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Increased intra-abdominal pressure linked to worse long-term prognosis among patients with orthotopic liver transplantation: a retrospective, observational study

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Abstract

Objective To investigate the prognostic value of intra-abdominal pressure (IAP) among patients with orthotopic liver transplantation (OLT).

Patients We enrolled adult patients admitted in the Department of Critical Care Medicine of the First Affiliated Hospital of Sun Yat-sen University after undergoing liver transplantation from January 2018 to March 2022.

Methods and results A total of 382 patients were included, with 73 patients who died within 1 year after admission. Intra-abdominal Hypertension (IAH) was defined as a sustained IAP ≥ 12 mmHg. The incidence of IAH among liver transplant patients was 46.2%. The IAP and sequential organ failure assessment (SOFA) scores were significantly lower in survivors than non-survivors ($P < 0.05$). Restricted cubic spline (RCS) analysis found that an IAP level above 16 mmHg was significantly associated with an elevated risk of 1-year mortality, and Kaplan–Meier survival curves further validated this finding (log-rank $P < 0.001$). Multivariate Cox proportional hazards regression model indicated that patients in IAH grade III (HR: 3.16, 95% CI: 1.31–7.62, $P = 0.010$) and IV (HR: 9.93, 95% CI: 2.84–34.7, $P < 0.001$) had significantly higher 1-year mortality risks adjusted by SOFA score classifications compared to individuals without IAH. Maximum IAP levels alone and a modified SOFA score incorporating IAH grade demonstrated satisfactory performance in predicting in-hospital mortality among OLT patients (AUC: 0.710, 0.834, respectively).

Conclusions Elevated intra-abdominal pressure above 16 mmHg was significantly related with worse 1-year survival among OLT patients. Both maximum IAP alone and SOFA score incorporated with IAH components showed strong prognostic values for in-hospital mortality of these individuals.

Keywords Intra-abdominal pressure, Sequential organ failure assessment, Orthotopic liver transplantation, Prognosis, Intensive care unit

Background

Intra-abdominal pressure (IAP), as one of the critical monitoring indicators after abdominal surgery, has received increasing attention in recent years. In ICU, elevated IAP is closely associated with mortality rates [1, 2]. Early identification of intra-abdominal hypertension (IAH) facilitates the distinction of high-risk patients and the prompt implementation of

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therapeutic interventions, thereby reducing the occurrence of abdominal compartment syndrome (ACS). Abdominal surgery, particularly orthotopic liver transplantation (OLT), stands out as a significant risk factor for IAH and ACS [3, 4]. The prognosis of liver transplantation patients, which involves a long surgical procedure and significant trauma, heavily relies on postoperative critical care. Comprehensive assessment of post-OLT recipients, identification of high-risk individuals, and evaluation of treatment outcomes have remained undetermined so far. Previous studies have suggested that the SOFA score is a noteworthy predictive model for assessing the prognosis of OLT patients [5–7]. Similarly, some studies have indicated that the IAH duration was an independent predictor of 60-day mortality among critically ill patients with sepsis (odds ratio: 1.196; $p=0.014$) [8]. IAH and ACS are associated with reduced organ perfusion pressure and subsequent ischemic injury, which may contribute to the development of renal failure and acute intestinal injury. Furthermore, IAH and ACS can induce diaphragmatic elevation, potentially leading to respiratory compromise and circulatory dysfunction. Therefore, our study aims to investigate the association between elevated IAP and long-term outcomes among OLT patients, and further explore the prognostic value of maximum IAP level and a novel scoring system integrating IAH grade and SOFA score for predicting in-hospital mortality in these patients.

Methods

Patients selection

We enrolled a total of 398 adult patients who underwent OLT and were admitted to the Department of Critical Care Medicine, First Affiliated Hospital of Sun Yat-sen University, from January 2018 to March 2022. Exclusion criteria included patients without a bladder pressure monitoring during ICU stay, inability to assess SOFA scores, and ICU length of stay (LOS) less than 24 h.

