Original Article

The ADOPT-LC score: a novel predictive index of in-hospital mortality of cirrhotic patients following surgical procedures, based on a national survey

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Aim: We aimed to develop a model for predicting in-hospital mortality of cirrhotic patients following major surgical procedures using a large sample of patients derived from a Japanese nationwide administrative database.

Methods: We enrolled 2197 cirrhotic patients who underwent elective (n = 1973) or emergency (n = 224) surgery. We analyzed the risk factors for postoperative mortality and established a scoring system for predicting postoperative mortality in cirrhotic patients using a split-sample method.

Results: In-hospital mortality rates following elective or emergency surgery were 4.7% and 20.5%, respectively. In multivariate analysis, patient age, Child–Pugh (CP) class, Charlson Comorbidity Index (CCI), and duration of anesthesia in elective surgery were significantly associated with in-hospital mortality. In emergency surgery, CP class and duration of anesthesia were significant factors. Based on multivariate analysis in the training set (n = 987), the Adequate Operative Treatment for Liver Cirrhosis (ADOPT-LC) score that used patient age, CP class, CCI, and duration of anesthesia to predict in-hospital mortality following elective surgery was developed. This scoring system was validated in the testing set (n = 986) and produced an area under the curve of 0.881. We also developed iOS/Android apps to calculate ADOPT-LC scores to allow easy access to the current evidence in daily clinical practice.

Conclusion: Patient age, CP class, CCI, and duration of anesthesia were identified as important risk factors for predicting postoperative mortality in cirrhotic patients. The ADOPT-LC score effectively predicts in-hospital mortality following elective surgery and may assist decisions regarding surgical procedures in cirrhotic patients based on a quantitative risk assessment.

Key words: ADOPT-LC, Child–Pugh score, in-hospital mortality, national database, scoring system

INTRODUCTION

Chronic liver diseases regardless of etiology can result in LC, which is characterized by the loss of liver function. The presence of LC was reported as an important risk factor for perioperative morbidity and mortality due to bleeding tendency, increased susceptibility to infection, malnutrition, and systemic edema. As clinical severity varies greatly, risk stratification of patients with LC in terms of major surgery is important to assess the risk and benefit of the procedure. To date, several studies have investigated the postoperative morbidity and mortality in cirrhotic patients.1–6 In colonic surgery, the mortality increased from 5 to 14% if the patients suffered from LC.7 Another study showed an increase in mortality rate from 0 to 6% after cholecystectomy in patients with LC compared with non-LC patients.8 However, evidence for precise risk stratification is insufficient due to inclusion of small sample sizes or a lack of detailed information.

The DPC is a database containing discharge abstract and administrative claims of inpatients who are admitted to secondary or tertiary care hospitals in Japan9–11 and represents approximately 50% of inpatient admissions to such hospitals.
hospitals. In the present study we evaluated the predictive factors for in-hospital mortality and developed a model for predicting in-hospital mortality following major surgical procedures using a large sample of patients derived from the DPC database.

**METHODS**

**Data source**

The DPC database contains the following information: hospital location (patient demographics, diagnosis), comorbidities at admission, and complications after admission recorded with Japanese text and International Classification of Diseases and Related Health Problems, Tenth Revision codes, therapeutic procedures encoded by Japanese original K-codes, length of stay (discharge status, including in-hospital death), and total costs. In the DPC database, it is strongly recommended that CP score is entered for patients with a diagnosis of LC. The DPC hospitals are surveyed by the DPC Study Group and funded by the Ministry of Health, Labour and Welfare, Japan. All 82 university teaching hospitals in Japan are required to adopt the DPC system, but it is optional for community hospitals. The survey started in 2003 with 82 teaching hospitals and the number of participating hospitals and registered patients has since increased. Data were collected over 6 months (from July 1 to December 31) until 2010 and throughout the year from 2011. There were 2.65, 2.82, 2.78, 3.30 and 6.96 million cases in the database in 2007, 2008, 2009, 2010 and 2011, respectively. As of 2011, inpatients in the DPC database represented approximately 50% of all inpatient admissions to secondary and tertiary care hospitals in Japan.

