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ORIGINAL SCIENTIFIC REPORT

Time to Readmission and Mortality Among Patients Undergoing Liver and Pancreatic Surgery

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Abstract

Background The impact of time to readmission (TTR) on post-discharge mortality has not been well examined. We sought to define the impact of TTR on postoperative mortality after liver or pancreas surgery.

Methods A retrospective cohort analysis of liver and pancreas surgical patients was conducted using 2013–2015 Medicare Provider Analysis and Review database. Patients were subdivided into TTR groups: 1–5 days, 6–15, 15–30, 31–60, 61–90, and no readmission. The association of index complication, readmission causes, TTR, and mortality was assessed.

Results Among 18,177 patients, a total of 4485 (24.7%) patients were readmitted within 90 days of discharge. Major causes for readmission differed across TTR groups. Patients readmitted within 1–15 days were more likely to be readmitted for postoperative infection compared with patients who had a late readmission (1–5 days: 63.1% vs. 6–15 days: 65.0% vs. 61–90 days: 39.3%; $P < 0.001$). In contrast, causes of late readmissions were more likely related to gastrointestinal complications (1–5 days: 28.9% vs. 61–90 days: 39.7%; $P < 0.001$). Compared with no readmission, 180-day mortality was highest among patients readmitted within 16–30 days (aOR 3.60; 95% CI 2.94–4.41). Among patients with index complications, patients who were readmitted within 1–5 days had a higher risk-adjusted 180-day mortality than late readmission (1–5 days: 37.3% vs. 61–90 days: 27.1%) ($P < 0.001$).

Conclusions Among patients who were readmitted, the incidence of mortality increased with TTR up to 60 days after discharge yet decreased thereafter. The relation of TTR and mortality was particularly pronounced among those patients who had an index complication. Future efforts should consider TTR when identifying specific approaches to decrease readmission.

Introduction

Medicare patients alone accounted for more than half the total number of readmissions with an annual cost of approximately $24 billion [1]. The Medicare Payment

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Advisory Commission (MedPAC) reported that 12% of hospital readmissions for Medicare patients were potentially avoidable, which could result in almost $1 billion annual savings [2, 3]. Preventing hospital readmissions has become a national healthcare priority [4–6]. In 2012, the Affordable Care Act instituted the Hospital Readmission Reduction Program (HRRP), which allows the Centers for Medicare and Medicaid Services (CMS) to reduce reimbursements to hospitals with readmission rates higher than expected [2, 7].

Postoperative complications and readmissions can have an impact on patient outcomes [8–11]. The relationship between short-term outcomes such as complications and readmission on early postoperative mortality is, however, poorly understood [12–15]. The impact of readmission timing on patient outcomes remains not well defined, as various definitions of postoperative readmission (i.e., 30, 45, and 90 days) may lead to conflicting results [10, 16–18]. Gonzalez et al. [19] stratified patients into subgroups based on time between discharge and readmission (i.e., time to readmission, TTR) and reported that shorter TTR was associated with higher risk of death.

Liver and pancreas operations are complex procedures that can be associated with high rates of postoperative complications and readmissions [8, 20, 21]. No study has examined the impact of TTR on post-discharge mortality following hepatopancreatic surgery. The objective of the current study was to define the impact of TTR on postoperative mortality after surgery among patients who underwent liver or pancreas surgery. Specifically, using data on Medicare beneficiaries, we sought to investigate whether post-discharge mortality varied by TTR among patients undergoing hepatopancreatic surgery.

Materials and methods

Data source and study population

The Medicare Provider Analysis and Review (MedPAR) Inpatient Files and the Medicare Denominator Files were used to identify Medicare beneficiaries who underwent liver and pancreas surgery between 2013 and 2015 (Supplementary Table 1) [22]. Patients who died during the index hospitalization were excluded. The primary outcome was risk-adjusted mortality at 90, 120, 150, and 180 days from the index procedure, defined as primary liver or pancreas surgery performed during the initial hospitalization (index hospitalization). Complications during the index hospitalization were identified using ICD-9-CM diagnosis and procedure codes (Supplementary Table 2) [23].

Time to readmission

Time to readmission (TTR) was defined as the number of days between discharge from index hospitalization and first readmission [19]. Readmission was defined as all-cause readmission within 90 days after discharge from the index hospitalization. Readmission after 90 days was excluded because readmission relative to surgery was the main outcome. While 30–90-day outcomes have been related to the index surgical event, readmission events after this period would be more difficult to discern whether they related to surgical or non-surgical factors [23]. Using TTR, patients were categorized into six groups: readmission within 1–5 days, 6–15 days, 16–30 days, 31–60 days, 61–90 days, and no readmission within 90 days, as previously reported [19]. Index readmission was defined as the readmission in the index hospital where surgery was performed.

Statistical analysis

The association between TTR and mortality was initially assessed by comparing risk-adjusted mortality rates and adjusted odds ratios (aOR) across TTR groups. Risk-adjusted mortality was estimated using a multivariable model including variables to account for patient-specific factors. The association between complications during index hospitalization and mortality was compared using risk-adjusted mortality rates for patients who experienced complications during the index hospitalization to patients who did not have a complication across TTR groups. The incidence of complications during the index hospitalization was also assessed across TTR groups. In addition, the major causes of readmission were examined using the ICD-9 diagnosis codes in the MedPAR Inpatient File. Pearson Chi-square test was utilized to compare categorical variables, while the Kruskal–Wallis test was used to compare continuous variables. Risk-adjusted mortality at 90, 120, 150, and 180 days was estimated using separate multiple logistic regression models. The 95% confidence intervals (CIs) were adjusted to account for non-independence of outcomes among patients treated at the same hospital. A P value <0.05 was considered statistically significant. Statistical analyses were performed with STATA 14.0 MP statistical software.

