Immediate tracheal extubation of pediatric liver transplant recipients in the operating room


Abstract: Keeping patients on mechanical ventilation after orthotopic liver transplantation (OLT) has been a standard anesthetic approach since the first utilization of liver transplantation. Advances in anesthetic management, surgical techniques and patient preparation, in addition to improved postoperative care and the reported advantages of early postoperative tracheal extubation of liver recipients, encouraged us to extubate most recipients at the end of the operation. The aim of the present study is to evaluate the pediatric liver recipients who were extubated immediately at the end of transplantation, in terms of respiratory complications and allograft function during their stay in the ICU. We retrospectively reviewed the records of 40 pediatric recipients who had undergone OLT at the Ege University Organ Transplantation Center between December 1997 and July 2002. Twelve out of 40 patients who had consecutively undergone OLT were extubated immediately at the end of the operation and were included this study. Mean Child–Pugh scores of the patients were 9 ± 2.3 (range 6–12) and the mean PELD score was 23.1 ± 12.3 (range 7–41). The mean age of the patients was 8.4 ± 5.2 (range 0.8–16.8 yr). Five of the 12 extubated patients received a cadaveric and seven a living donor liver graft. The mean ICU stay of the patients was 49.1 ± 24.2 h (6–120 h). No patients required reintubation or mechanical ventilation in the ICU. Respiratory complications diagnosed in the 12 extubated patients were hypercapnia without hypoxemia in three, atelectasis in one and plural effusion in two. No primary non-function or delayed graft function was detected. The aspartate transaminase (AST), alanine transaminase (ALT) and protrombin time (PT) were normalized within a week. We believe that immediate tracheal extubation in the operating room is a safe procedure for selected cadaveric and living-related liver transplant recipients and will facilitate the patients’ recovery and mobilization leading to reduction in complications and a reduced ICU stay.

Orhthotopic liver transplantation (OLT) is an established therapeutic option for children with end-stage liver disease and metabolic disorders (1, 2).

Tracheal extubation is one of the most critical steps following OLT, and timing of tracheal extubation is still debated. Over the last few years a number of studies have described the use of early or even immediate extubation in the operating room for those patients undergoing OLT (3–5). These reports involved a small series of patients and did not include pediatric OLT recipients.

Therefore, we conducted a retrospective study to evaluate the pediatric OLT recipients who were extubated in the operating room. This approach is evaluated in terms of feasibility, respiratory complications and allograft function during the stay in the ICU.
Patients and methods

We retrospectively reviewed the records of patients who had undergone OLT at the Ege University Organ Transplantation Center between December 1997 and July 2002. A total of 40 pediatric OLTs were performed during this period. After gaining experience during the first 28 cases we started extubating patients electively in the operating room. Twelve patients were extubated immediately after the transplant procedure.

Standard surgical technique without caval preservation for cadaveric OLT and piggy-back technique for living-donor OLT were applied. Venovenous bypass or temporary portacaval shunting was not applied to any patient.

Anesthesia induction was with sodium thiopental (3–4 mg/kg)/propofol (2 mg/kg), fentanyl (2–4 µg/kg/min) and vecuronium (0.1 mg/kg) or cisatracurium (0.2 mg/kg), and maintained by intermittent boluses of fentanyl (50–100 µg when required) or remifentanil infusion (0.125–0.5 µg/kg/min) combined with isoflurane (0.4–1.2% end-tidal concentrations) in air-oxygen (FiO2 40–50%). The patients were mechanically ventilated with a tidal volume of 8–10 mL/kg, and a respiratory rate of 10–16 breaths/min was adjusted to maintain end-tidal carbon dioxide (ETCO2) of 32–35 mmHg by a volume-controlled mode (Clarys-Taema, France). Standard anesthesia monitoring with radial artery catheters, electrocardiogram (ECG), pulse oximeter (SpO2), capnogram and anesthetic gas concentration, arterial-mixed venous blood gas analysis, core body temperature (Hewlett-Packard Viridia monitor, Germany) and urine output were used in all patients.

Pulmonary artery catheter (Baxter–Edwards Swan Ganz Thermodilution 7 F or 5 F, Baxter Healthcare Corporation, Irvine, CA, USA) was inserted via the internal jugular vein in five patients for monitoring pulmonary artery and pulmonary capillary wedge pressures and measuring cardiac output.

