World J Surg (2010) 34:2960–2968
DOI 10.1007/s00268-010-0756-1

World Journal of Surgery

Safety of Liver Resections in Obese and Overweight Patients

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Published online: 14 August 2010

Abstract
Background The new global epidemic, overweight and obesity, has a significant role in the etiology of liver tumors. However, the impact of body weight on the outcome after liver resection is unknown.
Methods We carried out a prospective study of 684 patients who underwent liver resections. Patients were stratified according their body mass index (BMI) as follows: normal (<25 kg/m^2) (52%), overweight (25–29 kg/m^2) (34%), and obese (≥30 kg/m^2) (14%), and according to the extent of resection, as either minor or major hepatectomy. Preoperative and intraoperative characteristics and outcomes were prospectively studied. The Dindo–Clavien classification of morbidity was used.
Results Overall postoperative morbidity and morbidity rates were not influenced by BMI. Pulmonary complications were significantly more frequent in obese patients irrespective of the extent of resection. During major resection obese had longer pedicular clamping and more frequently required blood transfusion. After major resection, major morbidity (Dindo–Clavien grade III or more) was more frequent in obese (57%) and overweight (54%) patients than in patients of normal body weight (35%; $P < 0.05$), including a higher rate of respiratory complications and ascites and longer intensive care unit (ICU) and hospital stays. Obesity and overweight were independent predictors of major morbidity (OR 2.6, 95% CI 1.2–5.8 and OR 1.9, 95% CI 1.2–3.2, respectively), and obesity was a predictor of the need for blood transfusion (OR 3.3, 95% CI 1.4–7.9) after major resections.
Conclusions Obese and overweight patients are at increased risk of potentially life-threatening morbidity after major hepatic resections. Because the risk of mortality is not increased significantly, there is no justification for a compromise in the indication or extent of surgery.

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Introduction

Candidates for a liver resection include an increasing proportion of obese or overweight patients. The last few decades have witnessed a sharp rise in obesity, with recent literature reporting a prevalence of over 30% in the United States [1–4] and 10–30% in Europe [3–6]. In addition, patients with a high body mass index (BMI) are at increased risk of developing hepatocellular carcinoma [7–9] and colorectal liver metastases [10, 11], the two most frequent indications for liver resection [12–14].

The studies that have tried to correlate BMI as a risk factor of morbidity after surgery have yielded conflicting results [15–19]. Although obesity has frequently been shown to increase the risk of intraoperative blood transfusions, postoperative sepsis, deep venous thrombosis, or abdominal collections [20–22], and of even mortality [20, 23] after various abdominal operations, other studies have demonstrated that obesity alone does not increase morbidity or in-hospital stay after abdominal operations [24–28]. Few studies have specifically looked at the influence of BMI on liver resection [17, 29, 30], and those few have failed to find a significant impact on postoperative outcome. However, two of these studies [17, 29] have not graded the high BMI group into obese and overweight, and none of them have analyzed minor and major hepatic resections separately or studied the complications according to the standardized Classification of Surgical Complications proposed by the Dindo–Clavien grading score [31].

In view of the paucity of evidence on the impact of BMI on liver resections, we analyzed a large series of liver resections performed in a single tertiary referral center over a short period of time. Our objectives were to analyze the characteristics of obese or overweight patients undergoing major and minor liver resections separately, and to determine if they were at increased risk of perioperative complications.

Patients and methods

Patients

We carried out a retrospective analysis of prospectively collected data on all elective liver resections performed in our department between August 2002 and October 2005. The institutional review board approved the study. Preoperative variables analyzed included age, sex, height, weight, associated medical conditions, preoperative laboratory data, and the diagnosis leading to surgery. The status of the nontumorous liver (fibrosis score [32] and percentage of steatosis), assessed on the resected specimen, was also included in the preoperative variables. No patient was excluded from surgery based on BMI.

