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Characterization of common bile duct injury after laparoscopic cholecystectomy in a high-volume hospital system

Julia F. Kohn[1,2] · Alexander Trenk[2] · Kristine Kuchta[2] · Brittany Lapin[2] · Woody Denham[2] · John G. Linn[2] · Stephen Haggerty[2] · Ray Joehl[2] · Michael B. Ujiki[2]

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Abstract

Background Despite the popularity of laparoscopic cholecystectomy, rates of common bile duct injury remain higher than previously observed in open cholecystectomy. This retrospective chart review sought to determine the prevalence of, and risk factors for, biliary injury during laparoscopic cholecystectomy within a high-volume healthcare system.

Methods 800 of approximately 3000 cases between 2009 and 2015 were randomly selected and retrospectively reviewed. A single reviewer examined all operative notes, thereby including all cases of BDI regardless of ICD code or need for a second procedure. Biliary injuries were classified per Strasberg et al. (J Am Coll Surg 180:101–125, 1995). Logistic regression models were utilized to identify univariable and multivariable predictors of biliary injuries.

Results 31.0% of charts stated that the Critical View of Safety was obtained, and 12.4% of charts correctly described the critical view in detail. Three patients (0.4%) had a cystic duct leak, and 4 (0.5%) had a common bile duct injury. Of the four CBDI, three patients had a partial transection of the CBD and one had a partial stricture. Patients who suffered BDI were more likely to have had lower hemoglobin, urgent surgery, choledocholithiasis, or acutely inflamed gallbladder. Multivariable analysis of BDI risk factors showed higher preoperative hemoglobin to be independently protective against CBDI. Acutely inflamed gallbladder and choledocholithiasis were independently predictive of CBDI.

Conclusions The rate of CBDI in this study was 0.5%. Acutely inflamed conditions were risk factors for biliary injury. Multivariable analysis suggests a protective effect of higher preoperative hemoglobin. There was no correlation of CVS with prevention of biliary injury, although only 12.4% of charts could be verified as following the technique correctly. Better implementation of CVS, and increased caution in patients with perioperative inflammatory signs, may be important for preventing bile duct injury. Additionally, counseling patients with acute inflammation on increased risk is important.

Keywords Laparoscopic cholecystectomy · Common bile duct injury · Critical View of Safety · Complications

Laparoscopic cholecystectomy (LC) is one of the most common surgeries in the United States, with over 700,000 performed per year [1]. LC was popularized in the 1980s after the advent of laparoscopy and quickly became the standard of care for symptomatic cholelithiasis. However, the rapid adoption of this procedure precluded detailed research into the technique at the time, and no level 1 studies were ever conducted to validate the overall safety of LC. More recently, a systematic review of laparoscopic versus open cholecystectomy found no difference in morbidity or mortality, but the authors were unable to find and include low-bias trials from the literature [2]. However, there have been many studies that expand the indications

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✉ Julia F. Kohn
Kohn3@uic.edu

1 University of Illinois at Chicago College of Medicine, Chicago, IL, USA

2 Department of Surgery, Section of Minimally Invasive Surgery, NorthShore University HealthSystem, Evanston, IL, USA

for LC. Systematic reviews examining the safety of LC in various circumstances, including acute cholecystitis, gallstone pancreatitis, and biliary colic, have encountered significant bias in many included studies [3–5].

