**Name of Journal:** *World Journal of Gastrointestinal Surgery*

**Manuscript NO:** 78953

**Manuscript Type:** ORIGINAL ARTICLE

***Retrospective Study***

**Impact of body mass index in elderly patients treated by laparoscopic liver resection for hepatocellular carcinoma**

Conticchio M *et al*. Postoperative outcome in elderly obese patients

Maria Conticchio, Riccardo Inchingolo, Antonella Delvecchio, Francesca Ratti, Maximiliano Gelli, Massimiliano Ferdinando Anelli, Alexis Laurent, Giulio Cesare Vitali, Paolo Magistri, Giacomo Assirati, Emanuele Felli, Taiga Wakabayashi, Patrick Pessaux, Tullio Piardi, Fabrizio di Benedetto, Nicola de’Angelis, Javier Briceño, Antonio Rampoldi, Renè Adam, Daniel Cherqui, Luca Antonio Aldrighetti, Riccardo Memeo

**Maria Conticchio, Antonella Delvecchio, Riccardo Memeo,** Unit of Hepato-Pancreatic-Biliary Surgery, “F. Miulli” Regional General Hospital, Bari 70021, Italy

**Riccardo Inchingolo,** Interventional Radiology Unit, “F. Miulli” Regional General Hospital, Bari 70021, Italy

**Francesca Ratti, Luca Antonio Aldrighetti,** Unit of Hepatobiliary Surgery, San Raffaele Hospital, Milano 20132, Italy

**Maximiliano Gelli,** Department de Chirurgie Viscérale, Gustave Roussy Cancer Campus Grand Paris, Paris 94800, France

**Massimiliano Ferdinando Anelli, Javier Briceño,** Unit of Oncologic and Pancreatic Surgery, Hospital University Reina Sofía, Cordoba 14004, Spain

**Alexis Laurent, Nicola de’Angelis,** Assistance Publique-Hôpitaux de Paris, Department of Digestive and Hepatobiliary Surgery, Centre Hospitalier Universitaire Henri Mondor, Créteil, Paris 94000, France

**Giulio Cesare Vitali,** Service of Abdominal Surgery, Poliambulanza Foundation, Brescia 25124, Italy

**Paolo Magistri, Giacomo Assirati, Fabrizio di Benedetto,** Hepato-Pancreato-Biliary Surgery and Liver Transplantation Unit, University of Modena and Reggio Emilia, Modena 41121, Italy

**Emanuele Felli, Taiga Wakabayashi,** Institut de Recherche Contre les Cancers de l’Appareil Digestif (IRCAD), Strasbourg 67000, France

**Patrick Pessaux,** Service de Chirurgie Viscérale et Digestive, Nouvel Hôpital Civil, Strasbourg 67000, France

**Tullio Piardi,** Department of Surgery, Hôpital Robert Debré, Reims 51092, France

**Antonio Rampoldi,** Interventional Radiology Unit, Niguarda Hospital, Milan 20162, Italy

**Renè Adam, Daniel Cherqui,** Department of Surgery, Centre Hepatobiliaire, Hopital Paul Brousse, Paris 94000, France

**Author contributions:** Conticchio M, Inchingolo R, Delvecchio A, Ratti F, Gelli M, Anelli MF, Laurent A, Vitali GC, Magistri P, Assirati G, Felli E, Wakabayashi T, Pessaux P, Piardi T, di Benedetto F, de’Angelis N, Briceño J, Rampoldi A, Adam R, Cherqui D, Aldrighetti LA, and Memeo R equally contributed to this paper with conception and design of the study, literature review and analysis, manuscript drafting, critical revision, and editing, and approval of the final version.

**Corresponding author: Riccardo Inchingolo, MD, Chief Doctor, Director,** Interventional Radiology Unit, “F. Miulli” Regional General Hospital, Strada Prov 127 Acquaviva-Santeramo Km, 410070021 Acquaviva delle Fonti (BARI), Bari 70021, Italy. riccardoin@hotmail.it

**Received:** July 24, 2022

**Revised:** October 14, 2022

**Accepted:** December 6, 2022

**Published online:** January 27, 2023

**Abstract**

BACKGROUND

The impact of obesity on surgical outcomes in elderly patients candidate for liver surgery is still debated.

AIM

To evaluate the impact of high body mass index (BMI) on perioperative and oncological outcomes in elderly patients (> 70 years old) treated by laparoscopic liver resection for hepatocellular carcinoma (HCC).

METHODS

A retrospective multicenter study including 224 elderly patients (> 70 years old) operated by laparoscopy for HCC (196 with a BMI < 30 and 28 with a BMI ≥ 30) was performed from January 2009 to January 2019.

RESULTS

After propensity score matching, patients in the two groups presented comparable results, in terms of operative time (median range: 200 min *vs* 205 min in non-obese and obese patients, respectively, *P* = 0.7), complication rate (22% *vs* 26%, *P* = 1.0), length of hospital stay (median range: 4.5 d *vs* 6.0 d, *P* = 0.1). There were no significant differences in terms of short- and long-term postoperative results.

CONCLUSION

The present study showed that BMI does not impact perioperative and oncologic outcomes in elderly patients treated by laparoscopic resection for HCC.

**Key Words:** Hepatocellular carcinoma; Body mass index; Laparoscopy; Surgical resection; Elderly patients; Propensity score matching

**©The Author(s) 2023.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Citation:** Conticchio M, Inchingolo R, Delvecchio A, Ratti F, Gelli M, Anelli MF, Laurent A, Vitali GC, Magistri P, Assirati G, Felli E, Wakabayashi T, Pessaux P, Piardi T, di Benedetto F, de’Angelis N, Briceño J, Rampoldi A, Adam R, Cherqui D, Aldrighetti LA, Memeo R. Impact of body mass index in elderly patients treated by laparoscopic liver resection for hepatocellular carcinoma. *World J Gastrointest Surg* 2023; 15(1): 72-81

**URL**: https://www.wjgnet.com/1948-9366/full/v15/i1/72.htm

**DOI**: https://dx.doi.org/10.4240/wjgs.v15.i1.72

**Core Tip:** In order to evaluate the impact of high body mass index (BMI) in elderly patients who underwent laparoscopic resection for hepatocellular carcinoma (HCC), we compared perioperative data and long-term outcomes of patients from 10 European centers before and after propensity score matching. The present study showed that BMI does not impact perioperative and oncologic outcomes in elderly patients treated by laparoscopic resection for HCC.

