Surgery for Gallstone Ileus: A Nationwide Comparison of Trends and Outcomes

Wissam J. Halabi, MD,∗ Celeste Y. Kang, MD,∗ Noor Ketana, BS,∗ Kelly J. Lafaro, MD,∗ Vinh Q. Nguyen, PhD,† Michael J. Stamos, MD,∗ David K. Imagawa, MD, PhD,∗ and Aram N. Demirjian, MD∗

Introduction: Gallstone ileus is a mechanical bowel obstruction caused by a biliary calculus originating from a bilioenteric fistula. Because of the limited number of reported cases, the optimal surgical method of treatment has been the subject of ongoing debate.

Methods: A retrospective review of the Nationwide Inpatient Sample from 2004 to 2009 was performed for gallstone ileus cases treated surgically by enterotomy with stone extraction alone (ES), enterotomy and cholecystectomy with fistula closure (EF), bowel resection alone (BR), and bowel resectionwith fistula closure (BF). Patient demographics, hospital factors, comorbidities, and postoperative outcomes were reported. Multivariate analysis was performed comparing mortality, morbidity, length of stay, and total cost for the different procedure types.

Results: Of the estimated 3,452,536 cases of mechanical bowel obstruction from 2004 to 2009, 3268 (0.095%) were due to gallstone ileus—an incidence lower than previously reported. The majority of patients were elderly women (>70%). ES was the most commonly performed procedure (62% of patients) followed by EF (19% of cases). In 19%, a bowel resection was required. The most common complication was acute renal failure (30.44% of cases). In-hospital mortality was 6.67%. On multivariate analysis, EF and BR were independently associated with higher mortality than ES [(odds ratio [OR] = 2.86; confidence interval [CI]: 1.16–7.07) and (OR = 2.96; CI: 1.26–6.96) respectively]. BR was also associated with a higher complication rate, OR = 1.98 (CI: 1.13–3.46).

Conclusions: Gallstone ileus is a rare surgical disease affecting mainly the elderly female population. Mortality rates appear to be lower than previously reported in the literature. Enterotomy with stone extraction alone appears to be associated with better outcomes than more invasive techniques.

Gallstone ileus is a mechanical bowel obstruction due to intraluminal intestinal occlusion by a biliary calculus.[1,2] This condition occurs when an inflamed gallbladder adheres to adjacent bowel forming a biliary-enteric fistula, which can allow gallstones to enter the gastrointestinal tract.[3–5] Although 25% to 72% of patients with gallstone ileus have a known history of cholelithiasis,[6–10] only 0.3% to 1.5% of patients with cholelithiasis will develop gallstone ileus.[2,7,11] It has previously been estimated that 1% to 5% of all cases of bowel obstruction are caused by this condition.[1,6,8,12,13]

The cornerstone of gallstone ileus management is surgery. Enterotomy with stone extraction should be performed urgently to relieve the obstruction. In some instances, firmly impacted stones can cause localized bowel necrosis, making segmental resection necessary.[4,12,14,15] However, there has been debate on whether the cholecystoenteric fistula should be approached during the initial procedure.[3,16]

Given the rare occurrence of this condition, available data consists of small case series accumulated over several decades with many disparities in diagnostic tools and management. As a result, a clear consensus on the optimal surgical intervention has not been reached. Moreover, most published series come from large, tertiarycare referral centers that may have a bias toward a specific surgical technique. Little is known about the incidence and trends of gallstone ileus as well as surgical outcomes at the national level.

This is a large retrospective review looking at the incidence and trends of gallstone ileus and its surgical management at the national level over a 6-year period. Outcomes of the various surgical approaches are compared.

METHODS

Patient Population

Using the Healthcare Cost and Utilization Project Nationwide Inpatient Sample (NIS) database, a retrospective analysis of cases with gallstone ileus that underwent surgical management was performed between January 1, 2004, and December 31, 2009. The NIS is the largest all-payer inpatient care database in the United States and contains information from nearly 8 million hospital stays each year across the country. The data set approximates a 20% stratified sample of American community, nonmilitary, nonfederal hospitals, resulting in a sampling frame that comprises approximately 95% of all hospital discharges in the United States. Researchers and policy makers can use the data set to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcomes. Data elements within the NIS are drawn from hospital discharge abstracts that allow determination of all procedures performed during a given hospitalization. Because NIS is a 20% stratified sample, national level estimates are obtained using a weighting coefficient provided by the database. National estimates and discharge information provided by the NIS correlate well with the numbers provided by the hospital discharge survey.[17] Approval for the use of the NIS patient-level data in this study was obtained from the institutional review board of the University of California—Irvine Medical Center and the NIS.

