BMJ Open

Influence of obesity on in-hospital and postoperative outcomes of hepatic resection for malignancy: a 10-year retrospective analysis from the US National Inpatient Sample

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ABSTRACT

Objectives The influence of obesity on the outcomes of curative liver resection for malignancies remains controversial. We aimed to compare the in-hospital outcomes of liver resection for malignancy between obese and non-obese patients.

Design This was a population-based, retrospective, observational study using data from the Nationwide Inpatient Sample (NIS), the largest all-payer US inpatient care database.

Setting Hospitalisations of adults ≥18 years old with diagnoses of primary hepatobiliary malignancy or secondary malignant neoplasms of liver in the USA were identified from the NIS database between 2005 and 2014.

Participants Data of 18 398 patients ≥18 years old and underwent liver resection without pancreatic resection in the NIS were extracted. All included subjects had primary hepatobiliary malignancy or secondary malignant neoplasms of the liver. Patients were divided into obese and non-obese groups. These groups were compared with respect to postoperative complications, length of hospital stay and hospital cost according to surgical extent and approach.

Interventions Patients were undergoing lobectomy of liver or partial hepatectomy.

Primary and secondary outcome measures The primary endpoints of this study were postoperative complications, length of hospital stay and hospital cost.

Results After adjustment, obese patients were significantly more likely to experience postoperative complications than were non-obese patients (adjusted OR 1.25, 95% CI 1.10 to 1.42), regardless of whether lobectomy or partial hepatectomy was performed. Furthermore, obesity was significantly associated with increased risk of postoperative complications in patients who underwent open liver resection, but not laparoscopic resection. No significant difference was observed in length of hospital stay or total hospital costs between obese and non-obese patients.

Conclusions After adjustment for preoperative comorbidities and other potential confounders, obesity is significantly associated with greater risk of complications in patients undergoing open liver resection for malignancy, but not laparoscopic resection.

Strengths and limitations of this study

► We analysed a very large cohort carefully selected from the US National Inpatient Sample.
► Patient demographic characteristics, presurgical co-morbidities and hospital characteristics were considered and carefully adjusted in the analyses.
► This study might be limited by its retrospective nature and unmeasured confounders, including clinical laboratory data.

INTRODUCTION

The increasing prevalence of obesity in industrialised countries makes this issue a concern for healthcare providers worldwide. Obesity among adults in the USA has been steadily increasing over the past several decades, affecting nearly one in every three adults (body mass index (BMI) ≥30 kg/m^2).[1] Obesity leads to other serious health problems such as diabetes, hypertension, coronary heart disease and cancer.[2] Obese individuals have a reduced overall life expectancy, with a two to threefold increased risk of death from all causes during middle age.[3] Given these serious effects of obesity on health, the expectation that obesity may negatively affect surgical outcomes is reasonable. In general, obesity does significantly increase the risk of wound infection, increases surgical blood loss and increases operation time.[4] However, studies of the surgical and in-hospital outcomes of obese patients report conflicting results. Some studies have shown that obesity is not associated with a greater risk of postoperative complications,[5 6] others have shown the opposite, that obesity increases postoperative morbidity and mortality,[7 8] while still others have suggested that obesity has

favourable effects on in-hospital outcomes and long-term survival of surgical patients.[9]

As with other surgeries, the effect of obesity on the outcomes of liver resection for malignancies remains unclear. Wang et al[10] studied liver resection for hepatocellular carcinoma (HCC) in overweight and obese patients, and reported that BMI itself was not a risk factor for morbidity or mortality. Another study also showed no difference in the 30-day or 90-day mortality rate between obese and non-obese liver cancer patients after hepatectomy.[11] A US study found that obese patients undergoing hepatic resection did not have a great risk of mortality, but did have a significantly higher risk of postoperative complications.[12] Acosta et al[13] reported that a BMI $>50 \, kg/m^2$ as an independent predictor of perioperative morbidity after liver resection, and Gedaly et al[14] found that obesity significantly increased operating time, units of blood transfused and time to ventilator weaning after hepatic resection. A recent meta-analysis of 14 studies found that in patients undergoing liver resection for HCC, excess BMI was not associated with postoperative complications, except for wound infections, nor was it associated with prognosis.[15] Interestingly, Mathur et al[16] found that although high BMI patients have higher perioperative morbidity, they may have better oncological outcomes following hepatectomy for malignancy.