Despite the popularity and wide use of laparoscopic cholecystectomy, the rate of serious complications with LC remains higher than seen with open cholecystectomy. One of the most serious intraoperative complications is common bile duct injury (CBDI), treatment of which may require additional procedures ranging from ERCP to surgical reconstruction and even liver transplantation. Previously, a 0.1–0.25% rate of CBDI was cited for open surgery [6, 7]; however, the rate of CBDI is generally acknowledged to be higher in LC. Various sources cite different rates of bile duct injury in LC, ranging from 0.3% [8, 9] to as high as 2.6% using NSQIP data [10]. In response to the increased rate of CBDI, Strasberg et al. introduced the Critical View of Safety in 1995, a technique designed to minimize the risk of injury to the extrahepatic bile ducts by identifying all structures within the triangle of Calot and that enter the gallbladder before dividing any [11]. This approach has three components: the triangle of Calot (bordered by the cystic duct, common hepatic duct, and inferior liver edge) is cleared, the lower third of the gallbladder is separated from the liver, and only two structures are seen entering the gallbladder. The common bile duct does not need to be exposed to achieve a Critical View, which could prevent injuries incurred while dissecting this structure. This technique has been widely disseminated, and the Society of Gastrointestinal and Endoscopic Surgeons (SAGES) Safe Cholecystectomy Task Force Program has encouraged more consistent implementation to improve the safety of LC (https://www.sages.org/safe-cholecystectomy-program/). However, the rate of CBDI during LC has not fallen to OC levels.

Common bile duct injury remains overall rare, though the true rate of CBDI after LC is difficult to determine. Definitions of bile duct injury vary within the literature, and study design has hindered the identification of risk factors for biliary injury. Many single-center series are too small to discover biliary injuries, given the low rate of occurrence; these studies often lack sufficient power to analyze complications. Larger cohorts studied by aggregating cases from ICD codes or examining cases referred to tertiary hepatobiliary centers may miss injuries that were repaired intraoperatively or not documented separately within the medical record.

NorthShore University HealthSystem consists of four teaching hospitals affiliated with the University of Chicago, and has a robust minimally invasive surgery practice, with an estimated 500–600 cholecystectomies performed per year and a mature electronic medical record dating to the year 2000. Our study sought to determine the prevalence of, and risk factors for, common bile duct injury during laparoscopic cholecystectomy at this four-hospital institution.

Materials and methods

This study was reported based on recommendations of the STROBE statement for reporting observational studies [12]. After institutional review board approval, 800 of approximately 3000 cholecystectomy cases performed at NorthShore between 2009 and 2015 were randomly selected. The electronic medical record was retrospectively reviewed to complete a database consisting of preoperative, intraoperative, and postoperative data. A data dictionary was created to ensure consistent data collection, and chart review strategies were designed to minimize missing data; any missing data were excluded from analysis. A single reviewer examined all operative notes, thereby including all cases of biliary injury regardless of severity, ICD code, or need for a second procedure.

Continuous variables were recorded as-is in the database and were not categorized. Cases where the gallbladder was removed only as part of a partial hepatectomy, with no history of gallbladder pathology, were excluded from the database. Intraoperative choledocholithiasis was determined by any intraoperative cholangiography or postop diagnosis of choledocholithiasis by the surgeon. Bile duct injuries were assigned a Strasberg class according to published standards [11] (Table 1). Intentional openings to the common bile duct, e.g., for laparoscopic common bile duct exploration, were not counted as biliary injuries and were analyzed as part of the no-injury cohort [11]. The Critical View of Safety was defined as per Strasberg [11, 13] and the SAGES Safe Cholecystectomy Task Force Program: (1) the triangle of Calot is fully cleared, (2) the lower third of the gallbladder is separated to expose the liver bed, and (3) only two structures are seen entering the gallbladder, with the liver bed visible, before any structure is divided. Operative reports where the surgeon chose and described a different method of dissection (e.g., fundus-first) or the surgery was converted to open before dissecting the triangle of Calot were recorded separately.

Differences in patient demographics, preoperative, and surgical characteristics were compared using non-parametric methods for small sample size (Fisher's Exact test or the Wilcoxon Rank-Sum test). Logistic regression analysis was utilized to identify predictors of biliary injury. Factors with $p < 0.10$ on univariable analysis were entered into a multivariable logistic model. Either pathology or surgeon diagnosis of a disease was entered into the multivariable model, due to colinearity. Patients with missing data were excluded from logistic regression analysis. All

