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Patients With Cirrhosis Have Higher Costs of Care, Longer Length of Stays, and More Perioperative Complications Following Total Knee Arthroplasty: A National Inpatient Sample-Based Study

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Abstract

Background

Cirrhosis is a growing disease affecting millions of people in the United States annually. Many cirrhosis patients undergo significant procedures and are met with increased risks such as encephalopathy, impaired immune response, ascites, variceal bleeding, renal disease, and increased malnutrition. Many cirrhosis patients need to undergo major surgical procedures such as total knee arthroplasty (TKA); however, perioperative complications following TKA in cirrhosis patients have not been studied. The purpose of this study was to analyze the demographic characteristics and perioperative complications of cirrhosis patients following TKA.

Methods

Using the National Inpatient Sample (NIS) database, we looked at retrospective data from the years 2016-2019 to analyze the incidence of perioperative complications, length of stay (LOS), and the cost of care (COC) among patients undergoing TKA who were categorized as cirrhosis patients, compared with those who are not. A propensity match was conducted to consider associated comorbidities that influence perioperative complications.

Results

Of the 558,256 patients analyzed who underwent TKA, 1670 (0.3%) were diagnosed with cirrhosis. After matching, cirrhosis patients had a longer LOS (4.22 vs. 3.68 days, $p=0.016$) and COC (\$90,624 vs. 80,676.87, $p<0.001$) than patients in the control group. Moreover, cirrhosis patients had a higher likelihood of developing acute renal failure (odds ratio (OR): 3.05, 95% CI: 2.07-4.50, $p<0.001$), blood loss anemia (OR: 1.60, 95% CI: 1.34-1.92, $p<0.001$), periprosthetic fracture (OR: 3.27, 95% CI: 1.31-8.18, $p=0.007$), periprosthetic infection (OR: 3.14, 95% CI: 1.99-4.95, $p<0.001$), and blood transfusions (OR: 1.62, 95% CI: 1.12-2.35, $p=0.009$) than patients in the control group.

Conclusion

The cirrhosis group had a significantly higher COC, longer LOS, and higher rates of perioperative complications than non-cirrhosis patients. This data will help providers make informed decisions about patient care and resource allocation for cirrhosis patients undergoing TKA.

Categories: Other, Internal Medicine, Orthopedics

Keywords: cost of care, postoperative complications, length of stay, cirrhosis, total knee arthroplasty

Introduction

Cirrhosis poses a significant surgical risk factor due to preexistent encephalopathy, coagulopathy, impaired immune response, malnutrition, osteopenia, ascites, variceal bleeding, renal disease, and infection [1,2]. The common etiological factors of cirrhosis include viral hepatitis, alcohol abuse, autoimmune hepatitis, biliary duct disease, genetic or metabolic disorders, non-alcoholic fatty liver disease (NAFLD), and prolonged exposure to toxins and industrial pollutants [3,4]. During the past decade, with the global burden of the disease gradually escalating, there have been substantial changes in its epidemiology [5-7]. Thus, North America is witnessing a surge in NAFLD and alcohol-related cirrhosis, while viral hepatitis remains the

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primary cause of cirrhosis worldwide [8-10]. As a chronic irreversible liver disease with multiorgan dysfunction, cirrhosis is associated with not just morbidity but also mortality. A total of 2.4% of global deaths in 2019 were attributed to cirrhosis, predicted to increase in the coming decade [9,10]. The Child-Pugh classification [11] is the go-to scoring system for assessing the overall prognosis and stratifying surgical risks. Three main classes, A, B, and C, are distinguished by increasing disease severity, and elective surgery like total knee arthroplasty (TKA) is usually well tolerated in class-A cirrhotic patients [12]. Notably, the rapid advances in medical management have led to a rise in the prevalence of cirrhosis, besides increasing the survival rates. Consequently, the utilization of TKA has risen substantially in this high-risk patient cohort with improving medical optimization [13,14].

