Test Characteristics of Emergency Medicine-Performed Point-of-Care Ultrasound for the Diagnosis of Acute Cholecystitis: A Systematic Review and Meta-analysis

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Acute cholecystitis accounts for up to 9% of hospital admissions for acute abdominal pain, and best practice entails early surgical management. Ultrasound is the standard modality used to confirm diagnosis. Our objective was to perform a systematic review and meta-analysis to determine the diagnostic accuracy of emergency physician–performed point-of-care ultrasound for the diagnosis of acute cholecystitis when compared with a reference standard of final diagnosis (informed by available surgical pathology, discharge diagnosis, and radiology-performed ultrasound). We completed a systematic review and meta-analysis, registered in PROSPERO, in adherence to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. We searched 7 databases as well as gray literature in the form of select conference abstracts from inception to February 8, 2023. Two independent reviewers completed study selection, data extraction, and risk of bias (QUADAS-2) assessment. Disagreements were resolved by consensus with a third reviewer. Data were extracted from eligible studies to create 2 × 2 tables for diagnostic accuracy meta-analysis. Hierarchical Summary Receiver Operating Characteristic models were constructed. Of 1855 titles/abstracts, 40 were selected for full-text review. Ten studies (n=2356) were included. Emergency physician–performed point-of-care ultrasound with final diagnosis as the reference standard (7 studies, n=1,772) had a pooled sensitivity of 70.9% (95% confidence interval [CI] 62.3 to 78.2), specificity of 94.4% (95% CI 88.2 to 97.5), positive likelihood ratio of 12.7 (5.8 to 27.5), and negative likelihood ratio of 0.31 (0.23 to 0.41) for the diagnosis of acute cholecystitis. Emergency physician–performed point-of-care ultrasound has high specificity and moderate sensitivity for the diagnosis of acute cholecystitis in patients with clinical suspicion. This review supports the use of emergency physician–performed point-of-care ultrasound to rule in a diagnosis of acute cholecystitis in the emergency department, which may help expedite definitive management. [Ann Emerg Med. 2023;■:1-12.]

Please see page XX for the Editor's Capsule Summary of this article.

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SEE EDITORIAL, P. XX.

INTRODUCTION

Background

Acute cholecystitis is the most common provisional diagnosis for right upper quadrant pain in the emergency department (ED), occurring in about one-third of patients.[1] Imaging is often required to confirm diagnosis, for which ultrasound is the imaging modality of choice.[2] A 2012 review showed that radiology-performed ultrasound has a sensitivity of 83% (95% confidence interval [CI] 75% to 87%) and a specificity of 83% (95% CI 74% to 89%) with substantial heterogeneity.[3]

A recent systematic review compared point-of-care ultrasound to radiology-performed ultrasound for diagnosing cholelithiasis and acute cholecystitis.[4] Although they included 8 studies, only one included diagnostic estimates for acute cholecystitis, preventing meta-analysis. To date, no systematic review has directly assessed the test characteristics of emergency physician–performed point-of-care ultrasound for the diagnosis of acute cholecystitis in the ED.

The objective of this study is to assess the diagnostic accuracy of emergency physician–performed point-of-care ultrasound compared with final diagnosis for acute cholecystitis in adults presenting to the ED with clinical suspicion of acute cholecystitis.

MATERIALS AND METHODS

The study protocol was registered with the PROSPERO International Prospective Register of Systematic Reviews

Editor's Capsule Summary

What is already known on this topic

Emergency physicians proficiently use point-of-care ultrasound for many conditions.

What question this study addressed

How well do emergency physicians detect or exclude cholecystitis using point-of-care ultrasound in emergency department patients?

What this study adds to our knowledge

In a meta-analysis and systematic review, emergency physician point-of-care ultrasound was highly specific (pooled specificity=94.4%), but with moderately sensitive (pooled sensitivity= 70.9%) in diagnosing cholecystitis.

How this is relevant to clinical practice

Emergency medicine bedside positive scans are likely to represent true positives and merit surgical consultation, but negative scans may often be false negatives and mislead.

Research we would like to see

What are the outcomes in patients where emergency physician point-of-care ultrasound for right upper quadrant pain is the main imaging tool?

(CRD42022354298). The protocol was developed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[5]

Eligibility Criteria

We included all English-language studies that enrolled adult patients with clinical suspicion of acute cholecystitis, who underwent emergency physician–performed point-of-care ultrasound in the ED for the same indication. We included randomized controlled trials and observational studies published in abstract or full-text form from January 1, 1981 to February 8, 2023.

We excluded case reports, case series, review articles, editorials, and expert opinions. Each study required sufficient data to build a 2 × 2 table of true positives, false positives, true negatives, and false negatives. Final diagnosis was informed by available surgical pathology, discharge diagnosis, radiology-performed ultrasound, and telephone follow-up. These data were either extracted directly from the articles or calculated from other reported data. If we were unable to obtain these values, we contacted the authors directly. Studies were excluded if the corresponding author did not respond after 3 attempts.

