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ORIGINAL ARTICLE – HEPATOBILIARY TUMORS

Facility Type is Associated with Margin Status and Overall Survival of Patients with Resected Intrahepatic Cholangiocarcinoma

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ABSTRACT

Background. Many studies have demonstrated associations between surgical resections at academic centers and improved outcomes, particularly for complex operations. However, few studies have examined this relationship in intrahepatic cholangiocarcinoma (ICC). The hypothesis of this study was that facility type is associated with improved postoperative outcomes and survival for patients with ICC who undergo resection.

Methods. Patients with stages 1 to 3 ICC who underwent hepatectomy were identified using the National Cancer Database (NCDB) (2004–2014). Facilities were categorized as academic or community centers per Commission on Cancer designations. High-volume hospitals were those that performed 11 or more hepatectomies per year. Multilevel logistic mixed-effects models to identify predictors of outcomes and parametric survival-time models were used to determine overall survival (OS).

Results. The study identified 2256 patients. Of these patients, 423 (18.8%) were treated at community centers, and 1833 (81.3%) were treated at academic centers. Nearly all high-volume centers were academic facilities (98.5% academic vs. 1.5% community centers), whereas low-volume centers were mixed (65.5% academic vs. 34.5% community centers) ($p < 0.001$). Surgery performed at an academic center was an independent predictor of decreased positive margins (odds ratio [OR], 0.71; 95% confidence interval [CI], 0.51–0.98; $p = 0.04$), a lower 90-day mortality rate (OR, 0.62; 95% CI, 0.39–0.97; $p = 0.03$), and improved OS (hazard ratio [HR], 0.78; 95% CI, 0.63–0.96; $p = 0.02$). Facility hepatectomy volume was not independently associated with any short- or long-term outcomes.

Conclusions. Treatment at an academic center is associated with fewer positive resection margins, a decreased 90-day mortality rate, and improved OS for patients who undergo ICC resection. Facility surgical volume was not shown to be significantly associated with any postoperative outcomes after adjustment for patient and disease characteristics.

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Intrahepatic cholangiocarcinoma (ICC) is a rare malignancy, diagnosed in an estimated 3000 cases each year in the United States, although its incidence has been increasing steadily.[1] Operative resection offers the only chance for cure and often requires complex hepatobiliary surgical and multidisciplinary intervention.[2] However, even after surgical resection, up to two-thirds of patients experience disease recurrence, and 5-year overall survival (OS) rates range from 15 to 40%.[1,3,4]

Many studies have demonstrated associations between treatment at academic, high-volume centers and improved outcomes, particularly for complex operations and rare malignancies.[5] This has led to mandated centralization of complex procedures in several European countries,[6] and to "passive" centralization and calls for restricting complex operations to high-volume "centers of excellence" in the United States.[6] However, increasing discussion maintains that hospital volume itself may not be the most accurate quality indicator because it may be a surrogate for other factors that have a stronger impact on outcomes.[7] Due to the rarity of ICC, few studies have evaluated relationships between facility type, volume, and outcomes after resection of ICC.[6,8]

We performed a retrospective analysis of patients who underwent hepatectomy for non-metastatic ICC using the National Cancer Database (NCDB). The primary objective of the study was to compare postoperative outcomes and OS based on facility type (community vs academic centers). The secondary objectives were to determine whether outcomes were more strongly correlated with facility type or facility surgical volume and to identify predictors of surgery performed at an academic center.

METHODS

Study Population

We performed a retrospective analysis of patients who underwent hepatectomy for clinical stages 1 to 3 ICC diagnosed between 2004 and 2014 in the NCDB. The NCDB is a nationwide, facility-based data set that captures 70% of all newly diagnosed malignancies in the United States. It is a joint project of the Commission on Cancer (CoC) of the American College of Surgeons and the American Cancer Society.[9] This study was exempt from institutional review board review due to the de-identified nature of the database.

