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Comparing percutaneous treatment and cholecystectomy outcomes in acute cholecystitis patients: a systematic review and meta-analysis

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Abstract

Background Acute cholecystitis (AC) is a common and serious condition characterized by gallbladder inflammation, most often caused by cystic duct obstruction due to gallstones. Although laparoscopic cholecystectomy (CC) is the preferred surgical treatment, percutaneous cholecystostomy (PC) is frequently considered for high-risk surgical patients. The optimal management strategy for these patients remains a topic of debate. These systematic review and meta-analysis aim to provide an updated evaluation of studies comparing the clinical outcomes of AC patients treated with PC versus those undergoing CC, as well as the outcomes of CC alone versus PC followed by CC.

Methods A literature search was carried out across Web of Science, Medline, Embase, and PubMed up to April 2024. Observational studies comparing patients undergoing PC versus CC, as well as CC versus PC followed by CC, and reporting mortality, morbidity, and readmission were included. Data extraction and quality assessment were independently performed by two reviewers, with bias risk evaluated using the Newcastle-Ottawa Quality Scale. The pooled odds ratio (OR) was obtained through meta-analyses by using STATA software (Version 18).

Results A total of 27 studies were included, with 16 comparing PC versus CC and 11 assessing PC followed by CC versus CC alone. Meta-analyses revealed that CC was associated with significantly lower mortality (OR = 0.26; 95% CI = 0.14–0.48) and readmission rates (OR = 0.37; 95% CI = 0.18–0.75) compared to PC. The benefits of laparoscopic cholecystectomy over percutaneous cholecystostomy were particularly evident for mortality (OR = 0.17; 95% CI = 0.09–0.33), while a non-significant trend towards reduced readmission rates was also observed (OR = 0.28; 95% CI = 0.07–1.13). However, PC was identified as a viable alternative in high-risk surgical patients. Studies examining PC followed by CC versus CC alone showed diverse results, with some indicating reduced surgical complications and improved outcomes, while others reported no significant benefits.

Conclusion This work highlights that CC is associated with better outcomes, including lower mortality and readmission rates, compared to both PC alone and PC followed by CC. The combined approach did not show a

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significant advantage over immediate CC. Further research with larger studies and standardized protocols is needed to refine treatment strategies for high-risk AC patients.

Keywords Cholecystostomy, Cholecystectomy, Acute cholecystitis, Surgical treatment, Outcome

Background

Acute cholecystitis (AC) is a common and significant condition marked by inflammation of the gallbladder, most often resulting from the obstruction of the cystic duct by gallstones. This blockage leads to bile stasis, gallbladder distension, and, ultimately, an inflammatory response that can escalate if untreated. The condition is a major contributor to acute abdominal pain presentations in emergency settings and frequently necessitates prompt medical attention, often culminating in surgical intervention [1, 2]. The disease not only poses a substantial burden on healthcare systems but also represents a critical condition that requires timely diagnosis and management to prevent severe complications, such as gallbladder gangrene, perforation, or systemic sepsis. The urgency of treatment is underscored by the fact that delayed intervention can lead to significant morbidity and mortality. The estimated overall prevalence of gallstones is 10–15% in the general population, with some differences across countries. Between 20 and 40% of patients with gallstones will develop gallstone-related complications, with an incidence of 1–3% annually; acute calculus cholecystitis (ACC) is the first clinical presentation in 10–15% of the cases [3]. Gallstones, a primary risk factor, are implicated in approximately 85% of cases. The prevalence of AC correlates strongly with advancing age, particularly among individuals over 60, where up to 30% may have cholelithiasis. This condition not only heightens the risk of cholecystitis but also underscores the importance of targeted prevention and management strategies in older populations [4, 5].

AC typically presents with pain in the right upper quadrant, fever, nausea, and vomiting. To establish a diagnosis, healthcare providers rely on a thorough clinical assessment, along with ultrasound imaging and laboratory tests [1]. The severity of the condition can vary widely, ranging from mild to severe, with serious complications such as gallbladder gangrene or perforation that can lead to significant morbidity and even mortality. To ensure consistent and effective management, the Tokyo Guidelines were created to offer a clear framework for diagnosing and treating AC, also providing a classification system for the severity of the disease and evidence-based protocols to improve patient outcomes [5]. According to the Tokyo Guidelines, cholecystectomy (CC), particularly the laparoscopic method, is the preferred surgical treatment for AC, especially when performed within 72 h of symptom onset, as it is associated with fewer complications and shorter hospital stays [5]. However, in patients at high surgical risk or those presenting later in the disease course, percutaneous cholecystostomy (PC), commonly referred to as drainage, represents a valuable alternative in clinical context [6]. While percutaneous drainage is associated with higher mortality and longer hospital stays compared to CC, it remains a critical option for patients who are not candidates for surgery [7, 8]. In certain cases [2], percutaneous drainage may be employed as a temporary solution, while in others, it can serve as a definitive therapeutic approach [1, 4, 9].

Recent meta-analyses have consistently shown that early CC, preferably laparoscopic, is associated with better outcomes compared to PC, even in high-risk surgical patients with AC [8, 10, 11]. The 2020 World Society of Emergency Surgery (WSES) guidelines strongly recommend early laparoscopic CC as the first-line treatment, reserving PC for patients unfit for surgery [3]. However, the role of PC, either as a definitive treatment or as a bridge to delayed surgery, remains debated in specific clinical scenarios.

