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ORIGINAL ARTICLE

Factors affecting outcome in liver resection

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Abstract

Background. Studies demonstrate an inverse relationship between institution/surgeon procedural volumes and patient outcomes. Similar studies exist for liver resections, which recommend referral of patients for liver resections to 'high-volume' centers. These studies did not elucidate the factors that underlie such outcomes. We believe there exists a complex interaction of patient-related and perioperative factors that determine patient outcomes after liver resection. We sought to delineate these factors.

Methods. Retrospective review of 114 liver resections by a single surgeon from 1993–2003: Records were reviewed for demographics; diagnosis; type/year of surgery; American Society of Anesthesiologists (ASA) score; preoperative albumin, creatinine, and bilirubin; operative time; intraoperative blood transfusions; epidural use; and intraoperative hypotension. Main outcome measurements were postoperative morbidities, mortalities and length of stay (LOS). Data were analyzed using a multivariate linear regression model (SPSS v10.1 statistical analysis program).

Results. Primary indications for resections were hepatocellular carcinoma (HCC) ($N = 57$), metastatic colorectal cancer ($N = 25$), and benign disease ($N = 18$). There were no intraoperative mortalities and 4 perioperative (30-day) mortalities (3.5%). Mortality occurred in patients with malignancies who were older than 50 years. Morbidity was higher in malignant (15.6%) versus benign (5.5%) disease. Complications included bile leak/stricture ($N = 6$), liver insufficiency ($N = 3$), post-operative bleeding ($N = 2$), myocardial infarction ($N = 2$), aspiration pneumonia ($N = 1$), renal insufficiency ($N = 1$), and cancer implantation into the wound ($N = 1$). Average LOS for all resections was 8.6 days. Longer operative time ($p = 0.04$), lower albumin ($p < 0.001$), higher ASA score ($p < 0.001$), no epidural use ($p = 0.04$), and higher creatinine ($p < 0.001$) all correlated positively with longer LOS. ASA score and creatinine were the strongest predictors of LOS. LOS was not affected by patient age, sex, diagnosis, presence of malignancy, intraoperative transfusion requirements, intraoperative hypotension, preoperative bilirubin, case volume per year or year of surgery.

Conclusions. Liver resections can be performed with low mortality/morbidity and with acceptable LOS by an experienced liver surgeon. Outcome as measured by LOS is most influenced by patient comorbidities entering into surgery. Annual case volume did not influence LOS and had no impact on patient safety. Length of stay may not reflect surgeon/institution performance, as LOS is multifactorial and likely related to patient population, patient selection and increased high-risk cases with a surgeon's experience.

Key Words: *Hospital volume, length of stay, liver resection, morbidity, mortality, surgeon volume*

Introduction

Numerous studies have shown an inverse relationship between the procedural volumes of an institution or individual surgeon and patient outcomes [1–6]. This relationship has been most consistent for more complex procedures, such has coronary artery bypass grafting, carotid endarterectomy, esophagectomy, and pancreatectomy [2–5]. Similar studies exist for liver resections which advocate referral of patients for liver resections to centers that perform more than 10–17 liver resections per year [6–9]. These studies did not clearly elucidate the factors that underlie such improved outcomes. We believe that institution or surgeon volume alone are not the sole determinants of patient outcomes after liver resection, as there is likely a more complex interaction of factors that have yet to be defined. We examined 114 liver resections done, over a ten-year period, by a single liver surgeon to address which factors are most predictive of patient outcome as measured by mortality, morbidity and length of stay (LOS) after liver resection.

