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Is Routine Intraoperative Cholangiogram Necessary in the Twenty-First Century? A National View

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Abstract

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Introduction—Intraoperative cholangiogram (IOC) can define biliary ductal anatomy. Routine IOC has been proposed previously. However, current surgeon IOC utilization practice patterns and outcomes are unclear.

Methods—Nationwide Inpatient Sample 2004–2009 was queried for patients with acute biliary disease undergoing cholecystectomy (CCY). Analyses only included surgeons performing 10 CCY/year. We dichotomized surgeons into a routine IOC group vs. selective. Outcomes included bile duct injury, complications, mortality, length of stay, and cost.

Results—Of the nonweighted patients, 111,815 underwent CCY. A total of 4,740 actual surgeon yearly volumes were examined. On average, each surgeon performed 23.6 CCYs and 7.9 IOCs annually, using IOC in 33 % of cases. The routine IOC group used IOC for 96 % of cases, whereas selective IOC group used IOC ~25 % of the time. Routine IOC surgeons had no difference in mortality (0.4 %) or rate of bile duct injury (0.25 vs. 0.26 %), but higher overall complications (7.3 vs. 6.8 %, $p=0.04$). Patients of routine IOC surgeons received more additional procedures and incurred higher costs.

Conclusion—Routine IOC does not decrease the rate of bile duct injury, but is associated with significant added cost. Surgeons' routine use of IOC is correlated with increased rates of postsurgical procedures, and is associated with increased overall complications. These data suggest routine IOC may not improve outcomes.

Keywords

Intraoperative cholangiogram; Cholecystectomy; Cost assessment; Bile duct injury; Complications and mortality

Introduction

Cholecystectomy is one of the most common abdominal surgical procedures performed in the USA and in the world.^{1,2} One of the most feared complications of cholecystectomy is bile duct injury (BDI), which can result in significant morbidity and long-term sequelae for the patient including persistently diminished quality of life.³⁻⁹ Once BDI occurs, the reported mortality increases from less than 0.5 % to near 18 %.¹⁰

Intraoperative cholangiogram (IOC) can define biliary ductal anatomy and identify anatomic variations, allows identification of bile duct stones, and aids in early detection of iatrogenic injury. Many surgeons use IOC on a selective basis-forgoing IOC when there is a low suspicion for retained stones, anatomic anomalies, or injury. Other surgeons use IOC routinely in all or nearly all cases. Routine IOC has previously been proposed as a method of reducing the rate of BDI, though its routine use is still a vigorously debated topic.^{2,11-17}

There are no national guidelines regarding the use of selective vs. routine intraoperative cholangiography. Prior studies comparing IOC patients to none IOC patients did not account for variations in practice among the operating surgeons, which may have introduced significant selection bias into the study design. Thus, it remains unclear whether routine vs. selective use of cholangiography by the surgeon has an effect on patients' short-term outcomes.

The aim of this study is to assess the surgeons' choices and practice patterns and utilization of intraoperative cholangiography and to determine whether having surgery performed by a routine IOC surgeon has any impact on patient outcomes including rates of BDI, major in-hospital complications, and mortality; and how surgeon preference affects the cost of patient care.

Methods

Data Source

The Nationwide Inpatient Sample (NIS) was queried from 2004 to 2009 for all patients with acute or urgent biliary disease undergoing laparoscopic and/or open cholecystectomy. The NIS, a part of the Healthcare Cost and Utilization Project is a national, all-payer discharge database containing information on a representative stratified sample of 20 % of non-federal US community hospitals from participating states, including academic and specialty hospitals.¹⁸

