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Management of choledocholithiasis in the elderly: Same-admission cholecystectomy remains the standard of care

Allison E. Berndtson, MD[a,*], Todd W. Costantini, MD[a], Alan M. Smith, PhD, MPH[a], Sara B. Edwards, MD[a], Leslie Kobayashi, MD[a], Jay J. Doucet, MD[a], Laura N. Godat, MD[a]

[a] Department of Surgery; Division of Trauma, Surgical Critical Care, Burns and Acute Care Surgery, UC San Diego, CA

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ABSTRACT

Background: Current guidelines recommend that patients with choledocholithiasis undergo same-admission cholecystectomy. The compliance with this guideline is poor in elderly patients. We hypothesized that elderly patients treated with endoscopic retrograde cholangiopancreatography (ERCP) alone would have higher complication and readmission rates than the patients treated with cholecystectomy.
Methods: The Nationwide Readmissions Database was queried for all patients aged ≥65 years with admission for choledocholithiasis January to June 2016. The patients were divided based on index treatment received: (1) no intervention; (2) ERCP alone; or (3) cholecystectomy. Multivariate analyses identified predictors of cholecystectomy during index admission and of readmissions.
Results: A total of 16,121 patients with choledocholithiasis were admitted; 38.4% underwent cholecystectomy, 37.6% endoscopic retrograde cholangiopancreatography alone, and 24.0% no intervention. The patients not receiving a cholecystectomy were more likely to be older, female, have a higher Elixhauser score, do-not-resuscitate status, and at a teaching hospital (all $P < .001$). Emergency readmissions for recurrent biliary disease were lowest in patients undoing a cholecystectomy (2.2% vs 9.2% endoscopic retrograde cholangiopancreatography and 12.4% no intervention, $P < .001$), as were readmissions for complications (3.6% vs 5.5% and 7.8%, $P < .001$). Cholecystectomy reduced rates of readmissions for recurrent disease (odds ratio 0.168, $P < .001$), for complications (odds ratio 0.540, $P < .001$), and death during readmission (odds ratio 0.503, $P = .007$); endoscopic retrograde cholangiopancreatography alone reduced only rates of readmissions. Age was not a predictor of readmission or death.
Conclusion: Index admission cholecystectomy is associated with a lower risk of readmission for biliary disease or complications, as well as death during readmission, in elderly patients. Age alone is not predictive of outcomes; surgical intervention should be guided by clinical condition, comorbidities, and patient preference.

Introduction

Choledocholithiasis (CDL) is a frequent and potentially morbid complication of cholelithiasis, constituting 10% to 20% of symptomatic gallstone disease overall and up to 32% in patients >70 years of age[1,2] Untreated, CDL may contribute to biliary obstruction, gallstone pancreatitis, cholangitis, sepsis, and death. Current guidelines recommend that patients presenting with choledocholithiasis undergo cholecystectomy after clearance of the common bile duct either spontaneously or via endoscopic retrograde cholangiopancreatography (ERCP).[3–5] Delays to cholecystectomy have been associated with rates of readmission for recurrent biliary disease ranging from 12% to 47%,[6–12] leading many surgeons to advocate for cholecystectomy before discharge.

Significant practice variation persists for management of all biliary disease, with recent studies showing low rates of same-admission cholecystectomy for choledocholithiasis,[9] gallstone pancreatitis,[13] and acute cholecystitis.[14] This is further complicated by additional data advocating for ERCP alone as a safe alternative to cholecystectomy in selected patients with choledocholithiasis,[15] particularly those >80 years of age.[16]

Compliance with guidelines for cholecystectomy may be particularly poor in elderly patients due to perceived risks of surgical intervention; however, readmissions, recurrent disease and procedural complications may also be poorly tolerated due to

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* Reprint requests: Allison E. Berndtson, MD, 200 W. Arbor Drive, MC 8896, San Diego, CA 92103

E-mail address: aberndtson@health.ucsd.edu (A.E. Berndtson);
Twitter: @ABerndtson, @TWCostantini, @jaydoucet, @godat_l

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underlying comorbid conditions and frailty. The aim of this study was to determine readmission rates and complications for older patients with CDL based on treatment offered during the index admission. We hypothesized that elderly patients treated with ERCP alone or no intervention would have higher complication and readmission rates than patients treated with cholecystectomy during the index admission.