Results

Patient and hospital characteristics

Among 18,177 patients included in the analytic cohort, 7167 (39.4%) and 11,010 (60.6%) patients underwent a

Table 1 Basic characteristics

Characteristic	No readmission	Readmission	*P* value
Total			
Count, *n*	13,692	4485	N/A
Age over 80, *n* (%)	1909 (13.9)	620 (13.8)	0.842
Gender, *n* (%) female	7028 (51.3)	2161 (48.2)	<0.001
Black race, *n* (%)	1113 (8.1)	375 (8.4)	0.622
3+ comorbidities, *n* (%)	8742 (63.9)	3131 (69.8)	<0.001
Malignant tumor, *n* (%)	4256 (31.1)	1602 (35.7)	<0.001
Palliative treatment, *n* (%)	225 (1.9)	17 (0.4)	<0.001
Hospital volume, median (IQR)	49 (19–114)	49 (19–114)	0.942
Complications, *n* (%)	3080 (22.5)	1372 (30.6)	<0.001
Non-elective, *n* (%)	2025 (14.8)	780 (17.4)	<0.001
Length of stay, mean (SD)	8.6 (10.6)	9.1 (10.1)	<0.001
Discharged home, *n* (%)	7909 (57.8)	2037 (45.5)	<0.001
Pancreas			
Count, *n*	5147	2020	N/A
Age over 80, *n* (%)	801 (15.6)	278 (13.8)	0.055
Gender, *n* (%) female	2633 (51.2)	943 (46.7)	0.001
Black race, *n* (%)	418 (8.1)	165 (8.2)	0.948
3+ comorbidities, *n* (%)	2416 (46.9)	1140 (56.4)	<0.001
Malignant tumor, *n* (%)	2018 (39.2)	905 (44.8)	<0.001
Palliative treatment, *n* (%)	90 (1.8)	8 (0.4)	<0.001
Hospital volume, median (IQR)	47 (18–112)	46 (17–100)	0.339
Complications, *n* (%)	1201 (23.3)	617 (30.5)	<0.001
Non-elective, *n* (%)	782 (15.2)	349 (17.3)	0.029
Length of stay, mean (SD)	9.9 (10.6)	11.5 (11.4)	<0.001
Discharged home, *n* (%)	2744 (53.3)	903 (44.7)	<0.001
Liver			
Count, *n*	8545	2465	N/A
Age over 80, *n* (%)	1108 (13.0)	342 (13.9)	0.24
Gender, *n* (%) female	4395 (51.4)	1218 (49.4)	0.077
Black race, *n* (%)	695 (8.1)	210 (8.5)	0.539
3+ comorbidities, *n* (%)	6326 (74.0)	1991 (80.8)	<0.001
Malignant tumor, *n* (%)	2238 (26.2)	697 (28.3)	0.039
Palliative treatment, *n* (%)	165 (1.9)	9 (0.4)	<0.001
Hospital volume, median (IQR)	50 (19–115)	51 (20–120)	0.2332
Complications, *n* (%)	1879 (22.0)	755 (30.6)	<0.001
Non-elective, *n* (%)	1243 (14.6)	431 (17.5)	<0.001
Length of stay, mean (SD)	7.9 (7.9)	10.0 (8.8)	<0.001
Discharged home, *n* (%)	5165 (60.4)	1134 (46.0)	<0.001

pancreatic or hepatic procedure, respectively. A total of 4485 (24.7%) patients were readmitted within 90 days of discharge. Most characteristics were different among patients who were or were not readmitted (Table 1). The incidence of a complication during the index hospitalization was higher among readmitted ($n = 1372$, 30.6%) versus non-readmitted ($n = 3080$, 22.5%) patients ($P < 0.001$). Patients readmitted to the hospitals tended to have a longer length of stay at the index hospitalization compared with patients non-readmitted to the hospitals (readmitted 9.1, standard deviation (SD) 10.1 vs. non-readmitted 8.6, SD 10.6; $P < 0.001$).