Surgical technique

Liver resections were performed by the same surgical team with an attendant senior surgeon for all procedures, irrespective of the BMI. The incision used was a subcostal, midline, or J-shaped incision and a thoraco-abdominal incision according to the requirements of the case. Suitable cases were performed by laparoscopy. Liver parenchyma transection was performed with the Kelly crush technique and/or an ultrasonic dissector. Portal triad clamping was left to the surgeons' choice but was not used routinely, and total vascular exclusion was only performed in selected patients with involvement of the inferior vena cava. Preoperative portal vein embolization was performed prior to right or extended right hepatectomies in patients with a "diseased liver," including chronic liver disease and chemotherapy-induced parenchyma injury, or when the predicted functional remnant liver volume was estimated to be less than 40% of the total functional liver volume [33]. Liver resections were designated as major hepatectomies when three or more Couinaud segments were resected, and all others were categorized as minor hepatectomies [34]. Fresh frozen plasma was not used routinely during operation. Intraoperative variables analyzed were the duration of surgery, the need for and duration of portal clamping, and transfusion requirements.

Surgical procedures

Of the 684 liver resections, major liver resections were performed in 423 (62%), patients including 271 right hepatectomies with extended resection of segment I or IVa or IVb in 40 patients; left hepatectomies in 79 cases, with extended resection of the segment I in 31 patients; trisectionectomies in 61 patients, including 45 right and 16 left trisectionectomies; another 12 patients underwent resections of 3 to 5 liver segments. Minor hepatectomies were performed in 261 (38%) patients, with 128 anatomical resections of two segments, 78 unisegmentectomies, and 54 wedge resections. Laparoscopic resection was performed in 14 patients.

Postoperative care and definition of complications

Postoperative overnight monitoring in the intensive care unit (ICU) was routinely performed in patients with cirrhosis, associated cardiovascular co-morbidities, major hepatic resection, or when severe intraoperative adverse events (such as hypothermia or massive bleeding) had occurred. These patients were discharged from ICU according to established protocols.

Postoperative variables analyzed included the kinetics of liver function tests (routinely sampled on postoperative days 1, 3, 5, and 7), morbidity, mortality, and duration of ICU and hospital stay. Postoperative complications were classified according to the Dindo–Clavien classification [31]. According to this classification, grade I includes minor complications that do not require any intervention and that can be treated with routine medications like antipyretics, analgesics, diuretics, or physiotherapy. Grade II includes conditions that require major pharmacological intervention, like respiratory infections, ascites, blood transfusions, and asymptomatic pulmonary embolism. Grade III includes any complication requiring a surgical, endoscopic, or radiological intervention, like a respiratory infection requiring broncoscopy, a pleural effusion requiring drainage, ascites or an abdominal collection requiring percutaneous drainage, and reoperation for abdominal collection, bleeding, or other reasons. Grade IV includes patients with life-threatening complications requiring ICU care,and grade V includes death in the postoperative period. Specific complications that were commonly encountered after liver resection were defined as follows: (1) respiratory complications, including pleural effusion requiring tapping or drainage, symptomatic lung infection, pulmonary embolism, and artificial ventilation for more than 48 h; (2) ascites, if abdominal drainage output was more than 500 ml/day after the third postoperative day, or if tapping was required; (3) liver failure defined as the presence of both a prothrombin time less than 50% (INR > 1.7) and a serum total bilirubin greater than 50 μmol/l (>3.0 mg/dl) on or after postoperative day 5 [35]; (4) abdominal collections, which required aspiration and/or drainage; and (5) biliary fistula, if bilirubin concentration in the drainage was more than twice that in the serum. Other complications included severe infection delaying discharge from the hospital. Operative mortality was defined as in-hospital death or death within 30 days of surgery. Because most of the Dindo–Clavien grade I complications were trivial, affected patients were grouped with those that had no complications. When patients had more than one complication, the most severe complication was considered.

Study design

The BMI was calculated using the criteria established by the World Health Organization (weight in kilograms divided by the square of the height in meters). Patients were divided into three groups by BMI: (1) <25 kg/m^2, normal weight patients; (2) 25–29 kg/m^2, overweight patients; and (3) ≥30 kg/m^2, obese patients.

Preoperative and surgical characteristics of these three groups of patients were compared. Patients were stratified according to the extent of liver resection, and univariate analysis and multivariate analyses were designed to assess whether an increased BMI was an independent risk factor for intraoperative blood transfusion, morbidity, or mortality in each group. The degree of steatosis was evaluated in the pathological assessment of the specimen.

