Surgery 165 (2019) 1128–1135

Contents lists available at ScienceDirect

Surgery

journal homepage: www.elsevier.com/locate/surg

Pancreas

Presented at the Academic Surgical Congress 2019

Predictors and outcomes of nonroutine discharge after hepatopancreatic surgery

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ARTICLE INFO

Article history:
Accepted 27 February 2019
Available online 11 April 2019

ABSTRACT

Background: Data on predictors of nonroutine discharge among patients undergoing hepatopancreatic surgery remain poorly defined. We sought to define factors associated with nonroutine discharge to home with home health care or to a skilled nursing facility or intermediate care facility and determine the impact of discharge destination on outcomes after hepatopancreatic surgery.

Methods: The Nationwide Readmissions Database was queried for individuals who underwent hepatopancreatic surgeries 2010–2014 and were discharged home with home health care or to a skilled nursing facility/intermediate care facility.

Results: A total of 42,189 patients underwent hepatopancreatic surgery. Of those, 2,825 (6.70%) were discharged to a skilled nursing facility or intermediate care facility, whereas 10,925 (25.9%) were discharged with home health care. A majority of patients underwent major hepatectomy ($N = 14,516$, 34.4%) or minor pancreatectomy ($N = 13,824$, 32.8%). Compared with patients discharged home, patients discharged to a skilled nursing facility or intermediate care facility were older (median age: 60 years, interquartile range: 50–68 vs 73, 67–79) and had more comorbidities (median score: 3, interquartile range: 1–8 vs 4, interquartile range: 2–8; $P < .001$). Type of operative procedure was not associated with discharge to a skilled nursing facility versus with home health care. Rather, patients with extreme loss of function, based on preoperative assessment, had 2.76 times higher odds of discharge to a skilled nursing facility or intermediate care facility versus with home health care (odds ratio 2.76, 95% confidence interval 1.98–3.85). Similarly, older (odds ratio 1.06, 95% confidence interval 1.06–1.07) and female patients (odds ratio 1.37, 95% confidence interval 1.25–1.51) were more likely to be discharged to a skilled nursing facility or intermediate care facility versus with home health care.

Conclusion: One in four patients undergoing hepatopancreatic surgery were readmitted within 90 days of surgery. Age, severity of comorbidities, and perioperative course, including incidence of complications, were associated with nonroutine discharge.

Introduction

In recent years, there has been an increased emphasis on the importance of quality and safety initiatives aimed at improving the health care delivered to Americans. Merath et al[1] recently noted that less than one-half of Medicare patients undergoing hepatopancreatic (HP) surgery experience a "textbook outcome." Furthermore, despite significant improvement in surgical technique and patient selection, 20% to 40% of patients undergoing hepatopancreatobiliary (HPB) procedures experience a complication.[2–5] In turn, after these complex surgical interventions, 10% to 50% of patients eventually require skilled assistance after discharge ("nonroutine" discharge), including the use of home health care (HHC), skilled nursing facilities (SNFs), or intermediate care facilities (ICFs).[6–9]

Among orthopedic surgical patients, discharge to SNFs and ICFs has been associated with increased postdischarge complications,

Presented at the 2019 Annual Academic Surgical Congress.

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https://doi.org/10.1016/j.surg.2019.02.020
0039-6060/

readmissions, and costs.[10–12] Nevertheless, the impact of nonroutine discharge on perioperative outcomes, including readmission rates among HP patients, has not been extensively studied. Although Kim et al[13] noted a relationship between nonroutine discharge and 90-day readmission after major abdominal procedures, Schneider et al[14] reported no correlation between SNF discharge and early or late readmission among patients undergoing pancreaticoduodenectomy. As a greater proportion of patients require an escalation of health services, including nursing care, after HP surgery, there has been increasing interest in mitigating associated adverse events as a means to improve quality of care.

Data on predictors of nonroutine discharge among patients undergoing HP surgery remain unclear. As such, the objective of the current study was to define predictors of nonroutine discharge to home with HHC or an SNF/ICF after HP surgery. In addition, we sought to determine the impact of postdischarge destination on short-term outcomes, including the incidence of early and late readmission, cause of readmission, and mortality among patients who had undergone HP surgery.

Methods

Data source and patient characteristics

The Nationwide Readmissions Database (NRD) is sponsored by the Agency for Healthcare Research and Quality (AHRQ) and is designed specifically for readmission analyses. Data are obtained from the Healthcare Cost and Utilization Project State Inpatient Databases and contain more than 100 clinical and nonclinical variables. States involved in the NRD assign patient linkage numbers that are used to track patients within and across hospitals in a particular state.[15]

Using ICD-9CM codes, we queried the NRD for individuals who underwent elective HP surgeries between 2010 and 2014 who had routine or nonroutine discharge (Supplemental Table). Surgical intervention was subcategorized into major and minor pancreatectomy and hepatectomy as described elsewhere.[16,17] Routine discharge was defined as discharged home, whereas nonroutine discharge was defined as discharge home with HHC or to an SNF/ICF. Because tracking between years is not possible in the NRD, to allow for 90-day follow-up of all patients, individuals discharged in the last 3 months of the year were excluded. In addition, patients who died during the initial hospitalization (N = 1,014) and individuals with missing data on length of hospital stay (LOS) were excluded because they were ineligible to be readmitted. In addition, patients discharged to a place other than home with or without HHC or to an SNF/ICF were also excluded from the final cohort.

