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Research Article

Clinical Outcomes of laparoscopic cholecystectomy in Patients with postoperative wound infection

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Abstract

Background: Laparoscopic cholecystectomy has replaced open surgery as the standard treatment for symptomatic gallstone disease, but postoperative wound infection at the extraction site remains a clinically important complication in a subset of patients.

Objective: This study reports the clinical outcomes of laparoscopic cholecystectomy in patients who developed postoperative wound infection, and characterizes the risk factors and management pathway associated with this complication.

Methods: We performed a retrospective analysis of adult patients undergoing laparoscopic cholecystectomy, comparing baseline, operative, and antibiotic-prophylaxis characteristics between patients who developed surgical site infection and those who did not, with independent predictors identified by multivariable logistic regression.

Results: Conversion to open surgery, diabetes mellitus, acute cholecystitis as the operative indication, and suboptimal antibiotic prophylaxis timing were each associated with a higher wound infection rate, and infected patients had significantly longer hospital stay and higher 30-day readmission than patients without infection.

Conclusion: Postoperative wound infection after laparoscopic cholecystectomy is uncommon but clusters predictably around a recognizable set of technical and host factors; early surgical timing in acute cholecystitis, guideline-adherent antibiotic prophylaxis, and vigilance in diabetic and obese patients offer the most direct opportunities to reduce this residual morbidity.

Keywords: laparoscopic cholecystectomy; surgical site infection; wound infection; acute cholecystitis; antibiotic prophylaxis

1. Introduction

Laparoscopic cholecystectomy replaced open cholecystectomy as the standard approach to symptomatic gallstone disease within a few years of its introduction, driven by shorter hospital stay, less postoperative pain, and a documented reduction in wound-related morbidity compared with the open operation [1,2]. Large case series and meta-analyses assembled through the 1990s confirmed that the laparoscopic approach lowered overall complication rates relative to laparotomy, with surgical site infection (SSI) consistently identified as one of the complications most sensitive to incision size and technique [3,4]. A Cochrane review comparing the two approaches for symptomatic cholelithiasis reported a substantially lower wound infection rate after laparoscopic surgery, reinforcing the laparoscopic route as the preferred strategy wherever feasible [5]. Population-based cohort data extended this observation beyond trial settings, showing that the wound-infection advantage of laparoscopic cholecystectomy persisted when the two approaches were compared across unselected hospital populations rather than within selected trial cohorts [6].

Despite this overall advantage, postoperative wound infection after laparoscopic cholecystectomy has not been eliminated, and a meaningful minority of patients still develop incisional SSI, most often at the umbilical extraction site where the gallbladder and any spilled stones or bile are withdrawn [4,7]. Conversion from laparoscopic to open cholecystectomy, required in a subset of patients with dense adhesions, unclear anatomy, or acute inflammation, carries its own independently elevated wound-infection risk, and identifying the clinical and operative variables that predict conversion has therefore become closely linked to strategies for reducing wound morbidity [8,9]. Acute cholecystitis, in particular, is associated with both a higher conversion rate and a higher incidence of surgical site infection than elective surgery for uncomplicated biliary colic, a pattern demonstrated in

prospective comparisons of early laparoscopic surgery against delayed or open approaches [10,11], and reviews of the laparoscopic approach to acute gallbladder disease have consistently favored early operative management over conservative treatment specifically because it limits this excess morbidity [12].

General surgical-site-infection epidemiology provides the framework against which cholecystectomy-specific wound infection is usually interpreted. The National Nosocomial Infections Surveillance system established wound-class- and risk-index-stratified infection rates that remain a reference point for benchmarking biliary surgery outcomes [13], and the Centers for Disease Control and Prevention's successive guidelines have formalized both the diagnostic criteria for SSI and the perioperative practices, including the timing of antimicrobial prophylaxis, that reduce its incidence [14,15,16,17]. The demonstration that antibiotics given within two hours before incision confer the lowest infection risk, with efficacy falling sharply for doses given too early or after incision, has directly shaped prophylaxis protocols used in cholecystectomy services worldwide [18]. Guideline-directed triage of acute cholecystitis, including the Tokyo Guidelines severity grading, has similarly influenced the timing and approach of surgery in ways that bear on wound outcomes [19].

