Perioperative Complications After Live-Donor Hepatectomy

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Current studies of complications following donor hepatectomy may not be generalizable to all hospitals performing this procedure. To address this, live liver donors were identified in the Nationwide Inpatient Sample (NIS). Complications after donor hepatectomy were categorized using International Classification of Diseases, Ninth Revision codes and risk factors for complications were tested using logistic regression. Negative binomial regression models were used to estimate the increase in length of stay and hospital charge associated with complications. Among 555 donors (representing 2783 donors nationwide), 23% had 1 or more complications and 5% had a major complication. The most common complications were ileus (27%) and atelectasis (26%). No patient or hospital factors were associated with complications. Having any complication was associated with increased length of stay (incidence rate ratio, 1.36; 95% CI, 1.16-1.58; \( P = .001 \)) and hospital charge (incidence rate ratio, 1.25; 95% CI, 1.09-1.44; \( P = .002 \)). Approximately 25% of liver donors have complications immediately postoperatively but most are minor, lending support to current practices in live liver donation and donor selection.

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Perioperative risks following living donation have been reported characterizing the postoperative risks following living donation, however, the estimates of overall complication rates vary widely.

In the most comprehensive study to date, the Adult to Adult Living Donor Liver Transplantation Cohort Study (A2ALL), 9 of the largest-volume American live-donor liver transplant centers reported postoperative complication rates. However, it is unclear whether the complications described by these highly selected centers can be generalized to all centers.

The Nationwide Inpatient Sample (NIS) allowed us to (1) provide more generalizable estimates for postoperative complications following donor hepatectomy and (2) explore patient- and hospital-level factors associated with complications.

Methods

The NIS is a 20% sample of all US hospitals available through the Health Care Cost and Utilization Project. To calculate national estimates, survey-weighted commands were used for all statistical analysis (svy commands in Stata version 11.0). Information provided in the NIS includes patient demographics and International Classification of Diseases, Ninth Revision (ICD-9) codes for each hospital admission. For this review, institutional review board approval was waived because the NIS dataset is publicly available and anonymous; patient consent was not obtained for this review.

Patients who underwent live-donor hepatectomy (2000-2008) were identified by diagnosis code for liver donor (v.596) combined with procedure codes for hepatic lobectomy or partial hepatectomy (50.3 or 50.22, respectively). The Charlson Comorbidity Index score was calculated for each donor. Hospital size, location, and region were available in the NIS; bed size designations (small, medium, and large) were determined by the NIS. General hospital volume per year for each center was calculated from the Organ Procurement and Transplantation Network website; high volume was defined as performing more than the median per year (n = 166).

All ICD-9 codes were reviewed and classified as a postoperative complication or premorbid condition. Postoperative complications were divided into venous thromboembolism, hepatobiliary, gastrointestinal, respiratory, bleeding, and other (ie, neurological, cardiac, and direct postoperative complications [eg, postoperative seroma]). Because patients in the NIS are not followed over multiple hospitalizations, the postoperative complications reviewed in this study were from the initial hospitalization alone.

Diagnosis and procedure codes from ICD-9 were used to grade complications by the Clavien severity system. Each complication was cross referenced to the 15 procedure codes available and assigned a Clavien grade (I-IV) based on the procedures performed. Major complications were defined as those requiring an additional procedure (Clavien grade III or higher).
Logistic regression was used to test patient and hospital characteristics associated with any complication, major complications, and each category of complication. Negative binomial models were used to quantify the increase in length of stay (LOS) and total hospital charge associated with having any complication, a major complication, and each category of complication, after adjusting for age, insurance status, and hospital bed size. Exponentiated coefficients were interpreted as the relative change in average LOS or cost associated with each complication.

Results

Of 555 living liver donors identified in the NIS (representing 2783 living donors nationally), 91% were between ages 18 to 50 years, and 73% were white. Our estimated demographics from the NIS sample were consistent with the available demographics reported by the Organ Procurement and Transplantation Network (Table 1).

Most donor operations (79%) were in large hospitals. All operations were performed in urban hospitals and most were performed in the Northeast (41%) or West (42%). Almost all operations were performed at teaching hospitals (99%) (Table 1).

At least 1 complication was reported in 23% of living liver donors (Table 2). The most common class of complication was respiratory (41% of complications). Major complications (Clavien grade III or higher) were reported in 5% (Table 2). Most complications were either ileus not requiring nasogastric tube decompression (27% of complications) or atelectasis (26% of complications) (Table 3).

None of the factors we examined (age: odds ratio [OR] for decade increase, 1.13; 95% CI, 0.85-1.52; nonwhite race (OR, 0.86; 95% CI, 0.62-1.18); female sex (OR, 0.88; 95% CI, 0.57-1.37); nonprivate insurance status (OR, 1.01; 95% CI, 0.71-1.43); any Clavien Comorbidity Index score (OR, 0.69; 95% CI, 0.09-5.53), large hospital size (OR, 0.88; 95% CI, 0.59-1.32), and high liver transplant volume (OR, 0.76; 95% CI, 0.36-1.60) were significantly associated with any complication. Similarly, none of the patient or hospital factors were associated with major complications or any category of complication.

The median initial hospital LOS was 7.1 days (interquartile range, 6-8; range, 1-39). Having any complication was associated with a 36% increase (incidence rate ratio [IRR], 1.36; 95% CI, 1.16-1.58; P < .001) in LOS. Having a major complication was associated with a 69% increase (IRR, 1.69; 95% CI, 1.26-2.27; P = .001) in LOS. All major classes of complication, except for respiratory and bleeding, were associated with a statistically significant increase in LOS. Venous thromboembolism was associated with the greatest increase (IRR, 2.22; 95% CI, 1.59-3.12; P < .001).