It is widely recognized that cirrhotic patients tend to have poorer outcomes than the non-cirrhotic groups following major orthopedic surgeries [15-17]. Similarly, TKA in this sick patient population carries a distinct set of perioperative and postoperative complications [2,18,19]. Although data exist on the general risk factors, challenges, and outcomes of TKA in cirrhotic patients, little is known about immediate perioperative outcomes and their impact on hospital resources. This research was conducted to evaluate the association between cirrhosis and inpatient complications following TKA, together with the duration of hospital stay and healthcare costs, based on the recent four-year Nationwide Inpatient Sample (NIS) data.

Materials And Methods

Database description

The NIS contains information on more than 7,000,000 hospital stays and is the biggest all-payer, publicly accessible inpatient care database in the US [20]. The NIS database was used to get information on patients who received primary TKA between 2016 and 2019 in the US. Due to the enormous sample size, it offers the perfect information for creating national and regional estimations. It also makes it possible to analyze unusual pathologies, uncommon treatments, and particular demographics. The diseases are categorized using the International Classification of Disease-Tenth Revision, Clinical Modification/Procedure Coding System (ICD-10-CM/PCS) in the NIS database that was available between 2016 and 2019. The NIS database contains data on patient demographics, length of stay (LOS), payment source, hospital charges, discharge status, comorbidities, and several other variables. Data was extracted from 2016 to 2019, and the ICD codes used in this study are described in Table 1.

Comorbidities Codes	Medical Complication Codes	Surgical Complication Codes
Diabetes without complications: E119	Acute Renal Failure: N170, N171, N172, N178, N179	Periprosthetic fracture: T84010A, T84011A, T84012A, T84013A, T84018A, T84019A, M9665, M96661, M96662, M96669, M96671, M96672, M96679, M9669, M9701XA, M9702XA, M9711XA, M9712XA
Diabetes with complications: E1169	Myocardial Infarction: I2101, I2102, I2111, I2113, I12114, I12119, I2121, I12129, I21A1	Periprosthetic dislocation: T84020A, T84021A, T84022A, T84023A, T84028A, T84029A
Tobacco-related disorder: Z87891	Blood loss anemia: D62	Periprosthetic mechanical complications: T84090A, T84091A, T84092A, T84093A, T84098A, T84099A
Obesity: E660, E6601, E6609, E661, E662, E668, E669, Z6830, Z6831, Z6832, Z6833, Z6834, Z6835, Z6836, Z6837, Z6838, Z6839	Pneumonia: J189, J159, J22	Periprosthetic infection: T8450XA, T8451XA, T8452XA, T8453XA, T8454XA, T8459XA
Morbidly Obese: Z6841, Z6842, Z6843, Z6844, Z6845	Blood transfusion: 30233N1	Superficial SSI: T8141XA
	Pulmonary embolism: I2602, I2609, I2692, I2699	
	DVT: I82401, I82402, I82403, I82409, I82411, I82412, I82413, I82419, I82421, I82422, I82423, I82429, I82431, I82432, I82433, I82439, I82441, I82442, I82443, I82449, I82491, I82492, I82493, I82499, I824Y1, I824Y2, I824Y3, I824Y9, I824Z1, I824Z2, I824Z3, I824Z4	
	Cirrhosis: K7400, K7401, K7402, K7402, K741 K742, K743, K744, K745, K746, K7460, K7469	

TABLE 1: ICD codes used for the analysis.
ICD: International Classification of Disease: SSI: Surgical site infection.

