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Adverse outcomes and short-term cost implications of bile duct injury during cholecystectomy

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Abstract

Background Bile duct injury (BDI) is an uncommon but major complication of cholecystectomy that has a poorly defined magnitude of effect on hospital costs. This study sought to calculate the healthcare costs, length of stay, and discharge status associated with bile duct injury in patients undergoing cholecystectomy in the United States.

Methods The Premier Healthcare Database, which comprises hospital-billing records from over 700 hospitals in the United States, was queried for all patients undergoing cholecystectomy between January 2010 and March 2018. BDI was defined by ICD-9-CM and ICD-10-CM codes. Patient demographics, clinical characteristics, and operative information were extracted. Hospital costs, length of stay, and discharge status were compared between BDI and non-BDI patients. Propensity score matching was used to minimize confounding factors. Multivariable regression models were used to estimate the association between BDI and the outcomes variables.

Results A total of 1,168,288 cholecystectomies were identified. BDI occurred in 878 patients (0.08%). Laparoscopy was the most common approach (> 95%). The majority of BDI occurred during inpatient admissions (71.0%). BDI patients had higher index admission hospital costs ($18,771 vs. $12,345, $p < 0.0001$), increased rate of discharge to an institutional post-acute care facility (odds ratio 3.89, 95% CI 2.92–5.19, $p < 0.0001$), and increased risk of readmission within 30 days after discharge (odds ratio 1.86, 95% CI 1.52–2.28, $p < 0.0001$), compared to patients without BDI. Among inpatient cholecystectomies, BDI was associated with increased length of stay (8.6 days vs. 4.8 days, $p < 0.0001$).

Conclusion BDI is associated with significantly increased hospital costs, length of stay, 30-day readmission, and discharge to an institutional post-acute care facility.

Keywords Cholecystectomy · Complication · Cost

Cholecystectomy is one of the most commonly performed abdominal surgical procedures in the United States [1]. Since the introduction of the laparoscopic technique in the late 1980s, the incidence of major complications has significantly decreased with improvements in equipment and surgical technique [2]. Laparoscopic cholecystectomy is the standard procedure for the management of cholelithiasis and acute cholecystitis, whereas open surgery is often used in oncologic cases.

Bile duct injury (BDI) is a serious complication after laparoscopic cholecystectomy, with reported incidence of BDI ranging from 0.4 to 1.5% [3, 4]. Although it is a relatively rare complication, it is associated with significant morbidity, decreased physical quality of life, work productivity, and an increased likelihood to receive disability benefits [5, 6] A recent study of 156,958 laparoscopic cholecystectomies

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for cholelithiasis reported a BDI incidence of only 0.08% (125/156,958). However, the all-cause mortality was 21% (26/125), which is 9% above the cohort's age-adjusted rate of death [7].

A recent systematic review indicated that the incidence of bile duct injury was only recorded in 32% of studies that describe the incidence of post-operative complications in patients undergoing a laparoscopic cholecystectomy [8]. The individual cost of treating a BDI is reported to vary substantially from €21,837 to €107,568 ($24,810–$122,214), depending on the severity of injury [9]. From a medico-legal standpoint, the majority of claims following laparoscopic procedures in general surgical patients are related to laparoscopic cholecystectomy. Within these laparoscopic cholecystectomy patients, BDI accounted for the majority of the claims [10].

Although the safety of laparoscopic cholecystectomy had significantly improved over the past 30 years, the incidence of BDI has remained a significant complication. Given that the cost of BDI in the United States remains poorly defined, this study sought to examine the incidence of BDI and to estimate the cost and healthcare utilization (length of stay and discharge status) associated with BDI among patients undergoing cholecystectomy in a large U.S. hospital database.

Methods

This retrospective, observational study was performed using de-identified hospital administrative, healthcare utilization, and cost data contained in the Premier Healthcare Database® (PHD). The PHD is a large hospital-based, service-level, all-payer database with information on inpatient discharges and hospital-based outpatient visits from over 700 US hospitals [11]. Institutional Review Board approval was not required for this study of de-identified patient data.

