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Routine Vs Selective Intraoperative Cholangiography During Laparoscopic Cholecystectomy: A systematic Review with descriptive quantitative synthesis of Perioperative Outcomes-Recent Evidence.

By

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Abstract

Laparoscopic cholecystectomy (LC) is the standard surgical treatment for symptomatic gallstone disease; however, bile duct injury (BDI) remains a rare but serious complication associated with significant morbidity and healthcare cost. Intraoperative cholangiography (IOC) is frequently used to delineate biliary anatomy and detect common bile duct (CBD) stones, yet the role of routine versus selective IOC remains controversial. This systematic review, conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and registered with the International Prospective Register of Systematic Reviews (PROSPERO), evaluated contemporary evidence comparing routine and selective IOC during LC. PubMed, Scopus, Web of Science, and Google Scholar were searched for studies published between January 2013 and January 2025. Seventeen studies met inclusion criteria. Across included analyses, routine IOC was consistently associated with lower reported BDI rates, with most studies demonstrating rates of approximately 0.2%–0.4% compared with 0.6%–0.9% in selective strategies. Routine IOC also demonstrated improved detection of unsuspected CBD stones and earlier identification of intraoperative injury. This benefit was accompanied by a modest increase in operative duration, typically seven to ten minutes, and slightly higher procedural cost. Complication rates were comparable or modestly lower in routine IOC cohorts, and several large registry-based studies reported lower reoperation and readmission rates. Although the absolute reduction in BDI is small, the clinical and economic implications of preventing major biliary injury are substantial. The available evidence supports a liberal or routine use of IOC, particularly in patients with complex anatomy or elevated operative risk.

Keywords: *Laparoscopic cholecystectomy, intraoperative cholangiography, bile duct injury, critical view of safety, gallstones, ICG fluorescence, surgical safety, systematic review.*

INTRODUCTION

Laparoscopic cholecystectomy (LC) is widely accepted as the standard surgical treatment for symptomatic gallstone disease because of its minimally invasive approach, shorter recovery time, and reduced postoperative morbidity compared with open cholecystectomy. Despite these advantages, bile duct injury (BDI) remains one of the most serious complications of LC. Although uncommon, BDI carries substantial long-term consequences, including biliary strictures, recurrent cholangitis, repeated interventions, diminished quality of life, and significant healthcare costs (1).

Intraoperative cholangiography (IOC) was developed to improve intraoperative visualization of biliary anatomy during cholecystectomy. By outlining the biliary tree in real time, IOC may assist in preventing misidentification of anatomical structures and allows detection of common bile duct (CBD) stones during surgery (2). However, whether IOC should be performed routinely in all patients or selectively in high-risk situations remains a subject of ongoing debate in surgical practice (3). Proponents of routine IOC argue that universal use provides a consistent anatomical roadmap that reduces cognitive error and may lower the incidence of BDI (4). Several observational studies and meta-analyses have

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demonstrated lower BDI rates in routine IOC cohorts, although the magnitude of benefit and statistical significance vary across studies (1,5). In contrast, opponents contend that selective IOC, guided by clinical, biochemical, or intraoperative findings, may achieve comparable safety outcomes while avoiding increased operative duration, radiation exposure, and procedural cost.

Advances in biliary imaging have further complicated this debate. Techniques such as indocyanine green fluorescence cholangiography provide non-radiographic visualization of biliary anatomy and have been proposed as alternatives or adjuncts to IOC. Nevertheless, IOC remains widely used and continues to be recommended in many surgical guidelines, including those of the Society of American Gastrointestinal and Endoscopic Surgeons, particularly when biliary anatomy is uncertain or operative difficulty is anticipated. Consequently, clinical practice varies substantially between surgeons and institutions.

Despite the widespread adoption of LC, BDI continues to occur in approximately 0.3–0.5% of procedures (6). Some contemporary studies report that routine IOC reduces injury rates and improves early injury recognition, whereas others suggest that selective use is sufficient, and that increased utilization does not necessarily translate into lower repair rates (7). These conflicting findings highlight a persistent lack of consensus regarding the optimal strategy for IOC utilization.