These systematic review and meta-analysis aim to provide a comprehensive and updated evaluation in light of these guidelines and recent evidence, providing a comparison not only between PC and CC but also evaluates the outcomes of a staged approach (PC followed by CC) versus immediate CC. This dual perspective offers novel insights into the optimal management strategies for high-risk patients with acute cholecystitis.

Methods

Literature search and selection criteria

A systematic literature search was conducted across the Web of Science, Medline, Embase, and PubMed databases from their inception to April 2024. Two independent reviewers (G.F. and G.B.) performed the search using a predefined set of search terms: *(acute cholecystitis OR cholecystitis OR acute calculous cholecystitis) AND (cholecystectomy OR laparoscopic cholecystectomy OR open cholecystectomy OR laparotomic cholecystectomy) AND (cholecystostomy OR percutaneous cholecystostomy OR gallbladder drain OR gallbladder tube OR gallbladder drainage OR cholecystostomy tube).* The methodology adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and followed the recommendations outlined in the Cochrane Handbook [12]. The PRISMA checklist is provided as a Supplementary file; Supplementary file 1.

Studies were deemed eligible for inclusion if they were observational in nature, available as full-text articles published in English, and included populations diagnosed with AC or acute calculous cholecystitis. Additionally, eligible studies were required to provide comparisons of clinical outcomes between PC and CC patients. No restrictions were applied regarding the type of CC, and both laparoscopic and open procedures were considered acceptable for inclusion. Studies were excluded if they focused on populations with conditions other than AC or acute calculous cholecystitis, or if they did not compare outcomes between PC and CC patients. Further exclusion criteria encompassed conference abstracts, letters, editorials, comments, case reports, case series, narrative reviews, systematic reviews, and meta-analyses.

Data extraction

For each eligible study, two authors (G.F. and G.B.) independently extracted key information using a structured format, including the first author, year of publication, country, and study design. Data collected for both PC and CC patients included the total number of patients, age, number of male patients, length of hospital stay, mortality, morbidities, and readmissions. Any discrepancies between investigators were resolved through consultation with a third author (A.A.).

Assessment of bias risk and study quality

The quality of the studies was assessed by two authors (G.F. and G.B.) utilizing the Newcastle-Ottawa Quality Assessment Scale (NOS), with particular attention to potential biases in patient selection, comparability, and outcomes. Publication bias was evaluated through visual inspection of the funnel plot and the application of Egger's test.

Statistical analyses

The primary objective of this meta-analysis was to compare clinical outcomes in patients with AC treated with PC versus CC, as well as to compare outcomes between CC and PC followed by CC. For each clinical outcome, including mortality, morbidity and readmission, we calculated the odds ratio (OR) with a 95% confidence interval (95%CI). The pooled estimate was derived through meta-analysis and reported as the OR for each surgical treatment comparison. A subgroup analysis has been conducted for studies comparing laparoscopic CC versus PC. Heterogeneity across studies was assessed using the Q-statistic test and the I^2 index, with significant heterogeneity defined as $P < 0.1$ for the Q-statistic and $I^2 > 50\%$. In the presence of significant heterogeneity, a random-effects model was applied. Statistical analyses were conducted using STATA (version 18).

Results

Study selection and characteristics of included studies

Figure 1 illustrates the study selection process following the PRISMA 2020 flowchart. A total of 1818 records were retrieved from database searches. After screening titles and abstracts, 1620 records were excluded. During the full-text eligibility evaluation of 198 studies, 171 articles were excluded for the following reasons: 71 studies did not compare surgical and medical treatments; 74 studies did not analyze clinical outcomes of PC versus CC; 20 studies did not specifically address high-risk patients with AC; 6 studies compared patients undergoing PC and those undergoing PC followed by CC. Thus, 27 studies were included in the current systematic review. According to the NOS, the quality score was evaluated for the 25 retrospective and 2 prospective studies included in the systematic review. All studies showed a low-to-moderate risk of bias, with total scores ranging from 4 to 7. Specifically, most studies received a maximum of 3 stars out of 4 in the selection category, 1 star out of 2 in the comparability category, and 3 stars in the exposure/outcome category. The subsequent sections summarize the findings from the included studies, organized by their methodological approaches and results.

Efficacy and risks of PC versus CC in acute cholecystitis

Sixteen studies compared the outcomes of PC and CC in patients with AC, focusing on mortality, morbidity, hospital stay, readmission rates, and overall clinical effectiveness. Table 1 shows that these studies were published between 2011 and 2023, with 5 conducted in the United States, 1 in the United Kingdom, 2 in Spain, 2 in China, 1 in Taiwan, 1 in Holland, 1 in Colombia, 1 in Turkey, 1 in Egypt, 1 in Switzerland, and 1 in the Netherlands. Among these, 14 studies were retrospective, and 2 were prospective. The number of patients undergoing PC ranged from 14 to 73.841, while the number of patients undergoing CC ranged from 19 to 2.005.728. Although results are controversial, some studies have highlighted the advantages of CC over PC. For example, Hall and colleagues, analyzing data from the Vizient UHC database in the United States, concluded that emergency CC is not only a safer option but also more cost-effective compared to PC, thereby reinforcing the clinical preference for surgical management in patients with AC [13]. Similarly, Wiggins and colleagues, utilizing data from the Hospital Episode Statistics database in England, highlighted the efficacy of surgical treatment by demonstrating that, in patients over 80 years of age, emergency CC was associated with significantly lower rehospitalization rates and reduced one-year mortality compared to PC [4]. Anderson and colleagues also observed that patients undergoing PC were generally older and presented with a higher prevalence of comorbidities compared to those treated

