

Review

Taku Harada*, Taiju Miyagami, Yukinori Harada and Taro Shimizu

Diagnostic errors in acute cholecystitis: a scoping review

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Abstract

Introduction: Diagnostic errors in acute cholecystitis significantly impact patient safety. Misdiagnosis, including both false negatives and false positives, is common due to the complex nature of abdominal pain and the overlapping symptoms of various conditions. This scoping review examines the definition, prevalence, and contributing factors of diagnostic errors in acute cholecystitis, emphasizing the need for improved diagnostic processes.

Content: Employing the PRISMA-ScR framework, this review examined definitions and factors contributing to diagnostic errors in cholecystitis. It highlights the variability in diagnostic criteria, with many studies relying on clinical judgment rather than standardized guidelines such as the Tokyo Guidelines. False negative diagnoses are often due to hypoalbuminemia, inconspicuous imaging findings, and the clinical setting, whereas false positives often result from misinterpreted imaging findings and failure to differentiate from other conditions.

Summary: This review found that approximately 30 % of acute cholecystitis cases may be missed (false negative), and 20–36 % of cases initially diagnosed can be incorrect (false positive). Adherence to standardized guidelines and improved recognition of atypical presentations could reduce diagnostic errors.

Outlook: Future research should aim for large-scale studies with clear diagnostic criteria and detailed clinical data to enhance diagnostic accuracy and patient safety.

Keywords: acute cholecystitis; false negative; false positive; diagnostic performance; acute abdomen

Introduction

Diagnostic errors are an important patient safety concern across healthcare settings, with approximately 6 % of emergency department patients affected and one-third of these experiencing harm [1, 2]. Abdominal pain is among the most frequent reasons for presentation, but within this broad category, acute cholecystitis represents a particularly challenging condition to diagnose accurately [3–5]. The level of difficulty is not uniform; it may differ across emergency departments, intensive care units (ICUs), and community hospitals. These variations arise from differences in patient populations, resource availability, and diagnostic workflows. While several studies have addressed diagnostic errors in appendicitis [6–8], only two studies in the literature had explicitly examined diagnostic errors in acute cholecystitis [9, 10], highlighting the very limited evidence base in this field. Existing reports differ in the definition of diagnostic errors, the diagnostic criteria applied, and the target population. This heterogeneity makes direct comparison difficult and obscures the overall magnitude and nature of diagnostic errors in cholecystitis. Such variation highlights the need for standardized diagnostic criteria to guide both clinical practice and research. The Tokyo Guidelines 2018 (TG2018), which incorporate systemic signs, local findings, and imaging features, have been developed for this purpose and demonstrate high diagnostic performance [11–13].

It is estimated that approximately 80 % of diagnostic errors across diverse clinical conditions are preventable [1]. Diagnostic errors can be reduced in two ways: by adhering to diagnostic criteria and clinical guidelines, and by recognizing patterns prone to diagnostic errors. Regarding the first point, several studies have shown that proper use of guidelines and clinical rules can improve diagnostic

*Corresponding author: Taku Harada, MD, PhD, Department of General Medicine, Nerima Hikarigaoka Hospital, 2-5-1 Hikarigaoka Nerima-ku, 179-0072, Tokyo, Japan; and Department of Diagnostic and Generalist Medicine, Dokkyo Medical University Hospital, Tochigi, Japan, E-mail: hrdtaku@gmail.com. <https://orcid.org/0000-0001-8794-6744>

Taiju Miyagami, Department of General Medicine, Faculty of Medicine, Juntendo University, Tokyo, Japan. <https://orcid.org/0000-0002-4893-2224>

Yukinori Harada and Taro Shimizu, Department of Diagnostic and Generalist Medicine, Dokkyo Medical University Hospital, Tochigi, Japan. <https://orcid.org/0000-0001-6042-7397> (Y. Harada). <https://orcid.org/0000-0002-3788-487X> (T. Shimizu)

accuracy [14, 15]. Therefore, applying the Tokyo Guidelines in patients with acute abdominal pain may improve diagnostic accuracy for acute cholecystitis. Regarding the second point, recent research has increasingly focused on understanding disease-specific patterns that contribute to diagnostic errors (patterns contributing to diagnostic errors) [16], particularly in cases with atypical symptoms [2, 17, 18]. Identifying these patterns is crucial for improving diagnostic accuracy and patient outcomes.

The existing literature on diagnostic errors in acute cholecystitis is limited, with few studies comprehensively mapping the extent and range of existing research. This paucity of literature necessitates a broader exploratory approach. Additionally, given the fragmentation of research in this area, a scoping review is warranted to identify existing knowledge and gaps, thereby guiding future research. Therefore, we conducted this scoping review to investigate the definitions used in studies on diagnostic errors in cholecystitis, as well as disease-specific patterns contributing to diagnostic errors, including false negative and false positive diagnoses.

Methods

This scoping review was conducted according to the methodological principles of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) statement [19].