Variables

Agency for Healthcare Research and Quality variables were used to generate a comorbidity score for each patient based on the number of comorbidities recorded (0, 1, 2, ≥3 comorbidities).[18] The All Patient Refined Diagnosis Related Group, created by the Centers for Medicare & Medicaid Services, was used to identify risk of mortality and severity of illness subclass (minor, moderate, major, extreme) that is dependent on the patient's primary illness, underlying medical comorbidities at the time of admission, secondary diagnoses, and procedures required.[19] Severity of illness was defined as "the extent of physiologic decompensation or organ system loss of function," whereas risk of mortality was defined as "the likelihood of dying."[19] Additional variables included primary payer source, median household income quartile based on the patient's ZIP code, size of hospital based on the number of beds, LOS of the initial hospitalization, type (major versus minor hepatectomy and pancreatectomy), and modality of surgery (minimally invasive surgery versus open). Time to readmission was based on date of admission for index events, LOS for the index event, and date of readmission. Causes of readmission were derived from diagnosis codes. If a patient had more than one readmission, only the first readmission was evaluated.

Data analysis

The cohort was subdivided based on discharge destination (home, SNF/ICF, HHC). Demographics, patient characteristics, hospital characteristics, and early and late outcomes were compared across the different discharge destination groups. Similar to other studies, early outcomes were defined as occurring 0 to 30 days from discharge, whereas late outcomes occurred between 31 to 90 days.[14,20] Categorical variables were presented as frequencies and percentages, whereas continuous variables were presented as medians and interquartile ranges (IQR). Categorical variables were compared using χ^2 tests and Fisher exact tests where appropriate. Continuous variables were compared using Wilcoxon rank-sum tests and Kruskal-Wallis one-way analysis of variance. Logistic regression was used to identify factors associated with discharge destination. Because of collinearity, number of comorbidities and risk of mortality category were not included in the final multivariable model. Variables included were age, sex, type of procedure, presence of malignancy, comorbidities, illness severity score, primary payer, median household income, LOS, hospital size, and teaching status. Results were reported as odds ratio (OR) where appropriate, with 95% confidence intervals (95% CI). Analysis was completed using SAS v 9.4 (SAS Institute, Cary, NC).

Results

A total of 42,189 individuals met the inclusion criteria (Table I). Median patient age was 62 years (IQR 53–71), and 52.3% (N = 22,046) of patients were female. The majority of patients underwent major hepatectomy (N = 14,516, 34.4%) or minor pancreatectomy (N = 13,824, 32.8%), and a smaller subset underwent minor hepatectomy (N = 4,617, 10.9%) or major pancreatectomy (N = 9,232, 21.9%). A larger proportion underwent surgery secondary to a malignant cause (N = 26,956, 63.9%) as opposed to a benign indication (N = 15,233, 36.1%). An overwhelming majority had an open surgery (N = 38,616, 91.5%) versus minimally invasive surgery (N = 3,573, 8.5%). The median number of comorbidity score was 3 (IQR 2–8). The majority of patients had a minor (N = 17,028, 40.4%) or moderate (N = 15,634, 37.1%) likelihood of dying. Regarding illness severity, the vast majority had moderate (N = 16,292, 38.6%) or major (N = 17,428, 41.3%) loss of function based on preoperative assessment. The most common payer source was private insurance (N = 19,083, 45.3%). Most individuals were treated at a large (N = 33,359, 79.1%) metropolitan-teaching (N = 37,425, 88.7%) hospital.

After HP surgery, the majority of patients had routine discharge home (N = 28,438, 67.4%), and a minority was discharged to an SNF/ICF (N = 2,825, 6.7%) or home with HHC (N = 10,925, 25.9%). Patients discharged home were more likely to be younger compared with individuals discharged to an SNF/ICF (median age: 60 years, IQR 50–68 versus 73, IQR 67–79, $P < .001$). Patients discharged to an SNF/ICF had a greater comorbidity score (4, IQR 2–8) versus patients discharged home (3, IQR 1–8) or home with HHC (3, IQR 2–8) ($P < .001$). Furthermore, patients discharged to an SNF/ICF had a greater proportion of major (N = 1,423, 50.4%) or extreme (N = 926, 32.8%) preoperative loss of function compared with patients discharged home who only 3.8% had extreme loss of

Table I
Characteristics of patients after hepatopancreatic surgery by discharge destination