Cohort Assembly

Acute and urgent biliary disease patients were identified if they had a primary ICD-9-CM¹⁹ diagnosis code for acute biliary disease with acute cholecystitis with or without obstruction or cholangitis, including 574.0, 574.1, 574.2, 574.3, 574.4, 574.6, 574.7, 575.0, 575.1, 575.2, 575.9, 576.1, 576.2, and 574.8. We then further limited cohort using ICD-9 CM procedure codes for open cholecystectomy: 51.21, 51.22, and laparoscopic cholecystectomy: 51.23, 51.24. Groups were subdivided by indication for surgery as follows: acute cholecystitis 574.0, 574.1, 575.0, 575.1, 575.2; common bile duct stones: 574.3, 574.4, 574.6, 574.7, 574.8, 576.1, 576.2, 575.9; gallstone pancreatitis if secondary diagnosis of 577.0; and biliary colic 574.2.

Patients were excluded if they were: younger than 18 years of age or older than 95 years of age, or had a diagnosis of biliary tract and/or gallbladder cancer 155.1, 156, 156.1, 156.8, 156.9. We limited analyses to states with consistent coding of provider and hospital ID data (including Virginia, Texas, South Dakota, South Carolina, Pennsylvania, New York, New Hampshire, Nevada, Maine, Maryland, Iowa, and Florida). As not all states were included, the actual numbers were used without NIS weighting. As physician identification numbers change from year to year, we looked at the annual volume of cholecystectomies performed by an individual surgeon per year, and excluded surgeons who performed <10 cholecystectomies per year. We dichotomized surgeons into a routine IOC group (using a yearly ratio of IOC/cholecystectomy ≥ 0.9 , those using IOC for more than 90 % of cases) vs. selective group (IOC/CCY <0.9). Intraoperative cholangiogram was defined using ICD-9 CM procedure codes 87.53, 87.51, 87.52, 87.54, and 87.59. Common BDI was defined using ICD-9-CM diagnosis codes 868.02, 864.x, 863.9x, or having ICD-9 CM procedure codes: 51.36, 51.37, 51.39, 51.71, 51.72, 51.79, 51.94, and 51.98. Endoscopic retrograde cholangiopancreatography (ERCP) was defined using ICD-9 CM procedure codes 51.10, 51.11, 51.15, 51.81, 51.84, 51.85, 51.88, and 51.89. Common bile duct exploration (CBDE) was defined using ICD-9-CM procedure codes: 51.4, 51.41, 51.42, 51.51, 51.59.

Outcomes

The primary outcome measures were rates of bile duct injury, overall complications (including cardiovascular/myocardial infarction/deep venous thrombosis, gastrointestinal, pulmonary, urinary, or infection, as defined by our group and others),²⁰⁻²² in-hospital mortality, length of stay (LOS), use of ERCP, CBDE, and hospitalization costs for the routine IOC group vs. the selective group. Hospitalization cost was calculated from total charges using the hospital-specific all-payer inpatient cost/charge ratio.

Statistical Analysis

All analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC, USA).²³ Univariate analyses were used to compare patient characteristics and outcomes between IOC groups, including chi-square tests of association for categorical variables. Trend tests for annual point estimates were performed using the Cochran–Armitage trend test for binary variables. A linear regression model was used to determine trends over time for continuous variables. *P* values less than 0.05 were considered statistically significant. For the analysis, the actual numbers were used and were not weighted using to weighting strategies provided by Health-care Cost and Utilization Project, as weighting would deem less accurate due to strict cohort selection criteria.¹⁸

Multivariable logistic regression models were constructed with the occurrence of bile duct injury, mortality, or major in-hospital complication as the dependent variable (outcome). Independent variables with either statistical significance at the $p < 0.05$ level on univariate analyses or clinical relevance (established a priori) were included in multivariable models including race (white, black, Hispanic, other/missing), age (less than <50 or ≥50), sex, Elixhauser comorbidity score (0, 1, ≥2),²⁴ using NIS comorbidity software version 3.7, hospital characteristics (including location, size, and teaching status), type of insurance (Medicare, Medicaid, private, uninsured, other/missing), indication for surgery (acute cholecystitis, biliary colic, gallstone pancreatitis, bile duct stones), and operative approach (open vs. laparoscopic). Adjusted odds ratios were calculated to determine the effects of the covariates on outcomes of interest. This study was determined to be exempt by the Institutional Review Board of University of Massachusetts Medical School.