Variable Definitions

The NCDB includes basic demographic characteristics including age, sex, race, and Charlson–Deyo Comorbidity Score (CDCC).[10] The definition of CoC facility types is based on cancer program structure, services provided, and number of cancer cases accessioned per year. These include community cancer programs (accessions if 100–500 cases of newly diagnosed cancer each year; training of resident physicians is optional), comprehensive community cancer programs (accessions of > 500 cases of newly diagnosed cancer each year; training of resident physicians is optional), academic/research programs (accessions of > 500 cases of newly diagnosed cancer each year; training of resident physicians occurs in at least four program areas including internal medicine and general surgery), and integrated network cancer programs (multiple facilities providing integrated cancer care; at least one facility is a hospital; training resident physicians is optional; no minimum caseload is required). We excluded integrated network cancer programs due to the heterogeneous types of facilities with that designation, consistent with prior work.[11,12] For our analysis, we compared community centers (community cancer programs and comprehensive community cancer programs) with academic programs, also consistent with prior work.[13]

Clinical stage was designated based on the American Joint Commission on Cancer (AJCC) 7th edition. Tumor size was defined as the largest dimension of the primary tumor diameter in centimeters. Hepatectomy included any procedure ranging from partial hepatectomy or segmental resection to major lobectomy or extended hepatectomy. Margin status (negative or positive) was obtained from the final surgical pathologic analysis. The number of lymph nodes examined and the node status (negative, positive, or nodes not examined) also were obtained from surgical pathology. Examination of six or more nodes was considered necessary for accurate oncologic staging, per AJCC 8th edition guidelines.[14] Adjuvant chemotherapy was defined as receipt of chemotherapy after primary-site surgery as part of the first course of treatment. Overall survival was defined as months from diagnosis to death.

Facility Volume Calculations

Facility hepatectomy volume was calculated using de-identified facility identification codes assigned by the NCDB. Facility codes are assigned regardless of cancer site and therefore may be used to identify the same facilities across cancer sites.

The NCDB participant user files for the "liver" and "intrahepatic bile duct" cancer sites were used to calculate each facility's annual hepatectomy volume between 2004 and 2014. Liver transplantations were excluded from volume calculations. Only facilities that submitted at least one case to the NCDB every year of the study were included to ensure a consistent population of hospitals and to ensure that hospital volume did not appear falsely low due to lack of membership in the CoC during certain years, per recommendations from the practical guide to the NCDB.[15] Patients were included in the cohort only if they underwent hepatectomy for ICC at the reporting facility.

We found that the median number of hepatectomies per year was 11 and therefore defined low-volume facilities as those that performed fewer than 11 hepatectomies per year and high-volume facilities as those that performed 11 or more hepatectomies per year.

Statistical Analysis

Variables were summarized as median with interquartile range (IQR) or number with percentage. Categorical variables were compared with Pearson's Chi square test, and continuous variables were compared with the two-sample *t* test. Kaplan–Meier curves were used to analyze OS. Multilevel logistic mixed-effects models were used for adjusted analyses of categorical outcomes, with fixed effects assigned to patient-level predictors and random effects assigned to individual hospitals to account for intraclass correlation for patients nested within the same facility.

Similarly, multilevel mixed-effects parametric survival-time models were used for the survival analyses. Because facility type and facility volume were highly collinear, separate logistic models and parametric survival-time models were used with either facility type or volume, together with potential confounders. The results of the logistic regressions and parametric survival-time models are reported as odds ratios (ORs) and hazard ratios (HRs), respectively, with corresponding 95% confidence intervals (CIs) and *p* values.

All statistical analyses were performed using Stata software, version SE 14.0 (StataCorp, College Station, TX, USA). All tests were two-sided, and statistical significance was accepted at *p* values lower than 0.05.