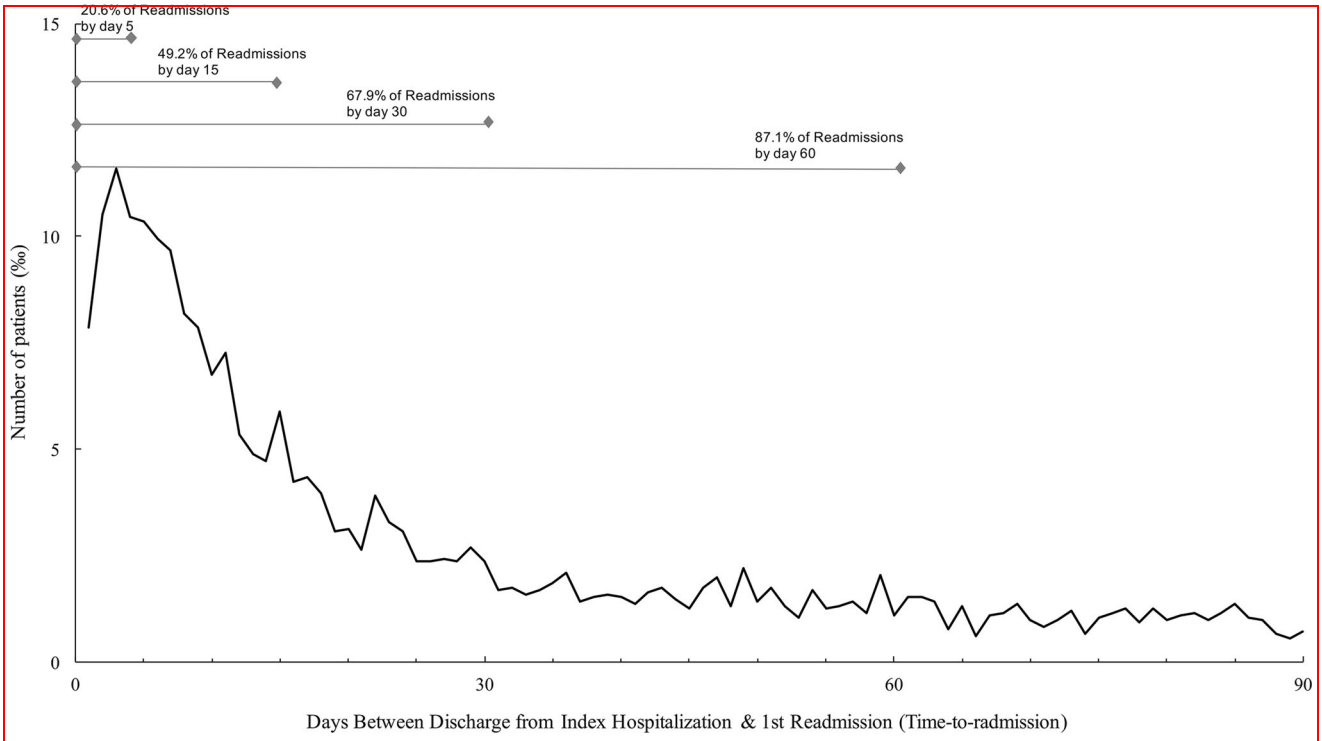


Fig. 1 Frequency of readmission following HPB procedure by time to readmission

Patterns of readmissions

Among the 4485 (24.7%) patients who had at least one readmission within 90 days of discharge, 2897 (64.6%) had one readmission, 1091 (24.3%) had two readmissions, and 497 (11.1%) patients had three or more readmissions. Stratifying data according to TTR, 923 (20.6%) patients were readmitted within 1–5 days of discharge, 1283 (28.6%) patients were readmitted within 6–15 days, 841 (18.8%) patients were readmitted within 16–30 days, 858 (19.1%) patients were readmitted within 31–60 days, and 580 (12.9%) patients were readmitted within 61–90 days (Fig. 1; Supplementary Table 3). Of note, the frequency of readmission decreased as TTR increased. Cumulatively, 49.2% (n = 2207) of all 90-day readmissions occurred within the first 15 days after discharge, while 67.9% (n = 3045) and 87.1% (n = 3906) of readmissions occurred within 30 and 60 days of discharge, respectively. Of note, the pattern of readmission was generally similar for patients undergoing either a pancreas or liver procedure. Specifically, the incidence of 90-day readmission among patients who underwent a pancreas operation was 28.2% (n = 2020) compared with 22.4% (n = 2465) among patients who had undergone a liver procedure ($P < 0.001$).

The incidence of patients who had experienced a complication during the index hospitalization was higher among patients readmitted early (1–5 days: n = 288, 31.2%) versus late (61–90 days: n = 144, 24.8%) (P = 0.008). In contrast, while 68.4% (n = 631) of patients readmitted within the first 1–5 days had ≥3 preoperative comorbidities, the proportion of patients with multiple comorbidities was even higher among patients readmitted within 61–90 days (n = 433, 74.7%) (P = 0.009). Differences in complications during index hospitalization across TTR are presented in Fig. 2. Of note, the incidence of complications during the index hospitalization was higher among patients with a very early or early readmission compared with patients who had a very late readmission (1–5 days: n = 288, 31.2% vs. 6–15 days: n = 434, 33.8% vs. 61–90 days: n = 144, 24.3%) (P = 0.001).

The incidence of readmission to the index hospital where the initial procedure was performed was 75.4% (n = 696) among patients readmitted within 1–5 days of discharge versus 52.9% (n = 307) among patients readmitted 61–90 days after surgery ($n < 0.001$). The data were similar when patients who underwent liver or pancreas surgery were analyzed separately (Table 1).

