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Presence of a fellowship improves perioperative outcomes following hepatopancreatobiliary procedures

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Abstract

Introduction There is an increase in subspecialization and in the number of surgeons seeking fellowship training in the USA. Little is known regarding the effect of hepatopancreatobiliary (HPB) fellowship programs' status of an institution on perioperative outcomes. This study aims to examine the effect of such status on perioperative outcomes across all institutions following complex surgeries involving HPB procedures in the State of New York (NYS).

Methods The Statewide Planning and Research Cooperative System administrative database was used to identify several complex surgeries involving the pancreas, liver, and gallbladder by using ICD-9 codes for inpatient procedures between 2012 and 2014. Procedures were compared in terms of 30-day readmission, hospital length of stay (HLOS), and major complications between institutions with and without fellowship. Linear mixed model and generalized linear mixed models were used to compare the differences.

Results There were 4156 procedures identified during 2012–2014 in NYS. Among these, 1685 (40.5%) were pancreatic surgeries only, 1031 (24.8%) were liver surgeries only, 1288 (31.0%) were gallbladder surgeries only, 11 (0.3%) were both pancreatic and liver surgeries, 124 (3.0%) were both liver and gallbladder, and 17 (0.4%) were both pancreatic and gallbladder. Elderly patients tended to go to the hospitals with HPB fellowship. Following multivariable regression and controlling for other factors, hospitals with fellowships remained significantly associated with less severe complications (OR 0.49, 95% CI 0.29–0.83, $p = 0.0075$). No significant differences were seen between hospitals with and without fellowship in terms of 30-day readmissions ($p = 0.6$) and HLOS ($p = 0.4$).

Conclusion Institutions offering HPB fellowship training were associated with significantly improved rate of complications, although there was no significant difference in terms of 30-day readmission rate or HLOS. This data highlight the importance of a presence of a fellowship in complex hepatopancreatobiliary procedures.

Keywords Fellowship · Hepatopancreaticobiliary · Outcomes

Regionalization of complex surgical operations to high-volume centers is a movement at the forefront of past and present national healthcare quality initiatives [1] Total and annual surgeon case volume minimums are widely used in a variety of surgical subspecialties, such as bariatrics and oncology, to set standards of excellence for postoperative outcomes [2–4]. In the field of hepatopancreaticobiliary (HPB) surgery, high-volume centers are linked to improvements in morbidity and mortality [5, 6]. In 2014, the Americas Hepatopancreaticobiliary Association

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(AHPBA) issued a consensus statement declaring that "the high volume HPB surgeon is the most important factor for reducing mortality," and advocates that volume metrics, and non-volume quality metrics are a critical aspect of training adept surgeons [7].

Hepatopancreaticobiliary surgery is technically challenging and still associated with higher morbidity, although improved mortality [8]. The AHPBA requires 100 total complex HPB cases to acquire these complex operative skills, which poses a significant potential risk for morbidity and mortality. With the advent of fellowship training, the leaning curve can be attenuated and complications can be minimized under the supervision of experienced surgeons. However, the presence of these trainees can have a negative impact on perioperative outcomes. As high-volume centers have acquired fellowship-training programs, the presence of these trainees needs to be considered as an independent factor for outcomes. The purpose of our study was to evaluate whether the presence of a formal HPB fellowship-training program at a hospital has an effect on perioperative and postoperative HPB surgical outcomes in New York State.

Methods

Following Institutional Review Board and New York Department of Health approvals, the New York Statewide Planning and Research Cooperative System (SPARCS) database was used. SPARCS is a comprehensive reporting system that collects information on discharges from hospitals and ambulatory centers. This administrative database collects information regarding patients' characteristics, diagnoses, treatments, services, and charges for hospital stays and outpatient surgery or emergency department visits. International Classification of Diseases, ICD-9, codes were used to identify patients undergoing complex pancreatic, hepatic, and biliary procedures between 2012–2014. Procedures included pancreatectomy and partial pancreatectomy; hepatectomy and partial lobectomy, and biliary procedures included complex anastomoses. Patients with age <18 and incomplete records were excluded from analysis. The first surgery from multiple surgeries was kept in the analysis ($N = 68$). Outcome measures included severe complications, hospital length of stay (HLOS), and 30-day re-admissions. Severe complications included abscess, hemorrhage, ventilation, anastomotic leak, respiratory failure/arrest, cardiac arrest, myocardial infarction, renal failure, shock, and surgical error. Hospitals with hepatopancreaticobiliary status ($N = 2$) were confirmed on the Americas Hepato-Pancreato-Biliary Association (AHPBA) website. If a hospital had a yearly average surgery volume of greater than 25 cases, then it was defined a high-volume hospital in this study. The two hospitals with HPB fellowship were ranked #1 and #4 from 25 high-volume centers. There were 117 low-volume centers.