Search Strategy

A comprehensive search was performed, as detailed in Appendix E1 (available at http://www.annemergmed.com), of the following databases from inception to February 8, 2023: Medline, Embase, Pubmed, SCOPUS, Database of Abstracts of Review of Effects, Google Scholar, and Cochrane Central Register of Controlled Trials.[6] The search was performed by a registered librarian, with peer review by a second specialist, following the Peer Review of Electronic Search Strategies guidelines.[7]

References of all relevant studies and select conference abstracts from 2018 to 2022 were explored by 2 reviewers (SW, JS). Medical conference abstracts were screened from *Canadian Journal of Emergency Medicine, Academic Emergency Medicine, Journal of Ultrasound in Medicine,* and *Annals of Emergency Medicine*.

Study Selection

Studies were screened using Covidence systematic review software (Veritas Health Innovation). Titles were imported directly into Covidence from the search database, and duplicates were removed. Two reviewers (SW, JS) independently performed title and abstract screening to identify relevant studies. The same reviewers (SW, JS) then independently assessed the full text of relevant articles for inclusion. Interrater reliability was assessed with a Cohen's kappa test. Disagreements were resolved by a third reviewer (RT).

Data Extraction

Two reviewers (SW, JS) extracted demographic data from the included studies and independently collected counts for number of included patients, true positives, false positives, true negatives, and false negatives. Reported sensitivity, specificity, positive predictive value, and negative predictive value were obtained when available. A third reviewer (WC) independently verified extracted counts for 2 × 2 tables and performed back-calculations, as required, prior to statistical analysis.

Quality Assessment

Two reviewers (SW, JS) independently assessed the risk of bias using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool.[8] Disagreements were resolved through consensus. The QUADAS-2 tool assessed 4 potential areas for bias.

1) Patient selection: Risk of bias was considered high if consecutive enrollment was not reported, a case-controlled design was used, or inappropriate exclusions were found.
2) Index test emergency physician–performed point-of-care ultrasound: Risk of bias was considered high if the index test results were interpreted without explicit blinding to the reference standard.
3) Reference standard: Risk of bias was considered high if it had the potential to misclassify the target condition.
4) Flow and timing: Risk of bias was considered high if criteria for disposition or time to disposition were unclear.

Evidence Synthesis

Results were pooled using the Hierarchical Summary Receiver Operative Characteristic (HSROC) model, as recommended by the Cochrane Handbook for Systematic Review and Diagnostic Test Accuracy, to obtain summary point estimates of the pairs of sensitivity, specificity, diagnostic odds ratio (DOR), and likelihood ratios (LRs) with 95% CI.[9,10] The HSROC model accounts for the correlation between sensitivity and specificity and incorporates both within-study and between-study variability, described in detail in Appendix E2 (available at http://www.annemergmed.com). Data analyses were conducted using MetaDAS (version 1.3; SAS) macro in SAS.[11] We presented individual study results graphically with plotted sensitivities and specificity estimates on one-dimensional Forest plots and the receiver operating characteristic (ROC) space to visually assess for heterogeneity. DOR is defined as the ratio of the odds of the test being positive if the subject has a disease relative to the odds of the test being positive if the subject does not have the disease. Summary estimates of the index test (emergency physician–performed point-of-care ultrasound) accuracy were plotted in the ROC space together with the ROC summary curve.

RESULTS

Search Results

A total of 1,855 studies were imported after literature search, as summarized in Figure 1, and 5 duplicates were removed. All 1,850 studies underwent title and abstract screening, and 40 were selected to undergo full-text review. Ten studies (n=2,356) met inclusion criteria and were included for systematic review and meta-analysis.[11-20] Interrater reliability demonstrated substantial agreement (k=0.755, 95% CI 0.561to 0.950).

Study Characteristics

Characteristics of included studies are detailed in Table 1. Five of the 10 included studies were prospective cross-sectional design.[14,15,17-19] The other 5 were retrospective and case-controlled.[12,13,16,20,21] All manuscripts were published full-text papers. Six of the studies were published in the last 5 years.[12,13,16,17,20,21] Seven studies were conducted in North America,[12,13,15,16,18,20,21] with one study from Europe,[19] one from Turkey,[17] and one from Iran.[14] There were 2,356 patients from 10 studies who fit inclusion criteria. All studies included patients aged more than 10 years, and a majority aged more than 18 years. Furthermore, 2 studies included patients aged more than 10 years.[20,21] The range of sample sizes was from 76 to 577 (median=194). Seven studies included gender demographics. A total of 398 (16.9%) patients had a final diagnosis of acute cholecystitis.

Accuracy Characteristics

Two of the 10 studies excluded patients with a history of biliary disease (including gallstones).[14,17] The other 8 studies included patients regardless of known gallstones.[12,13,15,16,18-21] Three studies informed their final diagnosis using radiology-performed ultrasound.[14,17,19] Conversely, the other 7 used clinical follow-up to inform their final diagnosis (including surgical pathology, laparoscopy, discharge diagnosis, radiology-performed diagnostic imaging, and telephone follow-up).[12,13,15,16,18,20,21] The length of clinical follow-up ranged from 28 days to 1 year.

