Effect of Preoperative Body Mass Index on Surgical Textbook Outcomes Following Curative-intent Resection for Perihilar Cholangiocarcinoma

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Abstract

Background & Objects:

A comprehensive evaluation of the performance during the perioperative period is essential to provide good surgical care. To incorporate numerous characteristics into a single specified quality indicator, "Textbook outcomes (TO)" has been presented. The effect of the preoperative body mass index (BMI) on the occurrence of achieving/not achieving TO (non-TO) among patients having curative-intent resection for perihilar cholangiocarcinoma (pCCA) was studied.

Methods

This cohort study enrolled patients who underwent curative-intent resection for pCCA between 2014 and 2018 from a multicentre database. All cohort patients were classified into three groups according to the preoperative BMI: normal BMI (18.5 ~ 24.9 kg/m²), low BMI (≤ 18.4 kg/m²), and high BMI (≥ 25.0 kg/m²). The occurrences of non-TO among the above groups were compared. Univariable and multivariable logistic analyses were used to determine whether there was any significant effect of the preoperative BMI on non-TO.

Results

A total of 313 patients were enrolled in this study, and 212 (67.7%), 46 (14.7%), and 55 (17.6%) were in the normal-BMI, low-BMI, and high-BMI groups, respectively. In all patients, the occurrence of non-TO was 71.6%, and the occurrence of non-TO in both the high- and low-BMI groups was significantly higher than that in the normal-BMI group (85.5% and 82.6% vs. 65.6%, both $P < 0.01$). The multivariable logistic analyses indicated that both high BMI and low BMI were independently associated with a greater occurrence of non-TO (OR: 2.517, 95CI: 1.052–6.021, $P = 0.038$; OR: 3.379, 95CI: 1.423–8.022, $P = 0.006$).

Conclusions

More than two-thirds of the patients following curative-intent resection for pCCA did not achieve surgical TO. In addition, both preoperative high BMI and low BMI were independently associated with a higher risk of not achieving surgical TO following curative-intent resection for pCCA.

Introduction

Cholangiocarcinoma is a rare primary malignant tumour that arises from bile duct epithelial cells and is the second most prevalent primary liver malignant tumour, and it accounts for 3% of all the gastrointestinal malignancies[1]. Perihilar cholangiocarcinoma (pCCA) comprises approximately

50%–67% of the cholangiocarcinoma cases, and its incidence in the Eastern region is higher than that in the Western region[2–4]. Surgical resection is the preferred and most effective therapeutic option for pCCA patients with the potential chance of cure. Nonetheless, the short-term prognosis after surgical resection is not expected; for example, the incidence risk of the perioperative mortality, morbidity and blood transfusion is considerable, with incidences ranging from 3.4–10.2%[5, 6], 44–47%[5, 6], and 43.0–45.0%[7, 8], respectively.

In the field of surgical oncology, the comprehensive assessment of surgical resection is becoming increasingly crucial. While the individual outcome metrics, such as the perioperative mortality[5, 6], postoperative surgical morbidity[5, 6], positive margin[9], readmission[10, 11], and hospital stay[12], can be used to assess the quality of the surgical resection in tumour patients, the abovementioned individual outcome metrics may not reflect the quality of the whole surgical procedure and hospital performance. Therefore, several studies have pointed out that summarizing the individual outcome metrics by using multiple variables for assessing the short-term prognosis as a comprehensive measure may better reflect the whole surgical care quality of the hospital[13–16]. In particular, textbook outcome (TO) is a new popular measure⁸ that attempts to use a single metric to cover the entire surgical procedure, which provides a comprehensive summary of the hospital performance. As previous studies have reported, when all of the given desirable short-term postoperative outcomes are achieved, the patient can be considered to obtain a TO[17, 18]. As such, it represents the perfect or "textbook" postoperative outcome, which has been used in the definition of the care quality and the evaluation of surgical procedures for multiple tumours[17–20]. Notably, to the best of our knowledge, TO has not been published as an endpoint for pCCA patients.

