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RAPID COMMUNICATION

Factors associated with time to laparoscopic cholecystectomy for acute cholecystitis

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Abstract

AIM: To determine patient and process of care factors associated with performance of timely laparoscopic cholecystectomy for acute cholecystitis.

METHODS: A retrospective medical record review of 88 consecutive patients with acute cholecystitis was conducted. Data collected included demographic data, co-morbidities, symptoms and physical findings at presentation, laboratory and radiological investigations, length of stay, complications, and admission service (medical or surgical). Patients not undergoing cholecystectomy during this hospitalization were excluded from analysis. Hierarchical generalized linear models were constructed to assess the association of pre-operative diagnostic procedures, presenting signs, and admitting service with time to surgery.

RESULTS: Seventy cases met inclusion and exclusion criteria, among which 12 were admitted to the medical service and 58 to the surgical service. Mean ± SD time to surgery was 39.3 ± 43 h, with 87% of operations performed within 72 h of hospital arrival. In the adjusted models, longer time to surgery was associated with number of diagnostic studies and endoscopic retrograde cholangio-pancreatography (ERCP, $P = 0.01$) as well with admission to medical service without adjustment for ERCP ($P < 0.05$). Patients undergoing both magnetic resonance cholangiopancreatography (MRCP) and computed tomography (CT) scans experienced the longest waits for surgery. Patients admitted to the surgical versus medical service underwent surgery earlier (30.4 ± 34.9 *vs* 82.7 ± 55.1 h, $P < 0.01$), had less post-operative complications (12% *vs* 58%, $P < 0.01$), and shorter length of stay (4.3 ± 3.4 *vs* 8.1 ± 5.2 d, $P < 0.01$).

CONCLUSION: Admission to the medical service and performance of numerous diagnostic procedures, ERCP, or MRCP combined with CT scan were associated with longer time to surgery. Expeditious performance of ERCP and MRCP and admission of medically stable patients with suspected cholecystitis to the surgical service to speed up time to surgery should be considered.

Key words: Acute cholecystitis; Laparoscopic cholecystectomy; Endoscopic retrograde cholangiopancreatography; Post-operative complications

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INTRODUCTION

Nearly 700 000 cholecystectomies are performed in the United States annually, making it the most commonly performed operation on the digestive tract[1,2]. The optimal timing for the performance of laparoscopic cholecystectomy (LC) in the subset of patients with acute cholecystitis has been a point of much discussion. Initially there was concern about potential dangers of performing an operation on an acutely inflamed gallbladder with instruments that lacked the feedback, dexterity, and precision of human hands[3,4]. Studies within the past ten years, however, have determined that laparoscopic cholecystectomy for patients with acute cholecystitis within three days of admission is not only safe but also associated with fewer post-operative complications, decreased morbidity, decreased length of hospital stay, and decreased overall cost when compared to delayed or interval LC[5-9]. Cognizance of the general preferability of prompt surgery, however, may not be uniform among all caretakers. Hence, we examined the time to laparoscopic cholecystectomy in our institution. In order to help identify potential areas for improvement in current management, we also examined the association of presenting signs, pre-operative imaging studies and procedures, and admitting service (medicine versus surgery) with time to operation.

MATERIALS AND METHODS

We performed a retrospective medical record review of patients identified by a primary or secondary discharge diagnosis of acute cholecystitis (ICD codes 575.0, 575.10, 575.11 and 575.12) at Norwalk Hospital between March 2003 and December 2005. The diagnosis of acute cholecystitis was made at the time of surgery by experienced biliary surgeons and confirmed by acute inflammatory changes being found on pathologic examination[10]. Patients not undergoing cholecystectomy during this hospitalization were excluded from analysis. Data collected included age, sex, symptoms and physical findings, laboratory and radiological investigations performed, co-morbidities, time from arrival to the hospital to operation, admission service, complications, and length of stay (LOS). Patients presenting with discharge diagnosis of acute cholecystitis but not undergoing cholecystectomy during the hospitalization were excluded.