Statistical analysis

Statistical analysis was carried out with the SPSS software package (version 10.0; Chicago, IL). The univariate analysis was tested using the chi-square test or the two-tailed Fisher's exact test (when indicated) for categorical variables; for continuous variables, the Student *t* test and analysis of variance (ANOVA) or the Kruskal–Wallis test (when a normal distribution was not present) were employed. The multivariate analysis was carried out using a nonconditional model of logistic regression to determine predictors and interactions in the overall group, all according to extension of liver resections (minor and major hepatectomies). Results were expressed as mean and standard deviation or percentages. Odds ratio (OR) with its 95% confidence intervals was calculated, and $P < 0.05$ was considered significant.

Results

Preoperative characteristics

During the study period, 684 liver resections were included in our analysis. The patient population, including 378 (55%) males, had a mean age of 54 years (range: 17–88 years). The indication of resection was a malignant lesion in 68% ($n = 465$) of these patients. The normal weight group included 359 (52%) patients, the overweight group had 228 (34%) patients, and the obese group had 97 (14%) patients. Patient characteristics of the three groups are summarized in Table 1. The BMI in the obese group was 32 ± 2 (range: 30–44). Compared to those with a normal weight, obese and overweight patients were more frequently operated on for a malignancy (76 and 75% vs. 62%; $P < 0.01$ and $P < 0.05$, respectively), had a higher incidence of diabetes (20 and 15% vs. 7%; $P < 0.05$ and $P < 0.001$, respectively), and hypertension (39 and 34% vs. 16%; $P < 0.001$), and had higher hemoglobin levels. Although preoperative liver function tests were comparable, the nontumorous liver was less frequently normal in obese and overweight patients (31 and 50%, respectively, vs. 59%; $P < 0.05$) because of a higher incidence of steatosis and fibrosis. There was a significant correlation between BMI and degree of steatosis ($r^2 = 0.39$, 95% CI 0.31–0.45; $P < 0.0001$).

Overall outcome

There were 19 (2.7%) perioperative deaths. All of these patients underwent surgery for malignancy. Among these patients, more than half ($n = 11$) had cirrhosis and 7 had mild to severe fibrosis. Major hepatic resection was performed in 14 (74%) of these patients. Mortality in the overweight group was slightly higher than in the normal group (9/228 [3.9%] vs. 8/359 [2.2%], $P =$ ns), whereas in the obese group [2/97 (2.1%)] the mortality rate was similar to the normal group [8/359 (2.2%)]. The BMI was not a significant independent risk factor for mortality (OR: 1.9 [95% CI 0.7–5.2]; $P = 0.218$ for overweight and OR: 0.64 [95% CI 0.3–4.2]; $P = 0.547$ if obese). The overall morbidity rate was 40%, comprising 445 complications in 274 patients. According to the Dindo–Clavien classification (Table 2), there is no statistical difference between normal, overweight, and obese patients and the grade of complications. The analysis of liver-specific complications showed that respiratory complications ($n = 128$) were the

Table 1 Preoperative characteristics and surgical procedures according to the body mass index (BMI) groups—normal (group A), overweight (group B), and obese (group C)

	Normal	Overweight	Obese	P value	
	(A, $n = 359$) 52%	(B, $n = 228$) 34%	(C, $n = 97$) 14%	A vs. B	A vs. C
Clinical data					
Age > 65 years	84 (23%)	76 (50%)	26 (27%)	<0.01	ns
Male sex	174 (49%)	147 (65%)	57 (59%)	<0.001	ns
Co-morbidities					
Diabetes mellitus	25 (7%)	31 (14%)	19 (20%)	<0.01	<0.001
Hypertension	59 (16%)	78 (34%)	38 (39%)	<0.001	<0.001
Malignancy	221 (62%)	170 (75%)	74 (76%)	<0.01	<0.01
Laboratory tests					
Hemoglobin, mg/dl	12.7 ± 1.6	13.5 ± 1.6	13.4 ± 1.7	<0.001	<0.001
Gamma GT, IU/l	134 ± 175	128 ± 206	141 ± 197	ns[a]	ns[a]
AST, IU/l	47 ± 68	46 ± 95	41 ± 32	ns[a]	ns[a]
Prothrombin time, %	96 ± 13	95 ± 12	93 ± 15	ns	ns
Bilirubin, μmol/l	13.9 ± 7.0	14.6 ± 6.1	14.2 ± 6.1	<0.05[a]	ns[a]
Nontumorous liver					
Steatosis					
30–60%	17 (4.7%)	30 (13%)	27 (28%)	<0.001	<0.001
>60%	2 (0.6%)	12 (5.3%)	11 (11%)	<0.001[b]	<0.001[b]
Fibrosis					
None	221 (62%)	127 (56%)	40 (41%)	ns	<0.001
Grade 1–2	71 (20%)	45 (20%)	27 (28%)	ns	ns
Grade 3–4	67 (19%)	56 (25%)	30 (31%)	ns	<0.01