A previous study indicated that the preoperative body mass index (BMI) affects the incidence of postoperative morbidity after pCCA resection[21]. In addition, the preoperative BMI was independently associated with a longer time for needing a perioperative blood transfusion and was also associated with the hospital stay[22–24]. However, in pCCA patients who underwent resection, the effect of the preoperative BMI on TO has never been reported. Therefore, using a multicentre database, the objective of this study was to investigate the effect of the preoperative BMI on the incidence of not achieving textbook outcomes (non-TO) after a curative-intent resection of pCCA.

Methods

Study Population

Patients who underwent curative-intent open resection for newly diagnosed pCCA, which was confirmed by a postoperative histopathological examination, between January 2014 and January 2018 at three hospitals in China were enrolled in a multicentre database (Southwest Hospital, Sichuan Provincial People's Hospital, and Affiliated Hospital of Qinghai University). pCCA was defined as tumours emerging from the biliary confluence, left or right hepatic duct, or common hepatic duct. As we previously reported, all of the patients had liver resection, extrahepatic bile duct resection, cholangiojejunostomy, and

locoregional lymphadenectomy[25]. Provided that the vasculature of the reserved side of the liver was violated, the patients needed to receive revascularization. Curative-intent resection was defined as the removal of all macroscopic tumours. The exclusion criteria included the following: 1) recurrent pCCA; 2) palliative-intent resection; 3) missing important factors associated with T0; 4) postoperative adjuvant therapy; and 5) other additional surgery during the pCCA resection. All patients in this study were separated into three groups based on their preoperative BMI: normal BMI (18.5–24.9 kg/m²), low BMI ($\leq$ 18.4 kg/m²), and high BMI ($\geq$ 25.0 kg/m²), according to the World Health Organization (WHO) classification[21]. This study complied with the Declaration of Helsinki, and approval was obtained from the Ethics Committee of Southwest Hospital (approval number: KY2021129). Because of the retrospective nature of the study and the fact that all clinical data were deidentified before analysis, it was not necessary to obtain informed consent from the patients.

Data Collection

The patient's clinical, laboratory, pathological, and surgical variables were prospectively collected at each hospital and were retrospectively analysed. The clinical variables included sex, age, BMI, American Society of Anaesthesiologists (ASA) score, previous hepatolithiasis, preoperative drainage, comorbidity, chronic hepatitis, cigarette smoking, alcohol drinking, and the Child–Pugh grade. The laboratory variables included alanine aminotransferase (ALT), aspartate transaminase (AST), total bilirubin (TB), haemoglobin, and carbohydrate antigen 19 – 9 (CA 19 – 9). The pathological variables included cirrhosis, tumour size, macro- or microvascular invasion, peripheral nerve invasion, differentiation, the 8th American Joint Committee on Cancer (AJCC) stage, the Bismuth classification, and lymph node (LN) metastasis. The surgical variables included the intraoperative blood loss, operation time, and extent of the liver resection (major or minor).

For the laboratory variables, this study used the upper and the lower limit of the normal values in clinical practice to divide the patients into normal or high/low groups, such as 40 U/L for ALT and AST, 110 g/L for haemoglobin, and 37 U/L for CA19-9. For the pathological variables, cirrhosis was confirmed by a postoperative histological examination of the nonneoplastic resected liver tissue. The tumour size, macro- or microvascular invasion, peripheral nerve invasion, differentiation, and LN metastasis were confirmed by a postoperative histological examination of the neoplastic resected liver or bile duct tissue. The tumour stage and classification were determined based on the 8th AJCC stage and Bismuth classification[26, 27]. A tumour size > 3 cm was revealed to be associated with a poor short-term outcome in a previous study. As a consequence, this study used 3 cm as the cut-off value to divide the patients into two groups[28]. For the surgical variables, the excision of two or fewer Couinaud liver segments was characterized as a minor liver resection, while the excision of three or more segments was characterized as a major liver resection.