The research questions for this review were as follows:

- (1) What definitions are used in studies examining diagnostic errors related to acute cholecystitis?
- (2) What factors related to diagnostic errors in acute cholecystitis, including false negative and false positive diagnoses, have been investigated?

Definitions of diagnostic errors in acute cholecystitis

Two patterns of diagnostic errors were anticipated: one in which acute cholecystitis was missed in the initial diagnosis, and the other in which acute cholecystitis was incorrectly diagnosed despite a different true diagnosis. Therefore, missing acute cholecystitis was considered underdiagnosis [20], defined as a false negative diagnosis in this study. Cases where acute cholecystitis was initially diagnosed but ultimately resulted in a different diagnosis were categorized as a false positive diagnosis [21]. When included studies reported “delayed diagnosis”, we extracted the authors’ time-based definitions and treated “delay” as a descriptive, time-

based measure that may overlap with, but is not synonymous with, underdiagnosis.

Search strategy

A literature search was conducted using PubMed and Web of Science Core Collection, targeting papers published until August 2024. The key terms used were “acute cholecystitis” and “diagnostic errors” (see Supplementary Material). To ensure linguistic consistency and reliability, and to avoid translation bias, the search was restricted to literature published in English. In this scoping review, no additional literature was included through hand searching.

Eligibility criteria

The eligibility criteria for this scoping review were as follows:

Population: Adult patients initially or ultimately diagnosed with acute cholecystitis.

Concept: Definitions, frequency, and factors related to diagnostic errors in acute cholecystitis.

Context: All healthcare settings.

Types of evidence: Any article except case reports, review articles, studies on diagnostic accuracy of tests, and studies focusing on treatment or management. Although diagnostic accuracy studies provide important information on the performance of imaging and laboratory modalities, we excluded them because our review focused on studies explicitly examining diagnostic errors (false negative and false positive diagnoses) as clinical outcomes in real-world settings.

Screening and data extraction

Two authors (TM and TH) independently screened the titles and abstracts of the retrieved articles based on the eligibility criteria, resolving any inconsistencies through discussion. Thereafter, the two authors independently screened the full texts, with discrepancies resolved through discussion. Rayyan (<https://www.rayyan.ai/>), a review software, was used for duplicate removal and paper screening. From the included studies, we extracted and organized the following data in Microsoft Excel: PubMed Identifier, Digital Object Identifier, author, year, country, inclusion criteria, number of patients, research objectives, study design, details of diagnostic errors, definitions of diagnostic errors, diagnostic criteria for cholecystitis, results, related factors, and data

collected in the study. In studies that reported delayed diagnosis, we also recorded how “delay” was defined, including whether a specific time threshold (in hours or days) was provided or whether delay was defined only as failure to diagnose acute cholecystitis at the initial consultation. For the purpose of this review, diagnostic delay was considered as the interval from the patient’s first contact with a healthcare facility to the establishment of the correct diagnosis of acute cholecystitis, whereas delays in seeking care (presentation delay, defined as the time from symptom onset to first medical contact) were outside the scope of this review and were not assessed. The inclusion and exclusion criteria applied in this review are summarized in Table 1.

Results

Definition of diagnostic errors

In this scoping review, 13 articles were considered relevant (Figure 1 and Table 2). The 13 included studies were all retrospective observational designs, with sample sizes ranging from 11 to 2,699 patients (median approximately 188). Five studies were conducted in the United States, two in Japan, and the remainder in Korea, Finland, China, and the United Kingdom, indicating a predominance of research from high-income countries. Only one study (Ikeda et al.) applied the TG2018 criteria, whereas the others relied on diverse bases such as clinical judgment, imaging

interpretations, or pathological confirmation, as detailed in Table 2 (see column ‘Diagnostic criteria for acute cholecystitis’). Most studies defined diagnostic errors based on discrepancies between initial and final diagnoses, though Ikeda et al. specified a 3-day timeframe as a prognostic threshold. The characteristics identified across the included studies highlight variation in study size, geographic origin, and diagnostic standards. Among these, only the study by Ikeda et al. defined a specific timeframe of three days [22, 23] as a critical threshold for delayed diagnosis impacting the prognosis of laparoscopic surgery for acute cholecystitis [9]. Yoo et al. described prolonged delays, with some diagnoses made more than one month after stroke onset, although no formal threshold was set [24]. Kelly-Schuetz et al., in contrast, presented a smaller case series that highlighted diagnostic delay in atypical patient populations. None of these studies, including Ikeda, Yoo, and Kelly-Schuetz, reported *a priori* sample size calculations, reflecting their retrospective and exploratory nature [9, 24, 25]. The remaining studies did not provide a time-based definition and instead considered delay operationally as the absence of a diagnosis of acute cholecystitis at the initial consultation. These differences are summarized in Table 2. Regarding the diagnostic criteria, only the study by Ikeda et al. adopted the Tokyo Guidelines [9], whereas others primarily relied on clinical or pathological diagnoses. Clinical diagnoses were based on fever, right upper quadrant tenderness on percussion, Murphy’s sign, and elevated liver function tests [24], which differed from the TG2018 criteria [12].