The database was queried for patients who underwent cholecystectomy at an inpatient hospital or a hospital-based outpatient facility between January 2010 and March 2018. The first of such admissions or visits with a primary diagnosis of cholecystectomy was termed as the index procedure. Patients were required to be at least age 18 years as of the index procedure. Cholecystectomy was identified with International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) procedure codes (51.22 and 51.23) in data prior to October 1, 2015, and ICD-10-PCS procedure codes (0FT40ZZ and 0FT44ZZ) in data after October 1, 2015.

BDI was identified by screening diagnosis codes recorded during the index procedure. Supplementary Table 1 provides a complete list of ICD-9-CM and ICD-10-CM diagnosis codes for bile duct injury, which were previously reported and validated by Tornquist et al. [12] Diagnoses designated as present on admission (POA) were excluded due to being representative of pre-existing conditions. Based on the occurrence of BDI during cholecystectomy, identified patients were categorized into two groups: BDI patients and non-BDI patients.

Patient demographics, comorbidities, procedure, and hospital/provider characteristics data were summarized for both BDI and non-BDI patients. Patient demographic data included age, gender, race, and payer type. Comorbidity data included the Charlson Comorbidity Index [13], selected individual comorbidities, and a classification of the primary diagnosis as the surgical indication (cholecystitis, gallstones, pancreatitis, cancer, and other). Procedure and hospital/provider characteristic data included surgical approach (open, laparoscopic, and robot-assisted), elective versus non-elective (including urgent and emergency) admission, hospital bed size, and hospital type (urban, teaching status). Patients were stratified as having an inpatient or outpatient procedure by facility type.

The specific study outcomes were index procedure hospital costs, length of stay (LOS), readmission within 30 days of discharge from index admission, and discharge status. These outcomes were compared between BDI and non-BDI patients. A propensity score-matching process was used to match the BDI patients to non-BDI patients who had the similar baseline characteristics at a ratio of 1:3. The use of propensity score matching intended to reduce the effect of confounding baseline characteristics of patients. The absolute standardized mean difference was used to indicate if variables are unbalanced between the BDI and non-BDI groups. A variable is considered unbalanced if the absolute standardized mean difference is greater than 0.1 [14]. The matching variables included patient demographics (age, gender, race, marital status, payer), surgical indication (primary diagnosis), comorbidities (Charlson index and comorbid conditions), procedure (elective, discharge year), and hospital/provider characteristics (setting, geographic region, rural/urban, teaching, and bed size). Among these matching variables, hospital setting (inpatient vs. outpatient) was matched exactly between BDI and non-BDI patients. Surgical approach (open, laparoscopic, and robot-assisted) was not used in the matching process because of the potential causal relation with the occurrence of BDI. For instance, the occurrence of BDI may result in a conversion from laparoscopic surgery to open surgery, thus laparoscopic surgery confers a higher risk of BDI than open surgery. Generalized estimating equation (GEE) models were used to estimate the incremental amount of total hospital costs and LOS for patients with BDI. Multivariable logistic regression models were used to examine the association between the occurrence of BDI and discharge status (home/home health vs institutional post-acute care facility, e.g., skilled nursing

facilities). Total hospital cost with the sum of all billable items during the hospitalization was adjusted for inflation into 2018 US dollars. While controlling for patient- and provider-level characteristics above, the regression models also accounted for potential within-hospital clustering, which may be caused by homogeneity of surgical procedure and after-procedure care within the same hospital. In addition to the analysis on overall cholecystectomy patients, separate analyses were performed for inpatient and outpatient admissions in the matched BDI and non-BDI patient groups. A sensitivity analysis was conducted to demonstrate the impact of differences in surgical approach on outcomes. Another sensitivity analysis was conducted using a subset of study data after October 1, 2015 when ICD-10 code was implemented in the US. Differences were considered significant at a threshold of $p < 0.05$. All statistical calculations were performed using SAS software (version 9.4, SAS Institute Inc., Cary, NC).