Biliary Ultrasonography Characteristics

All studies used a low-frequency curvilinear probe operated by an emergency clinician. Five studies included trained emergency physicians and emergency residents/fellows.[16-18,20,21] The other 5 studies only included attending emergency physicians. Ultrasonography technique was not routinely reported. One study reported a supine scanning position, moving to left lateral decubitus, as needed.[17] Six studies examined only the diagnosis of acute cholecystitis,[12,14,17-20] and 4 explored alternate biliary pathologies (cholelithiasis and choledocholithiasis).[13,15,17,21] No study reported ultrasonography duration. Four studies included relevant point-of-care ultrasound training for emergency clinicians as part of the study design, prior to data collection.[14,15,17,19]

Acute Cholecystitis Characteristics

A sonographic diagnosis for acute cholecystitis was most commonly defined as the presence of gallstones

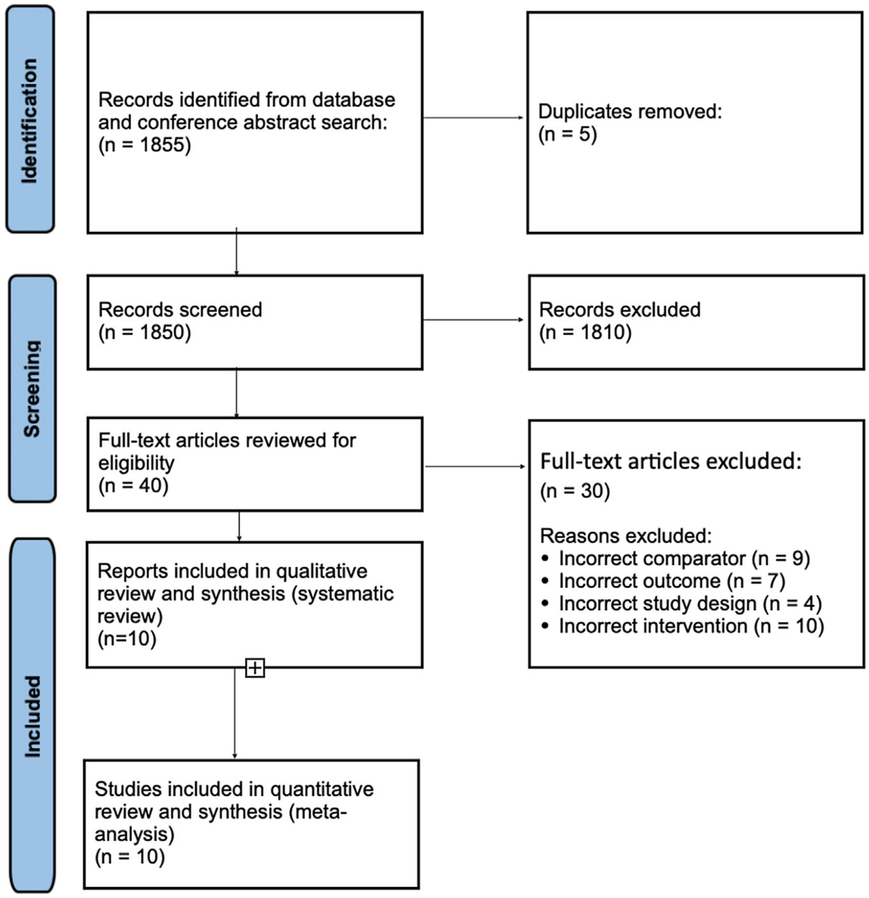


Figure 1. PRISMA flow chart summarizing study identification, screening, and inclusion. *PRISMA*, Preferred Reporting Items for Systematic Reviews and Meta-Analysis; *n,* number.

plus any one of: 1) positive sonographic Murphy sign, 2) gallbladder wall thickness more than 3 mm, or 3) pericholecystic fluid.[13,18,19,21] Two studies used a definition of any 2 of the following: sonographic Murphy sign, gallbladder wall thickness, or pericholecystic fluid.[16,20] One study specifically required the presence of gallstones and a positive sonographic Murphy sign.[15] Two studies reported signs of acute cholecystitis (Table 1), though did not report requirements for diagnosis.[12,17] One study did not describe how a diagnosis of acute cholecystitis was obtained.[14]

Quality Assessment

Quality assessments are summarized in Figure 2, as per QUADAS-2 criteria. Overall, there was a relatively low risk of bias in the reference standard and flow and timing domains, with a low risk of applicability concerns. Reference standards were routinely appropriate (surgical pathology, discharge diagnosis, or radiology-performed ultrasound) and blinded to the index test accordingly.

Unclear risk of bias in certain studies with respect to flow and timing were due to unreported time interval between point-of-care ultrasound in the ED and required radiology-performed ultrasound prior to disposition.[14,20,21] Patient selection had a high risk of bias. Only one study used a consecutive patient enrollment.[19] Three studies contributing to index test bias did not indicate index test blinding.[12,14,17] One study used a different sonographic definition for the diagnosis of acute cholecystitis for the index test and the reference test.[15]

RESULTS OF SYNTHESIS

Figure 3A shows the descriptive Forest plot of sensitivity and specificity for emergency physician–performed point-of-care ultrasound to diagnose acute cholecystitis, plotted in descending order of sensitivity. Figure 3B shows graphical display of the HSROC and bivariate summary points of sensitivity and specificity. Summary estimates of pooled diagnostic accuracy measures are tabulated in Table 2. Emergency physician–performed point-of-care ultrasound had a pooled sensitivity of 78.6% (95% CI 67.8

Table 1. Summary of included studies.