Textbook Outcomes (T0)

The definition of a surgical T0 was according to the selection of the various individual outcome parameters that indicate the best postoperative short-term prognosis of the patient: 1) no postoperative

surgical morbidity within 1 month; 2) no prolonged length of hospital stay; 3) no perioperative blood transfusion; 4) negative margins; 5) no mortality within 1 month after the index surgery; and 6) no readmission within 1 month after discharge[29, 30]. The postoperative surgical morbidities included liver failure, pleural effusion, ascites, intestinal leakage, bile leakage, delayed gastric emptying, cholangitis, abdominal haemorrhage, surgical site infections, and blood, lung, abdominal, and biliary infections, among others[31]. A prolonged length of hospital stay was defined as a length of hospital stay that was > the 75th percentile of the overall cohort. A negative margin was defined as the absence of a pCCA tumour at the edge of the resection upon microscopic examination, and the edges of the biopsy were clear under the microscope. Once all of the six outcomes mentioned above were all satisfactory, the surgical TOs were considered to be achieved. Putting this another way, not achieving surgical TOs included a postoperative surgical morbidity within 1 month, a prolonged length of hospital stay, a perioperative blood transfusion, a positive margin, mortality within 1 month after the index surgery, and readmission within 1 month after discharge.

Statistical Analysis

Continuous variables were expressed as the mean $\pm$ standard deviation or the median (quartile). The categorical variables were expressed as numbers (n) and proportions (%). Student's *t* test was applied for evaluating the continuous variables in applicable conditions; otherwise, the Mann–Whitney *U* test was used. The χ^2 test was applied for categorical variables with the Yates correction or Fisher's exact test as appropriate. The proportions and distribution of non-TO were compared between the normal-BMI and high-BMI patients, as well as between the normal-BMI and low-BMI patients. Univariable and multivariable analyses were performed to identify the independent risk factors associated with non-TO following curative-intent resection for pCCA. The multivariable analysis was accomplished by using a stepwise logistic regression analysis. In both the univariable and multivariable analyses, the odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated. All statistical analyses were performed using SPSS version 26.0 (IBM, Armonk, New York, USA). A *P* value < 0.05 was defined as statistically significant.

Results

A total of 313 pCCA patients following curative-intent resection were included in this analytic cohort, as shown in Fig. 1. All patients had a median preoperative BMI of 23.2 kg/m² (range 14.0–30.2 kg/m²). The number of normal BMI, low BMI, and high BMI patients (the BMI was measured within seven days before the index surgery) were 212 (67.7%), 46 (14.7%), and 55 (17.6%), respectively. The median tumour size in this analytic cohort was 2.88 cm (range 1.59–4.17 cm). For the liver resection surgeries, 207 (66.1%) patients underwent a major liver resection, and 106 (33.9%) patients underwent a minor liver resection. According to the postoperative pathologic examinations, 165 (52.7%), 95 (30.4%), 35 (11.2%), and 52 (16.6%) patients were determined to have LN metastasis, macrovascular invasion, microvascular invasion, and poor differentiation, respectively.

Comparisons of the Clinical, Laboratory, Pathological, and Surgical Characteristics

The comparison of the clinical, laboratory, pathological and surgical characteristics among the normal-, low-, and high-BMI groups of this analytic cohort is shown in Table 1. Compared with the normal-BMI patients, the low-BMI patients had an increased incidence of macrovascular invasion ($P = 0.008$), while the high-BMI patients had an elevated risk of having a high ASA score ($P = 0.042$). Moreover, both a low BMI and a high BMI were significantly associated with an increase in the intraoperative blood loss.