Methods

The Nationwide Readmissions Database (NRD), developed by the Agency for Healthcare Research and Quality (AHRQ) as a Federal-State-Industry partnership, contains data on approximately 17 million United States patient discharges per year, unweighted.[17] The patients are assigned a unique identifier that allows them to be tracked over the course of 1 year, through admissions to multiple hospitals, minimizing loss to follow-up. The NRD was retrospectively reviewed for all of the patients aged ≥65 years with an International Statistical Classification of Diseases and Related Health Problems (ICD)-10 diagnosis code for choledocholithiasis and an index admission between January 1, 2016, and June 30, 2016. The study population was limited to index admissions in the first half of the year to ensure up to 6 months of follow-up for patients admitted in June. Patients were excluded if the index admission was elective, if they died during the index admission, were transferred to another short-term hospital, or had a history of chronic pancreatitis, alcohol-related pancreatitis, or pancreatic neoplasm. The data collected from the index admission included demographics (age, sex, payer type, median income by zone improvement plan code), length of stay, hospital characteristics (teaching status, bed size, hospital charges), and disposition (routine, skilled nursing facility [SNF] or intermediate care, home health care, against medical advice [AMA]). The procedure(s) performed at the index admission were also collected using ICD-10 codes for laparoscopic cholecystectomy, open cholecystectomy, and endoscopic retrograde cholangiogram. Comorbidities were derived as described by Elixhauser et al and the AHRQ.[18] The Elixhauser comorbidities were initially defined in 1998 specifically for use with administrative data sets, with the intent of defining a set of clinical conditions that exist before hospital admission, are not related to the primary diagnosis, and are likely to be a significant factor in influencing mortality.[19] These criteria were subsequently incorporated into the data set provided by the NRD, and adapted to ICD-10; 38 comorbidity measures are currently defined. Do not resuscitate (DNR) status was also collected and treated as a comorbidity (ICD-10 code Z66) as patient frailty is not a discrete field within an NRD.[20] Patients were divided into three groups based on definitive procedure performed during the index admission—cholecystectomy (with or without ERCP), ERCP alone, or no intervention (neither cholecystectomy nor ERCP during index admission).

For each patient the number of readmissions, date and type of readmission, and associated diagnoses, procedures, outcomes, complications, and disposition was collected. Our primary outcome was 180-day rates of readmission for recurrent biliary disease, by index admission treatment. Secondary outcomes included readmissions for complications, elective versus emergent readmissions, hospital length of stay (LOS), discharge disposition, hospital charges, and mortality. For our primary outcome, we analyzed the readmissions with a diagnosis of biliary disease (choledocholithiasis, acute biliary pancreatitis, cholangitis, cholecystitis, and gallstone ileus) up to 180 days after index hospitalization discharge (Readmissions for Recurrent Disease). For one of our secondary outcomes, we assessed readmissions for complications based on ICD-10 diagnosis codes for post procedural hemorrhage, gastrointestinal (GI) perforation, retained gallstone, complications of biliary stents, wound infections, Clostridium difficile colitis, sepsis, shock, acute hepatic failure, acute renal failure, myocardial infarction, respiratory failure, and acute respiratory distress syndrome up to 30 days after index hospitalization discharge (Readmissions for Complication). Admissions after 30 days with complication codes but no recurrent disease code were excluded, as we felt serious complications were less likely to be directly related to the index procedure after this time point. Although each patient could potentially be readmitted more than once, the patient was treated as the primary unit of analysis and readmission as a binary (yes\no) variable in the data analysis. Patients were counted as having both 30-day complications and 180-day recurrent disease if both occurred.

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY). In bivariate analysis, we used the Pearson χ^2 analysis for categorical variables. For continuous variables, we used the nonparametric Kruskal-Wallis test. Independent variables were assessed for collinearity via the variance inflation factor and no evidence of collinearity was identified. Variables were considered for inclusion in logistic regression models if their bivariate P value was $< .2$. Model reduction was performed using backward stepwise regression with criteria for entry set at $P < .05$ and criteria to remove from the model at $P > .10$. Variables that did not meet the P value criteria were kept in the model if they were deemed to be important confounders; in this study only DNR status was included for this reason. We additionally performed propensity score matching between the cholecystectomy and ERCP alone groups. The patients were matched for age, sex, payer type, hospital urban\rural location, overall comorbidities, specific comorbidities (congestive heart failure, arrhythmias, neurological disorders, metastatic cancer, nonmetastatic cancer, coagulopathy, anemia, obesity, electrolyte disorders, drug abuse, depression, and hypertension), teaching hospital status, and DNR status. The subpopulations were then assessed for differences at the index and readmission visits.

The graphing function in Stata Statistical Software, Version 14.2 (StataCorp LP, College Station, TX) was used to create Kaplan-Meier failure curves representing days to readmission for biliary disease and complications. Nonoverlapping confidence intervals (CIs) represent statistically significant differences between groups.

This study was reviewed and approved with waiver of consent by the University of California San Diego Institutional Review Board, and performed in accordance with the Healthcare Cost and Utilization Project (HCUP) Nationwide Data Use Agreement. Due to HCUP use limitations, single cell numbers from 1 to 10 cannot be reported. Where present, these values have been generalized as "≤ 10" or "≤ a percentage that would lead to 10", and indicated as such in the tables. ICD-10 codes used for choledocholithiasis, procedures, recurrent disease, and complications are available online as Supplementary Material (Appendix 1).