Inclusion Criteria

In our primary analysis, cases of gallstone ileus [International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9 CM) diagnosis code 560.31] admitted urgently or emergently who underwent surgical management were included. These were divided according to the most commonly performed surgical procedures for gallstone ileus. The choice of procedure types was based on previously published data.[4,9,15,18]

The following procedures performed for gallstone ileus were examined:

1. Group 1: Patients who underwent enterotomy and stone extraction alone (ES) (ICD-9 CM procedure codes: 45.00–45.03).

2. Group 2: Patientswho underwent enterotomy and cholecystectomy with fistula closure (EF) in a single-stage procedure (ICD-9 CM procedure codes: 46.72, 46.74, 46.76, 51.22, and 51.23).
3. Group 3: Patients who underwent bowel resection (BR) alone as a treatment for gallstone ileus without fistula closure (ICD-9 CM procedure codes: 45.6, 45.61, 45.62, 45.7, and 45.79).
4. Group 4: Patients who underwent bowel resection with fistula closure (BF) in a single stage procedure.

A secondary analysis was performed, which included cases with a previous history of gallstone ileus, who in the past had urgent surgery to relieve the obstruction and are now admitted electively for fistula closure. This group was listed separately and was not compared with the other 4 groups, because of the elective nature of the admission.

Exclusion Criteria

Gallstone ileus patients treated nonsurgically (endoscopic treatment or lithotripsy), or those who did not undergo any of the aforementioned surgical procedures, were excluded from our study as they may represent potential coding errors. Also, patients who died before surgery were excluded from our analysis, as our aim was to investigate surgical outcomes. Missing variables were excluded from our analysis as well. These include data on ethnicity, payer type, hospital characteristics, and discharge disposition.

Endpoints

The primary aim of our analysis was to compare surgical outcomes between the 4 different surgical procedures most commonly used in the management of gallstone ileus. Our primary endpoints of morbidity and mortality were chosen on a priori basis. *Morbidity* was defined as the occurrence of any of the following 11 different postoperative complications: cardiac complications, acute renal failure, respiratory failure, pneumonia, cerebrovascular accident (CVA), deep venous thrombosis (DVT), ileus/bowel obstruction, anastomotic leakage including intraperitoneal abscess, wound complications, urinary tract infection, and postoperative bleeding. These complications are provided by the NIS database. To make our analysis more comprehensive and increase the sensitivity of detecting all complications, we added ICD-9 codes that were not provided by NIS. Secondary endpoints included total hospital charge and length of hospital stay.

Study Variables

When examining trends, bowel obstruction cases in our data represent patients with a discharge diagnosis of hernia with obstruction, obstruction due to mass/cancer/strictures, postoperative adhesions, volvulus, and intussusception. These numbers were provided after multiplying them by a weighting coefficient provided by

NIS to reflect national estimates. Variables such as age, gender, race, and primary payer type, as well as comorbidities (provided by NIS) such as anemia, congestive heart failure, chronic lung disease, diabetes, hypertension, chronic liver disease, obesity, peripheral vascular disease, renal failure, valvular heart disease, weight loss, and malnutrition were examined. Hospital characteristics included hospital type (teaching vs nonteaching), location (urban vs rural), and size (small vs medium vs large). The use of laparoscopy in the surgical management of gallstone ileus, as well as the associated conversion rates, was also reported.

Statistical Analysis

All statistical analyses were conducted using SAS (Version 9.3) and theRStatistical Environment. Demographic and comorbidity data are summarized using mean and interquartile range for continuous variables, and counts and proportions for categorical variables. P values are not reported for these data as information from these variables are descriptive in nature. Formal statistical tests on these variables would have to take into account the inflation of the experiment wise type I error due to multiple comparisons. Thus, the reporting of P values would be misleading and therefore has been omitted. Multivariate logistic regression was used to compare mortality and morbidity between groups after controlling for age, gender, hospital factors, surgery type (laparoscopic vs open), and comorbid conditions. We performed a comorbidity adjustment based on the Van Walraven summary score of the Elixhauser comorbidity index19 to mitigate the reduction in power associated with the number of adjustment parameters. Odds ratios were obtained with 95% confidence intervals. Robust standard errors were used for inference.20 Holm's method was used to account for multiple comparisons in the form of adjusted P values.21 Multivariate logistic regression was performed comparing outcomes for groups 1, 2, and 3. Group 4 was excluded from the multivariate analysis because of the relatively small sample size.

RESULTS

From 2004 to 2009, an estimated 3268 patients underwent surgery for gallstone ileus in the United States. This represents a weighted number as the NIS data set provides number based on a 20% stratified sample of American community hospitals, resulting in a sampling frame of approximately 95% of all hospital discharges in the United States. The weighting coefficient provided by NIS is roughly equal to 5. Our unweighted sample size is 660. With the exceptions of Table 1 and Figure 1, which reflect national estimates, all statistics reported in this article are based on the unweighted sample.

To put things into perspective and illustrate the rare incidence of gallstone ileus, the estimated number of admissions for mechanical bowel obstruction over the 6-year period was provided. Gallstone ileus accounted for a very small percentage (0.095%) of the total number of mechanical bowel obstructions (Table 1). The number of gallstone ileus cases admitted per year remained relatively stable while the admissions for mechanical bowel obstruction cases showed an upward trend.