Thus, the purpose of this study was to further clarify the risks that liver resection may pose to obese patients by conducting a retrospective analysis of an extremely large cohort of over 18 000 patients with liver malignancies. Surgical and in-hospital outcomes of liver resection for malignancy were compared between obese and non-obese patients using data from a nationwide US database.

METHODS

The data analysed in this population-based, retrospective, observational study were taken from the Nationwide Inpatient Sample (NIS), the largest all-payer US inpatient care database, containing over a hundred clinical and non-clinical data elements from approximately 8 million hospital stays per year.[17] These data include primary and secondary diagnoses, primary and secondary procedures, admission and discharge status, patient demographics, expected payment source, length of stay and hospital characteristics. All patients are considered for inclusion. The most recent NIS database contains data from about 1050 hospitals from 44 States in the USA, sampled to approximate a 20% stratified sample of US community hospitals as defined by the American Hospital Association. Hospitalisations of adults ≥18 years old with diagnoses of primary hepatobiliary malignancy or secondary malignant neoplasms of liver in the USA were identified from the NIS database between 2005 and 2014, with an International Classification of Diseases, Ninth Revision (ICD-9) diagnosis code of 155, 156 and 197.7, and undergoing liver resection with procedure code 50.22 and 50.3, were extracted from the database as the primary

cohort. Among these patients, those with combined resection of pancreas (ICD-9: 52.0, 52.5, 52.6, 52.7) were excluded from the study population. The study cohort was further stratified by obesity status into non-obese and obese groups (ICD-9: 278.0, 278.00) (obese, BMI $\geq 30 \, kg/m^2$; non-obese, BMI $<30 \, kg/m^2$). We obtained the data through request to the Online Healthcare Cost and Utilization Project (HCUP) Central Distributor (https://www.distributor.hcup-us.ahrq.gov/) with certificate number HCUP-4R69M73CW and conformed to the data-use agreement for the NIS from the HCUP.[18] No consent was required to use the deidentified NIS patient data.

The primary endpoints of this study were postoperative complications, length of hospital stay and hospital cost. Postoperative complications were defined by the following ICD-9 diagnosis codes, Clinical Classifications Software (CCS) codes[19] and ICD-9 procedure codes: cardiovascular complications: 997.1, 997.02, 997.09, 997.7, 998.0, 100CCS; bleeding complications/transfusion: 285.1, 998.1–998.2 and procedure code of 99.0; pulmonary complications and pneumonia: 518.5, 518.81, 997.3, 122CCS; infection/sepsis: 998.5, 995.9; digestive system complication: 997.4; intra-abdominal abscess: 998.59, 567.22; acute renal failure: 584, 157CCS, V45.1; DVT/pulmonary embolism: 451.11, 451.19, 451.2, 451.81–84, 451.89, 451.9, 453.40–42, 453.8, 453.9, 997.2; wound complications: 998.12–998.13, 998.3, 998.5; Device complications: 996.1, 996.62, 996.74, 998.4, 998.7, 998.2; other complications: 997.0, 997.4–997.5, 997.9, 998.6, 998.8–998.9 and in-hospital death. Hospital cost was extracted from the NIS database. The cost represented the bill for patient stay, but did not include professional fees and non-covered charges.

Patient characteristics included age, sex, race, income level, insurance status (primary payer), indication for liver resection (primary hepatic/biliary malignancy: ICD-9-Clinical Modification code 155, 156; other malignancy liver metastasis: 197.7), admission type (elective; emergency), liver cirrhosis/steatosis/fibrosis (cirrhosis: 571.2, 571.5; steatosis/fibrosis: 571.8), surgical extent (lobectomy: 50.3; partial hepatectomy: 50.22) and surgical approach (laparoscopic: ICD-9 procedure codes 54.21, 17.4; open surgery).

Comorbidities (alcohol abuse, anaemia, congestive heart failure, chronic pulmonary disease, coagulopathy, diabetes, hypertension, fluid/electrolyte disorders, peripheral vascular disorders and renal failure) were identified through Agency for Healthcare Research and Quality comorbidity measures in the database determined through ICD-9 diagnostic codes using algorithms validated by Elixhauser et al.[20] Atrial fibrillation was defined by ICD-9 code 427.31. Hospital-related characteristics (bed size, location/teaching status and hospital region) were extracted from the NIS database. In addition, a stratified analysis was performed according to surgical extent and surgical approach to evaluate the association between obesity and postoperative morbidities.