Comparisons of the TO and Non-TO

Among the whole analytic cohort, the occurrences of TO and non-TO were 28.4% (89/313) and 71.6% (224/313), respectively. Specifically, 209 (66.8%) patients experienced postoperative surgical morbidity within 1 month, 80 (25.6%) patients had a prolonged length of hospital stay, 158 (50.5%) patients received a perioperative blood transfusion, 42 (13.4%) patients had a positive margin at the edge of the resection, 11 (3.5%) patients died within 1 month after the index surgery, and 20 (6.4%) patients were readmitted within 1 month after discharge.

In the normal-BMI patients, the occurrence of TO was 34.4%, which was considerably greater than that in both the low-BMI and high-BMI patients (17.4%, $P = 0.024$; 14.5%, $P = 0.004$). The six individual outcome parameters that were included in the definition of non-TO among the three different BMI groups are depicted in Fig. 2. In virtually all six of the individual outcome parameters that comprised the TO, there were significant differences between the normal-BMI and low-BMI patients, as well as between the normal-BMI and high-BMI patients, as shown in Table 2.

Univariable and Multivariable Analyses of Non-TO

The results of the univariable and multivariable logistic analyses on the risk factors that were associated with not achieving surgical textbook outcomes following curative-intent resection for pCCA are shown in Table 3. In the multivariable logistic regression analysis, both high BMI and low BMI were independently associated with a greater occurrence of non-TO (OR: 2.517, 95% CI: 1.052–6.021, $P = 0.038$; and OR: 3.379, 95% CI: 1.423–8.022, $P = 0.006$, respectively). Moreover, comorbidities, cirrhosis, a tumour size > 3 cm, macrovascular invasion, LN metastasis, and intraoperative blood loss > 500 mL were also independently associated with a greater occurrence of non-TO following curative-intent resection for pCCA.

Discussion

TO is a composite metric representing the best (or textbook) postoperative outcome, especially in the field of surgical oncology. To our knowledge, this is the first study to investigate TO as a composite quality metric in the assessment of short-term outcomes after curative-intent pCCA resection. The individual outcomes, including morbidity, mortality, length of hospital stay, readmission, positive margin, and blood

transfusion, have traditionally been used to measure the surgical quality of care. Compared with the entire assessments of the care quality, the analysis of individual measures may be inherently flawed, since no individual measure can represent the overall "patient-centred" experience. It is important to note that any designated hospital may perform well on one particular outcome and poorly on others. In effect, from the patients' perspective, their hospitalization is a more comprehensive "all or none" experience. As a consequence, using a comprehensively measured outcome to assess the short-term prognosis, such as TO, can enable a more appropriate and truer assessment of the patient's care quality.

In this multicentre study of 313 patients following curative-intent resection for pCCA, only 89 (28.4%) patients achieved surgical TO. Unlike other published studies of other gastrointestinal tumours using TO as an endpoint, the present study analysed the effect of the preoperative BMI on TO. All patients in this analytic cohort were divided into three groups, and a high preoperative BMI and a low preoperative BMI were independently associated with an increased occurrence of non-TO after treatment for pCCA. Notably, the preoperative BMI was also demonstrated to be, for the first time, an independent predictive factor for surgical TO. Therefore, adjusting the patient's BMI while waiting for surgery, including improving the patient's nutrition in low-BMI patients and controlling the patient's weight in high-BMI patients, may increase the likelihood of achieving surgical TO.