Major causes of readmission and post-discharge mortality

Major causes of readmission differed across TTR groups (Fig. 3). Of note, patients readmitted within the first 15 days of discharge were more likely to be readmitted for

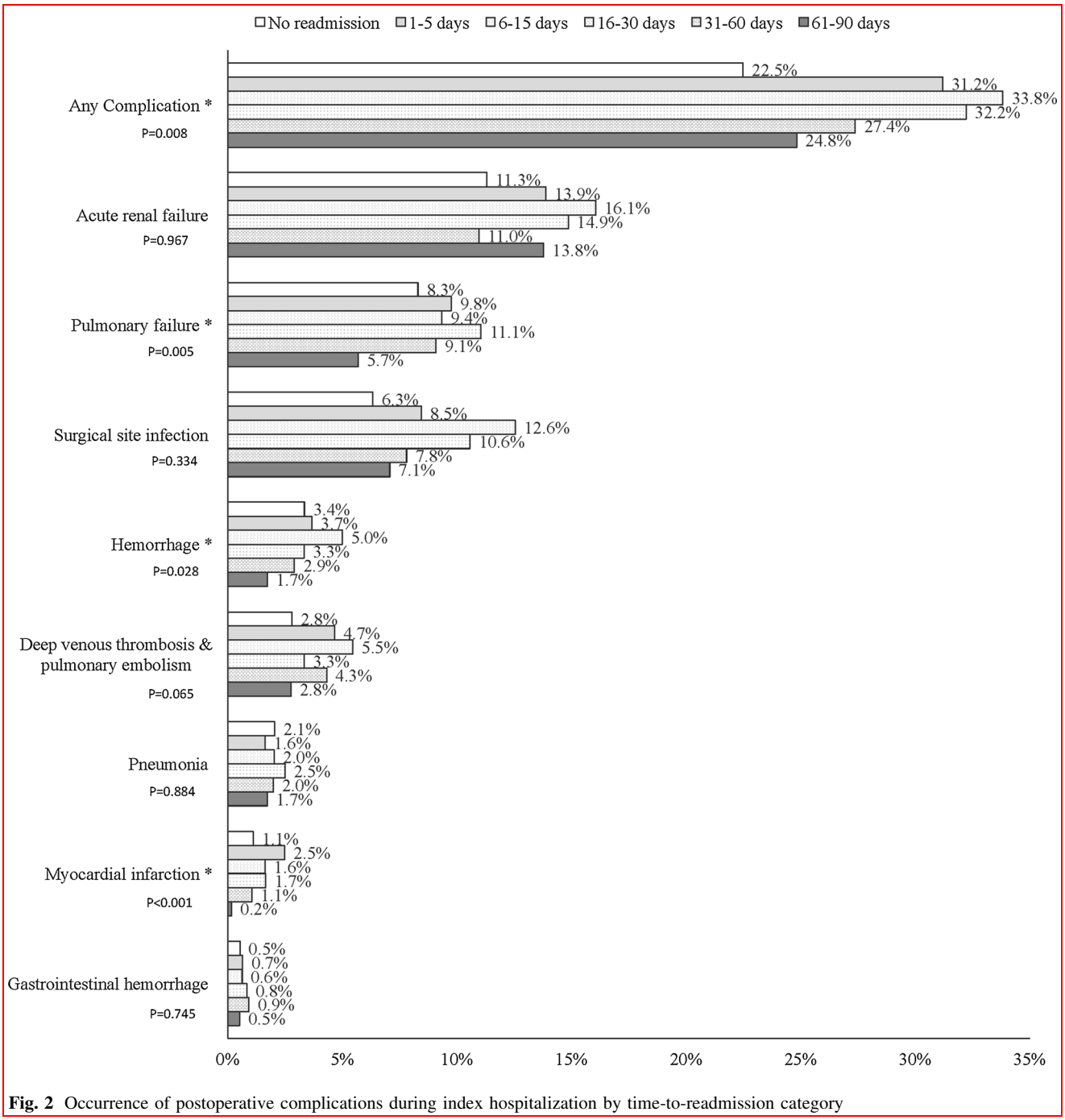


Fig. 2 Occurrence of postoperative complications during index hospitalization by time-to-readmission category

postoperative infection compared with patients who had a late readmission (1–5 days: 63.1% vs. 6–15 days: 65.0% vs. 61–90 days: 39.3%; $P < 0.001$). In contrast, compared with early readmission, causes of late readmissions were more likely related to gastrointestinal complications (1–5 days: 28.9% vs. 61–90 days: 39.7%; $P < 0.001$), or fluid and electrolyte abnormalities (1–5 days: 3.0% vs. 61–90 days: 5.9%; $P = 0.007$).

Overall risk-adjusted, post-discharge mortality was 3.8, 7.9, 9.4, 10.8, and 11.9% at 30, 90, 120, 150, and 180 days, respectively. Patients who were readmitted had a higher risk-adjusted mortality versus patients who did not have a readmission within 90 days (readmission vs. non-readmission: 11.0% vs. 6.6%), 120 days (readmission vs. non-readmission: 15.1% vs. 7.4%), 150 days (readmission vs. non-readmission: 17.9% vs. 8.3%), and 180 days (readmission vs. non-readmission: 19.8% vs. 9.2%) (all $P < 0.001$) (Fig. 4a). Among readmitted patients, the risk-adjusted, post-discharge mortality demonstrated an initial linear increase with longer TTR, yet decreased once TTR

exceeded 60 days. For example, risk-adjusted 180-day mortality increased from 17.7% among patients readmitted within 1–5 days to 20.7% among patients readmitted within 31–60 days ($P > 0.05$). In contrast, 180-day mortality decreased to 17.2% among patients readmitted between 61 and 90 days; 120-day and 150-day risk-adjusted post-discharge mortality demonstrated a similar trend (Fig. 4a). Moreover, compared with patients who did not have a readmission, 180-day mortality risk was highest among patients readmitted within 16–30 days post-discharge (aOR 3.60; 95% CI 2.94–4.41), while somewhat lower, the risk of 180-day mortality among patients readmitted within 1–5 days post-discharge was still over two-fold higher than non-readmitted patients (aOR 2.76; 95% CI 2.20–3.46; $P < 0.001$). Data on mortality relative to readmission were similar when analyzing pancreatic and liver procedures separately (Table 2).