Values are mean ± SD (range) or number of patients (%)

BMI body mass index (kg/m^2), *Gamma GT* gamma glutamyl transferase, *AST* aspartate aminotransferase, *ns* not significant

[a] Kruskal–Wallis test

[b] Fisher's exact test

most frequent, followed by ascites ($n = 99$), biliary leak ($n = 53$), abdominal collections ($n = 50$), and liver failure ($n = 24$). Blood transfusion during surgery was necessary in 143 (21%) cases, and additional postoperative blood transfusion was required in 30 of these patients. The overall complication rate was not significantly higher in overweight (102/228 44.7%]) and obese (44/97 [45.3%]) patients than in normal patients (128/359 [35.6%]). Analysis of overall risk of respiratory complications showed that none of the 14 patients treated with the laparoscopic approach developed any pulmonary complication.

Hospital stay varied from 4 to 83 days (14 ± 10.2), and 329 (48%) patients stayed more than 3 days in the ICU.

Outcomes of minor hepatectomies

Minor hepatectomies were performed in 261 (38%) patients with a mortality of 2% ($n = 5$) and morbidity of 32% ($n = 83$) (Table 3). Mortality rates were marginally higher in the overweight group (2.2%) as compared to both the normal group (1.7%) and the obese group (1.7%), but the difference was of no statistical significance. However, obese patients had a marginally higher morbidity than normal patients, with only the respiratory complications being significantly higher ($P < 0.05$). A significantly

Table 2 Clavien classification complications according to BMI status of the three groups—normal, overweight, and obese

Clavien grade	Total ($n = 684$)	Normal ($n = 359$)	Overweight ($n = 228$)	Obese ($n = 97$)
Grade II	68	35 (10%)	20 (9%)	13 (13%)
Grade III A	134	61 (17%)	48 (21%)	25 (26%)
Grade III B	24	11 (3%)	11 (5%)	2 (2%)
Grade IV A	25	12 (3%)	11 (5%)	2 (2%)
Grade IV B	4	1 (<1%)	3 (1%)	0 (0%)
Grade V (death)	19	8 (2%)	9 (4%)	2 (2%)

Grade II respiratory infection, ascites, blood transfusions, and asymptomatic pulmonary embolism, *Grade IIIA* respiratory infection (requiring fibroscopy), pleural effusion (requiring drainage), ascites or abdominal collection (requiring percutaneous drainage), *Grade IIIB* reoperation for abdominal collection, bleeding, or another reason, *Grade IVA* liver or renal failure, *Grade IVB* multiple organ failure

Table 3 Minor hepatectomies in normal (group A), overweight (group B), and obese (group C) patients

Total no. of patients 261	Normal	Overweight	Obese	P value	
	(A, $n = 114$) 44%	(B, $n = 90$) 34%	(C, $n = 57$) 22%	A vs. B	A vs. C
Intraoperative data					
Duration of surgery, min	245 ± 87	282 ± 111	298 ± 105	<0.05	<0.001
Pedicular clamping	48 (42%)	35 (40%)	28 (49%)	ns	ns
Duration of clamping, min	40 ± 20	42 ± 31	43 ± 23	ns	ns
Patients transfused	13 (11%)	8 (8.8%)	5 (8.8%)	ns	ns[a]
Postoperative data					
Mortality	2 (1.7%)	2 (2.2%)	1 (1.7%)	ns	ns[a]
Morbidity	31 (27%)	28 (31%)	24 (42%)	ns	ns
Major morbidity Clavien grade 3–5	21 (18%)	22 (24%)	13 (23%)	ns	ns
Minor morbidity Clavien grade 2	10 (9%)	6 (7%)	11 (19%)	ns	<0.05
Respiratory	12 (10%)	11 (12%)	13 (23%)	ns	<0.05
Ascites	9 (8%)	8 (9%)	9 (16%)	ns	ns
Liver failure	1 (0.9%)	0 (0%)	1 (1.8%)	ns[a]	ns[a]
Biliary leak	1 (0.9%)	4 (4.4%)	2 (3.5%)	ns[a]	ns[a]
Abdominal collections	8 (7%)	6 (6.6%)	3 (5.3%)	ns	ns[a]
Other	6 (5.3%)	6 (6.6%)	2 (3.5%)	ns[a]	ns[a]
Hospital stay, days	9 ± 5	10 ± 8	13 ± 9	ns	<0.001
ICU ≥ 4 days	30 (26%)	33 (37%)	27 (47%)	ns	<0.01