In this analytic cohort, the occurrence of surgical TO in high-BMI patients (14.5%) was significantly lower than that in normal-BMI patients (34.4%). After analysing the distribution of achieving non-TO, the occurrence of postoperative surgical morbidity (83.6% vs. 59.4%) and perioperative blood transfusion (61.8% vs. 43.4%) in the high-BMI patients were significantly higher than those in the normal-BMI patients (both $P < 0.05$). In addition, the occurrence of a prolonged length of hospital stay (36.4% vs. 23.6%) was potentially significantly higher than that in the normal-BMI patients ($P = 0.055$). In previous studies, a high BMI has been demonstrated to be independently associated with an increased postoperative morbidity among patients who had radical resection for pCCA[21, 22, 32]. Moreover, high-BMI patients have also been observed to need longer hospital stays and more blood transfusions after liver resection than normal-BMI patients[23, 33]. The interpretation of the above results is as follows. A high BMI is well known to be closely associated with chronic liver disease, such as nonalcoholic steatohepatitis, and other comorbidities, such as diabetes and cardiovascular disease[34]. Previous studies have revealed that patients with diabetes mellitus, nonalcoholic fatty liver disease, and cardiovascular disease after pCCA resection have a significantly increased incidence of postoperative morbidities[23, 35]. In addition, performing surgery on high-BMI patients is associated with higher requirements for the surgical techniques. There is a prolonged operative time and increased intraoperative blood loss due to the difficulty in exposing the surgical site[36, 37]. High-BMI patients often require higher intraoperative ventilation pressures, which may increase the hepatic venous pressure and affect the hepatic venous outflow[38]. Therefore, high-BMI patients may have more intraoperative blood loss than normal-BMI patients, leading to a higher risk for needing a perioperative blood transfusion.

Additionally, in this analytic cohort, the occurrence of surgical TO in low-BMI patients (17.4%) was significantly lower than that in normal-BMI patients (34.4%). After analysing the distribution of achieving

non-TO, the occurrence of postoperative surgical morbidity (80.4% vs. 59.4%), perioperative blood transfusion (69.6% vs. 43.4%), positive margin (26.1% vs. 11.3%), mortality (8.7% vs. 1.9%), and readmission (13.0% vs. 4.7%) in the low-BMI patients was significantly higher than that in the normal-BMI patients (both $P < 0.05$). The above results may be related to the following explanations. From a nutritional point of view, low-BMI patients usually have a poor nutritional status and insufficient physiological reserves[39]. Previous studies have reported that low-BMI patients are at increased risk of a delayed functional recovery due to reduced protein synthesis and a reduced regenerative capacity of hepatocytes[40, 41]. From an immunological perspective, low BMI is associated with sarcopenia and low albumin levels, which may impair the regeneration of the remnant liver and may reduce the immune function in the body[42, 43].

For pCCA patients with severe jaundice or hypoalbuminemia or who are scheduled to undergo a major liver resection, biliary drainage is usually performed before the surgery[44–46]. However, in the Asia-Pacific consensus recommendations, the optimal duration for the preoperative biliary drainage has not been proposed[47]. Nevertheless, a systematic review pointed out that the average duration of the preoperative biliary drainage in pCCA patients is approximately 23 days, and there are even some patients with preoperative biliary drainage times that are as long as 36 days[44]. During the period of preoperative biliary drainage, reducing the energy intake in high-BMI patients or supplementing the nutrition in low-BMI patients may potentially change their BMI to fall into the normal range before surgery, although further studies are needed to confirm this. Of note, such studies should distinguish between cachexia due to tumorigenesis and low-BMI patients who are naturally thin.

Several limitations of this study should be acknowledged. First, this study was a retrospective study, which inevitably introduces bias when collecting the data. In particular, patients with a preoperative particularly low- or high-BMI, were ineligible for surgery since their diagnosis. Second, all of the data in this study were from China, and data on Western patients were missing. The incidence of an abnormal body weight is higher in Western populations than in Chinese populations. Therefore, the results of this study cannot be representative of all populations. Third, the number of patients in this study was relatively small. Although this was a multicentre study including 3 hospitals, there were only 313 patients. The reason may be related to the lower incidence of pCCA. In the future, we will include data from more centres, including both Western and Eastern centres, for analysis to obtain more convincing and accurate results.

