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ORIGINAL ARTICLE

Patterns of perioperative thoracic fluid indices changes in liver transplantation with or without postoperative acute lung injury

Kuang-Cheng Chan [a,b], Chun-Yu Wu [a], Ming-Hui Hung [a,b], Po-Huang Lee [c], Ya-Jung Cheng [a,*]

[a] *Department of Anesthesiology, National Taiwan University, College of Medicine and Hospital, Taipei, Taiwan*
[b] *National Taiwan University, College of Medicine, Graduate Institute of Clinical Medicine, Taipei, Taiwan*
[c] *Department of Surgery, National Taiwan University, College of Medicine and Hospital, Taipei, Taiwan*

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Background/Purpose: Postoperative acute lung injury (ALI) after liver transplantation is clinically relevant and common. The perioperative thoracic fluid indices changes as well as the association with ALI in liver transplantation have not been thoroughly investigated.
Methods: A total of 52 consecutive adult recipients for elective living donor liver transplantation were enrolled. Each recipient received the same perioperative care plan. Thoracic fluid indices, including the cardiac index, intrathoracic blood volume index (ITBVI), extravascular lung water index (EVLWI), and pulmonary vascular permeability index (PVPI), were obtained at seven time points (pretransplantation, anhepatic phase, 30 minutes after reperfusion, 2 hours after reperfusion, and postoperative days 1–3) using the pulse contour cardiac output system. The indices of those who developed ALI ($PaO_2/FiO_2 < 300$ mmHg with lung infiltrates on chest X-ray) were compared with the indices of those who did not.
Results: Recipients who developed postoperative ALI had longer mechanical ventilation duration and had a higher model for end-stage liver disease score, required more platelet transfusion, and were higher in pretransplant EVLWI and PVPI level. During the anhepatic phase, ITBVI, central venous pressure, cardiac index, and EVLWI decreased and PVPI increased. After transplantation, ITBVI increased above pretransplant status, while EVLWI and PVPI were comparable in both groups.
Conclusion: Recipients who did or did not develop ALI after liver transplantation had a longer mechanical ventilation duration and showed different patterns of perioperative thoracic fluid

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

* Corresponding author. Department of Anesthesiology, National Taiwan University Hospital, Number 7, Chung-Shan South Road, Taipei, Taiwan.
E-mail address: chengyj@ntu.edu.tw (Y.-J. Cheng).

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indices, especially in the pretransplant status of PVPI level. Knowledge of these perioperative changes may provide clinicians with helpful information to make postoperative care choices.

Introduction

Postoperative acute lung injury (ALI) during the 1st 72 hours after liver transplantation is not uncommon.[1–3] Injury may occur because liver transplantation is often associated with prolonged operative time, large volumes of fluid administration and transfusion, as well as inflammatory responses related to ischemia–reperfusion injury.[4,5] For more precise perioperative hemodynamic and fluid management, modern monitoring systems, such as the pulse contour cardiac output (PiCCO) system, have been devised and reported in recent years.[6–8] The PiCCO system uses the thermodilution technique to determine the cardiac index (CI) and thoracic fluid indices such as the intrathoracic blood volume index (ITBVI), extravascular lung water index (EVLWI), and pulmonary vascular permeability index (PVPI), all of which may reflect pulmonary fluid and injury status. However, perioperative changes in thoracic fluid indices in liver transplantation and their associations with postoperative ALI are not yet clear. In this study, we aimed to determine patterns of changes in perioperative thoracic fluid indices and compare these changes in recipients who did or did not develop postoperative ALI.

Methods

Patients and anesthesia

Ethical approval for the study was provided by the Research Ethics Committee of National Taiwan University Hospital, Taipei, Taiwan. After receiving Institutional Review Board approval of our study protocol and written informed consents from all patients, we consecutively enrolled 52 adult recipients with end stage liver disease receiving living donor liver transplantation from February 2004 to October 2008. The exclusion criteria were as follows: $<$ 20 years of age, history of pulmonary resection, chronic respiratory insufficiency, cardiac dysfunction (as determined by preoperative echocardiography), and failure of the surgery.

General anesthesia was induced with intravenous fentanyl 2 μg/kg, etomidate 0.3 mg/kg, and cisatracurium 0.15 mg/kg, and then was maintained in a standard manner involving the use of desflurane in an air/oxygen mixture and intravenous infusions of fentanyl and cisatracurium. After general anesthesia, a triple-lumen 5.5-French catheter (Arrow Central Venous Catheter; Teleflex Life Sciences Ltd., Athlone, Ireland) was placed through a puncture into the right internal jugular vein. A 4-French thermistor-tipped arterial catheter (Pulsiocath Thermodilution Catheter; Pulsion Medical Systems, Munich, Germany) was inserted into the right femoral artery, advanced to the abdominal aorta, and connected to the PiCCO system monitor (version 6.0; Pulsion Medical Systems, Feldkirchen, Germany).[9] During the surgery, anesthetic depth was maintained by keeping the bispectral index between 40 and 60. Mechanical ventilation was set with a tidal volume of 8–10 mL/kg (based on ideal body weight) and respiratory rate 10–20/min to maintain normocapnia and positive end-expiratory pressure (PEEP) of 5 cmH_2O. The maximal peak inspiratory pressure was set at 35 cmH_2O.

Living donor liver transplantation procedure and intraoperative care

The same surgical team performed all liver transplantation procedures using the piggyback technique without veno-venous bypass.[1] Decisions regarding administration of fluids and blood products were made according to the same standards of care, to provide hemodynamic stability, correction of unexpected coagulation abnormalities, and bleeding. Temporary dopamine infusion or norepinephrine boluses were given to maintain the mean arterial pressure above 65 mmHg intraoperatively.

Thoracic fluid index calibration, measurement, and postoperative lung injury definition

After setup of the PiCCO system and calibration by transpulmonary thermodilution according to manufacturer's guidelines, the hemodynamic parameters were obtained and recorded.[10] The PiCCO system was used to measure CI, ITBVI, EVLWI, PVPI, and we recalibrated and recorded in the following sequence: (1) pretransplant status (right after set-up of the PiCCO system); (2) anhepatic phase; (3) 30 minutes after liver reperfusion ($R_{1/2}$); (4) 2 hours after liver reperfusion (R_2); (5) postoperative day (POD) 1; (6) POD 2, and (7) POD 3. Mean arterial pressure and central venous pressure (CVP) were also recorded concurrently. EVLWI was calculated by dividing the measured volume of lung water by the predicted body weight, which was calculated as $50 + 0.91 \times$ (centimeters of height $-$ 152.4) for men and $45.5 + 0.91 \times$ (centimeters of height $-$ 152.4) for women. Additionally, this technique allows for the determination of the intrathoracic blood volume and the global end-diastolic volume. The ITBVI was then determined by dividing the intrathoracic blood volumes by the body surface area. The pulmonary blood volume (PBV) was defined as the intrathoracic blood volume $-$ global end-diastolic volume. PVPI was calculated as the EVLW divided by the PBV (PVPI $=$ EVLW/PBV) as a means to normalize EVLW for differences in central blood volumes.

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