Table 1: Eligibility criteria for studies included in the scoping review.

Category	Inclusion criteria	Exclusion criteria
Population	Adult patients initially or ultimately diagnosed with acute cholecystitis	Pediatric patients
Concept	Studies examining definitions, frequency, or factors related to diagnostic errors in acute cholecystitis (including false negative, false positive, or delayed diagnosis)	Studies not addressing diagnostic errors in acute cholecystitis
Context	All healthcare settings	None specified
Types of evidence	Original research articles (any study design) explicitly examining diagnostic errors as clinical outcomes in real-world settings	– Case report – Review articles – Studies focusing solely on diagnostic accuracy of imaging or laboratory tests – Studies focusing on treatment or management
Language	English	Non-English publications

False negative diagnosis of cholecystitis

Six studies were relevant to this category. Four studies [9, 21, 24, 25] directly investigated the factors related to diagnostic errors, whereas the remaining two followed up on diagnoses after patients presented for abdominal pain and were sent home without a diagnosis [26, 27]. Notably, Eskelinen and Lipponen [27] reported that of 552 individuals diagnosed with nonspecific abdominal pain, 19 were eventually diagnosed with acute cholecystitis. This report suggests that patients with acute cholecystitis can initially present with clinical symptoms resembling nonspecific abdominal pain. Similarly, Powers et al. [26] reported that of 249 patients diagnosed with undifferentiated abdominal pain, one was ultimately diagnosed with acute cholecystitis. Studies investigating delayed diagnosis of acute cholecystitis include Ikeda et al., who examined 135 cases of acute cholecystitis in individuals over 65 years of age and demonstrated that 28.9 % experienced delayed diagnosis. Multivariate analysis indicated that hypoalbuminemia was associated with

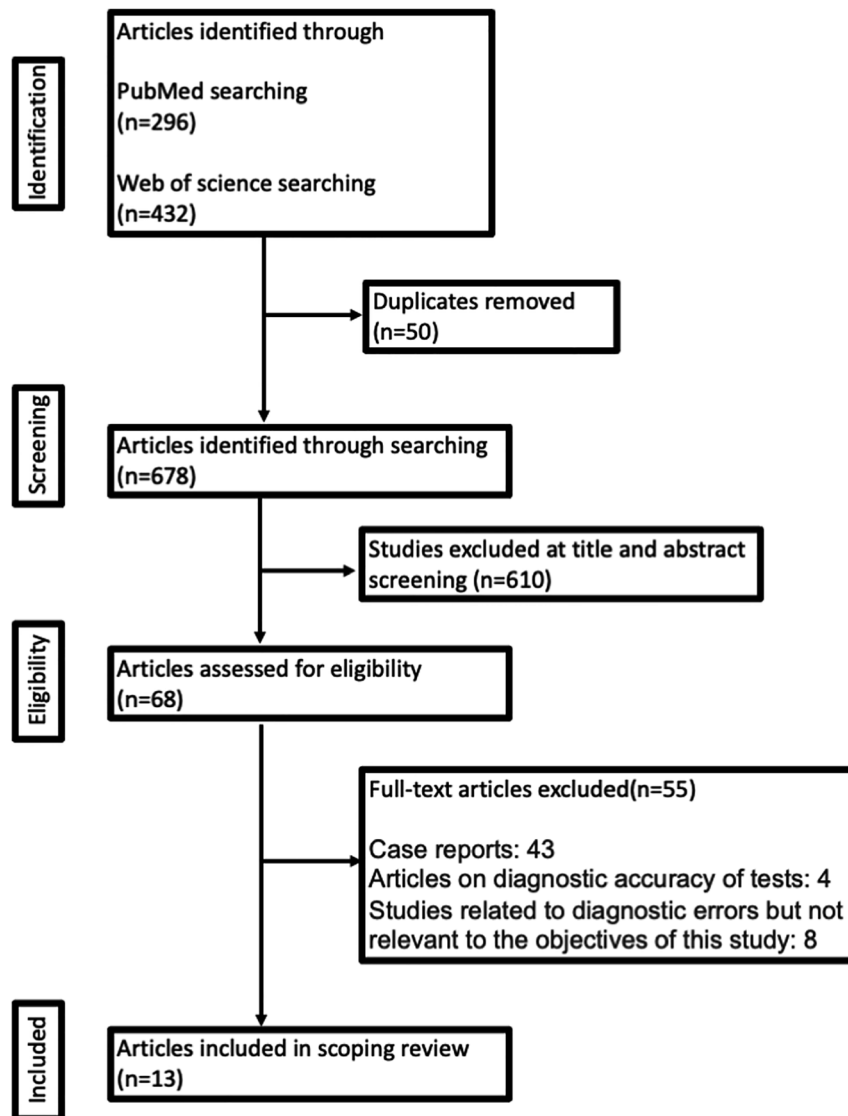


Figure 1: PRISMA flow diagram.