In conclusion, less than 1 in 3 patients achieved TO following curative-intent resection for pCCA, and both a preoperative low- and high-BMIs were adverse in the achievement of TO. Supplementing nutrition for low-BMI patients or controlling weight for high-BMI patients during the period of preoperative biliary drainage may potentially increase the opportunity to achieve TO for patients after having a curative-intent resection for pCCA.

Declarations

Ethics approval and consent to participate: The study was approved by the Institutional Review Board of the South West Hospital of Chongqing, China (No: KY2021129). Informed consent for clinical research was obtained from all the patients. All methods in this study were confirmed to be performed in accordance with the relevant guidelines and regulations

Consent for publication: Not applicable.

Availability of data and materials: All data generated or analysed during this study are included in this published article and its supplementary information files.

Authors' Disclosures of Potential Conflicts of Interest: The author(s) indicated no potential conflicts of interest.

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Author Contributions: ZY Chen and HS Dai designed the research. ZP Liu and SY Zhong performed the research. ZP Liu, SY Zhong, WY Chen, ZR Wang, JL Pu, XC Liu, HN Fan, Y Pan, D Xie, JJ Cheng, YS Yang, J Bai, and Y Jiang analyzed the data. ZP Liu, SY Zhong, and HS Dai wrote the paper. YQ Zhang and ZY Chen reviewed the manuscript. ZY Chen integrated the entire study. All authors read and approved the final manuscript. ZP Liu and SY Zhong contributed equally to this work.

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Abbreviations

ALT, alanine aminotransferase; ASA, American Society of Anaesthesiologists; AST, aspartate transaminase; BMI, body mass index; CA19-9, carbohydrate antigen 19-9; CI, confidence interval; LN, lymph node; NA, not available; OR, odds ratio; TB, total bilirubin.

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Tables

Table 1. Comparisons of the baseline characteristics among the three groups based on the preoperative BMI.

Variables	Overall (N=313)	Low-BMI (N=46)	Normal- BMI (N=212)	High-BMI (N=55)	<i>P</i> value (Normal- BMI vs. Low- BMI)	<i>P</i> value (Normal- BMI vs. High- BMI)
Male	188 (60.1)	29 (63.0)	131 (61.8)	28 (50.9)	0.874	0.143
Age, years*	57.4 ± 10.0	58.2 ± 10.3	57.6 ± 10.0	56.2 ± 10.0	0.700	0.349
BMI, kg/m ² *	24.0 ± 2.3	16.5 ± 1.6	22.5 ± 1.4	28.2 ± 2.1	< 0.001	< 0.001
ASA score > 2	39 (12.5)	3 (6.5)	24 (11.3)	12 (21.8)	0.335	0.042
Hepatolithiasis	22 (7.0)	9 (19.6)	9 (4.2)	4 (7.3)	<0.001	0.353
Preoperative drainage	84 (26.8)	14 (30.4)	59 (27.8)	11 (20.0)	0.722	0.239
Comorbidity	244 (78.0)	32 (69.6)	170 (80.2)	42 (76.4)	0.113	0.532
Chronic hepatitis	23 (7.3)	3 (6.5)	18 (8.5)	2 (3.6)	0.658	0.223
Cigarette smoking	122 (39.0)	22 (47.8)	75 (35.4)	25 (45.5)	0.114	0.169
Alcohol drinking	95 (30.4)	20 (43.5)	59 (27.8)	16 (29.1)	0.037	0.853
Child–Pugh B	63 (20.1)	5 (10.9)	49 (23.1)	9 (16.4)	0.064	0.279
ALT, U/L*	75.0 (49.6, 161.0)	72.6 (52.2, 161.0)	83.0 (49.2, 169.0)	72.7 (52.0, 119.0)	0.571	0.257
AST, U/L*	81.9 (50.2, 133.0)	81.9 (52.3, 127.5)	82.5 (50.0, 137.5)	77.0 (52.0, 89.0)	0.909	0.788
TB, µmol/L*	161.1 (70.0, 265.0)	142.6 (61.4, 228.1)	167.2 (83.2, 283.9)	151.7 (52.8, 212.7)	0.203	0.210
Haemoglobin, g/L*	121.5 ± 24.8	115.2 ± 13.9	120.9 ± 16.7	129.1 ± 47.0	0.032	0.208
CA19-9, U/L*	135.2 (47.3, 312.5)	150.2 (45.8, 403.1)	126.6 (48.3, 300.0)	145.0 (40.0, 308.8)	0.467	0.875
Cirrhosis	45 (14.4)	8 (17.4)	28 (13.2)	9 (16.4)	0.458	0.546
Tumour size, cm*	2.88 ± 1.29	3.18 ± 1.43	2.86 ± 1.32	2.70 ± 1.02	0.150	0.377
Macrovascular	95 (30.4)	6 (13.0)	69 (32.5)	20 (36.4)	0.008	0.593