Table 1. Demographics of Patients Undergoing Live-Donor Hepatectomya

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>National Inpatient Sample</th>
<th>Organ Procurement Transplantation Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age category, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;35</td>
<td>50</td>
<td>47</td>
</tr>
<tr>
<td>35-49</td>
<td>39</td>
<td>41</td>
</tr>
<tr>
<td>50-64</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>&gt;64</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>Race/ethnicity</td>
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<td></td>
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<tr>
<td>White</td>
<td>73</td>
<td>78</td>
</tr>
<tr>
<td>African American</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Hispanic</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Asian</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Insurance</td>
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<td></td>
</tr>
<tr>
<td>Private</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Charlson Comorbidity Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least 1 comorbidity</td>
<td>4</td>
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</tr>
</tbody>
</table>

*For demographics publicly available, we compared National Inpatient Sample estimates (survey weighted from nationally representative sample) with the fully national sample from the Organ Procurement Transplantation Network.

Table 2. Percentage of Living Liver Donors With Each Category of Complication From Initial Hospitalization

<table>
<thead>
<tr>
<th>Complication</th>
<th>Living Liver Donorsa</th>
<th>Total Complicationsb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any</td>
<td>23 (17-28)</td>
<td>41 (29-54)</td>
</tr>
<tr>
<td>Respiratory</td>
<td>10 (5-14)</td>
<td>11 (3-19)</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>7 (4-10)</td>
<td>32 (22-42)</td>
</tr>
<tr>
<td>Other</td>
<td>6 (3-9)</td>
<td>25 (15-35)</td>
</tr>
<tr>
<td>Infection</td>
<td>6 (4-9)</td>
<td>20 (13-27)</td>
</tr>
<tr>
<td>Hepatobiliary</td>
<td>2 (0-3)</td>
<td>7 (1-13)</td>
</tr>
<tr>
<td>Biliary</td>
<td>2 (0.8-4)</td>
<td>8 (5-12)</td>
</tr>
<tr>
<td>Venous thromboembolism</td>
<td>&lt;1 (0-1)</td>
<td>2 (0-5)</td>
</tr>
<tr>
<td>Major complicationc</td>
<td>5 (3-6)</td>
<td>21 (14-29)</td>
</tr>
</tbody>
</table>

aPercentage of living liver donors = number of donors with each complication/total number of living donors.

bPercentage of total complications = number of particular complications/total number of complications.

cMajor complication = Clavien grade III or IV. Respiratory complications included pneumonia, empyema, pleural effusion, pneumothorax, pulmonary collapse, hypoxemia, and surgical complication of the respiratory system. Bleeding complications included all blood transfusions. Gastrointestinal complications included gastritis, gastroparesis, obstruction, peritonitis, pancreatitis, and surgical complications of the digestive system. Other complications included neurological, cardiac, and direct postoperative complications (eg, postoperative seroma). Infection complications included candidiasis, urinary tract infection, cellulitis of the hand, fever, bacteremia, and other postoperative infection. Hepatobiliary complications included portal vein thrombosis, liver disorder, jaundice, and ascites. Biliary complications included fistula of bile duct and biliary anomaly. Venous thromboembolism complications included pulmonary embolism and deep venous thrombosis. Each patient may have had more than 1 category of complication.

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The median total charge for the initial hospital stay was $62,001 (interquartile range, $42,977-$100,219; range, $13,066-$386,172). On average, having any complication was associated with a 25% increase in total charges (IRR, 1.25; 95% CI, 1.09-1.44; P = .002). Major complications were associated with a 32% increase (IRR, 1.32; 95% CI, 1.01-1.73; P = .04) in total charges. Venous thromboembolism was associated with the largest increase in total charges (IRR, 2.29; 95% CI, 1.41-3.72; P = .001).

### Discussion

In this national study of complications following living liver donation, 23% of donors had at least 1 postoperative complication, but only 5% were major (Clavien grade III or higher). We were unable to identify any patient- or hospital-level factors associated with having a complication.

Our estimates of the overall postoperative complication rate are similar to previous studies. In the A2ALL cohort study, a slightly higher rate was reported (38%).\(^3\) As in A2ALL, there was a lack of severe cardiac complications. Severe complications identified included acute respiratory failure requiring reintubation and patients who required reoperation. As in A2ALL, there were no deaths reported in the NIS, although there have been 7 deaths after live liver donation.\(^15\)

One difference between previous studies and ours was fewer reported biliary complications. In previous studies, biliary leak has been a top complication.\(^16\) We found that only 2% of living donors had a hepatobiliary complication during the hospitalization for the donor operation. The reasons for this discrepancy include the lack of longitudinal follow-up in the NIS, lack of an explicit ICD-9 code for biliary leak, and differences in definitions of biliary leak.

Using the NIS to estimate postoperative complications has distinct limitations. Because only the original hospitalization could be identified, information on late postoperative complications is lacking. There are no distinct ICD-9 procedure codes for right and left hepatectomy. This is problematic because of different rates of complications associated with each procedure;\(^16\),\(^19\); however, there are no differences in the risk for a catastrophic event (early death or acute liver failure) among the different resection types.\(^15\) In addition, we were unable to adjust for other variables that have been associated with increased risk for complication including operative time, intraoperative blood loss, and preoperative liver function tests.\(^3\)

Despite limitations in the available data, using the NIS, we were for the first time able to generate nationally representative estimates for perioperative complications following live-donor hepatectomy and evaluate patient- and hospital-level risk factors for complications. Most (95%) of the complications following donor hepatectomy are minor, lending support to the continued practice of live liver donation in the context of rigorous donor screening and transparent patient counseling.
Perioperative Complications After Hepatectomy

Brief Report Research

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REFERENCES