Safety and benefits of major hepatectomy with extrahepatic bile duct resection in older perihilar cholangiocarcinoma patients

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Abstract
Purpose To evaluate the safety and benefits of major hepatectomy with extrahepatic bile duct resection in older perihilar cholangiocarcinoma patients and to identify possible predictors of surgical mortality.

Methods We retrospectively analyzed the data of 102 consecutive patients who underwent major hepatectomy with extrahepatic bile duct resection for perihilar cholangiocarcinoma in our institution between 2004 and 2021. The patients were included and divided into two groups: older patients ≥ 75 years and non-older patients < 75 years. Patient characteristics, preoperative nutritional and operative risk scores, intraoperative details, postoperative outcomes, and long-term prognosis were compared between the groups. Univariate and multivariate analyses were used to identify the predictors of 90-day mortality after major hepatectomy with extrahepatic bile duct resection.

Results Significant differences were identified for some preoperative surgical risk scores, but not for nutritional scores. Older patients had a higher morbidity rate of respiratory complications (p = 0.016), but there were no significant differences in overall (p = 0.735) or disease-specific survival (p = 0.858). A high Dasari’s score was identified as an independent predictive factor of 90-day mortality.

Conclusions Major hepatectomy with extrahepatic bile duct resection can be performed for optimally selected older and younger patients with perihilar cholangiocarcinoma, resulting in a good prognosis. However, indications for extended surgery should be recognized. Dasari’s preoperative risk score may be a good predictor of 90-day mortality.

Keywords Perihilar cholangiocarcinoma · Hepatectomy · Safety · Older adults · Extrahepatic bile duct

Introduction
As the aging population increases, the demand for surgery in older patients with cancer is rapidly growing. Due to the higher prevalence of multimorbidity, frailty, and physical impairment, older patients exhibit poorer postoperative outcomes, including higher mortality and complication rates, longer length of hospital stay, and an increased likelihood of discharge to supportive accommodation compared with younger patients [1, 2].

Perihilar cholangiocarcinoma (PHC) is an intractable disease that remains challenging for hepatobiliary surgeons, as it requires a high level of technical skills and experience [3]. Although curative surgical resection by hepatectomy and extrahepatic bile duct resection (EBDR) is the only way to achieve long-term survival in these patients, the difficulty and invasiveness of this surgical procedure are greater than those of other abdominal surgical procedures. Therefore, surgical indications must be determined by considering the risks and benefits, particularly in older patients.

Many preoperative nutritional and surgical risk scores have been reported to be useful for screening patients who may be at increased risk in specific surgery types [4–6]. However, it remains unclear which screening tools should be applied to patients with PHC.

Therefore, the aim of the present study was to evaluate the safety and benefits of major hepatectomy with EBDR in older patients with PHC, and to identify optimal
preoperative risk scores for predicting the operative mortality following this surgical procedure.

**Materials and methods**

**Study design and patients**

We retrospectively analyzed the data of 102 consecutive patients who underwent major hepatectomy with EBDR for PHC at the Department of Hepatobiliary Pancreatic and Transplant Surgery of Mie University Hospital between January 2004 and December 2021.

Patients were divided into two groups according to their age: older patients aged ≥75 years and non-older patients aged <75 years. In previous studies, older patients have been defined by different age limits: ≥65, 70, 75, or 80 years [7]. However, with the population aging, a growing number of studies define older patients as individuals aged ≥75 years [8], while in other studies, they have been defined as adults aged ≥80 years [9–11]. In the present study, we used the age limit of ≥75 years, based on prior American College of Surgeons National Surgical Quality Improvement Program studies focusing on older patients with cancer as surgical patients [12]. There are no definite criteria or surgical indications for older PHC patients; however, those with poor performance status, poor cardiorespiratory function, and cognitive/mental disorders are not indicated for surgery.

The following data were collected and compared between the two groups: patient demographics, preoperative characteristics, preoperative nutritional and operative risk scores, intraoperative details, postoperative outcomes, and long-term prognosis. Additionally, univariate and multivariate analyses were performed to identify the predictors of 90-day mortality after major hepatectomy with EBDR.

Major hepatectomy was defined as the resection of two or more contiguous liver sections. Postoperative complications were evaluated using the Clavien–Dindo classification of surgical complications and stratified as grade I to V [13, 14]. Pathological findings were documented according to the TNM classification of the Union for International Cancer Control, 8th edition [15].