Results

A total of 16,121 patients with an index admission for choledocholithiasis during the study period were included in the analysis. Of these, 6,183 (38.4%) underwent cholecystectomy during the index admission, 6,062 (37.6%) underwent ERCP alone, and 3,876 (24.0%) had no intervention (Table I). Of the 6,183 patients undergoing index admission cholecystectomy, 4,227 (68%) also underwent ERCP (Figure 1). The patients who received no intervention or ERCP alone were older, more likely to be female, had a higher mean Elixhauser score, had a higher likelihood of DNR status, and were more likely to have Medicare insurance. The patients undergoing index admission cholecystectomy had longer hospital

Table I
Demographics and outcomes by intervention group, index admission

	Cholecystectomy (n = 6,183)	ERCP alone (n = 6,062)	No intervention (n = 3,876)	P value
% of total	38.4%	37.6%	24.0%	
Age, y	76 [70–82]	79 [72–86]	80 [72–87]	< .001
Female (%)	51.7%	54.7%	59.4%	< .001
Elixhauser score (Mean [SD])	3.3 [2.0]	3.7 [2.1]	4.1 [2.2]	< .001
DNR status (%)	5.0%	11.4%	15.8%	< .001
Primary payer (%)				< .001
Medicare	88.9%	91.0%	91.3%	
Medicaid	2.1%	2.4%	2.1%	
Private	7.3%	4.9%	4.8%	
Self-pay	0.4%	0.4%	0.6%	
No charge	0.0%	0.0%	≤0.3%*	
Other	1.2%	1.3%	1.1%	
Hospital LOS	5 [4–8]	4 [3–7]	4 [3–7]	< .001
Hospital charges	$71,787 [$46,240– $111,476]	$50,448 [$30,505–$83,677]	$38,225 [$21,154– $70,039]	< .001
Disposition (%)				< .001
Routine	68.4%	61.1%	50.7%	
SNF or intermediate care	14.4%	20.4%	25.3%	
Home health care	17.0%	18.0%	22.7%	
AMA	0.2%	0.5%	1.3%	

All numbers are median [IQR] unless otherwise specified.
AMA, against medical advice; DNR, do not resuscitate; *ERCP,* endoscopic retrograde cholangiopancreatography; *LOS,* length of stay; *SNF,* skilled nurse facility; *y,* years.
* Due to HCUP use limitations, single cell numbers from 1 to 10 cannot be reported. These values have been generalized as "≤10" or "≤a percentage that would lead to 10".

lengths of stay and higher median charges, but were more likely to be discharged home. The predictors of index admission cholecystectomy on multivariate analysis were same-admission ERCP, younger age, male sex, lower Elixhauser score, and private insurance. Patients were less likely to undergo index admission cholecystectomy if they were in the highest quartile (fourth) of income by zone improvement plan code, were in a medium or large hospital (versus small), or in a teaching hospital, or were DNR status during the index admission (Table II). An assessment for collinearity showed no association between these factors.

Readmissions for recurrent biliary disease, by index admission treatment

The readmission rates for recurrent biliary disease were significantly different for each of the intervention groups (Figure 2, *A*). Emergent readmissions for recurrent biliary disease at 180 days were highest in patients undergoing no intervention during the index admission, and lowest in patients undergoing cholecystectomy (12.4% no intervention vs 9.2% ERCP alone vs 2.2% cholecystectomy, $P < .001$) (Table III). Elective readmissions for recurrent biliary disease within 180 days were highest in patients undergoing index ERCP only (2.9%, vs 2.3% no intervention and 0.2% cholecystectomy, $P < .001$). Rates of cholecystectomy during a readmission were higher for elective readmissions than for emergent readmissions (73.6% vs 26.0% for index ERCP alone and 60.4% vs 24.7% for index no intervention), though, in total, more delayed cholecystectomies were performed during emergent readmissions than during elective readmissions as emergent readmissions were more common. Patients were more likely to die during a readmission for recurrent biliary disease if they had either no intervention or ERCP alone during the index hospitalization (0.49% and 0.43% respectively, vs 0.08% cholecystectomy, $P < .001$). Cumulative hospital length of stay (LOS) of all biliary disease readmissions was also highest in the no intervention group (median 6 [IQR 4–10] days, $P <$ .001 versus index cholecystectomy or ERCP alone). There was no difference in the days to first readmission or cumulative charges for readmissions.

Readmissions for complications, by index admission treatment

Readmissions for complications within 30 days were also most common in patients with no intervention during their index admission (7.8%, vs 5.5% for ERCP alone and 3.6% for those undergoing index cholecystectomy, $P < .001$). Patients were also more likely to die during a readmission for complications if they had no intervention during the index hospitalization (1.14% vs 0.66% ERCP alone and 0.40% cholecystectomy, $P < 0.001$). There was no difference in cumulative charges or cumulative hospital LOS. Combining the rates and timing of 30-day complication readmissions, the patients who underwent a cholecystectomy had longer times to readmission than ERCP or no intervention patients (Figure 2, *B*).