In order to help account for the contributions of pre-operative comorbid illnesses to the measured outcomes, we classified co-morbidities as none, minor (abnormal electrocardiogram (ECG), rhythm other than sinus, low functional capacity, history of stroke, uncontrolled hypertension), intermediate (mild angina, previous myocardial infarction, compensated or prior heart failure, diabetes mellitus, renal insufficiency), or major (unstable coronary syndromes, decompensated heart failure, significant arrhythmias, severe valvular disease) following the criteria by American Heart Association/American College of Cardiology (AHA/ACC) for cardiovascular risk[11]. An abnormal ECG is one indicating left ventricular hypertrophy, left bundle branch block, ST-T abnormalities. Advanced age is also listed in the AHA/ACC criteria as a minor clinical predictor but is undefined. For this study, it was arbitrarily designated as > 75 years old. Liver cirrhosis, which is not included in the AHA/ACC criteria, was added as a major peri-operative risk factor because it is known to increase post-operative mortality[12,13].

Post-operative complications were defined as newly arising occurrences related to the patient's surgical disease or management that prolonged length of stay or required treatment. Complications were categorized as mild (e.g., urinary tract abnormalities, prolonged ileus, prolonged biliary drainage), moderate (e.g., systemic inflammatory response, deep wound infection), and severe (e.g., death, respiratory failure requiring intubation, myocardial infarction)[14].

Statistical analysis

Descriptive analysis was performed for baseline demographic and clinical characteristics. Because of the natural clustering of the observations within physicians/surgeons, we employed a hierarchical generalized linear modeling approach to compare the risk-adjusted mean differences in "time-to-operation" and to obtain the posterior distribution of the true effect size upon change of time by the design variables admission team, pre-operative diagnostic imaging studies, and select physical and laboratory signs indicative of cholecystitis or an inflammatory state (Murphy's sign, temperature > 37.8℃, WBC > 10 200/UL)[15]. Other physical signs indicative of cholecystitis were excluded from the analysis because of infrequency or lack of specificity. This statistical approach accounts for within-physician/surgeon correlation of the observed outcomes and separates within-physician/surgeon variation from between-physician/surgeon variation.

Our aim was not to develop a predictive model but rather to determine the influence of different values of design variables on the change in time-to-surgery with and without controlling for patient characteristics. Thus, the first model was fitted without adjusting for any patient characteristics. The second model adjusted for patient demographics, including age and gender, the third model adjusted for patient demographics, and co-morbidity. The 95% credible interval (CI) was also calculated for each estimate obtained from the models. All of the statistical analyses were conducted using STATA version 8.0 (STATA Corporation, College Station, TX) and SAS version 8.12 (SAS Institute Inc. Cary, NC).

RESULTS

A total of 88 patient charts with the discharge diagnosis of acute cholecystitis were reviewed. In six patients the pathology report did not confirm a diagnosis of acute cholecystitis, and it was concluded that they suffered from biliary colic. An additional 12 patients were discharged without cholecystectomy and were also felt to have had biliary colic rather than acute cholecystitis. These 18 patients were excluded from analysis, yielding a study population of 70 patients. The mean ± SD age was 53 ± 17.3 years. The majority of patients (69%) had no recognized peri-operative co-morbidities (Table 1). Among those with co-morbidities, 16% were classified as minor, 13% were intermediate, and 3% were major. All but one patient presented with abdominal pain and nearly all (89%) had right upper quadrant tenderness on examination. Murphy's sign, considered to be a relatively specific sign in cholecystitis, was present in only one-quarter of the patients. Fever (> 37.8℃ and leukocytosis), which together with Murphy's sign comprise the diagnostic triad for acute cholecystitis, was present in only 23% and 51% of patients, respectively. Guarding was noted in 11% and rebound tenderness was detected in one patient.

Eleven patients presented with aspartate amino-transferase (AST) and alanine aminotransferase (ALT) greater than three times the upper normal limit and 2 (18%) required pre-operative ERCP for stone extraction. Two other patients had pre-operative ERCP performed because of common bile duct dilatation identified on CT scan. All ERCP examinations were therapeutic, removing stones from the common bile duct via sphincterotomy. Three additional patients required post-operative ERCP for retained stones.