RESULTS

The study identified 2256 patients with a diagnosis of stages 1 to 3 ICC between 2004 and 2014, who underwent hepatectomy at 308 different facilities. Of these patients, 423 (18.8%) underwent resection at a community center, and 1833 (81.3%) underwent resection at an academic center. Half (50%) of facilities were academic centers. Nearly all the high-volume centers were academic facilities (98.5% academic vs 1.5% community centers), whereas the low-volume centers were mixed (65.5% academic vs 34.5% community centers) ($p < 0.001$). The median number of hepatectomies per year was 1.9 (IQR, 0.9–3.5) at the community centers and 14.1 (IQR, 6.4–22.8) at the academic centers ($p < 0.001$). The median follow-up time was 25.9 months (IQR, 12.6–44.3 months).

Regarding the type of hepatectomy, of the 804 patients who underwent partial hepatectomy or segmental resection, 20.1% were treated at community centers, and 79.9% were treated at academic centers. Of the 742 patients who underwent hepatic lobectomy, 18.1% were treated at community centers, and 81.9% were treated at academic centers. Of the 318 patients who underwent extended hepatic lobectomy, 19.5% were treated at community centers, and 80.5% were treated at academic centers. Of the 392 patients who underwent hepatectomy not otherwise specified, 16.6% were treated at community centers, and 83.4% were treated at academic centers.

Predictors of Treatment at an Academic Center

Univariate analysis demonstrated baseline differences between the patients who underwent operations at community centers versus academic centers (Table 1). The patients treated at academic centers were more likely to be younger than 65 years, with fewer comorbidities and private insurance, and tended to travel more than 40 miles between their home zip code and the hospital zip code (all $p < 0.001$). Clinical stage, tumor size, and tumor grade did not differ based on facility type (all $p > 0.05$).

Multivariable analysis then was performed to identify independent predictors of treatment received at an academic facility (Table 1). Higher comorbidity scores were predictive of treatment at a community facility ($p < 0.001$), whereas traveling more than 40 miles to the treating hospital predicted treatment at an academic center ($p < 0.001$).

Clinical and Oncologic Outcomes Based on Facility Type and Facility Volume

Univariate analysis demonstrated differences in clinical and oncologic outcomes associated with facility type (Table 2). The patients who underwent resection at academic centers were less likely to have positive surgical margins (21.4% vs. 26.1%; $p = 0.04$), six or more lymph nodes examined (12.6% vs. 8.0%; $p = 0.01$), and decreased rates of 30-day mortality (4.0% vs. 7.5%; $p = 0.01$) and 90-day mortality (8.0% vs. 12.8%; $p = 0.004$).

In the multilevel mixed-effects multivariable analysis (Table 2), surgery received at an academic facility remained significantly associated with fewer positive resection margins (OR, 0.71; 95% CI, 0.51–0.98; $p = 0.04$) and a lower 90-day mortality rate (OR, 0.62; 95% CI, 0.39–0.97; $p = 0.03$). In the subset analysis of only patients with negative margins, academic facility type remained significantly correlated with a decreased 90-day mortality rate (OR, 0.57; 95% CI, 0.33–0.997; $p = 0.049$).

In contrast, although the univariate analysis showed an association between surgery received at a high-volume center and increased likelihood of six or more lymph nodes examined ($p = 0.050$), a decreased 30-day mortality rate ($p = 0.02$), and a decreased 90-day mortality rate ($p = 0.04$), none of these associations remained significant

TABLE 1 Predictors of undergoing intrahepatic cholangiocarcinoma resection at an academic vs community facility based on uni- and multivariable analyses