Results

Surgeon, Hospital, and Patient Characteristics

During the course of the study, 111,815 nonweighted patients were identified with inpatient diagnosis of acute biliary disease who also underwent cholecystectomy during the index admission. Females made up two thirds of the cohort. The mean age was 52.6 years, with a mean Elixhauser comorbidity score of 1.5.

We identified annual surgical volumes for 12,692 actual nonweighted surgeons. After removal of any surgeons who performed fewer than 10 cholecystectomies a year, 4,740 actual annual surgeon volumes were included in the final analysis. On average, each surgeon performed 23.6 cholecystectomies and 7.9 IOCs annually, with mean annual surgeon-specific IOC/CCY ratio of 0.33. The indications for CCY included acute cholecystitis (79.1

%), biliary stones (10.2 %), biliary colic (3.6 %), and gallstone pancreatitis (7.1 %). The majority of surgeons practiced in large, urban, nonteaching hospitals (Table 1).

Utilization of IOC: Routine IOC vs. Selective IOC Provider

Of the entire cohort, 33.6 % of patients had IOC. Over time, surgeon utilization of IOC, as measured by mean IOC/CCY ratio, increased slightly (0.31–0.33, $p<0.0001$), while the annual number of total cholecystectomies remained stable. There was a wide variation in the distribution of IOC/CCY (Fig. 1). The routine IOC provider group (IOC/CCY >0.9) performed IOC for 96 % of cases, and this rate did not change whether the case was elective or urgent/emergent. In comparison, the selective IOC providers used IOC only for about 25 % of cases overall, for both elective and urgent/emergent cases. High IOC providers were more likely to practice in rural, smaller, nonteaching hospitals. Additional surgeon, hospital, and patient characteristics are listed in Table 1.

In-Hospital Outcomes: Univariate Analysis

Comparing routine IOC providers to selective IOC providers, there was no significant difference in the rate of bile duct injury identified during the index hospitalization (0.25 vs. 0.26 % for selective IOC group, $p=0.7$). There was also no difference in all-cause in-hospital mortality between routine IOC and selective IOC providers (0.39 vs. 0.38 % for selective IOC group, $p=0.8$). Further examination of rates of overall complications revealed that routine IOC provider cases had a higher rate of overall complications (7.3 vs. 6.8 %, $p=0.04$). This difference was mostly due to higher rates of post-operative infection in the routine IOC group (4.3 vs. 3.9 %, $p=0.03$). There was no significant difference in the rates of other major complications including pulmonary, myocardial infarction, deep venous thrombosis, pulmonary embolism, renal failure, and post-operative hemorrhage. Patients of routine IOC surgeons had statistically significant but clinically comparable LOS, 3 days for both, and clinically comparable postoperative LOS (median of 2 days; Table 2).

Utilization of Additional Procedures

Compared to selective IOC providers, routine IOC providers were more likely to utilize additional procedures during the index admission including ERCP (15.8 % for routine IOC providers vs. 12.7 %, $p<0.0001$) and CBDE (2.6 vs. 1.6 %, $p<0.0001$).

Predictors of Bile Duct Injury, Complications, and Mortality

Multivariable logistic regression models were created to identify predictors of bile duct injury, complications, and mortality among patients with acute biliary disease who had operations performed either by routine IOC providers or selective IOC providers.

After controlling for demographic and clinical variables, significant independent predictors of bile duct injury for patients included: operation for gallstone pancreatitis or common bile duct stones, and undergoing an open cholecystectomy (C statistic, 0.78). Being a routine IOC provider was not associated with any decrease in the rate of bile duct injury (Table 3).

