RESEARCH ARTICLE

Total Hip Arthroplasty in Cirrhosis is Associated with Increased Complications during the Hospital Stay, Length of Stay, and Cost of Care: A Propensity Matched Database Study

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Abstract

Objectives: The aim of the study is to evaluate the impact of cirrhosis on inpatient hospital complications and healthcare costs in elective Total Hip Arthroplasty (THA).

Methods: A 4-year retrospective analysis of the Nation Inpatient Sample (NIS) database, who underwent elective THA stratified by the presence or absence of cirrhosis was performed (2016-19). The records of specific postoperative complications, the cost of care (COC), and the length of stay (LOS) were evaluated by statistical analysis.

Results: The NIS database identified 367,894 patients who underwent THA, of which 1,134 (0.3%) were cirrhotic. In the unmatched analysis, patients with cirrhosis showed significantly elevated rates ($P< 0.05$) of in-hospital complications compared to non-cirrhotic controls, including mortality (0.7% vs. 0.1%), acute renal failure (9.2% vs. 2.5%), blood loss anemia (30.4% vs. 19.5%), pneumonia (1.1% vs. 0.3%), periprosthetic fracture (3% vs. 1.2%), dislocations (2.5% vs. 1.4%), infection (4.2% vs. 1%), wound dehiscence (0.8% vs. 0.1%) and blood transfusion (11.3% vs. 3.5%). After propensity matching, significantly higher rates of blood loss anemia (30.4% vs. 26.7%; P=0.05), periprosthetic dislocations (2.4% vs. 1%; P=0.008), and infections (4.2% vs. 2.7%, P=0.05) were seen in the cirrhotic cohort, while the rate of pulmonary embolism was significantly lower (0% vs. 0.8%, P=0.002), as was myocardial infarction (0.08% vs. 0.7%, P=0.017). Concerning LOS in the hospital, patients with cirrhosis stayed significantly longer in both the unmatched (4.2 vs. 2.3 days; $P <0.001$) and matched (4.2 vs. 3.68; $P=0.016$) controls. The average COC was greater in the cirrhotic group, with a mean value of $90,264 vs. $66,806.31 ($P$<0.001) in the unmatched and $90,624 vs. $80,676.87 ($P$=0.001) in the matched cohort.

Conclusion: Cirrhosis is associated with longer lengths of stay, higher hospital costs, and a greater risk of perioperative in-hospital complications such as blood loss anemia, dislocation, and infection after THA. This data could assist during preoperative patient counseling and improve the strategies for effectively utilizing the finite healthcare resources without compromising patient care and financial compensation from payers.

Level of evidence: IV

Keywords: Cirrhosis, Hospital costs, Length of stay, Postoperative complications, Total hip arthroplasty

Introduction

Cirrhosis of the liver is one of the significant healthcare burdens worldwide and is the fourth most common cause of death among people aged 45 to 64 years. [1] It represents the hallmark of end-stage liver disease characterized by irreversible parenchymal destruction and subsequent infiltration by dense fibrous

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scar tissue. The estimated prevalence of the disease in the United States is approximately 0.27%, affecting over 630,000 adults. [2] The most common causes of cirrhosis are viral infection, alcoholic liver disease (ALD), and nonalcoholic fatty liver disease (NAFLD). Given the advancements in the treatment of viral hepatitis, the landscape of the disease etiology has shifted toward alcohol misuse, obesity, and metabolic syndrome. [3]

Total hip arthroplasty (THA) has become a successful treatment for symptomatic patients, even with complex medical conditions, including cirrhosis. The typical indications of THA in patients who have cirrhosis include debilitating osteoarthritis and osteonecrosis. Improvements in medical care led to longer life expectancies in these patients, which contributed to an increase in the disease prevalence; therefore, the number of cirrhotic patients who will need THA, is expected to continue to rise. [4] However, due to its multisystem involvement with resultant comorbidities, THA in cirrhotic patients has been associated with a unique set of postoperative events and complications during their hospital stay. [5,6] Although there have been studies focused on the challenges and outcomes of total joint arthroplasty in general, there is a paucity of data available on immediate perioperative complications in this population and their impact on inpatient healthcare resource utilization.