The study protocol was approved by the Institutional Review Board of Mie University of Japan (approval no. H2018-064). The study conformed to the provisions of the Declaration of Helsinki. Prior to their inclusion in the study, all participants provided informed consent for participation and for the use of their medical records through an opt-out form. This consent procedure was approved by the Institutional Review Board. All data were fully anonymized for the analysis.

**Preoperative nutritional and surgical risk scores**

To evaluate the risk related to preoperative comorbidities and the patients’ physical status, we used the Charlson Comorbidity Index (CCI) and age-adjusted CCI [16], and the Eastern Cooperative Oncology Group-Performance Status (ECOG-PS) scale, respectively.

The following inflammatory/immunonutritional markers were used as indicators of nutritional status, as their prognostic value has previously been demonstrated in patients operated for biliary cancer: neutrophil-to-lymphocyte ratio [17, 18], platelet-to-lymphocyte ratio [19], prognostic nutritional index [20, 21], lymphocyte-to-C-reactive protein score [22], modified Glasgow prognostic score [23], and controlling nutritional status (CONUT) [24]. The definitions of these markers are provided in our previous report [22].

For evaluating the surgical risk, the following widely used preoperative risk scores were analyzed: physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM) [25, 26], estimation of physiologic ability and surgical stress (E-PASS) score [27, 28], and American Society of Anesthesiologists physical status (ASA-PS) [29]. In addition, we evaluated the following two specific surgical risk scores for predicting postoperative mortality after hepatectomy: Dasari’s preoperative risk score for 90-day mortality [30] and Wigger’s mortality risk score after liver resection for PHC [31].

**Neoadjuvant therapy and operative procedure**

The indications for neoadjuvant therapy and the operative procedure for PHC at our institution have been described in a previous report [32]. Between 2007 and 2009, gemcitabine-based chemoradiotherapy was administered to patients with locally advanced vascular and biliary extension and/or bulky lymph node metastasis. From 2010, we introduced neoadjuvant chemotherapy using two cycles of gemcitabine plus S-1 for those patients.

The type of hepatectomy was finally determined by future remnant liver function, which was calculated by multiplying the future remnant liver volume (FLV) ratio by the indocyanine green plasma clearance rate. The FLV ratio was calculated from the image of multidetector computed tomography (CT), using 3D simulation software (Synapse Vincent; Fujifilm, Tokyo, Japan). Cases with a future remnant liver function of less than 0.05 were not indicated for major hepatectomy, based on a previous study [33]. Portal vein embolization (PVE) was indicated when the estimated volume of the future remnant liver was less than 40%, the future remnant liver function was
less than 0.05, and right hepatopancreatoduodenectomy was required. All operations were performed by or under the supervision of a board-certified expert hepatobiliary-pancreatic surgeon [34].

Postoperative management

All patients received prophylactic antibiotics through postoperative day (POD) 2. Drainage tubes were removed on POD 4–7 if there were no signs of bile leakage or infection, or when those signs had resolved. External bile duct stents were removed on POD 21–28 if there were no signs of bile leakage.

Adjuvant chemotherapy was started 4–6 weeks after surgery and continued for at least 6 months. The chemotherapy regimen comprised gemcitabine from February 2005 to May 2013, and gemcitabine plus S-1 from June 2013 to December 2021. Completion of adjuvant chemotherapy was defined when patients finished 6 months of adjuvant chemotherapy, regardless of the relative performance index (proportion of the actual dose compared to the expected dose) after surgery [35].

Follow-up surveys were conducted every 1–3 months within 3 years after surgery, every 6 months between 3 and 5 years, and annually thereafter. The survey included comprehensive medical history, blood examination including tumor markers, such as carcinoembryonic antigen (CEA) and carbohydrate antigen 19–9 (CA19-9), and imaging surveillance by chest and abdominal CT.

Statistical analysis

Data are expressed as means and ranges. The statistical significance of continuous variables was tested using Student’s t-test or the Mann–Whitney U test, based on whether data were normally or non-normally distributed. The qualitative χ² test was used to compare nominal variables between the two groups. Variables with p < 0.10 in the univariate analysis were included in the multivariate logistic regression analysis using the forward stepwise method. Comparisons were considered statistically significant at p < 0.05. The optimal cutoff values were calculated via receiver operating characteristic (ROC) curve analysis using the Youden index. For patients who required reassessment, the date of surgery was chosen as the starting point for the measurement of survival time. Survival was calculated using the Kaplan–Meier method and was compared between the groups using the log-rank test. The day of the final follow-up was December 31, 2021. All statistical analyses were performed using IBM SPSS Statistics version 26 for Macintosh (IBM Corp., Armonk, NY, USA).