The occurrence of a complication during the index hospitalization was associated with readmission mortality across TTR categories. Specifically, among patients who experienced a complication during the index hospitalization, risk-adjusted mortality decreased in a linear fashion as TTR increased. Specifically, compared with late readmission (61–90 days), patients who had an early readmission (1–5 days) had a higher risk-adjusted postoperative mortality at 90 days (1–5 days: 27.5% vs. 61–90 days: 15.7%), 120 days (1–5 days: 31.1% vs. 61–90 days: 18.6%), 150 days (1–5 days: 35.6% vs. 61–90 days: 24.3%), and 180 days (1–5 days: 37.3% vs. 61–90 days: 27.1%) (all $P < 0.001$) (Fig. 4b, c). However, among patients who did not experience a complication during the index hospitalization, there was no difference in 180-day mortality among patients who had an early (1–5 days: 11.4%) versus late (61–90 days: 13.5%) readmission ($P = 0.288$). Additional analyses were performed to compare adjusted odds of post-discharge mortality following pancreas and liver surgery by time to readmission among patients who had an elective versus non-elective admission (Supplementary Table 4).

Fig. 4 Rates of risk-adjusted post-discharge mortality following hepatopancreatic surgery by time-to-readmission category (**a** overall, **b** patients with complications, **c** patients without complications)

Discussion

Hospital readmissions contribute to rising healthcare costs and are being used increasingly as an indicator of quality of care [24]. Previous studies of medical and surgical patients have suggested that higher quality care may decrease the likelihood of readmission [25–27]. Postoperative complications, in particular, have been associated with an increased risk of readmission and, consequently, additional costs [25, 28, 29]. For these reasons, reducing readmissions has become a national priority to minimize healthcare spending and to optimize quality of care [30]. Of note, patients readmitted to the hospital had a markedly higher risk of mortality compared with patients who were not readmitted. Post-discharge mortality was associated with TTR. In fact, roughly 1 in 5 patients who were readmitted within 60 days of discharge died within the 180 days of the index pancreas or liver procedure. As such, data from the current study serve to highlight the importance of