Values are mean ± SD (range) or number of patients (%)

[a] Fisher's exact test

ICU intensive care unit

longer operative time was observed in obese and overweight patients as compared to normal patients (298 ± 105 min and 282 ± 111 min vs. 245 ± 87 min, respectively; $P < 0.05$). Hospital and ICU stay were longer in obese than in normal-weight patients ($P < 0.05$).

Outcomes of major hepatectomies

Most of liver resections ($n = 423$ [62%]) in this series were major hepatectomies with a mortality rate of 3.1% ($n = 14$) and morbidity 43% ($n = 185$) (Table 4). Morbidity mainly included respiratory complications (22%) and ascites (17%). Portal clamping was performed in 258 (61%) patients, with a rate of 58%, 61%, and 77% in normal, overweight, and obese patients, respectively (P for trend <0.05). Despite the longer pedicular clamping, nearly half of obese patients (45%) required intraoperative blood transfusion compared to 24% of normal patients ($P < 0.05$) and 28% of overweight patients ($P = 0.06$).

Mortality rates were marginally higher in the overweight group (5%) as compared to the normal (2.5%) and obese (2.5%) groups, but the difference was of no statistical significance. Major morbidity (Clavien grade III and above) was significantly increased in overweight [60/140 (43%)] and obese [18/40 (45%)] patients compared to normal-weight (72/245 [29%]) patients ($P < 0.05$ for both); additionally, hospital stay was longer in obese than in normal ($P < 0.05$) patients. In addition, a longer ICU stay (more than 3 days) was more frequent in obese patients (72%) than in normal patients (53%) ($P < 0.05$).

In multivariate analysis (Table 5), obesity and overweight were independent predictors of major morbidity (OR: 2.6, 95% CI 1.2–5.8, $P < 0.05$ and OR: 1.9, 95% CI 1.2–3.2, $P < 0.01$, respectively), and obesity was an independent predictor of the need for blood transfusion (OR: 3.3, 95% CI 1.4–7.9, $P < 0.05$). In fact, unlike high BMI, steatosis (more than 30%) was not a significant predictor of postoperative complications.

Discussion

Because overweight and obesity play a significant role in the etiology of liver diseases, including hepatocellular carcinoma and colorectal metastasis [8, 36–39], more and more liver resections are being performed for patients with a high BMI.

Few studies in the literature have dwelled on the impact of high BMI on postoperative outcomes after liver resection [17, 29, 30]. Two earlier studies failed to find a

Table 4 Major hepatectomies in normal (group A), overweight (group B), and obese (group C) patients

Total no. of patients 423	Normal	Overweight	Obese	*P* value	
	(A, $n = 245$) 58%	(B, $n = 138$) 33%	(C, $n = 40$) 9%	A vs. B	A vs. C
Intraoperative data					
Duration of surgery, min	350 ± 100	371 ± 108	353 ± 91	ns	ns
Pedicular clamping	142 (58%)	85 (61%)	31 (77%)	ns	ns
Duration of clamping, min	46 ± 25	49 ± 25	56 ± 28	ns	<0.05
Patients transfused	60 (24%)	39 (28%)	18 (45%)	ns	<0.01
Postoperative data					
Mortality	6 (2.5%)	7 (5%)	1 (2.5%)	ns[a]	ns[a]
Morbidity	97 (39.5%)	74 (54%)	20 (50%)	ns	ns
Major (Clavien grade 3–5)	72 (29%)	60 (43%)	18 (45%)	<0.05	<0.05
Minor (Clavien grade 2)	25 (10%)	14 (10%)	2 (5%)	ns	ns
Respiratory	45 (18%)	34 (25%)	13 (32%)	ns	<0.05
Ascites	35 (15%)	25 (18%)	11 (27%)	ns	<0.05
Liver failure	11 (4.5%)	9 (6.5%)	2 (5%)	ns	ns[a]
Biliary leak	24 (9.8%)	18 (13%)	4 (10%)	ns	ns[a]
Abdominal collections	20 (8.2%)	10 (7.2%)	3 (7.5%)	ns	ns[a]
Reoperation	5 (2%)	5 (3.6%)	0 (0%)	ns[a]	ns[a]
Other	13 (5.3%)	14 (10%)	1 (2.5%)	ns	ns[a]
Hospital stay, days	10 ± 7	13 ± 9	14 ± 8	<0.001	<0.01
ICU stay ≥ 4 days	130 (53%)	80 (58%)	29 (72%)	ns	<0.05

