Morbidity and mortality after liver resection

Running title: Morbidity and mortality after liver resection

Sophia Virani, BS[1], James S. Michaelson, PhD [1], Matthew M. Hutter, MD, MPH, FACS [1], Robert T Lancaster, MD [1], Andrew L. Warshaw, MD, FACS [1], William G Henderson, PhD. [2], Shukri F. Khuri, MD, FACS[3], Kenneth K. Tanabe, MD, FACS[1]

[1]Department of Surgery, Massachusetts General Hospital and Harvard Medical School, Boston, MA

[2] Veterans' Affairs National Surgical Quality Improvement Program, Colorado Health Outcomes Program, University of Colorado, Denver, CO

[3]Veterans Administration Boston Healthcare System and Harvard Medical School, Boston, MA

Address correspondence to: Kenneth K. Tanabe, M.D., Yawkey 7.924, Massachusetts General Hospital, 55 Fruit Street, Boston, MA 02114

Background. Liver resection is performed with increasing frequency. Nearly all of the published information on operative mortality and morbidity rates associated with liver resection is derived from studies that rely on retrospective data collection from single centers. The goal of this study is to use audited data from private sector of the National Surgical Quality Improvement Program (NSQIP) Patient Safety Study (PSS) to characterize complications following liver resection and to identify variables that are associated with 30-day morbidity and mortality.

Study Design. Prospectively collected data on liver resection patients from 14 hospitals were collected using NSQIP PSS methodology. Rates of occurrence of 21 defined post-operative complications were measured. Bivariate analyses and stepwise logistic regression were used to identify factors associated with 30-day morbidity and mortality.

Results. At least one complication occurred in 22.6% of patients within 30 days. Stepwise logistic regression identified several preoperative factors associated with morbidity including serum albumin, SGOT > 40, previous cardiac surgery, operative work RVU, severe COPD, and open wound or wound infection at time of operation. Mortality within 30 days was observed in 2.6% of patients. Factors associated with mortality were found to be male gender, ASA 3 or higher, presence of ascites, dyspnea, and severe COPD. Only 0.7% of patients without any complications died, compared to 9.0% of patients with at least one complication ($p < 0.0001$).

Conclusions. Use of prospectively collected, audited, multi-institutional data in this study increases the likelihood that these results are representative of U.S. medical centers. Several preoperative and intraoperative factors associated with morbidity and mortality after liver resection were identified, and these factors should be considered during patient selection and peri-operative management.

INTRODUCTION

Liver resection is now performed more frequently than in prior decades (1). Analysis of the Nationwide Inpatient Sample (NIS) reveals that the number of liver resections nearly doubled from 1988 to 2000, with approximately 7,000 resections performed in the US in 2000. As diagnostic techniques advance and surgical outcomes improve, the rate of utilization of liver resection for various indications will continue to rise. Published literature suggests a reduction in morbidity and mortality rates in recent years, with many high volume centers reporting mortality rates less than 5% (2-5). Advances in peri-operative management and surgical techniques have improved mortality rates; however, reported morbidity rates remain high and range from 23% to 56% depending on indication for surgery (6, 7). Nearly all of these reports rely on retrospectively collected data from a single center, with varying definitions of morbidity. The present study is an analysis of prospectively collected and audited private sector NSQIP PSS data (8, 9)with systematic 30 day follow up for 785 patients from 14 centers that underwent liver resection.

METHODS

The NSQIP PSS provides prospective assessment of patient specific risk factors, intra-operative process measures, post-operative complication rates, and 30-day morbidity and mortality for 14 participating private sector hospitals. Trained senior nurse reviewers input specified data for the first 40 non-cardiac surgeries over an 8-day period. Each 8-day period begins on a different day to ensure fair sampling. Outcome variables are assessed up to 30 days, and include both in-hospital and out-of-hospital occurrences. Mortality is defined as death within 30 days of surgery. Morbidity is defined as an occurrence of one of the specific post-operative occurrences spanning each of the organ systems defined in the NSQIP PSS (9).