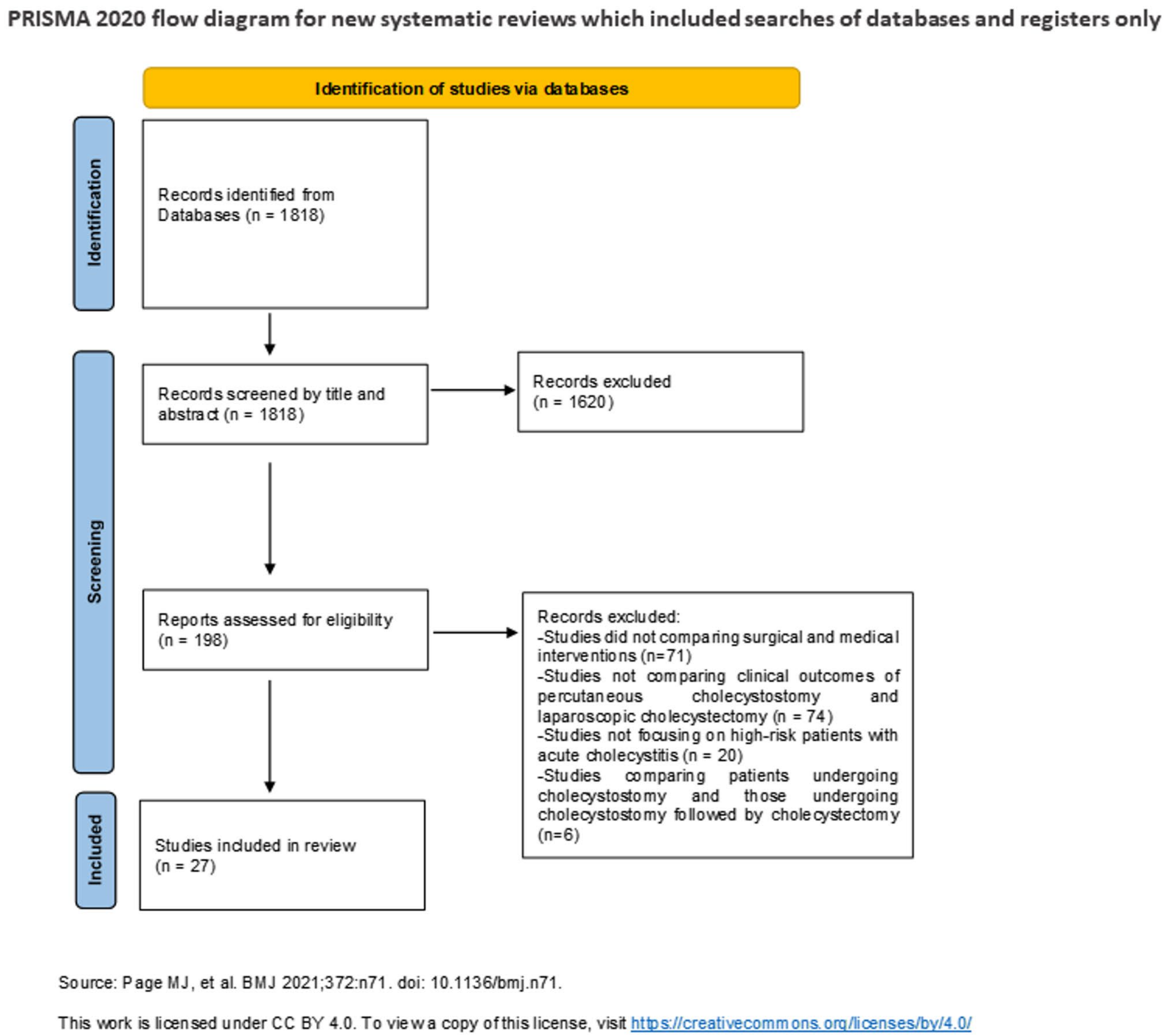

Fig. 1 PRISMA flow diagram of study selection process

with CC. Their analysis revealed that the PC group experienced significantly higher mortality rates and longer hospital stays than the CC group [2]. Building on these insights, the study by Zehetner and colleagues revealed that patients undergoing PC faced increased morbidity and longer hospital stays than CC [5]. The findings of Hadidi and colleagues further support this perspective, demonstrating that while the overall outcomes of both treatments were comparable, laparoscopic CC was preferred over the open surgical approach due to its associated benefits [14]. Although mortality rates were similar between the two groups, the study by Loozen and colleagues revealed that the PC group had a higher incidence of major complications, more reinterventions, and increased readmission rates, suggesting that PC may be associated with a greater risk of complications compared to cholecystectomy [15].

By contrast, some studies have highlighted that PC may be more beneficial in certain cases. Rodríguez-Sanjuán and colleagues suggested that PC may provide greater benefits for very elderly and high-risk surgical patients, offering a viable alternative to CC in these cases [16]. Jin and colleagues conducted a comparative analysis of open CC, laparoscopic CC, and PC in the management of AC, and notably found that PC offered distinct advantages, including faster recovery, improved survival rates, fewer complications, and more rapid normalization of laboratory values when compared to CC [17]. In a similar vein, Teoh and colleagues conducted a propensity score analysis of patients with AC, concluding that PC may be considered a valid option for patients who are not candidates