Author and Year	Country	Study Design	Enrollment	Subjects (n)	Woman (%)	Ultrasound Acute Cholecystitis Criteria	Ultrasound Machine	Final Diagnosis Comparator	Provider Level
Evans 2021	USA	Retrospective cohort	Convenience sampling, single center	194	N/A	Gallstones, wall thickening, pericholecystic fluid, sonographic Murphy sign, or enlargement of the common bile duct[*]	N/A	[†]Clinical follow-up (up to 6 months)	Attending MD
Hilsden 2018	Canada	Retrospective cohort	Convenience sampling, single center	266	N/A	Gallstones+any of the following: sonographic Murphy sign, gallbladder wall thickness $\geq$4 mm, and pericholecystic fluid	N/A	[†]Clinical follow-up (up to 28 days)	Attending MD
Katirci 2014	Turkey	Prospective cohort	Convenience sampling, single center	167	65.0	N/A	Mindray DC-3 (Mindray)	Radiology-performed ultrasound	Attending MD
Rosen 2001	USA	Prospective cohort	Convenience sampling, single center	76	71.6	Gallstones and presence of sonographic Murphy sign	Aloka Echo Camera SSD-500 (Olympus) or Siemens Sonoline Prima (Siemens)	[†]Clinical follow-up (up to 1 month)	Attending MD
Sharif 2021	Canada	Retrospective cohort	Convenience sampling, single center	577	N/A	Any 2 of the following: sonographic Murphy's sign, anterior gallbladder wall thickening >3 mm, and pericholecystic fluid	N/A	[†]Clinical follow-up (up to 1 month)	Attending MD and ultrasound fellows

Table 1. Continued.

Author and Year	Country	Study Design	Enrollment	Subjects (n)	Woman (%)	Ultrasound Acute Cholecystitis Criteria	Ultrasound Machine	Final Diagnosis Comparator	Provider Level
Shekarchi 2018	Iran	Prospective cohort	Convenience sampling, single center	341	63.2	Gallstones, gallbladder wall thickening >3 mm, fluid around the gallbladder, wall edema in the gallbladder*	HM-70 Samsung (Samsung) or M-Turbo Sonosite (Fujifilm)	Radiology-performed ultrasound	Attending MD and senior residents
Summers 2010	USA	Prospective cohort	Convenience sampling, single center	164	73%	Gallstones+any of the following: wall thickening >3 mm, pericholecystic fluid, positive sonographic Murphy sign	Sonosite Micromaxx (Fujifilm) or Toshiba Xario (Toshiba)	†Clinical follow-up (up to 1 year)	Attending MD and ultrasound fellows
Torres-Macho 2012	Spain	Prospective cohort	Consecutive sampling, single center	76	55.2	Gallstones+any of the following: wall thickening >3 mm, pericholecystic fluid, positive sonographic Murphy sign	Siemens Sonoline G-20 (Siemens)	Radiology-performed ultrasound	Attending MD
Werhle 2022	USA	Retrospective cohort	Convenience sampling, single center	147	72.1	Any 2 of the following: gallbladder wall hyperemia, pericholecystic fluid, positive sonographic Murphy sign	N/A	Surgical pathology, then radiology-performed ultrasound	Attending MD, fellow and senior residents
Zitek 2023	USA	Retrospective cohort	Conveinence sampling, single center	348	63.6	Gallstones+any of the following: wall thickening >3 mm, pericholecystic fluid, positive sonographic Murphy sign	Sonosite X-Porte (Fujifilm)	Surgical pathology, then HIDA scan, then radiology-performed ultrasound	Attending MD, fellow, senior and junior residents

HIDA, hepatobiliary iminodiacetic acid; *MD,* medical doctor; *N/A*, not available.
*No specific diagnostic algorithm for acute cholecystitis were reported.
†Clinical follow-up includes: surgical pathology, discharge diagnosis, radiology-performed diagnostic imaging, and then telephone encounter.