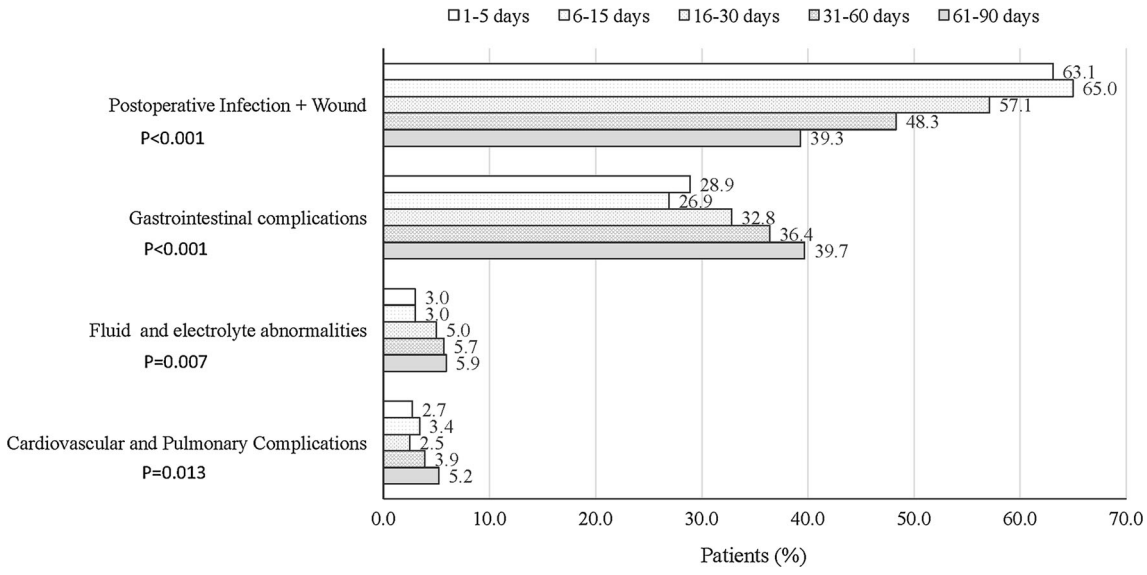
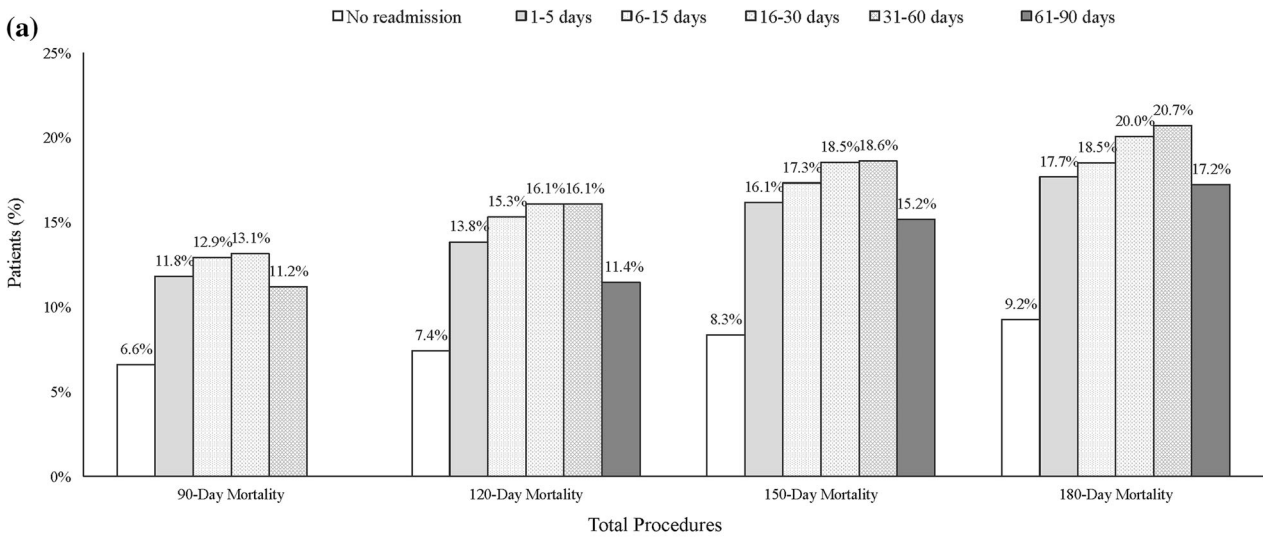
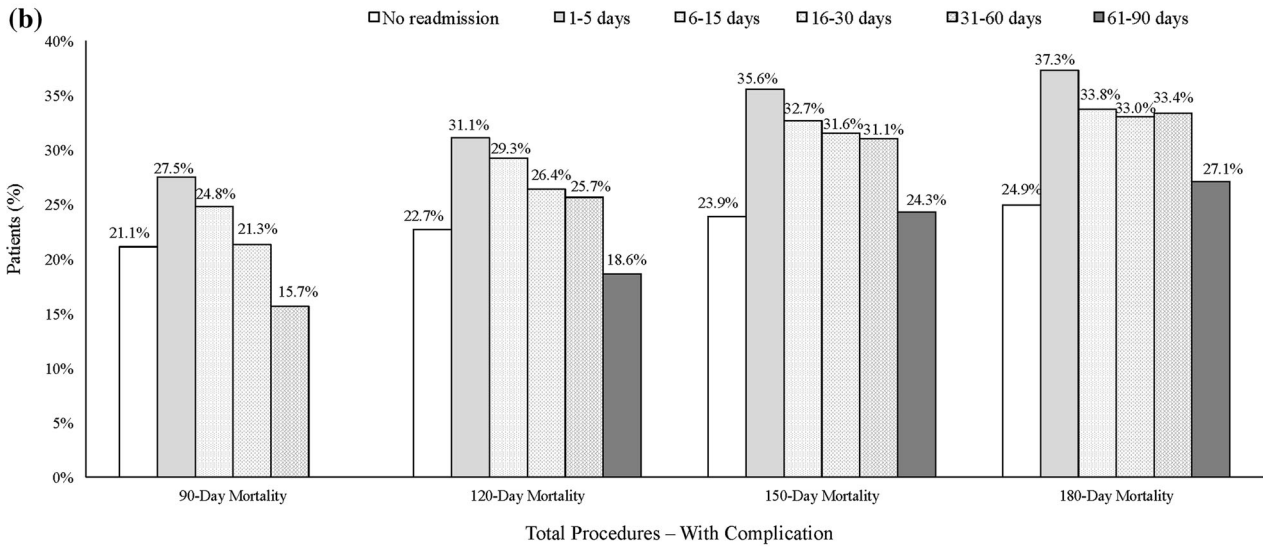


Fig. 3 Major diagnoses at first readmission stratified by time to readmission


(a)
No readmission
1-5 days
6-15 days
16-30 days
31-60 days
61-90 days
Patients (%)
25%
20%
15%
10%
5%
0%
6.6%
11.8%
12.9%
13.1%
11.2%
7.4%
13.8%
15.3%
16.1%
16.1%
11.4%
8.3%
16.1%
17.3%
18.5%
18.6%
15.2%
9.2%
17.7%
18.5%
20.0%
20.7%
17.2%
90-Day Mortality
120-Day Mortality
150-Day Mortality
180-Day Mortality
Total Procedures


(b)
No readmission
1-5 days
6-15 days
16-30 days
31-60 days
61-90 days
Patients (%)
40%
35%
30%
25%
20%
15%
10%
5%
0%
21.1%
27.5%
24.8%
21.3%
15.7%
22.7%
31.1%
29.3%
26.4%
25.7%
18.6%
23.9%
35.6%
32.7%
31.6%
31.1%
24.3%
24.9%
37.3%
33.8%
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33.4%
27.1%
90-Day Mortality
120-Day Mortality
150-Day Mortality
180-Day Mortality
Total Procedures – With Complication