Variable	Total ($N = 42,189$)	Home ($N = 28,438$)	SNF/ICF ($N = 2,825$)	HHC ($N = 10,925$)	P
Age (median, IQR)	62 (53, 71)	60 (50, 68)	73 (67, 79)	66 (57, 73)	<.001
Female N (%)	22,046 (52.3)	15,003 (52.8)	1,537 (54.4)	5,506 (50.4)	<.001
Comorbidity category (median, IQR)	3 (2, 8)	3 (1, 8)	4 (2, 8)	3 (2, 8)	<.001
Mortality category* ($N = 42,187$)					<.001
Minor likelihood of dying	17,028 (40.4%)	13,631 (47.9%)	343 (12.1%)	3,054 (28%)	
Moderate likelihood of dying	15,634 (37.1%)	10,642 (37.4%)	798 (28.2%)	4,194 (38.4%)	
Major likelihood of dying	7,088 (16.8%)	3,396 (11.9%)	948 (33.6%)	2,744 (25.1%)	
Extreme likelihood of dying	2,437 (5.8%)	767 (2.7%)	736 (26.1%)	934 (8.5%)	
Illness severity category* ($N = 42,187$)					<.001
Minor loss of function	5,014 (11.9%)	4,421 (15.5%)	54 (1.9%)	539 (4.9%)	
Moderate loss of function	16,292 (38.6%)	12,990 (45.7%)	422 (14.9%)	2,880 (26.4%)	
Major loss of function	17,428 (41.3%)	9,938 (34.9%)	1,423 (50.4%)	6,067 (55.5%)	
Extreme loss of function	3,453 (8.2%)	1,087 (3.8%)	926 (32.8%),	1,440 (13.2%)	
Primary payer ($N = 42,136$)					<.001
Medicare	17,960 (42.6%)	9,913 (34.9%)	2,259 (80.1%)	5,788 (53%)	
Medicaid	3,127 (7.4%)	2,287 (8.1%)	107 (3.8%)	733 (6.7%)	
Private insurance	19,083 (45.3%)	14,660 (51.6%)	404 (14.3%)	4,019 (36.8%)	
Self-pay	727 (1.7%)	590 (2.1%)	14 (0.5%)	123 (1.1%)	
No charge	90 (0.2%)	79 (0.3%)	4 (0.1%)	7 (0.1%)	
Other	1,149 (2.7%)	872 (3.1%)	33 (1.2%)	244 (2.2%)	
Median household income ($N = 41,389$)					<.001
Quartile 1 (lowest)	8,109 (19.6%)	5,291 (19%)	599 (21.6%)	2,219 (20.6%)	
Quartile 2	9,049 (21.9%)	6,103 (21.9%)	636 (22.9%)	2,310 (21.5%)	
Quartile 3	10,435 (25.2%)	7,110 (25.5%)	718 (25.9%)	2,607 (24.3%)	
Quartile 4 (highest)	13,796 (33.3%)	9,362 (33.6%)	822 (29.6%)	3,612 (33.6%)	
Size of hospital					<.001
Small	3,043 (7.2%)	2.203 (7.7%)	169 (6%)	671 (6.1%)	
Medium	5,787 (13.7%)	4,262 (15%)	376 (13.3%)	1.149 (10.5%)	
Large	33,359 (79.1%)	21,973 (77.3%)	2,280 (80.7%)	9,106 (83.3%)	
Teaching status of hospital					<.001
Metropolitan, nonteaching	4,554 (10.8%)	3,066 (10.8%)	432 (15.3%)	1,056 (9.7%)	
Metropolitan, teaching	37,425 (88.7%)	25,215 (88.7%)	2,376 (84.1%)	9,834 (90%)	
Nonmetropolitan	210 (0.5%)	157 (0.6%)	17 (0.6%)	36 (0.3%)	
Type of procedure					<.001
Minor hepatectomy	4,617 (10.9%)	3,451 (12.1%)	216 (7.6%)	950 (8.7%)	
Major hepatectomy	14,516 (34.4%)	11,203 (39.4%)	605 (21.4%)	2,708 (24.8%)	
Minor pancreatectomy	13,824 (32.8%)	7,080 (24.9%)	1,501 (53.1%)	5,243 (48%)	
Major pancreatectomy	9,232 (21.9%)	6,704 (23.6%)	503 (17.8%)	2,025 (18.5%)	
Modality of procedure					.48
Open	38,616 (91.5%)	26,060 (91.6%)	2,574 (91.1%)	9,982 (91.4%)	
MIS	3,573 (8.5%)	2,378 (8.4%)	251 (8.9%)	944 (8.6%)	
Malignant versus benign					<.001
Benign	15,233 (36.1%)	10,972 (38.6%)	781 (27.6%)	3,480 (31.9%)	
Malignant	26,956 (63.9%)	17,466 (61.4%)	2,044 (72.4%)	7,446 (68.1%)	

MIS, minimally invasive surgery.
* Dependent on the patient's primary illness, underlying medical comorbidities at time of admission, secondary diagnoses, and procedures required.

function ($P < .001$). Approximately 4 of 5 patients discharged to an SNF/ICF had Medicare as the primary payer source versus 53.0% of patients who were discharged home with HHC ($P < .001$). A large proportion of patients discharged home with HHC were treated at a large ($N = 9,106$, 83.3%), teaching (N = 9,834, 90.0%) hospital ($P < .001$). The majority of patients discharged home had a major hepatectomy ($N = 11,203$, 39.4%), whereas a greater proportion of patients discharged home with HHC or to an SNF/ICF had a minor pancreatectomy (SNF/ICF: 1,501, 53.1%; HHC: 5,243, 48.0%, $P < .001$) or major pancreatectomy (SNF/ICF: 503, 17.8%; HHC: 2,025, 18.5%). Operative approach was similar across discharge destinations ($P = .48$).