Table 1 Strasberg classification of biliary injury

Strasberg injury class[a]	Description of injury
A	Bile leak from a minor duct still in continuity with the common bile duct, including cystic duct or from liver bed
B	Occlusion of part of biliary tree
C	Bile leak from duct not in communication with common bile duct (complete transection)
D	Partial transection of extrahepatic bile ducts, including R or L hepatic duct
E: circumferential injury of major bile ducts (Bismuth class 1–5)	
E1	CBD or low common hepatic duct, greater than 2 cm distal to hepatic duct confluence
E2	Proximal common hepatic duct, less than 2 cm distal to hepatic duct confluence
E3	Hilar injury; no intact common hepatic duct
E4	Destruction of hepatic duct confluence such that R and L ducts are separated
E5	Involves a divided aberrant right sectoral hepatic duct, with or without common hepatic duct injury

[a] Adapted from Ref. [11]

statistical analysis was performed using SAS 9.3 (SAS Institute, Cary, NC). Statistical significance was defined as a p value <0.05.

Results

All 800 cases in the database were confirmed as eligible and included in this analysis. Of these 800 cases, cholangiography was performed selectively and attending surgeons were present in OR for critical parts of every case.

Seven patients (0.9%) had a biliary injury discovered intra- or postoperatively (Tables 2, 3). Three patients (0.4%) had a cystic duct stump leak, and four had an injury to the common bile duct (0.5%). Two patients had two unique biliary complications; in total, there were four Strasberg class A injuries, four class D injuries, and one class E2 injury. Only three of these cases were completed laparoscopically, and the remainder were converted to open procedures. No patient required surgical re-intervention or referral to an outside hospital for further care. The Critical View of Safety was stated to be obtained in 31.0% of charts; however, only 12.4% of charts described the critical view in detail consistent with the definitions by Strasberg and SAGES, and 12.0% both stated and described CVS correctly.

There were no statistically significant differences ($p \leq 0.05$) on demographic data or preoperative workup, except for lower hemoglobin in biliary injury patients (Table 4). Patients with biliary injuries were more likely to have had urgent surgery rather than elective, and the surgeon was more likely to choose a non-CVS dissection technique or convert the procedure to open. Biliary injury patients were significantly more likely to have acute

Table 2 Preoperative characteristics of patients with biliary injury

ID	Preop Hgb (g/dL)	Urgent surgery	Pathology diagnosis	Surgeon diagnosis	
				Preoperative	Postoperative
109	13.0	Yes	Acute cholecystitis, gangrenous necrosis, cholelithiasis	Cholelithiasis, acute cholecystitis with obstruction	Empyema
120	8.4	No	Chronic cholecystitis	Choledocholithiasis	Choledocholithiasis
129	12.0	Yes	Acute and chronic cholecystitis, cholelithiasis	Acute cholecystitis with gallstones	Acute cholecystitis with gallstones
242	11.3	No	Chronic cholecystitis, cholelithiasis	Chronic cholecystitis with dilated CHD	Chronic cholecystitis with dilated CHD and intraoperative BDI
243	12.5	Yes	Acute hemorrhagic cholecystitis, necrosis	Acute cholecystitis	Cholecystitis with gangrene; intraoperative BDI
416	13.1	Yes	Acute cholecystitis, necrosis, cholelithiasis	Acute cholecystitis	Acute cholecystitis, gangrene
798	13.9	Yes	Acute and chronic cholecystitis, cholelithiasis	Choledocholithiasis and acute cholecystitis	Choledocholithiasis and Mirizzi syndrome

Hgb hemoglobin, *CHD* common hepatic duct, *BDI* bile duct injury

Table 3 Perioperative characteristics of patients with biliary injury

ID	Urgent surgery	CVS stated	CVS description	Converted to open	BDI class	Repaired
109	Yes	Yes	Not consistent with Strasberg and SAGES Safe Cholecystectomy Program criteria—documentation states the cystic duct was divided before the cystic artery was revealed, and there was no discussion of liver bed	No	A and E2	ERCP and stent
120	No	Yes	Consistent with Strasberg and SAGES Safe Cholecystectomy Program criteria	No	A	ERCP and stent
129	Yes	N/a	N/a (BDI created after converting to open)	Yes	D	Oversewn
242	No	N/a	N/a (BDI created when trying to dissect window of safety; converted to open)	Yes	D	T-tube placement
243	Yes	N/a	N/a (different dissection technique chosen; BDI created after converting to open)	Yes	D and D	T-tube placement
416	Yes	No	N/a (different dissection method chosen)	No	A	ERCP and stent
798	Yes	N/a	N/a (cystic duct and artery could not be seen; converted to open)	Yes	A	Drain monitored