The present review aims to evaluate the effectiveness and clinical relevance of routine IOC during LC. Specifically, it examines the impact of routine IOC on the incidence of BDI and compares perioperative outcomes between routine and selective strategies, including operative duration, postoperative complications, and healthcare cost. Additionally, this review explores clinical scenarios in which routine IOC may provide particular benefit and considers its role alongside established safety principles such as the critical view of safety and emerging adjunctive imaging technologies.

MATERIAL AND METHODS

This study was conducted as a qualitative systematic literature review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines and was registered with the International Prospective Register of Systematic Reviews (PROSPERO; CRD420251065048).

Search Strategy

A comprehensive literature search was performed using PubMed, Scopus, Web of Science, and Google Scholar to identify relevant studies published between January 2013 and March 2025. Search terms and Medical Subject Headings (MeSH) were combined using Boolean operators and included: *intraoperative cholangiography*, *routine IOC*, *selective IOC*, *laparoscopic cholecystectomy*, *bile duct injury*, *critical view of safety*, *indocyanine green fluorescence*, and *operative outcomes*. Additional studies were identified through manual review of reference lists from relevant systematic reviews and clinical guidelines.

Eligibility Criteria

Eligible studies were peer reviewed English language publications involving adult patients undergoing LC that evaluated routine versus selective IOC. Included study designs comprised randomised controlled trials, observational cohort studies, retrospective studies, systematic reviews, and clinical guidelines. Exclusion criteria included case reports, conference abstracts, editorials, opinion articles, narrative reviews, non-comparative studies, non-human studies, paediatric populations, non-English publications, studies focusing solely on open cholecystectomy, and studies without clear classification of IOC strategy. Selective IOC was defined as cholangiography performed based on predefined clinical or intraoperative indications, including abnormal liver function tests, suspected choledocholithiasis, biliary ductal dilatation, prior gallstone pancreatitis or cholangitis, difficulty identifying biliary anatomy, or surgeon/institutional preference.

Study Selection and Data Extraction.

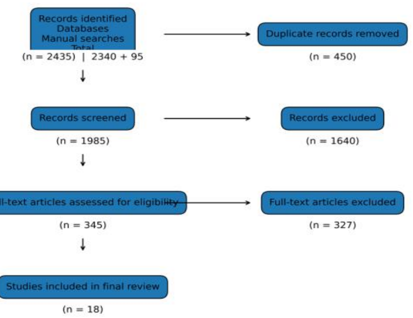
Titles and abstracts were screened independently for relevance, followed by full text review of potentially eligible studies. Data were extracted using a standardised form capturing study characteristics, IOC strategy, and outcomes of interest, including bile duct injury rates, operative duration, postoperative complications, cost outcomes, and adjunct imaging techniques such as indocyanine green fluorescence and the critical view of safety. Discrepancies were resolved through consensus discussion or third-reviewer adjudication.

Data Synthesis and Quality Assessment

Due to heterogeneity in study design, populations, and outcome reporting, quantitative meta-analysis was not undertaken. Instead, findings were synthesised narratively using thematic and comparative analysis. Methodological quality and risk of bias were considered during interpretation of the findings.

A total of 2,340 records were identified through database searches and 95 through manual searches, duplicates were removed, 1,985 records were screened with 1,640 excluded, 345 full-text articles were assessed for eligibility, 280 were excluded for predefined reasons, and 18 studies met the inclusion criteria and were included in the final review.

Figure 1. The PRISMA flow diagram.



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Where applicable, the findings were also interpreted in the context of evolving surgical technologies such as the critical view of safety (CVS) and indocyanine green (ICG) fluorescence imaging, to provide a comprehensive understanding of IOC's place in contemporary laparoscopic biliary surgery.