Data acquisition

The study received an exemption from the IRB as it utilized de-identified data that is publicly available. This study included all patients with ICD-10 and Clinical Modification/Procedure Coding System (CMP) codes for TKA. Patients were split up into two groups: Cirrhosis and non-cirrhosis (control). Our demographic analysis considered age, sex, ethnicity, and the presence of obesity. Complications following surgery, such as postoperative anemia, hypotension, acute renal failure, deep vein thrombosis (DVT), and pulmonary embolism (PE), were also considered. In addition to systemic medical effects, including myocardial infarction (MI) and pneumonia, our investigation took into account regional problems such as periprosthetic infections, prosthetic dislocations, and periprosthetic fractures. Finally, details on each patient's overall LOS in the hospital and associated medical expenses were acquired.

Statistical analysis

All statistical analyses were performed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to construct the patients' demographic data. Both matched and unmatched analyses were conducted. A 1:1 propensity matching algorithm was employed, considering preoperative factors such as age, sex, race, obesity, and diabetes (with and without complications). T-tests were used to examine the numerical variables. The Chi-square technique was used to evaluate binomial variables. Fisher's exact test was used when the incidence values were under 5. A p-value of less than 0.05 was deemed statistically significant for all tests. We calculated the odds ratios and their corresponding 95% CIs for surgical outcomes and complications by comparing the incidence rates in the cirrhosis group to those in the control group.

Results

The NIS database identified 558,256 patients who underwent TKA between 2016 and 2019. Within this sample, only 1670 patients (0.3%) had cirrhosis, while the rest were control patients who did not have cirrhosis.

Patient demographics

Of the cirrhosis group, the average age was 65.91 ± 8.29 years, and 60.1% (N=1003) of the patients were female. Although there was no major gender disparity between the two groups, it was observed that those with cirrhosis were younger, and this difference was statistically significant (mean age: 65.9 vs. 66.7 years, $P < 0.001$). Besides, the cirrhotic group demonstrated a higher prevalence of diabetes mellitus (18.9% vs. 14.8%, $P < 0.001$) and obesity (37.8% vs. 30.9%, $P < 0.001$). In comparison, a significantly higher rate of tobacco use was noted in the control population (16% vs. 12%, $P < 0.001$) (Table 2).

	Cirrhosis group (1670)	Control group (556586)	Significance
Mean Age (standard deviation) in years	65.91 (8.29%)	66.72 (8.29%)	$P < 0.001$
Sex (proportion female)	1003 (60.1%)	342417 (61.5%)	$P = 0.220$
Diabetes without complication (proportion diabetic)	315 (18.9%)	82149 (14.8%)	$P < 0.001$
Tobacco Use Disorder (proportion users)	207 (12.4%)	88162 (15.8%)	$P < 0.001$
Obesity (proportion obese)	628 (37.8%)	172033 (30.9%)	$P < 0.001$

TABLE 2: Patient demographics before propensity matching.

Unmatched postoperative outcomes analysis

Unmatched analyses revealed that the cirrhosis group patients had a much higher likelihood of mortality than the control group (OR: 5.13, 95% CI: 1.64-16.08, $p=0.02$). Moreover, acute renal failure (OR: 3.33, 95% CI: 2.73-4.06, $p<0.001$), blood loss anemia (OR: 1.57, 95% CI: 1.39-1.76, $p<0.001$), pneumonia (OR: 3.42, 95% CI: 1.88-6.20, $p<0.001$), periprosthetic fracture (OR: 2.86, 95% CI: 1.84-4.46, $p<0.001$), periprosthetic infection (OR: 4.71, 95% CI: 3.75-5.92, $p<0.001$), and blood transfusion (OR: 3.24, 95% CI: 2.57-4.08, $p<0.001$), were all more likely to occur in the cirrhosis group in comparison to the control group (Table 3). The ORs of the rest, comprising wound dehiscence, mechanical complications of the implants, DVT, PE, and MI, did not demonstrate statistical significance.