inflammatory conditions (acute cholecystitis, gangrene, necrosis, suppurative cholecystitis, or empyema), by both surgeon and pathologic diagnosis, and there were significantly lower rates of chronic cholecystitis in biliary injury patients per pathology. There were no significant differences in whether the Critical View of Safety was stated or described correctly.

Univariable analysis of risk factors for BDI (Table 5) identified risk factors for biliary injury ($p \leq 0.05$) to be higher ASA class; urgent surgery; preoperative diagnosis of acute cholecystitis; postoperative diagnosis of acute cholecystitis per pathology, gangrene/necrosis per pathology and surgeon; suppurative cholecystitis/gallbladder empyema per surgeon; and intraoperative choledocholithiasis. Converting to open, a longer operative time, and a different dissection method were also significantly associated with cases where biliary injury occurred. Protective factors included higher preoperative hemoglobin and a postoperative diagnosis of chronic cholecystitis by pathology.

Multivariable analysis (Table 6) demonstrated that higher preoperative hemoglobin was independently protective of BDI (OR 0.64, $p = 0.0065$). Converting to open, choledocholithiasis documented intraoperatively, a diagnosis of acute cholecystitis by pathology, or a postoperative diagnosis of gangrene or necrosis by the surgeon were also independently predictive of biliary injury.

Discussion

The rate of biliary injury in this study was 0.9%, with a 0.5% rate of common bile duct injury. Nearly all of the patients with biliary injury in this study had Class A (cystic duct leak) and Class D (partial common bile duct transection) injuries, and all were repaired within the institution; these are less likely to be identified by larger BDI studies. Longer operative duration and increased conversion to open were expected to be predictive of biliary injury, as all major biliary injuries in this study were discovered and repaired intraoperatively. In this study, choledocholithiasis was independently predictive of biliary injury, in keeping with previous studies [14].

Acute inflammation and a need for urgent surgery were independently predictive of biliary injury during LC. This seems to contradict findings from the Cochrane review of early LC for acute cholecystitis [3], which found no increase in BDI for patients having acute surgery for acute cholecystitis; however, the review also found high levels of bias in the studies used. Despite the increase in risk found by this study, it may remain more appropriate to perform surgery for acute cholecystitis urgently, given an increased risk of perioperative complications in patients who are treated with antibiotics and later undergo interval surgery [15–18].

Higher preoperative hemoglobin was independently protective of BDI based on multivariable analysis. Given that both groups of patients have close to normal-range hemoglobin (12.0 in BDI, 13.4 in no BDI), this may not be specifically related to preoperative anemia, but rather may function as another indication of increased preoperative inflammation that may increase risk for BDI. Although preoperative anemia has not been well documented as a contributing factor to laparoscopic cholecystectomy complications [19], it has been associated with an increased postoperative complications in other surgical specialties [20–23]; further examination of LC outcomes for patients with anemia may be warranted. Caution in interpreting this result is necessary, given the few data points in the biliary injury group.