Characteristic	Community center ($n = 423$) n (%)	Academic center ($n = 1833$) n (%)	Unadjusted p value	OR (95% CI)	Adjusted p value
Age ≥ 65 years	253 (59.8)	859 (46.9)	<0.001	0.78 (0.56–1.09)	0.14
Male sex	180 (42.6)	866 (47.2)	0.08	1.21 (0.94–1.55)	0.14
Race			0.12		
White	360 (86.1)	1468 (82.0)		Reference	
Black	16 (3.8)	121 (6.8)		2.34 (1.28–4.29)	0.01
Hispanic	22 (5.3)	108 (6.0)		1.58 (0.92–2.71)	0.10
Asian	20 (4.8)	93 (5.2)		1.28 (0.74–2.20)	0.37
Charlson–Deyo score			< 0.001		
0	247 (58.4)	1269 (69.2)		Reference	
1	108 (25.5)	404 (22.0)		0.74 (0.55–0.99)	0.04
≥ 2	68 (16.1)	160 (8.7)		0.45 (0.31–0.65)	<0.001
Insurance status			<0.001		
Private	147 (35.2)	776 (44.0)		Reference	
Medicaid	10 (2.4)	88 (5.0)		1.87 (0.86–4.09)	0.12
Medicare	247 (59.1)	835 (47.4)		0.81 (0.58–1.15)	0.24
None or other government	14 (3.4)	64 (3.6)		0.82 (0.41–1.67)	0.59
Distance between patient zip code and hospital (miles)			< 0.001		
< 10	166 (39.2)	392 (21.4)		Reference	
10–40	154 (36.4)	640 (34.9)		1.97 (1.47–2.65)	<0.001
> 40	103 (24.4)	801 (43.7)		3.77 (2.73–5.21)	<0.001
Clinical stage			0.37		
1	157 (37.2)	609 (33.3)		Reference	
2	81 (19.2)	344 (18.8)		0.94 (0.67–1.33)	0.74
3	40 (9.5)	178 (9.7)		1.02 (0.64–1.62)	0.93
Unknown	144 (34.1)	700 (38.2)		1.34 (1.00–1.81)	0.051
Tumor size (cm)			0.13		
< 3	67 (17.1)	360 (20.9)		Reference	
3–5	129 (32.9)	498 (28.9)		0.84 (0.59–1.22)	0.36
> 5	196 (50.0)	866 (50.2)		0.86 (0.61–1.21)	0.38
Tumor grade			0.44		
Well-differentiated	54 (14.6)	198 (12.5)		Reference	
Moderately differentiated	208 (56.4)	894 (56.2)		1.32 (0.91–1.93)	0.14
Poorly differentiated or undifferentiated	107 (29.0)	499 (31.4)		1.25 (0.83–1.89)	0.28

OR odds ratio, *CI* confidence interval

in the multilevel mixed-effects multivariable analysis (Table 2). In fact, in the multivariable analysis, hospital hepatectomy volume was not an independent predictor of any postoperative outcome.

Analysis of Overall Survival

Kaplan–Meier curves demonstrated better OS for the patients who underwent resection at academic facilities than for the patients treated at community centers ($p = 0.005$; Fig. 1). The 1-year OS rate was 71.5% for the patients at community hospitals compared with 81.1% for the patients at academic centers ($p < 0.05$), whereas the 5-year OS rate was 31.2% for the patients at community centers and 36.3% for those at academic hospitals ($p > 0.05$). When the patients who died within 90 days after surgery were excluded, the 1-year OS remained significantly improved for the patients treated at academic centers (88.0% vs. 82.0%; $p < 0.05$), whereas the 5-year

TABLE 2 Odds of oncologic and clinical outcomes for patients with intrahepatic cholangiocarcinoma who underwent resection at academic centers versus community centers and at high-volume centers versus low-volume centers based on multivariable analysis[a]