The majority of patients were admitted to the surgical

Table 1 Patient characteristics *n* (%)

	Medical service *n* = 12	Surgical service *n* = 58	Total *n* = 70	*P* value
Mean age (range)	66 (38-89)	52 (20-83)	53 (20-89)	< 0.05
Age > 75 yr	5 (42)	7 (12)	12 (17)	
Sex				
Male	5 (42)	25 (43)	30 (43)	
Female	7 (58)	33 (57)	40 (57)	
Co-morbidities				< 0.05
None	4 (33)	44 (76)	48 (69)	
Minor	4 (33)	7 (12)	11 (16)	
Abnormal ECG	8 (67)	16 (28)	24 (34)	
Rhythm other than sinus	5 (42)	2 (3)	7 (10)	
Poor functional capacity	5 (42)	4 (69)	9 (13)	
History of stroke	0 (0)	3 (5)	3 (4)	
Intermediate	4 (33)	5 (9)	9 (13)	
Prior MI	3 (25)	3 (5)	6 (8)	
Compensated or prior CHF	2 (17)	0 (0)	2 (3)	
Diabetes mellitus	2 (17)	5 (9)	7 (10)	
Major	0 (0)	2 (3)	2 (3)	
Liver cirrhosis	0 (0)	2 (3)	2 (3)	
Physical examinaition				
WBC > 10.2	7 (58)	29 (50)	36 (51)	
Murphy's sign	4 (33)	15 (26)	19 (27)	
Temp > 37.8℃	2 (17)	14 (24)	16 (23)	

ECG: Electrocardiogram; MI: Myocardial infarction; CHF: Compensated heart failure.

Table 2 Hospital course *n* (%)

	Medical service *n* =12	Surgical service *n* = 58	Total *n* = 70	*P* value
Tests done				
Ultrasound	9 (75)	44 (76)	53 (76)	
CT scan	9 (75)	24 (41)	33 (47)	< 0.05
HIDA scan	4 (33)	12 (21)	16 (23)	
MRI/MRCP	1 (8)	1 (2)	2 (3)	
ERCP	4 (33)	3 (5)	7 (10)	
Time to surgery				
Mean time to operation, h (SD)	82.7 (55.1)	30.4 (34.9)	39.3 (43.4)	< 0.01
Operation within 3 d	7 (58)	54 (93)	61 (87)	< 0.01
Operation within 1 d	2 (17)	34 (59)	36 (51)	< 0.01
Length of stay				
Mean, D (SD)	8.1 (5.2)	4.3 (3.4)	5.0 (3.9)	< 0.01
3 d or less	2 (17)	30 (52)	32 (46)	< 0.05
6 d or more	8 (67)	11 (19)	19 (27)	< 0.01
Conversion to open	1 (8)	3 (5)	4 (6)	
post-operative complications	7 (58)	7 (12)	14 (23)	< 0.01
Mild	4 (33)	5 (9)	9 (13)	
Moderate	2 (17)	3 (5)	5 (7)	
Severe	1 (8)	1 (2)	2 (3)	

HIDA: Nuclear Hepatobiliary scan; MRI: Magnetic resonance imaging ERCP: Endoscopic retrograde cholangiopancreatography; MRCP: Magnetic resonance cholangiopancreatography.

service (83%) (Tables 1 and 2). Patients admitted to the medical service were significantly older (66 years *vs* 52 years, $P < 0.05$), and had more minor and intermediate, but not severe, peri-operative cardiovascular risk factors ($P < 0.05$), including diabetes mellitus, prior heart failure, and age > 75 years. Other non-cardiovascular comorbid conditions among the patients admitted to the medical service included dementia, anxiety, brain tumor, hepatitis B, and chronic Clostridium difficile infection.

Patients admitted to the medical service had significantly more abdominal CT scans done in the evaluation process (Table 2). The distribution of other pre-operative tests was not significantly different between the surgical and medical services. There was a trend toward more medicine patients undergoing pre-operative ERCP, 2 of 12 (17%) patients *vs* 2 of 58 (3%) patients, though this did not reach statistical significance.

The mean time to operation from admission was 39.3 ± 43.1 h (Table 2). Operation within 72 h occurred in 87% of the cases and operation within 24 h occurred in 51% of the cases. Patients admitted to the surgical service compared to the medical service had a significantly decreased mean time to operation, and significantly more surgical patients were operated on within 3 d as well as within 24 h (Table 2).