Chi-square tests with exact p values based on Monte Carlo simulation were utilized to compare categorical variables between patients who underwent surgery from hospital with and without fellowship or between academic and non-academic hospitals. Univariate linear mixed models were used to estimate the marginal association between possible risk factors (*hospital with HPB fellowship, age as a categorical variable, payment, race, region, sex, hospital volume, comorbidities, any comorbidity, complications, severe complication*) and length of stay. Facilities and the operating physicians were considered as two random effects to take into account of clustering nature of patients from the same facility or the same physician. Univariate generalized linear mixed models were fit to estimate the marginal association between severe complication and possible risk factors, as well as between 30-day readmission and possible risk factors. Logistic regression models with firth bias correction were fit when a zero cell count exists in of the contingency table of two categorical variables and thus creating model fitting issues while fitting a generalized linear mixed model. *Hospital with HPB fellowship or not* and variables which were significant in the univariate analysis at a significance level of 0.05 were further included in the multivariable regression models. *Any comorbidity* and *any complication* were utilized instead of specific comorbidities and complications when a large number of them had small p values in the univariate models. Log-transformation was applied on (LOS + 1*)* to satisfy the normality assumption for linear mixed models. Statistical analysis was performed using SAS 9.4, and significance level was set at 0.05 (SAS Institute, Inc., Cary, NC).

Results

There were 4156 procedures performed in the State of New York during 2012–2014. Among these, 1685 (40.5%) were pancreatic surgeries, 1031 (24.8%) were liver surgeries, 1288 (31.0%) were gallbladder surgeries, 11 (0.3%) were combined pancreatic and liver surgeries, 124 (3.0%) were combined liver and gallbladder surgeries, and 17 (0.4%) were combined pancreatic and gallbladder surgeries. Patients with older age tended to go to hospitals with HPB fellowship. HPB fellowship and hospital volume are highly associated ($p < 0.0001$): All hospitals with HPB fellowship have high yearly volume. Patients were also different in terms of insurance, race, and region between hospital with and without HPB fellowship (Table 1). The complications

differences between hospitals with and without HPB fellowship are shown in Table 2: Hospitals with HPB fellowship were associated with less severe complications ($p < 0.0001$). Based on the multivariable generalized linear mixed model after controlling for other factors, hospitals with HPB fellowship were significantly associated with less severe complications (OR of hospital with HPB fellowship versus no fellowship: 0.49, 95% CI 0.29–0.83, $p = 0.0075$). Besides, given other risk factors controlled, gender and insurance were also significantly associated with severe complication (<0.0001, 0.0021, respectively, Fig. 1).

When examining 30-day readmissions, hospitals with HPB fellowship were not significantly different to those hospitals without HPB fellowship ($p = 0.6912$). After controlling for other risk factors, hospitals with HPB fellowship were not significantly different to those hospitals without HPB fellowship in terms of 30-day readmissions (OR of hospital with HPB fellowship versus no fellowship: 1.08, 95% CI 0.80–1.47, $p = 0.6059$, Fig. 2).

Univariate analysis showed that that there was no significant difference between hospitals with or without HPB fellowship in terms of HLOS ($p = 0.157$). After controlling for other risk factors, hospitals with HPB fellowship were estimated to have shorter length of stay but did not reach statistical significance (estimated difference in log (LOS + 1) between hospital with HPB fellowship and those without fellowship: −2.6432, $p = 0.4469$, Table 3).