The purpose of this study was to evaluate the association of cirrhosis with in-hospital outcomes following THA, along with the total length of hospital stay and inpatient costs, using the Nationwide Inpatient Sample (NIS) over a recent four-year period.

The above data could assist in cost-effective inpatient care while optimizing clinical outcomes in the current situation of bundled payment reimbursement and outpatient THA.

Materials and Methods

We queried the Nationwide Inpatient Sample (NIS) database from 2016 to 2019 for all inpatient admissions following THA, stratified by the presence or absence of cirrhosis. The NIS, with data from a 20% stratified sample of all hospital stays each year, is currently the largest inpatient healthcare database in the United States. The Healthcare Cost and Utilization Project (HCUP) developed the database, and the data were collected annually from approximately 8 million hospital admissions. The key components of the database include demographics, length of hospital stay (LOS), primary payer, inpatient costs, discharge status, and medical comorbidities. For the above study period, the system utilized the International Classification of Diseases, Tenth Revision, Clinical Modification/Procedure Coding System (ICD-10-CM/PCS).

Data Acquisition

Since the NIS is a publicly available database with de-identified patient information, our study met the institutional review board exemption criteria. The primary THA patients were identified using the ICD-10 procedural codes OSRB and OSR9. Data for cirrhosis were extracted from the database using the ICD code K74 [Table 1].

The following preoperative variables are depicted in table 2; 1) age, 2) sex, 3) diabetes without complications, 4) tobacco use disorder, and 5) obesity [Table 2]. The most common THA postoperative outcomes mentioned in the database included 1) length of stay, 2) total incurred charges, 3) mortality, 4) acute renal failure, 5) myocardial infarction, 6) blood loss anemia, 7) pneumonia, 8) pulmonary embolism, 9) deep vein thrombosis, 10) periprosthetic fracture, 11) periprosthetic dislocation, 12) periprosthetic mechanical complication, 13) periprosthetic infection, 14) wound dehiscence, and 15) blood transfusion [Table 3].

Statistical Analysis

All statistical analyses were conducted using SPSS version 27.0 (IBM; Armonk, NY, USA). Baseline patient characteristics were analyzed using descriptive statistics. In the study, the outcome variables were compared between the two groups before and after matching. Preoperative variables, including diabetes, smoking, obesity, and sex, were matched using 1: 1 propensity matching. Numerical variables, including age, length of stay, and cost of care, were analyzed using T-tests, and Binominal variables, including preoperative baseline characteristics and postoperative surgical and medical complications, were analyzed using binomial variables. Fischer Exact tests were used when the incidence values were less than 5. A p-value < 0.05 was considered statistically significant for all tests. Complications and other surgical outcomes were reported using Odds ratios and their corresponding 95% confidence intervals.

Results

Demographic data

Of the 367,894 patients that underwent primary THA extracted from the NIS database, 1,134 (0.3%) had the diagnosis of cirrhosis. We noted that patients in cirrhotic group are younger when compared to non-cirrhotic group and this finding is statistically significant (mean age: 64.6 vs. 65.9 years, P<0.001) and had a greater prevalence of diabetes mellitus (12.3% vs. 10%, P=0.009), while the non-cirrhotic group comprised of more females (56% vs. 52%, P=0.01) and significantly elevated rate of tobacco-related disorders (17% vs. 14%, P=0.009) as depicted in [Table 2]. Obesity was not significantly different between the groups.