The criteria for early extubation after OLT included an awake patient who obeys verbal commands, adequate ventilation (respiratory rate < 30 breaths/min with a good respiratory pattern, oxygen saturation above 95% in room air, end-tidal carbon dioxide concentration 30–40 mmHg), hemodynamic stability (no hypotension), normothermia, clinical findings indicating complete reversal of neuromuscular blockade and adequate hemostasis. Obeying a verbal command was not used in the two patients younger than age 2 yr. Their spontaneous motor activity and behavior were utilized instead. Respiratory rate might be considered higher for such very young patients. Following extubation in the operating room, all patients were admitted to the ICU and monitored by ECG, SpO2, respiratory rate, radial artery and central venous pressures (Datex–Ohmeda AS3 monitor, Helsinki, Finland). ICU treatment included physiotherapy, prophylactic antibiotics, nutritional support, fluid infusion and supplemental oxygen to keep the SpO2 above 94%. Initial total parenteral nutrition followed by early enteral feeding was attempted in patients without surgical complications.

Bolus 0.1 mg/kg morphine intermittent IV doses were used for postoperative analgesia and sedation. Blood samples for arterial blood gases, liver function tests [aspartate transaminase (AST), alanine transaminase (ALT) and prothrombin time (PT)] were taken at 6-h intervals. Chest X-ray and Doppler USG for checking liver blood flow were performed daily during the first week. The immunosuppressive regimen consisted of cyclosporin A or tacrolimus and steroids.

All patients were observed in terms of respiratory complications during their ICU stay and course of allograft function within the first week.

Wilcoxon’s test was used for the statistical analysis of the liver allograft function data within the first week. A p-value of less than 0.05 was considered statistically significant. Data are expressed as mean ± standard deviation (SD).

Results

Five of the 12 extubated patients had cadaveric and seven had living-donor OLT. Nine patients were male and three were female. The mean age was 8.4 ± 5.2 yr (range: 0.8–16.8 yr); height was 114 ± 30 cm (range: 75–165 cm); height SDS was −1.38 ± 1.34, and weight was 28.7 ± 19.7 kg (range: 10–72 kg). The clinical diagnosis was congenital hepatic fibrosis in two patients, Wilson’s Disease in three patients, Tyrosinemia type I in two patients, cryptogenic cirrhosis in one patient, biliary atresia in two patients and glycogen storage disease type IV in one patient. Mean Child–Pugh scores were 9 ± 2.3 (range 6–12; Class A: n = 1; Class B: n = 7; Class C: n = 3) and fulminant hepatitis n = 1) whereas mean PELD score was 23.1 ± 12.3 (range 7–41). Four patients were ICU-bounded before operation, but were not requiring mechanical ventilatory support. Two of those patients underwent OLT urgently because of fulminant hepatic failure and fulminant Wilson’s Disease (cases 6 and 12, Table 1).

The mean ICU stay of the patients was 49.1 ± 24.2 h (6–120 h) after a mean operation time of 452 ± 139 min (270–760 min). The mean packed red cell transfusion during surgery was 1.9 ± 1.2 units (range 0.5–4 units).

No patient required reintubation or mechanical ventilation in the ICU. Two of the patients were intubated for reoperations due to postoperative bleeding and vascular complications. Both were subsequently extubated in the operating room after reoperations.

Respiratory complications diagnosed in the 12 extubated patients were hypercapnia without hypoxemia in three, atelectasis in one and pleural effusion in two. Respiratory complications detected in the ICU did not necessitate intensive therapy and were treated by chest physiotherapy and incentive spirometry when possible. Hypercapnia without hypoxemia in three patients was due to the effects of opioid analgesia on respiratory drive in one, to atelectasis in one and secondary to metabolic alkalosis in one other patient. Right lower lobe atelectasis on chest X-ray on the second postoperative day was corrected with non-invasive positive pressure ventilation provided by a balloon–valve–mask system followed by coughing exercises. Right-sided pleural effusion resolved spontaneously within 8–10 day. Postoperative pneumonia was not detected at any patient.
Early postoperative allograft function was evaluated by ASP, ALT and PT. No primary non-function or delayed graft function was detected. The AST, ALT and PT were normalized within 1 week post-OLT (Table 2). All patients are alive with good graft function. Mean length of hospital stay after OLT was 1.6 ± 1 months.