**INTRODUCTION**

Obesity is a significant contributing factor for the development of liver disease, starting from the stage of non-alcoholic steatohepatitis up to cirrhosis and hepatocellular carcinoma (HCC)[1-4]. Due to the constant increase of population aging, the treatment of HCC in elderly obese patient has become a global clinical issue[5]. Laparoscopic liver resection (LLR) provides the benefits of minimally invasive approach in terms of short-term outcomes[6,7], guaranteeing oncological results comparable to the open surgical approach[8,9]. However, data about the impact of obesity in patients undergoing LLR remain controversial, with some studies reporting higher body mass index (BMI) as a predictor of an adverse postoperative outcome[10] and other studies not reporting an increased risk of postoperative morbidity linked to obesity[11]. The aim of this study was to evaluate the impact of BMI in elderly patients undergoing LLR for HCC, by comparing short- and long-term outcomes.

**MATERIALS AND METHODS**

This multicenter retrospective study included 224 patients treated between January 2009 and January 2019, at the following centers: Policlinico di Bari, Bari, Italy; Policlinico di Modena, Modena, Italy; Ospedale San Raffaele, Milan, Italy; Grande Ospedale Metropolitano Niguarda, Milan, Italy; Centre hépato-biliaire Paul Brousse, Villejuif, France; Hôpitaux Universitaires Henri Mondor, Créteil, France; Hospital Universitario Sofía, Córdoba, Spain; Hôpitaux Universitaires de Genève, Geneva, Switzerland; Nouvel Hôpital Civil, Strasbourg, France; Centre Hospitalier Universitaire, Reims, France.

This study investigated patients resected for HCC demonstrating the following inclusion criteria: Child-Pugh class A and B disease; age ≥ 70 years; no evidence of major vessel branch invasion and no distant metastases. Based on the World Health  
Organization (WHO) definition of obesity (BMI > 30 kg/m2)[12], the patients were divided into the following two groups: BMI < 30 kg/m2 group and BMI > 30 kg/m2 group.

The diagnosis of HCC was done, according to the European Association for Study of Liver (EASL) consensus criteria[13], based on non-invasive findings or histopathology. The type of treatment was planned following multidisciplinary tumor board discussions.

***LLR procedure***

The surgical procedure was planned based on tumor features and liver function. Minor and major liver resections were performed according to Brisbane classification[14]. The choice of position and the size of trocars depended on tumor location. Intraoperative ultrasonography represented a standardized initial step of surgical procedure. Liver parenchymal transection was performed with laparoscopic instruments using various energy devices such as the cavitation ultrasonic surgical aspirator and ultrasonic, monopolar and bipolar forceps. The extent of resection depended on the size and anatomical location of the tumor and it was defined as “minor” for the resection of two or fewer Couinaud’s liver segments, and ‘major’ for the resection ≥ 3 liver segments. The hepatic hilum was prepared for the Pringle’s maneuver. The specimen was placed in an endocatch bag and removed from one of the trocars’ incision sites.

***Follow-up***

Short-term outcomes after liver resection included the evaluation of the parameters in the perioperative period, including intraoperative variables such as operative time and blood transfusion rate, and postoperative variables such as complication rate (based on the Clavien-Dindo classification[15]) and length of hospitalization. Long-term outcomes included oncological results in terms of overall survival (OS) and disease-free survival (DFS). Liver blood tests were assessed on the first, third, and fifth postoperative days. Follow-up was performed once every 3 mo during the first year and every 4 mo thereafter with CT-scan and blood tests (including liver function and oncologic markers). Recurrence after treatment included repeat resection, locoregional treatment, liver transplantation, or supportive care based on the patient’s general status and liver disease according to the EASL-EORTC clinical practice guidelines[13].

***Statistical analysis***

Statistical analyses were carried out using the IBM SPSS Statistics 20 software. The *t*-test and Mann-Whitney *U* test were used to compare continuous variables. The chi-square test and Kruskal-Wallis test were performed to compare categorical variables. The Kaplan-Meier method was used to assess recurrence-free survival (RFS) and OS curves. The Cox proportional hazard model was used to analyse independent prognostic factors of long-term survival. A propensity score matching (PSM) analysis was performed to reduce selection bias, obtaining two more homogeneous matched groups of patients in the resection and ablation groups. Variables included in our propensity model included age, number of comorbidities ≥ 2, American Society of Anesthesiologists (ASA) score, Child-Pugh and model for end-stage liver disease (MELD) scores, extent of resection, and tumor number and size. A one-to-one PSM was performed with a caliper width of < 0.2 of the pooled standard deviation of estimated propensity scores, applying these variables to a logistic regression model and calculating C-statistics. A total of 27 out of the 196 patients in the BMI < 30 group and a total of 27 out of the 28 patients in the BMI > 30 group were matched for further analyses.

**RESULTS**

***Before PSM***

We included 224 patients treated by LLR for HCC and aged ≥ 70 years. One hundred and ninety-six patients presented a BMI < 30 kg/m2 and 28 presented a BMI > 30 kg/m2. Demographic data were similar between the two groups, except for a higher rate of males in the BMI ≥ 30 kg/m2 group than in the BMI < 30 kg/m2 group (69% *vs* 93%, *P* = 0.001). Associated comorbidities were not increased in obese patients, as ASA and MELD score (Table 1).