Results

A total of 1,168,288 patients underwent cholecystectomy, and 878 (or 0.08%) of them had BDI diagnosed during their index procedure. The mean age of cholecystectomy patients was 50.8 years. Laparoscopy was the most common approach (> 95%). BDI patients appeared to be older (mean 56.2 years vs. 50.8 years), were male (42.8% vs. 31.9%), have Medicare coverage (40.8% vs. 28.4%), have their surgery performed in a teaching hospital (40.1% vs. 33.7%), and have their surgery in a hospital with more than 500 beds (35.3% vs. 25.3%) compared to non-BDI patients. BDI patients had a greater Charlson comorbidity index than non-BDI patients did (49.5% vs. 36.9% with Charlson comorbidity index greater than 0). Examining specific comorbidities, a higher proportion of BDI patients had diabetes (20.4% vs. 16.2%), hypertension (46.5% vs. 38.8%), cardiac arrhythmia (11.0% vs. 7.3%), and liver disease (12.1% vs. 7.3%) than non-BDI patients (Tables 1, 2, 3).

For cholecystectomies that were performed at either inpatient or outpatient settings, patients with BDI incurred an increase of $6426 in total index admission costs ($18,771 vs. $12,345), a higher rate of readmission within 30 days of discharge (25.9% vs. 16.3%), and a higher rate of being discharged to institutional post-acute care facility (e.g., skilled nursing facility) (20.4% vs. 7.9%) in the multivariable adjusted analysis (Table 4).

Of all cholecystectomies, 639,532 (54.7%) were performed in inpatient facilities. Among inpatient cholecystectomies, 623 (0.10%) had a BDI. In contrast, 528,756 patients had an outpatient cholecystectomy and 255 (0.05%) had a BDI. The majority of BDI occurred during inpatient admissions (71.0%). For inpatient cholecystectomies, patients with BDI had an increased length of stay (LOS) of 4.4 days (8.7 vs. 4.3), increased total index admission hospital cost of $12,703 ($25,939 vs. $13,235), 12.6% higher rate of readmission within 30 days of index discharge (28.7% vs. 16.2%), and 19.5% higher rate of being discharged to institutional post-acute care facility (e.g., skilled nursing facility) (27.0% vs. 7.5%) in the unadjusted analyses. The multivariable adjusted results based on the propensity score-matched patients demonstrated that the BDI patients had significantly higher index admission hospital costs of $10,420 (95% confidence limits: $8379–$12,637, $p < 0.0001$), longer length of stay of 3.8 days (95% CI 3.1–4.6, $p < 0.0001$), more likely to be readmitted within 30 days of index discharge with odds ratio at 1.83 (95% CI 1.45–2.30, $p < 0.0001$), and more likely to be discharged to institutional post-acute care facility with odds ratio at 4.64 (95% CI 3.49–6.17, $p < 0.0001$) (Table 4).

For outpatient cholecystectomies, 74.6% were planned procedures via elective admissions, which was drastically higher than that rate for inpatient cholecystectomies (12.0%). Outpatient cholecystectomies with BDI incurred an increase of $618 in total index admission costs ($5210 vs. $4591), and trended toward 30-day readmissions (odds ratio 2.12, 95% CI 1.37–3.27, $p = 0.0008$) and discharge to institutional post-acute care facility (odds ratio 2.52, 95% CI 1.05–6.06, $p = 0.0386$) (Table 4).