Table 1 Studies included in the systematic review comparing PC and CC

						Age (Median in years)		Sex (*n*° of male patients)		Lenght of hospital stay (days)	
Study	Country	Study Design	Type of cholecystectomy (CC)	N° of patients undergoing percutaneous cholecystostomy (PC)	N° of patients undergoing CC	PC patients	CC patients	PC patients	CC patients	PC patients	CC patients
Melloul et al., 2011	Switzerland	Retrospective	Open and laparoscopic	23	19	65	63	18	16	Median = 25 (IQR = 7–97)	Median = 23 (IQR = 5–65)
Jin et al., 2022	China	Retrospective	Open and laparoscopic	14	20	62,5	64,6	6	10	Mean = 2.99 (SD = 1.31)	Mean = 3.99 (SD = 1.51)
Zehetner et al., 2014	United States	Retrospective	Laparoscopic	23	23	57,3	49,8	7	11	Mean = 15.9 (SD = 12.6)	Mean = 7.6 (SD = 4.9)
Teoh et al., 2021	Taiwan	Retrospective	Laparoscopic	30	30	78	76,4	17	18	Mean = 6.8 (SD = 8.1)	Mean = 5.5 (SD = 2.7)
Rodríguez-Sanjuán et al., 2012	Spain	Prospective	Open and laparoscopic	29	32	81,8	83,6	NA	NA	Median = 12.7 (IQR = 6–30)	Median = 9.3 (IQR = 2–26)
Ramirez et al., 2023	Columbia	Retrospective	Laparoscopic	31	65	92	92	7	33	Mean = 10.0 (SD = 6.0)	Mean = 10.5 (SD = 7.0)
Loozen et al., 2018	Holland	Retrospective	Laparoscopic	68	66	74,9	71,4	44	41	Median = 9 (IQR = 6–19)	Median = 5 (IQR = 4–8)
Hadidi et al.,2019	Egypt	Retrospective	Open and laparoscopic	65	160	65,8	70,9	22	57	Mean = 13.2 (SD = 2.45)	Mean = 8.5 (SD = 1.2)
Akarsu et al.,2018	Turkey	Retrospective	Laparoscopic	102	217	73,5	54	43	104	Median = 4 (IQR = 2–41)	Median = 2 (IQR = 1–29)
Garcés-Albir et al.,2020	Spain	Retrospective	Laparoscopic	222	239	78,6	74	115	138	Mean = 13.21 (SD = 8.18)	Mean = 7.48 (SD = 7.67)
Simorov et al.,2017	United States	Retrospective	Open	704	1.021	NA	NA	435	610	Median = 7 (IQR = 5–10)	Median = 8 (IQR = 5–12)
Wiggins et al.,2018	United Kindom	Prospective	Open and laparoscopic	1.341	3.539	85	83	837	2.210	NA	NA
Hall et al.,2018	United States	Retrospective	Open and laparoscopic	1.682	7.879	67,3	60	959	3.501	Mean = 14.0 (SD = 14.9)	Mean = 7.2 (SD = 6.5)
Lu et al.,2017	China	Retrospective	Open and laparoscopic	11.184	225.558	NA	NA	6.614	111.020	Mean = 17.2 (SD = 1.52)	Mean = 9.51 (SD = 1.06)
Anderson et al.,2013	United States	Retrospective	Open and laparoscopic	8.020	298.727	71,9	54,8	4489	118,793	Median = 12.7 (IQR = 12.2–13.1)	Median = 5.1 (IQR = 5.1–5.3)
Wadhwa et al.,2021	United States	Retrospective	Open and laparoscopic	73.841	2.005.728	70,6	53,8	33	802,291	Mean = 12.3; Median = 8.0	Mean = 4.72; Median = 3.0

for CC, as both treatments demonstrated comparable complication rates [18]. In a broader context, Wadhwa and colleagues found that the use of PC procedures has been steadily increasing and offers a higher success rate compared to non-intervention, with outcomes comparable to those of CC, reinforcing the growing acceptance of PC as an effective treatment option [1]. Garcés-Albir and colleagues, in their study on elderly patients with substantial comorbidities, found that while PC was linked to higher mortality and longer hospitalization compared to CC, it was associated with fewer severe complications, indicating its potential role as a viable option for high-risk patients [19].

Some evidence suggests that both PC and CC may offer effective management strategies for AC in selected patients. Melloul et al., for instance, observed that although CC was linked to increased iatrogenic morbidity, PC alone frequently failed to achieve definitive resolution. These results reinforce current recommendations advocating for post-cholecystostomy cholecystectomy to ensure effective control of sepsis in high-risk populations [20]. In line with this, Akarsu et al. investigated the management of AC in patients with elevated anesthetic risk and found that both PC and CC were comparably effective in controlling sepsis, suggesting that either approach may be appropriate for high-risk patients when tailored to their clinical status [21]. The study by Simorov and colleagues suggested that while PC is particularly beneficial for patients with severe comorbidities, CC remains the definitive treatment, best suited for clinically stable individuals [22]. However, the study by Ramirez and colleagues underscored the complexity of managing frail patients, suggesting that neither treatment can be definitively recommended for elderly patients with AC, as both approaches are associated with high morbidity and mortality rates [23]. The study by Lu and colleagues indicated that PC had poorer prognoses, suggesting that the role of PC in the Tokyo guidelines may be overestimated. This implies that its use should be limited to elderly patients and those in critical condition [24].