Discussion

The rate of complications and mortality from complex HPB procedures, such as pancreaticoduodenectomy, distal pancreatectomy, liver resections, and complex biliary reconstructions, is higher than in following other procedures. Schwartz et al. [9] showed a morbidity of 17.9% for hepatic procedures and 27.2% for pancreatic procedures, while others have shown even higher morbidity for certain complex hepatopancreatobiliary procedures [10]. Thus, improving outcomes of these patients is of particular importance. So far, studies concentrated on outcomes based on certain patient factors, such as patient age, baseline comorbidity profile, teaching status [11–13], volume of surgeon and hospital [14–16].

The effect of the teaching status of a hospital has been established [13]. Teaching hospitals differ in that they focus on the education of residents and medical students, while integrating their training into patient care. Thus, this can lead to concerns for worse patient outcomes. Dimick

Table 1 Descriptive table for patients' characteristics comparing HPB fellowship with non-HPB fellowship

Variable	Level	Total	No fellowship	HPB fellowship	*p* value
Age group	18–24	92 (2.23%)	85 (2.58%)	7 (0.84%)	0.0061
	25–34	211 (5.12%)	179 (5.44%)	32 (3.84%)	
	35–44	377 (9.15%)	305 (9.27%)	72 (8.64%)	
	45–54	690 (16.74%)	542 (16.48%)	148 (17.77%)	
	≥55	2752 (66.76%)	2178 (66.22%)	574 (68.91%)	
Gender	Female	2103 (51.02%)	1680 (51.08%)	423 (50.78%)	0.9088
	Male	2019 (48.98%)	1609 (48.92%)	410 (49.22%)	
Race/ethnicity	White	2444 (59.29%)	1732 (52.66%)	712 (85.47%)	<.0001
	Black	459 (11.14%)	428 (13.01%)	31 (3.72%)	
	Asian	299 (7.25%)	264 (8.03%)	35 (4.20%)	
	Hispanic	345 (8.37%)	321 (9.76%)	24 (2.88%)	
	Other	575 (13.95%)	544 (16.54%)	31 (3.72%)	
Region	East	454 (11.01%)	352 (10.70%)	102 (12.24%)	<.0001
	Mid/North	455 (11.04%)	455 (13.83%)	0 (0.00%)	
	Close to NYC	118 (2.86%)	118 (3.59%)	0 (0.00%)	
	NYC area	2723 (66.06%)	1992 (60.57%)	731 (87.76%)	
	Long island	372 (9.02%)	372 (11.31%)	0 (0.00%)	
Insurance	Medicaid	230 (5.58%)	219 (6.66%)	11 (1.32%)	<.0001
	Medicare	1494 (36.24%)	1230 (37.40%)	264 (31.69%)	
	Commercial	2326 (56.43%)	1771 (53.85%)	555 (66.63%)	
	Other	72 (1.75%)	69 (2.10%)	3 (0.36%)	
Hospitals' volume	Low volume	1116 (27.07%)	1116 (33.93%)	0 (0.00%)	<.0001
	High volume	3006 (72.93%)	2173 (66.07%)	833 (100.00%)	