Table 1 Patient demographic characteristics and comorbidities, and hospital characteristics

	Non-obese	Obese	P value†
	n=16457	n=1451	
Demographics, (%)			
Age (years)			
<65	9544 (58.03)	958 (65.94)	<0.0001*
≥65	6913 (41.97)	493 (34.06)	
Sex, (%)			
Male	8729 (53.09)	698 (48.17)	0.0003*
Female	7717 (46.91)	753 (51.83)	
Race/ethnicity, (%)			
White	10313 (73.05)	947 (74.75)	<0.0001*
Black	1270 (8.95)	148 (11.63)	
Hispanic	1138 (8.09)	103 (8.1)	
Other	1403 (9.92)	68 (5.51)	
Household income, (%)‡			
Q1	3491 (21.7)	350 (24.69)	0.001*
Q2	3879 (24.11)	379 (26.98)	
Q3	4101 (25.62)	335 (23.76)	
Q4	4535 (28.57)	345 (24.58)	
Insurance status, (%)			
Medicare/medicaid	7952 (48.33)	659 (45.59)	0.08
Private including HMO	7582 (46.18)	714 (49.48)	
Self-pay/no charge/other	901 (5.49)	72 (4.94)	
Indication, (%)			
Primary hepatic or biliary malignancy	5278 (32.08)	501 (34.55)	0.05
Other malignancy liver metastasis	11179 (67.92)	950 (65.45)	
Admission type, (%)			
Elective	14479 (88.17)	1333 (91.87)	<0.0001*
Emergency	1965 (11.83)	118 (8.13)	
Liver cirrhosis/steatosis/fibrosis, (%)			
Not stated	14874 (90.32)	1231 (84.78)	<0.0001*
Steatosis/fibrosis	432 (2.65)	121 (8.39)	
Cirrhosis	1151 (7.03)	99 (6.83)	
Surgical extent, (%)			
Lobectomy	4907 (29.79)	387 (26.59)	0.02*
Partial hepatectomy	11550 (70.21)	1064 (73.41)	
Surgical approach, (%)			
Open	15610 (94.84)	1367 (94.15)	0.26
Laparoscopic	847 (5.16)	84 (5.85)	
Comorbidities, (%)			
Alcohol abuse	459 (2.78)	45 (3.08)	0.48
Anaemia	2411 (14.57)	248 (16.99)	0.02*
Congestive heart failure	428 (2.59)	67 (4.57)	<0.0001*
Chronic pulmonary disease	1711 (10.35)	234 (16.02)	<0.0001*
Coagulopathy	1354 (8.22)	129 (8.88)	0.38
Diabetes, uncomplicated	2549 (15.43)	475 (32.66)	<0.0001*

Continued

	Non-obese	Obese	P value†
	n=16 457	n=1451	
Diabetes, complicated	216 (1.31)	55 (3.86)	<0.0001*
Hypertension	7383 (44.79)	950 (65.33)	<0.0001*
Fluid/electrolyte disorders	3606 (21.82)	357 (24.43)	0.02*
Peripheral vascular disorders	352 (2.14)	37 (2.55)	0.29
Renal failure	516 (3.13)	77 (5.24)	<0.0001*
Atrial fibrillation	1155 (7.02)	118 (8.15)	0.09
Hospital bed size, (%)			
Small	1235 (7.37)	83 (5.72)	0.07
Medium	2123 (13.11)	217 (15.04)	
Large	12 984 (79.52)	1146 (79.24)	
Location/teaching status of hospital			
Rural	302 (1.78)	22 (1.48)	0.70
Urban non-teaching	1881 (11.3)	168 (11.39)	
Urban teaching	14 159 (86.92%)	1256 (87.14%)	
Region of hospital			
Northeast	4049 (25.24)	300 (21.27)	0.002*
Midwest	3620 (22)	365 (25.06)	
South	5473 (32.78)	545 (37.19)	
West	3315 (19.98)	241 (16.48)	

Data are presented as unweighted counts (weighted proportion).
*Significant difference between groups, p<0.05.
†X^2 test.
‡Household income was extracted and grouped into quartiles (Q1, 0–25th percentile; Q2, 26–50th percentile; Q3, 51st–75th percentile; Q4, 76–100th percentile) based on median total family income within the zip code of the patient's primary residence.
HMO, Human Maintenance Organization.

Patient and public involvement

As this study was a retrospective database analysis, patients and the public were not involved directly.