Post-operative Variables	Cirrhosis group (1670)	Control group (556586)	Odds Ratio (Cirrhosis group/Control group)	Odds Ratio 95% CI	Significance
Mortality	*0.2%	195 (<0.0003%)	5.13	(1.64, 16.08)	$P = 0.02$
Acute Renal Failure	105 (6.3%)	10980 (2%)	3.33	(2.73, 4.06)	$P < 0.001$
Myocardial Infarction	0	109 (0.0002%)	NA	NA	$P = 0.567$
Blood Loss Anemia	369 (22.1%)	85188 (15.3%)	1.57	(1.39, 1.76)	$P < 0.001$
Pneumonia	11 (0.7%)	1077 (0.2%)	3.42	(1.88, 6.20)	$P < 0.001$
Pulmonary Embolism	*0.1%	1236 (0.2%)	0.53	(0.13, 2.15)	$P = 0.375$
Deep Vein Thrombosis	*0.3%	1257 (0.2%)	1.32	(0.55, 3.19)	$P = 0.527$
Periprosthetic Fracture	20 (1.2%)	2343 (0.4%)	2.86	(1.84, 4.46)	$P < 0.001$
Periprosthetic Mechanical Complication	20 (1.2%)	4484 (0.8%)	1.49	(0.96, 2.32)	$P = 0.674$
Periprosthetic infection	78 (4.7%)	5724 (1%)	4.71	(3.75, 5.92)	$P < 0.001$
Wound Dehiscence	0.2%	527 (0.1%)	1.89	(0.61, 5.91)	$P = 0.260$
Blood Transfusion	77 (4.6%)	8177 (1.5%)	3.24	(2.57, 4.08)	$P < 0.001$

TABLE 3: Unmatched analysis: Post-operative complications.

*Exact number not reported if value between 1 and 10 as per Healthcare Cost and Utilization Project (HCUP) Data Use Agreement (DUA).

The LOS analyses revealed that before matching, the cirrhosis group had a significantly longer stay than the control group (3.21 vs. 2.34 days, $p<0.001$). After matching, the difference remained statistically significant but with slight attenuation (4.22 vs 3.68 days, $p=0.016$). Likewise, the cirrhosis group incurred a higher COC before matching (\$81,282) and after matching (\$90,624) than the patients in the control group ($p<0.001$) (Table 4).

	Unmatched Cirrhosis Group	Unmatched Control Group	P-value	Matched Cirrhosis Group	Matched Control Group	P-value
Length of stay	3.21 (4.04)	2.34 (1.92)	<0.001	4.22 (5.86)	3.68 (4.56)	P=0.016
Hospital charges	81282 (96,932)	64761 (45,586)	<0.001	90624 (78180.84)	80676.87 (66353.87)	P<0.001

TABLE 4: Length of stay and cost of care in the unmatched and matched cohorts.

Matched postoperative outcomes analysis

Matched information regarding both groups can be found in Table 5. After matching, there was significant attenuation as patients in the cirrhosis group had a greater propensity for only acute renal failure (OR: 3.05, 95% CI: 2.07-4.50, $p<0.001$), blood loss anemia (OR: 1.60, 95% CI: 1.34-1.92, $p<0.001$), periprosthetic fracture (OR: 3.27, 95% CI: 1.31-8.18, $p=0.007$), periprosthetic infection (OR: 3.14, 95% CI: 1.99-4.95, $p<0.001$), and blood transfusions (OR: 1.62, 95% CI: 1.12-2.35, $p=0.009$). There were no significant differences between the groups regarding mortality, MI, pneumonia, PE, DVT, periprosthetic mechanical complication, and wound dehiscence (Table 6).