Unmatched Post-Operative Outcomes Analysis

Patients with cirrhosis had a greater propensity for perioperative complications after THA. Blood loss anemia (30%) was the most common medical complication, while periprosthetic infection (4%) was the most common local complication as depicted in [Table 3]. The highest odds, over nine-fold, were observed for wound dehiscence (odds ratio [OR] =9.8, confidence interval [CI] 5.06-19.14; P <0.001) followed by inpatient mortality (OR=9.1, CI 4.67-17.64; P <0.001). The odds of acute renal failure, pneumonia, periprosthetic infection, and blood transfusion were the next highest (approximately four times). About two-fold increased odds were observed for periprosthetic mechanical complications and blood loss anemia. The odds ratios for the remaining complications, including myocardial infarction, pulmonary embolism, and deep vein thrombosis, did not reach statistical significance.

Table 1. ICD codes used

Cirrhosis Codes	Obese Codes	Morbidly Obese codes	Comorbidities codes	Medical Complications codes	Surgical Complications codes
K7400 K7401 K7402 K741 K742 K743 K744 K745 K746 K7460 K7469	E660 E6601 E6609 E661 E662 E668 E669 Z6830 Z6831 Z6832 Z6833 Z6834 Z6835 Z6836 Z6837 Z6838 Z6839	Z6841 Z6842 Z6843 Z6844 Z6845	Diabetes without complications E119 Diabetes with complications E1169 Tobacco related disorder Z87891	Acute renal Failure N170, N171, N172, N178, N179 Myocardial Infarction I2101, I2102, I2111, I2113, I12114, I12119, I2121, I12129, I21A1 Blood loss anemia D62 Pneumonia J189, J159, J22 Blood transfusion 30233N1 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	Periprosthetic fracture T84010A, T84011A, T84012A, T84013A, T84018A, T84019A, M9665, M96661, M96662, M96669, M96671, M96672, M96679, M9669, M9701XA, M9702XA, M9711XA, M9712XA Periprosthetic dislocation T84020A, T84021A, T84022A, T84023A, T84028A, T84029A Periprosthetic mechanical complications T84090A, T84091A, T84092A, T84093A, T84098A, T84099A Periprosthetic Infection T8450XA, T8451XA, T8452XA, T8453XA, T8454XA, T8459XA Superficial SSI T8141XA Deep SSI T8142XA Wound Dehiscence T8130XA, T8131XA, T8132XA

Table 2. Patient Demographics before matching

	Cirrhosis group	Control group	Significance
	(1134)	(366760)	
Mean Age (standard deviation) in years*	64.57(10.0)	65.86 (11.39)	$P < 0.001$
Sex (proportion female)*	591 (52.1%)	205151 (55.93%)	$P = 0.010$
Diabetes without complication (proportion diabetic)	140(12.3%)	36688 (10.0%)	$P=0.009$
Tobacco Use Disorder (proportion users)*	163(14.3%)	63545 (17.3%)	$P =0.009$
Obesity (proportion obese)	240(21.1%)	79679(21.72%)	$P = 0.647$

Table 3. Unmatched Analysis

Post-Operative Variables	Cirrhosis group (1134)	Control group (366760)	Odds Ratio (Cirrhosis group / Control group)	Odds Ratio 95% Confidence Interval	Significance
Mortality	*** (0.7%)	323(0.1%)	9.072	[4.666, 17.640]	*P* <0.001
Acute Renal Failure*	105(9.2%)	9025 (2.5%)	4.045	[3.305, 4.950]	*P*<0.001
Myocardial Infarction	*** (0.08%)	141(0.03%)	2.295	[0.321, 16.419]	*P* = 0.395
Blood Loss Anemia	345(30.4%)	71626(19.5%)	1.802	[1.587, 2.045]	*P* < 0.001
Pneumonia	12(1.1%)	961(0.3%)	4.071	[2.297, 7.215]	*P* < 0.001
Pulmonary Embolism	0	475(0.1%)	NA	NA	*P* = 0.225
Deep Vein Thrombosis	*** (0.2%)	559(0.2%)	1.738	[0.558, 5.412]	*P*= 0.334
Periprosthetic Fracture	34(3.0%)	4391(1.2%)	2.551	[1.811, 3.593]	*P*<0.001
Periprosthetic Dislocation	28(2.5%)	5123(1.4%)	1.787	[1.227, 2.603]	*P* = 0.002
Periprosthetic Mechanical Complication	16(1.4%)	2840(0.8%)	1.834	[1.118, 3.008]	*P* = 0.015
Periprosthetic Infection*	48(4.2%)	3783 (1%)	4.241	[3.171, 5.672]	*P* <0.001
Wound Dehiscence	*** (0.8%)	298(0.1%)	9.838	[5.056, 19.143]	*P* <0.001
Blood Transfusion*	128(11.3%)	12774(3.5%)	3.526	[2.931, 4.241]	*P* <0.001