delayed diagnosis [9]. Yoo et al. [24] reviewed patients who developed cholecystitis after a stroke and observed that diagnosis took over a month in 4 out of 28 cases. The delay was attributed to the early closure of aspiration pneumonia or urinary tract infections, which are common in stroke patients, and the use of antibiotics for treatment. Kelly-Schuette et al. [25] examined patients who underwent cholecystectomy after initial negative or equivocal imaging tests and reported that 25 % were diagnosed with acute cholecystitis. Brook et al. [20] retrospectively analyzed initial diagnoses of individuals later diagnosed with cholecystitis using imaging databases. Factors such as unrecognized gallbladder wall edema (six cases), underrecognized gallbladder distension (four cases), ICU admission (two cases), and missing conclusions in radiology reports (two cases) were identified as causes of underdiagnosis. Integrating these studies reveals that factors leading to delayed

diagnosis of cholecystitis include hypoalbuminemia, inconspicuous/unrecognized imaging findings, and the likelihood of other conditions being considered post-stroke.

False positive diagnosis of cholecystitis

Eight articles were relevant to the false positive diagnosis of acute cholecystitis [10, 20, 28–33]. Brook et al. [20] reported three cases in which gallbladder edema was misdiagnosed as cholecystitis, with final diagnoses of hepatitis, sepsis, and chronic cholecystitis. These cases showed gallbladder wall edema but lacked gallbladder distension or gallstones. Silpapojakul et al. [28] reported a case among 137 individuals with rickettsial spotted fever and murine typhus, both of which can cause fever, abdominal pain, and liver damage; one individual underwent cholecystectomy. Although not

Table 2: Characteristics of the selected studies.

Classification of diagnostic error	Author and year	Country	Enrollment criteria	Number of patients	Study design	Research on diagnostic errors	Research targeting cholecystitis	Definition of diagnostic error	Diagnostic criteria for acute cholecystitis
False negative diagnosis	Ikeda et al. (2022)	Japan	Acute cholecystitis in aged 65 and over	135	Retrospective observational study	Y	Y	Cases not diagnosed within 3 days of onset were defined as delayed diagnosis.	Tokyo guideline
	Yoo et al. (2019)	Korea	Patients who developed cholecystitis following stroke	2,699	Retrospective observational study	N	Y	Concurrence of initial diagnosis	Clinical diagnosis
	Brook et al. (2011)	USA	Diagnosed with cholecystitis based on imaging data from a medical databases	11	Retrospective observational study	Y	Y	Concurrence of initial diagnosis	Pathology of cholecystectomy, positive bile culture during percutaneous cholecystostomy, and clinical diagnosis
	Powers et al. (1995)	USA	Patients presenting with abdominal pain at an emergency department	1,000	Retrospective observational study	N	N	Concurrence of initial diagnosis	Clinical diagnosis
	Eskelinen et al. (2012)	Finland	Patients presenting with abdominal pain in hospital	1,333	Retrospective observational study	N	N	Concurrence of initial diagnosis	Clinical diagnosis
False positive diagnosis	Kelly-Schuette et al. (2022)	USA	Cases underwent laparoscopic surgery following inconclusive initial imaging for acute cholecystitis.	257	Retrospective observational study	N	Y	Concurrence of initial diagnosis	Pathology (Studies on patients post-cholecystectomy)
	Brook et al. (2011)	USA	Cases diagnosed with acute cholecystitis from an imaging database	14	Retrospective observational study	Y	Y	Concurrence of initial diagnosis	
	Silpapojakul et al. (1996)	Thailand	Patients with murine typhus	137	Retrospective observational study	N	N	Concurrence of initial diagnosis	
	Mohanty et al. (2019)	India	Expanded dengue syndrome	520	Retrospective observational study	N	N	Concurrence of initial diagnosis	
	Halasz (1975)	USA	Initial diagnosis of acute cholecystitis	238	Retrospective observational study	Y	Y	Concurrence of initial diagnosis	

Table 2: (continued)