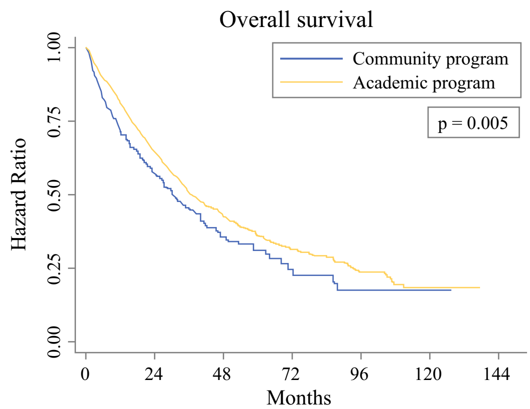
Outcomes	Facility type					Facility volume				
	Community center *n* (%)	Academic center *n* (%)	Unadjusted *p* value	OR (95% CI)	Adjusted *p* value	Low-volume center *n* (%)	High-volume center *n* (%)	Unadjusted *p* value	OR (95% CI)	Adjusted *p* value
Positive surgical margins	105 (26.1)	370 (21.4)	0.04	0.71 (0.51–0.98)	0.04	238 (23.0)	216 (21.9)	0.57	0.87 (0.64–1.19)	0.39
Lymph nodes examined ≥ 6	33 (8.0)	230 (12.6)	0.01	1.28 (0.75–2.16)	0.37	113 (10.6)	140 (13.4)	0.050	1.17 (0.72–1.91)	0.53
Length of stay ≥ 7 days	234 (55.3)	1056 (57.6)	0.39	1.12 (0.82–1.55)	0.47	607 (55.9)	608 (57.6)	0.43	1.06 (0.76–1.47)	0.73
Readmission within 30 days	30 (7.1)	154 (8.5)	0.36	0.82 (0.44–1.52)	0.53	76 (7.1)	99 (9.4)	0.052	1.39 (0.73–2.65)	0.32
Adjuvant chemotherapy administered	112 (27.8)	530 (30.6)	0.28	1.26 (0.91–1.74)	0.17	315 (29.9)	325 (31.1)	0.57	1.14 (0.84–1.55)	0.39
30-day mortality	26 (7.5)	62 (4.0)	0.01	0.60 (0.34–1.07)	0.09	52 (5.9)	33 (3.6)	0.02	0.68 (0.40–1.16)	0.16
90-day mortality	44 (12.8)	123 (8.0)	0.004	0.62 (0.39–0.97)	0.03	92 (10.5)	70 (7.7)	0.04	0.68 (0.46–1.01)	0.06
1 year overall survival[b]	71.5	81.1	0.01	0.78 (0.63–0.96)[c]	0.02^	76.8	81.7	0.32	0.95 (0.79–1.14)	0.59[b]

OR odds ratio, *CI* confidence interval

[a]Multilevel logistic mixed-effects model adjusted for Commission on Cancer (CoC) facility type or for facility volume, age, sex, race, Charlson score, clinical stage, tumor size, tumor grade, insurance type, and distance from patient's zip code to hospital zip code

[b]Multilevel mixed-effects parametric survival-time model adjusted for CoC facility type or for facility volume, age, sex, race, Charlson score, clinical stage, tumor size, tumor grade, insurance type, distance from patient's zip code to hospital zip code, margin status, and receipt of adjuvant chemotherapy

[c]Hazard ratio



Number at risk							
Community program	347	162	53	12	3	2	0
Academic program	1568	860	358	117	43	12	0

FIG. 1 Kaplan–Meier curves depicting overall survival for patients with resected intrahepatic cholangiocarcinoma based on facility type

OS again did not differ significantly based on facility type (39.5% vs. 35.7%; $p > 0.05$).

The multilevel mixed-effects parametric survival-time analysis demonstrated that the academic facility type was independently associated with a decreased risk of mortality (HR, 0.78; 95% CI, 0.63–0.96; $p = 0.02$) compared with the community facility type (Table 3). The independent predictors of worse OS included age of 65 years or older ($p = 0.002$), male sex ($p < 0.001$), advanced clinical stage ($p < 0.001$), tumor larger than 5 cm ($p = 0.01$), poorly differentiated tumor grade ($p < 0.001$), and positive surgical margins ($p < 0.001$). Receipt of adjuvant chemotherapy was an independent predictor of decreased mortality ($p = 0.02$).

In the subset analysis of only patients with negative margins, academic facility type continued to be significantly associated with lower mortality rates (HR, 0.71; 95% CI, 0.55–0.91; $p = 0.01$). In a separate subset analysis of only patients who survived more than 90 days after surgery, academic facility type again was associated with statistically improved mortality rates (HR, 0.79; 95% CI, 0.63–1.00; $p = 0.05$). In contrast, hepatectomy volume was not independently associated with OS ($p = 0.59$).