All patients undergoing hepatectomy were selected from the NSQIP PSS database, based on current procedure terminology (CPT) codes 47120 (partial lobectomy), 47122 (trisegmentectomy), 47125 (total left lobectomy) and 47130 (total right lobectomy). Pre- and intra-operative variables that correlated with morbidity and mortality were identified using bivariate analyses. Categorical variables were assessed using the chi-square test, and continuous variables were assessed using t-tests. Explanatory variables showing statistical significance were considered potential independent factors associated with morbidity. These variables were entered into a stepwise logistic regression against morbidity with entry criteria of $p = 0.20$ and exit criteria $p = 0.15$. The logistic regression was then repeated to incorporate intra-operative variables. All statistical analyses were performed using SAS v. 9.1.

RESULTS

Patient Population. The study yielded 783 patients who underwent liver resection between October 2001 and September 2004. The mean age was 57.5 ± 13.7 years, with an approximately even split of men and women (Table 1). Eighty percent of the patients were white, 40% had disseminated cancer, and 7.5% had been treated with chemotherapy for a malignancy within 30 days prior to surgery. The majority of patients had malignant disease, with 54% of patients having an ICD-9 diagnosis for a respiratory or digestive neoplasm. Twenty percent of patients had a diagnosis of malignant neoplasm of the liver or the intrahepatic bile ducts. Hypertension (38%), smoking within the last year (18%), diabetes (12%), and dyspnea (11%) were the most common co-morbid conditions. The mean serum albumin levels was 3.9 ± 0.6 gm/dl. Mean serum creatinine level was 1.0 ± 1.1 mg/dl and mean SGOT level was 40.9 ± 51.7 mU/ml.

Operation. During surgery, 270 of 783 patients (34%) had red blood cells transfused. The mean number of units of red blood cells used for those patients who received a transfusion was 4.5 ± 6.0. Mean operation time was 4.7 ± 2.2 hours and mean post-operative hospital length of stay was 9.0 ± 7.7 days.

Morbidity and Mortality. At least one complication occurred in 177 of 783 (22.6%) patients undergoing liver resection, and 41 patients (5.2%) were returned to the operating room for complications (Table 2). Sepsis, wound infection, urinary tract infection, and organ space infection were the most common. Of note, biloma is not a complication that is specifically defined and captured in the NSQIP PSS database. The following comorbidities were significantly associated with post-operative complications: male gender, previous cardiac surgery, ASA 3 or higher, and disseminated cancer (Table 1). There was a trend towards association between postoperative complications and hypertension ($p = 0.065$), diabetes ($p = 0.070$) and open wound or wound infection ($0 = 0.85$). The following categorical pre-operative variables were correlated with increased morbidity: elevated alkaline phosphatase, bilirubin , creatinine, or SGOT, and depressed sodium (Table 3). The mean albumin level was lower in patients with complications compared to those without. Intraoperative variables that correlated with complications included total longer operation time, higher mean operative work RVU, larger number of red blood cells transfused intraoperatively, and contaminated wound class (Table 4).

A step-wise logistic regression was used to model the occurrence of one or more complications to identify factors independently associated with morbidity (Table 6). In addition to clinically accepted risk-factors for morbidity (work RVU, smoking status and alcohol consumption), all preoperative variables which were related to the outcome of interest with a significance level of $p = 0.2$ or lower were considered for inclusion in the modeling process. For the modeling scheme, the significance level for entry was $p = 0.2$, and the significance level to stay was $p = 0.15$. For each covariate including in the predictive model, the 95% Wald Confidence Interval was calculated and is displayed, along with the associated p-value. Results of this analysis reveal that preoperative factors associated with morbidity included lower preoperative serum albumin, elevated SGOT, previous cardiac surgery, higher operative work RVU, history of severe COPD, and open wound or wound infection at time of operation.

On average, patients experiencing complications stayed in the hospital 15.0 $\pm$ 12.2 days compared to 7.3 $\pm$ 4.5 days for those without any complications ($p < 0.001$). The patients with morbidity were much more likely to return to the OR within 30 days (OR = 9.7; 95% CI = [4.8, 19.5].

Mortality. Twenty patients (2.6%) died within 30 days of operation. Comorbidities associated with mortality included male gender, ASA 3 or higher, presence of ascites, dyspnea, and COPD (Table 5). There was a statistically insignificant trend towards association between postoperative mortality and alcohol use ($p = 0.068$), previous cardiac surgery ($p = 0.090$), and bleeding disorder (8.2%). Operative variables associated with mortality were longer operative time, higher operative work RVU, higher number of RBC units transfused, and contaminated wound class (Table 4). Of patients who required an intraoperative transfusion, 4.8% died within 30 days, versus 1.4% of patients who did not require a transfusion ($p = 0.007$). Patients experiencing any complication had a statistically higher chance of dying within 30 day, as only 0.7% of patients without any complications died, compared to 9.0% of patients with at least one complication ($p < 0.0001$).