Table 2 Descriptive table for complications stratified by hospital status

Variable	Level	Total ($N = 4122$)	No fellowship ($N = 3289$)	HPB fellowship ($N = 833$)	p value[1]
Severe complication	Yes	1131 (27.44%)	996 (30.28%)	135 (16.21%)	<.0001[a]
Any complication	Yes	2021 (49.03%)	1758 (53.45%)	263 (31.57%)	<.0001[a]
Pulmonary embolism	Yes	59 (1.43%)	38 (1.16%)	21 (2.52%)	0.0391
Reoperative hemorrhage	Yes	29 (0.70%)	29 (0.88%)	0 (0.00%)	0.0573[a]
Anastomotic	Yes	78 (1.89%)	73 (2.22%)	5 (0.60%)	0.0054[a]
Abscess	Yes	51 (1.24%)	50 (1.52%)	1 (0.12%)	0.0142
Dehiscence	Yes	2 (0.05%)	1 (0.03%)	1 (0.12%)	0.2346[a]
Ventilation	Yes	140 (3.40%)	133 (4.04%)	7 (0.84%)	<.0001[a]
Tracheostomy	Yes	42 (1.02%)	42 (1.28%)	0 (0.00%)	0.0304[a]
Pneumonia	Yes	252 (6.11%)	215 (6.54%)	37 (4.44%)	0.1339
Respiratory failure	Yes	427 (10.36%)	393 (11.95%)	34 (4.08%)	0.0059
Respiratory arrest	Yes	2 (0.05%)	2 (0.06%)	0 (0.00%)	0.8785[a]
Pulmonary edema	Yes	28 (0.68%)	25 (0.76%)	3 (0.36%)	0.8740
Collapsed	Yes	301 (7.30%)	246 (7.48%)	55 (6.60%)	0.6848
Myocardial Infarction	Yes	4 (0.10%)	4 (0.12%)	0 (0.00%)	0.5801[a]
Cardiac arrest	Yes	30 (0.73%)	28 (0.85%)	2 (0.24%)	0.0874
Cardiac complication	Yes	169 (4.10%)	129 (3.92%)	40 (4.80%)	0.6377
Renal failure	Yes	360 (8.73%)	338 (10.28%)	22 (2.64%)	<.0001[a]
Shock	Yes	229 (5.56%)	220 (6.69%)	9 (1.08%)	0.0001
Bacterial disease	Yes	242 (5.87%)	225 (6.84%)	17 (2.04%)	<.0001
Hypertension	Yes	6 (0.15%)	6 (0.18%)	0 (0.00%)	0.4163[a]
Atherosclerosis	Yes	32 (0.78%)	31 (0.94%)	1 (0.12%)	0.0448[a]
Phlebitis	Yes	470 (11.40%)	405 (12.31%)	65 (7.80%)	0.3474
Enteritis	Yes	34 (0.82%)	29 (0.88%)	5 (0.60%)	0.5072[a]
Intestinal	Yes	555 (13.46%)	482 (14.65%)	73 (8.76%)	<.0001[a]
Systemic inflammation	Yes	405 (9.83%)	386 (11.74%)	19 (2.28%)	<.0001[a]
Nervous	Yes	7 (0.17%)	6 (0.18%)	1 (0.12%)	0.7668
Vascular	Yes	16 (0.39%)	12 (0.36%)	4 (0.48%)	0.6654
Digestive	Yes	423 (10.26%)	368 (11.19%)	55 (6.60%)	0.0001[a]
Surgical error	Yes	652 (15.82%)	545 (16.57%)	107 (12.85%)	0.0094[a]
Hemorrhage	Yes	43 (1.04%)	41 (1.25%)	2 (0.24%)	0.0224
Liver complication	Yes	88 (2.13%)	81 (2.46%)	7 (0.84%)	0.0816

[1] p value was based on univariate generalized linear mixed model accommodating the correlation within the same hospital and physician

[a] Univariate logistic regression with firth bias correction was used because GLMM had convergence issues

et al. examined patients undergoing esophageal, hepatic, and pancreatic resections and demonstrated that in fact, undergoing surgery at teaching hospitals was safe, as witnessed by a lower operative mortality rates for these procedures compared to non-teaching hospitals [13]. Moreover, fellowship status of a hospital might also represent an important predictor of outcomes. Fellows are expected to possess a higher level of skill and knowledge compared to medical students and residents. In fellowship training, fellows perform surgeries under the guidance of experienced surgeons in order to reduce the learning curve. However, this could hypothetically worsen perioperative outcomes compared to cases performed by the experienced surgeon. Thus, it is important to examine if the fellowship status of a hospital may have an effect on patient outcomes during and following these complex procedures. Our study examined the effect of presence of HPB fellowship on perioperative and postoperative outcomes. Hospitals with HPB fellowship programs had improved perioperative outcomes, although the fellowship status of a hospital had no effect in terms of 30-day readmissions and HLOS.