Temporal and Regional Patterns in Use of Academic and Community Centers

During the study period, our data demonstrated a slow but steady decline in the percentage of hepatectomies for ICC performed at academic centers, from 87.4% in 2004 to 77.7% in 2014. During that same period, the percentage of ICC resections performed at community centers increased from 12.6% in 2004 to 22.3% in 2014.

For the subset of patients treated at community centers, the outcomes appeared to be better for those with a cancer diagnosis in 2012–2014 than for those with a cancer diagnosis in 2004–2007, although none of the differences reached statistical significance. The rates of positive margins decreased from 34.8% to 22.4% ($p = 0.15$), adequate lymph node harvest increased from 4.3% to 8.7% ($p = 0.60$), 30-day mortality rates decreased from 12.2 to 7.0% ($p = 0.40$), and 90-day mortality rates decreased from 16.3% to 12.0% ($p = 0.73$).

Interestingly, there were vast regional variations in the percentage of ICC resections performed at community versus academic centers (Fig. 2a). In the New England region, 97.5% of the hepatectomies for ICC were performed at academic centers, whereas in the Pacific region, only 60.7% were performed at academic centers ($p < 0.001$). Evaluation of only patients treated at academic centers showed dramatic differences in the distances that patients traveled to reach the hospitals based on U.S. region (Fig. 2b). The median distance traveled for treatment at an academic center ranged from 16 miles (IQR, 7.1–32.8 miles) in New England to 98.6 miles (IQR, 33.0–250.4 miles) in the West North Central region ($p < 0.001$).

DISCUSSION

This analysis of 2256 patients who underwent hepatectomy for ICC at 308 facilities found that treatment at an academic center was associated with fewer positive resection margins, lower 90-day mortality rates, and better OS than treatment at a community center, even after adjustment for multiple patient factors and disease characteristics. Facility type was significantly correlated with facility annual hepatectomy volume, academic centers performing an average of 14.1 hepatectomies per year, and community centers averaging 1.9 hepatectomies per year. However, there were no significant associations between facility volume and postoperative outcomes after adjustment for other factors. Taken together, these data suggest that facility type is a more important predictor of mortality and long-term survival than facility surgical volume.

The reasons why academic facility type may be associated with improved postoperative outcomes are multifactorial. As a rare disease ICC, requires carefully coordinated, multidisciplinary care to optimize survival.[2] Favorable margin status may be related to increased surgeon experience and specialization at tertiary care centers, whereas decreased 90-day mortality rates may be related to facility infrastructure and the ability to rescue patients from complications (readily open intensive care units, experienced nursing staff, resident presence 24 h per day, and

TABLE 3 Multilevel mixed-effects parametric survival-time model of predictors of mortality for patients with resected intrahepatic cholangiocarcinoma

Variable	HR (95% CI)	*p* value
Academic center	0.78 (0.63–0.96)	0.02
Age ≥ 65 years	1.38 (1.12–1.70)	0.002
Male sex	1.33 (1.15–1.54)	< 0.001
Race		
White	Reference	
Black	0.90 (0.64–1.26)	0.54
Hispanic	0.89 (0.63–1.24)	0.49
Asian	0.81 (0.57–1.14)	0.22
Insurance status		
Private	Reference	
Medicaid	1.10 (0.74–1.63)	0.65
Medicare	0.95 (0.77–1.18)	0.65
None or other government	1.00 (0.63–1.57)	0.99
Distance between patient zip code and hospital (miles)		
< 10	Reference	
10–40	1.09 (0.89–1.33)	0.43
> 40	1.08 (0.88–1.33)	0.46
Charlson–Deyo score		
0	Reference	
1	1.11 (0.93–1.32)	0.23
≥2	1.25 (0.99–1.58)	0.06
Clinical stage		
1	Reference	
2	1.40 (1.13–1.74)	0.002
3	1.72 (1.33–2.22)	< 0.001
Unknown	1.34 (1.12–1.61)	0.002
Tumor size (cm)		
< 3	Reference	
3–5	0.94 (0.75–1.17)	0.58
> 5	1.32 (1.07–1.61)	0.01
Tumor grade		
Well-differentiated	Reference	
Moderately differentiated	1.38 (1.08–1.76)	0.01
Poorly differentiated or undifferentiated	1.61 (1.24–2.08)	< 0.001
Positive surgical margins	2.03 (1.70–2.41)	< 0.001
Adjuvant chemotherapy received	0.82 (0.69–0.96)	0.02