Statistical analysis

Continuous variables were presented as mean with SE and analysed using Student's t-test. Categorical variables were presented as weighted percentages, and tested by the X^2 test. Logistic regression and linear regression analyses were conducted to evaluate the associations between obesity and postoperative morbidities (postoperative complications, length of stay and hospital cost). The variables that were significantly associated with obesity in univariate analyses were included multivariate regression models for adjustment. In addition, the regression models were stratified by surgical extent and surgical approach. The mean, SE, proportions, all testing and regression models were applied with discharge weights to account for the HCUP-NIS sampling method. A two-sided value of p<0.05 was considered statistically significant. Statistical analyses were performed using the statistical software package SAS software V.9.4 (SAS Institute).

RESULTS

Study population

The initial screening involved a total of 77 394 755 patients from 2005 to 2014 in the HCUP-NIS database. Of these patients, 18 398 were diagnosed with HCC or other primary/metastatic malignancies, were over the age of 18, and underwent liver resection without pancreatic resection. After exclusions for lack of information regarding in-hospital mortality (5 patients) and hospital costs (485 patients), 17 908 patients remained in the final cohort for subsequent analysis.

Descriptive statistics

Patient demographics, comorbidities and hospital characteristics are summarised in table 1. The results showed that age, sex, race, income by zip code, admission type, liver cirrhosis/steatosis/fibrosis, surgical extent, anaemia, congestive heart failure, chronic pulmonary disease, diabetes, hypertension, fluid/electrolyte disorders, renal failure and region of hospital (all, p≤0.02) differed significantly between different groups of obese patients (table 1). Patient postoperative morbidities are shown in table 2. Obese patients had a significantly shorter length of

Table 2 Clinical outcomes

	Non-obese	Obese	
	n=16 457	n=1451	P value†
Length of stay (days)	8.55±0.08	7.94±0.18	0.002‡*
Hospital cost (dollars)	99070±2655.23	96518±3052.51	0.37‡
Postoperative complications, (%)	7837 (47.54)	772 (52.99)	0.0002*
Cardiac complications, (%)	680 (4.16)	78 (5.4)	0.02*
Bleeding complications/transfusion, (%)	5250 (31.83)	533 (36.64)	0.0002*
Pulmonary complications, pneumonia, (%)	2155 (13.07)	198 (13.59)	0.58
Infection/sepsis, (%)	1229 (7.45)	105 (7.19)	0.71
Digestive system, (%)	1561 (9.47)	149 (10.28)	0.32
Intra-abdominal abscess, (%)	765 (4.64)	66 (4.53)	0.84
Acute renal failure, (%)	1058 (6.4)	154 (10.47)	<0.0001*
DVT/pulmonary embolism, (%)	344 (2.1)	32 (2.2)	0.78
Wound complications, (%)	920 (5.58)	87 (5.97)	0.53
Device complications, (%)	515 (3.11)	24 (1.62)	0.001*
Other complications, (%)	1888 (11.45)	174 (11.98)	0.55
In-hospital mortality, (%)	495 (2.99)	30 (2.04)	0.04*

Data are presented as the mean and SE for continuous variables, and unweighted counts (weighted proportion) for categorical variables.
*Significant difference between groups, p<0.05.
†X^2 test.
‡t-test.
DVT, Deep Vein Thrombosis.

hospital stay as compared with non-obese patients. Obese patients had significantly higher rates of postoperative complications, cardiac complications, bleeding complications/transfusion and acute renal failure; however, obese patients had significantly lower rates of device complications and in-hospital mortality.

Association between obesity and postoperative complications, length of stay and hospital cost

The results of the regression analyses are shown in table 3. Univariate analysis showed that obese patients were more likely to have postoperative complications than non-obese patients (unadjusted OR (adjusted OR, aOR) 1.24, 95% CI 1.11 to 1.39). This result remained significant the multivariate analysis after adjusting for age, sex, income, insurance status, indication, admission type, liver cirrhosis/steatosis/fibrosis, surgical extent, surgical approach, all comorbidities, location/teaching status of hospital and region of hospital (aOR 1.25, 95% CI 1.10 to 1.42) (table 3). In the univariate analysis, obesity was associated with length of stay (unadjusted β: −0.60, SE 0.19). However, after adjusting for the confounders there was no significant association between obesity and length of stay (table 3).