When looking at predictors of major in-hospital complications, after controlling for demographics and clinical variables, significant predictors of complications included:

diagnosis of gallstone pancreatitis, non-elective case, black race, age >50, male sex, increasing number of comorbidities, having Medicare or Medicaid insurance, and undergoing open cholecystectomy. Being a routine IOC provider was a predictor of having a major in-hospital complication (C statistic, 0.78).

Similarly, when looking at predictors of all-cause in-hospital mortality, many of the same factors that predicted complications were associated with any-cause in-hospital mortality (C statistic, 0.84): non-elective case, age >50, increasing number of comorbidities, having insurance other than private, and undergoing open cholecystectomy. Being a routine IOC provider had no protective effect on the patients (Table 3).

Cost of Routine IOC Providers

The quality of life of the potential BDI patient, as well as long-term morbidity cannot always be quantified and assessed. When evaluating direct in-hospital cost of BDI injury, for our subset sample for initial hospitalization only is \$21,189 compared to per-patient \$9,555 cost for the subset without BDI injury. Thus, it costs an additional \$11,634 per bile duct injury for just initial hospitalization. For this cohort, with 291 injuries, the total additional cost of BDI was \$3,385,494 for index hospitalization.

A subset analysis was performed to evaluate the cost effectiveness of routine IOC due to missing cost data for ~40 % of the cohort. Routine IOC providers spent an additional \$930 per case (\$10,425–9,495). The proportion of cases done by the routine IOC group was 11.6 % of all cases (13,025/111,815). Assuming that routine IOC providers use IOC unnecessarily for 71 % of the cases (comparing 96 % use to 25 % use for selective IOC surgeons), projected additional cost for our cohort was calculated as $\$930 \times 111,815 \times 0.116 \times 0.71 = \$8,546,447$ (Table 4).

Discussion

This study of surgical practice patterns in utilization of IOC found that while selective IOC is performed frequently, a small proportion of surgeons approach IOC as routine. In the inpatient setting, routine IOC is not associated with a decrease of bile duct injury, but performance of IOC for every case is associated with a higher rate of complications and significant additional cost. To our knowledge, this is the first study to examine patient short-term outcomes based on surgeon practice patterns on a national level.

Intraoperative cholangiogram is an important procedure when utilized selectively for cases where there is a concern about atypical anatomy, possible residual bile duct stones, or concern for iatrogenic duct injury.²⁵⁻²⁷ However, when used routinely, the cost-effectiveness as well as the benefit of the IOC should be considered.²⁸⁻³⁰ Based on a national mail survey conducted by Massarweh et al., 39 % of routine IOC users thought that IOC use imparted at least a 50 % reduction in the risk of CBDI, and 78 % of routine IOC users agreed that that IOC could prevent all common bile duct injuries. In addition, the majority of routine IOC users thought that IOC cost is less than \$250 (65.7 %).³¹ This study compared two practice patterns, selective vs. routine IOC utilization and found that there is no risk reduction in BDI associated with being a routine IOC user both on univariate or

multivariable analysis. Contrary to the survey results examining surgeon perception of BDI injury prevention, routine IOC users had the same rate of BDI, with additional added cost of \$930 dollars per case and \$15,583 per surgeon annually, with projected additional annual cost for our cohort of 8.5 million. This estimate is based on the analysis of cholecystectomies performed in patient, and a subset analysis, so it is likely to underestimate the true number as we cannot account for outpatient cases. Prior studies had conflicting results on the effect of IOC use on the occurrence of BDI. While there are many supporters of IOC use,^{2,11-13} as more surgeons are trained with critical view of safely technique, the need for IOC can be reduced in many instances.¹⁴⁻¹⁷ Traverso et al. showed that in a series of 624 laparoscopies, with 420 IOCs reviewed by surgeons and radiologists, only 86 % of IOCs had filling of the entire biliary tree, with bifurcation seen in 95 % of cases. The rate of abnormal anatomy was 4 %.³² If IOC is performed, it should be complete and interpreted appropriately. Interestingly, in our study, most of the surgeons practicing in teaching hospitals were selective IOC providers, arguably decreasing teaching opportunities for residents for situations when IOC might be warranted.