	Cirrhosis group (1627)	Control group (1628)	Significance
Age (SD)	64.57 (10.0)	64.89 (11.04)	P = 0.472
Sex (proportion female) *	1003 (60.1%)	979 (60.1%)	p = 0.965
Diabetes without complications (proportion diabetic)	315 (18.9%)	312 (19.2%)	P = 0.825
Tobacco Use Disorder (proportion users) *	207 (12.4%)	200 (12.3% %)	P = 0.919
Obesity (proportion obese)	628 (37.8%)	615 (37.6%)	P = 0.919
Race			
White	1253 (77.0%)	1255 (76.9%)	p = 0.563
Black	125 (7.7%)	124 (7.6%)	
Hispanic	173 (10.6%)	173 (10.6%)	
Asian	24 (1.5%)	24 (1.5%)	
Native American	*0.60%	*0.60%	
Age Categorical			
<60	357 (21.4%)	346 (21.3%)	P= 1.000
60 to 70	774 (46.3%)	757 (46.5%)	
70 to 80	435 (26.7%)	447 (26.8%)	
80 to 90	89 (5.5%)	91 (5.4%)	
>90	* 0.10%	*0.10%	

TABLE 5: Patient demographics of matched cohort

*Exact number not reported if value between 1 and 10 as per Healthcare Cost and Utilization Project (HCUP) Data Use Agreement (DUA).

Post Operative Variables	Cirrhosis group (1670)	Control group (1628)	Odds Ratio (Cirrhosis group/Control group)	Odds Ratio 95% CI	Significance
Mortality	*0.2%	*0.1%	1.46	0.24-8.76	0.675
Acute Renal Failure	105 (6.3%)	35 (2.1%)	3.05	2.07-4.50	<0.001
Myocardial Infarction	0	*0.1%	0.49	0.47-0.51	0.31
Blood Loss Anemia	369 (22.1%)	294 (15%)	1.60	1.34-1.92	<0.001
Pneumonia	11 (0.7%)	*0.2%	2.69	0.85-8.47	0.078
Pulmonary Embolism	*0.1%	*0.4%	0.278	0.05-1.33	0.08
Deep Vein Thrombosis	*0.3%	*0.4%	0.81	0.24-2.66	0.731
Periprosthetic Fracture	20 (1.2%)	*0.4%	3.27	1.31-8.18	0.007
Periprosthetic Mechanical Complication	20 (1.2%)	0.6%	1.96	0.94-4.20	0.07
Periprosthetic Infection	78 (4.7%)	25 (1.5%)	3.14	1.99-4.95	<0.001
Wound Dehiscence	0.2%	0.4%	0.48	0.12-1.94	0.298
Blood Transfusion	77 (4.6%)	47 2.9%)	1.62	1.12-2.35	0.009

TABLE 6: Matched sample analysis: post-operative complications.

* Exact number not reported if value between 1 and 10 as per Healthcare Cost and Utilization Project (HCUP) Data Use Agreement (DUA).

Discussion

In the present research, an assessment of the in-hospital outcomes of 558,256 adult patients undergoing primary TKA revealed that liver cirrhosis was associated with higher rates of certain perioperative complications. Specifically, the odds of developing acute renal failure, periprosthetic fracture, and prosthetic joint infections were three times higher at a minimum. Further, the postoperative hospital stays of cirrhotic patients were approximately one day longer, and as a consequence, the overall costs were around \$10,000 greater than those of non-cirrhotic patients. Despite the five-fold increase in mortality and three-fold increase in pneumonia among cirrhotic patients, no significant differences were observed after matching.

As is well known, the liver plays a crucial role in developing and maturing various proteins, including those involved in the coagulation cascade and acute phase reactants [19]. As a consequence, patients with cirrhosis have increased rates of complications with numerous surgical procedures, including total joint arthroplasties [17,21]. A study by Shih LY et al. reported that cirrhotic TKA patients had increased blood loss, longer hospital stays, and higher mortality rates than control patients, with p-values less than 0.006 for each [12]. Bell JE et al. reviewed the Medicare database with a minimum one-year follow-up. They concluded that cirrhotic patients who have undergone TKA have about three times higher risk of disseminated intravascular coagulation (p= 0.003) and hepatic encephalopathy (p < 0.001), with prosthetic joint infection (p < 0.001) risk being about double than that of the control population [19]. In a study using the NIS database, Newman et al. reported that patients with cirrhosis had a higher likelihood of complications following TKA, with an odds ratio of 1.55 (95% CI: 1.47-1.63), and THA, with an odds ratio of 1.59 (95% CI: 1.50-1.69). Additionally, TKA patients with cirrhosis incurred additional costs of \$1,857 and an increased length of stay (LOS) by 0.30 days. In comparison, THA patients with cirrhosis faced extra costs of \$1,497 and an extension of LOS by 0.48 days [22].