Perioperative and postoperative data are described in Table 2. There were no significant differences in surgical time (median range: 200 min *vs* 220 min in the BMI < 30 and BMI > 30 groups, respectively, *P* = 0.70), rate of blood transfusion (16% *vs* 3%, *P* = 0.09), and length of hospitalization (median range: 6.0 d *vs* 5.5 d, *P* = 0.20)

The global rate of postoperative complications was higher in the non-obese group (47% *vs* 25%, *P* = 0.02) compared to the obese group. Only the rate of wound infection was higher in the obese group (11% *vs* 2%, *P* = 0.04).

The 90-d mortality rate did not present a significant difference between the two groups (5% in BMI < 30 group and 0% in BMI > 30 group, *P* = 0.60). The estimated 1- and 3-year OS rates were 100% and 92.3% in the BMI > 30 group, and 96% and 91.4% in the BMI < 30 group (*P* = 0.004; Figure 1A), respectively. The estimated 1- and 3-year DFS rates were 96% and 67% in the BMI > 30 group, and 82% and 36% in the BMI < 30 group (*P* = 0.50; Figure 1B), respectively.

***After PSM***

After matching, we obtained a more homogeneous population for both groups (Table 1). The variables included in the PSM were age, comorbidities, ASA and MELD scores, Child-Pugh score, tumor size, tumor number, and extent of resection. Perioperative and postoperative results are analytically described in Table 2. The postoperative follow up did not reveal any difference in the complication rate between the BMI > 30 and BMI < 30 groups (26% *vs* 22%, *P* = 1.0), nor in grade of severity (Clavien-Dindo grades III-IV) (4% *vs* 7%, *P* = 0.6). Moreover, operative time (median range: 205 min *vs* 200 min, *P* = 0.7) and rate of blood transfusion (3% *vs* 18%, *P* = 0.2) were similar. The estimated 1- and 3-year OS rates were 100% and 92.3% in the BMI > 30 group, and 88.4% and 83.5% in the BMI < 30 group (*P* = 0.2; Figure 1C), respectively.

The estimated 1- and 3-year DFS rates were 96.2% and 65.8% in the BMI > 30 group, and 87.5% and 86.2% in the BMI < 30 group (*P* = 0.5; Figure 1D), respectively.

**DISCUSSION**

The impact of obesity on surgical results in elderly patients who underwent liver resections remains a subject of vivid debate. An increased surgical risk has been expected because of comorbidities associated with obesity and old age, underlying liver disease, and technical difficulties[16-20]. Our multicenter study did not confirm this hypothesis and showed that LLR can be safely performed in treatment of HCC also in elderly patients with a BMI ≥ 30 kg/m2. The evaluation of the influence of BMI in elderly population is important because of the increasing prevalence of this condition associated with an higher average life expectancy[21,22].

The increasing BMI has been reported as a predisposition to develop various diseases, including diabetes mellitus, hypertension, respiratory disease, and certain types of cancer[23-25]. Our data did not show differences in term of rate of comorbidities or tumor characteristics, even after PMS analysis, according to various preoperative parameters (age, comorbidities, ASA and MELD scores, Child-Pugh score, tumor size, tumor number, and extent of resection), which resulted in a more homogeneous and therefore comparable population.

Even though the initial hypothesis that obesity negatively affected the outcomes of minimally invasive approach was not verified[26], data regarding LLR in obese patients were controversial. After the evaluation of surgical procedures ended with Second International Consensus Conference on LLR[27], a scoring system was built to stratify LLR into groups with increasing degree of difficulty[28]. This IWATE score aimed to preoperatively predict the technical difficulty of various LLR, but without including body habitus. So, the question whether anthropometric variables really have an impact on perioperative outcomes remains.

Using operative time, rate of blood transfusion, and rate of conversion as surrogates of surgical difficulty, Ome *et al*[29] reported significantly longer median operation time in obese compared to non-obese patients, while Uchida *et al*[30] found that BMI was an independent predictor of longer operative time > 200 min. Lee *et al*[31] reported a significant difference in operative time and incidence of blood transfusion in overweight compared to normal weight patients, but no difference for obese patients. In accordance to the abovementioned data, the results of this study also suggest similar rate of blood transfusion and operative time in patients with a BMI < 30 kg/m2 and those with a BMI ≥ 30 kg/m2.

The advantages of a minimally invasive approach in liver surgery, including lower abdominal wall morbidity and early postoperative rehabilitation[32,33], may be more beneficial for the subgroup of obese patients. A recent systematic review[34] reported similar rates of postoperative complications between obese and non-obese patients, although several issues including discrepancy in the obesity definition, limit the validity of these results. Nomi *et al*[35] reported that the postoperative course of obese patients was not negatively affected by a higher incidence of infectious complications nor liver specific complications. Yu *et al*[36] reported a higher rate of bile leak in obese compared to non-obese patients. The herein presented data demonstrate a similar postoperative outcome, with no significant differences in major complications (Clavien-Dindo III-IV) nor liver related complications in obese compared to non-obese patients.

View magnification of and optimal exposure with liver mobilization, as well as the increase of dedicated tools, allow a clearer visualization of deep structures, small vessels, and biliary ducts[7,36,37]. The authors speculate that this “power” of laparoscopy can justify a lower rate of postoperative complications not only in terms of preservation of abdominal wall integrity, linked with prevention of respiratory diseases and reduction of postoperative pain, but also with a greater accuracy in resection technique, especially in the hands of experienced surgeons.

Oncological outcomes following PSM were also similar, as no differences were noted in DFS and OS in obese *vs* non-obese patients undergoing LLR for HCC. This is also in accordance with the majority of published data[34]. These results suggest that elderly obese patients can also benefit from surgical treatment in terms of long-term outcomes, mainly driven by the excellent short-term outcome of laparoscopy.