Similar to our study, others have examined the effect of presence of HPB fellowship on patient outcomes. Bhayani et al. [17] searched outcomes following hepatic resection

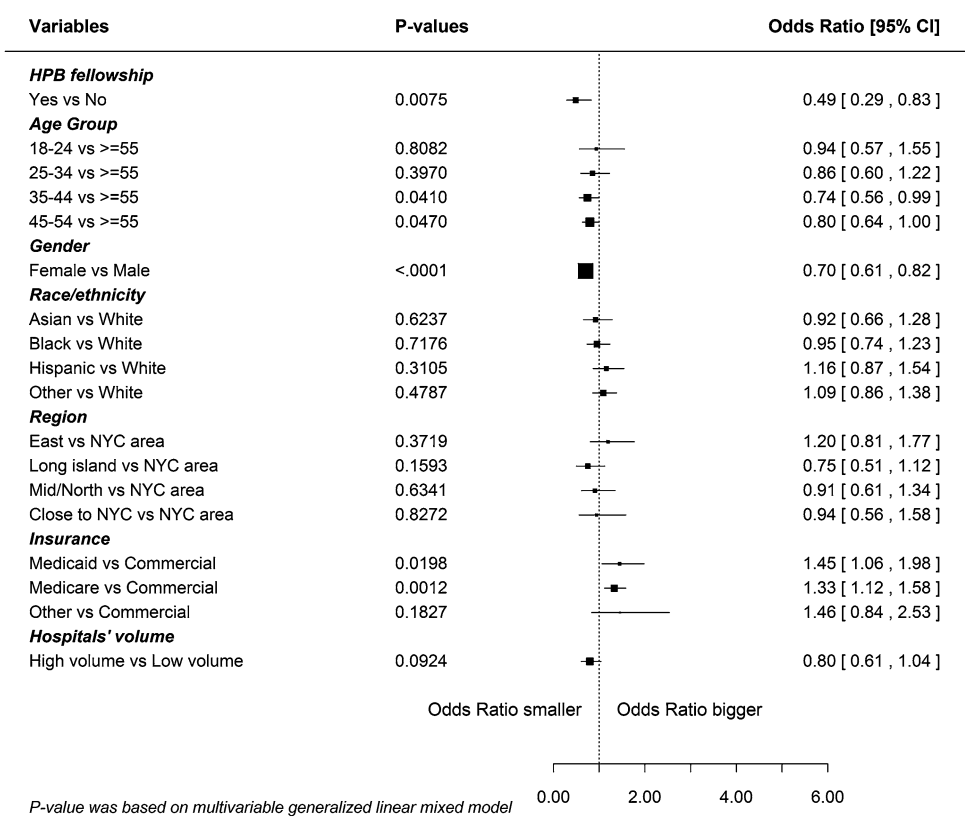

Fig. 1 Forest plot of estimated odds ratios and their 95% confidence intervals of factors for severe complication