Patients with and without disseminated cancer. The variable "disseminated cancer" is associated with a lower risk of morbidity, although the association is only a trend in a stepwise regression analysis (odds ratio = 0.68, $p = 0.078$). This variable has an odds ratio less than 1; patients with disseminated cancer at the time of surgery were *less* likely to experience a post-operative complication than those without disseminated cancer. Of patients without disseminated cancer, 32% developed a complication compared to only 19% of patients with disseminated cancer (data not shown). Patients without disseminated disease had more complicated operations and longer total hospital stays by 2.1 days (0 = 0.0001) and longer post-operative length of stays by 1.6 days ($p = 0.0006$). The observed "protective" effect of disseminated cancer is likely attributable to this variable being correlated with indication for surgery. Of patients coded as having disseminated cancer, 83% had an ICD-9 code of 197.7: "Secondary malignant neoplasm of the respiratory and digestive system: liver specified as secondary." In the group of patients coded as not having disseminated cancer, 38% had an ICD-9 diagnosis indicating a malignant neoplasm of the liver, intrahepatic bile ducts, gall bladder and bile ducts, whereas only 20% of these patients were diagnosed with a "secondary malignant neoplasm of the respiratory and digestive tract." Thus, it appears that patients coded as having disseminated cancer are likely to have been treated for liver metastases whereas patients without disseminated cancer were more likely to have been treated for primary liver cancer, and thus were more likely to have cirrhosis.

DISCUSSION

The 2.6% overall 30-day mortality rate in this NSQIP PSS study is lower than other mortality rates published based on population-wide data for unselected patients. For example, based on data from the Nationwide Inpatient Sample (NIS), Dimick et al. reported that the rate of mortality for liver resection declined from 10.4% (1988 – 1999) to 5.3% (1998 – 2000) (1). High volume hospitals (> 10 resections per year) in the NIS data set reported a 3.9% overall mortality rate from 1998-2000. Although there are important differences between NSQIP and NIS data sets (e.g. NSQIP reports 30-day mortality and NIS reports in-hospital mortality), both data sets support a trend of decreasing mortality. Because the majority of hospitals included in the NSQIP PSS data set reported more than 30 liver resections over the 3-year time period, the results of this study are representative of "high volume" hospitals.

Although mortality rates following liver resection have declined over the years, complication rates remain high, with 22.6% of patients in the NSQIP PSS sample experiencing at least one complication and 5.2% undergoing a second operation for comlications. There has been significant variation in both the reported rates and definitions of morbidity across the literature. Morbidity rates in large studies of unselected patients range from 22% to 45% (2-7). Furthermore, definitions for morbidity are not standardized and varying criteria for morbidity make the results of different studies difficult to compare. In addition, results of single-center studies may not be reliable indicators of population-wide results, as single-center studies are more sensitive to institution-specific case mix. Poon et al. conducted a large retrospective review of unselected patients who underwent liver resection at the University of Hong Kong medical center (5). They report a 30% overall morbidity rate for the 806 patients who underwent surgery between July 1996 and June 2003. In that population, 71% of patients presented with hepatocellular carcinoma. In contrast, only 20% of NSQIP have a primary liver cancer diagnosis, and 56% of patients have metastatic disease. This is similar to the distributions reported by Jarnagin et al. and Dimick et al., both of which are based on US hospitals (1, 4).

The quality of the NSQIP PSS data is very high based on its collection only by trained nurse reviewers, use of precise and uniform definitions; and prospective data collection. However, the NSQIP data set was designed for utility across an extremely broad range of operations, and is therefore limited in its ability to capture procedure-specific data such as the frequency of bilomas, which is a common post-operative complication following liver resection. The utility of NSQIP PSS data as applied to liver surgery will be more useful with expansion to include outcomes relevant specifically to liver surgery. And taking into consideration recent reports of an association between specific types of neoadjuvant chemotherapy and mortality from liver resections (10), consideration should be given to inclusion of additional preoperative variables.