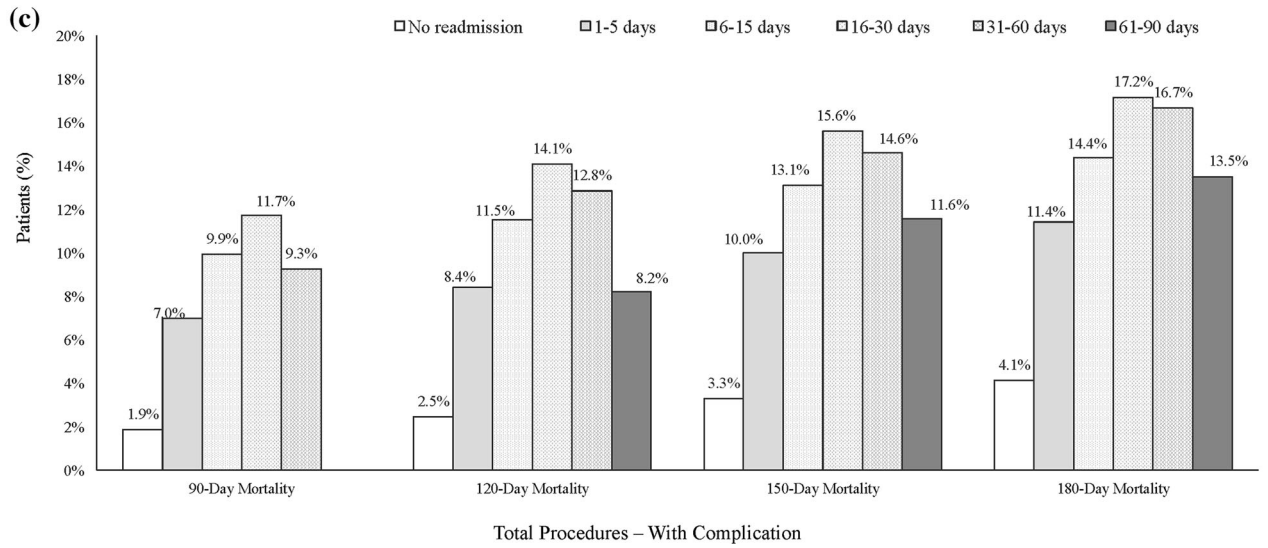
(c)
No readmission
1-5 days
6-15 days
16-30 days
31-60 days
61-90 days
Patients (%)
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
1.9%
7.0%
9.9%
11.7%
9.3%
2.5%
8.4%
11.5%
14.1%
12.8%
8.2%
3.3%
10.0%
13.1%
15.6%
14.6%
11.6%
4.1%
11.4%
14.4%
17.2%
16.7%
13.5%
90-Day Mortality
120-Day Mortality
150-Day Mortality
180-Day Mortality
Total Procedures – With Complication

Table 2 Adjusted odds ratios for post-discharge mortality following pancreas and liver surgery by time to readmission and operation

Time to readmission	Index admission complication			90-day mortality			120-day mortality			150-day mortality			180-day mortality		
Not readmitted	AOR Reference	95% CI	*P* value	AOR Reference	95% CI	*P* value	AOR Reference	95% CI	*P* value	AOR Reference	95% CI	*P* value	AOR Reference	95% CI	*P* value
All patients															
1–5 days	1.21	0.99–1.49	0.060	2.54	1.91–3.39	<0.001	2.71	2.10–3.50	<0.001	2.85	2.25–3.60	<0.001	2.76	2.20–3.46	<0.001
6–15 days	1.32	1.12–1.55	0.001	2.96	2.29–3.84	<0.001	3.22	2.58–4.02	<0.001	3.20	2.60–3.93	<0.001	2.98	2.45–3.63	<0.001
16–30 days	1.26	1.04–1.53	0.020	3.04	2.24–4.12	<0.001	3.50	2.67–4.58	<0.001	3.60	2.83–4.56	<0.001	3.41	2.72–4.27	<0.001
31–60 days	1.04	0.85–1.27	0.731	2.33	1.70–3.18	<0.001	3.49	2.73–4.48	<0.001	3.63	2.88–4.56	<0.001	3.60	2.94–4.41	<0.001
61–90 days	1.08	0.86–1.35	0.516	–	–	–	1.98	1.41–2.78	<0.001	2.57	1.94–3.39	<0.001	2.64	2.02–3.44	<0.001
Pancreas															
1–5 days	1.20	0.89–1.62	0.223	2.06	1.32–3.23	0.002	2.36	1.56–3.56	<0.001	2.44	1.70–3.49	<0.001	2.81	1.95–4.03	<0.001
6–15 days	1.44	1.14–1.81	0.002	2.14	1.48–3.09	<0.001	2.61	1.91–3.56	<0.001	2.52	1.88–3.39	<0.001	2.57	1.94–3.41	<0.001
16–30 days	1.37	1.04–1.80	0.026	2.40	1.44–3.72	<0.001	3.25	2.19–4.82	<0.001	3.83	2.69–5.46	<0.001	3.57	2.52–5.07	<0.001
31–60 days	0.98	0.71–1.35	0.879	1.64	0.98–2.73	0.058	2.96	1.99–4.41	<0.001	3.30	2.28–4.80	<0.001	3.20	2.27–4.50	<0.001
61–90 days	1.11	0.80–1.54	0.537	0.21	0.06–0.75	0.016	1.48	0.79–2.75	0.219	1.73	1.02–2.93	0.042	2.05	1.29–3.26	0.042
Liver															
1–5 days	1.23	0.95–1.60	0.108	2.92	2.03–4.20	<0.001	2.98	2.16–4.10	<0.001	3.18	2.34–4.32	<0.001	2.75	2.06–3.66	<0.001
6–15 days	1.22	0.96–1.55	0.104	3.73	2.67–5.21	<0.001	3.74	2.76–5.05	<0.001	3.77	2.87–4.96	<0.001	3.30	2.52–4.32	<0.001
16–30 days	1.18	0.91–1.53	0.206	3.49	2.34–5.21	<0.001	3.57	2.48–5.14	<0.001	3.29	2.37–4.56	<0.001	3.18	2.36–4.28	<0.001
31–60 days	1.08	0.84–1.39	0.559	2.86	1.94–4.21	<0.001	3.84	2.82–5.23	<0.001	3.81	2.86–5.07	<0.001	3.86	3.00–4.98	<0.001
61–90 days	1.05	0.78–1.43	0.743	0.49	0.21–1.15	0.102	2.36	1.55–3.60	<0.001	3.21	2.29–4.50	<0.001	3.08	2.21–4.28	<0.001