Outcomes at an index hospitalization

Overall, approximately 1 of 4 patients ($N = 9795$, 23.2%) had a complication on index admission (Table II). The most common complications were surgical site infection ([SSI] $N = 3,390$ 8%), acute renal failure ($N = 2,233$, 5.3%), and urinary tract infection ([UTI] $N = 2,009$, 4.8%). Median index LOS was 7 days (IQR 5–10). More than half ($N = 1,547$, 54.8%) of patients discharged to an SNF/ICF suffered a complication during index admission, whereas only a minority ($N = 4,405$, 15.5%) of patients discharged home experienced a complication. Patients discharged to an SNF/ICF had a greater incidence of pulmonary failure, pneumonia, myocardial infarction, deep venous thrombosis or pulmonary embolus, acute renal failure, hemorrhage, SSI, gastrointestinal (GI) hemorrhage, UTI, shock and neurologic complications versus patients discharged home or home with HHC (all $P < .001$). Patients discharged to an SNF/ICF had more than a 2-times longer LOS (13, IQR 8–22) compared with an individual discharged home (6, IQR 5-8; $P < .001$).

Early outcomes

Within 30 days of operation, 14.6% (N = 6,159) of individuals who underwent HP surgery were readmitted (Table II). Overall, the median time to readmission was shortest among patients discharged home (home: 22 days, IQR 14–43; SNF/ICF: 35 days, IQR 22–54; HHC: 27 days, IQR 16–46; Fig 1). The majority ($N = 5,317$, 86.3%) were readmitted to an index hospital. Of interest, a greater proportion of patients discharged home with HHC were readmitted early compared with patients discharged home or to an SNF/ICF (home: 3,763, 13.2%; SNF/ICF: 428, 15.2%; HHC: 1,968, 18.0%; $P <$

Table II
Index hospitalization and early and late outcomes after hepatopancreatic surgery

	Total ($N = 42,189$)	Home ($N = 28,438$)	SNF/ICF ($N = 2,825$)	HHC ($N = 10,925$)	P
Outcomes at index hospitalization					
Any complication	9,795 (23.2%)	4,405 (15.5%)	1,547 (54.8%)	3,843 (35.2%)	< .001
Complications					
Pulmonary failure	1,771 (4.2%)	657 (2.3%)	484 (17.1%)	630 (5.8%)	< .001
Pneumonia	472 (1.1%)	134 (0.5%)	167 (5.9%)	171 (1.6%)	< .001
Myocardial infarction	1,188 (2.8%)	557 (2%)	190 (6.7%)	441 (4%)	< .001
DVT/PE	886 (2.1%)	356 (1.3%)	164 (5.8%)	366 (3.3%)	< .001
Acute renal failure	2,233 (5.3%)	914 (3.2%)	516 (18.3%)	803 (7.3%)	< .001
Hemorrhage	1,498 (3.6%)	732 (2.6%)	219 (7.8%)	547 (5%)	< .001
Surgical site infection	3,390 (8%)	1,063 (3.7%)	628 (22.2%)	1,699 (15.6%)	< .001
GI hemorrhage	97 (0.2%)	36 (0.1%)	22 (0.8%)	39 (0.4%)	<0.001
Urinary tract infection	2009 (4.8%)	943 (3.3%)	373 (13.2%)	693 (6.3%)	<0.001
Neurologic	259 (0.6%)	106 (0.4%)	61 (2.2%)	92 (0.8%)	< .001
Shock	104 (0.2%)	48 (0.2%)	19 (0.7%)	37 (0.3%)	< .001
Index LOS (median, IQR)	7 (5, 10)	6 (5, 8)	13 (8, 22)	9 (7, 14)	< .001
Early outcomes (0–30 d)					
Readmission	6,159 (14.6%)	3,763 (13.2%)	428 (15.2%)	1,968 (18.0%)	< .001
Cause of readmission					
Infection	2,352 (38.2%)	1,393 (37.0%)	174 (40.7%)	785 (39.9%)	.06
UTI	120 (5.1%)	59 (4.2%)	13 (7.5%)	48 (6.1%)	.054
SSI	209 (8.9%)	66 (4.7%)	23 (13.2%)	120 (15.3%)	< .001
PNA/pulmonary failure	9 (0.4%)	2 (0.1%)	4 (2.3%)	3 (0.4%)	< .001
Bleeding	304 (4.9%)	182 (4.8%)	23 (5.4%)	99 (5.0%)	.86
Cardiac/renal	575 (9.3%)	356 (9.5%)	52 (12.2%)	167 (8.5%)	.056
Chemo	14 (0.2%)	13 (0.4%)	1 (0.2%)	0 (0.0%)	.033
GI complications	1,866 (30.3%)	1,203 (32.0%)	99 (23.1%)	564 (28.7%)	< .001
Cancer	165 (2.7%)	103 (2.7%)	9 (2.1%)	53 (2.7%)	.74
Endocrine	415 (6.7%)	245 (6.5%)	29 (6.8%)	141 (7.2%)	.64
Other	468 (7.6%)	268 (7.1%)	41 (9.6%)	159 (8.1%)	.12
Nonindex readmission	842 (13.7%)	514 (13.7%)	80 (18.7%)	248 (12.6%)	.004
Readmission in-hospital mortality	85 (1.4%)	38 (1.0%)	17 (4.0%)	30 (1.5%)	< .001
Late outcomes (31–90 d)					
Readmission	4,323 (10.2%)	2,243 (7.9%)	603 (12.3%)	1,477 (13.5%)	< .001
Cause of readmission					
Infection	1,318 (30.5%)	624 (27.8%)	222 (36.8%)	472 (32.0%)	< .001
UTI	114 (8.7%)	41 (6.6%)	38 (17.1%)	35 (7.4%)	< .001
SSI	291 (22.1%)	73 (11.7%)	80 (36.0%)	138 (29.2%)	< .001
PNA/pulmonary failure	18 (1.4%)	3 (0.5%)	10 (4.5%)	5 (1.1%)	< .001
Bleeding	123 (2.9%)	64 (2.9%)	19 (3.2%)	40 (2.7%)	.86
Cardiac/renal	466 (10.8%)	208 (9.3%)	86 (14.3%)	172 (11.7%)	< .001
Chemo	79 (1.8%)	54 (2.4%)	5 (0.8%)	20 (1.4%)	0 009
GI complications	995 (23.0%)	520 (23.2%)	125 (20.7%)	350 (23.7%)	.33
Cancer	485 (11.2%)	320 (14.3%)	31 (5.1%)	134 (9.1%)	< .001
Endocrine	283 (6.6%)	152 (6.8%)	31 (5.1%)	100 (6.8%)	.32
Other	574 (13.3%)	301 (13.4%)	84 (13.9%)	189 (12.8%)	.76
Nonindex readmission	1,195 (27.6%)	655 (29.2%)	166 (27.5%)	1,103 (74.7%)	.035
Readmission in-hospital mortality	136 (3.2%)	48 (2.1%)	40 (6.6%)	48 (3.3%)	< .001