Routine IOC users are more likely to identify CBD stone or stenosis intraoperatively, leading to an immediate intervention when compared to the selective IOC group whose patients are more likely to represent at an interval with persistent symptoms. This is consistent with our finding of higher ERCP and CBDE rates in routine IOC users. As only a very small fraction of retained stones are symptomatic postoperatively, intervening on an as needed basis on a select group of patient who represent to the ED or have persistent symptoms will avoid unnecessary intervention on the majority of patients.

Some researchers have made an argument that IOC has virtually no evidence of complications, with minimal radiation exposure,³³ and with no additional risk of complications. In this study, we showed that being a routine IOC user was associated with increased rate of major in-hospital complications.

To date, there has been no definitive randomized clinical trial of routine versus selective intraoperative cholangiography due to the large sample size required to detect differences between rare injuries.^{34,35} As the rate of injury is so low, even to see a difference of 50 % in injury rate, more than 25,000 patients need to be enrolled to properly power the study.²⁸ Our study, although retrospective, had over 110,000 patients, with sufficient power to assess differences in rare outcomes, thus allowing us to definitively show that routine IOC is not warranted.

Assessment of cost is challenging. Prior estimates of IOC cost ranged from \$700 to over \$2,000.^{16,28-30} However, generally the cost assessment was done using hospitalization charges, or calculated cost based on number of cholangiograms needed to prevent one injury. As the relation between IOC and BDI prevention is still debated, this study took a different approach by focusing on additional cost attributable to the routine IOC providers compared to a selective IOC group, and found that each routine IOC provider costs over \$15,000 more per year than selective IOC providers in this limited cohort of acute disease, without evidence of any protective effect of routine IOC use on rate of BDI.

Bile duct injury can be potentially devastating for the patient, with mortality rate increasing from <0.5 % to the 9–20 % range,^{3,4} and short-term complications ranging from biloma, sepsis, multiorgan dysfunction syndrome, biliary fistula, cholangitis, abscess, as well as long-term complications such as strictures (33 %) among others.^{5–8} It was further shown that the patients' quality of life after the injury is poor, and does not improve overtime.⁹ A British study of litigation after laparoscopic cholecystectomy found that bile duct injury claims resulted in the highest proportion of successful claims (86 %), and were associated with the highest payout.^{36,37} De Reuver et al., found that in Netherlands 80 % of medical litigation cases was associated with delayed diagnosis of duct injury.³⁸ There are no studies currently assessing the benefit of intraoperative cholangiography from medicolegal perspective, but certainly one can argue that timely IOC on a selected group of high-risk patients will identify the injury early and will prevent the delay in diagnosis and the accompanying potentially devastating and costly complications.

This study has several important limitations. The NIS is an administrative database and lacks certain clinical variables, including patient-level factors (e.g., assessment of disease severity, imaging, laboratory values) specific perioperative data (e.g., sequence of events in the operating room, operative time), and long-term follow-up/readmission information. Major postoperative complications were assessed using a validated set of ICD-9 codes. However, the complication rates can be underestimated, as individual medical records cannot be reviewed, and NIS does not include complications occurring after patient discharge, thus potentially excluding patients who return to the emergency room with retained stones. The database also does not allow us to assess the perioperative variables that influenced surgeons' decisions to selectively perform an IOC, resulting in some selection bias. Thus, we cannot definitively say that high-frequency IOC causes complications or increased cost, but is merely associated with these outcomes.