Meta-analyses comparing outcomes in CC and PC patients

Overall, the meta-analyses showed that patients undergoing CC had significantly lower odds of death (OR = 0.26; 95% CI = 0.14–0.48) (Fig. 2) and readmission (OR = 0.37; 95% CI = 0.18–0.75) (Fig. 3) compared to those treated with PC. However, the majority of included studies ($n = 10$) encompassed both open and/or laparoscopic CC procedures, without distinguishing outcomes based on surgical technique. In contrast, a smaller number of studies ($n = 6$) explicitly analyzed patients treated exclusively with laparoscopic CC. In this subgroup analysis, the benefits of cholecystectomy (CC) were even more evident, with patients undergoing laparoscopic CC exhibiting significantly lower odds of death (OR = 0.17; 95% CI = 0.09–0.33) compared to those treated with percutaneous cholecystostomy (PC). Although a reduction in readmission rates was also observed (OR = 0.28; 95% CI = 0.07–1.13), this difference did not reach statistical significance.

To assess the presence of publication bias in the studies included in the present meta-analysis, funnel plots were visually inspected and Egger's test was performed. However, although Egger's test was not significant ($p = 0.655$ for mortality and $p = 0.896$ for readmission; Supplementary files 2 and 3), the funnel plots inspection did not completely rule out the presence of publication bias.

In addition, comorbidity profiles were assessed to evaluate whether baseline patient characteristics could account for differences in clinical outcomes between treatment groups. The overall meta-analysis revealed no statistically significant difference in the prevalence of comorbidities between patients undergoing CC and those treated with PC (OR = 1.41; 95% CI = 0.74–2.67; $P > 0.05$) (Supplementary File 4). Subgroup analysis focusing on studies that exclusively included laparoscopic CC confirmed these findings, showing comparable comorbidity rates between laparoscopic CC and PC patients (OR = 0.76; 95% CI = 0.26–2.23; $P > 0.05$).

Is there still a role for PC as a bridge to delayed CC?

Eleven studies have investigated the outcomes of PC followed by CC compared to CC alone (Table 2). All the included studies - published between 2004 and 2023 - employed a retrospective design, with 5 conducted in Korea, 2 in China, 1 in Japan, 1 in Turkey, 1 in Egypt, and 1 in Israel. The number of patients undergoing PC followed by CC ranged from 21 to 201, and from 44 to 627 for those who undergone CC alone. It is important to note that all included studies referred to laparoscopic CC when reporting outcomes for CC patients.

Several studies have highlighted the potential benefits of a staged approach, combining PC followed by CC, particularly in patients deemed high-risk for surgical intervention. Building on these insights, Karakayali and colleagues focused on patients with AC classified as ASA II or III, suggesting that this sequential strategy may reduce surgical risk and shorten recovery time. Specifically, their study demonstrated that patients who underwent PC followed by CC experienced fewer surgical complications and a shorter overall hospital stay compared to those treated with immediate CC alone [25]. El-Gendi and colleagues noted that both treatments were found to be highly effective in resolving sepsis induced by AC. However, the combination of PC followed by CC demonstrated better outcomes, with a lower conversion rate to open surgery and shorter overall hospital stays, highlighting its potential advantages over CC alone [26].