**CONCLUSION**

In conclusion, according to the present study, BMI does not impact surgical outcomes of LLR in elderly patients treated for HCC. Thorough patient selection, based on liver volume and function evaluation, as well as patient habitus and comorbidities, could result in safe and feasible LLR in elderly obese patients.

**ARTICLE HIGHLIGHTS**

***Research background***

A high body mass index (BMI) could represent a factor which impacts perioperative outcomes in elderly patients who underwent laparoscopic liver resection (LLR).

***Research motivation***

To evaluate postoperative outcomes between elderly (age > 70 years) patients with a BMI ≥ 30 and BMI < 30 who underwent a LLR for hepatocellular carcinoma (HCC).

***Research objectives***

To analyse short- (perioperative) and long-term (oncological results) outcomes.

***Research methods***

The analysis of data was performed before and after propensity score matching.

***Research results***

After propensity score matching, patients in the two groups presented comparable results, in terms of operative time, complication rate, and length of hospital stay. There were no significant differences in terms of short- and long-term postoperative results.

***Research conclusions***

The present study showed that BMI does not impact perioperative and oncologic outcomes in elderly patients treated by laparoscopic resection for HCC.

***Research perspectives***

Randomized controlled studies are needed to better explore these results.

**REFERENCES**

1 **Kleiner DE**, Brunt EM, Van Natta M, Behling C, Contos MJ, Cummings OW, Ferrell LD, Liu YC, Torbenson MS, Unalp-Arida A, Yeh M, McCullough AJ, Sanyal AJ; Nonalcoholic Steatohepatitis Clinical Research Network. Design and validation of a histological scoring system for nonalcoholic fatty liver disease. *Hepatology* 2005; **41**: 1313-1321 [PMID: 15915461 DOI: 10.1002/hep.20701]

2 **Pascale A**, Pais R, Ratziu V. An overview of nonalcoholic steatohepatitis: past, present and future directions. *J Gastrointestin Liver Dis* 2010; **19**: 415-423 [PMID: 21188334]

3 **Ascha MS**, Hanouneh IA, Lopez R, Tamimi TA, Feldstein AF, Zein NN. The incidence and risk factors of hepatocellular carcinoma in patients with nonalcoholic steatohepatitis. *Hepatology* 2010; **51**: 1972-1978 [PMID: 20209604 DOI: 10.1002/hep.23527]

4 **Caldwell SH**, Crespo DM, Kang HS, Al-Osaimi AM. Obesity and hepatocellular carcinoma. *Gastroenterology* 2004; **127**: S97-103 [PMID: 15508109 DOI: 10.1053/j.gastro.2004.09.021]

5 **Zhao LY**, Huo RR, Xiang X, Torzilli G, Zheng MH, Yang T, Liang XM, Huang X, Tang PL, Xiang BD, Li LQ, You XM, Zhong JH. Hepatic resection for elderly patients with hepatocellular carcinoma: a systematic review of more than 17,000 patients. *Expert Rev Gastroenterol Hepatol* 2018; **12**: 1059-1068 [PMID: 30145919 DOI: 10.1080/17474124.2018.1517045]

6 **Nguyen KT**, Marsh JW, Tsung A, Steel JJ, Gamblin TC, Geller DA. Comparative benefits of laparoscopic vs open hepatic resection: a critical appraisal. *Arch Surg* 2011; **146**: 348-356 [PMID: 21079109 DOI: 10.1001/archsurg.2010.248]

7 **Martin RC**, Scoggins CR, McMasters KM. Laparoscopic hepatic lobectomy: advantages of a minimally invasive approach. *J Am Coll Surg* 2010; **210**: 627-634, 634-636 [PMID: 20421019 DOI: 10.1016/j.jamcollsurg.2009.12.022]

8 **Abu Hilal M**, Aldrighetti L, Dagher I, Edwin B, Troisi RI, Alikhanov R, Aroori S, Belli G, Besselink M, Briceno J, Gayet B, D'Hondt M, Lesurtel M, Menon K, Lodge P, Rotellar F, Santoyo J, Scatton O, Soubrane O, Sutcliffe R, Van Dam R, White S, Halls MC, Cipriani F, Van der Poel M, Ciria R, Barkhatov L, Gomez-Luque Y, Ocana-Garcia S, Cook A, Buell J, Clavien PA, Dervenis C, Fusai G, Geller D, Lang H, Primrose J, Taylor M, Van Gulik T, Wakabayashi G, Asbun H, Cherqui D. The Southampton Consensus Guidelines for Laparoscopic Liver Surgery: From Indication to Implementation. *Ann Surg* 2018; **268**: 11-18 [PMID: 29064908 DOI: 10.1097/SLA.0000000000002524]

9 **Buell JF**, Cherqui D, Geller DA, O'Rourke N, Iannitti D, Dagher I, Koffron AJ, Thomas M, Gayet B, Han HS, Wakabayashi G, Belli G, Kaneko H, Ker CG, Scatton O, Laurent A, Abdalla EK, Chaudhury P, Dutson E, Gamblin C, D'Angelica M, Nagorney D, Testa G, Labow D, Manas D, Poon RT, Nelson H, Martin R, Clary B, Pinson WC, Martinie J, Vauthey JN, Goldstein R, Roayaie S, Barlet D, Espat J, Abecassis M, Rees M, Fong Y, McMasters KM, Broelsch C, Busuttil R, Belghiti J, Strasberg S, Chari RS; World Consensus Conference on Laparoscopic Surgery. The international position on laparoscopic liver surgery: The Louisville Statement, 2008. *Ann Surg* 2009; **250**: 825-830 [PMID: 19916210 DOI: 10.1097/sla.0b013e3181b3b2d8]

10 **Mathur AK**, Ghaferi AA, Osborne NH, Pawlik TM, Campbell DA, Englesbe MJ, Welling TH. Body mass index and adverse perioperative outcomes following hepatic resection. *J Gastrointest Surg* 2010; **14**: 1285-1291 [PMID: 20532666 DOI: 10.1007/s11605-010-1232-9]