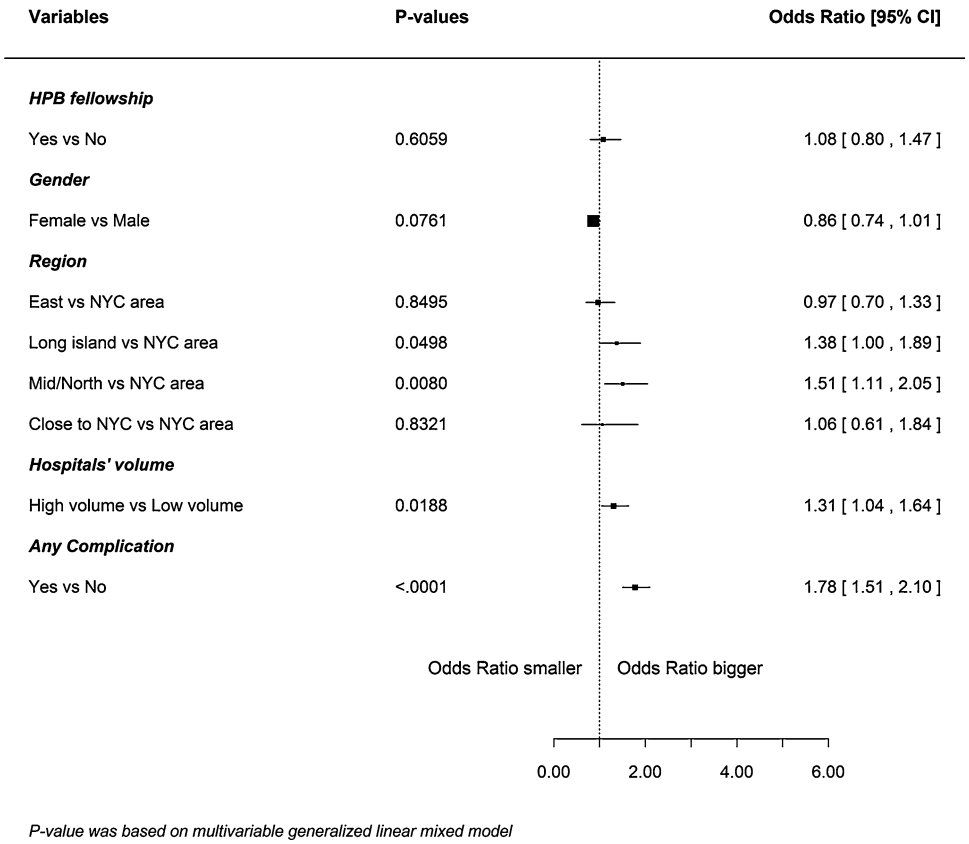

Fig. 2 Forest plot of estimated odds ratios and their 95% confidence intervals of factors for 30-day readmissions

Table 3 Estimated difference in length of stay based on the fitted linear mixed model

Variable	Level	Estimate	p value[1]	p value[2]
HPB fellowship	Yes versus no	0.051	0.7290	0.7290
Age Group	18–24 versus ≥55	0.007	0.9049	0.4528
	25–34 versus ≥55	−0.034	0.4002	
	35–44 versus ≥55	−0.025	0.4126	
	45–54 versus ≥55	−0.043	0.0780	
Gender	Female versus male	–0.031	0.0686	0.0686
Race/ethnicity	Asian versus white	0.001	0.9768	0.0003
	Black versus white	0.12	<.0001	
	Hispanic versus white	0.086	0.0135	
	Other versus white	0.009	0.7473	
Insurance	Medicaid versus commercial	0.23	<.0001	<.0001
	Medicare versus commercial	0.05	0.0110	
	Other versus commercial	0.14	0.0464	
Hospitals' volume	High volume versus low volume	−0.13	0.0318	0.0318
Any comorbidity	Yes versus no	0.19	<.0001	<.0001
Any complication	Yes versus no	0.51	<.0001	<.0001

[1] p value was based on student's t-test comparing estimate with 0

[2] p value was based on Wald test from multivariable linear mixed model with facilities and physicians as clustering effect comparing if there is any significant difference among different levels in one variable

performed by a fellow with an attending versus attending alone between 2005 and 2011 using the National Surgical Quality Improvement Program (NSQIP) database. Besides an increased risk of surgical site infections, no differences were seen in terms of mortality and complications. The authors concluded that fellowship training maintained excellent patient outcomes [17]. Kohn and Nikfarjam demonstrated no association in terms of overall complications and mortality rates following hepatectomy at hospitals with fellowship programs. However, institutions with fellowship status had an increased rate of wound dehiscence, among several other complications [16]. While these studies have also examined the effect of presence of a HPB fellowship on patient outcomes, they concentrated on just a single procedure, rather than the array of procedures that are being performed in such institutions.

There are several limitations of our study. First, it only includes one specific geographical region, and thus it may not be a generalization for the country, as could be obtained with the use of NIS or NSQIP databases. However, compared to those databases that may capture only a percentage of patient cases, the SPARCS database captures all patient procedures, and thus represents a more accurate description of patient outcomes. Other limitations are mostly inherent to the use of an administrative database. It is possible that some coding errors may exist, thus leading to either over- or under-capture of cases based on ICD-9 codes.

Despite its limitations, our study shows that institutions with HPB fellowship training were associated with significantly improved perioperative outcomes. There were no significant differences in terms of 30-day readmission rate or HLOS between hospitals with or without fellowship following complex hepatopancreaticobiliary procedures.

Conclusion

Hospitals with HPB fellowships have improved complications following complex surgical procedures. These data highlight the safety and importance of a presence of a fellowship in complex hepatopancreatobiliary procedures.

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Compliance with ethical standards

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