Discussion

The results of this study demonstrate that BDI in inpatient cholecystectomy is associated with a significantly increased length of stay (3.8 days), a significantly increased risk of 30-day readmission (OR 1.86, 95% CI 1.52–2.28, $p < 0.001$), and with an increased risk of being discharged to an institutional post-acute care facility (OR 4.64, 95% CI 3.49-6.17, $p < 0.001$.) The immediate effect of this was that BDI was associated with a significantly increased short-term hospital costs compared to non-BDI patients (difference of $10,420). While some studies have demonstrated the adverse long-term complications of BDI in patients undergoing cholecystectomy, this large study describes demographics and characteristics of patients with a BDI following cholecystectomy, and also identifies the significant short-term financial burden of a BDI following cholecystectomy in the index procedure.

The reported incidence of BDI in this cohort is lower than previously published studies [15–19]. This is likely due to the narrower selection of ICD-9 and ICD-10 codes in defining a BDI. Although there are a number of classification systems for defining BDI [20], the ICD codes selected likely represent those which were of more clinical significance. In this analysis, only BDI which were diagnosed during the hospitalization of index cholecystectomy were considered, and the presence of a BDI after discharge from the hospital

Table 1 Demographics of patients who underwent cholecystectomy

	Before propensity score matching			After propensity score matching		
	Patients with BDI ($n=878$)	Patients with no BDI ($n=1{,}167{,}410$)	Standardized mean difference	Patients with BDI ($n=872$)	Patients with no BDI ($n=2{,}614$)	Standardized mean difference
Age, mean (SD)	56.2 (18.3)	50.8 (18.3)	−0.30	56.2 (18.3)	55.7 (18.2)	−0.03
Age group						
18–34	15.3%	23.4%	−0.21	15.4%	15.1%	0.01
35–44	13.1%	16.4%	−0.09	13.0%	14.5%	−0.04
45–54	15.0%	17.6%	−0.07	15.1%	15.5%	−0.01
55–64	19.0%	16.8%	0.06	19.0%	17.5%	0.04
65–74	19.8%	14.0%	0.16	19.8%	20.7%	−0.02
≥75	17.8%	11.8%	0.17	17.7%	16.7%	0.03
Gender						
Female	57.2%	68.1%	−0.23	57.5%	57.3%	0.00
Race						
White	45.1%	48.6%	−0.07	45.1%	44.8%	0.01
African American	43.4%	41.8%	0.03	43.5%	44.4%	−0.02
Other	11.5%	9.7%	0.06	11.5%	10.9%	0.02
Marital status						
Married	71.5%	73.7%	−0.05	71.8%	74.1%	−0.05
Single	9.5%	8.7%	0.03	9.5%	8.6%	0.03
Other	19.0%	17.6%	0.04	18.7%	17.3%	0.04
Payer						
Commercial	36.2%	45.2%	−0.18	36.2%	37.6%	−0.03
Medicaid	13.1%	14.4%	−0.04	13.2%	12.7%	0.01
Medicare	40.8%	28.4%	0.26	40.7%	39.7%	0.02
Other	9.9%	12.0%	−0.07	9.9%	9.9%	0.00
Setting						
Inpatient	71.0%	54.7%	0.34	71.1%	71.1%	0.00
Outpatient	29.0%	45.3%	−0.34	28.9%	28.9%	0.00
Code version						
ICD-9	69.1%	79.8%	−0.25	69.0%	70.1%	−0.02
ICD-10	30.9%	20.2%	0.25	31.0%	29.9%	0.02
Admission type						
Elective	37.8% (inpatient: 23.9%, outpatient: 71.8%)	40.3% (inpatient: 12.0%, outpatient: 74.6%)	−0.05	37.6% (inpatient: 23.6%, outpatient: 72.2%)	37.6% (inpatient: 23.8%, outpatient: 71.7%)	0.00
Discharge year						
2010	8.4%	11.7%	−0.11	8.4%	9.0%	−0.02
2011	12.8%	13.8%	−0.03	12.7%	13.3%	−0.02
2012	12.1%	14.7%	−0.08	11.9%	11.8%	0.00
2013	10.7%	14.8%	−0.12	10.8%	11.1%	−0.01
2014	12.8%	14.4%	−0.05	12.8%	13.5%	−0.02
2015	14.8%	12.7%	0.06	14.8%	13.7%	0.03
2016	11.6%	8.7%	0.1	11.6%	10.9%	0.02
2017	12.2%	6.7%	0.19	12.3%	12.6%	−0.01
2018	4.7%	2.6%	0.11	4.7%	4.1%	0.03