The requirement for informed consent was legally waived in this study due to the anonymous nature of the data. Study approval was obtained from the Institutional Review Board of the University of Tokyo (Tokyo, Japan).

**Samples**

We obtained inpatient data for a total of 21 months: July 1 to December 31, 2010, January 1 to December 31, 2011, and January 1 to March 31, 2012 (the DPC survey was only carried out between July and December in 2010). Among 12 million inpatients included in the DPC database during the above period, we identified the patients whose CP score was stored in the database to extract the patients with LC. Among them, we identified the patients who underwent major surgical procedures, excluding liver surgery containing liver transplantation. The procedures and K-codes identified for the present study are shown in Table S1. Then, we collected information regarding the CCI, a well-validated weighted comorbidity score derived from unselected hospital admissions that predicts 1-year mortality after hospital discharge based on Quan’s algorithm. Generally, operative risk was reported to be defined by patient-related factors such as gender, age, or comorbidities as indicators of patient background, as well as operative invasiveness or duration of anesthesia as indicators of procedural risk. Of these factors, information on patient age, gender, comorbidities (CCI), and duration of anesthesia was extractable from the DPC database. Thus, we used these factors for predictive variables of in-hospital mortality.

Emergency or elective hospitalizations are required in this database; thus, the surgeries were divided into emergency and elective. Emergency surgery was defined as a surgery within 1 day after emergency hospitalization. As patients included in the current study underwent a wide range of surgeries, we also investigated in-hospital mortality and predictive factors in patients who received elective gastroenterological surgery.

**Statistical analysis**

Continuous variables were expressed as medians with the first and third quartiles while categorical variables were expressed as frequencies (%). The univariate association among groups was assessed by the $\chi^2$-test. Stepwise logistic regression model analysis was used to calculate adjusted ORs and 95% CIs of various factors. The trend towards higher mortality with an increase in variable was evaluated using the Cochrane–Armitage trend test. For elective surgery, a split-sample method was applied to develop a scoring system as a predictor of in-hospital mortality. The patients were assigned randomly to either the training set or testing set group. The clinical data on admission were assessed as predictors of mortality using stepwise logistic regression analysis in the training set. Then, the ratio of beta coefficient of the final model was determined and was rounded to whole digits for convenience. This scoring system was then validated in the test group using ROC curve analysis. The AUC was evaluated as the ability to predict in-hospital death and the optimum cut-off levels for prediction were determined using the Youden test. Comparison of the AUC values was carried out using the Delong test. The Cochran–Armitage trend test and the Delong test were undertaken using R software version 3.1.1 (http://www.r-project.org). All other statistical analyses were carried out using IBM SPSS version 19.0 (IBM SPSS, Armonk, NY, USA). The randomization into a training and a testing set was carried out according to a software-generated protocol (SPSS version 19.0) based on a computerized random number sequence. A P-value <0.05 was considered to indicate statistical significance.

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RESULTS

Patient characteristics

A TOTAL OF 2197 patients were identified from the database. Among them, 1973 and 224 patients underwent elective and emergency surgeries, respectively. Patient characteristics are shown in Table 1. The median age and male proportion were approximately 70 years and 60%, respectively. The proportion of female patients, patients with CP class A, and patients with CCI 6 or more were higher in elective surgery compared to emergency surgery.

Surgical subcategory

In the elective surgery group, intra-abdominal surgery (gastroenterological surgery and abdominal hernia repair) accounted for approximately 60% (1173 patients), followed by breast surgery (9.1%, 181 patients), musculoskeletal surgery (7.7%, 151 patients), cardiovascular surgery (6.7%, 132 patients), and urological surgery (6.7%, 132 patients). Intra-abdominal surgery accounted for approximately 85% (195 patients) in the emergency surgery group, followed by cardiovascular surgery (10.3%, 23 patients). Only 2.6% (6 patients) of patients received other surgical procedures (Table S2).