Data extraction

The following variables were extracted: age, gender, height, weight, comorbidities, the intra-abdominal pressure at ICU admission and the maximum value during ICU stay, the SOFA score at ICU admission and the maximum score during ICU stay, APACHE II score at ICU admission, and 1-year follow-up outcomes. Additionally, the age and BMI of their corresponding donors were also recorded. All data were extracted using Structured Query Language (SQL) queries via the pgAdmin4 (version 6.15) interface for PostgreSQL.

Measurements

SOFA Score

After the patient was admitted to the ICU, experienced ICU doctors recorded vital signs, blood gas analyses, liver and kidney function, coagulation function and blood routine results. The SOFA score includes the functional assessment of six systems, including respiratory, coagulation, cardiovascular, neurological, liver, and kidney function. Each item is scored from 0 to 4 points, and the worst values of each day's results were selected for calculation, with the first and the maximum total score during ICU stay recorded.

Intra-abdominal Pressure (IAP)

IAP was measured every 6 h via an indwelling urinary catheter starting from ICU admission [9]by trained ICU nurses. The first IAP at admission, maximum IAP during ICU stay, and IAP at the time of maximum SOFA score during ICU stay were recorded.

Intra-abdominal Hypertension (IAH)

According to the recommendations of the World Society of the Abdominal Compartment Syndrome in 2013, IAH was defined as a sustained IAP ≥ 12 mmHg. IAH was further graded as follows: Grade I, 12–15 mmHg; Grade II, 16–20 mmHg; Grade III, 21–25 mmHg; Grade IV, > 25 mmHg [10].

Modified SOFA Score

The IAH grade (0–4 points based on I-IV grades) was incorporated as a sub-item into the original SOFA score, yielding a novel modified SOFA score for the assessment of OLT patients.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation and compared between groups using the Student's t-test. Categorical variables were analyzed using the χ^2 test. Baseline characteristics and clinical outcomes were compared between survivors and non-survivors, patients with and without IAH during ICU stay, separately. We utilized the restricted cubic spline (RCS) with 3 knots to visualize the potential non-linear relationships between maximum IAP and 1-year mortality. Next, Kaplan–Meier curves and log-rank tests were used to compare the 1-year survival outcomes between patients with maximum IAP values greater or less than 16 mmHg, as a cutoff value of 16 mmHg was found to be associated with greater 1-year mortality risk in the RCS analysis. Moreover, we constructed univariate and multivariate Cox proportional hazards regression models to evaluate the prognostic effect of IAP related to 1-year mortality, adjusting for both IAH grade and SOFA score classifications. The Receiver Operating Characteristic (ROC) curve and Wald-χ^2 test were employed to evaluate the prognostic value of IAP, APACHE-II, SOFA score, and the modified SOFA score (with IAH grade incorporated) among post-OLT patients. Lastly, we conducted stratified Kaplan–Meier analysis by further separating patients into four groups and examining their 1-year survival outcomes using a log-rank test (Group 1: IA$P<16$ mmHg and SOFA <8 points, Group 2: IA$P>=16$ mmHg and SOFA <8 points, Group 3: IA$P<16$ mmHg and SOFA $>=8$ points, Group 4: IA$P>=16$ mmHg and SOFA >8 points).

A two-sided P-value <0.05 was considered statistically significant. All statistical analyses were performed using R software (version 4.32).

Results

After excluding 16 patients without any IAP or SOFA data, 382 post-OLT patients were retrospectively included. Among them, 309 patients survived within 1 year after ICU admission, and 73 patients died (Table 1). Baseline characteristics such as age, gender, BMI, and comorbidities were comparable between the two groups. However, non-survivors demonstrated significantly worse SOFA scores (6.5 vs 4.9, $P<0.001$) and increased IAP levels (12.9 vs 11.3 mmHg, $P=0.002$) than survivors at admission.