The most commonly performed procedure was enterotomy with ES, followed by EF closure, and BR alone and finally BF (Fig. 1). Patients in our sample were mostly

elderly, especially in groups 1 and 3, with females accounting for the vast majority of patients. This was true across all surgical groups. The majority of patients were white, and Medicare was the most common payer type in all groups. By using the Elixhausser–VanWalraven comorbidity score, we found that patients who underwent fistula closure (groups 2 and 4) had lower comorbidity scores when compared with patients in group 1 or group 3 (Table 2).

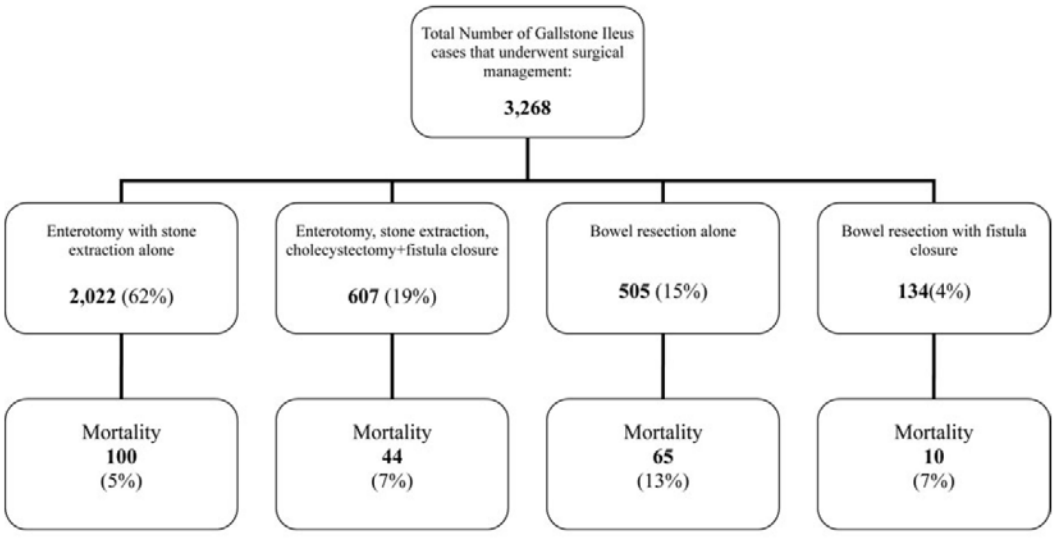
When looking at hospital factors, the majority of surgical cases were performed in nonteaching large and urban hospitals. This was seen for all procedure types (Table 3). Laparoscopy played a minor role in the surgical management of this disease, as it was only used in 10% of cases, and had a relatively high conversion rate (53.03%) to laparotomy. This conversion rate was highest in the EF group (76.92%) and lowest in ES group (37.84%) (Table 3).

Table 4 lists the total charge, length of hospital stay, postoperative complication rate, and in-hospital mortality rate in an unadjusted manner. The overall mortality rate was 6.67% for all surgical procedures. When stratified by gender, we found that mortality rates were similar: 7.65% for men and 6.25% for women. In-hospital mortality was also similar across teaching and nonteaching hospitals, 6.45% vs 6.82%, respectively.

TABLE 1. National Estimates* of Gallstone Ileus Cases That Underwent Surgery per Year and Yearly Admissions for Mechanical Bowel Obstruction in the United States According to the NIS Database

Year	2004	2005	2006	2007	2008	2009	Total
Gallstone ileus	501	507	639	482	496	643	3268
Mechanical bowel obstruction	533,471	548,362	557,681	572,669	619,781	620,572	3,452,536

*The NIS provides numbers based on a 20% stratified sample. National estimates are obtained using a weighting coefficient (approximately equal to 5) provided by NIS. National estimates correlate well with discharge data from the National Hospital Discharge Survey.



*National estimates are obtained using a weighting coefficient (approximately equal to 5) provided by NIS. National estimates correlate well with discharge data from the National Hospital Discharge Survey.

FIGURE 1. National estimates of cases and in-hospital mortality.

Looking at other outcomes such as length of stay, we observed that the median length of stay was long, with 12 days for groups 1 and 4, and even longer for groups 2 and 3 (Table 4). Among postoperative complications, acute renal failure was the most common in all surgical groups with a combined total of 30.45%. This was followed by urinary tract infection (13.79%), Ileus (12.42%), and anastomotic leak/intraabdominal abscess/enteric fistula (12.27%). Wound infections were observed in 7.73% of cases.

After adjusting for age, gender, hospital factors, surgery type, and comorbidity adjustment based on the Walraven summary score, group 3 patients appeared to have an associated twofold increase in the odds for the development of any surgical complication (odds ratio = 1.98, 95% confidence interval: 1.13–3.46)when compared with group 1. We also observed a tendency toward higher total hospital charge in patients who underwent EF (group 2) than in patients undergoing ES only (group 1). We also noticed a statistically significant higher length of stay in group 2 than in Group 1. There was no difference in length of hospital stay between patients in groups 1 and 3.