Table 1 Clinical characteristics of patients undergoing elective (n = 1973) and emergency (n = 224) surgeries in Japan

| Variables                        | Elective surgery | Emergency surgery | P-value |
|----------------------------------|------------------|-------------------|---------|
| Age, years, median (1st–3rd quartile) | 69 (61–75) | 69 (62–78) | 0.060   |
| Age, years, n (%)               |                  |                   |         |
| ≤65                             | 783 (39.7)       | 74 (33.0)         |         |
| ≥66                             | 1190 (60.3)      | 150 (67.0)        | 0.040   |
| Gender, n (%)                   |                  |                   | <0.001  |
| Male                            | 1079 (54.7)      | 139 (62.1)        |         |
| Female                          | 894 (45.3)       | 85 (37.9)         |         |
| Child–Pugh classification, n (%) |                  |                   |         |
| A                               | 1246 (63.1)      | 68 (30.4)         |         |
| B                               | 570 (28.9)       | 82 (36.6)         |         |
| C                               | 157 (8.0)        | 74 (33.0)         |         |
| Charlson Comorbidity Index, n (%) |                  |                   | 0.010   |
| ≤2                              | 581 (29.4)       | 78 (34.8)         |         |
| 3–5                             | 956 (48.5)       | 115 (51.3)        |         |
| ≥6                              | 436 (22.1)       | 31 (13.8)         |         |

Data from the Diagnosis Procedure Combination database, 1 July 2010–31 March 2012.

In-hospital mortality following surgical procedures

The numbers of in-hospital deaths among patients who underwent elective and emergency surgeries were 92 (4.66%) and 46 (20.5%), respectively.

Table 2 shows the in-hospital mortality associated with each procedure and univariate association between patient characteristics and procedural backgrounds. The in-hospital mortality associated with elective surgery was higher in older patients (P < 0.001), in patients with moderate (CP class B) or severe (class C) hepatic impairment (P < 0.001), higher CCI (P < 0.001), and longer duration of anesthesia (P < 0.001). The in-hospital mortality associated with emergency surgery was higher in patients with moderate (CP class B) or severe (class C) hepatic impairment (P < 0.001), higher CCI (P = 0.02), and longer duration of anesthesia (P < 0.001). The results of multivariate logistic regression analysis of in-hospital mortality are shown in Figure 1. Multivariate logistic regression revealed that in-hospital mortality increased significantly with older age (65 ≥ years vs ≤ 66 years: OR = 2.16, P = 0.006), higher CP class (B vs A: OR = 2.38, P = 0.004; C vs A: OR = 21.5, P < 0.001), higher CCI (CCI 3–5 vs CCI ≤ 2: OR = 2.58, P = 0.04; CCI 6 vs CCI ≤ 2: OR = 5.69, P < 0.001), and longer duration of anesthesia (181–420 min vs ≤ 180 min: OR = 3.32, P = 0.003; > 420 min vs ≤ 180 min: OR = 10.7, P < 0.001) for elective surgery (Fig. 1a). In-hospital mortality also increased significantly with higher CP class (C vs A: OR = 10.8, P < 0.001) and longer duration of anesthesia (181–420 min vs ≤ 180 min: OR = 5.89, P < 0.001; > 420 min vs ≤ 180 min: OR = 13.6, P < 0.001) for emergency surgery (Fig. 1b).