The mean maximum IAP during ICU stay after liver transplantation was 12.5 mmHg, with an IAH incidence rate of 46.1%. As shown in Table 2, patients who experienced IAH during ICU stay had significantly higher in-hospital mortality (9.7% vs 3.4%, $P=0.021$), 30-day mortality (13.1% vs 5.8%, $P=0.023$), and even 1-year mortality (24.4% vs 14.6%, $P=0.021$) compared to those without IAH. Additionally, patients with IAH had a prolonged ICU length of stay compared to their counterparts (6.4 vs 3.7 days, $P<0.001$), suggesting a greater need for advanced organ support for these individuals. Notably, the age and BMI of the donors showed no significant difference between the two groups. Among all patients with IAH, nearly 70% of them experienced it on the first day of ICU admission (see Additional file 1). Grouping based on survival status at various time points reveals a similar pattern: the intra-abdominal pressure (IAP) levels in the in-hospital mortality group, 30-day mortality group, and 1-year mortality group were significantly higher than those in the corresponding survival groups.

As illustrated in Fig. 1, RCS was used to explore the optimal IAP range associated with 1-year mortality risks. We found a J-shaped relationship between IAP and 1-year mortality ($P<0.001$), while an IAP level above 16 mmHg was significantly associated with an elevated risk of 1-year mortality. Hence, we further conducted survival analysis stratifying patients into IAP <16 mmHg and ≥ 16 mmHg groups. Patients with IAP ≥ 16 mmHg after liver transplantation had significantly worse 1-year survival compared to those with IAP <16 mmHg (log-rank $P<0.001$), as depicted in Fig. 2.

Next, we conducted univariate Cox regression analysis and incorporated significant risk factors into a multivariate model, as presented in Table 3. Both maximum SOFA and IAP values remained significant in the univariate

Table 1 Patient characteristics divided as survivors and non-survivors based on 1-year mortality

	All patients	Survivors	Non-Survivors	*P* value
No of patients	382	309	73	
Male gender (%)	327 (85.6)	307 (85.8)	20 (83.3)	NS
Age (years)	51.3 ± 10.2	51.0 ± 10.2	52.2 ± 10.4	NS
BMI (kg/m)	23.7 ± 14.0	23.9 ± 15.4	22.9 ± 3.8	NS
Donor Age (years)	44.2 ± 11.3	44.1 ± 11.1	44.8 ± 12.0	NS
Donor BMI (kg/m)	22.7 ± 3.4	22.8 ± 3.4	22.4 ± 3.3	NS
ICU stay (days)	4.9 ± 5.9	3.7 ± 4.3	10.0 ± 8.7	< 0.001
Hospital stay (days)	42.1 ± 27.8	39.9 ± 25.4	51.2 ± 35.0	0.002
Hypertension (%)	39 (10.2)	35 (11.3)	4 (5.5)	NS
Diabetes (%)	62 (16.2)	48 (15.5)	14 (19.2)	NS
CKD (%)	17 (4.5)	16 (5.2)	1 (1.4)	NS
Cancer (%)	218 (57.1)	183 (59.2)	35 (47.9)	NS
Cirrhosis (%)	292 (76.4)	242 (78.3)	50 (68.5)	NS
APACHE II , points	16.5 ± 6.0	15.4 ± 5.2	21.0 ± 7.2	< 0.001
IAP first day (cmH2O)	15.7 ± 4.7	15.3 ± 4.1	17.4 ± 6.6	0.002
IAP first day (mmHg)	11.6 ± 3.5	11.3 ± 3.1	12.9 ± 4.9	0.002
SOFA first day, points	5.2 ± 3.3	4.9 ± 3.0	6.5 ± 4.1	< 0.001
SOFA max, points	6.6 ± 4.1	5.7 ± 3.4	10.1 ± 4.8	< 0.001
IAP max (cmH2O)	17.0 ± 5.2	16.4 ± 4.5	19.4 ± 6.9	< 0.001
IAP max (mmHg)	12.5 ± 3.8	12.1 ± 3.3	14.3 ± 5.0	< 0.001
IAH (%)	176 (46.1)	133 (43.0)	43 (58.9)	0.021
IAH Grade (%)				< 0.001
Grade 0	206 (53.9)	176 (57.0)	30 (41.1)	
Grade 1	98 (25.7)	77 (24.9)	21 (28.8)	
Grade 2	64 (16.8)	51 (16.5)	13 (17.8)	
Grade 3	11 (2.9)	5 (1.6)	6 (8.2)	
Grade 4	3 (0.8)	0 (0.0)	3 (4.1)	
SOFA in IAP max, points	5.0 ± 3.4	4.5 ± 3.1	7.1 ± 3.5	< 0.001
modified SOFA, points	5.9 ± 3.7	5.2 ± 3.4	8.2 ± 3.9	< 0.001

