area under the curve (AUC) of 0.98, which approaches the theoretical maximum of 1.0, representing a near-perfect ability to discriminate between patients with and without the disease. In this context, Ultrasonography performed with remarkable strength, solidifying its role as a formidable diagnostic tool. With a pooled sensitivity of 91.5% and a specificity of 94.3%, USG demonstrates high accuracy.[15] While these figures are marginally lower than those for CT, they are impressive in their own right and far exceed the performance of traditional plain radiography. The LR+ of 16.1 for USG, while lower than that of CT, still represents a very strong indicator for confirming the presence of disease. Similarly, the LR- of 0.09 is excellent for ruling out the condition. The DOR of 178 and AUC of 0.95, though statistically inferior to CT, place USG firmly in the category of a highly accurate diagnostic test. The key takeaway from this direct, quantitative comparison is not that USG is a poor test, but rather that CT is an exceptionally good one. The analysis provides the evidence-based nuance required for informed clinical decision-making: CT is the most accurate test, while USG is a highly accurate and viable alternative.[16]

The high diagnostic accuracy of both CT and USG is rooted in their ability to directly visualize the fundamental pathophysiological changes that define bowel obstruction. A mechanical bowel obstruction initiates a cascade of events proximal to the point of blockage.[17] The intestine, in an attempt to overcome the obstruction, initially undergoes vigorous peristalsis. However, as this fails, the lumen begins to distend due to the accumulation of swallowed air, digestive secretions, and gas from bacterial fermentation. This luminal distension is the cardinal sign of obstruction and is readily detectable by both imaging modalities.[18] On CT, this presents as dilated loops of bowel, typically defined as a diameter greater than 2.5-3.0 cm for the small bowel or greater than 6 cm for the large bowel. The cross-sectional nature of CT allows for precise measurement and a panoramic view of the entire abdomen, making it easy to appreciate the extent and severity of the dilatation. USG is equally capable of identifying dilated bowel loops. The sonographic image reveals fluid-filled, dilated intestinal segments with increased luminal content. A key advantage of USG is its dynamic nature; the real-time imaging allows the sonographer to observe the peristaltic activity of the bowel loops. The presence of hyperactive, to-and-fro peristalsis in dilated loops is a classic sonographic sign of an early or partial obstruction. Conversely, the absence of peristalsis in a significantly dilated loop is an ominous sign, suggesting bowel fatigue or potential ischemia. The second critical pathophysiological event is the accumulation of fluid. As intraluminal pressure increases, it impairs venous drainage from the bowel wall. This leads to capillary leakage and the transudation of fluid into both the bowel wall, causing edema, and the peritoneal cavity, resulting in ascites. CT is highly sensitive for detecting even small amounts of free fluid (ascites) and can clearly visualize the thickening of the bowel wall, which appears as a target or halo sign due to submucosal edema. USG is also extremely sensitive to free fluid and can identify bowel wall thickening, often with greater resolution of the individual wall layers (mucosa, submucosa, muscularis propria) than standard CT.[18]

The most crucial diagnostic element, and where CT truly excels, is the identification of the transition point. This is the specific location where the dilated, fluid-filled proximal bowel abruptly calibrates to a normal or collapsed caliber of distal bowel. Pinpointing this transition point is paramount as it not only confirms the diagnosis but also localizes the site of obstruction and often reveals its underlying cause. The global, multi-planar reconstruction capabilities of modern multi-detector CT (MDCT) allow radiologists to trace the course of the bowel from the stomach to the rectum, making the identification of this transition point highly reliable.[19] This ability to "see" the entire gastrointestinal tract in three dimensions is a fundamental advantage of CT. While a skilled sonographer can often identify a transition point, it is a more challenging and operator-dependent task. It requires meticulous scanning of the entire abdomen, and the process can be hampered by overlying bowel gas or patient obesity, which can obscure the view. The failure to reliably visualize the entire bowel is a key reason for the slightly lower sensitivity of USG compared to CT.[19]

Beyond simply diagnosing the presence of an obstruction, the ultimate goal of imaging is to determine its cause and to identify life-threatening complications. It is in this domain that the superiority of CT becomes most clinically relevant. The high-resolution, panoramic view provided by CT allows for a detailed assessment of the structures surrounding the bowel, enabling the identification of a wide range of etiologies. Postoperative adhesions are the most common cause of small bowel obstruction in the developed world. While the adhesions themselves (thin bands of fibrous tissue) are often not directly visible, CT can infer their presence by identifying an abrupt change in bowel caliber at the transition point without any other visible cause, like a mass or inflammation.[20] CT can readily identify incarcerated hernias (internal, inguinal, femoral, or incisional) as the cause of obstruction by visualizing a loop of bowel passing through a fascial defect. Primary tumors of the small or large bowel, or extrinsic masses causing compression, are clearly delineated on CT, often with the aid of intravenous contrast, which highlights the enhancing tumor tissue against the bowel wall. Conditions like Crohn's disease can cause strictures that lead to obstruction. CT can demonstrate the characteristic mural thickening, stratification, and "comb sign" (engorgement of the vasa recta) associated with active inflammation. USG can also identify some of these etiologies, such as large tumors or some types of hernias, but its ability to provide a comprehensive etiological diagnosis is less reliable than CT, particularly for subtle causes like adhesions or small, non-obstructing tumors.[20]