We noted that fistula closure, when performed emergently or urgently during the initial procedure, was independently associated with a higher mortality rate than enterotomy and stone extraction alone. When bowel resection was necessary (group 3), it was also independently associated with a higher mortality rate than enterotomy alone. Table 5 lists the adjusted odds ratios with 95% confidence intervals for the 2 primary and 2 secondary endpoints.

Among patients who survived any type of surgery for gallstone ileus, 39.28% were discharged home without ancillary services, 29.71% went to short-term nursing facility or hospice and 14.28% with home health. The remaining patients had missing information on discharge disposition.

We performed a secondary analysis independent of our main analysis aiming at identifying cases of gallstone ileus admitted electively for fistula closure and cholecystectomy. We identified 34 cases: 11 men (32.35%) and 23 women (67.65%). Patients in this group were younger with a mean age of 60, compared with the emergent groups. They also had a lower incidence of comorbidities with a mean comorbidity score of 2.53, reflecting a higher performance status. The mean length of hospital stay was 8 days (range: 3–12), and the mean hospital charge US $46,221 (22,626–67,917). The following postoperative complications occurred: CVA (2.94%), wound complications (2.94%), anastomotic leak and abscess (2.94%), pneumonia (2.94%), urinary tract infection (2.94%), postoperative bleeding (2.94%), respiratory failure (5.88%), cardiac complications (5.88%), and acute renal failure (11.76%). In-hospital mortality was low as well (2.94%).

DISCUSSION

Gallstone ileus is caused by the passage of a stone through a cholecystoenteric fistula and subsequently causing a bowel obstruction. The fistula is usually located between the gallbladder and the duodenum, and the site of obstruction is usually the terminal ileum.[6,9–11,14,22–25] Although this is a rare disease with 1001 reported cases in the 20th century literature,26 many cases are probably underreported as we have shown 3268 surgical cases for gallstone ileus in a 6-year period in the United States. This number may even be an underestimate of the true incidence of the disease as we excluded

patients who died before surgery and patients who were treated conservatively without surgery, allowing spontaneous passage of the stone.[9,18,23,27] We also excluded patients who were treated with endoscopic or colonoscopic techniques and with lithotripsy.[23,27]

Historically, gallstone ileus was found to be the cause in 1% to 5% of mechanical bowel obstructions.[1,6,8,12,13] Our data show that gallstone ileus actually accounts only for 0.095% of mechanical bowel obstruction in the United States, a much lower percentage than previously thought. Despite an aging population [28] that theoretically is at higher risk for developing a condition like gallstone ileus, the number of cases per year does not appear to be increasing. This expected increase may be offset by the escalating numbers of laparoscopic cholecystectomies performed yearly.[29]

Gallstone ileus is a disease that predominantly affects elderly women,∗ (∗References 2, 5, 6, 9–12, 18, 22, 25, 30) a fact confirmed by our nationwide data analysis.† (†References 2, 5, 6, 9–12, 18, 22, 25, 31) Gender predominance likely comes from the fact that women are more prone to developing gallstones.[30] Elderly patients with gallstone ileus represent a medical challenge because of their multiple comorbidities. Our data is in agreement with previously published reports regarding this fact.[5,16,22] The calculated Elixhauser–Van Walraven score was relatively high across all groups, which indicates a sick patient population at high risk for mortality and postoperative complications.

TABLE 2. Patients Characteristics, Comorbidities, and Comorbidity Scores in the Different Surgical Groups

	ES	EF	BR	BF
Number*	409	123	101	27
Age, yrs	75 (67–83)	70 (60–81)	76 (70–84)	72 (68–82)
Gender, %				
Male	29.10	30.08	32.67	25.93
Female	70.90	69.92	67.33	74.07
Ethnicity, %				
White	63.33	60.16	61.39	66.67
African-American	4.65	1.63	3.96	3.70
Hispanic	6.36	12.20	2.97	3.70
Asian/Pacific Islander	1.71	0	2.97	0
Native American	0.24	0	1.98	0
Other	3.18	0.81	1.98	0
Missing	20.54	25.20	24.75	25.93
Primary payer, %				
Medicare	63.08	49.59	71.29	74.07
Medicaid	1.96	4.07	0.99	3.70
Private including HMO	12.96	21.95	14.85	18.52
Self-pay	3.18	6.50	1.98	0
No charge	0.98	0.81	0	0
Other	0.24	2.44	0	0
Missing	17.60	14.63	10.89	3.70
Comorbidities, %				
Congestive heart failure	14.18	5.69	17.82	14.81
Valvular disease	6.36	1.63	7.92	3.70
Chronic pulmonary disease	14.43	7.32	13.86	18.52
Chronic liver disease	1.47	3.25	0.99	3.70
Chronic kidney disease	10.27	4.88	6.93	3.70
Anemia	12.47	11.38	19.80	3.70
Diabetes	23.71	23.88	17.82	14.81
Hypertension	56.97	49.59	55.45	44.44
Obesity	7.82	8.13	7.92	3.70
Peripheral vascular disorders	5.13	1.63	5.94	7.41
Weight loss	13.20	13.82	10.89	14.81
Comorbidity scores†	6.00 (1.00–10.00)	4.83 (0.00–7.00)	6.23 (3.00–9.00)	5.85 (0.00–10.50)

*Numbers listed are based on the 20% stratified sample and are thus unweighted.
†Comorbidity scores are based on the Elixhauser–Van Walraven model.