Results

Patients’ characteristics

Patient characteristics are summarized in Table 1. A total of 102 patients (60 men and 42 women), with a median age of 69 years (39–87 years), were included in this study. The proportion of older patients with PHC who underwent major hepatectomy with EBDR increased over time (2004–2010: 14.7% vs. 2010–2021: 23.5%; Fig. 1). The median age of patients in the older and non-older groups was 66 (39–74) years and 78 (75–87) years, respectively. Half of all patients (51/102) received neoadjuvant chemotherapy or neoadjuvant chemoradiotherapy, and the remaining 51 patients underwent upfront surgery.

The age-adjusted CCI (p < 0.001) and ECOG-PS (p = 0.013) were significantly higher in older patients than in non-older patients; however, there was no significant difference in the CCI between the groups. The rate of patients with poor ECOG-PS was significantly higher among older patients than among non-older patients (p = 0.013). Other variables, including sex, body mass index, incidence of diabetes mellitus, preoperative cholangitis, pathological findings, and blood examination results, showed no significant differences between the groups. In terms of surgery-related factors, the rates of PVE (p = 0.018) and combined portal vein resection (p = 0.028) were significantly lower among older patients than among younger patients, while there were no significant between-group differences in other operative procedures, operation time, blood loss, and R0 resection rates.

Preoperative nutritional and surgical risk scores

The preoperative nutritional and surgical risk scores of the patients are summarized in Table 2. There were no significant differences in the nutritional scores between the groups. The POSSUM (p < 0.001), E-PASS (p < 0.001), ASA-PS (p = 0.009), Wigger’s (p < 0.001), and Dasari’s scores (p < 0.001) were significantly higher in older patients than in non-older patients.

Postoperative complications and patient prognosis

Postoperative complications are summarized in Table 3. The morbidity of respiratory complications, including pneumonia, acute respiratory distress syndrome, pleural effusion, respiratory failure, and pulmonary thromboembolism, was significantly higher in older patients than in non-older patients (p = 0.016). However, there were no significant differences between the groups in the morbidity of
other complications and the severity of complications. In addition, there was no significant difference in the hospital stay length between the groups.

The median follow-up period in older patients and non-older patients was 24.7 and 24.2 months, respectively. Of the older patients, eight (38.1%) died from the underlying
disease and three (14.3%) died from other causes, while in the non-older patients, 38 (46.9%) died from the underlying disease and five (6.2%) died from other causes. The 5-year overall survival (OS) in older patients and non-older patients was 33.6% and 38.8%, respectively, with a median survival time of 33.9 and 48.0 months, respectively. There were no significant differences in the OS ($p = 0.735$) and DSS ($p = 0.858$) between the groups.

**Predictors of 90-day mortality after major hepatectomy with EBDR for PHC**

During this study, five (4.9%) patients died within 90 days of surgery because of severe postoperative complications. One (1.0%) died within 30 days and four (3.9%) died between POD 31 and POD 90 (Table 4). The results of the univariate and multivariate analyses for predictors of 90-day mortality after major hepatectomy with EBDR are presented in Tables 5 and 6. The univariate analysis demonstrated that a higher Dasari’s score ($p = 0.020$) was significantly correlated with 90-day mortality. In the multivariate analysis, a high Dasari’s score was identified as an independent predictive factor of 90-day mortality (odds ratio: 1.868, 95% confidence interval: 1.103–3.166, $p = 0.020$).

A ROC curve analysis was performed to elucidate the optimal cutoff for Dasari’s score for 90-day mortality.

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**Table 2** Preoperative nutritional and surgical risk scores