HR hazard ratio, *CI* confidence interval

availability of consulting services) at academic centers accustomed to high-risk complex surgical procedures.[8,11,16–18]

In our study, academic facility type was associated not only with improved short-term outcomes, but also with OS. An explanation for this finding may be the lower rate of positive resection margins for patients who underwent hepatectomy at academic centers, given the recognized importance of complete tumor excision for long-term survival.[19] Academic centers also may have better longitudinal cancer care, with experienced multidisciplinary teams, involvement in clinical trials, and close patient follow-up evaluation.[12] In addition, patients treated at academic centers tend to be younger, with fewer comorbidities and private insurance.[11,20] Although we attempted to adjust for these characteristics, it is possible that favorable outcomes associated with academic hospitals remained confounded by their patients' better overall health and socioeconomic status than experienced by patients at community centers.

Although 1-year OS was significantly improved for the patients treated at academic facilities, the unadjusted analysis showed no significant difference in 5-year OS. This likely was due to lack of power at the 5-year time point (data was available only for 28 community center patients and 212 academic center patients). Using the more accurate methodology of time-to-event analysis, the data demonstrated a significant improvement in OS for the patients treated at academic centers (unadjusted log-rank $p = 0.005$; adjusted $p = 0.02$). A potential reason for the lack of significant difference in 5-year OS could be that some patients were managed at different types of facilities for their longer-term oncologic care because the NCDB captures only the first stage of treatment. Another reason could be that the benefit of academic facility type has the most impact at the time of diagnosis and operative intervention.

Interestingly, we found a stronger association of outcomes with facility type than with facility hepatectomy volume. Although numerous studies have demonstrated a clear association between high volume and improved outcomes, there is recent consensus that volume likely is a "proxy measure" for more influential drivers of postoperative outcomes.[7,21] Our data suggested that academic facility type is perhaps one of those influential drivers because the infrastructure and specialist care provided at academic hospitals are likely to be associated with improved outcomes as well as increased surgical volume. Other studies have demonstrated similar findings; Hyder et al.[22] found that even among high-volume hospitals, teaching hospitals were associated with better outcomes after complex hepatopancreaticobiliary operations than nonteaching hospitals. It is important to note, however, that this concept is not uniformly validated. Dimick et al.[23] demonstrated that the association between facility type and outcomes disappeared after adjustment for surgical volume and therefore concluded that lower mortality rates at teaching hospitals still may be explained by higher procedural volume.