11 **Utsunomiya T**, Okamoto M, Kameyama T, Matsuyama A, Yamamoto M, Fujiwara M, Mori M, Aimitsu S, Ishida T. Impact of obesity on the surgical outcome following repeat hepatic resection in Japanese patients with recurrent hepatocellular carcinoma. *World J Gastroenterol* 2008; **14**: 1553-1558 [PMID: 18330947 DOI: 10.3748/wjg.14.1553]

12 Obesity: preventing and managing the global epidemic. Report of a WHO consultation. *World Health Organ Tech Rep Ser* 2000; **894**: i-xii, 1-253 [PMID: 11234459]

13 **European Association for the Study of the Liver**. EASL Clinical Practice Guidelines: Management of hepatocellular carcinoma. *J Hepatol* 2018; **69**: 182-236 [PMID: 29628281 DOI: 10.1016/j.jhep.2018.03.019]

14 **Pang YY**. The Brisbane 2000 terminology of liver anatomy and resections. HPB 2000; 2:333-39. *HPB (Oxford)* 2002; **4**: 99; author reply 99-99; author reply100 [PMID: 18332933]

15 **Dindo D**, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004; **240**: 205-213 [PMID: 15273542 DOI: 10.1097/01.sla.0000133083.54934.ae]

16 **Berkalp B**, Cesur V, Corapcioglu D, Erol C, Baskal N. Obesity and left ventricular diastolic dysfunction. *Int J Cardiol* 1995; **52**: 23-26 [PMID: 8707431 DOI: 10.1016/0167-5273(95)02431-u]

17 **Pi-Sunyer FX**. Medical hazards of obesity. *Ann Intern Med* 1993; **119**: 655-660 [PMID: 8363192 DOI: 10.7326/0003-4819-119-7\_part\_2-199310011-00006]

18 **Veteläinen R**, van Vliet A, Gouma DJ, van Gulik TM. Steatosis as a risk factor in liver surgery. *Ann Surg* 2007; **245**: 20-30 [PMID: 17197961 DOI: 10.1097/01.sla.0000225113.88433.cf]

19 **McCormack L**, Petrowsky H, Jochum W, Furrer K, Clavien PA. Hepatic steatosis is a risk factor for postoperative complications after major hepatectomy: a matched case-control study. *Ann Surg* 2007; **245**: 923-930 [PMID: 17522518 DOI: 10.1097/01.sla.0000251747.80025.b7]

20 **Kooby DA**, Fong Y, Suriawinata A, Gonen M, Allen PJ, Klimstra DS, DeMatteo RP, D'Angelica M, Blumgart LH, Jarnagin WR. Impact of steatosis on perioperative outcome following hepatic resection. *J Gastrointest Surg* 2003; **7**: 1034-1044 [PMID: 14675713 DOI: 10.1016/j.gassur.2003.09.012]

21 **NCD Risk Factor Collaboration (NCD-RisC)**. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet* 2017; **390**: 2627-2642 [PMID: 29029897 DOI: 10.1016/S0140-6736(17)32129-3]

22 **Woolf AD**. Number 17 World Health Organization World Report on Ageing and Health. *J Can Rheumatol Assoc* 2018

23 **Henry ZH**, Caldwell SH. Obesity and Hepatocellular Carcinoma: A Complex Relationship. *Gastroenterology* 2015; **149**: 18-20 [PMID: 26008860 DOI: 10.1053/j.gastro.2015.05.024]

24 **Bianchini F**, Kaaks R, Vainio H. Overweight, obesity, and cancer risk. *Lancet Oncol* 2002; **3**: 565-574 [PMID: 12217794 DOI: 10.1016/s1470-2045(02)00849-5]

25 **Mokdad AH**, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, Marks JS. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 2003; **289**: 76-79 [PMID: 12503980 DOI: 10.1001/jama.289.1.76]

26 **Loffer FD**, Pent D. Laparoscopy in the obese patient. *Am J Obstet Gynecol* 1976; **125**: 104-107 [PMID: 132120 DOI: 10.1016/0002-9378(76)90902-9]

27 **Wakabayashi G**, Cherqui D, Geller DA, Buell JF, Kaneko H, Han HS, Asbun H, OʼRourke N, Tanabe M, Koffron AJ, Tsung A, Soubrane O, Machado MA, Gayet B, Troisi RI, Pessaux P, Van Dam RM, Scatton O, Abu Hilal M, Belli G, Kwon CH, Edwin B, Choi GH, Aldrighetti LA, Cai X, Cleary S, Chen KH, Schön MR, Sugioka A, Tang CN, Herman P, Pekolj J, Chen XP, Dagher I, Jarnagin W, Yamamoto M, Strong R, Jagannath P, Lo CM, Clavien PA, Kokudo N, Barkun J, Strasberg SM. Recommendations for laparoscopic liver resection: a report from the second international consensus conference held in Morioka. *Ann Surg* 2015; **261**: 619-629 [PMID: 25742461 DOI: 10.1097/SLA.0000000000001184]

28 **Ban D**, Tanabe M, Ito H, Otsuka Y, Nitta H, Abe Y, Hasegawa Y, Katagiri T, Takagi C, Itano O, Kaneko H, Wakabayashi G. A novel difficulty scoring system for laparoscopic liver resection. *J Hepatobiliary Pancreat Sci* 2014; **21**: 745-753 [PMID: 25242563 DOI: 10.1002/jhbp.166]

29 **Ome Y**, Hashida K, Yokota M, Nagahisa Y, Okabe M, Kawamoto K. The safety and efficacy of laparoscopic hepatectomy in obese patients. *Asian J Surg* 2019; **42**: 180-188 [PMID: 29273265 DOI: 10.1016/j.asjsur.2017.10.002]