In-hospital mortality following elective gastroenterological surgery

We also investigated in-hospital mortality and predictive factors in patients who underwent elective gastroenterological surgery. When restricted to elective gastroenterological surgery, the proportions of patients with CP classification A or CCI 2 or less were lower than those of overall elective surgery (Table S3). The number of in-hospital deaths among patients who underwent elective gastroenterological surgery was 60 (6.40%). In univariate analysis, higher in-hospital mortality following elective gastroenterological surgery was significantly associated with moderate (CP class B) or severe (class C) hepatic impairment (P < 0.001), higher CCI (P < 0.001), and longer duration of anesthesia (P = 0.03). Multivariate logistic regression revealed that in-hospital mortality was
significantly associated with higher CP class (B vs A: OR = 2.85, *P* = 0.01; C vs A: OR = 25.1, *P* < 0.001) and higher CCI (CCI ≥ 6 vs CCI ≤ 2: OR = 8.22, *P* = 0.007), and marginally with longer duration of anesthesia (>420 min vs ≤ 180 min: OR = 2.55, *P* = 0.053) (Table S4).

**In-hospital mortality following surgical procedures in each CP score**

We then analyzed in-hospital mortality rates for each CP score in elective and emergency surgeries. Rising trends of mortality with increasing CP score were observed in elective and emergency surgery. Analysis using the Cochran–Armitage trend test showed a significant increase in in-hospital mortality with higher CP score for both elective (*P* < 0.001) (Fig. S1a) and emergency (*P* < 0.001) (Fig. S1b) surgeries.

**Receiver–operating characteristic curve analysis of predictive factors of in-hospital mortality**

The ROC curve for the prediction of in-hospital mortality was plotted for the CP score (Fig. 2). The AUCs for the prediction of in-hospital mortality for elective and emergency

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**Table 2** Univariate analysis for in-hospital mortality of patients with liver cirrhosis undergoing elective and emergency surgeries in Japan

|                | Elective surgery |         |         |          | Emergency surgery |         |          |
|----------------|------------------|---------|---------|----------|-------------------|---------|----------|
|                | *n/N*            | % (95% CI) | *P*-value | *n/N*    | 95% CI            | *P*-value |
| Overall        | 92/1973          | 4.66 (3.78–5.69) | 0.040     | 46/224   | 20.5 (15.4–26.4)  | 0.390    |
| Gender         |                  |          |          |          |                   |          |
| Female         | 32/894           | 3.58 (2.46–5.02)  |          | 20/85    | 23.5 (15.0–34.0)  |          |
| Male           | 60/1079          | 5.56 (4.27–7.10)  |          | 26/139   | 18.7 (12.6–26.2)  |          |
| Age, years     |                  |          |          |          |                   |          |
| ≤65            | 22/783           | 2.81 (1.77–4.22)  | 0.002     | 15/74    | 20.3 (11.8–31.2)  | 0.950    |
| ≥66            | 70/1190          | 5.88 (4.61–7.37)  |          | 31/150   | 20.6 (14.5–28.0)  |          |
| Child–Pugh classification |          |          |          |          |                   |          |
| A              | 21/1246          | 1.69 (1.05–2.56)  | <0.001    | 6/68     | 8.82 (3.31–18.2)  | <0.001    |
| B              | 27/570           | 4.74 (3.14–6.82)  |          | 7/82     | 8.54 (3.50–16.8)  |          |
| C              | 44/157           | 28.0 (21.2–35.7)  | <0.001    | 33/74    | 44.6 (33.0–56.6)  | 0.020    |
| Charlson Comorbidity Index |          |          |          |          |                   |          |
| ≤2             | 6/581            | 1.03 (0.380–2.23) | <0.001   | 8/78     | 10.3 (4.53–19.2)  |          |
| 3–5            | 43/956           | 4.50 (3.27–6.01)  |          | 29/115   | 25.2 (17.6–34.2)  |          |
| ≥6             | 43/436           | 9.86 (7.23–13.1)  |           | 9/31     | 29.0 (14.2–48.0)  |           |
| Duration of anesthesia, min |          |          |          |          |                   |          |
| ≤180           | 8/601            | 1.33 (0.576–2.61) | <0.001    | 7/103    | 6.80 (2.78–13.5)  | <0.001    |
| 181–420        | 44/1002          | 4.39 (3.21–5.85)  |          | 26/90    | 28.9 (19.8–39.4)  |          |
| >420           | 40/370           | 10.8 (7.84–14.4)  |          | 13/31    | 41.9 (24.5–60.9)  |          |

Data from the Diagnosis Procedure Combination database, 1 July 2010–31 March 2012. CI, confidence interval.
surgeries were 0.804 (95% CI, 0.751–0.856) and 0.702, respectively, for elective surgery, and 0.784, 0.535, 0.642 and 0.764, respectively, for emergency surgery.