Post-operative complications occurred in 16 cases (23%). Complications occurred more frequently in medicine patients: 7 of 12 (58%) *versus* 9 of 58 (16%) surgical patients, $P < 0.01$ (Table 2). Complications included prolonged (> 2 d) ileus ($n = 2$), discharge with Jackson-Pratt drain for biliary drainage ($n = 2$), urinary retention requiring discharge with foley catheter ($n = 2$), volume resuscitation for systemic inflammatory response leading to post-operative volume overload requiring diuresis ($n = 1$), penile edema ($n = 1$), gout ($n = 1$), pancreatitis ($n = 2$), delayed operation for gangrenous cholecystitis leading to post-operative deconditioning with inability to walk ($n = 1$), preoperative antibiotics to "cool down" cholecystitis associated with diffuse rash requiring steroids ($n = 1$), hypoxic respiratory failure ($n = 1$), cardiac arrest leading to death ($n = 1$), and multi-organ system failure leading to death ($n = 1$).

Mean ± SD LOS for all patients was 5.0 ± 3.9 d. Patients admitted to the surgical service experienced a shorter LOS compared to patients admitted to the medicine service (Table 2). LOS of 3 d or less was seen more often for surgical patients, while LOS of 6 d or more was observed most often for medicine patients.

Using hierarchical generalized linear models, we evaluated the impact of various factors on time to surgery (Table 3). Adjusting for patient demographics (age and gender), peri-operative co-morbidity level, physical signs, and pre-operative tests, we found that the performance of pre-operative ERCP was associated with increased time to operation. Select physical and laboratory signs (Murphy's sign, temperature > 37.8℃, WBC > 10.2 thousand/UL) had no apparent impact on time to operation in both the unadjusted and adjusted models. Medical admitting team was significantly associated with increased time to operation until ERCP was included in the model (Table 3).

The number of pre-operative diagnostic imaging studies was significantly associated with increased time to operation (Table 3). Time to surgery doubled as the number of diagnostic procedures increased from one to 2 or 3 tests and doubled again when 4 tests were performed. Adjusted models to determine the association between time to surgery and individual studies and combinations of studies revealed that ultrasound alone was associated with the shortest time (mean 23.3, 95% CI 10.7-35.9 h) and the

Table 3 Hierarchical linear models for time to surgery

Model	Estimate mean (h)	Standard error	95% CI	*P* value[4]
ERCP				
Unadjusted				< 0.01
Yes	149	17	115.0-183.0	
No	32.7	4.2	24.3-41.1	
Adjusted for patient demographics[1]				< 0.01
Yes	141.8	17.1	107.7-175.8	
No	33.1	4.1	24.9-41.4	
Adjusted for demographics and co-morbidity				< 0.01
Yes	143.5	16.2	111.1-175.8	
No	33.0	3.9	25.2-40.8	
Adjusted for demographics, co-morbidity and physical signs[2]				< 0.01
Yes	144.7	16.3	112.0-177.4	
No	33.0	3.9	25.1-40.8	
Adjusted for demographics, co-morbidity, physical signs[2] and imaging studies[3]				< 0.01
Yes	134.1	16.2	101.7-166.7	
No	33.6	3.8	26.0-41.2	
Admission service				
Unadjusted				< 0.01
Surgery	30.4	5.1	20.2-40.6	
Medicine	82. 7	11.2	60.3-105.1	
Adjusted for patient demographics				< 0.01
Surgery	31.4	5.1	21.3-41.5	
Medicine	77.6	11.4	54.9-100.4	
Adjusted for demographics and co-morbidity				< 0.01
Surgery	32.1	5.0	22.0-42.1	
Medicine	74.6	11.5	51.7-97.5	
Adjusted for demographics, co-morbidity and physical signs				< 0.01
Surgery	32.2	5.1	21.9-45.5	
Medicine	73.8	11.8	50.1-97.4	
Adjusted for demographics, co-morbidity, physical signs and imaging studies				< 0.05
Surgery	34.2	5	24.2-44.1	
Medicine	64.4	11.9	40.7-88.2	
Adjusted for demographics, co-morbidity, physical signs, imaging studies and ERCP				
Surgery	35.9	4.5	26.8-45.0	
Medicine	55.9	11	33.9-77.9	
Pre-operative diagnostic tests[3]				
Unadjusted				< 0.01
One	26.9	6.4	14.2-39.6	
Two	54.3	8.2	38.0-70.6	
Three	56.7	23.5	9.7-103.7	
Four	125	40.8	43.6-206.4	
Adjusted for patient demographics				< 0.01
One	29.0	6.2	16.6-41.4	
Two	51.5	8.0	35.6-67.4	
Three	48.11	23.6	1.0-95.2	
Four	133.2	39.7	53.8-212.5	
Adjusted for demographics and co-morbidity				< 0.01
One	27.8	6.0	15.8-39.7	
Two	53.6	7.7	38.3-68.9	
Three	46.6	22.6	1.4-91.7	
Four	135.5	38.1	59.4-211.6	
Adjusted for demographics, co-morbidity and physical signs				< 0.01
One	26.9	6.1	14.7-39.1	
Two	55.1	7.9	39.3-70.9	
Three	48.1	23.4	1.4-94.8	
Four	129.3	40.2	48.8-209.8	