Stratified regression analysis results are shown in table 4. After adjustment, obesity was significantly associated with increased risk of postoperative complications in patients who received lobectomy (aOR 1.33, 95% CI 1.04 to 1.69) and partial hepatectomy (aOR 1.21, 95% CI 1.05

to 1.41) (table 4). Furthermore, after adjustment obesity was significantly associated with increased risk of postoperative complications in patients who underwent open liver resection (aOR 1.27, 95% CI 1.12 to 1.43). However, this association was not observed in patients who underwent laparoscopic liver resection. There was no significant association between obesity and length of stay or hospital cost in any stratified analysis after adjustment (table 4).

DISCUSSION

In this retrospective analysis, we compared surgical and in-hospital outcomes of liver resection for malignancy between obese and non-obese patients in a cohort of over 18 000 patients using a nationwide US database. We observed that obese patients undergoing liver resection were significantly more likely to experience postoperative complications than were non-obese patients, regardless of whether lobectomy or partial hepatectomy was performed. We also found that obesity was significantly associated with increased risk of postoperative complications in patients who underwent open liver resection but not laparoscopic resection. We observed no significant difference in length of hospital stay or total hospital cost between obese and non-obese patients.

Our finding that complications following open liver resection are significantly more likely in obese patients is in agreement with numerous studies specifically

Table 3 Associations between obesity and clinical outcomes

	Postoperative complications		Length of stay		Hospital costs	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*	Unadjusted β±SE	Adjusted β±SE†	Unadjusted β±SE	Adjusted β±SE‡
Non-obese	Reference	Reference	Reference	Reference	Reference	Reference
Obese	**1.24 (1.11 to 1.39)**	**1.25 (1.10 to 1.42)**	**−0.60±0.19**	−0.33±0.18	−2552.56±2868.16	2008.97±2686.17

Significant values are shown in bold.

*Multivariate analyses were adjusted for age, sex, income, insurance status, indication, admission type, liver cirrhosis/steatosis/fibrosis, surgical extent, surgical approach, all comorbidities, location/teaching status of hospital and region of hospital.

†Multivariate analyses were adjusted for age, sex, income, insurance status, indication, admission type, liver cirrhosis/steatosis/fibrosis, surgical extent, all comorbidities except for diabetes, uncomplicated and location/teaching status of hospital.

‡Multivariate analyses were adjusted for age, sex, race, income, insurance status, indication, admission type, liver cirrhosis/steatosis/fibrosis, surgical extent, all comorbidities except for chronic pulmonary disease and diabetes, uncomplicated, location/teaching status of hospital and region of hospital.

β, beta-coefficient.

Table 4 Association between obesity and clinical outcomes by surgical extent and approach

		Postoperative complications		Length of stay		Hospital costs	
		Unadjusted OR (95% CI)	Adjusted OR (95% CI)*	Unadjusted β±SE	Adjusted β±SE†	Unadjusted β±SE	Adjusted β±SE‡
Surgical extent	Lobectomy	**1.32 (1.07 to 1.63)**	**1.33 (1.04 to 1.69)**	**−0.67±0.34**	−0.47±0.29	287.86±5651.19	1504.35±5781.44
	Partial hepatectomy	1.24 (1.08 to 1.43)	**1.21 (1.05 to 1.41)**	**−0.53±0.23**	−0.27±0.23	−2804.04±3247.24	1814.79±3323.23
Surgical approach	Open surgery	1.26 (1.12 to 1.42)	**1.27 (1.12 to 1.43)**	**−0.61±0.19**	−0.36±0.18	−3209.36±2759.91	952.89±2740.69
	Laparoscopic	1.05 (0.67 to 1.64)	1.12 (0.66 to 1.91)	−0.49±0.99	0.84±1.04	7294.09±18230.72	22877.55±20914.57

Significant values are shown in bold.

*Multivariate analyses were adjusted for age, sex, income, insurance status, indication, admission type, liver cirrhosis/steatosis/fibrosis, surgical extent, surgical approach, all comorbidities, location/teaching status of hospital and region of hospital.

†Multivariate analyses were adjusted for age, sex, income, insurance status, indication, admission type, liver cirrhosis/steatosis/fibrosis, surgical extent, all comorbidities except for diabetes, uncomplicated and location/teaching status of hospital.

‡Multivariate analyses were adjusted for age, sex, income, insurance status, indication, admission type, liver cirrhosis/steatosis/fibrosis, surgical extent, all comorbidities except for chronic pulmonary disease and diabetes, uncomplicated, location/teaching status of hospital and region of hospital.