invasion						
Microvascular invasion	35 (11.2)	6 (13.0)	21 (9.9)	8 (14.5)	0.529	0.324
Peripheral nerve invasion	107 (34.2)	19 (41.3)	69 (32.5)	19 (34.5)	0.256	0.779
Poor differentiation	52 (16.6)	11 (23.9)	31 (14.6)	10 (18.2)	0.122	0.514
LN metastasis	165 (52.7)	26 (56.5)	110 (51.9)	29 (52.7)	0.568	0.911
8th AJCC stage $\geq$ III/IV	174 (55.6)	19 (41.3)	121 (57.1)	34 (61.8)	0.052	0.525
Bismuth type $\geq$ III/IV	235 (75.1)	35 (76.1)	159 (75.0)	41 (74.5)	0.877	0.945
Major hepatectomy	207 (66.1)	24 (52.2)	143 (67.5)	40 (72.7)	0.049	0.453
Intraoperative blood loss, mL*	700 (400, 1000)	800 (500, 1025)	600 (400, 1000)	750 (4000,1400)	0.033	0.066
Operation time, min*	535 $\pm$ 150	554 $\pm$ 149	528 $\pm$ 154	547 $\pm$ 139	0.294	0.408

Note: * Values are the mean $\pm$ standard deviation or median (quartile).

Abbreviations: ALT, alanine aminotransferase; ASA, American Society of Anaesthesiologists; AST, aspartate transaminase; BMI, body mass index; CA19-9, carbohydrate antigen 19-9; LN, lymph node; TB, total bilirubin.

Table 2. Distribution of achieving surgical nontextbook outcomes.

Distribution of the surgical nontextbook outcomes	Overall (N=313)	Low-BMI (N=46)	Normal-BMI (N=212)	High-BMI (N=55)	<i>P</i> value (Normal-BMI vs. Low-BMI)	<i>P</i> value (Normal-BMI vs. High-BMI)
Overall	224 (71.6)	38 (82.6)	139 (65.6)	47 (85.5)	0.024	0.004
a) Postoperative surgical morbidity within 30 days	209 (66.8)	37 (80.4)	126 (59.4)	46 (83.6)	0.007	0.001
b) Prolonged length of hospital stays*	80 (25.6)	10 (21.7)	50 (23.6)	20 (36.4)	0.788	0.055
Hospital stays, days**	21.5 ± 9.6	19.4 ± 7.4	21.1 ± 10.0	24.7 ± 8.9	0.277	0.018
d) Perioperative blood transfusion	158 (50.5)	32 (69.6)	92 (43.4)	34 (61.8)	0.001	0.015
d) Positive margin	42 (13.4)	12 (26.1)	24 (11.3)	6 (10.9)	0.009	0.931
e) Mortality within 30 days after index surgery	11 (3.5)	4 (8.7)	4 (1.9)	3 (5.5)	0.016	0.140
e) Readmission within 30 days after discharge	20 (6.4)	6 (13.0)	10 (4.7)	4 (7.3)	0.034	0.449

Note: * Prolonged length of hospital stay was defined as a length of hospital stay > the 75th percentile of the overall cohort; ** Values are the mean ± standard deviation.