BMI Body mass index, *ICU* Intensive care unit, *CKD* Chronic kidney disease, *APACHE II* Acute Physiology and Chronic Health Evaluation II, *SOFA* Sequential organ failure assessment, *IAP* Intra-abdominal pressure, *IAH* Intra-abdominal hypertension, *IAH Grade* Grade 0 < 12 mmHg, Grade I 12–15 mmHg, Grade II 16–20 mmHg, Grade III 21–25 mmHg, Grade IV > 25 mmHg, modified SOFA: the IAH grade was incorporated as a sub-item into the original SOFA score, yielding a modified SOFA score

Table 2 Patient characteristics divided by IAH and no IAH

	All patients	No IAH during ICU	IAH during ICU	*P* value
No of patients	382	206	176	
Male gender (%)	327 (85.6)	174 (84.5)	153 (86.9)	NS
Age (years)	51.3 ± 10.2	51.2 ± 10.7	51.3 ± 9.7	NS
BMI (kg/m)	23.7 ± 14.0	23.0 ± 3.3	24.6 ± 20.3	NS
Donor Age (years)	44.2 ± 11.3	44.1 ± 10.9	44.4 ± 11.7	NS
Donor BMI (kg/m)	22.7 ± 3.4	22.9 ± 3.5	22.5 ± 3.3	NS
ICU stay (days)	4.9 ± 5.9	3.7 ± 5.4	6.4 ± 6.2	< 0.001
Hospital stay (days)	42.1 ± 27.8	41.7 ± 29.9	42.5 ± 25.2	NS
APACHE II , points	16.5 ± 6.0	16.0 ± 6.3	17.0 ± 5.6	NS
SOFA, points	6.6 ± 4.1	5.6 ± 3.7	7.6 ± 4.2	< 0.001
Hypertension (%)	39 (10.2)	22 (10.7)	17 (9.7)	NS
Diabetes (%)	62 (16.2)	40 (19.4)	22 (12.5)	NS
CKD (%)	17 (4.5)	13 (6.3)	4 (2.3)	NS
Cancer (%)	218 (57.1)	113 (54.9)	105 (59.7)	NS
Cirrhosis (%)	292 (76.4)	160 (77.7)	132 (75.0)	NS
ICU mortality (%)	11 (2.9)	3 (1.5)	8 (4.5)	NS
Hospital mortality (%)	24 (6.3)	7 (3.4)	17 (9.7)	0.021
30 days mortality (%)	35 (9.2)	12 (5.8)	23 (13.1)	0.023
1 year mortality (%)	73 (19.1)	30 (14.6)	43 (24.4)	0.021

ICU Intensive care unit, *BMI* Body mass index, *APACHE II* Acute Physiology and Chronic Health Evaluation II, *SOFA* Sequential organ failure assessment, *CKD* Chronic kidney disease, *IAP* Intra-abdominal pressure, *IAH* Intra-abdominal hypertension