Multivariate analysis of predictors of readmission or death during readmission

Logistic regression was used to examine the predictors of readmission or death during readmission, divided by type of readmission. Readmissions for recurrent biliary disease were associated with patients who had a higher Elixhauser score (odds ratio [OR] 1.051 per comorbidity [CI 1.02–1.082], $P < .001$), or were discharged to an SNF or Intermediate Care from the index admission (OR 1.211 [CI 1.038–1.412], $P = .015$) (Table IV). The factor associated with the lowest risk of readmission for recurrent biliary disease was index admission cholecystectomy (OR 0.168 [CI 0.138–0.205], $P < .001$), followed by index admission ERCP alone (OR 0.734 [CI 0.644–0.836], $P < .001$) and being female (OR 0.835 [CI 0.740–0.943], $P = .004$). Regarding the readmissions for complications within 30 days, patients were more likely to be readmitted if they were discharged anywhere other than home without services from the index admission (leaving against medical advice, OR 2.546 [CI 1.295–5.007], $P = .007$; discharge to SNF or Intermediate Care, OR 2.094 [CI 1.744–2.515], $P < .001$; discharge with

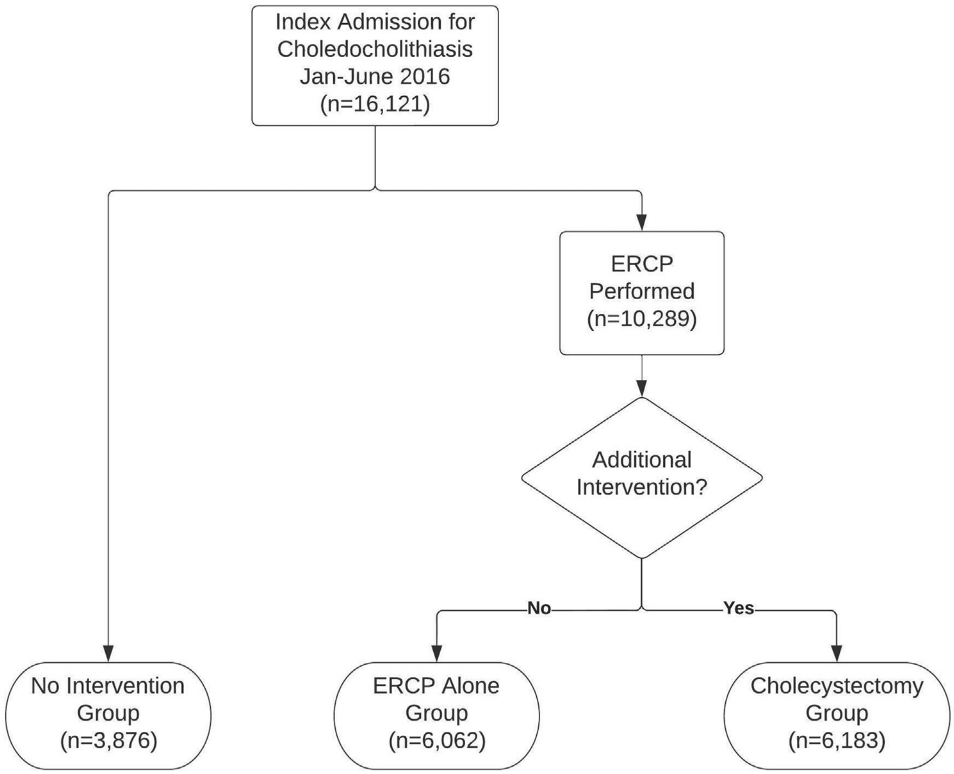

Figure 1. Flowchart of patient accrual into analysis groups, by index admission procedure, *ERCP*, endoscopic retrograde cholangiopancreatography.

Table II
Multivariate analysis, predictors of cholecystectomy during index admission

	Odds ratio	CI		*P* value
		Lower	Upper	
ERCP also performed	1.344	1.253	1.442	< .001
Age, y	0.963	0.959	0.968	< .001
Female sex	0.889	0.832	0.950	.001
Elixhauser score	0.908	0.893	0.923	< .001
Primary expected payer				
Medicare	REF			
Medicaid		0.651	1.019	.073
Private insurance	1.186	1.032	1.363	.016
Self-pay		0.426	1.154	.162
Other		0.675	1.250	.590
Median household income by ZIP				
First quartile	REF			
Second quartile		0.839	1.011	.085
Third quartile		0.905	1.091	.890
Fourth quartile	0.827	0.750	0.911	< .001
Hospital bed size				
Small	REF			
Medium	0.876	0.787	0.976	.016
Large	0.890	0.806	0.983	.022
Teaching hospital	0.761	0.711	0.816	< .001
DNR status	0.509	0.445	0.582	< .001

Not significant: hospital urban-rural location, admission day is a weekend
CI, confidence interval; *DNR*, do not resuscitate; *ERCP*, endoscopic retrograde cholangiopancreatography; *REF*, reference; *y*, years; *ZIP*, zone improvement plan.

Home Health Care, OR 1.692 [CI 1.401–2.043], *P* < .001), had an Elixhauser score of ≥4 (OR 1.405 [CI 1.111–1.778], *P* = .005), or a longer index hospital length of stay (OR 1.017 per day [CI 1.009–1.025], *P* < .001; Table V). The factor associated with the lowest risk of readmission for complications was index admission cholecystectomy (OR 0.540 [CI 0.448–0.651], *P* < .001), followed by index admission DNR status (OR 0.718 [CI 0.567–0.910], *P* = .006), index admission ERCP alone (OR 0.775 [CI 0.655–0.917], *P* = .003), and female sex (OR 0.715 [CI 0.620–0.826], *P* < .001).