Despite these limitations, this is the first national study to compare patient outcomes based on surgeon practice preference and patterns, examining occurrence of bile duct injury, mortality, and comprehensively examining morbidity associated with being in a mandatory IOC group. Since the rate of bile duct injury is rare (0.15–0.6 %),^{10,25,26,39} a creation of adequately powered prospective randomized study is not feasible, as even to show 50 % difference in injury rate, over 26,000 patients need to be enrolled.²⁸ The use of a national database gives the study adequate power, and allows for a robust multivariable analysis that adjusts for the effect of multiple clinical and demographic variables to look at the question of interest, which is not possible otherwise.

Conclusion

Intraoperative cholangiogram remains a frequently used procedure. While nationally, most surgeons appear to be using cholangiography selectively, a minority of surgeons appear to approach intraoperative cholangiogram as mandatory. A surgeon's routine use of cholangiogram is correlated with increased rates of post-surgical procedures and is associated with increased overall complications, with no additional decrease in bile duct injury rate in the inpatient setting. As routine intraoperative cholangiogram does not aid in

bile duct injury risk reduction and is costly, further studies are warranted to develop criteria for selective use of intraoperative cholangiogram.

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Fig. 1.
Surgeon rank by IOC/CCY use ratio

Table 1

Physician, hospital, and patient characteristics

Variable	Routine IOC surgeons	Selective IOC surgeons	P value
Surgeon characteristics			
Number of surgeons (actual)	513	4,227	
% Elective cases in practice	24.0 %	18.2 %	<0.0001
IOC/CCY ratio	0.96	0.25	
Elective cases	0.95	0.27	
Urgent/emergent cases	0.96	0.25	
Hospital characteristics			
Urban	87.5 %	90.4 %	<0.0001
Teaching	22.7 %	39.6 %	<0.0001
Hospital bed size			<0.0001
Small	10.7 %	9.3 %	
Medium	28.0 %	26.6 %	
Large	61.3 %	64.1 %	
Patient characteristics			
Number of patients	13,025	98,790	
Age (years, mean)	53.5	52.5	<0.0001
Male sex	33.1 %	34.0 %	0.05
Race			<0.0001
White	63.9 %	61.8 %	
Black	7.5 %	10.4 %	
Hispanic	20.6 %	18.8 %	
Other/unknown	8.0 %	9.0 %	
Elixhauser comorbidity (mean)	1.6	1.4	<0.0001
Primary insurance			<0.0001
Medicare	33.9 %	31.3 %	
Medicaid	8.4 %	11.3 %	
Private	45.0 %	42.3 %	
Uninsured	10.6 %	11.8 %	
Other/missing	2.2 %	3.3 %	
Type of cholecystectomy			<0.0001
Laparoscopic	91.0 %	87.1 %	
Open	9.0 %	12.9 %	
Indication for cholecystectomy			<0.0001
Gallstone pancreatitis	7.3 %	7.1 %	
Biliary colic	3.1 %	3.6 %	
CBD stones	14.0 %	9.7 %	
Acute cholecystitis	75.6 %	79.6 %	

Table 2

Bile Duct injury, major post-operative in-hospital complications and in-hospital mortality after cholecystectomy for routine IOC providers and selective IOC providers, nationally weighted, NIS 2004–2009

	Total	Routine IOC provider	selective ioc provider	P value
Bile duct injury	291	0.25 %	0.26 %	0.7
Major in-hospital complications	7,669	7.3 %	6.8 %	0.04
Mortality	427	0.4 %	0.4 %	0.8
Length of stay (days, median)	–	3.0 days	3.0 days	<0.0001 ^a
Length of stay after operation	–	2.0 days	2.0 days	0.0008 ^a
ERCP	14,582	15.8 %	12.7 %	<0.0001
CBDE	1,970	2.6 %	1.6%	<0.0001

ERCP endoscopic retrograde cholangiopancreatography, CBDE common bile duct exploration

^aWhile statistically significant based on distribution, this finding is not clinically significant

Table 3

Multivariable logistic regressions: adjusted odds of bile duct injury, major complications and mortality during the hospitalization