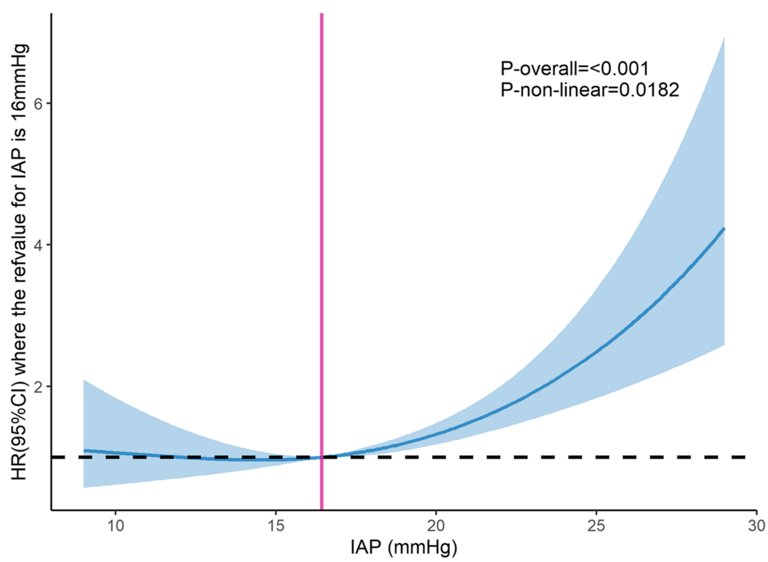

Fig. 1 Restricted cubic spline of IAP for 1-year survival prediction

analysis (HR: 1.20, 95% CI:1.14–1.25, $P < 0.001$; HR: 1.09, 95%CI: 1.04–1.12, $P < 0.001$, respectively). Multivariate Cox regression model showed that compared to Grade 0, patients in the IAH grade III (HR: 3.16, 95% CI: 1.31–7.62, $P = 0.010$) and grade IV (HR: 9.93, 95% CI: 2.84–34.7, $P < 0.001$) were correlated with increased risks of 1-year mortality, after adjusting for SOFA score classifications.

In Fig. 3, we performed ROC analysis of various scoring models for predicting in-hospital mortality. Maximum IAP values alone already showed satisfactory performance (AUC: 0.710), while the modified SOFA score with

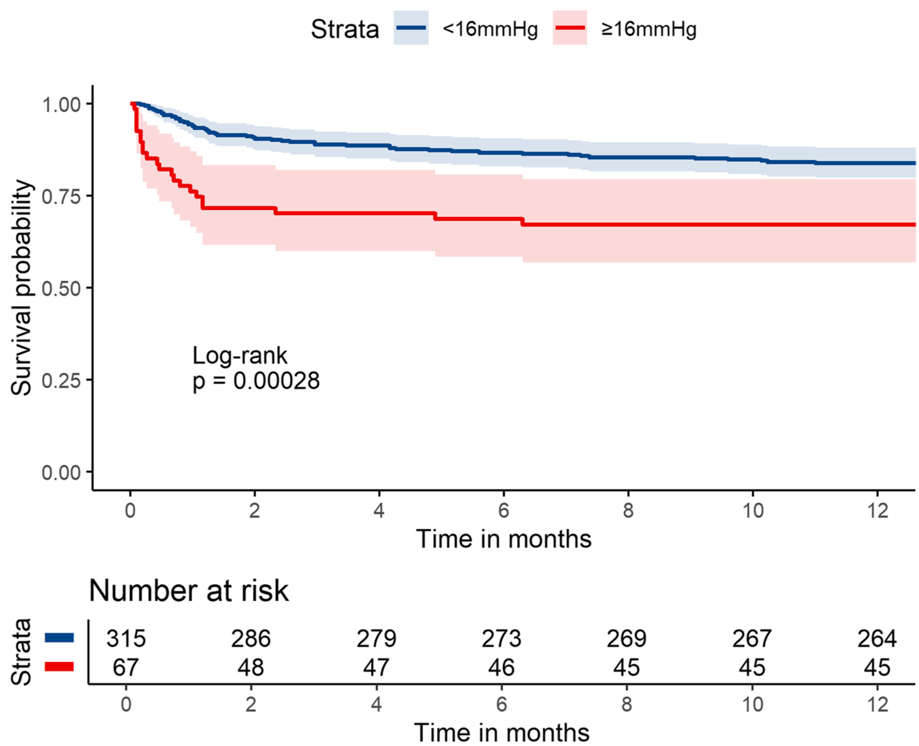

Fig. 2 Kaplan Meier cumulative survival curve of 1-year mortality split according to patients with or without Intra-abdominal Pressure (IAP) ≥ 16 mmHg

IAH grades demonstrated improvements compared to the original SOFA score (AUC: 0.834, 0.830, respectively). This suggests that IAP may serve as a competent predictor alone for in-hospital mortality among OLT patients, while providing enhancement to the predictive performance of the SOFA score.