Classification of diagnostic error	Author and year	Country	Enrollment criteria	Number of patients	Study design	Research on diagnostic errors	Research targeting cholecystitis	Definition of diagnostic error	Diagnostic criteria for acute cholecystitis
	Eagle et al. (1986)	USA	Cases initially diagnosed with cholecystitis that later evolved into aortic dissection	55	Retrospective observational study	N	N	Concurrence of initial diagnosis	
	Li et al. (2015)	China	Autopsy cases where the final diagnosis was aortic dissection	31	Retrospective observational study	Y	N	Concurrence of initial diagnosis	
	Schofield et al. (1986)	UK	Initial diagnosis of acute cholecystitis	100	Retrospective observational study	Y	Y	Concurrence of initial diagnosis	
	Matsu et al. (2019)	Japan	Cases where cholecystectomy was performed and the final diagnosis was gallbladder edema	12	Retrospective observational study	Y	Y	Concurrence of initial diagnosis	

directly related to the diagnostic process, Mohanty et al. [29] reported that 21 % of patients with dengue hemorrhagic fever developed acalculous cholecystitis, emphasizing the importance of conservative management to avoid unnecessary cholecystectomy. Halasz [10] analyzed the diagnostic accuracy in 235 cases of acute cholecystitis from 1975 and found diagnostic errors in 47 cases (20 %), primarily involving renal, hepatic, acute pancreatitis, acute appendicitis, and thoracic diseases. Among these, 18 were of renal origin, with acute pyelonephritis (eight cases), pyonephrosis (four cases, three with stones), and other conditions such as hemorrhagic cysts, obstructive renal cell carcinoma, and polycystic kidneys. Key differential clinical features included back pain and tenderness, which were common in renal diseases (83 %) but less so in acute cholecystitis (27 %). Liver-related issues accounted for 12 cases, half of which were due to hepatic lesions with elevated alkaline phosphatase levels. Ten patients had acute pancreatitis, with elevated serum amylase or lipase levels and back pain or tenderness as distinguishing features. Thoracic diseases were differentiated from acute cholecystitis based on the presence of pleuritic pain. Eagle et al. [30] reported a case initially diagnosed as cholecystitis, which was later diagnosed as aortic dissection on contrast computed tomography (CT) imaging. Li et al. [31] also reported four cases from 31 autopsies where the final diagnosis was aortic dissection but were initially misdiagnosed as cholecystitis. Schofield et al. [32] studied 100 cases of acute right upper quadrant pain, initially diagnosed as acute cholecystitis by experienced surgeons; among these, 64 cases were ultimately confirmed as such. They concluded that clinical symptoms and test results were not useful for distinguishing acute cholecystitis from alternative diagnoses, emphasizing the importance of confirming the presence of gallstones. Matsui et al. [33] reported that among 2,661 individuals diagnosed with cholecystitis, 12 (0.5 %) had gallbladder edema, five of whom underwent cholecystectomy. Of these, four were diagnosed with alcoholic hepatitis and one with drug-induced hepatitis. Seven patients with gallbladder edema who were conservatively treated were diagnosed with liver failure (two), renal failure (two), alcoholic cirrhosis (one), malnutrition-induced hypoalbuminemia due to severe depression (one), and drug-induced liver injury with Stevens-Johnson syndrome (one). Gallbladder edema is characterized by mesh-like wall thickening on ultrasonography and wall thickening without distension or debris on CT imaging. Integrating these findings, 20 % of cases initially diagnosed as cholecystitis were later identified as false positives. Five studies, including the one by Halasz et al. [10], identified back pain, pleuritic pain, and elevated alkaline phosphatase and amylase levels as differential points for cholecystitis vs.

other conditions. Matsui et al. [33] emphasized that the absence of gallbladder distension or gallstones and the presence of mesh-like wall thickening on ultrasonography are key features for differentiating gallbladder edema from cholecystitis. Brook et al. [20] also noted that three gallbladder edema cases, falsely diagnosed as cholecystitis, lacked gallbladder distension or gallstones. Additionally, two cases initially diagnosed as acute cholecystitis were ultimately diagnosed as aortic dissection. Notably, none of the studies addressing false positive diagnoses, including those by Halasz [10] and Matsui et al. [33], reported the use of formal scoring tools or structured decision rules to minimize misclassification. Diagnostic assessments were instead based on clinical evaluation, imaging interpretation, and surgical or pathological confirmation. In summary, careful attention to imaging findings, such as gallbladder edema without gallbladder distension or gallstones, as well as clinical signs considered less indicative of cholecystitis, such as back pain and pleuritic pain, is crucial for preventing the false positive diagnosis of acute cholecystitis. Although no formal diagnostic algorithms were proposed in the included studies, recurring features – such as the absence of gallbladder distension or gallstones, mesh-like wall thickening on ultrasonography, and associated systemic conditions (e.g., hepatitis or heart failure) – may assist in distinguishing gallbladder edema from acute cholecystitis. The development of validated diagnostic algorithms remains an important topic for future research.

Discussion

In this scoping review, 13 articles were examined, leading to four key findings:

- (1) Definition of timely diagnosis: Most studies defined timely diagnosis as a diagnosis made during the initial consultation.
- (2) Misalignment of definition standards: Only one study incorporated the TG2018 criteria for diagnosing cholecystitis, whereas the remaining studies relied on clinical or pathological diagnoses.
- (3) False negative diagnosis of acute cholecystitis: Approximately 30 % of acute cholecystitis cases were false negatives. Contributing factors included hypoalbuminemia, inconspicuous imaging findings, and situations where alternative diseases were prioritized, particularly following a stroke.
- (4) False positive diagnosis of acute cholecystitis: False positive diagnoses occurred in 20–36 % of cases. These diagnoses were more likely in the absence of gallbladder

enlargement or gallstones or in the presence of back pain or pleuritic pain, which are not typically indicative of acute cholecystitis.