Mortality during readmission

Death during readmission was assessed for both types of readmissions combined. Death during any readmission was most highly associated with discharge to SNF or Intermediate Care from the index admission (OR 3.069 [CI 1.966–4.788], *P* < .001), followed by an increasing Elixhauser score (OR 1.257 per comorbidity [CI 1.160–1.362], *P* < .001), and hospital LOS during index admission (OR 1.014 per day [CI 1.005–1.024], *P* = .004; Table VI). The only factor associated with a lower risk of death during a readmission was index admission cholecystectomy (OR 0.503 [CI 0.306–0.829], *P* = .007). Neither ERCP alone during index admission nor DNR status were statistically significant predictors of death during readmission. Age, hospital bed size, teaching status, median household income, and the primary expected payer were all factors that influenced the likelihood of cholecystectomy during the index admission, but were not statistically significant predictors of readmission or death.

Propensity score matching sub-analysis, cholecystectomy versus ERCP alone groups

We were able to match 4,816 patients between the cholecystectomy and ERCP alone groups within 1% propensity score (standardized mean differences available electronically as Appendix 2). The groups were clinically well matched for age (median 78 years [IQR 72–84] cholecystectomy group vs 77 years [IQR 71–84] ERCP alone group, *P* = .001) and sex (58.0% female cholecystectomy group vs 55.7% female ERCP alone group, *P* = .022) despite statistical differences. Elixhauser scores were also well matched at a

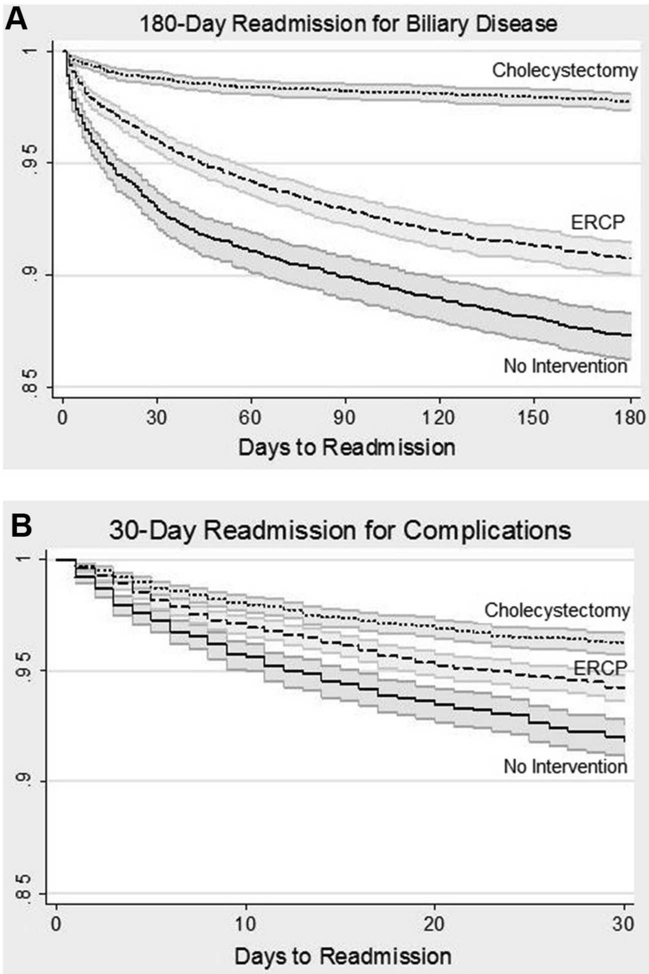

Figure 2. Failure curves for time to readmission, (A) for biliary-related diagnoses, and (B) for complications, based on the intervention performed at the index admission.

median of 3.7 in each group ($P = .803$). There was no difference between groups in primary payer ($P = .484$). When assessing outcomes, the patients undergoing ERCP alone had a shorter median hospital LOS (4 days [IQR 3–7] ERCP Alone vs 6 days [IQR 4–8] cholecystectomy, $P < .001$) and lower median hospital charges ($50,091 [IQR $30,116–83,453] ERCP alone vs $75,659 [IQR $48,309–$118,117] cholecystectomy, $P < .001$). ERCP alone patients were slightly more likely to be discharged home (65.3% ERCP alone vs 62.7% cholecystectomy) and slightly less likely to be discharged with home health care (16.8% ERCP alone vs 19.2% Cholecystectomy, overall disposition $P = .001$). When readmissions were considered, however, the patients that underwent a cholecystectomy were again much less likely to be readmitted both for recurrent biliary disease within 180 days (2.2% cholecystectomy vs 9.2% ERCP alone, $P < .001$) and for complications within 30 days (4.3% cholecystectomy vs 5.8% ERCP alone, $P = .001$). The cholecystectomy patients were also less likely to die during readmissions for biliary disease ($\leq$0.2% vs 0.4% ERCP alone, $P = .001$).