To further explore the interaction between IAP and SOFA score, we performed a stratified Kaplan–Meier survival analysis by dividing patients into four groups based on the combination of SOFA (<8 and> =8 points) and IAP levels (<16 and> =16 mmHg) (Fig. 4). Results showed that for patients with SOFA scores less than 8, IAP values did not stratify their 1-year survival outcomes. However, for those with a greater SOFA score, the high IAP group had worse prognosis than the low IAP group, indicating the prognostic value of IAP among OLT patients with greater organ dysfunction severity (log-rank $P<0.001$).

Discussions

We conducted a retrospective observational study of 382 OLT patients, indicating that an elevated intra-abdominal pressure above 16 mmHg was significantly related with worse 1-year survival outcomes. Moreover, both maximum IAP level alone and a novel modified SOFA score incorporating IAH grade demonstrated satisfactory performance in predicting in-hospital mortality among these patients.

Orthotopic liver transplantation is a high-risk factor for intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) [11]. Post-operatively, factors such as the volume of the transplanted liver, intestinal congestion due to portal vein occlusion, massive fluid resuscitation, and the release of infectious or inflammatory factors can easily lead to an increase in IAP [12], causing IAH and potentially ACS. A study in 2003 involving 108 patients reported an ACS incidence rate of 32% post-liver transplantation [13]. Shu et al. found an IAH incidence rate of 38.7%, [14] while Freitas et al. reported an IAH incidence rate of 48% within the first three days post-surgery7. Our study found an IAH incidence rate of 46% during ICU monitoring post-liver transplantation, which is similar to previous studies. Notably, we observed a significant reduction in ACS cases with IAP > 25 mmHg, with only 3 cases out of 382, likely due to advancements in surgical techniques and the early management of IAH in our ICU, significantly reducing the incidence of ACS post-surgery [15].

IAH is common in critically ill patients and post abdominal surgery patients, and has been proven to be an independent predictor of mortality in many studies12. Previous research has shown that elevated IAP can

Table 3 Univariate and multivariate Cox regression analysis for predictors of 1-year mortality

Analysis	Univariate			Multivariate		
Variables	**HR**	**95%CI**	***P* value**	**HR**	**96%CI**	***P* value**
Male gender	0.71	0.42–1.20	0.203	-	-	-
Age	1.38	0.86–2.21	0.179	-	-	-
BMI	1.19	0.79–1.80	0.398	-	-	-
Hypertension	0.47	0.19–1.15	0.096	-	-	-
Diabetes	1.03	0.59–1.79	0.912	-	-	-
CKD	0.43	0.11–1.74	0.237	-	-	-
Cancer	0.91	0.61–1.37	0.652	-	-	-
Cirrhosis	0.66	0.43–1.02	0.063	-	-	-
SOFA max	1.20	1.14–1.25	< 0.001	-	-	-
IAP max	1.09	1.04–1.12	< 0.001	-	-	-
IAH Grade						
Grade 0	1.00			1.00		
Grade 1	1.12	0.68–1.86	0.656	0.88	0.52–1.46	0.611
Grade 2	1.39	0.80–2.41	0.238	0.95	0.53–1.69	0.866
Grade 3	4.34	1.85–10.20	< 0.001	3.16	1.31–7.62	0.010
Grade 4	22.72	6.74–76.55	< 0.001	9.93	2.84–34.70	< 0.001
SOFA						
SOFA 0–3	1.00			1.00		
SOFA 4–7	0.93	0.48–1.82	0.841	0.91	0.46–1.78	0.776
SOFA 8–11	3.52	1.85–6.72	< 0.001	3.12	1.60–6.09	0.001
SOFA 12–15	4.82	2.23–10.43	< 0.001	4.45	2.00–9.93	< 0.001
SOFA 16–24	8.00	3.49–18.36	< 0.001	8.41	3.52–20.10	< 0.001

BMI Body mass index, *CKD* Chronic kidney disease, *SOFA* Sequential organ failure assessment, *IAP* Intra-abdominal pressure, *IAH* Intra-abdominal hypertension, *IAH Grade*: Grade 0 < 12 mmHg, Grade I 12–15 mmHg, Grade II 16–20 mmHg, Grade III 21–25 mmHg, Grade IV > 25 mmHg