There was no correlation of Critical View of Safety with prevention of biliary injury, although only 31.0% of charts

Table 4 Differences between patients with BDI/cystic duct leak versus those without

	Biliary complication		No complication		*p* value
	N	%	*N*	%	
Total # of patients	7	0.9	793	99.1	
Male sex	2	28.6	206	26.0	0.8762
Tobacco use					
Never	4	57.1	463	58.4	
Former	3	42.9	254	32.0	0.6294
Current	0	0.0	76	9.6	
BMI ($n = 798$), mean ± SD	31.0	10.0	30.2	7.1	0.8549
BMI group ($n = 798$)					
<30	5	71.4	434	54.7	0.6626
30–34.9	1	14.3	187	23.6	
35–39.9	0	0.0	102	12.9	
≥40	1	14.3	68	8.6	
ASA class, mean ± SD	2.7	1.1	2.1	0.6	0.0708
Previous abdominal surgery	0	0.0	62	7.8	0.4412
Previous ERCP	2	28.6	88	11.1	0.1810
Percutaneous cholecystostomy	1	14.3	28	3.5	0.2285
Preoperative hemoglobin ($n = 787$), mean ± SD	**12.0**	**1.8**	**13.4**	**1.6**	**0.0374**
Urgent surgery	**5**	**71.4**	**226**	**28.5**	**0.0444**
Surgeon					0.5333
Critical view described correctly	1	14.3	98	12.4	0.6048
Critical view described incorrectly					
Insufficiently detailed	**0**	**0.0**	**515**	**64.9**	
Detailed but wrong	**1**	**14.3**	**145**	**18.3**	**<0.0001**
Different dissection method chosen	**5**	**71.4**	**35**	**4.4**	
Critical view stated and described correctly	1	14.3	95	12.0	0.3267
Convert to open	**4**	**57.1**	**15**	**1.9**	**<0.0001**
Operative time (min) ($n = 780$), median, IQR	**92**	**56–262**	**49**	**36–70**	**0.0064**
Preoperative surgeon diagnosis					
Acute cholecystitis	**5**	**71.4**	**173**	**21.8**	**0.0017**
Gangrene, necrosis	0	0.0	1	0.1	0.9251
Suppurative cholecystitis, empyema	0	0.0	2	0.3	0.8942
Postoperative surgeon diagnosis					
Acute cholecystitis	2	28.6	183	23.1	0.7314
Gangrene, necrosis	**2**	**28.6**	**19**	**2.4**	**<0.0001**
Suppurative cholecystitis, empyema	**1**	**14.3**	**6**	**0.8**	**0.0001**
Intraoperative choledocholithiasis	2	28.6	54	6.8	0.0805
Pathology diagnosis					
Chronic cholecystitis	**2**	**28.6**	**620**	**78.2**	**0.0017**
Acute cholecystitis	**3**	**42.9**	**37**	**4.7**	**<0.0001**
Necrosis, gangrene, ulceration	**3**	**42.9**	**28**	**3.5**	**<0.0001**

Statistically significant values are in bold

ASA American Society of Anesthesiologists, *SD* standard deviation, *IQR* interquartile range

stated it had been obtained, and only 12.0% of charts both stated that CVS had been obtained and described it correctly. This low rate of documentation suggests that this technique is not universally used at NorthShore. Of the operative notes where CVS was stated as obtained, 13.9% were too brief to determine precisely how the dissection had occurred, and 5.0% of charts where CVS was stated had inaccurate descriptions, mainly relating to dividing the cystic artery prior to identification of the cystic duct or dissecting the cystic duct—common bile duct junction.