Discussion

Current guidelines recommend that patients admitted with choledocholithiasis undergo same-admission cholecystectomy, though compliance with this guideline is thought to be poor, particularly in elderly patients. In this study of 16,121 patients over the age of 65, we found that cholecystectomy during the index admission offered the lowest rates of readmissions for recurrent biliary disease, readmissions for complications, and death during hospital readmission. Patients undergoing ERCP alone had significantly higher rates of both readmissions and death than those who underwent cholecystectomy in the index admission, while patients undergoing no intervention had higher rates yet. Although the patients undergoing cholecystectomy were younger than those receiving ERCP alone or no intervention, age was not a predictor of hospital readmission or death. In addition to index procedure performed, readmissions and death were also associated with Elixhauser score, disposition from index admission, initial hospital LOS, and female sex.

It is striking how few patients in this study received a cholecystectomy during their index admission (38.4%), despite multiple national guidelines recommending this practice.[3–5] Previous studies have shown higher rates of readmission for recurrent biliary disease than we found here,[6–9,11] but even with this widely available evidence patients continue to be discharged without a definitive operation. Including cholecystectomies during elective readmissions within 180 days, to account for possible planned delayed operation, increased the cholecystectomy rate to only 39.5%. Even when emergent readmissions were included nearly 60% of patients initially admitted with choledocholithiasis did not receive a cholecystectomy within 180 days.

The reasons for performing or declining index cholecystectomy are complex and varied. On multivariate analysis we did identify older age as a predictor of nonoperative management (OR 0.963 per year of age); age was not a contributor to models of readmission or death, however. Avoiding surgery based on age alone may not be justified, a finding also noted by Kim et al (2009).[21] Comorbidities, as assessed by Elixhauser score, were associated with nonoperative management during the index admission, while also correlating with increased risk of readmissions and death. This suggests that critical assessment of a patient's overall health status may be a more important and widely used decision-making tool than age alone. Comorbidities, however, also negatively influence outcomes for patients with recurrent disease,[8] and both readmissions for biliary disease and death during readmission were significantly higher in the patients with more comorbidities as well as in those who did not receive either cholecystectomy or ERCP during their index admission. Rates of cholecystectomy were also significantly higher in those patients that also had an ERCP performed during the index admission—this may indicate that providers are more willing to remove the gallbladder if stones were persistent enough to require endoscopic extraction, or that they felt patients who had already tolerated a procedure were more appropriate surgical candidates. Conversely, patients whose bile duct cleared spontaneously or who were deemed poor candidates for even procedural sedation may not have been offered intervention.

Another potential assessment of a patient's overall state is DNR status during the index admission, which has previously been shown to be an independent risk factor for postoperative complications and mortality.[20] DNR status was significantly higher in patients undergoing no intervention or ERCP alone than in those undergoing index cholecystectomy, though DNR status was still present in 5% of all patients receiving index surgical intervention. DNR status was a significant predictor against receiving index cholecystectomy, but was not associated with either type of readmission or with death during readmission. There are many reasons a patient may have or become DNR status during their care, including associated disease states with poor prognosis, overall frailty, or poor quality of life, all of which may indicate appropriate reasons for avoiding or delaying surgical intervention; or it may simply be a personal preference, and unrelated to any increased

Table III
Readmissions, by index admission procedure

	Readmissions for biliary disease (180 d)			
	Cholecystectomy ($n = 6,183$)	ERCP alone ($n = 6,062$)	No intervention ($n = 3,876$)	*P* value
Emergent readmission	137 (2.2%)	558 (9.2%)	481 (12.4%)	< .001
Procedures done during emergent readmission				
Cholecystectomy	≤10* (≤0.2%)	145 (26.0%)	119 (24.7%)	< .001
ERCP alone	63 (46.0%)	174 (31.2%)	112 (23.3%)	
No intervention	73 (53.3%)	239 (42.8%)	250 (52.0%)	
Elective readmission	≤10* (≤0.2%)	178 (2.9%)	91 (2.3%)	< .001
Procedures done during elective readmission				
Cholecystectomy	≤10*	131 (73.6%)	55 (60.4%)	< .001
ERCP alone	≤10*	22 (12.4%)	13 (14.3%)	
No intervention	≤10*	25 (14.0%)	23 (25.3%)	
Died during readmission	≤0.2*%	0.43%	0.49%	< .001
Cumulative charges	$51,720.50 [$30,750.50–$74,866.50]	$51,471 [$29,758–$95,637]	$54,135 [$28,798–$95,912]	.612
Cumulative hospital LOS	4 [3–8]	5 [3–9]	6 [4–10]	.001
	Readmissions for complications (30 d)			
	Cholecystectomy ($n = 6,183$)	ERCP alone ($n = 6,062$)	No intervention ($n = 3,876$)	*P* value
Readmission	232 (3.6%)	346 (5.5%)	309 (7.8%)	< .001
Procedures done during emergent readmission				
Cholecystectomy	0 (0.0%)	17 (4.9%)	29 (9.4%)	< .001
ERCP Alone	18 (7.8%)	39 (11.3%)	26 (8.4%)	
No Intervention	214 (92.2%)	290 (83.8%)	254 (82.2%)	
Died during readmission	0.40%	0.66%	1.14%	< .001
Cumulative charges	$53,228 [$26,503–$104,650]	$52,542 [$27,453–$107,503]	$61,728.50 [$30,657–$134,025]	.154
Cumulative hospital LOS	6 [3–11]	6 [3–11]	7 [4–12]	.408

All of the numbers are n (%) or median [IQR] unless otherwise specified.
ERCP, endoscopic retrograde cholangiopancreatography; *LOS*, length of stay.
* Due to HCUP use limitations, single cell numbers from 1–10 cannot be reported. These values have been generalized as "≤10" or "≤a percentage that would lead to 10".