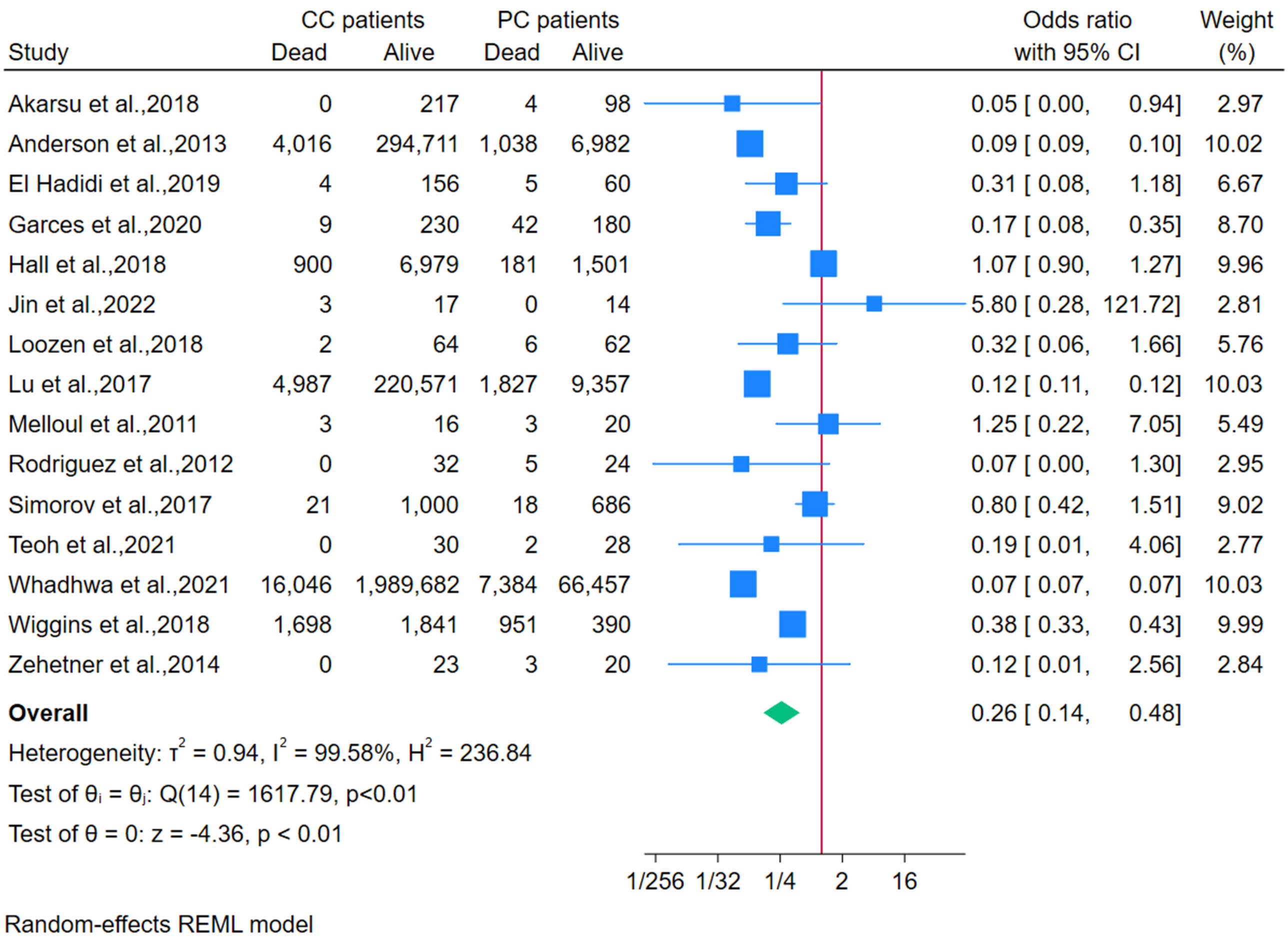

Fig. 2 Forest plot showing the proportion of deaths in PC and CC patients

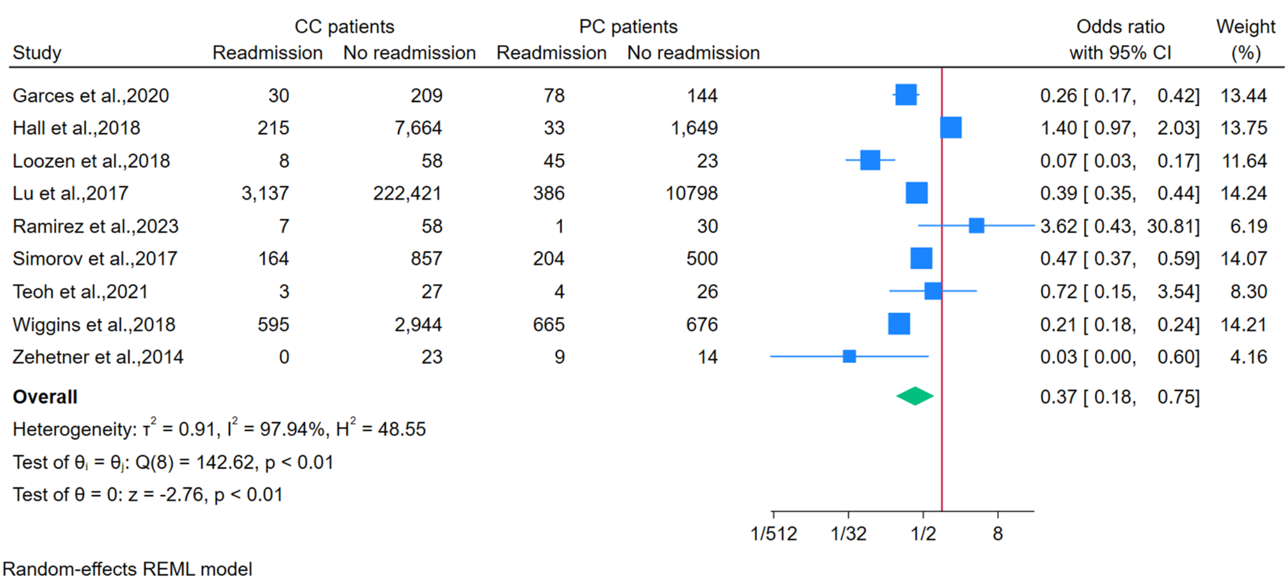

Fig. 3 Forest plot showing the proportion of readmissions in PC and CC patients

Table 2 Studies included in the systematic review comparing PC followed by CC and CC

						Age (Median in years)		Sex (n° of male patients)		Lenght of hospital stay (days)	
Study	**Country**	**Study design**	**Type of cholecystectomy (CC)**	**Patients undergoing percutaneous cholecystostomy (PC) followed by CC**	**Patients undergoing (CC)**	**CC patients**	**PC+CC patients**	**CC patients**	**PC+CC patients**	**PC patients**	**CC patients**
Oh et al.,2016	Korea	Retrospective	Laparoscopic	57	44	56.3	65.5	28	35	Mean = 11.14 (SD = 7.22)	Mean = 6.23 (SD = 5.17)
Ke et al.,2018	China	Retrospective	Laparoscopic	49	47	62	67	26	23	Mean = 11.6 (SD = 4.6)	Mean = 8.2 (SD = 3.2)
Jia et al.,2018	China	Retrospective	Laparoscopic	38	48	65.3	62.1	29	22	Mean = 13.05 (SD = 2.61)	Mean = 9.65 (SD = 2.80)
Karakayali et al.,2014	Turkey	Retrospective	Laparoscopic	43	48	NA	NA	NA	NA	Mean = 3.0 (SD = 2.4)	Mean = 5.3 (SD = 3.3)
Choi et al.,2011	Korea	Retrospective	Laparoscopic	40	63	60.4	72.5	25	NA	Mean = 20.08 (SD = 7.33)	Mean = 12.92 (SD = 5.63)
Park et al.,2022	Korea	Retrospective	Laparoscopic	21	69	55	79	27	12	NA	NA
Tsumura et al.,2004	Japan	Retrospective	Laparoscopic	60	73	55.4	64.5	47	39	Mean = 11.1 (SD = 7.1)	Mean = 11.1 (SD = 7.1)
El-Gendi et al.,2017	Egypt	Retrospective	Laparoscopic	75	75	50.2	49.6	27	30	Mean = 10.76 (SD = 5.75)	Mean = 51.71 (SD = 49.39)
Kim et al.,2018	Korea	Retrospective	Laparoscopic	131	194	52.1	65	104	77	Mean = 15.6 (SD = 10.3)	Mean = 11.0 (SD = 5.1)
Mizrahi et al.,2015	Israel	Retrospective	Laparoscopic	163	476	48	64	186	155	Mean = 4.3 (SD = 0.4)	Mean = 2.4 (SD = 0.1)
Lee et al.,2023	Korea	Retrospective	Laparoscopic	201	627	60.5	70.3	377	128	Median = 16.2 (IQR = 2–369)	Median = 10.7 (IQR = 1–739)