Methods

We retrospectively examined 114 liver resections done by a single liver surgeon over a ten-year period, 1993–2003. All cases, with the exception of 5 (4.4%), were

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Table I. Preoperative patient-related and intraoperative factors and effect on LOS

	Mean	Range	Effect on LOS
Preoperative serum albumin*	3.8 g/dl	1.7–4.6 g/dl	lower albumin increased LOS
Preoperative bilirubin	0.95 mg/dl	0.2–8.4 mg/dl	no effect
Preoperative creatinine*†	0.9 mg/dl	0.4–3.6 mg/dl	higher creatinine increased LOS
ASA score*†	2.3	1–4	higher ASA increased LOS
Intraoperative blood transfusion	2.8 units	0–18 units	no effect
Operative time*	276 min	80–555 min	longer operative time increased LOS
Intraoperative hypotension (SBP <90) per patient	0.3 episodes	0–8 episodes	no effect
Epidural use*	67.7% of cases		no epidural increased LOS

* $p<0.05$.
† strongest predictors of LOS.

done at a single institution, which is a tertiary referral center and teaching affiliate of the University of Hawaii School of Medicine. This institution also has the only liver transplant program and liver disease center in the State and is the sole referral center for liver disease for the American territories of the Pacific Basin. Other complex procedures such as open-heart surgery, vascular surgery, neurosurgery, and endocrine surgery are routinely performed at this institution.

The cohort consisted of 67 males and 47 females. Patients ranged in age from 1–85 years with a mean age of 57 years. Eighteen underwent resection for benign processes, including 5 for focal nodular hyperplasia, 4 for hemangioma, 3 for biliary cystadenomas, and 2 for stones/strictures. Ninety-six underwent resection for malignancies, including 57 for HCC, 25 for metastatic colorectal cancer, and 6 for cholangiocarcinoma. Patients were deemed operable if the resection was anatomically possible and had a Child-Turcotte-Pugh score equal to or less than 7, without significant ascites or encephalopathy. A total of 43 right lobectomies, 36 wedge resections, 19 left lateral segmentectomies, 11 left lobectomies, 3 trisegmentectomies, 1 resection of segments 7 and 8, and 1 caudate resection were performed.

Charts were reviewed for patient demographics, diagnosis, type of resection and year of surgery. Preoperative patient-related factors noted included serum albumin, creatinine and bilirubin. Intraoperative factors were recorded, including ASA score, operative time, packed red blood cell transfusion requirements, epidural use, and intraoperative hypotension episodes (SBP <90). Main outcome measures were postoperative morbidities, mortalities and LOS. Length of stay was defined as the period from the date of surgery to the date of discharge (or expiration in the hospital).

Data were analyzed using a multivariate linear regression model using the SPSS v10.1 statistical analysis program.

Results

There were 114 liver resections performed over a ten-year period. Table I summarizes the patient-related and intraoperative factors reviewed. The average LOS was 8.6 days with a range of 5–35 days. A longer LOS was significantly correlated with a lower preoperative albumin ($p<0.001$), higher creatinine ($p<0.001$), higher ASA score ($p<0.001$), longer operative time ($p=0.04$), and the lack of an intra/perioperative epidural ($p=0.04$). Length of stay was not significantly affected by patient age, sex, diagnosis, presence of malignancy, intraoperative transfusion requirements, intraoperative hypotension episodes, preoperative bilirubin, case volume per year or year of surgery. Linear regression modeling revealed that ASA score and creatinine were the strongest predictors of longer LOS. For every increase of 1 mg/dL in creatinine, LOS increased by 4.4 days. For every increase in ASA score of 1, LOS increased by 1.5 days.

There were no intraoperative mortalities. There were 4 postoperative deaths resulting in a 30-day perioperative mortality rate of 3.5%. All mortalities occurred in patients being treated for malignancies and who were more than 50 years old. Two patients died from myocardial infarction, one patient died from aspiration pneumonia and one died from postoperative hemorrhage.

Overall there were 16 postoperative complications. Morbidity was higher in malignant (15.6%) than in benign (5.5%) disease. Complications included: bile leak or stricture, 6; liver insufficiency, 3; bleeding requiring re-operation, 2; myocardial infarction, 2; and aspiration pneumonia, renal insufficiency, and cancer implantation into the wound, 1 each.