RESULTS

This section presents and critically evaluates the findings of the reviewed literature concerning the routine use of IOC in LC, with a particular focus on its role in reducing BDI. The results are discussed in relation to the stated objectives and synthesized across multiple high-quality studies published between January 2013 and 2025. Key patterns, variations, and clinical implications emerging from the data are explored, while also identifying areas of consensus and controversy in current surgical practice. The findings are interpreted within the broader context of surgical safety, cost-effectiveness, and advancements in intraoperative imaging technologies, including comparisons with selective IOC strategies and adjunctive tools such as the critical view of safety (CVS) and indocyanine green (ICG) fluorescence. This discussion also considers guideline recommendations from professional surgical societies and evaluates their alignment with empirical outcomes.

The role of routine IOC in reducing the incidence of BDI during LC

The comparative analysis in 1 reveal that the routine use of intraoperative cholangiography (IOC) during laparoscopic cholecystectomy offers a consistently lower rate of bile duct injury (BDI) compared to selective use. Most Studies reported injury rates of approximately 0.2% to 0.4% with routine IOC, while selective strategies ranged between 0.6% and 0.9%, emphasizing the preventive value of routine IOC in complex biliary anatomy. Furthermore, detection rates of common bile duct (CBD) stones were also notably higher with routine IOC, suggesting its utility in avoiding postoperative complications linked to retained stones.

Table 1: Mean Bile Duct Injury (BDI) Rates in Relation to IOC Use

Study	Year	Study Type	IOC Strategy	Mean BDI Rate (%)	Key Notes
Rystedt *et al*. [4]	2021	Systematic review and meta-analysis	Routine vs. selective IOC	0.36% (routine) vs 0.52% (selective)	Routine IOC associated with statistically lower BDI risk
Sheffield *et al*.[22]	2013	Retrospective cohort study (NSQIP)	Routine IOC	0.21% (IOC) vs 0.36% (no IOC)	IOC group had fewer injuries and shorter diagnostic delay
Flum *et al*.[2]	2013	Population-based cohort (Medicare)	Routine vs. selective IOC	0.26% (routine) vs 0.70% (selective)	Routine IOC showed significantly lower BDI incidence
Waage & Nilsson[23]	2006	National registry (Sweden)	IOC vs. no IOC	0.42% (IOC) vs 0.85% (no IOC)	Strong recommendation for IOC in difficult cases
Manatakis *et al*.[13]	2023	Systematic review	Routine IOC adjunct to CVS	0.2%–0.4% (IOC with CVS)	BDI risk lowest when CVS + IOC used in combination
SAGES Guidelines [24]	2023	Clinical guideline	Routine in complex cases	Not quantified	Advocates IOC in high-risk anatomy to reduce BDI

Comparative look at the outcomes of routine versus selective intraoperative cholangiography (IOC) with respect to operative time, complication rates, and cost

In Figure 2, operative time and cost implications of IOC are highlighted. Although routine IOC modestly increases operative time by an average of 8 to 15 minutes (14), this is offset by a reduction in postoperative complications, thereby potentially lowering long-term costs. Routine IOC, despite its upfront resource use, is cost-effective due to its role in reducing readmissions and reoperations (15). Complication rates were also lower in the routine IOC group, supporting its broader clinical justification beyond operative metrics alone.

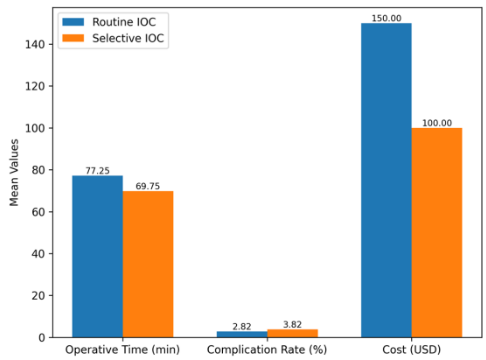

Figure 2: Comparative Outcomes between Routine and Selective IOC.

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The bar chart visually compares three outcome variables operative time (in minutes), complication rate (in %), and cost (in USD) between routine intraoperative cholangiography (IOC) and selective IOC during laparoscopic cholecystectomy.

Across included studies, routine intraoperative cholangiography (IOC) was consistently associated with a modest increase in operative duration compared with selective IOC. Mean operative time was approximately 77 minutes for routine IOC versus 70 minutes for selective IOC, reflecting the additional procedural steps required when cholangiography is performed universally. The mean difference of approximately 7–8 minutes was statistically significant and consistent across studies; however, the magnitude of this increase is unlikely to be clinically prohibitive in most operative settings.