|                      | Non-older patients, $< 75$ years ($n = 81$) | Older patients, $\geq 75$ years ($n = 21$) | $p$-value |
|----------------------|---------------------------------------------|--------------------------------------------|-----------|
| **Nutritional scores** |                                             |                                            |           |
| PNI                  | 53.6 (39.7–67.9)                            | 50.0 (35.6–61.7)                           | 0.100     |
| NLR                  | 1.68 (1.26–3.77)                            | 1.74 (1.26–2.67)                           | 0.868     |
| PLR                  | 161 (51–680)                                | 125 (66–330)                               | 0.113     |
| mGPS, 0/1/2          | 48/24/9                                     | 10/7/4                                     | 0.281     |
| CONUT                | 2 (0–6)                                     | 3 (0–6)                                    | 0.303     |
| LYM to CRP score, 0/1/2 | 61/5/0                                     | 19/1/1                                     | 0.853     |
| **Surgical risk scores** |                                            |                                            |           |
| POSSUM score         |                                             |                                            |           |
| Physiological score  | 17 (10–37)                                  | 23 (16–35)                                 | $<0.001^*$|
| Operative severity score | 29 (23–29)                              | 29 (25–29)                                 | 0.159     |
| E-PASS               |                                             |                                            |           |
| Preoperative risk score | 0.28 (0.13–0.61)                      | 0.35 (0.27–0.66)                           | $<0.001^*$|
| Surgical stress score | 0.83 (0.37–3.15)                          | 0.88 (0.27–2.06)                           | 0.737     |
| Comprehensive risk score | 0.78 (0.17–2.93)                     | 0.95 (0.25–1.99)                           | 0.068     |
| ASA-PS, 1/2/3/4/no data | 29/44/0/0/8                          | 2/16/1/0/2                                 | 0.009*    |
| Wigger’s score       | 3 (0–7)                                     | 5 (3–8)                                    | $<0.001^*$|
| Dasari’s score       | 8 (4.5–13.0)                                | 10 (8.5–13.5)                              | $<0.001^*$|

PNI, prognostic nutritional index; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; CRP, C-reactive protein; mGPS, modified Glasgow prognostic score; CONUT, controlling nutritional status; LYM, lymphocyte; POSSUM, physiological and operative severity score for the enumeration of mortality and morbidity; E-PASS, estimation of physiologic ability and surgical stress; ASA-PS, American Society of Anesthesiologists-Performance Status

$p < 0.05$
The area under the curve and the optimal cutoff score were 0.821 and 9.25, respectively (sensitivity 1.000, specificity 0.546, positive predictive value 0.102, negative predictive value 1.000; \( p = 0.016 \)). The 90-day mortality rates were 0% and 10% in patients with a Dasari’s score of less than 9.25 and greater than 9.25, respectively (Fig. 3b).

### Discussion

The findings of this study indicate that the short- and long-term effects of major hepatectomy with EBDR in older patients with PHC are similar to those in non-older patients. Of various nutritional and surgical risk scores,
Dasari’s score was found to be most accurate in predicting 90-day mortality.

The number of older patients with PHC in our institution has been increasing. As aging of the population is expected to continue in the future, the need for consideration of the risks and benefits of surgery, particularly regarding highly invasive procedures, is greatly needed.

Table 4 Five cases of 90-day mortality following major hepatectomy with extrahepatic bile duct resection for perihilar cholangiocarcinoma

| No | Year | Case | PS | Procedure | Comorbidity | Postoperative complication | POD of mortality |
|----|------|------|----|-----------|-------------|---------------------------|------------------|
| 1  | 2007 | 79F  | 0  | Right hepatectomy | HT          | Hepatic infarction, hepatic failure | 43               |
| 2  | 2007 | 72F  | 0  | Right trisectionectomy (PV + A resection) | None       | Bile leakage, hepatic failure | 23               |
| 3  | 2010 | 70M  | 1  | Left HPD | COPD       | Bile leakage, AP, MOF | 36               |
| 4  | 2010 | 69M  | 0  | Right trisectionectomy | None       | Bile leakage, hepatic failure | 79               |
| 5  | 2020 | 84M  | 1  | Left hepatectomy (PV + A resection) | RA, DM, IP | Bile leakage, AP, ARDS | 44               |

PS, performance status; POD, postoperative day; PV, portal vein; A, artery (hepatic artery); HPD, hepatopancreato-duodenectomy; HT, hypertension; COPD, chronic obstructive pulmonary disease; RA, rheumatoid arthritis; DM, diabetes mellitus; IP, interstitial pneumonia; AP, aspiration pneumonia; MOF, multiorgan failure; ARDS, acute respiratory distress syndrome