In a similar manner, Ke et al. reported that the group undergoing both PC and subsequent CC demonstrated improved outcomes, characterized by a reduced conversion rate and fewer ICU admissions, despite experiencing an extended length of hospital stay [27]. Jia and colleagues focused on elderly, high-risk patients with AC, suggesting that the combination of PC and CC was an effective treatment option for this group, with some patients showing even better outcomes compared to those who had cholecystectomy alone [28].

Although the combined approach of PC followed by CC shows potential benefits, several studies have emphasized its limitations. Choi et al. reported increased complication rates and longer hospital stays with delayed CC after PC, suggesting added risks compared to direct CC [29]. Likewise, Mizrahi et al. observed that this staged strategy was linked to prolonged hospitalization, more frequent surgical complications, and higher readmission rates [30].

In contrast to studies highlighting clear advantages or disadvantages of the combined approach, several investigations have reported that adding PC prior to CC offers no significant benefit compared to immediate CC alone. For instance, Oh and colleagues conducted a comparative analysis in which patients were divided into two groups: one undergoing PC followed by CC, and the other treated with CC alone. Their findings revealed no significant differences in clinical outcomes between the two groups, suggesting that while PC may be a suitable option for high-risk patients, it does not adversely affect the success or safety of subsequent cholecystectomy [31]. Lee and colleagues found that, despite more severe baseline conditions in patients undergoing both PC and CC, surgical complication rates were comparable to those treated with CC alone. They therefore recommended considering PC as a preparatory step for patients with elevated anesthetic risk [32]. Similarly, Kim and colleagues found no clear advantage to the combined approach of PC followed by CC, suggesting that this strategy should be reserved for carefully selected cases where immediate surgery is not feasible [33]. In addition, Park and colleagues assessed postoperative quality of life in patients undergoing either PC followed by CC or CC alone. Their analysis revealed no significant differences between the two groups, supporting the notion that the staged approach remains a viable option for elderly or high-risk patients when direct cholecystectomy poses excessive risk [34]. Finally, the study by Tsumarra and colleagues showed that laparoscopic CC after selective Percutaneous transhepatic gallbladder drainage (PTGBD) in high-risk AC patients shows comparable surgical outcomes and recovery to non-PTGBD cases, supporting its safety and efficacy [35].

Discussion

AC is a frequent clinical condition with considerable implications, particularly in critically ill or high-risk surgical patients. While laparoscopic CC is the gold standard for stable patients [4, 13], the optimal strategy for those with significant comorbidities remains debated. In these cases, PC is often employed as a less invasive, temporizing measure. However, its role remains controversial due to reported associations with higher complication and mortality rates, and uncertain long-term outcomes [2, 5].

Our work aimed to assess current evidence comparing outcomes in patients treated with PC, CC, and PC followed by delayed CC. All included studies predominantly evaluated high-risk patients, often classified as ASA III or IV. Across the literature, there is general agreement favoring CC over PC in terms of short-term outcomes, particularly for patients who are clinically stable. Multiple systematic reviews and meta-analyses support these findings. Markopoulos et al. reported a fivefold increase in mortality and a threefold increase in readmissions among elderly patients managed with PC compared to those undergoing CC [10]. Similarly, Huang et al. highlighted nearly threefold higher mortality and a greater incidence of recurrent biliary events in high-risk patients treated with PC [8]. Our findings further support existing literature by demonstrating that CC, and particularly laparoscopic CC, is associated with significantly lower mortality rates compared to PC. A significant reduction in readmission rates was also observed with CC overall, although this benefit was less evident in the subgroup analysis limited to laparoscopic procedures, where only a non-significant trend was noted. Regarding postoperative complications, no substantial differences emerged between CC and PC. Given the absence of significant differences in comorbidity profiles between treatment groups, these outcomes suggest that the poorer results observed with PC are likely attributable to the intrinsic limitations of the procedure itself, rather than to baseline patient characteristics. These findings reinforce the preference for early laparoscopic cholecystectomy when feasible, reserving PC for cases where surgery poses an unacceptable risk.

This recommendation is consistent with the 2020 WSES guidelines, which advocate urgent laparoscopic CC as the preferred treatment - even in high-risk patients - when technically and clinically feasible [3]. According to these guidelines, PC should be reserved for critically ill patients who are temporarily unfit for surgery, particularly in cases of sepsis or gallbladder empyema. The CHOCOLATE randomized controlled trial further validated this approach by showing significantly fewer major complications with early laparoscopic CC compared to PC in high-risk patients [15].