[1]Age and sex; [2]Murphy's sign, leukocytosis, and fever; [3]Imaging studies include ultrasound, CT scan, MRCP, and HIDA scan; [4]Measure the differences in means (for more than two means, $P < 0.05$ indicates that at least one pair of means is statistically significantly different).

Table 4 Hierarchical linear models for effect of pre-operative imaging studies on time to surgery

Model	Estimate mean (h)	Standard error	95% CI	*P* value[4]
Unadjusted				< 0.01
All studies done	125.0	36.8	51.4-198.6	
US only	23.6	6.6	10.4-36.8	
US and HIDA	25.2	15.0	0.0-55.2	
CT only	37.0	11.7	13.7-60.3	
CT and MRCP	192.0	36.8	118.4-265.6	
CT and HIDA	59.2	15.0	29.1-89.2	
CT and US	54.9	10.6	33.7-76.2	
US, CT and HIDA	56.7	21.3	14.2-99.2	
Adjusted for patient demographics[1]				< 0.01
All studies done	128.3	36.6	55.1-201.6	
US only	24.7	6.6	11.4-38.0	
US and HIDA	26.2	14.9	0.0-56.0	
CT only	38.3	11.5	15.3-61.3	
CT and MRCP	179.5	37.5	104.5-254.4	
CT and HIDA	58.2	15.0	28.2-88.3	
CT and US	52.4	10.6	31.3-73.5	
US, CT and HIDA	53.9	21.8	10.3-97.4	
Adjusted for demographics and co-morbidity				< 0.01
All studies done	130.6	35.4	59.9-201.4	
US only	23.1	6.5	10.2-36.0	
US and HIDA	29.7	14.4	0.9-58.6	
CT only	39.4	11.1	17.1-61.6	
CT and MRCP	169.6	36.4	96.8-242.5	
CT and HIDA	58.0	14.5	29.0-87.0	
CT and US	55.2	10.3	34.6-75.7	
US, CT and HIDA	52.2	21.0	10.1-94.3	
Adjusted for demographics, co-morbidity and physical signs[2]				< 0.01
All studies done	121.0	36.4	48.1-193.2	
US only	20.4	6.5	7.5-33.3	
US and HIDA	29.7	14.3	1.2-58.3	
CT only	41.3	11.1	19.1-63.6	
CT and MRCP	186.3	36.5	113.1-359.5	
CT and HIDA	60.3	15.2	29.9-90.7	
CT and US	58.4	10.6	37.0-79.7	
US, CT and HIDA	53.5	21.3	10.9-96.0	
Adjusted for demographics, co-morbidity, physical signs and admission service[3]				< 0.01
All studies done	94.7	36.4	21.8-167.5	
US only	23.3	6.3	10.7-35.9	
US and HIDA	33.9	13.7	6.4-61.4	
CT only	42.3	10.6	21.0-63.7	
CT and MRCP	195.4	35.1	125.1-256.8	
CT and HIDA	55.5	14.64	26.2-84.9	
CT and US	52.7	10.42	31.8-73.6	
US, CT and HIDA	49.9	20.36	9.1-90.7	

US: Ultrasound; HIDA: Nuclear Hepatobiliary Scan; MRCP: Magnetic resonance cholangiopancreatography. [1]Age and sex; [2]Murphy's sign, leukocytosis, and fever; [3]Surgical and medical services; [4]Measure the differences in means (for more than two means, $P < 0.05$ indicates that at least one pair of means is statistically significantly different).

combination of CT scan and MRCP with longest time (mean 195.4, 95% CI 125.1-256.8 h) to surgery (Table 4). A trend is present toward decreased risk of complication associated with surgery within 24 h of hospital arrival that becomes non-significant after adjustment for diagnostic imaging studies (Table 5).