Discussion

Multiple studies, reviewing primarily administrative databases, show an inverse relationship between institution/surgeon volumes and patient outcomes [1–6]. These relationships are most striking in complex cases including liver resections. Choti et al. reviewed data from 606 liver resections from 52 non-federal acute-care hospitals in Maryland from 1990 to 1996 [7]. He demonstrated a 7.9% mortality rate at centers that performed less than 15 liver resections per year compared with 1.5% for centers that performed more than 15 resections per year. Glasgow *et al.* studied

Table II. Outcomes in liver resections in single surgeon series [10–14]

Study	Sample size	Study duration (years)	Mortality (%)	Morbidity (%)	Mean LOS (days)
Sitzmann *et al.*—1994	105	4	2.8	31.4	–
Holbrook *et al.*—1996	46	3	7	11	–
Shiu *et al.*—1999	61	6	0	36	11
Stone *et al.*—2000	18	2.5	0	27	–
Helling—2002	147	22	3.4	22	7.52

discharge abstracts from 507 liver resections from 138 California hospitals done between 1990 and 1994 [8]. He demonstrated similar volume-outcome relationships showing a mortality rate of 6.2% for institutions performing more than 17 liver resections per year. Hospitals performing 16 or less resections per year had a mortality rate ranging from 14.7% to 24.4%. Dimick et al. reviewed the National Inpatient Sample between 1996 and 1997 and, from 2097 liver resections, found an overall mortality rate of 5.8% [9]. The National Inpatient Sample includes a 20% stratified random sample of all US hospital discharges. Dimick's study group comprised 221 hospitals from 19 states in 1996, and 251 hospitals from 22 states in 1997. High-volume centers (> 10 resections/year) had a significantly lower mortality rate of 3.9% versus 7.6% for low-volume centers, which performed 9 or less liver resections annually. Although we performed a mean of 11 resections annually over the ten-year study period and may therefore be considered a 'low-volume' center by many of these studies, our mortality was 3.5%. This was comparable to that achieved at 'high-volume' centers.

Single-surgeon series of liver resections have been reported in the literature (Table II). Factors that were reported to influence morbidity include preoperative bilirubin, extent of resection, degree of blood loss, and operative time [10]. Additionally, Shiu et al. noted that Child-Pugh class significantly influenced the rate of complications and LOS [12]. These single-surgeon studies demonstrate that providers who would otherwise be categorized as low-volume providers based on prevailing literature can achieve low and acceptable mortality and morbidity rates.

The role of surgeon experience has also been addressed in several studies. Lieberman et al. looked at patients undergoing pancreatectomy for malignancy and suggested that an institution's volume had a greater role in patient outcome than the annual volume of individual surgeons [3]. This was also concluded by Harmon and colleagues who looked at surgeon experience in colorectal procedures and found that low-volume surgeons practicing in high-volume centers have similar outcomes as their high-volume counterparts operating at the same center [15]. These studies suggest that an institution's practices can compensate for surgeon experience. This has not been substantiated in the context of liver resections. There is a persisting clinical impression that the practices adopted by an institution are greatly influenced by surgeon experience and preference—to what extent, however, is difficult to measure. With time, a senior surgeon's influence may become ingrained in the institution's practice. As a result, nursing and ancillary care practices may then carry over to the care of other surgeons' patients. This may partially explain how an institution can 'compensate' for an individual surgeon's case volume and experience.

At our medical center, which performs the most liver resections in the State along with all liver transplants, the operating rooms are staffed with knowledgeable individuals and have the technology necessary for successful major liver operations. Patients also receive their postoperative care in the same intensive care unit or on one particular ward in the hospital. Staff in these dedicated areas are educated frequently by both physicians and liver transplant coordinators and the nursing practices in these two units are thus more focused on the postoperative care of these patients.

Despite uniform institution-specific factors for patients at our center, there were still notable differences in outcomes. Patient age may have been a factor, as mortalities occurred only in patients more than 50 years old. All morbidities also occurred in patients older than 50, with the exception a 43-year-old patient who had cancer implanted into the surgical wound, and a 48-year-old who had postoperative liver insufficiency. All mortalities and a majority of morbidities occurred in patients who were being treated for malignancy. This suggests that other factors are involved in patient outcome independent of institutional or surgeon case volume. Our study, however, is limited by a small patient sample size with a small number of mortalities and morbidities and therefore lacked the statistical power necessary to elucidate these differences.