30 **Uchida H**, Iwashita Y, Saga K, Takayama H, Watanabe K, Endo Y, Yada K, Ohta M, Inomata M. Benefit of laparoscopic liver resection in high body mass index patients. *World J Gastroenterol* 2016; **22**: 3015-3022 [PMID: 26973397 DOI: 10.3748/wjg.v22.i10.3015]

31 **Lee SJ**, Hauch A, Kane E, DuCoin C, Darden M, Parker G, Kandil E, Buell JF. Effect of Obesity on Perioperative Outcomes after Laparoscopic Hepatectomy. *Hepatoma Res* 2016 [DOI: 10.20517/2394-5079.2016.34]

32 **Nomi T**, Fuks D, Kawaguchi Y, Mal F, Nakajima Y, Gayet B. Laparoscopic major hepatectomy for colorectal liver metastases in elderly patients: a single-center, case-matched study. *Surg Endosc* 2015; **29**: 1368-1375 [PMID: 25149638 DOI: 10.1007/s00464-014-3806-1]

33 **Delvecchio A**, Conticchio M, Ratti F, Gelli M, Anelli FM, Laurent A, Vitali GC, Magistri P, Assirati G, Felli E, Wakabayashi T, Pessaux P, Piardi T, Di Benedetto F, de'Angelis N, Briceño-Delgado J, Adam R, Cherqui D, Aldrighetti L, Memeo R. Laparoscopic major hepatectomy for hepatocellular carcinoma in elderly patients: a multicentric propensity score‑based analysis. *Surg Endosc* 2021; **35**: 3642-3652 [PMID: 32748269 DOI: 10.1007/s00464-020-07843-7]

34 **Kwan B**, Waters PS, Keogh C, Cavallucci DJ, O'Rourke N, Bryant RD. Body mass index and surgical outcomes in laparoscopic liver resections: a systematic review. *ANZ J Surg* 2021; **91**: 2296-2307 [PMID: 33682289 DOI: 10.1111/ans.16674]

35 **Nomi T**, Fuks D, Ferraz JM, Kawaguchi Y, Nakajima Y, Gayet B. Influence of body mass index on postoperative outcomes after laparoscopic liver resection. *Surg Endosc* 2015; **29**: 3647-3654 [PMID: 25737295 DOI: 10.1007/s00464-015-4121-1]

36 **Yu HB**, Dong YD, Wang LC, Tian GJ, Mu SM, Cao Y, Peng YN, Lou CY, Liu P, Li DY. Laparoscopic Liver Resection can be an Effective Way in Obese Patients: A Single Center of 2-Year Experience. *Surg Laparosc Endosc Percutan Tech* 2016; **26**: e69-e72 [PMID: 27258919 DOI: 10.1097/SLE.0000000000000268]

37 **Vibert E**, Perniceni T, Levard H, Denet C, Shahri NK, Gayet B. Laparoscopic liver resection. *Br J Surg* 2006; **93**: 67-72 [PMID: 16273531 DOI: 10.1002/bjs.5150]

**Footnotes**

**Institutional review board statement:** This study did not require the approval by the Ethics Committee of the Azienda Ospedaliera Universitaria Policlinico of Bari, General Regional Hospital “F. Miulli”, Acquaviva delle Fonti (BA), San Raffaele Hospital of Milan, Gustave Roussy Cancer Campus Grand Paris of Paris, Hospital University Reina Sofía of Córdoba, Centre Hospitalier Universitaire Henri Mondor of Paris, Geneva University Hospitals and Medical School of Geneva, University of Modena and Reggio Emilia of Modena, Institut de Recherche Contre les Cancers de l’Appareil Digestif (IRCAD) of Strasbourg, Hôpital Robert Debré of Reims, Niguarda Hospital of Milan, and Centre Hepatobiliaire, Hopital Paul Brousse of Paris.

**Informed consent statement:** Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written consent.

**Conflict-of-interest statement:** All the authors are aware of the content of the manuscript and have no conflict of interest to disclose.