BDI bile duct injury; patients with inpatient and outpatient admissions were exactly matched

Table 2 Clinical characteristics of patients who underwent cholecystectomy

	Before propensity score matching			After propensity score matching		
	Patients with BDI ($n=878$) (%)	Patients with no BDI ($n=1167{,}410$) (%)	Standardized mean difference	Patients with BDI ($n=872$) (%)	Patients with no BDI ($n=2614$) (%)	Standardized mean difference
Approach type[a]						
Laparoscopy	84.6	95.3	−0.36	85.0	91.6	−0.21
Open	13.0	2.3	0.41	12.6	5.7	0.24
Robotic	2.4	2.3	0	2.4	2.6	−0.01
Indication						
Gallstones	56.6	68.9	−0.26	57.0	56.5	0.01
Cholecystitis	18.3	16.8	0.04	18.3	19.2	−0.02
Pancreatitis	3.9	4.8	−0.05	3.9	3.2	0.04
Cancer	1.9	0.1	0.18	1.6	1.6	0.00
Other	19.2	9.3	0.29	19.2	19.5	−0.01
CCI score						
0	51.5	63.1	−0.24	51.6	53.1	−0.03
1–2	33.8	29.4	0.09	33.9	33.2	0.02
3–4	8.8	5.3	0.14	8.7	8.4	0.01
≥5	5.9	2.2	0.19	5.7	5.3	0.02
Comorbidities						
Diabetes	20.4	16.2	0.11	20.3	18.9	0.03
Hypertension	46.5	38.8	0.16	46.4	45.5	0.02
Cardiac arrhythmia	11.0	7.3	0.13	11.0	11.1	0.00
Congestive heart failure	5.1	3.7	0.07	5.2	4.6	0.03
Chronic pulmonary disease	15.3	13.0	0.06	15.4	14.2	0.03
Depression	11.4	8.9	0.08	11.5	10.9	0.02
Hypothyroidism	11.2	9.0	0.07	11.1	10.8	0.01
Liver disease	12.1	7.3	0.16	11.9	12.2	−0.01
Obesity	18.3	18.3	0.00	18.5	17.6	0.02
Other neurological disorders	3.3	2.4	0.06	3.3	2.5	0.05
Peptic ulcer disease	2.6	0.5	0.12	2.4	2.2	0.00
Peripheral vascular disorders	4.6	2.2	0.13	4.5	3.9	0.03
Renal failure	6.8	4.6	0.10	6.8	5.8	0.04
Valvular disease	4.1	2.6	0.08	4.1	4.0	0.01

BDI bile duct injury, *CCI* Charlson comorbidity index

[a]Approach type was not matched in the propensity score models

was not accounted. This could lead to some potential underreporting. Although the cost of treating BDI during the index admission is captured in the database, information on the modality on individual BDI treatment was not available. However, the results indicating prolonged hospital stay and increased hospital costs are similar to contemporary studies. The incidence of BDI defined with ICD-9 and ICD-10 diagnosis code was consistent (0.09% in ICD-9 and 0.07% in ICD-10), despite this being lower than in other studies. Supplemental Table 3 shows that the results of ICD-10 data had similar results to overall results. Additionally, the reported association between BDI and not being discharged home, after what is thought to be a straightforward procedure, is an important finding. This has both implications for individual patients and for hospital administrators. It may be an important aspect to include in the pre-operative counseling of patients and in terms of resource planning for hospitals.