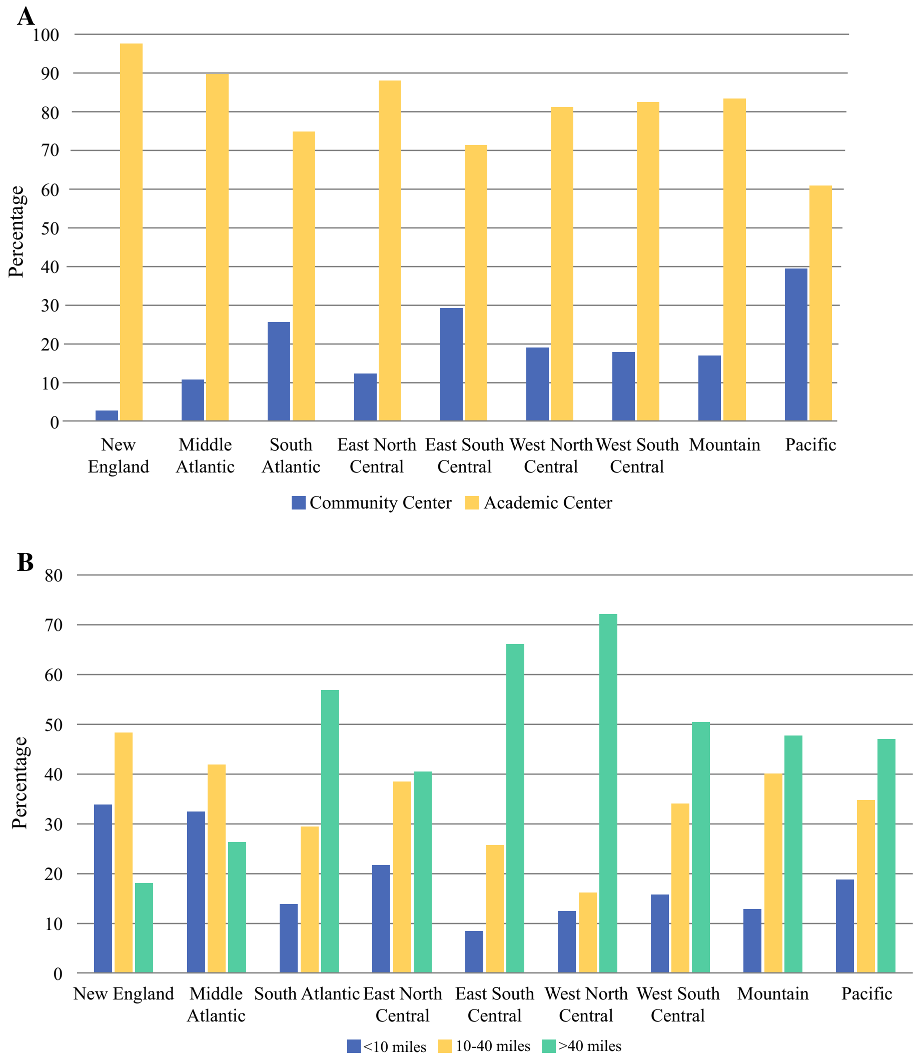


FIG. 2 United States regional variations in (**a**) distribution of hepatectomies for intrahepatic cholangiocarcinoma between academic and community centers and **b** distances patients traveled to academic centers for intrahepatic cholangiocarcinoma resection

Finally, it is important to appreciate that academic centers differ significantly in terms of density of across U.S. regions, which influences patients' decisions to undergo treatment at academic or community centers and may affect how far patients are willing to travel to receive care at academic institutions. The distance required for travel to academic centers may exacerbate disparities in access to care because prior work has demonstrated that older patients, racial minorities, and patients with Medicaid insurance are less likely to travel for care than their counterparts.[24]

The limitations of this study included those inherent to retrospective analyses such as selection bias and potential unmeasured confounders that could not be subjected to control. The NCDB does not include outcomes such as postoperative morbidity and disease recurrence, and because of significant missing data, variables related to patients' underlying liver function were not included in our analysis. Furthermore, although we compared academic centers with community centers, all hospitals that contributed to this data set are members of the CoC, which may limit generalizability of the findings to non-CoC facilities.

CONCLUSIONS

In this analysis of 2256 patients who underwent ICC resection at 308 facilities, we found that academic facility type was an independent predictor of fewer positive resection margins, lower 90-day mortality rates, and improved OS. Facility type was likely a superior quality metric compared with facility hepatectomy volume, which was not significantly associated with any postoperative outcomes. Although these data may appear to support centralization of complex surgical procedures such as ICC resection at academic rather than simply high-volume, centers, access to care may be limited by marked variations in regional density of academic centers.

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DISCLOSURE There are no conflicts of interest.

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