*** Exact number not reported if value between 1 to 10 as per HCUP Data use agreement

Regarding resource utilizations, the cirrhotic group demonstrated significantly greater inpatient costs ($90,624 vs $66,806, P <0.001) and a prolonged length of hospital stay (4.22 vs 2.32 days, P <0.001; compared with the control population with no cirrhosis [Table 4].

Matched Post-Operative Outcomes Analysis

Patients' demographics of matched cohort are presented in [Table 5]. We summarized the results of the 1:1 matching algorithm for the propensity score, comprising 1,134 patients in the Cirrhosis group and 1,098 patients in the control (non-cirrhotic) group [Table 6]. Patients with cirrhosis were found to be at significantly higher risk of blood loss anemia (OR=1.2, CI 0.99-1.44, P =0.05), periprosthetic dislocation (OR=2.5, CI 1.23-5.05, P =0.008), and deep infection (OR=1.57, CI 0.98-2.50, P =0.05). Whereas the risks were significantly lower for myocardial infarction (OR=0.12, CI 0.01-0.96, P =0.017) and pulmonary embolism (OR=0.49, CI 0.47-0.51, P =0.002). The other perioperative outcomes did not reach significant group differences according to this matched analysis. Similar to the unmatched data, the matched analysis of hospital resource utilizations [Table 4] showed that cirrhosis was associated with longer inpatient LOS (4.22 vs 3.68 days, P= 0.016) and higher inpatient COC ($90,624 vs $80,676.87, P = 0.001).

Table 4. Length of stay and cost of care in unmatched and matched cohort

	Unmatched Cirrhosis	Unmatched control	P value	Matched Cirrhosis	Matched Control	P value
Length of stay	4.22 [5.86]	2.32[2.50]	<0.001	4.22 [5.86]	3.68 [4.56]	*P*=0.016
Hospital charges	90624 [78180.84]	66806.31 [47700.26]	<0.001	90624 [78180.84]	80676.87 [66353.87]	*P*=0.001

Table 5. Patient demographics of matched cohort

	Cirrhosis group (1134)	Control group (1098)	Significance
Age (SD)	64.57(10.0)	64.89 (11.04)	P =0.472
Sex (proportion female)*	591 (52.1%)	573 (52.1%)	p = 0.974
Diabetes without complications (proportion diabetic)	140(12.3%)	137(12.4%)	P=0.925
Tobacco Use Disorder (proportion users)*	163(14.3%)	155(14.1%)	P=0.862
Obesity (proportion obese)	240(21.1%)	230(20.9%)	P=0.900
Race			P= 1.000
White	924(81.4%)	924(84.1%)	
Black	80(7%)	80(7.2%)	
Hispanic	61(5.3%)	61(5.5%)	
Asian	*** (0.2%)	*** (0.2%)	
Native American	*** (0.3%)	*** (0.36%)	
Age Categorical			P= 1.000
<60	340(29.9%)	340(30.9%)	
60 to 70	458(40.3%)	458(41.7%)	
70 to 80	250(22.0%)	250(22.7%)	
80 to 90	82(7.2%)	82(7.4%)	
>90	*** (0.3%)	*** (0.36%)	