Discussion

In recent years, early or immediate tracheal extubation after OLT is advocated to decrease ICU stay and respiratory complications (3, 6). Respiratory complications after OLT are important causes of postoperative death due to multiple organ failure. Consequently, hospital cost significantly increases in patients with respiratory failure (7).

Our early experience with 12 pediatric OLT recipients extubated immediately after surgery showed good emergence from anesthesia with no problem in meeting the previously determined criteria for extubation immediately after the operation.

The mean duration of stay in the ICU after OLT was 49 h, which was significantly shorter when compared with the historical controls (8, 9). Our previous tendency was to mechanically ventilate patients until we were satisfied that they would not experience any surgical problems. Improved surgical technique and anesthetic management allowed us to extubate the patients immediately after the operation. Planning to extubate the patient immediately after the operation has necessitated more meticulous perioperative management.

Studies concerning adult patients with end-stage liver disease who had undergone OLT and were extubated immediately after the operation involved different anesthetic techniques utilizing drugs whose metabolism was dependent on liver function (3–5). We used different anesthetics, which allowed us to extubate our pediatric patients on the operating table immediately after the operation. Recently, remifentanil (10), which is an opioid with short duration of action and is metabolized by non-specific esterases in the blood and tissues, and cisatracurium (11), as a non-depolarizing neuromuscular blocker metabolized by Hoffman elimination in the blood independent of liver metabolism, changed our anesthetic practice by allowing predictable and

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Table 1. Characteristics of patients

<table>
<thead>
<tr>
<th>Case No</th>
<th>Primary Diagnosis</th>
<th>Sex</th>
<th>Age (year)</th>
<th>LR-OLT/C-OLT</th>
<th>UNOS status</th>
<th>PELD</th>
<th>BW/GS %</th>
<th>Respiratory complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Congenital hepatic fibrosis</td>
<td>M</td>
<td>16.8</td>
<td>C-OLT</td>
<td>3</td>
<td>7</td>
<td>FS</td>
<td>Hipercapnia hypoxemia</td>
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<tr>
<td>2</td>
<td>Biliary atresia</td>
<td>M</td>
<td>1.2</td>
<td>LR-OLT</td>
<td>2b</td>
<td>23</td>
<td>3.7</td>
<td>ND</td>
</tr>
<tr>
<td>3</td>
<td>Congenital hepatic fibrosis</td>
<td>M</td>
<td>12</td>
<td>C-OLT</td>
<td>2b</td>
<td>14</td>
<td>FS</td>
<td>ND</td>
</tr>
<tr>
<td>4</td>
<td>Wilson’s Disease</td>
<td>M</td>
<td>7.5</td>
<td>LR-OLT</td>
<td>2a</td>
<td>41</td>
<td>1.2</td>
<td>ND</td>
</tr>
<tr>
<td>5</td>
<td>Cryptogenic cirrhosis</td>
<td>F</td>
<td>8</td>
<td>LR-OLT</td>
<td>2a</td>
<td>32</td>
<td>1</td>
<td>Right pleural effusion</td>
</tr>
<tr>
<td>6</td>
<td>Fulminant hepatic failure</td>
<td>M</td>
<td>4.8</td>
<td>LR-OLT</td>
<td>1</td>
<td>36</td>
<td>0.6</td>
<td>Right lower lobe atelectasis</td>
</tr>
<tr>
<td>7</td>
<td>Glycogen storage disease type IV</td>
<td>M</td>
<td>4.3</td>
<td>LR-OLT</td>
<td>3</td>
<td>9</td>
<td>0.7</td>
<td>Hipercapnia without hypoxemia</td>
</tr>
<tr>
<td>8</td>
<td>Tyrosinemia</td>
<td>M</td>
<td>0.8</td>
<td>LR-OLT</td>
<td>2b</td>
<td>30</td>
<td>1.7</td>
<td>ND</td>
</tr>
<tr>
<td>9</td>
<td>Tyrosinemia</td>
<td>F</td>
<td>8.5</td>
<td>LR-OLT</td>
<td>2b</td>
<td>9</td>
<td>1.6</td>
<td>ND</td>
</tr>
<tr>
<td>10</td>
<td>Wilson’s Disease</td>
<td>F</td>
<td>15.8</td>
<td>C-OLT</td>
<td>2b</td>
<td>16</td>
<td>FS</td>
<td>ND</td>
</tr>
<tr>
<td>11</td>
<td>Chronic rejection</td>
<td>F</td>
<td>8.5</td>
<td>C-OLT</td>
<td>2b</td>
<td>26</td>
<td>FS</td>
<td>ND</td>
</tr>
<tr>
<td>12</td>
<td>Fulminant Wilson’s Disease</td>
<td>M</td>
<td>13</td>
<td>C-OLT</td>
<td>2a</td>
<td>37</td>
<td>FS</td>
<td>Right pleural effusion</td>
</tr>
</tbody>
</table>