TABLE 3. Hospital Characteristics, Use of Laparoscopy, and Mean Duration From Admission to Procedure Day for Each Group

	ES	EF	BR	BF
Number*	409	123	101	27
Hospital type, %				
Nonteaching	54.52	65.85	60.40	59.26
Teaching	45.48	34.15	39.60	40.74
Hospital location, %				
Urban	87.29	80.49	88.12	88.89
Rural	12.71	19.51	11.88	11.11
Hospital bed size, %				
Small	12.47	8.13	12.87	7.41
Medium	24.45	21.95	17.82	44.44
Large	45.48	55.28	58.42	44.44
Missing	17.60	14.63	10.89	3.70
Surgery type, %				
Open	90.95	89.43	89.11	81.48
Laparoscopic	9.05	10.57	10.89	18.52
Conversion rates	37.83	76.92	36.36	60
Procedure day	2 (0–3)	3 (0–4)	2 (0–4)	2 (0–3)

*Numbers listed are based on the 20% stratified sample and are thus unweighted.

TABLE 4. Summary of Surgical Outcomes by Group

	ES	EF	BR	BF
Number*	409	123	101	27
Total charge, $	72,556 (29,294–84,623)	91,190 (40,401–104,192)	78,889 (35,747–91,175)	85,143 (42,317–88,325)
Length of stay, d	12 (7–14)	14 (9–15)	13 (8–15)	12 (8–14)
Postoperative complications				
CVA	0.49	0	0	0
Cardiac complications	3.67	3.25	2.97	0
Respiratory failure	8.31	8.94	14.85	7.41
Pneumonia	8.31	6.50	8.91	3.70
Ileus/Bowel obstruction	11.98	12.20	13.86	14.81
Anastomotic leak and peritoneal abscess	10.27	16.26	18.81	0
Acute renal failure	29.58	26.83	38.61	29.63
Urinary tract infection	15.16	10.57	13.86	7.41
Urinary retention	2.44	0	0.99	0
DVT	1.22	0.81	0.99	0
Bleeding	1.96	0	1.98	3.70
Wound complications	7.33	8.94	7.92	7.41
In-hospital mortality	4.89	7.32	12.87	7.41
Male	5.88	8.11	12.12	14.29
Female	4.48	6.98	13.24	5.00
Teaching	5.91	0	15.00	9.09
Nonteaching	4.04	11.11	11.48	6.25
Urban	5.32	9.09	13.48	8.33
Rural	1.92	0	8.33	0

*Numbers listed are based on the 20% stratified sample and are thus unweighted.

TABLE 5. Adjusted Odds Ratios for Mortality and Morbidity and Mean Difference for Total Charge and Length of Stay

	Adjusted Odds Ratio/Mean Difference (95% Confidence Interval)	Naive *P* Value	Adjusted *P* Value
Total charge, $			
Group 2 vs Group 1	31,532.78 (7,372.62, 55,692.95)	0.01	0.07
Group 3 vs Group 1	6,770.81 (−9,664.36, 23,205.97)	0.42	1
Length of stay, d			
Group 2 vs Group 1	3.68 (1.59, 5.76)	<0.01	<0.01
Group 3 vs Group 1	0.13 (−1.51, 1.77)	0.88	1
In-hospital mortality			
Group 2 vs Group 1	2.86 (1.16, 7.07)	0.02	0.09
Group 3 vs Group 1	2.96 (1.26, 6.96)	0.01	0.08
Morbidity			
Group 2 vs Group 1	1.16 (0.71, 1.91)	0.55	1
Group 3 vs Group 1	1.98 (1.13, 3.46)	0.02	0.08

Historically, wound infections and dehiscence have been cited as being the most common complications after surgery in 25% to 50% of gallstone ileus cases.∗ (∗References 2, 5, 6, 8–10, 14, 15, 22, 25, 26, 31) This is due to the spillage of enteric content during enterotomy and stone extraction, and because in a significant number of cases, patients did not receive preoperative or postoperative antibiotics.9 In contrast to what has been published so far, the most common postoperative complication in our data was acute renal failure, followed by urinary tract infection. Wound infections occurred less frequently than other complications such as gastrointestinal complications related to anastomotic leaks and intraabdominal abscesses, which were the highest in patients undergoing enterotomy with fistula closure.