	Predictors of bile duct injury OR (95%CI)	Predictors of in-hospital complications OR (95%CI)	Predictors of in-hospital mortality OR (95%CI)
Routine IOC provider (vs. selective)	0.96 (0.66–1.41)	1.10 (1.02–1.20)	1.03 (0.76–1.39)
Age 50 (vs. <50)	1.29 (0.94–1.78)	1.89 (1.75–2.03)	4.58 (2.84–7.40)
Male (vs. female)	0.87 (0.68–1.12)	1.51 (1.43–1.59)	1.27 (1.04–1.54)
Race			
Black (vs. white)	1.06 (0.72–1.58)	1.22 (1.13–1.32)	1.15 (0.83–1.59)
Hispanic (vs. white)	0.93 (0.66–1.31)	1.00 (0.92–1.07)	0.80 (0.58–1.11)
Other/unknown (vs. white)	0.96 (0.63–1.48)	1.06 (0.97–1.17)	0.95 (0.64–1.41)
Elixhauser comorbidity score			
1 (vs. 0)	1.12 (0.79–1.58)	1.73 (1.57–1.92)	1.83 (1.08–3.31)
2 (vs. 0)	1.21 (0.88–1.68)	4.52 (4.14–4.94)	4.70 (2.91–7.57)
Elective (vs. not)	1.12 (0.84–1.50)	0.66 (0.62–0.71)	0.71 (0.55–0.93)
Type of cholecystectomy			
Open (vs. laparoscopic)	6.70 (5.25–8.54)	2.61 (2.47–2.76)	2.86 (2.34–3.50)
Indication (ref. acute cholecystitis)			
Gallstone pancreatitis	1.73 (1.09–2.75)	1.10 (1.01–1.20)	1.26 (0.91–1.74)
Biliary colic	0.33 (0.08–1.33)	0.76 (0.64–0.89)	0.54 (0.24–1.21)
Bile duct stones	6.01 (4.70–7.68)	0.98 (0.91–1.06)	1.25 (0.95–1.64)
Hospital location			
Urban (vs. rural)	1.75 (1.07–2.86)	1.17 (1.08–1.27)	1.24 (0.90–1.71)
Hospital bed size			
Medium (vs. small)	1.08 (0.66–1.76)	0.97 (0.89–1.07)	1.12 (0.75–1.66)
Large (vs. small)	1.32 (0.85–2.06)	1.02 (0.93–1.11)	1.21 (0.84–1.73)
Teaching hospital (vs. not)	1.20 (0.94–1.53)	0.94 (0.89–0.99)	0.83 (0.67–1.03)
Patient's insurance			
Medicare vs. private	1.18 (0.87–1.61)	1.80 (1.69–1.91)	3.64 (2.66–4.98)
Medicaid vs. private	1.45 (0.96–2.19)	1.24 (1.12–1.38)	1.85 (1.05–3.25)
No insurance/self pay vs. private	1.08 (0.69–1.68)	1.03 (0.93–1.16)	1.89 (1.08–3.31)
Other/missing vs. private	1.29 (0.66–2.50)	1.11 (0.93–1.33)	1.53 (0.61–3.86)

Table 4

Hospitalization cost for routine IOC providers and selective IOC providers, NIS 2004–2009

	Routine IOC provider	Selective IOC provider
Total per-case charges	\$35,510	\$30,643
Total per-case cost	\$10,425	\$9,495
Additional per-case cost	\$930	–
Additional annual cost per average surgeon	\$15,583 ^a	–
Number of cases done by each provider group	13,025	98,790
Proportion of all cases done by each provider group	11.6 %	88.4 %
IOC/CCY ratio for each provider group	0.96	0.25
Proportion of unnecessary IOC cases	71 %	
Additional cost for study group	\$8,546,447	

^aBased on average surgeon volume of 23.6×0.71 = cholecystectomies/year