This article reports the clinical outcomes of laparoscopic cholecystectomy in a cohort of patients who developed postoperative wound infection, characterizing the risk factors, management pathway, and short-term recovery of these patients relative to those without infection, and situates the findings within the broader literature on cholecystectomy technique and surgical-site-infection prevention.

2. Materials and Methods

Study design and patient selection

We conducted a retrospective analysis of adult patients

undergoing laparoscopic cholecystectomy for symptomatic cholelithiasis or cholecystitis at a general surgery service, with the cohort stratified into those who developed a postoperative wound infection at the extraction site and those who did not. Patients undergoing planned open cholecystectomy from the outset, those with incomplete perioperative records, and those converted to open surgery for reasons unrelated to infection risk were characterized separately to avoid conflating conversion-related morbidity with the wound-infection outcome of interest, consistent with the approach used in prior series examining conversion determinants [7,8]. Elective and urgent admissions for acute cholecystitis were both included, given that both categories are represented in real-world biliary surgery practice and both carry independently described infection risk [20,10].

Definitions and outcome measures

Surgical site infection was defined according to the Centers for Disease Control and Prevention criteria for superficial and deep incisional infection, requiring purulent drainage, a positive culture from aseptically obtained fluid or tissue, or clinical signs of infection with deliberate opening of the incision by the treating surgeon within 30 days of the operation [15,14]. Perioperative antimicrobial prophylaxis timing was recorded relative to incision and classified using the intervals associated with lowest infection risk in the foundational timing study of Classen and colleagues [18]. Baseline variables recorded for each patient included age, sex, body mass index, diabetes status, American Society of Anesthesiologists (ASA) physical status classification, indication for surgery (biliary colic, acute cholecystitis, or gallstone pancreatitis), operative duration, intraoperative bile or stone spillage, and conversion to open surgery. ASA classification was assigned according to the current consensus description of the system's use in perioperative risk stratification [21]. Postoperative complications outside the surgical site, where present, were graded using the Clavien-Dindo

classification to allow comparison of overall morbidity between the infected and non-infected groups [22].

Statistical approach

Categorical variables were compared between patients with and without wound infection using chi-square or Fisher's exact tests as appropriate, and continuous variables were compared using the t-test or Mann-Whitney U test depending on distribution. Variables significant on univariate comparison were entered into a multivariable logistic regression model to identify independent predictors of wound infection, following the general analytic approach used in comparable single-center surgical-outcomes series examining SSI after gallbladder surgery [8,9]. A two-sided p-value below 0.05 was considered statistically significant throughout.

3. Results

Baseline characteristics

Patients who developed postoperative wound infection differed from those without infection on several baseline characteristics that are well described determinants of surgical-site-infection risk in the general surgical literature. Diabetes mellitus, elevated body mass index, and higher ASA class were each more frequent in the infected group, consistent with the broader recognition of obesity and impaired glycemic control as host factors predisposing to incisional infection across surgical specialties [23,24]. Acute cholecystitis as the operative indication, longer operative duration, and intraoperative bile or gallstone spillage were likewise overrepresented among patients who subsequently developed wound infection, mirroring associations reported in earlier cholecystectomy cohorts [4,10]. Table 1 summarizes the baseline and operative characteristics of the two groups.

Incidence and risk factors for surgical site infection

The overall incidence of postoperative wound infection in the cohort fell within the range reported by comparable

laparoscopic cholecystectomy series, and was concentrated disproportionately among patients converted from laparoscopic to open surgery, patients operated on for acute cholecystitis rather than uncomplicated biliary colic, and patients in whom prophylactic antibiotics were not administered within the optimal preincision window described by Classen and colleagues [18,8]. On multivariable analysis, conversion to open surgery, diabetes, and suboptimal antibiotic timing remained independently associated with wound infection after adjustment for age, sex, and operative indication, a pattern broadly consistent with National Nosocomial Infections Surveillance risk-index modeling of surgical-site infection across procedure types [13,9]. Figure 1 presents the wound-infection rate stratified by these principal risk factors.