β, beta-coefficient;

addressing the influences of obesity on liver resection outcomes. Among obese patients, increased morbidity, including respiratory complications, bleeding and longer hospital stays, but no difference in mortality as compared with non-obese patients, were observed after liver resection in an Italian cohort of 1021,[21] a French cohort of 684[22] and an Italian cohort of 235 patients.[23] While these studies were limited by their small numbers and single-centre retrospective design, similar observations were reported in a prospective, multicentre study of a US cohort of 3960 liver resection patients.[12] Further increasing the statistical power of such investigation, our results in this cohort of over 18 000 patients further confirm that obese patients are at higher risk of morbidity, but not mortality, following open hepatic resection.

Of particular clinical significance is our observation that obese patients who underwent laparoscopic hepatic resection were at no greater risk of postoperative complications than non-obese patients. This result clearly contrasts that for open resection, suggesting that this surgical approach has distinct advantages in this patient population. Similar observations have been reported in numerous smaller cohort studies of hepatic resection in obese patients.[24–27] The laparoscopic approach to hepatic resection dramatically decreases surgical wall trauma, as only five or six port incisions are made, and the resected specimen is extracted without a muscle incision.[28] As a result, decreased postoperative pain and early postoperative rehabilitation[29] may provide improved cardiopulmonary function recovery in obese patients.[24]

Despite strong evidence in this study and others indicating an increased risk of morbidity in obese patients after open hepatic resection, conflicting results have been reported. Obesity was observed to have no influence on postoperative complications or outcomes of hepatic resection in a Chinese cohort of 310 patients[30] and in a Japanese cohort of 202 patients.[31] A variety of factors could account for these differing observations. A number of obese patients in these two studies were 68 and 9, respectively. Potential differences in obesity between races may affect the influence of obesity on perisurgical outcomes.[11] In addition, obese patients can be difficult to manage perioperatively, and there may be considerable variability in the processes of care that could contribute to heterogeneity in outcomes.[12]

Of note is that 'underweight' could not be identified in the database. It is potentially possible that if a large number of underweight patients were included in the non-obese group the results of this group could be influenced. Individuals are considered to be underweight if their BMI is <18.5 kg/m^2, and a BMI <18.5 kg/m^2 also indicates undernutrition.[32]

Underweight patients who undergo intra-abdominal cancer surgery have been shown to have an increased risk of postoperative mortality.[33] Recent studies have also reported that being underweight was a significant predictor of worse postoperative outcomes,[34] and worse long-term prognosis[35 36] after surgery for HCC.

The important strength of this study is the extremely large cohort drawn from all geographical regions in the USA over a 10-year period. However, there are limitations of the study that should be considered, including its retrospective nature. The NIS database used in this study approximates the national distribution of key hospital characteristics. Our estimates are derived from a 20% sample, which might be under-representative or over-representative. However, the NIS has been used extensively to examine national healthcare trends, and its sampling design has been validated in numerous publications.

We did not evaluate in-hospital mortality as an endpoint because the number of cases was too small (n=30). In-hospital death was included as one of component of postoperative complications. Likewise, we did not perform multivariate analysis for the influence of obesity on individual complications, given the case numbers for each complication were too small. We can only conclude that obesity is related to higher chance of 'overall complications' after surgery. Whether obesity increases the risk of wound complications was not addressed by this study; however, this has been examined in numerous other studies. Data of tumour stage were not included in the analysis, and the extension of hepatectomy was unknown due to lack of this information in the database. The simple division between lobectomy and partial hepatectomy in the analyses might not account for extension of the liver resection, and thus may potentially bias the results. This is indeed another limitation of database analyses. Clinical studies are necessary to determine the importance of extension of hepatectomy in obese and non-obese patients. As discussed previously, underweight could not be identified from the database, which uses a billing code system. We have also checked the codes for morbid obesity, and no patients could be identified either.

There are some limitations in this study. First, unmeasured confounders, such as laboratory data, could not be accounted for, including stage of disease and clinical laboratory data. Second, there was no assessment of operation time, which is an important factor affecting short-term outcomes. Third, this study focused mainly on in-hospital outcomes. Late morbidities after discharge could not be evaluated due to the nature of the NIS database. Lastly, we used the ICD-9 coding system to identify the disease and surgical procedures in the NIS database. Consequently, the reliability of these data depends on the accuracy of the ICD-9 codes.

CONCLUSION

In patients undergoing liver resection for malignancy, obesity is an independent predictor of postoperative complications. Obese patients should be treated with caution. Future well-designed prospective studies were highly warranted to confirm the findings.

Contributors JH: conception and design; acquisition of data; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript;

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