**Data sharing statement:** No additional data are available.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

**Provenance and peer review:** Invited article; Externally peer reviewed.

**Peer-review model:** Single blind

**Peer-review started:** July 24, 2022

**First decision:** September 19, 2022

**Article in press:** December 6, 2022

**Specialty type:** Surgery

**Country/Territory of origin:** Italy

**Peer-review report’s scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): B

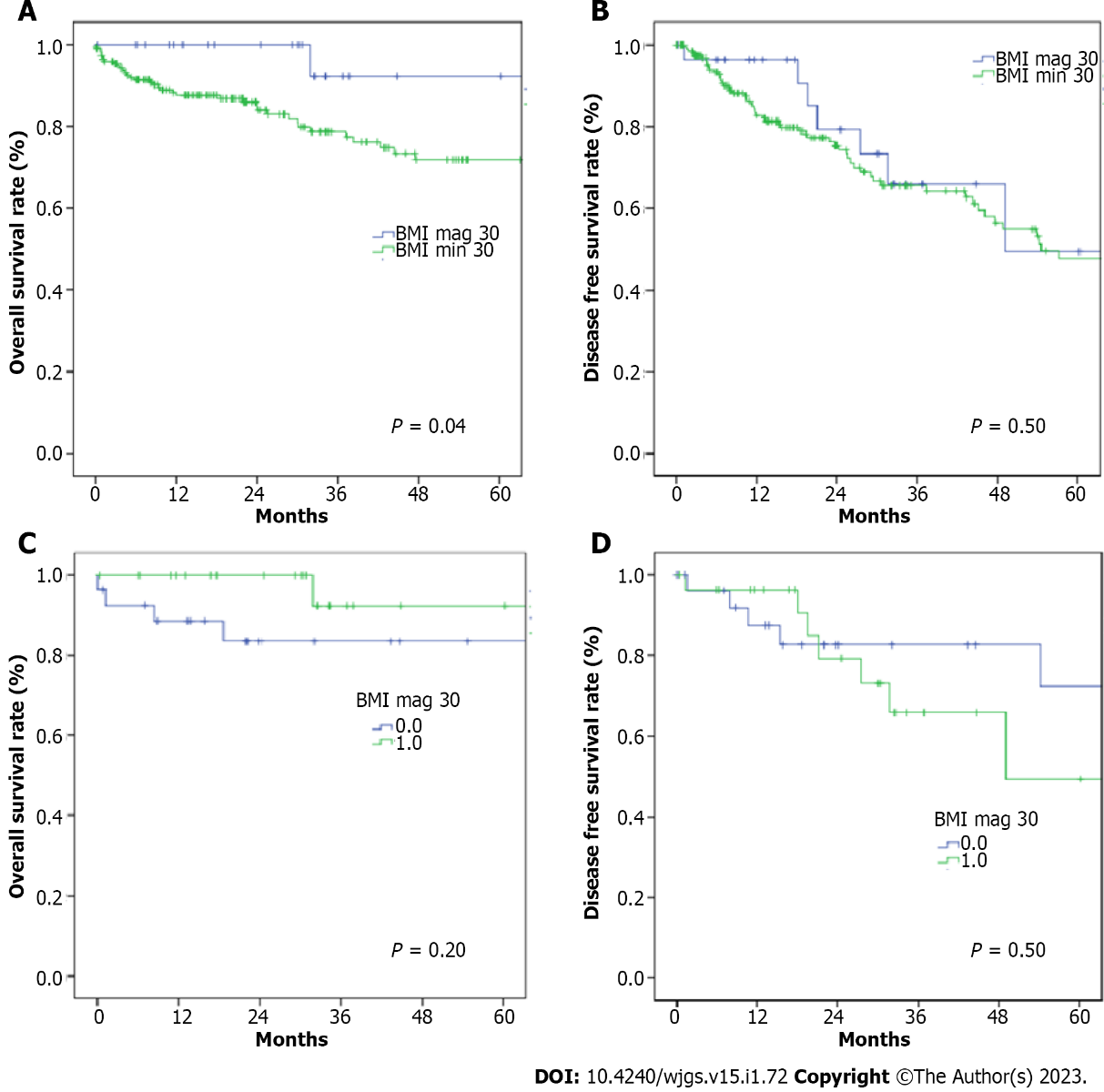
Grade C (Good): C

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Zhang XQ, China; Zhang CZ, China **S-Editor:** Chen YL **L-Editor:** Wang TQ **P-Editor:** Chen YL

**Figure Legends**



**Figure 1 Survival curves and tumor recurrence curves (Kaplan-Meier method) of elderly patients with hepatocellular carcinoma with a body mass index < 30 or ≥ 30 who underwent laparoscopic liver resection before propensity score matching.** A: Overall survival (OS) curves were constructed using the Kaplan-Meier method and compared using the log-rank test. OS significantly did not differ between the two groups; B: Recurrence-free survival (RFS) curves were constructed using the Kaplan-Meier method and compared using the log-rank test. Hepatocellular carcinoma recurrence significantly differed between the two groups; C: OS curves were constructed using the Kaplan-Meier method and compared using the log-rank test. After propensity score matching, survival remained significantly different; D: RFS curves were constructed using the Kaplan-Meier method and compared using the log-rank test. After propensity score matching, recurrence remained significantly different. BMI: Body mass index.

**Table 1 Preoperative and clinical characteristics of elderly patients with hepatocellular carcinoma with a body mass index < 30 or ≥ 30 who underwent laparoscopic liver resection**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **LLR before PSM (224)** | | | **After PSM (54)** | | |
| **BMI < 30 (196)** | **BMI ≥ 30 (28)** | ***P*** | **BMI < 30 (27)** | **BMI ≥ 30 (27)** | ***P*** |
| MALE | 135 (69) | 26 (93) | 0.00 | 17 | 25 | 0.02 |
| Age (yr), median (range) | 75.2 (69.5-90.0) | 75.3 (69.7-86.6) | 0.70 | 76.3 (70.6-81.2) | 73.1 (70-82.3) | 0.70 |
| BMI (kg/cm²), median (range) | 26.7 (19.0-29.0) | 32.5 (30.0-52.0) | 0.00 | 26.7 (25.0-267.0) | 33 (30-37) |  |
| Co-morbidities > 2, *n* (%) | 77 (80) | 9 (32) | 0.50 | 14 | 9 | 0.27 |
| Cause of Cirrhosis, *n* (%) |  |  |  |  |  |  |
| Hepatitis C virus | 102 (52) | 12 (43) | 0.40 | 16 | 11 | 0.27 |
| Hepatitis B virus | 39 (20) | 4 (14) | 0.60 | 7 | 4 | 0.50 |
| Alcohol | 23 (12) | 7 (25) | 0.07 | 1 | 7 | 0.05 |
| Others | 32 (16) | 5 (18) | 0.80 | 3 | 5 | 0.70 |
| ASA score, *n* (%) |  |  | 0.80 |  |  | 1.00 |
| I-II | 84 (43) | 11 (39) |  | 10 | 10 |  |
| III-IV | 112 (57) | 17 (61) |  | 17 | 17 |  |
| Blood tests median (range) |  |  |  |  |  |  |
| Bilirubin (mg/dL) | 0.9 (0.2-4.2) | 0.9 (0.2-2.1) | 0.8 | 0.9 (0.3-1.1) | 0.5 (0.2-1.1) | 0.70 |
| Creatinine (mg/dL) | 0.9 (0.2-2.5) | 0.9 (0.4-1.9) | 1.00 | 0.9 (0.8-1.5) | 0.9 (0.7-2) | 0.80 |
| Platelet count, × 109/L | 176 (45-421) | 187 (72-468) | 0.3 | 144 (47-337) | 168 (117-396) | 0.80 |
| INR | 1.1 (0.6-2.0) | 1.08 (0.7-1.67) | 0.3 | 1.1 (1-1.5) | 1 (1-1.3) | 0.50 |
| CHILD-PUGH, *n* (%) |  |  | 0.2 |  |  | 1.00 |
| A | 177 (90) | 23 (82) |  | 23 | 22 |  |
| B | 19 (68) | 5 (18) |  | 4 | 5 |  |
| MELD median (range) | 6 (6-16) | 6 (6-13) | 0.6 | 8 (6-12.5) | 8 (6-13) | 0.40 |
| Tumors number *n* (%) |  |  | 0.06 |  |  | 1.00 |
| Single nodule | 191 (97) | 25 (89) |  | 24 | 24 |  |
| Multi nodules | 5 (3) | 3 (11) |  | 3 | 3 |  |
| Tumors size (mm), median (range) | 30 (9-50) | 30 (18-50) | 0.6 | 30 (9-50) | 27 (24-35) | 0.30 |
| Bilobar tumor, *n* (%) | 1 (0.5) | 1 (3) | 0.2 | 1 | 1 | 1.00 |
| Tumor in PS segment, *n* (%) | 41 (21) | 6 (21) | 1.00 | 5 | 5 | 1.00 |
| Histologically proven *n* (%) | 31 (16) | 8 (29) | 0.11 |  |  |  |
| Previous treatment, *n* (%) | 12 (6) | 3 (10) | 0.4 |  |  |  |
| Major hepatectomy, *n* (%) | 22 (11) | 2 (7) | 0.7 | 1 | 2 | 1.00 |
| Operative time > 240 min | 73 (37) | 12 (43) | 0.7 | 150 (80-210) | 150 (65-155) | 0.70 |