Scoring system for prediction of in-hospital mortality following elective surgery

Finally, the ADOPT-LC score, which predicts in-hospital mortality following elective surgery, was developed. We randomly divided the elective surgery group into two sets: a training set (n = 987) and a testing set (n = 986) to develop a scoring system to predict in-hospital mortality after surgery. In stepwise logistic regression model analysis, age of patients, CP classification, CCI, and duration of anesthesia were selected as factors in the final model. Scores were assigned to each factor according to the estimated regression coefficient (beta coefficient) in the final model and the prognosis score was defined as the sum of each score, ranging from 0 to 8 points (Table 3). The ADOPT-LC score was then validated using the testing set of 986 patients. In-hospital mortality rates for risk scores 0, 1, 2, 3, 4, 5, 6, 7, and 8 were 0%, 0%, 0.5%, 1.1%, 5.5%, 8.9%, 25.0%, 60.0%, and 100.0%, respectively (Fig. 3). In-hospital mortality was well distributed among the groups based on the risk score (Cochran–Armitage trend test, \( P < 0.001 \)). The ROC curve for the prediction of in-hospital death was plotted for the ADOPT-LC score (Fig. 4). The AUC for the prediction of in-hospital mortality was 0.881 (95% CI, 0.832–0.930). The optimal cut-off level for our risk score was 3.5. Using this cut-off, sensitivity and specificity were 90.5% and 69.7%, respectively.

We then compared the AUC values of the ADOPT-LC score to that of CP score. In the testing set of 986 patients, the AUC of CP score for the prediction of in-hospital mortality was 0.803 (95% CI, 0.720–0.886). The Delong test showed significantly higher AUC value of the ADOPT-LC score than that of the CP score (\( P = 0.01 \)).

To allow easy access to the current evidence in daily clinical practice, we developed iOS/Android apps to calculate the ADOPT-LC score. The download link for iOS is https://itunes.apple.com/JP/app/id976986669?mt=8 and for Android, https://play.google.com/store/apps/details?id=jp.cureapphandlinglivercirrhosis.

DISCUSSION

REPORTEDLY, LC IS associated with increased mortality after a surgical procedure.\(^4\,7\) In patients with LC undergoing a surgical procedure, the CP class was shown to be an accurate preoperative predictor of in-hospital mortality,\(^19\) with elective surgery generally considered safe in CP class A or B patients. Surgery in patients with CP class
C and emergency surgery has been associated with high mortality.20 However, the majority of previous studies evaluating the usefulness of predictors for postoperative mortality, including CP score, were limited by a small sample size due to the limited number of surgical procedures undertaken on cirrhotic patients. To our knowledge, the current study is the largest investigation of predictive factors — including CP — of in-hospital mortality following major surgical procedures in cirrhotic patients and the first to develop a predictive model. In particular, the data for in-hospital mortality were expected to be 100% reliable and free from recall bias because outcome was a required item on patient discharge.