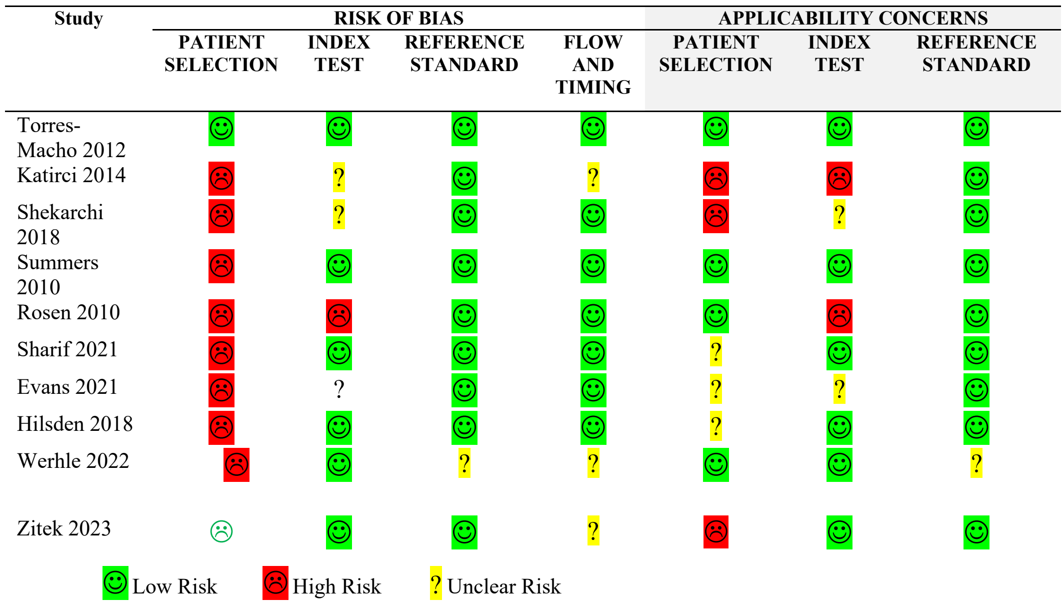


Figure 2. QUADAS-2 risk of bias assessment of included studies. *QUADAS-2,* a revised tool for the Quality Assessment of Diagnostic Accuracy Studies.

to 86.5) and a pooled specificity of 94.9% (95% CI 89.7 to 97.5). Emergency physician–performed point-of-care ultrasound with final diagnosis (informed by available surgical pathology, discharge diagnosis, and then diagnostic imaging results) as the reference standard (7 studies, n=1,772) had a pooled sensitivity of 70.9% (95% CI 62.3 to 78.2) and a pooled specificity of 94.4% (95% CI 88.2 to 97.5). The estimated DOR of emergency physician–performed point-of-care ultrasound to diagnose acute cholecystitis was 41.1 (95% CI 16.8 to 100.2), and the pooled estimates of positive and negative LRs were 12.7 (95% CI 5.8 to 27.5) and 0.31 (95% CI 0.23 to 0.41), respectively. The curves of positive and negative predictive values against prevalence are presented in Figures 4 and 5. Emergency physician–performed point-of-care ultrasound with radiologist-determined diagnosis as the reference standard had only 3 studies which met inclusion criteria. Albeit too few to fit the HSROC model, they had a pooled sensitivity of 91.0% and pooled specificity of 95.1% by weighted average.

LIMITATIONS

Some limitations were identified in this review that may contribute to heterogeneity and possible selection bias. We included all studies with comparator of final diagnosis of acute cholecystitis in our analysis. As this was informed by a step-down approach (surgical pathology, discharge diagnosis, radiology-performed imaging, and then telephone follow-up as available), there was potential for significant heterogeneity in our comparator outcome measure. Seven studies were identified, which used the same composite outcome as above; however, 3 studies, which used radiology-performed ultrasound as a sole comparator, were included. We attempted to compare the 2 subgroups. There were insufficient data in the comparator subgroup of radiology-performed ultrasound to power the HSROC model. For this reason, our study was unable to compare the diagnostic accuracy of emergency physician–performed point-of-care ultrasound with that of radiology-performed ultrasound for diagnosing acute cholecystitis. In addition, we could not comment on how diagnostic accuracy of emergency physician–performed point-of-care ultrasound relates to radiology-performed ultrasound for this question.

We only included English-language studies, though multiple studies were included from countries where English is not the first language. Our search strategy may have missed studies published in these countries that were only available in non-English languages. Further, our search strategy included select conference abstracts as a source for data. None of these conferences were international outside of Canada and the United States, and we may have missed relevant studies for this reason.

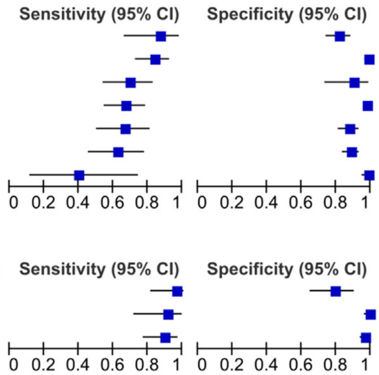
Of the included articles, patient selection was subject to a high risk of bias throughout, with only one study describing consecutive patient enrollment.[19] There was variation in patient exclusion criteria, as some studies excluded patients with a known history of previous biliary disease.[14,17] These selection biases for emergency

PoC Ultrasound (Ref: Final diagnosis)

Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Summers 2010	20	26	3	115	0.87 [0.66, 0.97]	0.82 [0.74, 0.88]
Zitek 2023	57	4	11	276	0.84 [0.73, 0.92]	0.99 [0.96, 1.00]
Rosen 2001	32	3	14	27	0.70 [0.54, 0.82]	0.90 [0.73, 0.98]
Sharif 2021	47	12	23	495	0.67 [0.55, 0.78]	0.98 [0.96, 0.99]
Evans 2021	28	19	14	133	0.67 [0.50, 0.80]	0.88 [0.81, 0.92]
Hilsden 2018	25	26	15	200	0.63 [0.46, 0.77]	0.88 [0.84, 0.92]
Werhle 2022	4	2	6	135	0.40 [0.12, 0.74]	0.99 [0.95, 1.00]

PoC Ultrasound (Ref: Radiologist-performed)

Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Torres-Macho 2012	27	10	1	38	0.96 [0.82, 1.00]	0.79 [0.65, 0.90]
Katirci 2014	21	1	2	143	0.91 [0.72, 0.99]	0.99 [0.96, 1.00]
Shekarchi 2018	43	10	5	283	0.90 [0.77, 0.97]	0.97 [0.94, 0.98]



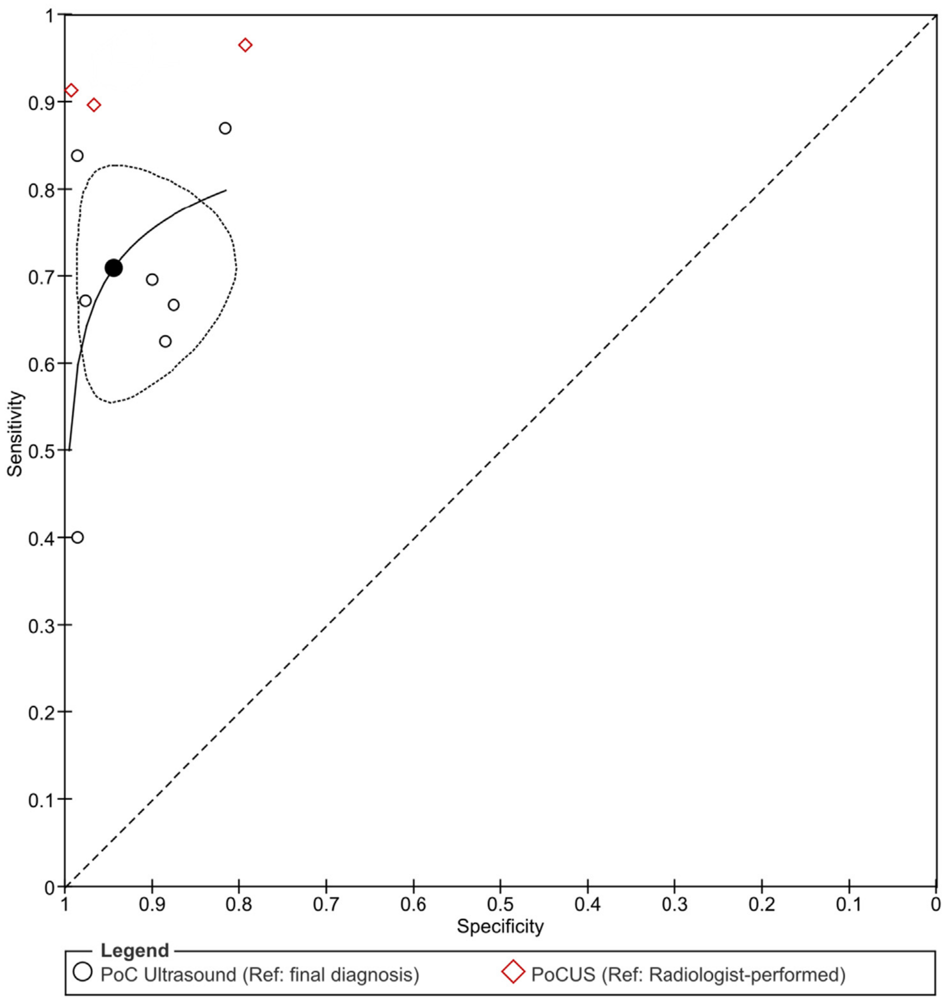


Figure 3. *A*, Descriptive Forest plots of sensitivity and specificity and *B,* hierarchical summary receiver operating characteristic curves and bivariate summary points (specificity, sensitivity) for emergency physician–performed point-of-care ultrasound to diagnose acute cholecystitis, their 95% confidence regions (dotted line) and 95% prediction regions (dashed line). *TP,* true positive; *FP,* false positive; *FN*, false negative; *TN*, true negative; *CI,* confidence interval.

physician–performed point-of-care ultrasound could contribute to possible overestimated specificity. A relatively small number of true positives (n=398) were observed in our included patients. This likely contributed to the relatively narrow CI for specificity compared with the relatively wide CI for sensitivity, given the HSROC model accounts for the correlation between sensitivity and specificity.

Table 2. Summary estimates for the sensitivity and specificity for emergency physician–performed point-of-care ultrasound to diagnose acute cholecystitis.

	Sensitivity (95% CI)	Specificity (95% CI)	DOR (95% CI)	LR+ (95% CI)	LR-(95% CI)
All 10 studies	78.6% (67.8-86.5)	94.9% (89.7–97.5)	67.7 (28.1-163.0)	15.3 (7.5–30.9)	0.23 (0.15-0.35)
Reference: Final diagnosis ** **(7 studies)**	70.9% (62.3-78.2)	94.4% (88.2–97.5)	41.1 (16.8-100.2)	12.7 (5.8–27.5)	0.31 (0.23-0.41)
Reference: Radiologist-determined diagnosis (3 studies)	91.0%*	95.1%*	–	–	–

*Pooled sensitivity, specificity by weighted average.
**Final diagnosis was informed by (where available) surgical pathology, discharge diagnosis, and then radiology-performed diagnostic imaging.