In this study, operative time and intraoperative blood transfusion in this study were strongly associated with morbidity, a result that is consistent with previous studies. In an analysis of 155 patients undergoing extended hepatic resection for hepatocellular carcinoma, Wei et al. noted that the need for a perioperative blood transfusion was the only risk factor for significant morbidity (7). Managing intraoperative blood transfusions has also been shown to increase long term survival (11). Thus, an emphasis on improved surgical technique and minimization of intraoperative blood loss may be effective in reducing post-operative morbidity and mortality.

Serum albumin level is also an independent predictor in the stepwise regression with an odds ratio of 0.62 (Table 6). Hence, higher serum albumin levels are associated with decreased morbidity, as expected. This result is in accordance with previously published NSQIP literature, which show serum albumin levels as one of the strongest predictors of morbidity for general surgery with an odds ratio of 0.68 and for gastrectomy for cancer with an odds ratio of 0.67 (8).

The finding of an *absence* of disseminated cancer as a factor associated with 30-day morbidity warrants further comment. Previous NSQIP studies have documented that the *presence* disseminated cancer is associated with higher rates of mortality for many types of surgery (9), and higher rates of morbidity for urologic surgeries (8, 12). However, among the patients treated by hepatic resection, the majority of patients with disseminated cancer were being treated for metastases to the liver (e.g. disseminated cancer), while a larger fraction of patients without disseminated cancer were being treated for primary liver cancer. Primary liver cancer is associated with a greater frequency of underlying cirrhosis, which in turn is associated with additional operative technical challenges, and higher rates of bleeding and post-operative complications.

Over 80% of patients with disseminated cancer were classified under ICD-9 197.7: “Secondary malignant neoplasm of respiratory and digestive system.” The converse association – that patients *without* disseminated cancer had a primary liver tumor, was not as robust: 30% of patients without disseminated cancer were diagnosed with “malignant neoplasm of the liver and intrahepatic bile duct” and 18% of patients in this group were actually diagnosed with secondary neoplasms. These observations suggest inconsistency in the manner in which variable “disseminated cancer” is entered into NSQIP databases. The NSQIP definition for disseminated cancer is as follows: “Patients who have cancer that (1) has spread to one site or more sites in addition to the primary site; AND (2) in whom the presence of multiple metastases indicates the cancer is widespread, fulminant, or near terminal. Other terms describing disseminated cancer include ‘diffuse,’ ‘widely metastatic,’ ‘widespread,’ or ‘carcinomatosis.’ Common sites of metastases include major organs (e.g., brain, lung, liver, meninges, abdomen, peritoneum, pleura, bone).” According to this NSQIP definition, a patient with a solitary colorectal liver metastases, with no other evidence of disseminated disease, should presumably be coded as NOT having disseminated cancer. Indeed, 20% of patients without disseminated cancer have a diagnosis of secondary liver cancer from the respiratory or digestive system. Informal discussion with a senior nurse clinical reviewer indicates that at one NSQIP PSS site, a single colorectal liver metastases would be considered “disseminated cancer.” The accuracy of NSQIP data collection will benefit from clarification of the definition of disseminated cancer.

In conclusion, several preoperative and intraoperative factors associated with morbidity and mortality after liver resection were identified, and these factors should be considered during patient selection and peri-operative management. Use of prospectively collected, audited, multi-institutional data in this study increases the likelihood that these data are accurate and representative of U.S. medical centers.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to Suzanne Sokol for administrative support, and to the NSQIP nurse reviewers and investigators.