Mortality rates for gallstone ileus have been notoriously high. Mortality rates greater than 60% were recorded before 1925.[13] Later reports from the 1960s to the early 2000s reported mortality rates ranging from 7% to 30%∗ (∗References 2, 4, 7–9, 12, 14–16, 18, 22, 24, 32–37) with an average mortality rate of 18%. The high mortality rate seen previously was not only due to advanced age and associated comorbidities but also due to delayed presentation. Gallstone ileus presents with waxing and waning symptoms caused when the stone obstructs, becomes free, and moves distally to reobstruct—the so-called “tumbling obstruction.” Patients thus presented with symptoms occurring 4 to 8 days before presentation.[2,8–10,14,18] In addition, delayed diagnosis occurred as plain x-rays and barium studies were mainly used for diagnosis before 1990. These studies had a reported accuracy rate of diagnosis of 40%.[8,22] The lower mortality in our data is probably attributed to earlier diagnosis and management. Patients in our data had surgery within 2 to 3 days of admission. This short delay before surgery is needed for fluid and electrolyte resuscitation and attention to concomitant medical conditions. Moreover, the liberal use of CT scans with an overall sensitivity, specificity, and diagnostic accuracy of 93%, 100%, and 99%,[38] respectively, and ultrasound techniques has shortened the time needed to make a diagnosis.

It is interesting to see that laparoscopy was attempted in 10% of cases. The use of laparoscopy in the management of gallstone ileus has been previously described and was shown to have lower incidence of major complications[39–42] and acceptable conversion

rates of 11%.[41] The data, however, is limited to case reports or small case series in highly selected patients. Our data shows that laparoscopy is associated with high conversion rates, especially when fistula closure is attempted. The role of laparoscopy is not clearly defined at this time but its use should be limited to cases where only a simple enterotomy and stone extraction are needed.

The rarity of the disease probably explains the controversy in its surgical management given the limited experience and the small series of patients. Up until the early 1960s, reports had warned against fistula closure at the time of initial surgery because of the high morbidity and mortality associated with extensive surgery in an elderly population.[1,43,44] Later reports from the mid 1960s to the 2000s[6,7,14,16,24,35,36,45] advocated fistula closure as a feasible option during the initial operation because of the higher risk of cholangitis and gallbladder cancer in patients with a patent fistula.[14,45] Also, fistula closure would prevent recurrence, which has been reported to be as high as 8.3%.46 Even those favoring fistula closure at the time of initial surgery advocate it only for patients who are good operative candidates, and who do not have severe right upper quadrant inflammation or dense fibrous adhesions.[9,47] Proponents of enterotomy and stone extraction alone argue that closure of the fistula can be technically difficult and healing can be impaired in the elderly patients.∗ (∗References 4, 5, 8, 10, 15, 18, 22, 25, 32, 34, 37, 48.) Moreover, the fistula may not be able to be identified intraoperatively and few patients experience biliary colic or cholecystitis and an even smaller number will require surgery. Spontaneous closure of the fistula can occur in cases of a stone-free gallbladder and open
cystic duct.[4,6,8,49,50] Others have found no risk of cancer after leaving the fistula open.[4] This has led some controversy in the surgical community.

In the largest published review of gallstone ileus, Reisner and Cohen[26] found a small mortality difference in favor of enterotomy and stone extraction alone; however, their analysis was performed without adjusting for comorbid conditions. Our data shows that even after adjusting for patient and hospital factors, performing the fistula closure at the time of the initial procedure is not only independently associated with a higher mortality when compared with enterotomy and stone extraction alone, it is also associated with a longer length of hospital stay and higher overall hospital charge. Thus, our findings provide a clearer answer as to which surgical approach should be chosen. Our data also shows that fistula closure on an elective basis, in relatively younger and healthier patients, is feasible and is associated with low morbidity, mortality, and shorter length of stay, which is in agreement with previous reports.[6] However, because of the limitation of our database and the inability to track individual patients, we were unable to determine the percentage of patients that subsequently required a fistula closure on an elective basis.

Patients undergoing small bowel resection at the time of the initial surgery appear to have higher mortality and morbidity rates than those undergoing enterotomy and stone extraction alone. Stones at least 2.5 cm in diameter can lead to obstruction.[10,24,25] These can cause spasm of the bowel wall leading to necrosis and subsequent peritonitis,[10,12,15] which likely explains the high mortality in this group. Higher mortality rates in patients undergoing small bowel resection was also observed by others and found to be as high as 66%[14,15] suggesting that time is of the essence, and early intervention should be made to avoid bowel ischemia and a bowel resection.

Regardless of the surgical technique employed, careful and thorough examination of the entire small bowel should be performed as multiple stones can occur in up to 25% of patients.[9,10,12] Also, if other stones are suspected, some authors advocate the use of intraoperative ultrasound46 or palpation of the gallbladder for additional stones.1 This will likely reduce recurrent gallstones. Most recurrences reported in the literature occur in the first 3 months and are usually due to stones missed during initial surgery.[46,51–53]

Limitations

Our study has several limitations. The main limitation lies in its retrospective nature and its inherent biases. Coding errors exist due to the use of discharge data using ICD-9 codes.[54,55] However, these limitations are likely to affect all groups. NIS does not provide specific information such as surgeons' experience. Most surgeons have dealt or will only deal with a fewcases of gallstone ileus in their career. NIS does not contain long-term data. Patients who underwent an enterotomy and stone extraction initially could present with a recurrence. The inability to track patients over time did not allow us to determine the number of patients who were initially treated with enterotomy and stone extraction alone who required subsequent surgery directed at the gallbladder. The NIS database has no information available on complications, reoperations, and readmissions after discharge. Mortality rates can be underestimated as the NIS only gives information about in-hospital mortality whereas the 30-day mortality rate remains unknown. This limitation is, however, likely to affect all groups. Nevertheless, the main objective of our study was to compare outcomes among different surgical techniques.