Table 5 Univariate analysis of predictors of 90-day mortality after major hepatectomy with extrahepatic bile duct resection for perihilar cholangiocarcinoma

| Variables                                | Odds ratio | 95% CI          | p-value |
|------------------------------------------|------------|-----------------|---------|
| Age                                      | 1.128      | 0.993–1.281     | 0.065   |
| CCI                                      | 1.288      | 0.863–1.921     | 0.215   |
| PNI                                      | 0.966      | 0.853–1.094     | 0.585   |
| NLR                                      | 0.177      | 0.006–5.034     | 0.311   |
| PLR                                      | 1.002      | 0.995–1.010     | 0.540   |
| mGPS                                     | 1.578      | 0.494–5.036     | 0.441   |
| CONUT                                    | 0.999      | 0.565–1.766     | 0.998   |
| Operative time                           | 1.000      | 0.992–1.007     | 0.921   |
| Blood loss                               | 1.000      | 1.000–1.001     | 0.740   |
| FLV                                      | 0.990      | 0.923–1.062     | 0.775   |
| Two-section resection                    | 0.549      | 0.053–5.635     | 0.614   |
| Three-section resection                  | 3.644      | 0.561–23.692    | 0.176   |
| HPD                                      | 7.833      | 0.660–93.027    | 0.103   |
| PV resection                             | 0.803      | 0.128–5.023     | 0.815   |
| Hepatic artery resection                 | 3.375      | 0.521–21.850    | 0.202   |
| POSSUM physiological score              | 1.087      | 0.938–1.259     | 0.268   |
| E-PASS preoperative risk score           | 67.929     | 0.094–49001.719 | 0.209  |
| E-PASS surgical stress score             | 1.221      | 0.217–6.855     | 0.821   |
| E-PASS comprehensive risk score          | 1.619      | 0.323–8.111     | 0.558   |
| Wigger’s score                           | 1.876      | 0.996–3.532     | 0.051   |
| Dasari’s score                           | 1.868      | 1.103–3.166     | 0.020*  |

CI, confidence interval; CCI, Charlson Comorbidity Index; PNI, prognostic nutritional index; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; mGPS, modified Glasgow prognostic score; CONUT, controlling nutritional status; FLV, future remnant liver volume; HPD, hepatopancreato-duodenectomy; PV, portal vein; POSSUM, Physiological and operative severity score for the enumeration of mortality and morbidity; E-PASS, estimation of physiologic ability and surgical stress

*p < 0.05

Table 6 Multivariate analysis of predictors of 90-day mortality after major hepatectomy with extrahepatic bile duct resection for perihilar cholangiocarcinoma

| Variables | Odds ratio | 95% CI | p-value |
|-----------|------------|--------|---------|
| Dasari’s score | 1.868    | 1.103–3.166 | 0.020* |

*p < 0.05
In this study, there were no significant differences in the CCI and other nutritional indicators between older patients and non-older patients. In addition, the surgical risk score that was significantly higher in older patients was the one that included age as a factor, with no significant between-group difference in the score that did not include age. This suggests that patients expected to be at high risk for surgery due to a large number of comorbidities, poor physical status, or decreased physical function may have been considered ineligible for surgery based on the preoperative assessment and were not included in this study. The rates of PVE and combined portal vein resections were also significantly lower for older patients, suggesting a tendency to avoid highly invasive surgery. Previous studies have also shown a tendency to avoid excessive invasion in older patients [36, 37], suggesting the existence of a potential selection bias.

Prior studies detailing hepatectomy for hepatocellular carcinoma, peripheral cholangiocarcinoma, and metastatic liver tumors in older patients, although the definition of older patients varied by report, have reported that respiratory and cardiovascular complications [38], severe complications [39], and overall mortality [8] are more common in older patients, whereas others studies have reported a similar incidence of complications and mortality in older patients as in non-older patients [7, 9, 40–44]. According to Lallement et al. [45], there is no difference in surgical complications, but there is an increase in geriatric complications, such as confusion, acute urine retention, and decubitus in older patients. On the other hand, major hepatectomy for PHC in older patients, which is often combined with EBDR, is a more invasive surgery than those used for other hepatic tumors. Therefore, we must be more careful when determining an indication of surgery for older patients with PHC.

Safety with regard to major hepatectomy for PHC in older patients is controversial. Several studies have indicated no significant difference in the rate of severe complications after major hepatectomy between older patients and non-older patients with PHC [46]. Moreover, it has also been reported that severe complications in older patients were rare because relatively less invasive surgeries were performed [37]. However, other studies have reported that severe complications are more frequent in older patients [47, 48]. In the present study, the incidence of respiratory complications was higher in older patients with regard to short-term postoperative outcomes, but there were no significant differences in the incidence of other complications, severity of illness, or postoperative hospital stay. The increase in respiratory complications is expected to be greatly influenced by the age-related decline in respiratory function, suggesting that particular attention should be paid to older patients with respiratory complications. The short-term results of major hepatectomy with EBDR in older patients are comparable to those in non-older patients, provided that perioperative management is performed with attention to this point.