Table 2. Laboratory values of patients for first postoperative week

<table>
<thead>
<tr>
<th></th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST (10–50 U/L)</td>
<td>751 ± 710</td>
<td>631 ± 717</td>
<td>375 ± 581*</td>
<td>267 ± 517*</td>
<td>139 ± 232*</td>
<td>93 ± 96*</td>
<td>90 ± 75*</td>
</tr>
<tr>
<td>ALT (10–50 U/L)</td>
<td>489 ± 433</td>
<td>524 ± 450</td>
<td>464 ± 434</td>
<td>441 ± 538</td>
<td>318 ± 346*</td>
<td>247 ± 247*</td>
<td>221 ± 182*</td>
</tr>
<tr>
<td>Protrombin time (13–16 s)</td>
<td>19.0 ± 4.2</td>
<td>18.2 ± 3.9</td>
<td>16.5 ± 3.4*</td>
<td>15.1 ± 2.3*</td>
<td>15.4 ± 2.7*</td>
<td>14.9 ± 2.3*</td>
<td>14.8 ± 3.1*</td>
</tr>
</tbody>
</table>

*p < 0.05, compared with Day 1 values. Data are the mean ± SD and range.
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rapid recovery after anesthesia for both pediatric and adult OLT recipients.

Several studies have described respiratory complications after OLT as infection, atelectasis, pleural effusion, pneumothorax, respiratory insufficiency, reintubation of the patients, prolonged mechanical ventilation or weaning difficulties (5, 12–15). Hasegawa et al. (12) reported the incidence of respiratory complications after the pediatric OLT of 45% including atelectasis (23%), pleural effusion (23%) and pneumonia (12%). All of our patients tolerated immediate tracheal extubation, and respiratory complications detected in the ICU did not necessitate intensive therapy and were treated by chest physiotherapy and incentive spirometry. Hypercapnia without hypoxemia in three patients and pleural effusion in two patients resolved spontaneously without intervention. Right lower lobe atelectasis without respiratory insufficiency, detected on chest X-ray at the second postoperative day, was reinfated with non-invasive positive-pressure ventilation provided by a balloon–valve–mask system followed by coughing exercises within 1 day.

The necessity of mechanical ventilatory support during respiratory insufficiency is obvious but the usefulness of prophylactic postoperative use is not clear. Meanwhile, prolonged mechanical ventilation may be deleterious. The early extubated patients in our study did not have any graft dysfunction associated with beneficial effects of spontaneous breathing in those patients.

As a result of this study, tracheal extubation in the operating room is a safe procedure for selected cadaveric and living-related pediatric OLT recipients. It facilitates a reduction in the respiratory complications and ease of management during the early postoperative period. In our series four patients were in the ICU at the time of OLT and two underwent an urgent operation. Furthermore, one of the two patients had full inotropic-volume support and had active variceal bleeding during the OLT. The other patient had grade IV encephalopathy due to fulminant hepatic failure, and received mannitol together with supportive treatment during the course of the operation. It is for this reason that accelerated preoperative preparation and living-related OLT was performed. The antiedema effect of mannitol and a good functioning graft resulted in faster recovery of the encephalopathic patient. It is important to keep patients at nearly normal physiological values during the course of OLT to facilitate extubation immediately after surgery. Both of these patients were extubated successfully in the operating room and neither of them required reintubation and/or mechanical ventilatory support. Their postoperative courses were excellent with no graft or any organ dysfunction.

In our opinion, pediatric OLT recipients can be extubated immediately after the procedure. Our current practice is to try extubating the patients who meet the selected criteria at the end of the operation.

References