Table 5 Univariable logistic regression model for predicting biliary injury

	Odds ratio	95% confidence interval		*p* value
Male sex	1.29	0.29	5.83	0.7379
Tobacco use				
Never (reference)				
Former	1.42	0.35	5.79	0.6278
Current	0.67	0.03	12.85	0.7926
BMI (continuous)	1.02	0.94	1.12	0.5975
BMI group (categorical)				
30–34.9 vs. <30	0.63	0.10	3.89	0.6208
35–39.9 vs. <30	0.39	0.02	7.12	0.5217
≥40 vs. <30	1.73	0.28	10.83	0.5581
ASA class	**3.76**	**1.36**	**10.43**	**0.0109**
Previous abdominal surgery	0.78	0.04	14.13	0.8666
Previous ERCP	3.62	0.79	16.52	0.0963
Percutaneous cholecystostomy	6.20	0.98	39.02	0.0520
Preoperative hemoglobin	**0.68**	**0.50**	**0.91**	**0.0099**
Urgent surgery	**5.50**	**1.22**	**24.78**	**0.0264**
Surgeon				0.4616
Critical view described correctly	6.70	0.69	65.52	0.1018
Critical view described incorrectly				
Insufficiently detailed	0.06	0.00	1.59	0.0931
Detailed but wrong	0.68	0.07	6.67	0.7382
Different dissection method chosen	**10.17**	**1.59**	**65.24**	**0.0144**
Critical view stated and described correctly	4.28	0.55	32.97	0.1633
Convert to open	**63.91**	**14.20**	**287.72**	**<0.0001**
Operative time	**1.01**	**1.01**	**1.02**	**0.0001**
Preoperative surgeon diagnosis				
Acute cholecystitis	**7.87**	**1.74**	**35.50**	**0.0073**
Gangrene, necrosis	35.56	0.37	256.75	0.1258
Suppurative cholecystitis, empyema	21.12	0.48	931.88	0.1144
Postoperative surgeon diagnosis				
Acute cholecystitis	1.51	0.34	6.83	0.5907
Gangrene, necrosis	**18.05**	**3.69**	**88.31**	**0.0004**
Suppurative cholecystitis, empyema	**27.95**	**3.60**	**216.96**	**0.0014**
Intraoperative choledocholithiasis	**6.17**	**1.34**	**28.48**	**0.0198**
Pathology diagnosis				
Chronic cholecystitis	**0.13**	**0.03**	**0.57**	**0.0073**
Acute cholecystitis	**15.69**	**3.70**	**66.59**	**0.0002**
Necrosis, gangrene, ulceration	**15.26**	**3.60**	**64.70**	**0.0002**

Statistically significant values are in bold

Although the Critical View of Safety should be effective in reducing bile duct injuries, rates of CBD injury have not fallen in countries where CVS is now mandatory during laparoscopic cholecystectomy [24]. However, it is also important to note that the utility of the Critical View is to prevent injury due to misidentification of structures, and is probably less likely to prevent class A injuries (cystic duct stump leaks).

The number of charts with dissections not consistent with CVS suggests two possibilities: either surgical documentation does not reflect actual technique in the OR or some surgeons may be aware of the Critical View of Safety but lack complete understanding of its requirements. Programs such as the Safe Cholecystectomy Task Force may be helpful in increasing surgeon awareness of proper CVS technique. Moreover, photographic or video documentation of the Critical View intraoperatively has been shown to be feasible [24, 25]; these additional methods of recording the Critical View intraoperatively would improve documentation, and could also assist with

Table 6 Multivariable logistic regression model for predicting biliary injury, $N = 765$

	Odds ratio	95% confidence interval		p value
ASA class	1.65	0.61	4.49	0.3254
Previous ERCP	1.98	0.37	10.76	0.4272
Percutaneous cholecystostomy	0.73	0.06	9.20	0.8095
Preoperative hemoglobin	**0.63**	**0.45**	**0.89**	**0.0074**
Urgent surgery	3.09	0.70	13.71	0.1378
Surgeon				0.8466
Critical view described incorrectly				
Correctly (reference)				
Insufficiently detailed	0.10	0.00	2.81	0.1764
Detailed but wrong	1.63	0.09	30.53	0.7443
Different dissection method chosen	4.47	0.26	76.32	0.3009
Convert to open	**72.53**	**3.36**	**420.91**	**0.0063**
Operative time	0.99	0.97	1.01	0.2008
Pathology diagnosis				
Chronic cholecystitis	4.67	0.52	42.09	0.1699
Acute cholecystitis	**17.16**	**1.40**	**210.86**	**0.0264**
Postoperative surgeon diagnosis				
Gangrene, necrosis	**19.62**	**1.08**	**357.11**	**0.0443**
Suppurative cholecystitis, empyema	12.24	0.71	212.22	0.0853
Intraoperative choledocholithiasis	**6.63**	**1.05**	**41.78**	**0.0439**

Statistically significant values are in bold

continuing education for surgeons and residents. With consistently improved operative technique and documentation, it would be valuable to see if consistent application of the Critical View actually reduces common bile duct injury.