There remains considerable room for improvement in the diagnostic criteria and standards for delayed diagnosis of cholecystitis. In our review, the definition of “delay” varied across studies: Ikeda et al. applied a 3-day threshold based on prognostic implications, Yoo et al. reported cases with delays longer than 1 month after stroke onset, and the remaining studies did not specify a time-based cutoff, defining delay only as a missed diagnosis at the initial consultation [9, 24]. This heterogeneity limits direct comparisons and underscores the need for standardized definitions in future research.

In addition to variability in delay definitions, inconsistency was also observed in the diagnostic criteria themselves. Yoo et al. [24] assessed clinical indicators such as fever, right upper quadrant tenderness on percussion, Murphy’s sign, and elevated liver function tests. However, no single test reliably confirms or excludes acute cholecystitis [34], and elevated liver function tests occur in only 40–70 % of acute cholecystitis cases [35, 36]. Diagnostic criteria relying on elevated liver function test results may fail to identify cases that lack these findings. Therefore, it is advisable that the diagnostic criteria for acute cholecystitis prioritize pathological diagnoses or adhere to the TG2018.

Most studies did not define specific criteria for diagnostic delay. Ikeda et al. proposed a 3-day post-onset timeframe based on the review article by Gallaher and Charles [9, 22]. However, Polo et al. [23] highlighted that the prognosis changes when laparoscopic surgery is performed within three days of hospitalization, necessitating the verification of criteria set by Ikeda et al. Furthermore, a 3-day post-onset timeframe risks conflating delays in seeking medical attention with delays in diagnosis by healthcare professionals, complicating the analysis of symptoms and physical findings contributing to delayed diagnosis. Considering that acute cholecystitis typically requires inpatient treatment, diagnostic error criteria should focus on whether an accurate diagnosis is made during the initial consultation.

According to Ikeda et al., false negative diagnoses occurred in approximately 30 % of cases, with hypoalbuminemia identified as the sole factor in a multivariate analysis [9]. This estimate was derived from a single study and should not be interpreted as a pooled rate across the literature. However, their study primarily focused on baseline patient data, providing limited information about clinical setting, symptoms, physical findings, or imaging findings at presentation. In particular, Ikeda et al. [9] identified

hypoalbuminemia as a factor associated with delayed diagnosis, suggesting that poor nutritional status may attenuate typical abdominal pain and hinder timely recognition. Notably, their definition of delay – diagnosis made more than three days after symptom onset – may capture not only delays in the in-hospital diagnostic process but also delays in seeking care, which should be considered when interpreting this association. Studies by Yoo et al. [24] and Brook et al. [20] suggested the need for further studies that consider specific clinical situations, such as patients who had a stroke or those in ICU, where delayed diagnoses are common. Studies by Eskelinen and Lipponen and Powers et al. reported cases initially misdiagnosed as nonspecific acute abdominal pain that were eventually identified as acute cholecystitis [26, 27], suggesting that early acute cholecystitis may present as nonspecific abdominal pain. Brook et al. [20] also identified inconclusive imaging findings and lack of recognition as contributors to delayed diagnosis, whereas Kelly-Schuette et al. [25] reported cases of acute cholecystitis with negative or ambiguous initial imaging tests. Addressing delays related to imaging findings requires integrating clinical symptoms and physical findings with effective communication with radiologists. These reports suggest the importance of implementing follow-up plans when the initial diagnosis or imaging findings for acute abdominal pain are nonspecific or unclear. This strategy may help prevent delays in the diagnosis and treatment of acute cholecystitis.

False positive diagnoses occur in 20–36 % of cases and may result from findings suggestive of other diseases, cases of acalculous cholecystitis due to rickettsia or dengue, or gallbladder edema misinterpreted as acute cholecystitis in the absence of gallstones or gallbladder distension. Acalculous cholecystitis, accounting for 5–10 % of acute cholecystitis cases [37, 38], involves complex multifactorial etiologies, including anatomical and functional factors, and is epidemiologically linked to trauma, surgery, shock, burns, sepsis, total parenteral nutrition, and mechanical ventilation, often occurring in ICU or post-surgical patients [37, 38]. Although the clinical presentation of acalculous cholecystitis resembles that of calculous cholecystitis, making diagnosis challenging, its epidemiology – frequently linked to infections or hospitalizations – differs significantly from that of acute calculous cholecystitis [37]. Therefore, acalculous cholecystitis is rarely encountered in outpatient and emergency care settings. Schofield et al. [32] emphasized that confirming the presence of gallstones cases of acute cholecystitis may help reduce diagnostic errors.