There was a significant difference between surgical approach (laparoscopy vs. open. vs. robotic) and the incidence of bile duct injury, in the study sample before and after propensity score matching. It is likely that this is due to case selection (e.g., the complexity of the case or anatomical considerations). On suspicion of a probable causal link, surgical approach was neither included in the propensity score-matching process, nor controlled for in the multivariable regression models. Supplemental Table 4 shows the results

Table 3 Hospital/provider characteristics of patients who underwent cholecystectomy

	Before propensity score matching			After propensity score matching		
	Patients with BDI ($n=878$) (%)	Patients with no BDI ($n=1167{,}410$) (%)	Standardized mean difference	Patients with BDI ($n=872$) (%)	Patients with no BDI ($n=2614$) (%)	Standardized mean difference
Rural/urban hospital						
Rural	11.6	13.8	−0.06	11.7	11.1	0.02
Urban	88.4	86.2		88.3	88.9	
Teaching hospital						
Yes	40.1	33.7	0.13	40.0	38.6	0.03
No	59.9	66.3		60.0	61.4	
Provider region						
Midwest	19.2	18.5	0.02	19.3	18.9	0.01
Northeast	13.1	11.6	0.04	13.2	12.5	0.02
South	48.1	49.4	−0.03	48.1	48.5	−0.01
West	19.6	20.5	−0.02	19.5	20.1	−0.02
Cost type						
Procedural	67.5	66.2	0.03	67.5	68.4	−0.02
Cost-to-charge ratio	32.5	33.8		32.5	31.6	
Hospital bed size						
1–299	36.2	42.3	−0.12	36.5	35.9	0.01
300–499	28.5	32.4	−0.09	28.7	28.7	0.00
≥500	35.3	25.3	0.22	34.9	35.4	−0.01
Physician specialty						
General surgery	84.2	86.5	−0.07	84.3	85.4	−0.03
Other surgery	15.8	13.5		15.7	14.6	

BDI bile duct injury

from regression models with surgical approached included a co-variable. However, the cost difference from this sensitivity analysis was $6047, which is consistent with the main results ($6426). In a study of 210 patients with BDI, the majority (162/210) occurred during an open procedure, but the authors noted that nearly 75% of the BDI were as a result of anatomical anomalies or failure to identify anatomical features of the Calot triangle [21]. The results of our study reflect that of previously published data on the incidence of open versus laparoscopic-related BDI. Similarly, there was a significant difference in the incidence of BDI between the outpatient and inpatient cholecystectomies. This, again, is likely a surrogate for the complexity of the patient as more complex gallbladder disease is likely to necessitate open surgery and inpatient admission. Additionally, ambulatory laparoscopic cholecystectomy is recognized to be a safe and effective surgical option for selected patients, namely, those with less acute and severe pathology (i.e., symptomatic cholelithiasis, biliary dyskinesia) [22].

Other studies have reported on the difference of treatment modality and in time to treatment in BDI. While endoscopic treatment at the index procedure was associated with lower cost, this effect was lost at 2 months and endoscopic treatment was associated with significantly increased hospital cost beyond 3 months [19]. As expected, more complex injuries are also associated with significantly increased cost [23]. Additionally, patients with BDI were found to have an increased long-term mortality when compared to the cohorts expected death rate [7]. The results of our study complement these results in showing the major healthcare costs at index procedure with BDI. Post-cholecystectomy syndrome is a poorly defined condition with a range of symptomatology [24, 25], but, anecdotally, the senior authors have also noted the long-term intestinal dysmotility following bile duct injury, which can be extremely difficult to manage.