Thus, it is imperative to recognize this select patient group's unique medical and surgical issues, especially how to optimize controllable factors [2,23]. The results of our study presented the highest odds, more than three-fold, for three distinct complications comprising acute renal failure, periprosthetic fracture, and prosthetic joint infection. Anemia caused by blood loss and the need for blood transfusion was 1.5 times more likely than in the control group. This data is indispensable to construct a multi-disciplinary strategy with adequate pre-, intra-, and postoperative considerations to maximize outcomes. Similarly, our previous study found that dialysis patients also had increased perioperative complications to consider [24].

A significant factor contributing to high medical expenses is the LOS, so total lower joint arthroplasty patients with comorbidities face higher costs. It has been estimated that cirrhotic TKA patients incurred a \$1857 higher cost and 0.30 days extra LOS, while cirrhotic THA patients experienced \$1497 more costs and

0.48 days extra LOS [22]. According to a recent NIS study, patients with cirrhosis who underwent primary hip arthroplasty spent an additional \$10,000 compared to the control group, a statistically significant difference ($p=.001$) [21]. Likewise, Medicare patients with cirrhosis had longer hospital stays (3.57 vs. 3.23, $p<0.001$) and higher 90-day charges (\$76,082 vs. \$56,940, 0.001) after having total knee replacement compared to those without cirrhosis, according to a recent study [19]. The results of the present study are in agreement, showing extra costs (\$90,634 vs. \$80,676) during their hospital stays after a TKA besides a longer LOS (4.22 vs. 3.68), both of which were statistically significant. The data we have obtained in the recent four years could be employed as a reasonable cost estimation for healthcare centers in today's bundled payment plans.

This study has noteworthy strengths and shortcomings that deserve consideration. Being an administrative database, the NIS is prone to sampling bias because of potential data entry errors, missing information, and coding discrepancies. Despite the abundant patient data, the lack of specific clinical details, lab investigators, and patient outcomes following discharge can affect the conclusions. Without factoring in outpatient treatment and postoperative readmissions, the NIS data is inadequate to determine late-term morbidities and fatalities. Besides, the available inpatient data does not offer insights into major intraoperative events and complications, which could impact the LOS and hospital costs. Finally, as a national estimate, the geographic granularity may not apply to regional or local research or certain demographic groups, limiting its generalizability.

Nevertheless, due to its extensive sample size, the NIS data closely represents the US population and serves as an invaluable resource for understanding national healthcare trends and disparities. Our study, spanning the years 2016 to 2019, presents the most comprehensive yet cost-effective approach for analyzing the effects of cirrhosis among TKA patients in the trending era of outpatient joint replacement procedures and bundled payment reimbursement systems.

Conclusions

To the best of our knowledge, this is the first large-database study that has examined perioperative complications and hospital admission characteristics of cirrhotic patients following TKA. Cirrhosis is linked to extended hospital stays, increased medical expenses, and a higher likelihood of perioperative in-hospital complications following TKA, such as anemia due to blood loss, acute renal failure, and periprosthetic fractures and infection. This information can be valuable for preoperative patient counseling and enhancing healthcare resource allocation without compromising patient well-being and financial reimbursement from payers. When assessing hospital expenditures for cirrhotic patients, it is crucial to consider the higher rate of perioperative problems in this patient group. This data will help providers make informed decisions about patient care and resource utilization for cirrhotic patients undergoing TKA.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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