Table IV
Multivariate analysis, predictors of readmission for recurrent disease (within 180 days)

	Odds ratio	CI Lower	CI Upper	*P* value
Procedure during index admission				
Neither	REF			
ERCP Alone	0.734	0.644	0.836	<.001
Cholecystectomy	0.168	0.138	0.205	<.001
Female sex	0.835	0.740	0.943	.004
Elixhauser score	1.051	1.02	1.082	.001
Disposition, index admission				
Routine	REF			
Transfer to SNF or intermediate care	1.211	1.038	1.412	.015
Home health care	1.140	0.973	1.336	.104
AMA	1.147	0.589	2.233	.687

Not significant: age (years), primary expected payer, hospital length of stay, Elixhauser score ≥4, teaching hospital, total hospital discharges.
AMA, against medical advice; *CI*, confidence interval; *ERCP*, endoscopic retrograde cholangiopancreatography; *REF*, reference; *SNF*, skilled nursing facility.

surgical risk. This however explains, at most, a low percentage of those not undergoing index cholecystectomy. DNR is only a partial surrogate for frailty, and future studies evaluating patient frailty in more detail may further elucidate specific surgical risks for patients presenting with choledocholithiasis.

One group excluded from our study were the patients who died during the index hospitalization, as our intent was primarily to assess readmissions. This patient group may be at the forefront of concern for surgeons, however, and physician judgment that a patient was at increased risk of postoperative death may be a reason for surgeons to avoid cholecystectomy in selected patients. On re-evaluation we noted that a total of 436 patients were excluded from the primary study due to death during index hospitalization. Of these patients, 78 underwent cholecystectomy, 133 ERCP alone, and 225 no intervention before death. Combined with our included patients, this provided an index admission mortality rate of 1.2% for all of the patients initially treated with a cholecystectomy, 2.1% for those treated with ERCP alone, and 5.5% for those with no intervention. Although there is significant selection bias in these findings, and cause and effect could not be fully determined retrospectively, we feel that the low rate of mortality in patients that underwent a cholecystectomy compared with the other groups is reassuring.

Other reasons for avoiding cholecystectomy during index admission may include lack of available operating room time, financial barriers, lack of surgical team consultation, surgeon comfort, availability and success rate of ERCPs, and patient preference. We found that medium and large hospitals were less likely to perform index cholecystectomy than small hospitals, and that teaching hospitals had lower cholecystectomy rates than non-teaching hospitals. Reasons for this are likely multifactorial and require further investigation; it is unclear if there is any relation to severity of disease or comorbidities, operating room time, hospital bed availability, surgeon compensation model, or patient payer mix. There may have also been an intention for more patients to follow-up for delayed cholecystectomy than ultimately did; however, this lack of follow-up is one reason for the strong recommendation for index admission cholecystectomy in the first place. One known limitation of the NRD is also that only inpatient admissions are included; it is possible that we undercounted elective delayed cholecystectomies that were performed as an outpatient procedure. This may partially explain the interesting finding that those patients in the highest income quartile were less likely than those in the lowest to undergo same-admission cholecystectomy, though this cannot be proven; there may be additional confounding between income and comorbidities. Despite this, we continue to advocate for same-admission cholecystectomy for the majority of patients with choledocholithiasis, in order to prevent loss to follow-up.

Table V
Multivariate analysis, predictors of readmission for complication (within 30 days)

	Odds ratio	CI		*P* value
		Lower	Upper	
Procedure during index admission				
Neither	REF			
ERCP alone	0.775	0.655	0.917	.003
Cholecystectomy	0.540	0.448	0.651	< .001
Female sex	0.715	0.620	0.826	< .001
Elixhauser score	1.133	1.077	1.193	< .001
Elixhauser score ≥4	1.405	1.111	1.778	.005
DNR status at index admission	0.718	0.567	0.910	.006
Disposition, index admission				
Routine	REF			
Transfer to SNF or intermediate care	2.094	1.744	2.515	< .001
Home health care	1.692	1.401	2.043	< .001
AMA	2.546	1.295	5.007	.007
Hospital LOS, index admission (d)	1.017	1.009	1.025	< .001

Not significant: age (years), hospital bed size, teaching hospital, hospital urban-rural location, total charges, total hospital discharges, primary expected payer.
AMA, against medical advice; *CI*, confidence interval; *DNR,* do not resuscitate; *ERCP,* endoscopic retrograde cholangiopancreatography; *LOS,* length of stay; *REF,* reference; *SNF,* skilled nursing facility.