In the present study, in-hospital mortality rates among cirrhotic patients who underwent elective and emergency surgeries were 4.7% and 20.5%, respectively. Previously

| Variables | n / N | % (95% CI) | Odds ratio (95% CI) | Beta coefficient | P-value | Score |
|-----------|------|------------|---------------------|------------------|---------|-------|
| Overall   | 49/987 | 4.96 (3.70–6.51) | | | |
| Age, years | | | | | |
| ≤65      | 13/394 | 3.30 (1.77–5.58) | 1.00 | | |
| ≥66      | 36/593 | 6.10 (4.29–8.31) | 2.05 (1.01–4.16) | 0.719 | 0.047 | 1 |
| Child–Pugh classification | | | | | |
| A        | 11/613 | 1.79 (0.899–3.19) | 1.00 | | |
| B        | 17/286 | 5.94 (3.50–9.35) | 2.72 (1.23–6.02) | 1.00 | 0.010 | 1 |
| C        | 21/88  | 23.9 (15.4–34.1) | 15.7 (6.99–35.4) | 2.76 | <0.001 | 3 |
| Charlson Comorbidity Index | | | | | |
| ≤2      | 4/293 | 1.37 (0.373–3.46) | 1.00 | | |
| 3–5     | 21/475 | 4.42 (2.76–6.68) | 1.96 (0.63–6.09) | 0.671 | 0.250 | 1 |
| ≥6     | 24/219 | 11.0 (7.15–15.7) | 4.91 (1.57–15.3) | 1.59 | 0.006 | 2 |
| Duration of anesthesia, min | | | | | |
| ≤180  | 5/298 | 1.68 (0.547–3.87) | 1.00 | | |
| 181–420 | 23/498 | 4.62 (2.95–6.85) | 2.76 (0.99–7.67) | 1.01 | 0.052 | 1 |
| >420   | 21/191 | 11.0 (6.94–16.3) | 8.77 (3.08–25.0) | 2.17 | <0.001 | 2 |

Data from the Diagnosis Procedure Combination database, 1 July 2010–31 March 2012.

CI, confidence interval.

**Figure 3** In-hospital mortality rates following surgical procedures patients with cirrhosis according to Adequate Operative Treatment for Liver Cirrhosis (ADOPT-LC) score (points). *P*-value based on the Cochran–Armitage trend test.

**Figure 4** Receiver–operating characteristic curve for prediction of in-hospital mortality in patients with cirrhosis based on the Adequate Operative Treatment for Liver Cirrhosis scoring system in the testing set.

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reported in-hospital mortality rates following major surgical procedures were 11.6–28% \(^1\,2,21\) and increased to 35–64% in emergency surgery.\(^{23,24}\) The mortalities in the present study were lower than in previous studies; therefore, surgical procedures carried out in Japan on cirrhotic patients appear to be safer. However, the criteria in those studies might have been different from those in the present work, for example, approximately 40% of patients were CP class B or C in the study by Ziser et al.\(^{21}\) Also, mean or median age of patients in previous studies investigated the postoperative mortality in cirrhotic patients ranged from 55.6 to 66 years.\(^3,4,7,8,21–24\) In the current study, the median age of the study group was 69 years and higher than previous studies. Moreover, surgical procedures have varied over time, thus, straightforward comparison between the present and previous studies may be difficult.

Liver cirrhosis is associated with increased mortality in patients choosing elective surgery.\(^4,7\) Nguyen et al.\(^4\) reported that cirrhotic patients requiring colorectal surgery had a higher in-hospital mortality rate (14%) compared with patients without cirrhosis (5%).\(^7\) In previous studies using the Japanese nationwide DPC database, the mortality rates after surgical procedures were reported to be 0.9% for gastrectomy, 0.5% for colorectal resection,\(^25\) 0.11% for orthopedic surgery,\(^26\) and 0.84% for nephrectomy.\(^11\) Compared to previously reported mortality rates, the in-hospital mortality of 4.66% in cirrhotic patients following elective surgery was considered especially high.