Despite these clear recommendations, clinical practice often includes the use of PC as a bridge to delayed CC, particularly in frail or elderly individuals [1, 16–19]. PC, introduced by Radder, is a non-surgical method for decompression of the gallbladder, often performed under local anesthesia [8]. While some view PC as a final treatment that makes follow-up CC unnecessary, this remains a topic of debate. The 2018 Tokyo guidelines suggest PC can serve as a bridge to surgery, particularly in high-risk patients [36]. Some studies suggest this staged approach can reduce surgical risk, minimize ICU admissions, and optimize patient conditions preoperatively [25, 26]. In patients with severe or moderate AC, delaying surgery may seem intuitive. However, many patients treated with PC never undergo definitive surgery, with one study reporting that only 23% proceeded to elective CC [37]. This leads to higher recurrence rates, prolonged catheter dependency, and increased risk of complications such as tube dislodgement and infection [20, 24]. Furthermore, the optimal timing of surgery following PC remains uncertain. A systematic review by Kourounis et al. found no clear advantage in performing CC within 30 days versus later, underscoring the need for further investigation [38]. In our systematic review, results from the comparison between patients undergoing immediate CC and those treated with PC followed by delayed CC are controversial. Due to the limited number of studies providing comparable quantitative data, a meta-analysis for this comparison could not be reliably performed. These findings, based on qualitative assessment, challenge the presumed advantage of a staged approach and suggest that, when early CC is clinically feasible, it should be favored over initial decompression followed by interval surgery.

The strength of our work lies in its comprehensive and up-to-date evaluation of existing studies comparing clinical outcomes of critically ill patients with AC treated with PC versus CC, as well as PC followed by CC. A key novelty of our study is the direct comparison between PC followed by CC and CC alone, which provides unique insights into the added benefits of this sequential approach. Additionally, our work is particularly valuable as it also includes a direct comparison between PC and CC within the same study, offering a more complete perspective on the effectiveness, safety, and long-term outcomes of these treatment strategies.

This study, however, presents several limitations that must be acknowledged when interpreting the results. First, the relatively small number of included studies and patients, particularly in certain subgroups, limits the generalizability of our findings and highlights the need for larger, multicenter studies to develop standardized protocols. Additionally, significant heterogeneity was observed across the studies, stemming from variations in patient selection criteria, definitions of critically ill patients, surgical techniques (both for CC and PC), and differences in postoperative management protocols. Although statistical methods were applied to account for this variability, clinical heterogeneity - driven by factors such as disease severity, comorbidity profiles, surgical expertise, and institutional practices - remains a critical element influencing outcomes. Notably, while comorbidity rates appeared similar between groups in our meta-analysis, subtle clinical differences may not have been fully captured in aggregated data. Another important limitation is the inconsistent and incomplete reporting of key clinical outcomes, such as postoperative complications and length of hospital stay. This lack of uniform data prevented us from performing meta-analyses on several clinically relevant endpoints, thereby reducing the overall strength and precision of our conclusions. Future studies should also explore subgroup analyses based on patient age, comorbidities, and disease severity to better identify which patients may benefit most from PC, CC, or a staged approach. Furthermore, the majority of the included studies were retrospective in nature and potentially subject to selection bias, as many focused on patients with high ASA scores or significant comorbidities. This selective focus restricts the applicability of our results to the broader population of patients with acute cholecystitis, particularly those with milder disease profiles. A critical gap in the available literature - and consequently in our analysis - is the absence of standardized data regarding the timing of cholecystectomy following PC. Given that the optimal interval remains a subject of ongoing debate, this omission limits guidance for clinical decision-making and underscores the need for prospective studies addressing this issue. Moreover, long-term outcomes, including recurrence rates, delayed complications, and patient-reported quality of life, were rarely and inconsistently reported. This hampers a comprehensive evaluation of the sustained effectiveness and safety of PC compared to CC. Finally, it is important to highlight that not all studies clearly distinguished between laparoscopic and open CC, which may have introduced heterogeneity into the overall analysis. Given that laparoscopic procedures are generally associated with superior postoperative outcomes compared to open surgery, this variability in surgical approach could have influenced the pooled results. To address this limitation, a subgroup analysis was performed including only studies that explicitly reported outcomes for patients treated with laparoscopic CC. This analysis confirmed and even reinforced the benefits observed in the overall population, underscoring that the advantages of CC over PC are particularly evident when minimally invasive techniques are employed.

Conclusions

In conclusion, this systematic review and meta-analysis aligns with previous evidence and confirms that CC, preferably laparoscopic, should remain the first-line treatment for AC whenever feasible, due to its association with lower mortality and readmission rates. PC remains a valuable option for critically ill patients unfit for surgery. The staged approach (PC followed by CC) does not appear to offer significant advantages over immediate CC. Clinicians should carefully evaluate patient risk profiles to tailor the most appropriate treatment strategy. Future research should focus on defining optimal timing for delayed surgery, long-term outcomes, and the role of minimally invasive techniques in high-risk populations.

Supplementary Information

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Supplementary Material 1: PRISMA 2020 Checklist

Supplementary Material 2: Funnel plot of studies comparing the proportion of deaths in PC and CC patients

Supplementary Material 3: Funnel plot of studies comparing the proportion of readmissions in PC and CC patients

Supplementary Material 4: Forest plot showing the proportion of morbidities in PC and CC patients

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Not applicable.

Author contributions
Guido Basile and Antonella Agodi contributed to the conceptualization of the study. Giuliana Favara, Andrea Maugeri, Martina Barchitta, Gabriele Fanciulli, and Guido Basile were responsible for data curation. Gabriele Fanciulli, Giuliana Favara, Andrea Maugeri, and Martina Barchitta drafted the original manuscript. All authors contributed to the review and editing of the manuscript. All authors read and approved the final version of the manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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