Improvements in the diagnostic process for acute cholecystitis and strategies for achieving diagnostic excellence can be approached from several perspectives. The first involves integrating information from symptoms, physical

findings, and imaging results for decision making. Halsey-Nichols et al. [4] emphasized the importance of incorporating symptoms, physical findings, and imaging results in the clinical diagnosis of acute abdomen, which aligns with the diagnostic criteria for acute cholecystitis in the TG2018 guidelines. These criteria report a sensitivity of 91.2 % and a specificity of 96.6 % [12, 13]. Given these favorable diagnostic performance metrics, wider adoption of TG2018 as a standardized diagnostic framework should be encouraged. However, further validation in diverse clinical settings is warranted before strong recommendations can be universally applied. For example, in elderly patients who may present with subtle fever or only mild right upper quadrant tenderness, applying TG2018 criteria in combination with imaging findings can still lead to timely recognition of acute cholecystitis, illustrating the utility of standardized frameworks even in less typical presentations. The second strategy focuses on optimizing the use of imaging examinations. For instance, in diagnosing acute cholecystitis, ultrasound demonstrates a sensitivity of 81 % and a specificity of 80 %; CT achieves a sensitivity of 94 % and a specificity of 59 %, with 20 % of gallstones not being identified; and MRI shows a sensitivity of 88 % and a specificity of 89 % [22]. Physicians should familiarize themselves with the accuracy and limitations of these imaging modalities. Additionally, the use of contrast agents in CT imaging warrants attention. Studies indicated that the diagnostic accuracy of CT for acute abdominal pain can vary by 30 % depending on the use of contrast agents [39]. Case reports, such as one describing portal vein thrombosis presenting with symptoms resembling cholecystitis [40], suggest contrast-enhanced CT is recommended for assessing acute cholecystitis as it facilitates evaluation of surrounding organs and potential complications. In practice, patients with negative or equivocal findings on initial ultrasonography have later been diagnosed with acute cholecystitis when CT or MRI was performed, illustrating the complementary role of multimodal imaging. Moreover, the absence of gallbladder distension or gallstones on ultrasonography has been emphasized as a clue to differentiate gallbladder edema from true cholecystitis [20, 33]. These clinical examples underscore the importance of optimizing imaging strategies rather than relying on a single modality. The third strategy highlights the importance of effective communication with radiologists. When performing CT imaging for acute abdominal pain, providing detailed clinical information to radiologists can enhance interpretation accuracy (93.7 % vs. 87.8 %) [41]. For instance, conveying clinical suspicion of acute cholecystitis or providing relevant laboratory data has been shown to increase radiologists' diagnostic precision, particularly when findings are subtle. The fourth strategy involves