DVT, deep venous thrombosis; *GI*, gastrointestinal; *MI*, myocardial infarction; *PE*, pulmonary embolus; *PNA*, pneumonia; *UTI*, urinary tract infection.

.001). Patients discharged to an SNF/ICF were more likely to be readmitted to a nonindex hospital (home: 514, 13.7%; SNF/ICF: 80, 18.7%, HHC: 248, 12.6%; $P = .004$).

The most common complication present on readmission was an infection ($N = 2,352$, 38.2%). Furthermore, patients discharged home were at a higher risk of being readmitted secondary to a GI complication (home: 1,203, 32.0%; SNF/ICF: 99, 23.1%; HHC: 564, 28.7%; $P < .001$). In addition, a greater proportion of patients discharged to an SNF or home with HHC were readmitted with an SSI versus individuals discharged home (home: 66, 4.7%; SNF/ICF: 23, 13.2%; HHC: 120, 15.3%; $P < .001$). On readmission, patients discharged to an SNF/ICF were more than 2 times more likely to die than patients readmitted who were discharged home with or without HHC, respectively (home: 38, 1.0%; SNF/ICF: 17, 4.0%, HHC: 30, 1.5%; $P < .001$).

Late outcomes

Within 31 and 90 days of HP surgery, 1 in 10 patients were readmitted ($N = 4,323$, 10.2%; Table II). Overall, roughly 1 in 4 ($N = 1,195$, 27.6%) late readmissions were to nonindex hospitals. Compared with patients discharged home or to an SNF/ICF, a greater proportion of patients discharged home with HHC were readmitted within 31 and 90 days (home: 2,243, 7.9%, SNF/ICF: 603, 12.3%; HHC: 1,477, 13.5%, $P < .001$). The most common complication present on late readmission was an infection ($N = 1,318$, 30.5%). Of note, compared with patients discharged to home or with HHC, individuals discharged to an SNF/ICF had a greater proportion of patients readmitted with an infection (home: 624, 27.8%; SNF: 222, 36.8%; HHC: 472, 32.0%; $P < .001$). Specifically, patients initially discharged to an SNF/ICF were more likely to present with an SSI in comparison with patients discharged home or with HHC (home: 73, 11.7%; SNF: 80, 36.0%; HHC: 138, 29.2%; $P < .001$). As similarly noted in early readmissions, during late readmission, patients discharged to an SNF were more likely to experience an in-hospital mortality versus individuals discharged home with or without HHC (home: 48, 2.1%; SNF/ICF: 40, 6.6%; HHC: 48, 3.3%; $P < .001$). Overall, the most common cause of readmission within 90 days of surgery was infection (36.6%) and GI

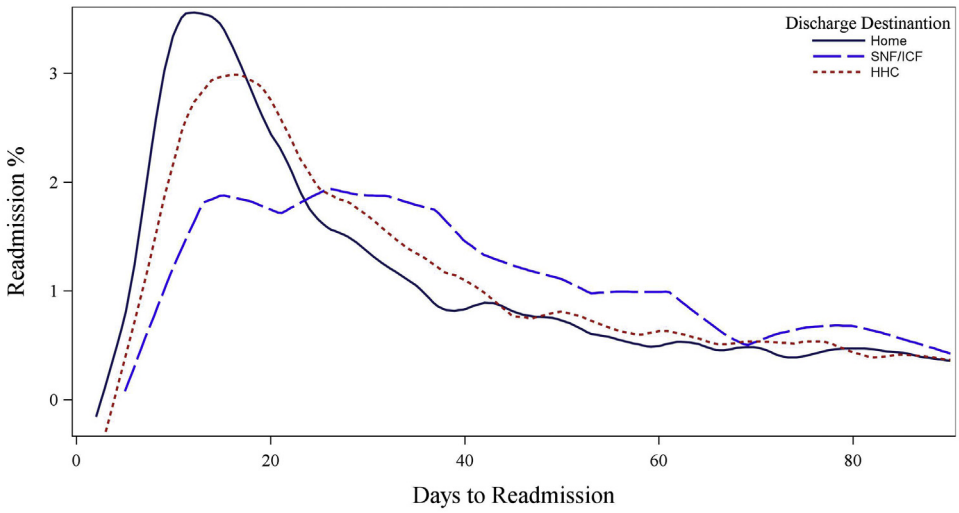

Fig 1. Time to readmission categorized by discharge destination after hepatopancreatic surgery.