[a] Fisher's exact test

Values are mean ± SD (range) or number of patients (%)

significant impact of BMI on the immediate postoperative morbidity and mortality after liver resection. However, in both studies, the threshold limit set for the BMI (25 kg/m^2) did not allow differentiation between obese and overweight. Moreover, the two studies dealt with very specific subgroups of patients, like living donors and re-resections in hepatocellular carcinoma. A recent study found an association between morbid obesity and longer operative time, need for blood transfusion, and greater length of hospital stay. However, the focus of that study was resource utilization [30]. None of the published studies have addressed major and minor liver resections separately; nor have they evaluated complications by a standardized objective classification like the one proposed by Dindo–Clavien [31].

Our study is the first published comprehensive analysis looking at major and minor hepatic resections among patients categorized according to BMI. We have shown that obese and overweight patients have a significantly higher risk of major postoperative morbidity after a major hepatic resection, something not observed in the mortality rate. The interesting finding on the use of the Dindo–Clavien classification was that obese and overweight patients had a higher likelihood of developing potentially life-threatening complications (grade III or more). Considering only minor hepatectomies, obese patients had a higher risk of minor morbidity; however, life-threatening morbidity was similar.

Results of the present study showed that respiratory complications, the most common complication after hepatic resection [40], were significantly more frequent in obese patients, irrespective of the extent of resection. These patients should undergo careful preoperative evaluation associated with weight reduction, whenever possible. In the same way postoperative measures (like incentive spirometry and chest physiotherapy) should be implemented as soon as possible [41, 42]. Interestingly, we found that none of the 14 patients operated by laparoscopy developed respiratory complications. Although a smaller incidence of postoperative morbidity is reported in laparoscopic series of liver resections, most of these series include mainly minor hepatectomies [43, 44]. Comparison of the postoperative respiratory complications in laparoscopic versus open major hepatic resection, especially in obese and overweight patients, would be a crucial subject for future studies.

We found that obese patients submitted to a major hepatectomy had greater blood transfusion requirements despite higher preoperative hemoglobin levels. Also, they required a more frequent and prolonged use of portal triad clamping. The reasons for bleeding in these patients are not clear. It is a common experience that patients with

Table 5 Multivariate logistic regression to determine risk factors after major hepatectomies

Variable	Minor morbidity OR (95% CI) *P*	Major morbidity OR (95% CI) *P*
Age		
<65 years	1	1
≥65 years	2 (0.9–4.8)	1.2 (0.7–2.1)
Sex		
Female	1	1
Male	1.1 (0.5–2.4)	1 (0.6–1.6)
BMI		
Normal	1	1
Overweight	1 (0.4–1.9)	1.9 (1.2–3.2) <0.01
Obese	0.4 (0.2–1.8)	2.6 (1.2–5.8) <0.05
Diabetes		
No	1	1
Yes	0.7 (0.2–2.7)	1.6 (0.8–3.3)
Hypertension		
No	1	1
Yes	0.4 (0.2–1.2)	1.7 (1–2.9)
Liver steatosis		
<30%	1	1
≥30%	2.5 (1–6.4)	1 (0.5–1.8)
Fibrosis		
None	1	1
F1–F2[a]	1.6 (0.7–3.6)	1.1(0.6–1.9)
F3–F4[a]	1 (0.3–2.8)	1.4 (0.7–2.7)
Malignancy		
No	1	1
Yes	1 (0.4–2.5)	0.9 (0.5–1.5)
Liver resection		
3 or 4 segments	1	1
>4 segments	2.8 (1.2–6.4) <0.05	1.5 (0.8–2.9)
Preoperative AST		
<2 N	1	1
≥2 N	0.5 (0.2–1.6)	1.8 (0.9–3.4)
Preoperative PT		
≥75%	1	1
<75%	1.3 (0.3–6.4)	1.9 (0.7–5.3)
Associated procedure		
None	1	1
Minor	0.7 (0.3–1.8)	3.6 (2.1–6.4) <0.01
Major	1.6 (0.6–4.8)	2.3 (1.1–4.9) <0.05