Table 3. Logistic regression analyses of the risk factors associated with a surgical nontextbook outcome following curative-intent resection for pCCA.

Variables	Comparison	Univariable analyses		Multivariable analyses*	
		<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)
Gender	Male vs. Female	0.377	1.252 (0.761-2.059)		
Age, years	> 60 vs. ≤ 60	0.285	1.313 (0.797-2.165)		
BMI, kg/m ²	High-BMI vs. Normal-BMI	0.028	2.495 (1.106-5.626)	0.038	2.517 (1.052-6.021)
	Low-BMI vs. Normal-BMI	0.006	3.085 (1.384-6.876)	0.006	3.379 (1.423-8.022)
ASA score	> 2 vs. ≤ 2	0.245	1.626 (0.717-3.690)		
Hepatolithiasis	Yes vs. No	0.540	1.380 (0.493-3.860)		
Preoperative drainage	Yes vs. No	0.149	0.673 (0.393-1.153)		
Comorbidity	Yes vs. No	0.012	2.049 (1.169-3.591)	0.013	2.236 (1.182-4.230)
Chronic hepatitis	Yes vs. No	0.462	1.468 (0.528-4.082)		
Cigarette smoking	Yes vs. No	0.145	1.469 (0.876-2.463)		
Alcohol drinking	Yes vs. No	0.584	1.164 (0.677-2.000)		
ALT, U/L	> 40 vs. ≤ 40	0.122	1.613 (0.880-2.955)		
AST, U/L	> 40 vs. ≤ 40	0.371	1.363 (0.692-2.686)		
Haemoglobin, g/L	< 110 vs. ≥ 110	0.228	1.443 (0.795-2.618)		
CA19-9, U/L	> 37 vs. ≤ 37	0.695	1.132 (0.610-2.100)		
Cirrhosis	Yes vs. No	0.009	3.652 (1.392-9.585)	0.047	2.853 (1.015-8.024)
Tumour size, cm	> 3 vs. ≤ 3	0.001	2.495 (1.419-4.385)	0.032	1.960 (1.058-3.632)
Macrovascular invasion	Yes vs. No	0.007	2.263 (1.247-4.105)	0.016	2.243 (1.163-4.323)

Microvascular invasion	Yes vs. No	0.705	1.167 (0.524-2.601)		
Peripheral nerve invasion	Yes vs. No	0.879	0.961 (0.573-1.610)		
Differentiation	Poor vs. Well/moderate	0.791	1.094 (0.561-2.136)		
LN metastasis	Yes vs. No	0.001	2.435 (1.468-4.038)	0.009	2.112 (1.208-3.691)
Extent of hepatectomy	Major vs. Minor	0.070	1.598 (0.962-2.657)	0.585	NA
Intraoperative blood loss, mL	> 500 vs. ≤ 500	< 0.001	2.871 (1.730-4.762)	0.008	2.117 (1.217-3.682)

Note: *Those variables that had a $P < .10$ in the univariable analyses were entered into the multivariable logistic regression analyses.

Abbreviations: ALT, alanine aminotransferase; ASA, American Society of Anaesthesiologists; AST, aspartate transaminase; BMI, body mass index; CA19-9, carbohydrate antigen 19-9; CI, confidence interval; LN, lymph node; NA, not available; OR, odds ratio.

Figures

Figure 1

Flow chart of the analytic cohort. pCCA, perihilar cholangiocarcinoma; BMI, body mass index; TO, textbook outcome.

Note: *, $P < 0.05$; **, $P < 0.01$

Figure 2

Distribution of achieving surgical nontextbook outcomes among the three groups based on the preoperative BMI. BMI, body mass index.

Supplementary Files

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