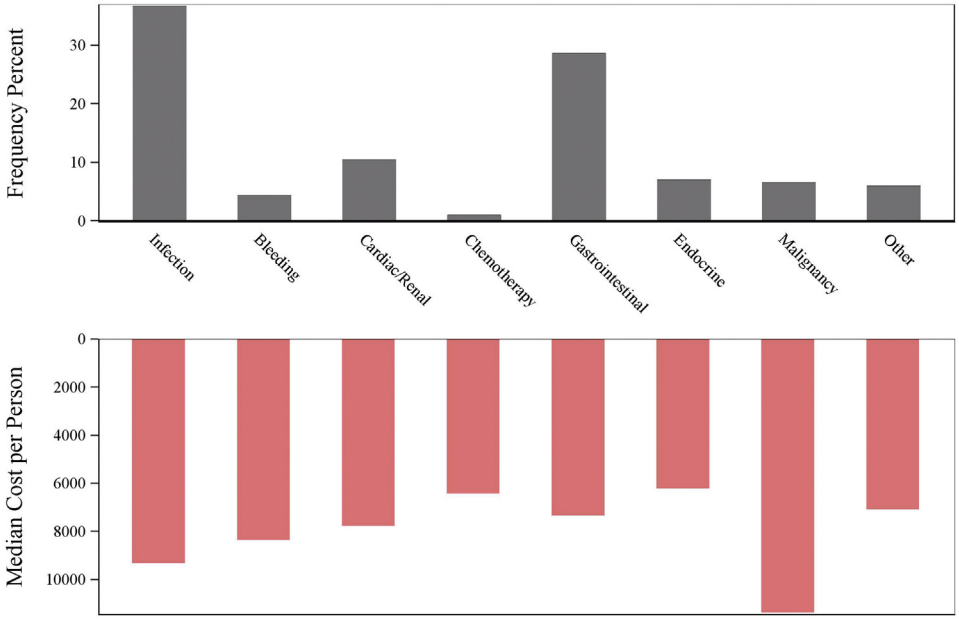

Fig 2. Cause of readmission and associated readmission median cost after hepatopancreatic surgery.

complication (28.5%; Fig 2). Of note, the highest median readmission cost was associated with malignancy ($11,375) and infections ($9,310).

Predictors of discharge destination

On multivariable analysis, after controlling for other relevant covariates, older (HHC: OR 1.03, 95% CI 1.02–1.03; SNF/ICF: OR 1.10, 95% CI 1.09 – 1.11) and female (HHC: OR 1.14, 95% CI 1.09–1.20; SNF/ICF: OR 1.60, 95% CI 1.45–1.76) patients were more likely to be discharged to HHC or an SNF/ICF versus home (Table III). In addition, individuals with Medicare coverage were 15% more likely than patients with Medicaid coverage to be discharged with HHC (OR 1.15, 95% CI 1.03–1.28) and 32% more likely to be discharged to an SNF (OR 1.32, 95% CI 1.01–1.72) versus home. Furthermore, individuals who had a complication on index admission had 47% (OR 1.47, 95% CI 1.38–1.57) and 85% (OR 1.85, 95% CI 1.65–2.08) higher odds of being discharged with HHC or to an SNF/ICF versus home, respectively.

In assessing predictors to an SNF discharge versus home with HHC (Table IV), type of HPB procedure was not associated with discharge to an SNF/ICF. Rather, patients with extreme loss of function on preoperative assessment were 2.76 times more likely to be discharged to an SNF/ICF versus HHC (OR 2.76, 95% CI 1.98–3.85). Similarly, older (OR 1.06, 95% CI 1.06–1.07) and female (OR 1.37, 95% CI 1.25–1.51) patients were more likely to be discharged to an SNF/ICF versus HHC. Regarding perioperative complications, individuals with neurologic complications (OR 1.67, 95% CI 1.16–2.41) and pulmonary failure (OR 1.57, 95% CI 1.33–1.85) had the highest odds of being discharged to an SNF versus HHC.

Discussion

An increasing proportion of patients undergoing abdominal surgery will require additional services, including skilled nursing

Table III
Multivariable analysis for predictors of discharge to HHC and SNF compared with home after hepatopancreatic surgery