REFERENCES

1. Dimick JB, Wainess RM, Cowan JA, Upchurch GR, Jr., Knol JA, Colletti LM. National trends in the use and outcomes of hepatic resection. JACS 2004;199(1):31-8.
2. Belghiti J, Hiramatsu K, Benoist S, Massault P, Sauvanet A, Farges O. Seven hundred forty-seven hepatectomies in the 1990s: an update to evaluate the actual risk of liver resection. JACS 2000;191(1):38-46.
3. Dimick JB, Cowan JA, Jr., Knol JA, Upchurch GR, Jr. Hepatic resection in the United States: indications, outcomes, and hospital procedural volumes from a nationally representative database. Arch Surg 2003;138(2):185-91.
4. Jarnagin WR, Gonen M, Fong Y*, et al.* Improvement in perioperative outcome after hepatic resection: analysis of 1,803 consecutive cases over the past decade.[see comment]. Ann Surg 2002;236(4):397-406; discussion -7.
5. Poon RT, Fan ST, Lo CM*, et al.* Improving perioperative outcome expands the role of hepatectomy in management of benign and malignant hepatobiliary diseases: analysis of 1222 consecutive patients from a prospective database. Ann Surg 2004;240(4):698-708; discussion -10.
6. Sun HC, Qin LX, Wang L*, et al.* Risk factors for postoperative complications after liver resection. Hepatobil Panc Dis Internat 2005;4(3):370-4.
7. Wei AC, Tung-Ping Poon R, Fan ST, Wong J. Risk factors for perioperative morbidity and mortality after extended hepatectomy for hepatocellular carcinoma. Br J Surg 2003;90(1):33-41.
8. Daley J, Khuri SF, Henderson W*, et al.* Risk adjustment of the postoperative morbidity rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. JACS 1997;185(4):328-40.

9. Khuri SF, Daley J, Henderson W*, et al.* Risk adjustment of the postoperative mortality rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. JACS 1997;185(4):315-27.

10. Vauthey JN, Pawlik TM, Ribero D*, et al.* Chemotherapy regimen predicts steatohepatitis and an increase in 90-day mortality after surgery for hepatic colorectal metastases. J Clin Oncol 2006;24(13):2065-72.

11. Poon RT, Fan ST, Lo CM*, et al.* Improving survival results after resection of hepatocellular carcinoma: a prospective study of 377 patients over 10 years. Ann Surg 2001;234(1):63-70.

12. Hollenbeck BK, Miller DC, Taub D*, et al.* Identifying risk factors for potentially avoidable complications following radical cystectomy. J Urol 2005;174(4 Pt 1):1231-7; discussion 7.

Table 1: Comparison of Comorbidities – Overall and by Morbidity Status.

Variable	Overall (N=783)	With Complication (N=177)	Without Complication (N=606)	p-value
Male gender	48.5%	55.4%	46.5%	0.041
Mean age in years (±SD)	57.5 (±13.7)	58.3 (±13.8)	57.2 (±13.7)	0.340
White race	80.1%	76.8%	81.0%	0.240
Cardiovascular				
Previous cardiac surgery	2.6%	5.1%	1.8%	0.026
Hypertension requiring medication	38.1%	44.1%	36.3%	0.065
History of angina	1.2%	2.3%	0.8%	0.123
Previous coronary angioplasty	5.1%	7.3%	4.5%	0.125
History of revascularization/amputation due to peripheral vascular disease	0.8%	1.1%	0.7%	0.622
History of congestive heart failure	0.1%	0.0%	0.2%	1.000
History of myocardial infarction within 6 months	0.4%	0.0%	0.5%	1.000
Rest-pain/gangrene	0.1%	0.0%	0.2%	1.000
CNS				
Cerebrovascular accident with neurologic deficit	2.0%	0.6%	2.5%	0.139
History of transient ischemic attack	1.7%	2.8%	1.3%	0.183
Hemiplegia	0.8%	0.0%	1.0%	0.346
Impaired sensorium	0.4%	0.6%	0.3%	0.537
CVA without neurologic deficit	1.8%	1.7%	1.8%	1.000
Pre-operative coma	0.1%	0.0%	0.2%	1.000
CNS tumor	0.5%	0.6%	0.5%	1.000
General				
ASA 3 or higher	54.5%	65.0%	39.9%	0.002
Mean pack-years of tobacco (±SD)	14.2 (±25.1)	16.6 (±24.7)	13.5 (±25.1)	0.167
Smoker	18.4%	21.5%	17.5%	0.227
Alcohol use	4.9%	5.7%	4.6%	0.554
Emergency status	0.8%	1.1%	0.7%	0.622
DNR status	0.0%	0.0%	0.0%	1.000
Hepatobiliary				
Esophageal varices	1.2%	1.7%	1.0%	0.430
Ascites	1.7%	1.1%	1.8%	0.743
Pulmonary				
Dyspnea	10.7%	14.1%	9.7%	0.099
History of chronic obstructive pulmonary disease	4.0%	6.2%	3.3%	0.122
Ventilator dependent	0.4%	1.1%	0.2%	0.130
Current pneumonia	0.4%	0.6%	0.3%	0.537
Renal				
Renal failure	0.1%	0.0%	0.2%	1.000
Dialysis	0.5%	0.6%	0.5%	1.000
Nutritional/Immune/Other				
Disseminated cancer	39.6%	32.2%	41.8%	0.023
Diabetes	12.4%	16.4%	11.2%	0.070
Open wound or wound infection	1.7%	3.4%	1.2%	0.085
Pre-operative sepsis	1.2%	2.3%	0.8%	0.123
Transfusion >4 units PRBC	0.3%	0.6%	0.2%	0.401