CONCLUSIONS

Gallstone ileus is a rare condition affecting mainly the older population with a female predominance. Its incidence, which was stable over the study period, has been underreported, and this study represents the largest and the only population-based report on this condition. Despite lower mortality rates than previously reported mainly due to improvement in diagnostic techniques and more efficient management, it still carries a significant morbidity and mortality. Early recognition before bowel necrosis, and treatment with enterotomy and stone extraction alone, should be advocated in most cases as this carries a lower mortality rate as compared with segmental bowel resection and the 1-stage procedure, which includes fistula closure. The latter should be undertaken in highly selected patients, and only on an elective basis.

REFERENCES

1. Buetow GW, Crampton RS. Gallstone ileus: a report of 23 cases. Arch Surg. 1963;86:504–511.
2. Kurtz RJ, Heimann TM, Kurtz AB. Gallstone ileus: a diagnostic problem. Am J Surg. 1983;146:314–317.
3. Fitzgerald JE, Fitzgerald LA, Maxwell-Armstrong CA, et al. Recurrent gallstone ileus: time to change our surgery? J Dig Dis. 2009;10:149–151.
4. Raf L, Spangen L. Gallstone ileus. Acta Chir Scand. 1971;137:665–675.

5. Rodriguez-Sanjuan JC, Casado F, Fernandez MJ, et al. Cholecystectomy and fistula closure versus enterolithotomy alone in gallstone ileus. Br J Surg. 1997;84:634–637.
6. Clavien PA, Richon J, Burgan S, et al. Gallstone ileus. Br J Surg. 1990;77:737–742.
7. Kasahara Y, Umemura H, Shiraha S, et al. Gallstone ileus: review of 112 patients in the Japanese literature. Am J Surg. 1980;140:437–440.
8. Andersson A, Zederfeldt B. Gallstone ileus. Acta Chir Scand. 1969;135:713–717.
9. Deitz DM, Standage BA, Pinson CW, et al. Improving the outcome in gallstone ileus. Am J Surg. 1986;151:572–576.
10. Heuman R, Sjodahl R,Wetterfors J. Gallstone ileus: an analysis of 20 patients. World J Surg. 1980;4:595–598.
11. Brockis JG, Gilbert MC. Intestinal obstruction by gall-stones: a review of 179 cases. Br J Surg. 1957;44:461–466.
12. Fiddian RV. Gall-stone ileus: recurrences and multiple stones. Postgrad Med J. 1959;35:673–676.
13. Vick RM. Statistics of acute intestinal obstruction. Br Med J. 1932;2:546–548.
14. Day EA, Marks C. Gallstone ileus: review of the literature and presentation of thirty-four new cases. Am J Surg. 1975;129:552–558.
15. Svartholm E, Andren-Sandberg A, Evander A, et al. Diagnosis and treatment of gallstone ileus: report of 83 cases. Acta Chir Scand. 1982;148:435–438.
16. Kirchmayr W, Muhlmann G, Zitt M, et al. Gallstone ileus: rare and still controversial. ANZ J Surg. 2005;75:234–238.
17. HCUP.Healthcare Cost and Utilization Project—Nationwide inpatient Sample 2012. http://www.hcup-us.ahrq.gov/. Accessed December 24, 2012.
18. Hesselfeldt P, Jess P. Gallstone ileus: a review of 39 cases with emphasis on surgical treatment. Acta Chir Scand. 1982;148:431–433.
19. vanWalraven C, Austin PC, Jennings A, et al. A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data. Med Care. 2009;47:626–633.
20. Huber PJ. The behavior of maximum likelihood estimates under nonstandard conditions. In: Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability. Berkeley, CA: University of California Press; 1967:221–233.
21. Holm S.Asimple sequentially rejectivemultiple test procedure. Scand J Statist. 1979;6:65–70.
22. van Hillo M, van der Vliet JA, Wiggers T, et al. Gallstone obstruction of the intestine: an analysis of ten patients and a review of the literature. Surgery. 1987;101:273–276.
23. Nakao A, Okamoto Y, Sunami M, et al. The oldest patient with gallstone ileus: report of a case and review of 176 cases in Japan. Kurume Med J. 2008;55:29–33.
24. Cooperman AM, Dickson ER, ReMineWH. Changing concepts in the surgical treatment of gallstone ileus: a review of 15 cases with emphasis on diagnosis