Variable	HHC		SNF	
	Odds ratio	95% CI	Odds ratio	95% CI
Age (years)	1.03	1.02–1.03	1.10	1.09–1.11
Female	1.14	1.09–1.2	1.60	1.45–1.76
Illness severity category*				
Minor loss of function	Ref		Ref	
Moderate loss of function	1.47	1.32–1.63	1.89	1.41–2.54
Major loss of function	2.17	1.95–2.42	3.71	2.77–4.99
Extreme loss of function	2.36	2.04–2.74	7.67	5.52–10.66
Primary payer				
Medicaid	Ref		Ref	
Medicare	1.15	1.03–1.28	1.32	1.01–1.72
Private insurance	0.90	0.81–1	0.64	0.49–0.84
Self-pay	0.55	0.43–0.7	0.51	0.26–0.97
No charge	0.21	0.09–0.5	0.48	0.1–2.19
Other	0.92	0.77–1.11	0.80	0.49–1.3
Median household income				
Quartile 1 (lowest)	Ref		Ref	
Quartile 2	0.90	0.84–0.97	0.94	0.82–1.09
Quartile 3	0.88	0.82–0.95	0.95	0.82–1.1
Quartile 4 (highest)	0.95	0.89–1.02	0.82	0.71–0.94
Size of hospital				
Small	Ref		Ref	
Medium	0.93	0.82–1.05	1.30	1.03–1.64
Large	1.56	1.41–1.72	1.83	1.49–2.24
Teaching status of hospital				
Metropolitan, nonteaching	Ref		Ref	
Metropolitan, teaching	1.29	1.19–1.4	0.90	0.78–1.04
Nonmetropolitan	0.64	0.42–0.96	0.76	0.41–1.42
Type of HPB procedure				
Minor hepatectomy	Ref		Ref	
Major hepatectomy	1.00	0.92–1.1	0.99	0.82–1.2
Minor pancreatectomy	1.58	1.48–1.69	1.25	1.09–1.42
Major pancreatectomy	1.25	1.16–1.34	1.18	1.01–1.38
Malignant versus benign				
Benign	Ref.		Ref	
Malignant	1.11	1.05–1.18	1.20	1.06–1.34
Operative approach				
Open	Ref		Ref.	
MIS	1.09	1–1.19	1.23	1.04–1.46
Incidence of a complication on index				
No	Ref		Ref	
Yes	1.47	1.38–1.57	1.85	1.65–2.08
Length of stay (days)	1.08	1.08–1.09	1.10	1.09–1.1

MIS, minimally invasive surgery.
* Dependent on the patient's primary illness, underlying medical comorbidities at time of admission, secondary diagnoses, and procedures required.

assistance at home or an independent facility. In the current study, the NRD was used to define predictors for nonroutine discharge to home with HHC or an SNF/ICF after HP surgery and to examine the impact of discharge destination on readmission and cause of readmission. Roughly 1 in 3 patients did not have a routine discharge after HP surgery and required additional services in the form of HHC or admission to a an SNF/ICF. Of note, the majority of patients readmitted from an SNF/ICF were readmitted within 31 to 90 days of discharge. This may, in part, be reflective of the transition of care from an SNF/ICF to home. Infection was the primary cause of readmission among patients discharged at an SNF/ICF, whereas GI complications as cause of readmission were higher among patients discharged home versus an SNF/ICF and HHC. It is important to point out that, on readmission, patients who were discharged to an SNF/ICF were more likely to die. The current study was important because we specifically examined risk factors for nonroutine discharge using a large national database designed to examine readmissions. Age and illness severity categories were strongly associated with nonroutine discharge. In particular, older age, the illness severity category, and complications on index admission were associated with discharge to an SNF/ICF or with HHC versus home. Collectively, these data demonstrate a high use of additional services after HP surgery and identified risk factors for nonroutine discharge and causes of readmission in this patient population.

The Medicare Payment Advisory Commission (MedPAC) has estimated that failure to adequately provide transitional care at the time of discharge had led to an additional $15 billion in health care spending in part because of associated complications and readmissions.[21] Coleman et al[22] define transitional care as broad services and actions designed to ensure the coordination and continuity of health care as patients are transferred between different locations and levels of care. Perhaps patients undergoing complex abdominal surgeries are in the greatest need of these services. For example, Shah et al[6] noted that nearly half of patients required assistance in the form of HHC or facility after a pancreatic resection for a malignancy. In the current study, the use of additional services at the time of discharge was lower, but still significant, at 34%. The reason for the lower incidence in the current study was likely multifactorial and in part secondary to the difference in the patient cohort. For example, unlike the current study, Shah et al[6] only included patients who underwent a pancreatectomy for

Table IV
Predictors of discharge to SNF/ICF versus HHC among patients after hepatopancreatic surgery

Variable	Odds ratio	95% CI
Age	1.06	1.06–1.07
Female	1.37	1.25–1.51
Illness severity category*		
Minor loss of function	Ref	
Moderate loss of function	1.35	0.99–1.85
Major loss of function	1.82	1.34–2.47
Extreme loss of function	2.76	1.98–3.85
Primary payer		
Medicaid	Ref	
Medicare	1.20	0.94–1.54
Private insurance	0.73	0.57–0.94
Self-pay	0.82	0.43–1.58
No charge	1.82	0.45–7.34
Other	0.78	0.49–1.23
Median household income		
Quartile 1 (lowest)	Ref	
Quartile 2	1.02	0.89–1.17
Quartile 3	1.05	0.92–1.21
Quartile 4 (highest)	0.87	0.76–0.99
Size of hospital		
Small	Ref	
Medium	1.34	1.07–1.69
Large	1.13	0.93–1.38
Teaching status of hospital		
Metropolitan, nonteaching	Ref	
Metropolitan, teaching	0.77	0.67–0.88
Nonmetropolitan	1.07	0.56–2.05
Type of HPB procedure		
Minor hepatectomy	Ref	
Major hepatectomy	0.93	0.76–1.12
Minor pancreatectomy	0.89	0.79–1.01
Major pancreatectomy	1.05	0.9–1.22
Malignant versus benign		
Benign	Ref.	
Malignant	1.04	0.93–1.16
Operative approach		
Open	Ref	
MIS	1.08	0.92–1.27
Index complications		
Pulmonary failure	1.57	1.33–1.85
Pneumonia	1.36	1.04–1.78
ARF	1.38	1.19–1.6
UTI	1.43	1.23–1.67
Neurologic	1.67	1.16–2.41
Length of stay	1.03	1.03–1.04