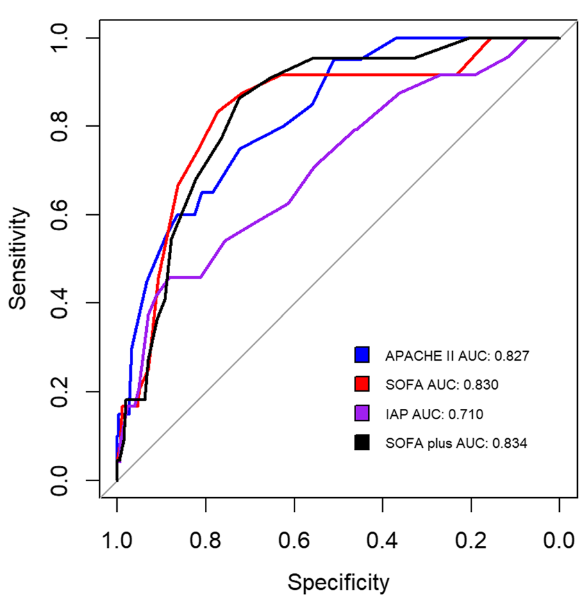

Fig. 3 ROC curves of various scoring models for predicting in-hospital mortality

delay postoperative ventilator weaning and is associated with hemodynamic instability and renal dysfunction [16]. In liver transplant patients, elevated IAP is particularly prone to causing ischemic insult to organs, with the renal system being the most susceptible due to the anatomic proximity of the transplanted liver. Previous studies have strongly indicated a close correlation between elevated IAP after liver transplantation and renal dysfunction [17, 18]. The respiratory system is equally susceptible [19]. Elevation of the diaphragm and accumulation of pleural and ascites fluid often result in decreased oxygenation, causing postoperative weaning difficulties or even acute respiratory distress syndrome. The function of the transplanted liver is even more critical for long-term prognosis. There is limited research on the long-term impact of IAH on transplanted liver function recovery. Factors such as inadequate liver perfusion, Inflammatory reaction and ischemia–reperfusion injury caused by IAH may exacerbate dysfunction in the transplanted liver [20, 21], potentially leading to a decline in long-term survival rates. These factors collectively contribute to worsened prognosis in liver transplant patients with IAH. Our findings

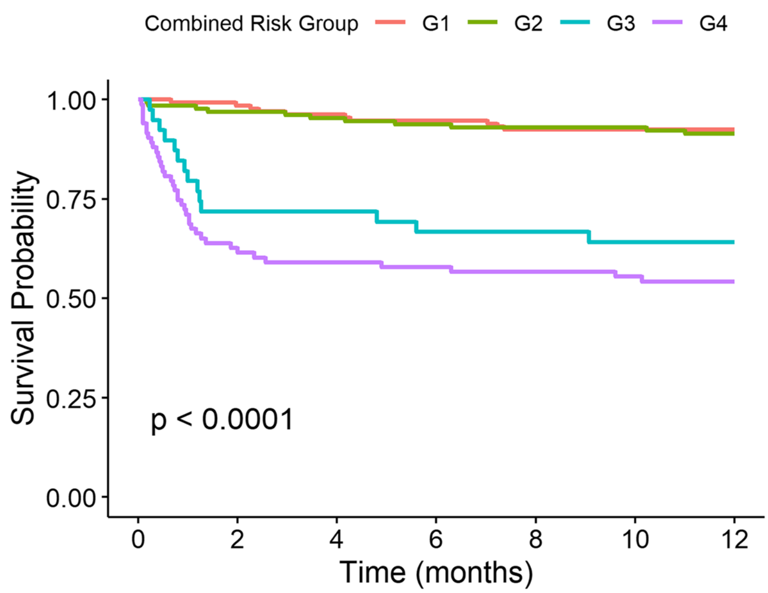

Fig. 4 Kaplan Meier cumulative survival curve split according to different IAP and SOFA groups. SOFA: sequential organ failure assessment, IAP: Intra-abdominal pressure, G1: IAP < 16 mmHg and SOFA < 8 points, G2: IAP > = 16 mmHg and SOFA < 8 points, G3: IAP < 16 mmHg and SOFA > = 8 points, G4: IAP > = 16 mmHg and SOFA > 8 points

are aligned with these observations, when both RCS and survival analysis indicated that an elevated intra-abdominal pressure above 16 mmHg was significantly related with worse 1-year survival outcomes of OLT patients.