[a] According to the METAVIR score

OR odds ratio, *PT* prothrombin time

Minor morbidity is defined by classification of surgical complications (CSC) as grade II; major morbidity is defined by CSC as grades III–V

increased BMI require higher intraoperative ventilation pressure. This could impair hepatic venous outflow and increase the pressure in the hepatic veins [45, 46], causing troublesome bleeding not stopped by portal triad clamping. Because total vascular exclusion is not always well tolerated [47], clamping of the infrahepatic vena cava, either alone or in association with portal triad clamping [48, 49], could be an option in this context.

Ascites is a commonly encountered complication after a major hepatic resection, especially in patients with chronic liver disease [50]. We also found a higher incidence of postoperative ascites in the obese patients following major hepatectomy, probably the result of a combination of the higher prevalence of fibrosis, longer operative time with overinfusion of fluids, and blood transfusion. Despite a direct correlation between BMI and percentage of liver steatosis, our multivariate statistical model did not reveal steatosis as a significant independent risk factor for complications. The association of high BMI and steatosis has been well documented in the literature [51, 52]. However, there are conflicting reports regarding the impact of steatosis alone on the postoperative outcome after liver resection [15, 18, 51–55]. The threshold of steatosis above which the risk is increased remains unknown, and whether the risk is related to steatosis per se or to the associated inflammation in a context of steato-hepatitis is another matter of concern that deserves study. Our policy requiring performance of a preoperative biopsy of the nontumoral liver to identify steatosis and fibrosis in patients at risk may hide this risk in the present study. Indeed, the presence of severe steatosis, especially associated with fibrosis, led us to perform a portal vein embolization prior to each major resection [56, 57]. This method is useful in evaluating the functional regenerative capacity of the future remnant liver, and it helps to predict a poor liver reserve after hepatic resection [56]. We could also postulate that our usual strategy of hepatic resection via the anterior approach might minimize the injury to a steatotic parenchyma [58].

Results from our study show that the incidence of postoperative liver failure was not influenced by the BMI. This conflicts with the existing evidence in the literature [18, 53], considering the high prevalence of both steatosis and fibrosis in our overweight or obese patients. Apart from our policy of portal vein embolization, the other reason for this result could be our stringent criteria for defining postoperative liver failure, a complication that is highly predictive of postoperative mortality [35]. In fact only 24 of our patients had liver failure according to our criteria, and 50% of them eventually died.

Our finding that BMI does not influence postoperative mortality is similar to the results of the other studies on the subject [17, 29] and in concurrence with the recent observation that obesity, cardiac risk classification [59], diabetes, or systemic hypertension do not predict 30-day mortality in noncardiac major surgical procedures [60]. However, one interesting finding in the pattern of mortality in our series was that the overweight group had a higher death rate than the obese and normal group, although the difference was not statistically significant. This is probably a reflection of the finding that while the "obvious" obese patients are managed with vigilance, the "not so obvious" overweight patients need to be managed with the same degree of caution.

We found that the incidence of diabetes was significantly higher among the patients with higher BMI, but that it was not a significant independent risk factor for postoperative morbidity on multivariate analysis. Nevertheless, diabetes is usually associated with a significant increase in postoperative morbidity after a major surgical procedure [61]. The literature is conflicting concerning the role of diabetes in immediate and long-term outcomes after liver resection [16, 61, 62]. Glycemic control during the postoperative period appears to play a crucial role in reducing postoperative morbidity and mortality in critically ill patients [63]. In our study, we did not analyze the effect of blood sugar control on the postoperative outcomes. One recently published study has shown that obesity, diabetes and smoking are independent factors for utilization of resources due to higher transfusions, operative time, and hospital and ICU stay [30].

In conclusion, obesity and overweight are independent risk factors for life-threatening complications after major hepatic resections. Being overweight or obese should not be a deterrent to a major hepatic surgical intervention. These patients must be approached with caution and should be treated in high-volume, experienced centers, where specially designed protocols could improve these results.

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