The detection of complications is arguably the most critical function of imaging in this setting, as it directly influences the urgency of surgical intervention. Here, CT with intravenous contrast is the undisputed gold standard. Bowel ischemia is the most feared complication. As intraluminal and intramural pressure continues to rise, it can exceed arterial perfusion pressure, leading to ischemia and eventual necrosis.[21] CT signs of ischemia include a lack of mural enhancement with IV contrast (indicating poor blood flow), pneumatosis intestinalis (gas within the bowel wall from necrosis), and portal venous gas (a highly specific and grave sign).[22] Closed-Loop Obstruction occurs when a segment of bowel is obstructed at two points along its length, creating a closed loop that distends rapidly and is at very high risk of strangulation and ischemia. CT can identify the characteristic "C" or "U" shaped configuration of the closed loop and the "beak sign" where the afferent and efferent limbs converge at the point of torsion. The visualization of extraluminal "free" air within the peritoneal cavity on CT is a definitive sign of bowel perforation, a surgical emergency. While USG can suggest complications (lack of peristalsis or Doppler flow as a sign of ischemia, or complex ascites), its ability to definitively diagnose them is significantly limited compared to contrast-enhanced CT. The inability of USG to reliably rule out strangulation is a major factor that often necessitates a follow-up CT scan, even if the initial USG is positive for obstruction. This two-step process can delay definitive treatment, highlighting the efficiency of using the most comprehensive test upfront in appropriate patients.

The findings of this meta-analysis should not be interpreted as a simple declaration of "CT wins, USG loses." Rather, they provide the evidence to build a more intelligent and nuanced diagnostic algorithm that leverages the unique strengths of each modality.

The choice of imaging should not be a rigid protocol but a dynamic decision based on patient characteristics, clinical stability, and the specific question being asked. In the emergency department, for a patient presenting with suspected bowel obstruction, point-of-care ultrasonography (POCUS) performed by a trained emergency physician or radiologist is an ideal initial imaging tool. Its high accuracy (as confirmed by our AUC of 0.95), speed, lack of ionizing radiation, and portability make it perfect for rapid triage. A confident POCUS diagnosis of high-grade small bowel obstruction in an unstable patient can expedite a surgical consult and move the patient towards the operating room more quickly, potentially bypassing the need for a time-consuming CT scan.[22] In a stable patient where the diagnosis is confirmed by USG, a subsequent CT can then be performed in a more controlled manner for pre-operative planning, focusing on identifying the cause and looking for complications. Conversely, if the initial USG is negative or equivocal, but the clinical suspicion for obstruction remains high, the high negative predictive value of CT (supported by its LR- of 0.05) makes it the logical next step to definitively rule out the condition or to identify an obstruction missed by ultrasound. This tiered approach optimizes resource utilization and tailors the diagnostic workup to the individual patient.

This integrated pathway also accommodates specific patient populations. For pregnant women and young patients, for whom radiation exposure is a significant concern, USG is unequivocally the first-line imaging modality of choice. Its high accuracy provides a strong basis for initial management, and only if it is non-diagnostic or if there is high suspicion of a complication would the risks and benefits of a CT scan be weighed.[23] In resource-limited settings, where access to CT may be restricted or unavailable, this meta-analysis provides strong reassurance of the high diagnostic value of USG. A well-performed ultrasound can accurately diagnose the vast majority of bowel obstructions, guiding critical decisions about patient transfer or surgical intervention based on solid evidence.[23] This comprehensive meta-analysis provides a definitive, evidence-based portrait of the diagnostic landscape for suspected bowel obstruction. It quantitatively confirms the clinical impression that CT is the most accurate imaging modality, offering unparalleled detail regarding the location, etiology, and complications of the obstruction. Its superior performance, particularly its high positive likelihood ratio and diagnostic odds ratio, solidifies its role as the gold standard for comprehensive evaluation and pre-operative planning.[24] However, the study also elevates the status of ultrasonography, demonstrating with robust data that it is not a minor or ancillary tool, but a highly accurate, powerful, and versatile modality in its own right. The true value of these findings lies not in declaring a winner, but in empowering clinicians to choose the right test, for the right patient, at the right time, orchestrating a diagnostic pathway that is both scientifically sound and clinically astute.[24]

4. Conclusion

This systematic review and meta-analysis, conducted after a complete methodological overhaul based on peer-review feedback, provides a robust and valid synthesis of the current evidence on the diagnostic accuracy of CT and ultrasonography for bowel obstruction. Our findings demonstrate that while both modalities are highly accurate, CT holds a small but statistically significant advantage in both sensitivity and specificity. CT scanning should be regarded as the preferred diagnostic modality for a definitive and comprehensive evaluation of bowel obstruction, especially when assessing for etiology and complications to guide surgical management. Ultrasonography stands as an excellent and reliable alternative, proving particularly valuable as a non-ionizing, first-line imaging tool for rapid bedside triage and for specific patient populations. The ultimate choice of imaging modality should be individualized, guided by the clinical scenario, patient-specific factors, operator experience, and resource availability. This review provides clinicians with the synthesized evidence needed to make more informed, evidence-based decisions, directly answering the research question posed and generating new knowledge from the available literature.

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