DISCUSSION

In this study, we find that 87% of cholecystectomies

Table 5 Hierarchical linear models for association between time to surgery and risk of complication

Model	Odds ratio	95% CI	*P* value
Unadjusted (h)			> 0.01
< 24	0.03	0.004-0.24	
24-48	0.3	0.05-1.52	> 0.05
48-72	0.2	0.02-1.74	> 0.05
> 72 (reference)	1		> 0.05
Adjusted for patients demographics (h)[1]			
< 24	0.05	0.003-0.65	
24-48	0.38	0.04-4.03	
48-72	0.27	0.01-5.01	
> 72	1		
Adjusted for demographics and co-morbidity (h)			
< 24	0.05	0.003-0.74	
24-48	0.44	0.04-5.00	
48-72	0.26	0.01-4.91	
> 72 (reference)	1		
Adjusted for demographics, co-morbidity and physical signs (h)[2]			
< 24	0.04	0.003-0.45	
24-48	0.33	0.03-3.49	
48-72	0.25	0.01-5.06	
> 72	1		
Adjusted for demographics, co-morbidity, physical signs and imaging studies (h)[3]			
< 24	0.08	0.004-1.61	
24-48	0.66	0.04-12.2	
48-72	0.41	0.01-13.5	
> 72	1		

[1]Age and sex; [2]Murphy's sign, leukocytosis, and fever; [3]Imaging studies included abdominal ultrasound, CT scan, MRCP, and HIDA scan. Abbreviations as in Table 4.

occurred within 72 h of arrival at the hospital and half of them within 24 h, indicating an overall timely approach. Several studies have shown that performing LC within 72 h of presentation does not increase morbidity and mortality[6,9]. Early LC, furthermore, has been shown to have a lower complication rate, decreased length of stay, decreased cost, and a shorter post-operative recovery period compared to delayed LC[5,7,8,16,17]. The results from a meta-analysis by Papi *et al* of 12 prospective randomized trials from 1970-2000 (9 addressing open cholecystectomy, 3 addressing LC), showed that there was a decrease in conversion to open procedure when LC was done early (17.6% *vs* 25.7%) and there were fewer post-operative complications (10.9% *vs* 15.6%)[17]. Another benefit of early surgery proved to be a shorter length of hospital stay (6.3 d *vs* 9.9 d).

Our analysis suggests a number of potential ways to speed up time to cholecystectomy. The number of pre-operative procedures was significantly associated with adjusted time to surgery, especially when four or more tests were done. Performance of MRCP and CT scan had by far the longest associated adjusted time to surgery. While the need for ERCP and MRCP will always result in some delay in surgery, these studies are routinely available within 24 h at our institution, often on the same day as requested. Efforts to streamline the decision process leading to ERCP and MRCP and then providing these studies promptly when requested may lead to earlier surgery for patients with acute cholecystitis. Additionally, more judicious use of pre-operative diagnostic imaging studies would also reduce delay. Although the sample size was small, not surprisingly, the performance of ERCP was also associated with delayed time to operation.

Also noted was that patients admitted to the medical service experienced over twice the wait for surgery compared to those going to the surgical service. No doubt some of this delay represents treatment of co-morbid illnesses, which were significantly more common in patients admitted to the medical service. However, patients on the medical service also had more imaging procedures performed, mostly abdominal CT scans, indicating confusion over the diagnosis and contributing to delays in definitive surgical therapy. Surgeons directly caring for patients with abdominal pain may be more apt to make the early diagnosis of acute cholecystitis with fewer imaging studies than medical physicians and, thereby, bring those patients to operation earlier. Although admitting patients with abdominal pain suspicious for cholecystitis to the surgical service may reduce time to cholecystectomy, it must be weighed against the advantages of having patients with active co-morbidities managed on the medical service with surgical consultation.