Table 6. Matched sample analysis

Post Operative Variables	Cirrhosis group (1134)	Control group (1098)	Odds Ratio (Cirrhosis group / Control group)	Odds Ratio 95% Confidence Interval	Significance
Mortality	*** (0.7%)	*** (0.5%)	1.74	0.58-5.23	0.312
Acute Renal Failure*	105(9.3%)	101(9.2%)	1.00	0.75-1.34	0.96
Myocardial Infarction	*** (0.08%)	*** (0.7%)	0.12	0.01-0.96	0.017
Blood Loss Anemia	345(30.4%)	293(26.7%)	1.20	099-1.44	P=0.05
Pneumonia	12(1%)	13(1.2%)	0.893	0.40-1.96	0.778
Pulmonary Embolism	0	*** (0.8%)	0.49	0.47-0.51	0.002
Deep Vein Thrombosis	*** (0.2%)	*** (0.5%)	0.483	0.12-1.93	0.293
Periprosthetic Fracture	34(2.9%)	28(2.6%)	1.18	0.71-1.96	0.520
Periprosthetic Dislocation	28(2.4%)	11(1%)	2.50	1.23-5.05	0.008
Periprosthetic Mechanical Complication	16(1.4%)	*** (0.6%)	2.23	0.91-5.44	0.07
Periprosthetic Infection	48(4.2%)	30(2.7%)	1.57	0.98-2.50	P=0.05
Wound Dehiscence	*** (0.7%)	*** (0.6%)	1.24	0.46-3.36	0.662
Blood Transfusion*	128(11.3%)	99(9.0%)	1.28	0.97-1.169	0.07

*** Exact number not reported if value between 1 to 10 as per HCUP Data use agreement

Discussion

The present review of the NIS database evaluated the impact of cirrhosis among 367,894 patients that underwent elective THA surgeries. Over the four-year study period, the incidence of cirrhosis was 0.3%, closely matching that of the US general population (0.27%).2 As per the extracted data, there was a significantly higher inpatient complication rate and greater utilization of hospital resources in cirrhotic patients than in non-cirrhotic controls.

After THA, ischemic heart disease (41.1%) followed by cerebrovascular accidents (23.1%) and pulmonary embolism (11.8%) are the common causes of mortality in the immediate postoperative period.[7] Compared to a steady decline in the immediate post-THA mortality data globally, from 0.56% in 2003 to 0.29% in 2011,[8,9] this study identified a higher mortality rate (0.7%) in the cirrhotic cohort. However, no significant differences were noted between the groups in the 1:1 matched cohort. Further, significantly lower rates of myocardial infarction (0.08% vs 0.7%) and pulmonary embolism (0% vs 0.8%) can be observed in the cirrhotic group comparable to previously published data.[3, 10, 11] this trend may be attributed to potential coagulopathy in patients with liver cirrhosis.

In cirrhotic patients undergoing THA, acute blood loss anemia stems from substantial alterations in the hemostatic system, such as a dysfunctional coagulation cascade leading to prolonged prothrombin time (PT) and activated partial thromboplastin time (APTT) accompanied by platelet dysfunction and thrombocytopenia.[12] Our matched analysis found a significant increase in the incidence of the cirrhotic population during their hospital stay. The increased need for transfusions of blood and/or blood products increases the risk of various systemic complications, including fluid overload and infections, which are likely to increase the hospital LOS and COC.

Preoperative correction of coagulation abnormalities, including vitamin K supplementation, followed by preprocedural administration of thrombopoietin receptors (TPO) agonists like avatrombopag and lusutrombopag to increase platelet counts, together with intraoperative use of tranexamic acid, and viscoelastic testing (VET) of hemostatic analysis have shown promise in reducing the incidence of blood/blood product-related transfusions and the resultant complications that would otherwise impact hospital resources.[13]

Besides hemorrhagic complications, patients with cirrhosis,

due to their dysfunctional hemostatic potential, are also prone to thrombotic events. Despite prolonged PT or international normalized ratio (INR), these patients are not protected against deep vein thrombosis (DVT) as cirrhotic patients typically have impaired synthesis of anticoagulant factors, in addition to an increase in the circulating levels of prothrombotic cytokines. Although the current extracted data from the NIS database did not show statistical group differences in the DVT incidence, venous thromboembolism (VTE) prophylaxis should still be recommended for cirrhotic patients when exposed to high-risk conditions such as THA.[14] At this time, no clear guidelines are available regarding the ideal pharmacologic agent in cirrhotic patients due to the potential risk of hemorrhagic complications; therefore, mechanical measures by sequential compression device (SCD) should be considered as a means of VTE prophylaxis whenever necessary.