Improving diagnosis of Acute Cholecystitis

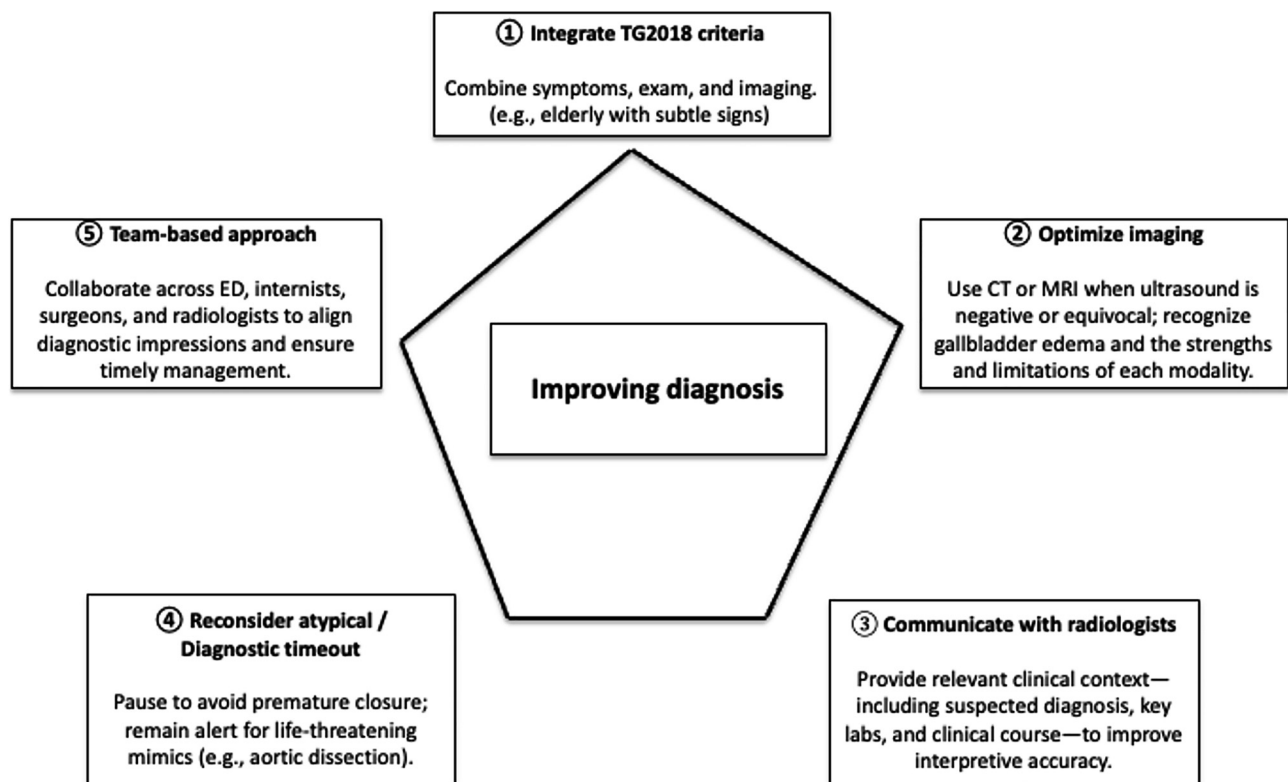


Figure 2: Strategies for improving diagnosis of acute cholecystitis.

reconsidering diagnoses in the presence of atypical symptoms or findings. Recognizing atypical presentations can help prevent diagnostic errors [2, 17, 18]. Moreover, avoiding premature diagnostic closure [40] and using strategies such as diagnostic timeouts [42–44] to reassess and debias the diagnostic process is deemed sensible [45, 46]. In addition, although our review did not primarily address differential diagnoses, it should be noted that conditions such as aortic dissection can occasionally mimic acute cholecystitis [30, 31]. Awareness of such rare but serious differential diagnoses is important, even if they fall outside the main scope of this scoping review. The fifth strategy underscores the value of a team-based approach. Future diagnostic excellence is envisioned to rely increasingly on collective, team-based efforts rather than individual actions [47]. In the context of acute cholecystitis, this may include collaboration between emergency physicians, internists, and surgeons to align initial diagnostic impressions with surgical decision-making, as well as structured communication with radiologists to ensure that relevant clinical details are considered in imaging interpretation. Creating organizational systems and support mechanisms that facilitate team-based approaches is also desirable [48]. Although our review did not identify interventional studies specifically targeting acute

cholecystitis, organizational strategies such as structured multidisciplinary discussions, morbidity and mortality conferences, diagnostic cross-checks, and diagnostic safety checklists have been proposed in the broader diagnostic safety literature. Future research is warranted to evaluate which of these team-based strategies may be most effective in reducing diagnostic errors in acute cholecystitis. To complement these textual descriptions, we additionally created a schematic figure (Figure 2) that visually summarizes the five proposed strategies for improving diagnosis of acute cholecystitis. This figure integrates clinical examples, highlights the role of standardized frameworks, multimodal imaging, communication, reconsideration of atypical cases, and team-based approaches, thereby providing readers with a concise overview of diagnostic improvement strategies.

This scoping review has few limitations that should be considered when interpreting the results. First, search was conducted using only PubMed and Web of Science and restricted to English-language publications, with no citation searching performed. Consequently, potentially relevant studies not indexed in PubMed or Web of Science or published in other languages may have been excluded. Second, all included studies were retrospective observational studies,

which are inherently susceptible to selection bias, incomplete data, and unmeasured confounding factors. Furthermore, inconsistencies in the definition of diagnostic errors across studies hinder direct comparisons and limit the generalizability of the results. Regarding the diagnosis of acute cholecystitis, only one study applied the TG2018 criteria, whereas other studies relied on clinical or pathological criteria that varied, underscoring the need for standardized diagnostic criteria in future research. Although we summarized diagnostic error rates in Table 2, these rates were not consistently reported across studies, and in several cases were entirely absent. This variability highlights a gap in the current evidence base and emphasizes the need for future studies to report diagnostic error rates in a standardized manner. Last, this review relied on secondary data from electronic medical records and imaging databases, making it difficult to capture the nuanced details of the clinical decision-making process, such as the impact of physician expertise or diagnostic workflows. Additionally, this review did not assess healthcare system factors, such as the availability of medical resources or institutional protocols, which may significantly influence diagnostic errors. Although system-level factors such as resource availability, diagnostic infrastructure, and institutional workflows were not addressed in this review, these contextual variables may influence the frequency and recognition of diagnostic errors, and future studies should integrate them to provide a more comprehensive understanding of diagnostic performance. Selection bias and heterogeneity in definitions may have led to both underestimation and overestimation of error frequencies, underscoring the need for standardized criteria in future research.

In summary, false positive and false negative diagnoses of acute cholecystitis occurred in 20–36 % and 30 % of the cases, respectively. Suggested improvements in the diagnostic process include adhering to TG2018 criteria, accounting for cases without gallstones, and making optimal utilization of imaging tests while maintaining effective communication with radiologists.

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