aOR adjusted odds ratios

The model was risk-adjusted for age, gender, race (White, Black, Asian, Other), Charlson comorbidity score, admission priority (elective, urgent, emergent, and others), complication during the index hospitalization, index hospitalization length of stay (LoS), and discharge destination (home, skilled nursing facility/intermediate facility/intermediate care facility, long-term care facility, other destination)

coordinating care not only at the index hospital (i.e., where the surgery was performed), but also at non-index hospitals—as 25% of readmissions occurred in these other hospitals.

While several studies have sought to examine risk factors associated with readmission, the consequences of readmission have been poorly defined—especially relative to the global risk of death following the index surgical procedure [10, 19, 31, 32]. In one study of 2133 hospitalized, community-dwelling Medicare patients, Lum et al. [31] reported that patients who had a hospital readmission within 30 days of discharge were at higher risk of one-year mortality versus patients who never had a readmission (readmitted vs. non-readmitted: 38.7% vs. 12.1%; $P < 0.001$). In a separate study, Gonzalez and colleagues examined the effect of readmission on mortality among a cohort of patients who had undergone colectomy, lung resection, and CABG procedures [19]. In this study, readmission was strongly associated with a higher risk-adjusted post-discharge mortality. Data on the global risk of mortality following liver and pancreas surgery relative to readmission have not, however, been well investigated. Schneider et al. [14] reported that readmission following hepatopancreatic surgery was associated with higher rates of complications and inpatient mortality. In contrast, several other smaller single-institution series reported no association between readmission and survival among patients undergoing hepatopancreatic surgery [10, 14, 32]. In the current analysis, the incidence of postoperative 90-day readmission for patients undergoing hepatopancreatic surgery was 25%. Perhaps of more interest, mortality was strongly associated with readmission. Specifically, patients who experienced a readmission had a 90-, 120-, 150-, and 180-day mortality roughly doubled that of patients who did not have a readmission.

Gonzalez and colleagues examined the effect of TTR among a cohort of patients who had undergone colectomy, lung resection, and CABG procedures [19]. TTR was inversely correlated with the risk of death, as increased TTR was associated with a lower incidence of mortality. In particular, patients readmitted within 1–5 days following discharge had a particularly high risk of death (12.6%) [19]. In the current study, unlike the findings by Gonzalez and colleagues, the risk of mortality did not generally decrease as TTR increased among patients who had undergone liver and pancreas surgery. For example, 180-day mortality among patients readmitted 1–5 days (18%), 31–60 days (21%), and 61–90 days (17%) post-discharge was roughly comparable. The reasons for these disparate results are undoubtedly multifactorial and may be related to patient factors, as well as differences in the types and timing of procedure-specific complications. For example, Sadot et al. [33] noted that patients readmitted after a pancreatic resection were more likely to have infectious complications as the cause of early readmission; in contrast, causes of late readmissions were more procedure-specific related (i.e., leak, fistula, gastroduodenal bleed). Among patients undergoing liver surgery, Tamandl et al. [15] reported that readmission within the first 15 days after surgery was more often related to wound infection, pneumonia, and peri-hepatic fluid collections. In contrast, late readmissions after liver surgery can sometimes be related to more serious complications such as liver insufficiency or liver failure [34, 35]. In the current study, causes of readmission were correlated with TTR. In particular, postoperative infection was the cause of readmission in roughly two-thirds of patients readmitted within the first 15 days, yet was a less common indication for readmission as TTR increased. While it is unlikely patients died within 90 days from disease recurrence, it may be possible that patients died of an AE related to readmission.

The use of MEDPAR data limited the analytic cohort to patients who were ≥65 years old (or younger Medicare beneficiaries). While many patients who undergo liver and pancreatic surgery are generally older, exclusion of young patients may limit the generalizability of the data to this population of patients. Moreover, due to the administrative nature of the MEDPAR database, data on specific surgical techniques (i.e., lymphadenectomy, associated surgical procedures), readmission specific causes (i.e., elective or non-elective readmission), as well as detailed disease-specific information (i.e., tumor size, number) were limited. However, the large sample size, as well as the national sampling frame, were strengthens of the current study that allowed for greater statistical power and assessment of aggregate data from multiple hospitals across the USA

Readmission remains a challenge following hepatopancreatic surgery as up to 1 in 4 patients was readmitted. Among patients who were readmitted, the incidence of mortality increased with TTR up to 60 days after discharge yet decreased thereafter. The relation of TTR and mortality was particularly pronounced among patients who had a complication during the index hospitalization.

Compliance with Ethical Standards

Conflict of interest All authors declare that they have no disclosures to report.

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