There was also significant heterogeneity in emergency physician–performed point-of-care ultrasound operator experience. This limitation has been well described in ultrasonography, particularly for point-of-care ultrasound.[22] All included studies were performed at a single center, with highly variable training requirements for the emergency physician–performed point-of-care ultrasound provider. These ranged from no additional training to a 10-hour hands-on teaching session prior to patient enrollment. In practitioners with more limited experience, sensitivity may be overestimated. Previous work has reassuringly demonstrated that emergency physician–performed point-of-care ultrasound performed by junior residents against criterion standard had similar results to those by more senior residents and faculty (specifically for diagnosing acute cholecystitis).[18] For this reason, we opted to include studies that used emergency physician–performed point-of-care ultrasound regardless of operator experience in our search strategy; however, this still remains a limitation of our search strategy. Furthermore, the diagnostic criteria for emergency physician–performed point-of-care ultrasound were highly variable in the included studies, which could lead to heterogeneity in index test interpretation. One study did not include any diagnostic algorithm and could be influenced by significant confirmation bias.[14]

Recent research supports the use of emergency physician–performed point-of-care ultrasound for safe surgical decisionmaking in the right clinical context.[23] Our study also supports this when emergency physician–performed point-of-care ultrasound is positive for acute cholecystitis. Further questions would benefit

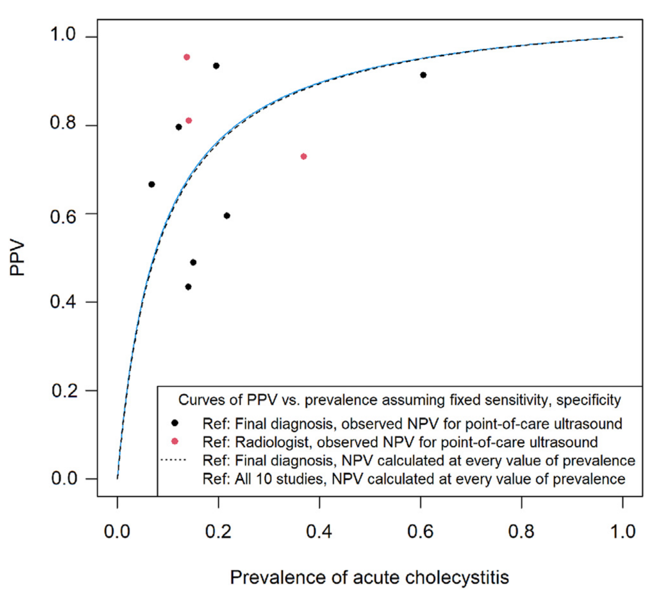


Figure 4. Curve of positive predictive value (PPV) for emergency physician–performed point-of-care ultrasound to diagnose acute cholecystitis against prevalence of acute cholecystitis, based on the 10 analyzed studies.

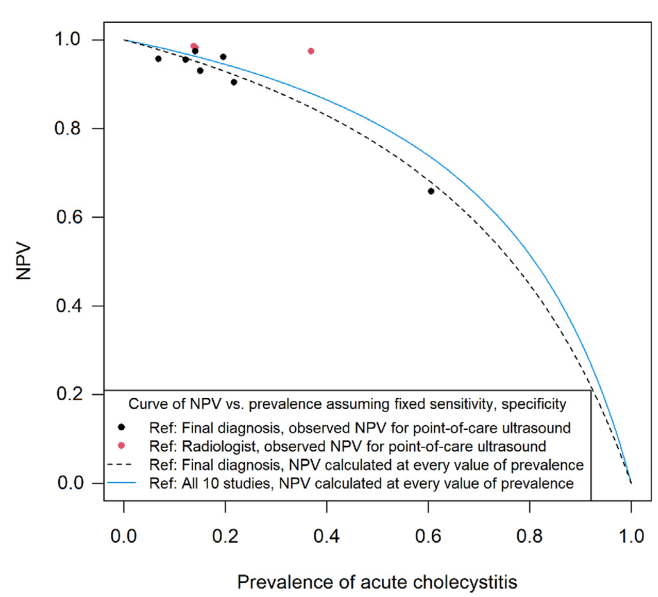


Figure 5. Curve of negative predictive value (NPV) for emergency physician–performed point-of-care ultrasound to diagnose acute cholecystitis against prevalence of acute cholecystitis, based on the 10 analyzed studies.

from further analysis of patient-centered outcomes in relation to the form of imaging obtained in the ED. Such patient-oriented outcomes may include time to disposition, time to definitive management, length of hospital stay, and morbidity and mortality.

Our registered search strategy attempted to collect data on patient-oriented outcomes; however, these data were not available in the body of literature we systematically assessed. Further, a heterogeneous diagnostic definition for emergency physician–performed point-of-care ultrasound for the diagnosis of acute cholecystitis was identified in included studies, which is a significant limitation of our included studies. Insufficient data existed to compare these subgroups directly, and further studies would benefit from exploring such patient-oriented outcomes available to better guide emergency physician–performed point-of-care ultrasound practice.

Importantly, although emergency physician–performed point-of-care ultrasound has been shown to be specific and sensitive for the diagnosis of cholelithiasis and acute cholecystitis, its role in other hepatobiliary pathology like choledocholithiasis is more limited. By relying on only emergency physician–performed point-of-care ultrasound to inform this question, there is risk of missing alternate hepatobiliary diagnoses. Our review did not appraise these potential associated harms.