As BDI is a rare complication of cholecystectomy, the routine use of intraoperative cholangiography is debated [26, 27]. The early recognition and diagnosis of a BDI is associated with a reduced risk of death [3], but intraoperative cholangiography, in itself may not decrease the incidence of BDI [28]. The identification of the critical view of safety is now widely advocated for laparoscopic cholecystectomy, and the systematic approach to the surgery is also thought to reduce the incidence of BDI [29, 30]. Simple methods for the permanent recording of the critical view of safety have been suggested by doublet photography (anterior and

Table 4 Summary of outcomes in cholecystectomy patients

Outcome	Hospital Setting	Patients with BDI	Patients with no BDI	Difference	95% Confidence Limits	*p* value
Unadjusted results from the full sample						
Total hospital cost, 2018 USD	Inpatient	$25,939	$13,235	$12,703		
	Outpatient	$5233	$4633	$600		
	Overall	$19,925	$9341	$10,584		
Length of stay, days	Inpatient	8.7	4.3	4.4		
Discharge to institutional post-acute care facility	Inpatient	27.0%	7.5%	19.5%		
	Outpatient	6.3%	3.0%	3.2%		
	Overall	21.0%	5.5%	15.5%		
30-day readmission	Inpatient	28.7%	16.2%	12.6%		
	Outpatient	19.2%	10.2%	9.0%		
	Overall	26.0%	13.5%	12.5%		
Multivariable regression adjusted amount from the propensity score-match patient sample						
Total hospital cost, 2018 USD	Inpatient	$25,730	$15,310	$10,420	($8379, $12,637)	< 0.0001
	Outpatient	$5210	$4591	$618	($345, $906)	< 0.0001
	Overall	$18,771	$12,345	$6426	($5223, $7711)	< 0.0001
Length of stay, days	Inpatient	8.6	4.8	3.8	(3.1, 4.6)	< 0.0001
Outcome	Hospital setting	Patients with BDI (%)	Patients with no BDI (%)	Odds ratio	95% confidence limits	*p* value
Discharge to institutional post-acute care facility	Inpatient	26.3	9.7	4.64	(3.49, 6.17)	< 0.0001
	Outpatient	6.7	3.3	2.52	(1.05, 6.06)	0.0386
	Overall	20.4	7.9	3.89	(2.92, 5.19)	< 0.0001
30-day readmission	Inpatient	28.5	18.4	1.83	(1.45, 2.30)	< 0.0001
	Outpatient	19.8	11.1	2.12	(1.37, 3.27)	0.0008
	Overall	25.9	16.3	1.86	(1.52, 2.28)	< 0.0001

BDI bile duct injury, *USD* United States Dollar

posterior photographs) have been advocated [31]. It is interesting to note that BDI was more common in teaching hospitals despite recent data demonstrating increased critical view of safety scores with resident teaching [32].

Although this database aggregated data on more than 1 million cholecystectomies across a wide spectrum of healthcare facilities in the United States, there are some limitations. As this is a hospital-billing database, information on individual patient risk factors associated with increased risk of complications is limited. Additionally, information on the subsequent management of the BDI is described only by the length of hospital stay and cost of index admission, as information on the individual management of BDI was not available from the database. However, the cost of the BDI treatment intervention is captured in the cost of index admission. Readmissions were not specific to conditions caused by BDI, and only limited to those readmissions to the hospitals in the network of Premier database. There are no follow-up data on the acute treatment, disease management, and quality of life after discharge from index hospitalization. Although the increased risk of readmission and discharge to institutional post-acute care facility suggested that BDI incurs additional costs, these specific long-term cost burden associated with BDI was not quantified which underestimates the overall cost of BDI treatment.

Conclusion

This study highlights the diverse care of patients needing cholecystectomies in the United States and describes the short-term financial implications of a major complication. Bile duct injury is an uncommon complication of cholecystectomies at both inpatient and outpatient admissions. However, it is associated with prolonged length of hospital stay, higher risk of readmission, and more likely being discharged to an institutional post-acute care facility for further care, and with significantly increased short-term hospital costs.

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Compliance with ethical standards

Disclosure Dr. Wei and Mr. Johnson are employees of and have an equity interest in Johnson & Johnson, New Brunswick, NJ, USA. Dr. Patkar is an employee of and has an equity interest in Ethicon, Somerville, NJ, USA. Drs. O'Brien, Bhutiani, Rao, Vitale, and Martin have no conflicts of interest or financial ties to disclose.

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