The limitations of this study included reduced statistical power, given the rarity of biliary injuries; the data will be stronger with eventual completion of the 3000-patient database when resources permit. Moreover, known risk factors for biliary injury could not be analyzed due to the retrospective nature of this study. Due to the format of operative documentation, we could not analyze the impact on biliary injury of surgical residents, who were actively supervised by attending surgeons in all cases, or the role of operating room equipment malfunction on biliary injury. Despite these limitations, this study may yield a greater biliary injury rate and greater detail of injuries than a large national administrative database review, potentially providing a better understanding of biliary injury causes during LC.

In conclusion, our findings suggest that acute inflammation remains a risk factor for biliary injury during laparoscopic cholecystectomy. Better implementation of the Critical View of Safety, and increased caution in dissecting acutely inflamed tissues, may be in order to prevent even minor biliary injuries. Patients must also be appropriately informed on the risks of laparoscopic cholecystectomy for acute cholecystitis.

Compliance with ethical standards

Disclosures Julia Kohn, Dr. Trenk, Kristine Kuchta, Dr. Lapin, Dr. Denham, Dr. Linn, Dr. Joehl, and Dr. Ujiki have no conflicts of interest or financial ties to disclose. Dr. Haggerty reports personal fees from Medtronic and personal fees from Gore outside the submitted work.

References

1. McKinley SK, Brunt LM, Schwaitzberg SD (2014) Prevention of bile duct injury: the case for incorporating educational theories of expertise. Surg Endosc 28:3385–3391. doi:10.1007/s00464-014-3605-8
2. Keus F, de Jong J, Gooszen H, Laarhoven C (2006) Laparoscopic versus open cholecystectomy for patients with symptomatic cholecystolithiasis. Cochrane Database Syst Rev. doi:10.1002/14651858.CD006231
3. Gurusamy KS, Davidson C, Gluud C, Davidson BR (2013) Early versus delayed laparoscopic cholecystectomy for people with acute cholecystitis. Cochrane Database Syst Rev. doi:10.1002/14651858.CD005440.pub3
4. Gurusamy KS, Koti R, Fusai G, Davidson BR (2013) Early versus delayed laparoscopic cholecystectomy for uncomplicated biliary colic. Cochrane Database Syst Rev. doi:10.1002/14651858.CD007196.pub3
5. Gurusamy KS, Nagendran M, Davidson BR (2013) Early versus delayed laparoscopic cholecystectomy for acute gallstone pancreatitis. Cochrane Database Syst Rev. doi:10.1002/14651858.CD010326.pub2
6. Chuang KI, Corley D, Postlethwaite DA, Merchant M, Harris HW (2012) Does increased experience with laparoscopic

cholecystectomy yield more complex bile duct injuries? Am J Surg 203:480–487. doi:10.1016/j.amjsurg.2011.08.018