ARF, acute renal failure; *UTI*, urinary tract infection.
* Dependent on the patient's primary illness, underlying medical comorbidities at time of admission, secondary diagnoses, and procedures required.

a malignant indication. The interplay between the complexity of procedure and malignancy likely help explain the higher rates of nonroutine discharge. To this end, the current study highlighted that patients who were older and experience a complicated hospital course had greater odds of requiring HHC or an SNF/ICF. Furthermore, patients who were discharged to an SNF were more likely to be readmitted within 1 month of the index event, which may reflect the shift in care from an SNF to home. As such, an emphasis should be placed on transition of care because the most complex patients—patients with a complicated hospital course—require additional services after HP surgery before independently returning to home.

The impact of nonroutine discharge on early and late outcomes remains unknown. Lucas et al[23] reported that minor and major outpatient complications were the strongest risk factors for readmission. Moreover, among patients who underwent total hip or knee replacement, Keswani et al[24] noted that patients discharged to an SNF and inpatient rehab facilities had higher odds of postdischarge adverse events. Specifically though, Schneider et al[14] reported no correlation between SNF discharge and early or late readmission among patients undergoing pancreaticoduodenectomy identified in the MarketScan database.[13] However, in a different study by Chen et al[25] that investigated the association between discharge destination and readmission among Medicare beneficiaries undergoing HP surgery, discharge with HHC or to SNF was associated with a higher risk of readmission within 30 and 90 days of operation. Similarly, in the current study, nearly 43% of patients readmitted were discharged to an SNF/ICF or with HHC. Furthermore, on readmission, patients who were discharged to an SNF/ICF were more than 2 times as likely to experience a death compared with patients discharged home with or without HHC. This may, in part, be attributable to the medical complexity of patients discharged to an SNF/ICF, but additional studies are needed to further investigate this trend. Taken together, the present data emphasize that discharge requiring an escalation of care in the form of complex care provided through HHC or an SNF/ICF may serve as a marker for a worse prognosis or outcomes among these patients. It is important to incorporate these findings when counseling patients regarding their perioperative and postoperative course.

Furthermore, hospital readmissions may indicate missed opportunities to coordinate and provide interdisciplinary individualized care.[21,26] Medicare Payment Advisory Commission has called for reform to the current Medicare payment system to incorporate community SNF discharge and rehospitalization rates among patients requiring HCC and SNF/ICF care.[21] In fact, Lucas et al[23] noted that outpatient complications were a strong risk factor for readmission among patients who underwent HPB surgery because 40% of patients experienced a major complication after discharge and 83% of patients who had a major outpatient complication were readmitted. Evaluating institutional data, Margonis et al[27] reported that postoperative morbidity predicted poor overall survival after hepatectomy for early-stage hepatocellular carcinoma. In the current study, although infection was the most common cause of readmission overall, a greater proportion of patients discharged to an SNF or with HHC presented with this complication versus patients readmitted from home without HHC services. Moreover, a greater percentage of patients discharged home or with HHC were readmitted with GI complications versus individuals discharged to an SNF/ICF. Outpatient management has been determined to be feasible for at least one-quarter of readmissions.[28] The present study identified areas of improvement for nursing homes, such as detecting infections earlier, and underscore the need for caregivers and HHC agencies to identify GI complications earlier in their onset to prevent readmissions.

Several limitations should be considered when interpreting the results of the current study. Despite the NRD being a comprehensive data set to examine readmission patterns, patients could not be tracked across years. Thus, to obtain 90-day follow-up on all patients, the last 3 months were excluded. In addition, individuals also could not be tracked between states. Nevertheless, earlier investigations have noted the impact of missed readmissions to other states is minimal.[29] In addition, the ability to assess fully the baseline health status of patients is limited in this current data set. To minimize this limitation, the All Patient Refined Diagnosis Related Group was used to identify the risk of mortality and the severity of illness subclass (minor, moderate, major, extreme) that was dependent on the primary illness of the patients, underlying medical comorbidities at time of admission, secondary diagnoses, and procedures required.[19] Also, although the definition of minor versus major hepatectomy and pancreatectomy is based on studies published elsewhere, this categorization may not be adequately representative of the complexity of the procedure.[16,17]

In conclusion, roughly 1 in 4 patients undergoing HP surgery were readmitted within 90 days of surgery, with the majority of

readmissions occurring early. Nearly 43% of patients readmitted were discharged to an SNF/ICF or with HHC. A greater proportion of patients discharged home were readmitted with a GI complication, whereas a larger proportion of patients discharged to an SNF/ICF and with HHC presented with an infection. When readmitted, a greater proportion of patients who were initially discharged to an SNF died during the readmission hospitalization. Of note, rather than age itself, the severity of patient comorbidities and the perioperative course, including the incidence of complications, were associated with nonroutine discharge. Because patients with complicated perioperative courses are more likely to experience a nonroutine discharge, further research is needed to investigate the quality of care delivered by home health care agencies and SNFs/ICFs to determine their impact on readmission rates and the causes of readmission.

Conflict of interest

The authors have indicated that they have no conflict of interest regarding the content of this article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.surg.2019.02.020.

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