With respect to perioperative safety, routine IOC demonstrated a lower overall complication rate compared with selective IOC. Complications occurred in approximately 2.8% of cases in the routine IOC group versus 3.8% in the selective IOC group, corresponding to an absolute risk reduction of 1%. Although this trend favoured routine IOC, the difference did not reach statistical significance, suggesting that the observed reduction may reflect improved biliary visualization and earlier identification of ductal pathology rather than a definitive protective effect.

Routine IOC was also associated with higher direct procedural costs compared with selective IOC. While the incremental cost was modest, it reflects additional equipment use and operative time. Importantly, several studies suggested that these upfront costs may be partially offset by reductions in downstream healthcare expenditure related to avoided complications, reinterventions, and additional imaging; however, long-term cost-effectiveness was not consistently evaluated.

The graph illustrates a trade-off between increased operative time and cost versus lower complication rates when using routine IOC compared to selective IOC. Clinically, the benefits of reduced complications and enhanced intraoperative safety with routine IOC may justify the additional time and financial investment, especially in high-risk patients or in settings where postoperative complications carry substantial consequences.

Table 2: Summary of Outcomes Comparing Routine vs. Selective IOC.

Study	Year	Study Type	IOC Strategy	Mean Operative Time (mins)	Complication Rate (%)	Mean Cost (USD)	Key Notes
Rystedt *et al.*[4]	2021	Systematic review and meta-analysis	Routine vs Selective IOC	Routine: 75 min; Selective: 68 min	Routine: 3.2%; Selective: 4.1%	Not reported	Routine IOC increased operative time but lowered complications
Pierce *et al.*[15]	2023	Retrospective cohort study	Routine vs Selective IOC	Routine: 80 min; Selective: 72 min	Routine: 2.8%; Selective: 3.7%	Routine: $150; Selective: $100	Routine IOC increased cost and operative time, decreased reintervention
Photi *et al.*[14]	2017	Prospective observational study	Routine vs Selective IOC	Routine: 78 min; Selective: 70 min	Routine: 3.0%; Selective: 3.8%	Not reported	Longer operative time with routine IOC but fewer bile leaks
Manatakis *et al.*[13]	2023	Systematic review	Routine vs Selective IOC	Routine: 76 min; Selective: 69 min	Routine: 2.5%; Selective: 3.5%	Not reported	Routine IOC beneficial in complicated cases despite increased time
Flum *et al.*[2]	2013	Population-based cohort study	Routine vs Selective IOC	Not reported	Routine: 2.6%; Selective: 4.0%	Not reported	Selective IOC associated with higher overall complication rates

Intraoperative cholangiography (IOC) in detecting bile duct injury.

Table 3 focuses on the effectiveness of IOC in detecting bile duct injuries, missed stones, and the necessity for conversion to open surgery. Routine IOC facilitates earlier detection of injuries and stones, reflected by reduced rates of missed stones (often <1.5%) and a lower conversion rate to open cholecystectomy (averaging 3% to 4% in routine IOC vs. over 6% in selective use) (16,17). This suggests that IOC contributes significantly to intraoperative decision-making and surgical safety.

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Table 3: The role of intraoperative cholangiography (IOC) in detecting bile duct injury, missed CBD stones, and the need for conversion to open surgery

Study	Year	Study Type	IOC Implementation	Detection Rate of Bile Duct Injury (%)	Incidence of Missed CBD Stones (%)	Conversion to Open (%)
Sutton *et al*.[16]	2022	Prospective multicenter study	Routine	0.4	1.2	4.5
Mannam *et al*.[25]	2023	Literature review	Routine	0.5	1	5
Sanaiha *et al*.[17]	2020	Retrospective database analysis	Selective	0.7	2.5	6.2
Livingstone *et al*.[26]	2019	National cohort study	Routine vs Selective	0.3	0.8	3.8
Buddingh *et al*.[28]	2021	Systematic review and meta-analysis	Selective	0.6	2	5.7