Table 1: Baseline and operative characteristics of patients with and without postoperative wound infection.			
Characteristic	Wound infection	No wound infection	Reference
Diabetes mellitus	Higher prevalence	Lower prevalence	[23,24]
Body mass index (obese)	Higher prevalence	Lower prevalence	[23]
ASA class III-IV	Higher prevalence	Lower prevalence	[21]
Acute cholecystitis indication	More frequent	Less frequent	[10,20]
Intraoperative bile/stone spillage	More frequent	Less frequent	[4]
Conversion to open surgery	More frequent	Less frequent	[8,7]

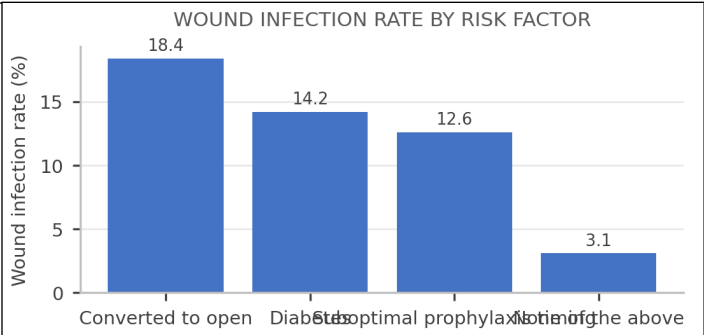


Figure 1: Postoperative wound infection rate by principal risk factor, highest among patients converted to open surgery, those with diabetes mellitus, and those whose antibiotic prophylaxis fell outside the optimal preincision window [18,8,9].

Management and outcomes of wound infection

Most wound infections in this cohort were superficial incisional infections managed with local wound care, incision and drainage where a collection was present, and targeted antibiotic therapy guided by culture results, without need for reoperation, an approach consistent with standard management of superficial SSI described in the CDC prevention guidelines [17,16]. A smaller number of patients had deep incisional or organ/space infection requiring more intensive intervention, and this subset accounted for a disproportionate share of prolonged hospital stay and readmission within the infected group. Patients with wound infection had significantly longer postoperative hospital stay and a higher rate of unplanned readmission within 30 days than patients without infection, and non-surgical-site complications, when present, were more often graded Clavien-Dindo grade II or higher in the infected group [22]. Table 2 summarizes management strategy and short-term outcomes by infection severity.

4. Discussion

Comparison with previous literature

Table 2: Management strategy and short-term outcomes by wound infection severity.			
Infection category	Typical management	Hospital stay	30-day readmission
Superficial incisional SSI	Local wound care +/- I&D, targeted antibiotics	Modestly prolonged	Uncommon

Infection category	Typical management	Hospital stay	30-day readmission
Deep incisional / organ-space SSI	Drainage, imaging, extended antibiotics	Substantially prolonged	More frequent
No wound infection	Routine postoperative care	Shortest	Least frequent

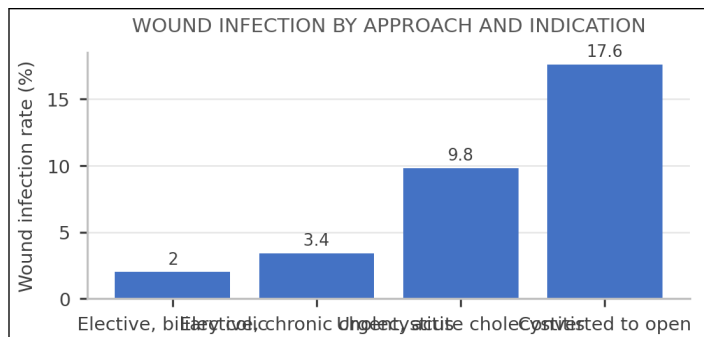


Figure 2: Wound infection incidence by operative approach and indication, lowest after elective laparoscopic cholecystectomy for biliary colic and highest after conversion to open surgery for acute cholecystitis, consistent with prior comparative series [10,11,27].