With regard to LOS, patients with a greater ASA score and a higher creatinine were more likely to have longer hospital stays. Since ASA score indicates a patient's anesthetic risk based on pre-existing comorbidities, it is intuitive that patients with a higher ASA score would be at greater risk for perioperative complications that could delay discharge. Similar studies have shown ASA score to correlate positively with greater postoperative morbidity rates [10,16–17] Preoperative hypoalbuminemia was also a significant prognosticator for LOS in our study, but to a lesser extent. These findings suggest that the most significant determinants of hospital stay may be a patient's condition entering into surgery.

There may be other factors that influence LOS but there is no consensus. In the population Dimick studied, median length of stay was 7 days [9]. High-volume centers overall had a LOS one day shorter than low-volume centers. Length of stay was most influenced by age greater than 65, urgent/emergent admission, female gender, malignancy, metastatic disease, chronic pulmonary disease and severe liver disease. Length of stay, although a useful indicator of overall financial savings to third party payers, may not reflect accurately the quality of care provided by a surgeon or institution. The determinants that affect LOS are multifactorial and may in fact be specific to the patient population served. In comparison to other centers, our center had a higher proportion of patients with HCC. Although not statistically significant, there was a trend towards longer LOS for patients with HCC. We also saw a significant correlation between the intra/perioperative use of epidural analgesia and shorter hospital stays. Epidurals may help in timely discharge due to improved pain control, better mobility and decreased postoperative ileus [18]. As in other studies, we also noted longer operative times were significantly correlated with longer hospital stays [10,16].

Studies that show such volume-outcome relationships have prompted organizations like the Leapfrog Group to recommend the referral of patients to centers that fulfill an annual case volume criterion set by the group [19]. The Leapfrog Group is comprised of Fortune 500 companies that provide healthcare insurance for about 24 million employees, spending about 45 billion dollars annually. They hope to use their economic influence to improve patient safety. The Leapfrog Group has set criteria as to which institutions are eligible to provide care to their employees based on annual case volume in the areas of coronary artery bypass grafting, coronary angioplasty, carotid endarterectomy, abdominal aortic aneurysm repair, and esophageal cancer surgery. Similar patient advocacy groups and commercial endeavors that provide consumers with institution ratings or 'grades' are increasing and advocating the referral of patients to high-volume centers for other procedures. With more studies showing volume-outcome relationships for other complex procedures it is inevitable that similar initiatives will be set for liver resection.

Although annual hospital volume is an easy benchmark to follow, it may not be a true indication reflective of quality care. There are institutions that may not meet a set annual volume criterion, but still provide excellent quality of care with good patient outcomes. These centers may be eliminated with initiatives such as the Leapfrog Group. Despite the demonstrated volume-outcome relationships there are also no universally accepted annual volume 'cutoff' that would qualify a center or surgeon as a 'high-volume' provider. There are clearly centers that may not meet the volume criteria set by some of these studies, but nevertheless provide acceptable mortality and morbidity rates and achieve other nationally accepted benchmarks of quality and excellence, such as LOS. As our own series illustrates, there are factors other than volume alone that must be taken into consideration before implementing mandates as to which institutions or surgeons are deemed safe to conduct liver resections.

Conclusion

Liver resections can be performed with low mortality and morbidity and with acceptable LOS by an experienced liver surgeon; however, outcome based on this matrix is most influenced by patient comorbidities entering into surgery. The strongest predictors of outcome were creatinine and ASA score. Preoperative albumin also influenced LOS but to a lesser degree. The use of epidural anesthesia intraoperatively and measures to decrease operative time may also help in reducing LOS. Annual case volume did not influence LOS and had no impact on patient safety. Length of stay may not reflect a surgeon's or institution's performance, as LOS is multifactorial and more likely related to patient population variable, patient selection and increased high-risk cases with a surgeon's cumulative experience.

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