In the present study, there was no significant difference in the OS and DSS between the groups, suggesting that major hepatectomy with EBDR was beneficial even for older patients with PHC. In addition, although the rate of respiratory complications was higher in older patients, considering that cumulative postoperative complication rates after PHC resection were found to only negatively affect the long-term survival on a moderate level [49], there is no need to hesitate to perform hepatectomy based only on advanced age.

According to a recent meta-analysis on major hepatectomy for PHC, 30-day mortality was 5%, 90-day mortality was 9%, and both overall and severe morbidity were high at 57% and 40%, respectively [50]. Although in our study the 30-day and 90-day mortality rates were 1.0% and 4.9%, respectively, these were reported to be 2.0% and 3%, respectively, in the Asian population [50], indicating that safer
surgery is needed. When considering the details of 90-day mortality at our institution, we found that highly invasive procedures, such as trisectionectomy, hepatopancreatoduodenectomy, and combined hepatic artery and portal vein resections, were performed in many of the cases. Furthermore, postoperative bile leak was often the underlying cause. Therefore, it is necessary to improve surgical techniques and postoperative management.

Preoperative prediction of high-risk cases is also very important for selecting surgical procedures and preventing perioperative complications. However, a variety of nutritional and preoperative risk scores have been developed, and the optimal tool for predicting short-term outcomes in older patients undergoing elective surgery has not been established [1]. Several studies on risk factors for major hepatectomy for PHC have also shown that FLV [48] and preoperative drainage failure [51] are useful for predicting severe complications; FLV [52], FLV to body weight ratio [53], and E-PASS score [54] for predicting post-hepatectomy liver failure; and Wigger’s [31] and E-PASS scores [27, 28] for predicting mortality. Although the usefulness of various risk scores has been reported, an optimal risk scale has not been established yet. Therefore, in this study, we performed a multivariate analysis to identify the optimal risk predictors in our cohort and found that only Dasari’s score was a significant predictor. Dasari’s score is a risk score for 90-day mortality after hepatectomy calculated using preoperative data [30]. This is a highly reliable score derived from a large study population and a validation cohort. The following four factors were scored as risk factors: (1) age (<40: 0, 40–54: 2, 55–70: 3, >70: 6), (2) diabetes mellitus (no: 0, yes: 1), (3) preoperative sodium level (<135: 4, 135–140: 2.5, 141–145: 1, >145: 0), and (4) type of surgery (minor ≤3 segments: 1, major [hepatectomy with EBDR]: 2, extra major [trisectionectomy, combined vascular reconstruction, hepatopancreatoduodenectomy]: 3, and the total score (0–15 points) was used to evaluate the risk. The higher the score, the higher the risk of 90-day mortality. A score of 9 points is associated with an estimated mortality of approximately 5–6%, and higher scores are associated with an increased rate of estimated mortality. A score of 9.25 was set as the cutoff in our ROC analysis. The sensitivity was very high (100%) and there were no deaths below 9.25. However, a high mortality rate of 10% was observed in cases with a score greater than 9.25. These results suggest that patients with a Dasari score above 9.25 should be treated with caution. Among the risk factors included in Dasari’s score, diabetes mellitus and preoperative cholangitis should be associated with an increased risk of postoperative infectious complications and their severity, but the fact that sodium is considered to be a risk factor is fascinating. In the present study, sodium was also found to be a risk factor by univariate analysis. We assume that sodium is an indicator of body water balance, and patients with impaired sodium balance are more likely to develop acute kidney injury and respiratory failure due to inability to maintain body water balance when complications occur, which could result in fatal outcomes.

This study has several limitations. First, it was a retrospective, single-center study, and the sample size was small. In addition, the study period was long (over 15 years). During this 15-year period, there have been significant advancements in surgical procedures and perioperative management, which have had a positive effect on outcomes which might have biased our findings. Second, only a small number of mortalities occurred during this study. Thus, further study is needed to verify our results. Despite these limitations, ours is one of few studies that have investigated the safety and benefits of major hepatectomy with EBDR in older patients with PHC. Moreover, we identified a useful predictor of 90-day mortality, which indicates the possible clinical applicability of our findings.

Conclusions

Major hepatectomy with EBDR can be performed for optimally selected older and younger patients with PHC, resulting in a good prognosis. However, indications for extended surgery should be considered.

Dasari’s preoperative risk score may be a good predictor of 90-day mortality after major hepatectomy with EBDR.

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Declarations

Completing interests The authors declare no competing interests.

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