Periprosthetic mechanical complications, including fractures and dislocations, were found to be significantly higher among the cirrhotic population in the unmatched data, while the matched cohort demonstrated a significant increase in the odds of periprosthetic dislocation (OR=2.5, CI 1.23-5.05, P =0.008). The presence of metabolic bone disease, osteoporosis, and deranged bone remodeling with resultant morphological changes of the proximal femur increase the technical challenges as well as the mechanical complications. Poor soft tissue tension and gait imbalance due to sarcopenic obesity and alcohol abuse can further enhance the risk of component dislocation during the postoperative hospital stay.[15] The risk of periprosthetic infection, also known as prosthetic joint infection (PJI), was significantly higher in both matched and unmatched cohorts of cirrhotic patients after THA. The possible etiologies include lower complement factors and opsonin together with dysfunction of reticuloendothelial cells and leukocytes, all contributing to poor immunity in patients affected by cirrhotic liver disease.[16] After matching, no statistically significant differences were noted between the groups for other inpatient postoperative incidents such as acute renal failure, pneumonia, wound dehiscence, and blood transfusion.

Bundled payment programs, introduced in total joint arthroplasty within the past decade, are cost-effective management of patient's care while in the hospital and over the following 90-day post-discharge period. In contrast to the fee-for-service model, this value-based payment system makes providers and healthcare facilities more accountable for the total cost of patients' treatment and recovery delivered during an episode of care. While effectively reducing the variable cost and quality associated with the historical fee-for-service payment model, the bundled payment reimbursement system can be a financial challenge in maintaining high-quality care for patients with a high proportion of comorbidity burden, such as cirrhosis.[17] These medically delicate patients are more likely to need postoperative care in the intensive care unit (ICU) or high dependency unit (HDU), transfusions, and other specialists' interventions, impacting the finite healthcare resources. The collected data over four years demonstrated a significant increase in the hospital LOS and COC after THA, both in the unmatched and propensity-matched cohorts.

The main strengths of our analysis include the large size of the patient cohorts and population-based data, closely resembling the US population. However, certain limitations must be acknowledged. This retrospective administrative data is based on the CPT and/or ICD codes, not originally developed for research purposes but applicable to isolate diagnosis, procedures, and complications. Due to total reliance on these codes, the NIS database is subject to high variability with documentation errors in coding and reporting. Also, apart from inpatient events, the database lacks information on preoperative medical treatment of cirrhosis, intraoperative documentation, including surgery duration, blood loss or type of anesthesia, and post-discharge events such as readmission rates or mortality, which are likely to underestimate the actual complication rate. Complications after THA in PWC can be related the staging of the disease, status of compensation. This database could not capture the severity of cirrhosis. Despite these limitations, ours is the first study capturing the immediate postoperative outcomes and effects of hepatic cirrhosis in patients undergoing THA. With data collected from 2016 through 2019, after the introduction of protocols for outpatient joint arthroplasty, bundled payment, tranexamic acid, multimodal postoperative analgesia, and advanced treatment for cirrhosis, the present study represents the most comprehensive picture to date of the impact of cirrhosis on in-hospital outcomes following THA.

Conclusions

Cirrhosis has been shown to be a significant risk factor for acute blood loss anemia, dislocation, and deep infection after THA. Further, longer lengths of hospital stay and higher inpatient costs can be observed in cirrhotic patients compared with non-cirrhotic controls during their postoperative stay. In the face of finite healthcare resources, the provided insight from the NIS database could assist in risk stratification, patient counseling, improving the current strategies for preserving high-quality perioperative care in the most cost-effective manner, and better financial collaborations with the payers.

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