

## ORIGINAL ARTICLE

# A nationwide analysis of re-exploration after liver transplant

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## Abstract

**Background:** A retrospective review to investigate rate and outcomes of re-exploration following liver transplantation in the United States.

**Methods:** The NIS database was used to examine outcomes of patients who underwent re-exploration following liver transplantation from 2002 to 2012. Multivariate regression analysis was performed to compare outcomes of patients with and without reoperation.

**Results:** We sampled a total of 12,075 patients who underwent liver transplantation. Of these, 1505 (12.5%) had re-exploration during the same hospitalization. Hemorrhagic (67.9%) and biliary tract anastomosis complication (14.8%) were the most common reasons for reoperation. Patients with reoperation had a significantly higher mortality than those who did not (11.6% vs. 3.8%, AOR: 3.01,  $P < 0.01$ ). Preoperative coagulopathy (AOR: 1.71,  $P < 0.01$ ) and renal failure (AOR: 1.57,  $P < 0.01$ ) were associated with hemorrhagic complications. Peripheral vascular disorders (AOR: 2.15,  $P < 0.01$ ) and coagulopathy (AOR: 1.32,  $P < 0.01$ ) were significantly associated with vascular complications. Risk of wound disruption was significantly higher in patients with chronic pulmonary disease (AOR: 1.50,  $P < 0.01$ ).

**Conclusion:** Re-exploration after liver transplantation is relatively common (12.5%), with hemorrhagic complication as the most common reason for reoperation. Preoperative coagulation disorders significantly increase hemorrhagic and vascular complications. Further clinical trials should investigate prophylactic strategies in high risk patients to prevent unplanned reoperation.

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## Introduction

Reoperation after surgery has been reported as a quality of care measure that has significant implications on patient outcomes.<sup>1–3</sup> Overall, unplanned reoperation was caused by errors in surgical technique in 70% of events and by patient

comorbidities in 21% of cases.<sup>2</sup> With operative problems being most common, reoperation rates may be useful for monitoring quality across hospitals and for identifying quality improvement opportunities.<sup>1–3</sup>

There has been a significant improvement in liver transplantation outcomes during past decades.<sup>4–6</sup> The improvement has been attributed to advances in surgical technique, post-operative management, and immunosuppression.<sup>4–6</sup> Despite improvements in graft and recipient survival, the reoperation rate after liver transplantation remains high (9.2–34%).<sup>6–11</sup> Patients who underwent reoperation have been reported to have higher mortality and lower graft survival compared to

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patients who did not undergo reoperation.<sup>6,12</sup> However, a recent study suggested that early reoperation can improve graft survival rate.<sup>6</sup> In this study, a retrospective analysis was conducted using a national database to report the incidence, trends, reasons, risk factors, and early outcomes of reoperation after liver transplantation.

## Methods

The Nationwide Inpatient Sample (NIS) database was used to identify patients who underwent liver transplantation from 2002 through 2012. The NIS is a large inpatient care database in the United States maintained by the Agency for Healthcare Research. It is an annually compiled database that contains information on more than 8 million hospital admissions each year, which represents 20% of all hospital discharges in the United States and is regarded as a representation of national estimates.<sup>13</sup> Informed consent is obtained from individual patients within each hospital by the NIS. This study was exempt from institutional review board approval since no personal patient information was examined.

This study investigated re-exploration after liver transplantation during the same hospitalization based on the International Classification of Diseases, 9th Revision, clinical modifications (ICD-9-CM) procedure codes of 50.5, 50.51, and 50.59 for liver transplant during 2002–2012. Reoperation was defined as an unplanned re-exploration (exploratory laparotomy) due to the complications of liver transplantation, based on the ICD-9 procedure codes of 54.11, 54.12, and 54.19 for exploratory laparotomy. Patients' diagnoses for surgery were extracted using ICD-9-CM diagnosis codes from the database. Surgical procedures that were not directly related to the primary procedure (liver transplant) were not included in the analysis. Planned reoperations in separate surgeries, such as an abdominal fascia closure or a planned second look were excluded from the study.

Patient demographics (age, sex, and race), comorbidities (such as hypertension and diabetes mellitus), hospitalization length, admission type (elective vs. non-elective), reasons for reoperation, and patient outcomes were recorded. The primary endpoints were rates, reasons, and outcomes of re-exploration after liver transplantation. The reasons for re-exploration were obtained from the database according to the ICD-9 diagnosis codes that were reported as the second to twenty fifth patient diagnoses in the database. Risk adjusted analysis was performed to investigate the outcomes of reoperation after liver transplantation.

The Statistical Package for Social Sciences (SPSS) software, Version 22 (SPSS Inc., Chicago, IL) was used for statistical analyses. A multivariate analysis using logistic regression was conducted to reveal associations between re-exploration and postoperative complications. All variables in the study were possible confounders and included as covariates within the model. The estimated adjusted odds ratio (AOR) with a 95% confidence interval was calculated for each correlation. Type-I

error rate was set to 5%, where  $P$ -values  $< 0.05$  were considered statistically significant.

## Results

A total of 12,075 patients who underwent liver transplantation within the NIS database from 2002 to 2012 were identified. The median patient age was 54 years old. The majority of the patients were Caucasian (66.7%) and male (65.3%). The most common comorbidities other than liver disease were hypertension (31.1%) and diabetes (25.4%). Coagulopathy and fluid/electrolyte disorders were reported in 36.1% and 41.1% of patients, respectively. The most common indications for liver transplantation were viral hepatitis (46.6%), followed by alcoholic cirrhosis of the liver (23.9%). The median hospitalization length was 12 days. Patient demographics and clinical characteristics are displayed in Table 1.

Among patients who underwent liver transplantation, 1505 (12.5%) underwent re-exploration during the same hospitalization after transplantation. The most common day of reoperation was postoperative day one (Fig. 1), with the most common reasons for reoperation being hemorrhagic complications (68%), biliary tract anastomosis complications (14.8%), and vascular complications (10%). Wound disruption was the indication for reoperation in 3.6% of patients. The overall mortality and morbidity of patients who underwent liver transplantation were 4.8% and 56.1%, respectively. Patients with reoperation had significantly higher morbidity and mortality than those without reoperation (Table 2). Overall, 12.5% of patients were re-explored after liver transplantation. Reoperation significantly increased hospitalization length (median 11 days vs. 23 days,  $P < 0.01$ ) and total hospital expenses (median \$235,560 vs. \$395,869,  $P < 0.01$ ).

In multivariate analysis, preoperative coagulopathy (AOR: 1.71,  $P < 0.01$ ) and renal failure (AOR: 1.57,  $P < 0.01$ ) were the best predictors of hemorrhagic complications, one of the most common reasons for reoperation after transplantation. Preoperative peripheral vascular disorders (AOR: 2.15,  $P < 0.01$ ) and coagulopathy (AOR: 1.32,  $P < 0.01$ ) were significantly associated with vascular complications. The risk of wound disruption was significantly higher in patients with chronic pulmonary disease (AOR: 1.50,  $P < 0.01$ ).

## Discussion

Reoperation after liver transplantation is associated with a significant increase in patient mortality, morbidity, hospitalization length, total hospital charge, and early graft failure. Patients undergoing reoperation after liver transplantation incur a three-fold increase in mortality rate compared to those who do not undergo a reoperation. These findings from a national database are consistent with those reported in single institution retrospective reviews.<sup>6,12</sup>

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