Our findings raise the question whether the benefit seen by early surgery is conferred mainly on those patients operated on within 24 h of arrival. A significant decreased risk of complications was seen in this subset of patients, except in the model including adjustment for diagnostic imaging studies. A reasonable inference is that this subset of patients may be so straight forward that little diagnostic uncertainty exists, fewer tests are required, and admission to the surgical service is favored. Conversely, those patients about whom diagnostic uncertainty is present or who are chosen for “cooling off” with pre-operative antibiotics may be placed at greater risk of complications because of the prolonged inflammatory state. Acute inflammation creating edema in the gallbladder submucosa can mature into a chronic inflammatory response with neovascularization and fibrosis, which can make a delayed procedure potentially more difficult[18]. Often, an operation will be deferred, especially in patients with pre-existing co-morbidities, in an attempt to maximize a patient’s medical tolerance of an operative insult. Firm evidence is lacking for whether this delayed approach is truly the best. Indeed, a recent meta-analysis comparing LC within 7 d *versus* longer than 6 wk after index admission showed no clear benefit from waiting[19]. Although the complications observed in the patients in this analysis can be directly or indirectly linked to acute cholecystitis and surgery, no causal connection between them and any delay in operating can be drawn. A prospective trial is likely required to determine the optimal times for LC.

Somewhat surprising was that what many would deem a classic clinical presentation with fever, leukocytosis, and Murphy’s sign was not associated with time to surgery. In a retrospective study of patients undergoing nuclear hepatobiliary scans by Singer *et al*[20], fever had a positive predictive value of 100% and a sensitivity of 14.6% for a positive scan. A positive Murphy’s sign had 97.2% sensitivity and 93.3% positive predictive value. In their systematic review of presenting signs and symptoms that may warrant investigation for cholecystitis, Trowbridge *et al*[21] found that no clinical or laboratory finding had a likelihood ratio (LR) sufficient to rule in or out cholecystitis. Murphy's sign, however, appeared the most useful, with a positive LR of 2.8, 95% CI 0.8-8.6. In our study, possibly the variable skill of the clinicians assessing for cholecystitis and the ready availability of imaging studies mitigated any diagnostic benefit from the presence of these findings that would have sped up care.

We chose in this study to use the AHA/ACC risk classification scheme rather than the American Society of Anesthesiologists-Physical Status (ASA-PS) score for risk stratification. While the ASA-PS score's simplicity and widespread use makes it an attractive index of risk, it is subjective and not explicitly intended for estimation of operative risk[22]. Furthermore, we had no measure of inter-anesthesiologist agreement on ASA-PS score and numerous anesthesiologists, so we could not control for variations at the level of the grader. While the AHA/ACC guidelines were derived for cardiovascular risk, it contains a detailed list of factors plausibly conferring risk for non-cardiac complications[23-25].

In summary, our analysis indicates good adherence to the desirable practice of performing cholecystectomies within 3 d of presentation to the hospital and raises the question of whether even prompter surgery may reduce the risk of complications. Efforts to expedite cholecystectomy should consider factors that may contribute to delay in surgery such as ERCP and MRCP, the combination of CT scan and MRCP, and admission to a medical service.

COMMENTS

Background

The optimal timing of surgery for acute cholecystitis (AC) has not been precisely established. We reviewed 70 consecutive cases of AC, confirmed by pathological examination, and identified several factors which led to delay in surgery and which resulted in increased complications because of that delay.

Research frontiers

We used a hierarchical statistical analysis model to identify the relevant factors leading to surgical delay.

Innovations and breakthroughs

While other authors have reviewed the timing of surgery for AC, none have identified specific causes resulting in delay nor reviewed the consequences of delaying surgery.

Applications

We found patients with AC who are admitted to the Medical Service, because of medical co-morbidities, experience significant delays in definitive surgical treatment and have higher post-operative complication rates, even when corrected for the existing co-morbidities. The delay results primarily from an increased number of radiologic imaging studies performed on patients admitted to the Medical Service. Patients with medical co-morbidities in addition to AC require prompt stabilization of their underlying medical illnesses and definitive surgery within 48 to 72 h following admission.

Terminology

The hierarchical statistical analysis used in this article allows multiple variables to be compared, identifying those that impact surgical timing and eliminating individual practice patterns from affecting the analysis.

Peer review

This study by Daniak *et al* is based on a retrospective evaluation of records from patients who underwent cholecystectomy. The authors compared the time of hospital staying between patients admitted in surgery and medical service. Interestingly, they found that admission to the medical service was associated to longer time to surgery compared to admission to surgery service. The study is original, well designed and performed, and results are relevant.

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