Our study found that post-liver transplantation patients who developed IAH had significantly higher maximum SOFA and APACHE II scores compared to those without IAH. The overall in-hospital mortality rate was 6.5%, with significant differences in in-hospital, 30-day, and 1-year mortality rates between the two groups. Shu et al. observed that 79.2% of IAH cases occurred within 24 h post-surgery, and our study found a similar trend with 70% of IAH cases occurring on the first day of ICU admission. However, our analysis did not show a statistically significant difference in ICU mortality for this subgroup. Reintam et al. found that the prognosis differs between primary and secondary IAH, which may be a crucial factor [22]. Primary IAH caused by abdominal surgery may have a better prognosis than secondary IAH caused by other factors. Similarly, Kyoung et al. reported that IAH duration was an independent predictor of 60-day mortality among critically ill patients with sepsis (odds ratio: 1.196; $p = 0.014$) [8]. Our multivariate Cox regression model also suggested that patients with IAH grade III and IV had significantly higher risks of 1-year mortality than those without IAH, which further highlights the need for clinicians to continuously monitor IAH occurrences among abdominal surgical patients that may persist postoperatively.

The SOFA score is a good indicator of prognosis for ICU patients [23]. Compared to other prognostic models for liver transplantation, the SOFA has unique advantages in the ICU. The Model for End-Stage Liver Disease (MELD) score is often used to assess the prognosis of patients with liver failure, however, in predicting the prognosis of OLT patients, the performance of the MELD score could be unsatisfactory [24]. However, the SOFA score has limitations, as it does not include an evaluation of gastrointestinal function and only uses bilirubin as a single indicator of liver function, failing to reflect the overall liver function. For post-OLT patients, who are at high risk of liver and gastrointestinal injury, these limitations may be particularly evident. Previous studies have attempted to combine the Acute Gastrointestinal Injury (AGI) grade [25] or Gastrointestinal Dysfunction Score (GIDS) [26] with the SOFA score [27], both of which showed significant improvement in the predictive value of the SOFA score. However, AGI grading and GIDS involve considerable symptomatic assessment, making them less convenient for clinical use. IAH grading is a core indicator in AGI and GIDS, and is a relatively objective and easily obtainable clinical parameter. We conducted ROC analysis and found that both maximum IAP alone and a novel SOFA score incorporated with IAH components demonstrated strong prognostic performance for in-hospital mortality among OLT patients. Future investigations are needed to further validate the utility of the novel scoring system in OLT prospectively.

Conclusion

As an easily monitored clinical indicator, an increased intra-abdominal pressure greater than 16 mmHg was significantly linked to worse 1-year survival among patients with orthotopic liver transplantation. Either maximum IAP alone or SOFA score incorporated with IAH components demonstrated satisfactory performance for predicting in-hospital mortality of OLT patients.

Abbreviations

ICU	Intensive care unit
CKD	Chronic kidney disease
APACHE II	Acute Physiology and Chronic Health Evaluation II
SOFA	Sequential organ failure assessment
IAP	Intra-abdominal pressure
IAH	Intra-abdominal hypertension
OR	Odds ratio
CI	Confidence interval

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12876-025-03772-8.

Supplementary Material 1.

Acknowledgements

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Authors' contributions

All authors contributed to the study design. R.J. participated in statistical analysis, manuscript writing and revision. H.M, X.S. and Y.L. participated in data extraction and statistical analysis. X.H. and K.L. helped manuscript revision. C.C. were the guarantors of the content of the manuscript and helped to revise the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Approval was granted by the Ethics Committee of the First Affiliated Hospital of Sun Yat-sen University, and the need to obtain informed consent was waived. All procedures performed in research involving human participants were in accordance with the 1964 Helsinki Declaration and its later amendments.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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