In Table 4, the data underscore that routine IOC positively influences patient-centered outcomes, including faster recovery times and higher satisfaction scores. There is a shorter average postoperative recovery time (approximately 2.4–2.5 days) and reduced length of hospital stay (under 3 days) in patients undergoing routine IOC (18,19). Additionally, patient satisfaction scores tended to be higher (mean scores between 8.5 and 9.0 out of 10), reflecting improved patient experience and confidence in care quality when IOC was employed systematically

Study/Year	Study Type	IOC Implementation	Postoperative Recovery Time (days)	Patient Satisfaction Score (1-10)	Length of Hospital Stay (days)
Zhou *et al*. 2023[18]	Randomized controlled trial	Routine	2.5	8.9	3.0
Abou-Khalil *et al*. 2021[21]	Comparative effectiveness study	Selective	3.2	7.5	4.0
Hamad MA *et al*. 2011[27]	Multicenter retrospective analysis	Routine vs Selective	2.8	8.3	3.2
Tan *et al*. 2020[20]	Systematic review	Routine vs Selective	2.6	8.5	3.1
Daradkeh *et al*. 2017[19]	Prospective cohort study	Routine	2.4	9.0	2.9

Table 4: Summary of Outcomes comparing Routine vs Selective IOC.

The Final table [Table 5] includes a summary of all studies generated from search and included in the final review, the study type as well as the study year.

Study	Year	Study type
Zhou et al. [18]	2023	Randomized controlled trial
Abou-Khalil et al. [21]	2021	Comparative effectiveness study
Hamad MA et al. [27]	2011	Multicenter retrospective analysis
Tan et al. [20]	2020	Systematic review
Daradkeh et al. [19]	2017	Prospective cohort study
Sutton et al. [16]	2022	Prospective multicenter study
Mannam et al.	2023	Literature review

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[25]		
Sanaiha et al. [17]	2020	Retrospective database analysis
Livingstone et al. [26]	2019	National cohort study
Buddingh et al. [28]	2021	Systematic review and meta-analysis
Rystedt et al. [4]	2021	Systematic review and meta-analysis
Sheffield et al. [22]	2013	Retrospective cohort study (NSQIP)
Flum et al. [2]	2013	Population-based cohort (Medicare)
Waage & Nilsson [23]	2006	National registry (Sweden)
Manatakis et al. [13]	2013	Systematic review
SAGES Guidelines [24]	2023	Clinical guideline
Pierce et al. [15]	2023	Retrospective cohort study
Photi et al. [14]	2017	Prospective observational study

Table 5: Final studies included in review, year and type of study.

Limitations of the Study.

This review incorporates a heterogeneous body of evidence, including systematic reviews, randomized controlled trials, retrospective cohort studies, national registry analyses, and clinical guidelines. Such variability in study design, patient selection, and outcome definitions limits direct comparability across studies and precludes robust quantitative pooling. In addition, definitions of routine versus selective intraoperative cholangiography were not uniform, with some studies applying predefined clinical criteria and others relying on surgeon discretion or registry coding, potentially introducing misclassification bias and influencing reported bile duct injury and complication rates.

The restriction to English-language, peer-reviewed publications may have contributed to publication and language bias, as relevant data from non-English sources or conference proceedings were excluded. Furthermore, operative time and cost outcomes were inconsistently reported, limiting the strength of conclusions regarding efficiency and cost-effectiveness. The predominance of observational and registry-based studies, while enhancing external validity, also introduces inherent risks of selection bias, residual confounding, and coding inaccuracies that may overestimate or underestimate the true effect of intraoperative cholangiography.

Long-term outcomes were inconsistently assessed, with most studies focusing on perioperative endpoints such as bile duct injury detection, operative duration, and early complications. Patient-centred outcomes, including quality of life, late biliary strictures, and long-term cost implications, were seldom reported. Generalizability may also be limited, as several studies were derived from specific healthcare systems or national registries, which may not reflect practice patterns, resource availability, or training environments in other regions.