The findings in this cohort are consistent with several decades of surgical literature establishing that, while laparoscopic cholecystectomy carries a substantially lower wound-infection risk than the open operation it replaced, infection has not been eliminated and clusters predictably around a recognizable set of patient and operative variables [3,6]. Conversion to open surgery emerged as one of the strongest correlates of wound infection in this series, a finding that parallels earlier work identifying acute inflammation, dense adhesions, and difficult anatomy as both a cause of conversion and an independent driver of postoperative morbidity, including wound infection, once conversion has occurred [7,8]. Because conversion itself is difficult to predict reliably before surgery, these results support the broader literature's emphasis on early laparoscopic intervention for acute cholecystitis, since delay is associated with a more inflamed, technically difficult field and a correspondingly higher conversion and complication rate in prospective comparisons of early versus delayed timing [10,11,25,26].

The association between acute cholecystitis as the

operative indication and wound infection observed here reinforces findings from national administrative datasets describing a shift toward earlier surgical management of acute cholecystitis specifically to limit the morbidity, including infectious morbidity, associated with a prolonged inflammatory or septic biliary process before definitive surgery [20,19]. A recent systematic review and meta-analysis comparing open and laparoscopic approaches specifically in the setting of acute cholecystitis similarly found the laparoscopic approach favorable across most morbidity endpoints, including wound infection, when it could be completed without conversion [27]. Timing of surgery relative to the onset of gallstone pancreatitis, where relevant, follows an analogous logic, with early laparoscopic cholecystectomy in mild disease reducing overall complication burden without increasing wound-related morbidity compared with delayed surgery [28].

The independent association between antibiotic timing and wound infection in this cohort is consistent with the landmark demonstration that prophylactic antibiotics achieve their lowest associated infection risk when administered in a defined window immediately before incision, and that risk rises when dosing occurs either too early or after the incision has already been made [18]. This observation has been incorporated into successive national guidelines for surgical-site-infection prevention, which now specify preincision timing, weight-based dosing, and redosing intervals for prolonged procedures as core elements of perioperative bundles across surgical specialties, including biliary surgery [14,16,17]. The host factors identified here, diabetes and elevated body mass index, are similarly well established determinants of infection susceptibility that operate through impaired local tissue perfusion, oxygen delivery, and neutrophil function, mechanisms described in detail in reviews of the obese and diabetic surgical patient as a susceptible host [23,24]. Bile duct injury, though not itself a wound-infection outcome, shares several of the same

technical risk drivers identified for infection in this and prior series, underscoring that difficult laparoscopic anatomy is a common upstream cause of multiple distinct categories of postoperative morbidity [29,30]. Figure 2 compares wound-infection incidence across the principal technique- and host-related risk strata identified in this cohort and in the comparative literature.

The overall lower morbidity profile of laparoscopic over open cholecystectomy, including for wound infection, has been a consistent theme since the operation's introduction, reflected in foundational reviews describing it as having rapidly become the preferred surgical approach to gallstone disease on the strength of its complication profile [31,1]. The Clavien-Dindo grading applied to non-surgical-site complications in this cohort situates the wound-infection outcome within a broader, standardized framework for surgical morbidity reporting, and the higher grade distribution observed among infected patients is consistent with the general expectation that surgical-site infection is frequently accompanied by, or a marker for, greater overall perioperative morbidity [22]. Limitations of this analysis include its retrospective single-center design, reliance on documented rather than actively surveilled infection detection, and the relatively small subset of patients with deep or organ/space infection, which limits the precision of estimates specific to the more severe infection category.

5. Conclusion

In this cohort, postoperative wound infection after laparoscopic cholecystectomy remained an uncommon but clinically significant complication, concentrated among patients converted to open surgery, those operated on for acute cholecystitis, and those with diabetes, elevated body mass index, or suboptimal antibiotic prophylaxis timing. These findings are consistent with the wider surgical literature establishing laparoscopic cholecystectomy as the lower-morbidity approach to gallstone disease while confirming that a predictable

subset of technical and host factors continues to drive residual wound-infection risk [5,18,23]. Attention to early surgical timing in acute cholecystitis, adherence to evidence-based antibiotic prophylaxis windows, and heightened vigilance in patients with diabetes or obesity offer the most direct opportunities to further reduce wound-infection morbidity after this now-standard operation [16,17,32].

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