7. MacFadyen BV, Vecchio R, Ricardo A, Mathis C (1998) Bile duct injury after laparoscopic cholecystectomy: the United States experience. Surg Endosc 12:315–321
8. Yamashita Y, Kimura T, Matsumoto S (2010) A safe laparoscopic cholecystectomy depends upon the establishment of a critical view of safety. Surg Today 40:507–513. doi:10.1007/s00595-009-4218-z
9. (2014) The sages safe cholecystectomy program. http://www.sages.org/safe-cholecystectomy-program/
10. Aziz H, Pandit V, Joseph B, Jie T, Ong E (2015) Age and obesity are independent predictors of bile duct injuries in patients undergoing laparoscopic cholecystectomy. World J Surg 39:1804–1808. doi:10.1007/s00268-015-3010-z
11. Strasberg SM, Hertl M, Soper NJ (1995) An analysis of the problem of biliary injury during laparoscopic cholecystectomy. J Am Coll Surg 180:101–125
12. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP (2014) The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Int J Surg 12:1495–1499. doi:10.1016/j.ijsu.2014.07.013
13. Strasberg SM, Brunt LM (2010) Rationale and use of the critical view of safety in laparoscopic cholecystectomy. J Am Coll Surg 211:132–138. doi:10.1016/j.jamcollsurg.2010.02.053
14. Chinnery GE, Krige JEJ, Bornman PC, Bernon MM, Al-Harethi S, Hofmeyr S, Banderker MA, Burmeister S, Thomson SR (2013) Endoscopic management of bile leaks after laparoscopic cholecystectomy. South African J Surg 51:116–121. doi:10.7196/sajs.1829
15. Wu X-D, Tian X, Liu M-M, Wu L, Zhao S, Zhao L (2015) Meta-analysis comparing early versus delayed laparoscopic cholecystectomy for acute cholecystitis. Br J Surg 102:1302–1313. doi:10.1002/bjs.9886
16. Banz V, Gsponer T, Candinas D, Güller U (2011) Population-based analysis of 4113 patients with acute cholecystitis: defining the optimal time-point for laparoscopic cholecystectomy. Ann Surg 254:964–970. doi:10.1097/SLA.0b013e318228d31c
17. Gutt CN, Encke J, Köninger J, Harnoss J-C, Weigand K, Kipfmüller K, Schunter O, Götze T, Golling MT, Menges M, Klar E, Feilhauer K, Zoller WG, Ridwelski K, Ackmann S, Baron A, Schön MR, Seitz HK, Daniel D, Stremmel W, Büchler MW (2013) Acute cholecystitis: early versus delayed cholecystectomy, a multicenter randomized trial. Ann Surg 258:385–393. doi:10.1097/SLA.0b013e3182a1599b
18. de Mestral C, Rotstein OD, Laupacis A, Hoch JS, Zagorski B, Alali AS, Nathens AB (2014) Comparative operative outcomes of early and delayed cholecystectomy for acute cholecystitis: a population-based propensity score analysis. Ann Surg 259:10–15. doi:10.1097/SLA.0b013e3182a5cf36
19. Mihaileanu F, Zaharie F, Mocan L, Iancu C, Vlad L (2012) Management of bile duct injuries secondary to laparoscopic and open cholecystectomy. The experience of a single surgical department. Chirurgia (Bucur) 107:454–460
20. Musallam KM, Tamim HM, Richards T, Spahn DR, Rosendaal FR, Habbal A, Khreiss M, Dahdaleh FS, Khavandi K, Sfeir PM, Soweid A, Hoballah JJ, Taher AT, Jamali FR (2011) Preoperative anaemia and postoperative outcomes in non-cardiac surgery: a retrospective cohort study. Lancet 378:1396–1407. doi:10.1016/S0140-6736(11)61381-0
21. Kim YW, Kim IY (2016) Factors associated with postoperative complications and 1-year mortality after surgery for colorectal cancer in octogenarians and nonagenarians. Clin Interv Aging 11:689–697
22. White MC, Longstaff L, Lai PS (2017) Effect of pre-operative anaemia on post-operative complications in low-resource settings. World J Surg 41:644–649. doi:10.1007/s00268-016-3785-6
23. Tohme S, Varley PR, Landsittel DP, Chidi AP, Tsung A (2016) Preoperative anemia and postoperative outcomes after hepatectomy. HPB 18:255–261. doi:10.1016/j.hpb.2015.09.002
24. Sanford DE, Strasberg SM (2014) A simple effective method for generation of a permanent record of the critical view of safety during laparoscopic cholecystectomy by intraoperative “doublet” photography. J Am Coll Surg 218:170–178. doi:10.1016/j.jamcollsurg.2013.11.003
25. Nijssen MAJ, Schreinemakers JMJ, Meyer Z, Van Der Schelling GP, Crolla RMPH, Rijken AM (2015) Complications after laparoscopic cholecystectomy: a video evaluation study of whether the critical view of safety was reached. World J Surg 39:1798–1803. doi:10.1007/s00268-015-2993-9