and treatment. Ann Surg. 1968;167:377–383.
25. Syme RG. Management of gallstone ileus. Can J Surg. 1989;32:61–64.
26. Reisner RM, Cohen JR. Gallstone ileus: a review of 1001 reported cases. Am Surg. 1994;60:441–446.
27. Fujita N, Noda Y,KobayashiG, et al. Gallstone ileus treated by electrohydraulic lithotripsy. Gastrointest Endosc. 1992;38:617–619.
28. Alpert JS. Changing US and world demographics: consequences for the practice of medicine. Am J Med. 2012;125:427–428.
29. Csikesz NG, Tseng JF, Shah SA. Trends in surgical management for acute cholecystitis. Surgery. 2008;144:283–289.
30. Stinton LM, Shaffer EA. Epidemiology of gallbladder disease: cholelithiasis and cancer. Gut Liver. 2012;6:172–187.
31. Riaz N, Khan MR, Tayeb M. Gallstone ileus: retrospective review of a single centre's experience using two surgical procedures. Singapore Med J. 2008;49:624–626.
32. Deckoff SL. Gallstone ileus; a report of 12 cases. Ann Surg. 1955;142:52–65.
33. Fox PF. Planning the operation for cholecystoenteric fistula with gallstone ileus. Surg Clin N Am. 1970;50:93–102.
34. Kvist E.Gallstone ileus: a retrospective study. Acta Chir Scand. 1979;145:101–103.
35. VanLandingham SB, Broders CW. Gallstone ileus. Surg Clin N Am. 1982; 62:241–247.
36. Warshaw AL, Bartlett MK. Choice of operation for gallstone intestinal obstruction. Ann Surg. 1966;164:1051–1055.
37. Whitesell FB, Jr. Gallstone ileus. Am Surg. 1970;36:317–322.
38. Yu CY, Lin CC, Shyu RY, et al. Value of CT in the diagnosis and management of gallstone ileus. World J Gastroenterol. 2005;11:2142–2147.
39. Shiwani MH, Ullah Q. Laparoscopic enterolithotomy is a valid option to treat gallstone ileus. JSLS. 2010;14:282–285.
40. Franklin ME, Jr, Dorman JP, Schuessler WW. Laparoscopic treatment of gallstone ileus: a case report and review of the literature. J Laparoendosc Surg. 1994;4:265–272.
41. Moberg AC, Montgomery A. Laparoscopically assisted or open enterolithotomy for gallstone ileus. Br J Surg. 2007;94:53–57.
42. Soto DJ, Evan SJ, Kavic MS. Laparoscopic management of gallstone ileus. JSLS. 2001;5:279–285.
43. Jenkins HP, Evans R, Kollert W. Gallstone ileus. Surg Clin N Am. 1961;41:71–81.
44. Raiford TS. Intestinal obstruction due to gallstones. (Gallstone ileus). Ann Surg. 1961;153:830–838.
45. Berliner SD, Burson LC. One-stage repair for cholecyst-duodenal fistula and gallstone ileus. Arch Surg. 1965;90:313–316.
46. Doogue MP, Choong CK, Frizelle FA. Recurrent gallstone ileus: underestimated. Aust N Z J Surg. 1998;68:755–756.
47. Doromal NM, Estacio R, Sherman H. Cholecysto-duodeno-colic fistula with gallstone ileus: report of a case. Dis Colon Rectum. 1975;18:702–705.

48. Muthukumarasamy G, Venkata SP, Shaikh IA, et al. Gallstone ileus: surgical strategies and clinical outcome. J Dig Dis. 2008;9:156–161.
49. Abou-Saif A, Al-Kawas FH. Complications of gallstone disease: Mirizzi syndrome, cholecystocholedochal fistula, and gallstone ileus. Am J Gastroenterol. 2002;97:249–254.
50. Wright PJ, Trafford PA. Gallstone ileus. Br J Surg. 1953;41:6–8.
51. Buetow GW, Glaubitz JP, Crampton RS. Recurrent gallstone ileus. Surgery. 1963;54:716–724.
52. Hussain Z, Ahmed MS, Alexander DJ, et al. Recurrent gallstone ileus. Ann R Coll Surg Engl. 2010;92:W4–6.
53. Ulreich S, Massi J. Recurrent gallstone ileus. AJR Am J Roentgenol. 1979; 133:921–923.
54. Campbell SE, Campbell MK, Grimshaw JM, et al. A systematic review of discharge coding accuracy. J Public Health Med. 2001;23:205–211.
55. Lorence DP, Ibrahim IA. Benchmarking variation in coding accuracy across the United States. J Health Care Finance. 2003;29:29–42.

∗Department of Surgery, University of California—Irvine School of Medicine; and
†Department of Statistics, University of California—Irvine, Irvine, CA.
Disclosure: The authors declare no conflicts of interest.
Reprints: Aram N. Demirjian, MD, Department of Surgery, University of California—Irvine Medical Center, 333 City Boulevard West, Suite 1205, Orange, CA 92868. E-mail: a.demirjian@uci.edu.