Chemotherapy	7.5%	6.2%	7.9%	0.520
Bleeding disorder	2.4%	2.8%	2.3%	0.781
Weight loss >10%	8.9%	8.5%	9.1%	0.882
Radiation therapy	1.4%	1.1%	1.5%	1.000
Steroid use	2.2%	2.3%	2.2%	1.000

Table 2: Frequency of Post-Operative Occurrences by Organ System (Total N=783)

Occurrence	N	Percent
30-day Mortality	20	2.6%
30-day Morbidity	177	22.6%
Return to OR	41	5.2%
Cardiac Occurrences		
Cardiac arrest requiring CPR	3	0.4%
Myocardial infarction	0	0.0%
CNS Occurrences		
Coma >24 hrs	3	0.4%
CVA/Stroke	2	0.3%
Peripheral nerve injury	1	0.1%
Pulmonary Occurrences		
Failure to wean from ventilator >48 hours	31	4.0%
Pneumonia	25	3.2%
Unplanned reintubation	22	2.8%
Pulmonary Embolism	7	0.9%
Renal Occurrences		
Urinary Tract Infection	39	5.0%
Acute Renal Failure	11	1.4%
Progressive renal insufficiency	11	1.4%
Wound Occurrences		
Wound Infection (superficial or deep)	46	5.9%
Organ Space Infection	15	4.7%
Wound disruption/dehiscence	12	1.5%
Other Occurrences		
Systemic Sepsis	46	5.9%
Bleeding requiring >4u PRBC	15	1.9%
DVT/Thrombophlebitis	12	1.5%
Graft/prosthesis failure	1	0.1%
Prolonged ileus	0	0.0%

Table 3: Pre-Operative Laboratory Data by Morbidity Status

Variable	With Complication (N=177)	Without Complication (N=606)	p-value
Alk Phos > 125 U/L	33.1%	22.8%	0.012
Bilirubin > 1.0 mg/dl	23.2%	12.5%	0.002
BUN > 40 mg/dl	2.5%	1.1%	0.243
Creatinine > 1.2 mg/dl	15.1%	8.2%	0.012
Hct > 45%	10.4%	7.6%	0.270
Hct <38%	43.9%	39.8%	0.335
Platelets < 150,000 /cumm	11.6%	8.7%	0.238
Platelets > 400,000 /cumm	12.1%	8.7%	0.183
SGOT > 40 U/L	34.9%	20.3%	<0.001
Sodium < 135 mmol/L	13.6%	6.3%	0.003
Sodium > 145 mmol/L	1.2%	0.9%	0.661
WBC < 4.5 th/cumm	11.0%	13.2%	0.517
WBC > 11.0 th/cumm	8.7%	5.6%	0.154
Mean PTT (±SD) sec	30.0 (±4.9)	29.5 (±6.4)	0.430
Mean Albumin (±SD) g/dl	3.7 (±0.6)	3.9 (±0.6)	<0.001