Continuous variables were compared using an independent sample *t*-test and Mann-Whitney *U* test. Categorical variables were compared using the chi-square test and Kruskal-Wallis test respectively. LLR: Laparoscopic liver resection; PSM: Propensity score matching; HCC: Hepatocellular carcinoma; BMI: Body mass index; ASA: American Society of Anesthesiologists; MELD: Model for End Stage Liver Disease.

**Table 2 Preoperative and clinical characteristics of elderly patients with hepatocellular carcinoma with a 30 > body mass index ≥ 30 who underwent laparoscopic liver resection**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **LLR before PSM (224)** | | | **After PSM (54)** | | |
| **BMI < 30 (196)** | **BMI ≥ 30 (28)** | ***P*** | **BMI < 30 (27)** | **BMI ≥ 30 (27)** | ***P*** |
| Operative time (min), median (range) | 200 (70-600) | 220 (65-337) | 0.70 | 200 (80-320) | 205 (65-337) | 0.7 |
| Blood transfusion, *n* (%) | 32 (16) | 1 (3) | 0.09 | 5 (18) | 1 (3) | 0.2 |
| Dindo-Clavien classification, *n* (%) |  |  | 0.23 |  |  | 0.6 |
| I-II | 18 (92) | 27 (97) |  | 23 (93) | 26 (96) |  |
| III-IV | 16 (8) | 1 (3) |  | 2 (7) | 1 (4) |  |
| Postoperative complications, *n* (%) |  |  | 0.02 |  |  | 1.0 |
| Yes | 93 (47) | 7 (25) |  | 6 (22) | 7 (26) |  |
| No | 103 (53) | 21 (75) |  | 21 (78) | 20 (74) |  |
| Type of complication, *n* (%) |  |  |  |  |  |  |
| Liver failure | 15 (8) | 1 (3) | 0.70 | 2 (7) | 1 (4) | 1.0 |
| Ascites | 24 (12) | 2 (7) | 0.70 | 3 (11) | 2 (7) | 1.0 |
| Biliary leakage | 2 (1) | 1 (3) | 0.30 | 0 | 1 (4) | 1.0 |
| Hemorrhage | 8 (4) | 0 | 0.60 | 2 (7) | 0 | 0.5 |
| Systemic infection | 14 (7) | 1 (3) | 0.70 | 2 (7) | 1 (4) | 1.0 |
| Intra-abdominal abscess | 7 (3) | 0 | 0.60 | 2 (7) | 1 (4) | 1.0 |
| Wound infection | 4 (2) | 3 (11) | 0.04 | 0 | 3 (11) | 0.2 |
| Portal thrombosis | 2 (1) | 0 | 1.00 | 1 (4) | 0 | 1.0 |
| Pulmonary | 15 (7) | 0 | 0.20 | 2 (7) | 0 | 0.5 |
| Cardiac | 11 (5) | 1 (3) | 1.00 | 2 (7) | 1 (4) | 1.0 |
| Renal | 8 (4) | 0 | 0.60 | 2 (7) | 0 | 0.5 |
| Reoperation, *n* (%) | 6 (6) | 1 (3) | 1.00 | 0 | 1 (4) | 1.0 |
| Postoperative death, *n* (%) | 7 (3) | 0 | 0.60 | 2 (7) | 0 | 0.5 |
| Postoperative treatment, *n* (%) | 6 (3) | 1 (3) | 1.00 | 0 | 1 (4) | 1.0 |
| Length of hospital stay, median (range) | 6 (2-40) | 5.5 (3-21) | 0.20 | 4.5 (2-40) | 6 (3-21) | 0.1 |
| Mortality at 90 d, *n* (%) | 9 (5) | 0 | 0.60 | 2 (7) | 0 | 0.5 |

Continuous variables were compared using an independent sample *t*-test and Mann-Whitney *U* test. Categorical variables were compared using the chi-square test and Kruskal-Wallis test; LLR: Laparoscopic liver resection; PSM: Propensity score matching; BMI: Body mass index.



Published by **Baishideng Publishing Group Inc**

7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA

**Telephone:** +1-925-3991568

**E-mail:** bpgoffice@wjgnet.com

**Help Desk:** https://www.f6publishing.com/helpdesk

https://www.wjgnet.com



**© 2023 Baishideng Publishing Group Inc. All rights reserved.**