DISCUSSION

This systematic review and meta-analysis confirms that emergency physician–performed point-of-care ultrasound with final diagnosis as the reference standard is both moderately sensitive (70.9%, 95% CI 62.3 to 78.2) and highly specific (94.4%, 95% CI 88.2 to 97.5) for diagnosing acute cholecystitis. Emergency physician–performed point-of-care ultrasound with radiologist-determined diagnosis as the reference standard had only 3 studies with weighted average sensitivity of 91.0% and specificity of 95.1%. The negative predictive value was also very high (>90%) for all prevalence ranges below 40%, which is consistent with the prevalence of acute cholecystitis in the ED patient population.[1] Compared with previously described estimates for radiology-performed ultrasound sensitivity (83%, 95% CI 75% to 87%) and specificity (83%, 95% CI 74% to 89%), emergency physician–performed point-of-care ultrasound is similarly sensitive and more specific in diagnosing acute cholecystitis.[3] These findings suggest that emergency physician–performed point-of-care ultrasound may play a larger role in the diagnosis of acute cholecystitis.

This review used the final diagnosis as a comparator, where surgical pathology, operative findings, clinical impression, and radiology-performed imaging were appraised in combination to inform the clinical opinion. Seven studies used this definition for final diagnosis as above, whereas 3 studies used a definition based only on radiology-performed ultrasound. In comparing point estimates on the Forest plot, sensitivities were slightly higher when radiology-performed ultrasound was the only contributor to final diagnosis, but this was not statistically significant.

A previous systematic review compared emergency physician–performed point-of-care ultrasound with radiology-performed ultrasound for diagnosing cholelithiasis and cholecystitis.[4] They identified significant clinical and methodological heterogeneity of the available studies at that time for acute cholecystitis, preventing meta-analysis. Much of this heterogeneity was attributed to the operator-dependent nature of ultrasound and variable training in each study. Studies captured in our review demonstrate a more uniform baseline ultrasound training background for emergency physicians, which may have contributed to a more homogeneous sample. Furthermore, by using final diagnosis as the comparator, we allowed for inclusion of a much larger sample of patients, as well as emergency physician–performed point-of-care ultrasound providers, compared with the study by Dupriez et al,[4] which may have contributed to less selection bias. Significant heterogeneity was noted in the emergency physician–performed point-of-care ultrasound definition of acute cholecystitis for this review. CIs on the Forest plot; however, overlap, suggesting that this does not appear to have meaningfully affected obtained point estimates.

A recent study by Hilsden et al[23] examined the use of point-of-care ultrasound in the ED to predict the surgical management of acute cholecystitis. In 100 patients presenting to the ED with abdominal pain where biliary disease was identified on point-of-care ultrasound, fewer than 10% of patients had a change in surgical management strategy based on the addition of a radiology-performed ultrasound. Further, among the patients who remained clinically stable between emergency physician–performed point-of-care ultrasound and radiology-performed ultrasonography, only 2 (2%) patients had an imaging discrepancy prompting a change in management. The authors concluded that emergency physician–performed point-of-care ultrasound offers a safe diagnostic pathway for surgical decisionmaking without the use of radiology.[23] With respect to the diagnosis of acute cholecystitis, the high specificity and negative predictive value in the ED setting identified in this review further support this conclusion.

The 2020 World Society of Emergency Surgery guidelines have a strong recommendation that “no feature has significant diagnostic power to establish or exclude the diagnosis of acute (calculous) cholecystitis, [and] it is recommended not to rely on a single clinical or laboratory finding."[24] The 2013 Tokyo guidelines (updated in 2018) is a tool commonly used to diagnose acute cholecystitis, and includes imaging findings characteristic of acute cholecystitis as one criterion.[25,26] The reliability of these guidelines is limited; however, in the absence of a reliable clinical diagnostic tool, emergency physician clinical gestalt will often drive surgical referral. Emergency physician–performed point-of-care ultrasound is readily available compared with radiology-performed ultrasound, and its use in clinical practice may lead to shorter ED length of stay, without significantly affecting final diagnosis.[13,23] Emergency physician–performed point-of-care ultrasound is also readily available in many small, rural locations, whereas radiology-performed ultrasound is not. Emergency physician–performed point-of-care ultrasound could play a role in expediting transfers in those with identified acute cholecystitis. There remains a significant absence of data involving the effect of emergency physician–performed point-of-care ultrasound on patient-centered outcomes. To better identify the utility of emergency physician–performed point-of-care ultrasound in guiding need for urgent surgical management or expediting transfer, future studies are needed to appraise these outcomes to better guide clinical practice.

In conclusion, our systematic review and meta-analysis demonstrated that emergency physician–performed point-of-care ultrasound is moderately sensitive and highly specific in diagnosing acute cholecystitis. These findings support the use of emergency physician–performed point-of-care ultrasound to rule in a diagnosis of acute cholecystitis at the bedside, prompting appropriate surgical referral. Patients for whom emergency physicians have ongoing concern for acute cholecystitis should have additional evaluation to further rule out this diagnosis.

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