Table 4: Intra-Operative Variables by Morbidity and Mortality Status

Variable	With Complication (N=177)	Without Complication (N=606)	p-value	Death within 30 days (N=20)	Alive at 30 days (N=763)	p-value
Emergency case	1.1%	0.7%	0.622	5.0	0.7	0.144
Mean operative time (±SD) hours	5.5 (±2.8)	4.5 (±2.0)	<0.001	6.06 (3.87)	4.69 (2.18)	0.007
Mean operative work RVU (±SD)	44.5 (±8.9)	42.3 (±8.5)	0.003	47.15 (11.79)	42.72 (8.53)	0.024
RBC units transfused (±SD)	3.1 (±6.7)	1.1 (±2.8)	<0.001	6.95 (10.53)	1.39 (3.72)	<0.0001
Wound Class						
Clean	31.1%	37.6%	0.020	35.0	36.2	0.034
Clean/contaminated	62.7%	60.2%		50.0	61.1	
Contaminated	3.4%	1.5%		10.0	1.7	
Infected	2.8%	0.7%		5.0	1.0	
Anesthesia						
General	99.4%	99.7%	0.537	100.0	99.6	1.000
Epidural	0.6%	0.3%		0.0	0.4	
Spinal	0.0%	0.0%		0.0	0.0	
Transfer from						
Home	96.1%	98.2%	0.074	90.0	97.9	0.091
Other hospital	4.0%	1.2%		10.0	1.6	
Nursing home	0.0%	0.5%		0.0	0.4	
Other	0.0%	0.2%		0.0	0.1	

Table 5: Comparison of Comorbidities by Mortality Status

Variable	Death within 30 days (N=20)	Survival at 30 days (N=763)	p-value
Male gender	75.0	47.8	0.022
Mean age in years (±SD)	59.8 (±16.1)	57.4 (±13.7)	0.453
White race	85.0	79.9	0.779
Cardiovascular			
Previous cardiac surgery	10.0	2.4	0.090
Hypertension requiring medication	45.0	37.9	0.642
History of angina	0.0	1.2	1.000
Previous coronary angioplasty	0.0	5.2	0.618
History of revascularization/amputation due to peripheral vascular disease	0.0	0.8	1.000
History of CHF	0.0	0.1	1.000
History of MI within 6 months	0.0	0.4	1.000
Rest-pain/gangrene	0.0	0.1	1.000
CNS			
Cerebrovascular accident with neurologic deficit	0.0	2.1	1.000
History of transient ischemic attack	0.0	1.7	1.000
Hemiplegia	0.0	0.8	1.000
Impaired sensorium	0.0	0.4	1.000
CVA without neurologic deficit	0.0	1.8	1.000
Pre-operative coma	0.0	0.1	1.000
CNS tumor	0.0	0.5	1.000
General			
ASA 3 or higher	80.0	53.9	0.023
Mean pack-years tobacco (±SD)	8.0 (±15.1)	14.4 (±25.2)	0.300
Smoker	15.0	18.5	1.000
Alcohol use	15.0	4.6	0.068
Emergency status	5.0	0.7	0.144
DNR status	0.0	0.0	1.000
Hepatobiliary			
Esophageal varices	5.0	1.1	0.209
Ascites	10.0	1.4	0.041
Pulmonary			
Dyspnea	30.0	10.2	0.014
History of chronic obstructive pulmonary disease	15.0	3.7	0.041
Ventilator dependent	0.0	0.4	1.000
Current pneumonia	0.0	0.4	1.000
Renal			
Renal failure	0.0	0.1	1.000
Dialysis	5.0	0.4	0.099
Nutritional/Immune/Other			
Disseminated cancer	20.0	40.1	0.103
Diabetes	5.0	12.6	0.496
Open wound or wound infection	5.0	1.57	0.288
Pre-operative sepsis	5.0	1.1	0.209
Transfusion >4 units PRBC	0.0	0.3	1.000

Chemotherapy	0.0	7.7	0.390
Bleeding disorder	10.0	2.2	0.082
Weight loss >10%	10.0	8.9	0.698
Radiation therapy	0.0	1.4	1.000
Steroid use	0.0	2.2	1.000

Table 6: 30-Day Morbidity: Stepwise Logistic Regression

Step	Variable	Odds Ratio	95 % Wald Confidence Interval		p-value
1	Pre-Operative Albumin	0.62	0.44	0.87	<0.001
2	SGOT >40	1.64	1.03	2.60	0.014
3	Previous Cardiac Surgery	3.01	1.10	8.23	0.032
4	Work RVU	1.03	1.00	1.05	0.035
5	History of Severe COPD	2.14	0.92	4.98	0.030
6	Open Wound/Wound Infection	4.95	1.20	20.43	0.043
7	History of Angina	5.30	1.08	26.10	0.095
8	CVA with Neurologic Deficit	0.11	0.01	1.09	0.051
9	Disseminated Cancer	0.68	0.4	1.05	0.078
C-statistic = 0.689; Hosmer-Lemeshow p-value = 0.364					

*significance level for entry: p<0.20; significance level to stay: p<0.15