In univariate and multivariate logistic regression analyses, in-hospital mortality increased significantly with higher CP class; moreover, analysis using the Cochran–Armitage trend test showed a significant increase in in-hospital mortality with higher CP score. Previous studies also reported the CP score to be a reliable predictor of in-hospital mortality after a surgical procedure in patients with cirrhosis.\(^24,27,28\) The large sample size in the present study allowed a further stratification. In the present study, we compared the predictive value of the CP score with patient age, CCI score, or the duration of anesthesia, which were shown to be strongly associated with higher postoperative mortality or complications in previous studies.\(^29,30\)\) using ROC analyses. The CP score showed a higher AUC for the prediction of in-hospital mortality compared with patient age, CCI score, or the duration of anesthesia, for both elective and emergency surgeries. Therefore, liver function is the most important factor for the prediction of in-hospital mortality following surgical procedures in cirrhotic patients. The large study population also allowed the original sample to be divided for cross-validation. The ADOPT-LC score using simple parameters (age, CP classification, CCI, and (estimated) duration of anesthesia) proposed in the current study showed significantly higher predictive AUC value than that of CP score, and may enable determination of whether surgical procedures in cirrhotic patients are warranted based on a quantitative risk assessment.

In the present study, we also investigated in-hospital mortality and predictive factors in patients who underwent elective gastroenterological surgery, as patients included in the current study underwent a wide range of surgeries. When restricted to gastroenterological surgery, in-hospital mortality following elective surgery was elevated to 6.4%. The proportions of CP classification A or CCI 2 or less were lower in patients who underwent gastroenterological surgery compared to the overall elective surgery group. Also, median duration of anesthesia in elective gastroenterological surgery (294 min) was longer than that of overall elective surgery (255 min) (data not shown). These factors may be related to higher in-hospital mortality in gastroenterological surgery.

Several limitations of this study should be acknowledged. First, the study population may not be representative of the general population because community hospitals participated voluntarily in the DPC database. Second, the DPC database included only inpatient data, thus the mortality after leaving a hospital could not be investigated. In some cases, critical complications related to the surgical procedure may occur after the patient leaves the hospital, and thus postoperative mortality may be underestimated. However, hospitals often provide both early postoperative care and subsequent rehabilitation in a single hospitalization in Japan. According to the Organization for Economic Co-operation and Development’s Health Statistics in 2014, the national average length of hospital stay in Japan was 17.2 days, which is much longer than in other countries (e.g. 4.8 days in the USA and 7.0 days in the UK).\(^31\) Actually, in the present study, the median length of hospital stay in patients who underwent elective surgery was 19 days (1st–3rd quartile range, 11–35 days) (data not shown). Thus, underestimation of postoperative mortality may be minimized. Third, as the DPC system was designed to assess reimbursement, co-existing diseases are usually reported when a specific treatment is necessary. Thus, the cirrhotic patients included in the present study may be biased toward patients with more serious disease who have received treatment, which could lead to overestimation of the in-hospital mortality rate. Finally, the immediate cause of death is not a required item in the DPC database. Accordingly, the in-hospital deaths recorded in this database may include those unrelated to treatment; therefore, the procedure-related mortality rate could have been overestimated. However,
the processes used for submission of data to the DPC database have several advantages, including diagnoses reported by attending physicians, the requirement for use of a well-specified reporting format, and mandatory submission that is linked to reimbursement.

In conclusion, LC is associated with higher rates of inhospital mortality in patients who have undergone major surgical procedures compared to the general population in Japan. The mortality rate was affected by the duration of anesthesia and patient background characteristics, particularly liver function, as assessed by the CP score. The usefulness of the CP score for the prediction of in-hospital mortality following surgical procedure was validated in a large nationwide Japanese database. The ADOP-LC score, a new scoring system developed in the current study, may enable determination of whether surgery is warranted in patients with LC.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher’s website:

Table S1. Procedures and K-codes identified for the present study.
Table S2. Surgical subcategory of elective and emergency surgery.
Table S3. Clinical characteristics of patients undergoing elective gastroenterological surgery (n = 938).
Table S4. Univariate and multivariate analyses for in-hospital mortality of patients received elective gastroenterological surgeries.
Table S5. Area under the curve, optimum cut-off level, and the sensitivity and specificity with this cut-off.