Table VI
Multivariate analysis, predictors of death during readmission for recurrent disease or complication

	Odds ratio	CI		*P* value
		Lower	Upper	
Procedure during index admission				
Neither	REF			
ERCP alone	0.883	0.591	1.317	.542
Cholecystectomy	0.503	0.306	0.829	.007
Elixhauser score	1.257	1.160	1.362	< .001
Disposition, index admission				
Routine	REF			
Transfer to SNF or intermediate care	3.069	1.966	4.788	< .001
Home health care	1.278	0.740	2.206	.379
AMA	2.015	0.271	14.990	.494
Hospital LOS, index admission (d)	1.014	1.005	1.024	.004

Not significant: age, sex, number of chronic conditions, primary expected payer, median household income by ZIP, hospital bed size, hospital teaching status, hospital urban-rural location, admission day weekend, Elixhauser score ≥4, Do Not Resuscitate status.
AMA, against medical advice; *CI*, confidence interval; *ERCP,* endoscopic retrograde cholangiopancreatography; *LOS,* length of stay; *REF,* reference; *SNF,* skilled nursing facility; *ZIP,* zone improvement plan.

One prior study by Yasui et al argued that ERCP alone may be a safer alternative than cholecystectomy in elderly patients.[16] Our data demonstrates that the rate of death during any readmission is significantly higher in both patients undergoing an index ERCP alone or no intervention than for those with index admission cholecystectomy, and that only index cholecystectomy was associated with a lower likelihood of death during readmission when compared to no intervention, whereas ERCP alone was not. An ERCP alone was also associated with higher rates of readmissions for both biliary disease and for complications, thus perhaps increasing both morbidity and mortality in comparison to cholecystectomy. In comparison with the study by Yasui et al, we used a different age cutoff for elderly patients (aged >65 years vs aged >80 years) which may impact results. They also separated recurrent common bile duct stones, which were not significantly different between younger and older patients, from acute cholecystitis, which was less common in elderly patients—this may explain some of our difference in findings. Our findings were more in line with those published by Elmunzer et al,[22] who looked at patients >65 years of age who did or did not undergo cholecystectomy after ERCP. They similarly found reduced rates of recurrent disease in patients who received a cholecystectomy, without an increase in postoperative complications.

The primary strength of our study is our large sample size from the NRD, representative of millions of admissions from across the country. An analysis of >16,000 patients allowed us to describe the current treatment of choledocholithiasis in the United States, and analyze predictors of treatment, readmissions, and death. Our study was not without limitations, however. Large databases contain inherent limitations, such as the possibility of incorrect coding or missed diagnoses, and lack granular data on questions such as surgical consultation or patient frailty. Of particular note is the lack of specific codes for bile leak or biloma separate from bile duct injury or perforation, and an inability to accurately capture patients who may have undergone endoscopic ultrasound without ERCP intervention. It is possible that this group of patients who underwent endoscopic ultrasound is instead counted in the cholecystectomy or no intervention groups. It is important to note that large, retrospective studies of this type are descriptive in nature rather than prescriptive; they are also inherently subject to potential selection bias that is difficult to control for. This contributes to our inability to separate correlation from causation, including elucidating why patients did or did not undergo cholecystectomy and how these decisions affected future care, though this may be partially mitigated by our propensity score matching sub-analysis. Risk adjustment by ICD code remains crude, but better options for large patient groups have yet to be developed. We were also able to study only deaths during hospital readmission; deaths outside the hospital such as at hospice were not captured, and may have influenced results. Finally, our length of follow-up was limited by the nature of the NRD, and readmissions beyond 6-months were not captured; rates of readmissions for recurrent disease would likely be higher if a longer follow-up period could be reviewed.

There is significant room for ongoing analysis in this area. As described, the reasons why the patients do not undergo index admission cholecystectomy can be theorized but have not been described in detail. Our identification of comorbidities as a significant predictor not only of cholecystectomy but also readmissions and death also may bear further investigation; this could lead to the development of a risk calculator to predict outcomes for patients presenting with choledocholithiasis or other complicated biliary disease. Finally, efforts to improve compliance with same-admission cholecystectomy guidelines should be developed and their influence on practice evaluated, as we find it unlikely that nearly 60% of patients >65 years of age are truly prohibitively risky surgical candidates. It is also unclear how these findings would compare with those in patients <65 years of age; compliance in this group may be similarly poor.

In conclusion, patients >65 years of age presenting with choledocholithiasis who underwent cholecystectomy during their index admission had lower rates of readmissions for recurrent biliary disease, readmissions for complications, and death during hospital readmission. An ERCP alone during the index admission was associated with reduced rates of readmissions when compared with no intervention, but not with a reduction in the risk of death during readmission. Clinical condition, comorbidities, and patient preferences should guide surgical intervention rather than age alone, and existing guidelines for same-admission cholecystectomy should be more widely adopted.

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Conflict of interest/Disclosure

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Supplementary materials

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