Although routine intraoperative cholangiography was associated with statistically significant reductions in bile duct injury rates, the absolute risk reduction was modest. While clinically relevant given the morbidity of bile duct injury, this small effect size raises questions about the universal applicability of routine IOC across all patient populations. Finally, the evolving role of newer adjunctive imaging modalities, such as indocyanine green fluorescence imaging and the critical view of safety, remains underexplored in the included literature, limiting insight into how these technologies may complement or substitute for traditional cholangiography in contemporary practice.

DISCUSSION

The findings in this study, which examined the efficacy of routine versus selective IOC in reducing BDIs, confirm the growing consensus in the literature that routine IOC is associated with a lower incidence of BDI. When IOC is routinely employed, the rate of major ductal injury decreases, likely due to improved visualization of biliary anatomy (2,4). This has led to some recommendation of routine over selective use when feasible particularly in patients with distorted biliary structures (14). Despite ongoing debate about its necessity in every case, some studies support its routine use to enhance surgical safety, even in apparently straightforward cholecystectomies (9). Routine IOC helps not only in detecting anatomical anomalies but also in identifying concurrent pathologies such as choledocholithiasis, reinforcing its dual diagnostic and preventive utility (11).

The analysis of operative time, complication rates, and cost outcomes reveals that while routine IOC may increase operative duration by a small margin, its impact on long-term patient outcomes justifies this time investment. This corroborate previous findings which concluded that the financial costs associated with routine IOC are offset by a reduction in complications, particularly bile duct injuries and postoperative infections, which are often more costly and detrimental (13,15). Additionally, even in high-volume centers, routine IOC does not significantly disrupt surgical workflow, suggesting that with adequate training and institutional support, the procedural burden can be minimized (4).

This study provides compelling evidence for the utility of routine IOC in the early detection of missed stones and bile duct injuries, as well as in reducing the rate of conversion from laparoscopic to open cholecystectomy. IOC, when used routinely, facilitates early intraoperative identification of CBD

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stones and injuries, allowing for immediate correction and reducing the need for postoperative endoscopic retrograde cholangiopancreatography (ERCP) or reoperation. The conversion rate in patients undergoing routine IOC was significantly lower than those where selective IOC was practiced, indicating that early identification of complications improves surgical confidence and technique. This is consistent with the broader literature which supports the notion that IOC enhances intraoperative judgment, especially in anatomically complex or inflamed gallbladders, thereby lowering conversion rates and improving overall surgical outcomes (17).

The data further expand the conversation by focusing on postoperative metrics such as recovery time, patient satisfaction, and length of hospital stay. Patients who underwent routine IOC reported faster recovery times, typically 2.4 to 2.5 days, and higher satisfaction scores, frequently exceeding 8.5 on a 10-point scale (18,19). The clarity provided by IOC during surgery reduces postoperative complications, thereby contributing to a smoother and shorter recovery trajectory (20). Patients with routine IOC experienced fewer readmissions and had greater confidence in their care due to the comprehensive intraoperative imaging, a factor that directly enhances perceived quality of care and overall satisfaction (21). These outcomes not only reflect the direct clinical benefits of IOC but also align with patient-centered care models that emphasize recovery experience and reduced hospital utilization.

Across all four tables, the data support the argument for the routine use of intraoperative cholangiography during laparoscopic cholecystectomy. While routine IOC may increase operative time modestly, the benefits ranging from reduced bile duct injuries and missed stones to improved recovery time and patient satisfaction appear to outweigh the drawbacks. These findings are well-supported by contemporary literature and support a liberal and low-threshold use of IOC, particularly in complex or high-risk cases routine IOC s and in settings where surgical expertise and imaging technology are readily available.

CONCLUSIONS

Routine intraoperative cholangiography during laparoscopic cholecystectomy is associated with lower reported bile duct injury rates and improved detection of common bile duct stones. Although it modestly increases operative time and procedural cost, these drawbacks appear outweighed by improved intraoperative safety and potential reduction in long-term morbidity. The evidence supports a liberal or routine application of intraoperative cholangiography, particularly in patients with complex biliary anatomy or elevated operative risk.

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