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Successful extracorporeal life support in a pediatric trauma patient following angioembolization of pelvic hemorrhage

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Abstract

Extracorporeal Life Support (ECLS) is rarely used in pediatric trauma patients due to bleeding risk, and the use of ECLS following angioembolization of traumatic hemorrhage has never been reported in a child. We report a case of a 10-year-old boy run over by a parade float resulting in severe thoracic, abdominal, and pelvic trauma, with hemorrhage from pelvic fractures requiring massive transfusion. Due to ongoing blood product requirements and contrast extravasation near the symphysis pubis, angioembolization of the internal iliac arteries was performed. Extreme hypoxemia persisted despite maximal ventilator support due to pulmonary contusions and aspiration pneumonitis. Six hours after angioembolization, venovenous ECLS was initiated. Following an initial heparin bolus, ECLS was run without anticoagulation for 12 h, but development of circuit clot required resumption of low-dose heparin. After four days, his respiratory status improved substantially and ECLS was discontinued. There were no hemorrhagic complications. The patient was discharged home in good health following inpatient rehabilitation. In this case, ECLS was successfully used in the treatment of post-traumatic respiratory failure 6 h following angioembolization of pelvic hemorrhage in a pediatric trauma patient. Further research is needed to determine the safest interval between hemorrhage control and ECLS in severely injured children.

Keywords

Extracorporeal life support; Pediatric trauma; Angioembolization

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Authorship

All authors attest that they meet the current ICMJE criteria for Authorship.

Patient consent

Parental consent was obtained to report this case.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

1. Introduction

The use of extracorporeal life support (ECLS) in pediatric trauma patients is rare. Most published cases involve drowning victims [1] or those with significant chest trauma [2]. Anticoagulation for ECLS in the setting of multiple injuries may increase the risk of hemorrhage, but ECLS has been successfully used in children following both motor vehicle collisions and firearm injuries with survival rates of 56% and 33%, respectively [3]. Initiation of ECLS following angioembolization for traumatic hemorrhage in a pediatric patient has never been reported in the literature.

We present a case of a child who suffered severe blunt thoracoab-dominal trauma, requiring angioembolization of pelvic hemorrhage followed by ECLS for respiratory failure due to aspiration pneumonitis and severe pulmonary contusions.

2. Case report

A 10-year-old otherwise healthy boy suffered blunt trauma after being found underneath the trailer wheels of a parade float. Upon arrival at the level 1 trauma center, he was hypotensive with a blood pressure of 83/54 and a heart rate of 140. The patient underwent intubation and massive transfusion. There was concern for aspiration and the presence of blood in the airway during intubation raised concern for pulmonary hemorrhage. Initial arterial blood gas (ABG) revealed a pH of 7.22, PaO_2 of 188 mmHg, $PaCO_2$ of 43 mmHg and a base deficit of 10. After resuscitation and hemodynamic stabilization, imaging showed a basilar skull fracture, complex facial fractures, grade III liver injury, right adrenal hemorrhage, and extensive pelvic fractures. Imaging also revealed a right pneumothorax, pulmonary contusions, and evidence of massive aspiration pneumonitis (Fig. 1). A right tube thoracostomy was performed in the Emergency Department, and the patient was transferred to the pediatric intensive care unit (PICU).

In the PICU, the patient had sudden hemodynamic decompensation requiring further blood product transfusion. Due to persistent hypoxia, a left tube thoracostomy was performed with minimal improvement. Interventional Radiology (IR) was consulted for pelvic angioembolization due to concern for ongoing hemorrhage, however the patient could not be transported because of his tenuous and unstable respiratory status. Oxygen saturation was persistently between 40 and 75% on 100% FiO2 and PEEP of 12 and peak airway pressures were frequently greater than 40 cm H_2O. An ABG revealed an unchanged base deficit of 10 with PaO_2 of 52 mmHg; his PaO_2/FiO_2 ratio was 42 and his oxygenation index (FiO_2 × Mean Airway Pressure (P_{aw})/PaO_2) was 53.7 ([100% FiO_2 × P_{aw} 27 cm H_2O]/PaO_2 of 37 mmHg). Inhaled nitric oxide was initiated and frequent suctioning performed with minimal improvement in oxygenation. Discussion regarding extracorporeal life support (ECLS) was initiated, but given the persistent hypotension and blood transfusion requirement, ECLS could not be initiated due to risk of hemorrhage with anticoagulation. An attempt to address ongoing bleeding was pursued, despite the need to transport the patient while severely hypoxic. In IR, contrast extravasation was identified near the symphysis pubis. Angioembolization of bilateral internal iliac arteries was performed. Given the grade III

hepatic injury, prophylactic partial angioembolization of hepatic artery branches was also performed.

Upon return to the PICU, the patient had persistent hypoxemia with a PaO_2 of 37 mmHg. High frequency oscillatory ventilation, airway pressure release ventilation, and intentional right mainstem intubation were attempted with no improvement. Chest radiographs revealed diffuse opacification of the left hemithorax secondary to pulmonary contusion and massive aspiration (Fig. 2a). After consultation with the ECLS team, the patient underwent a six-hour period of observation to ensure hemorrhage control post-angioembolization prior to initiation of ECLS and heparinization. During this time, mechanical ventilation was alternated with hand-bagging as necessary to maintain oxygenation. The best oxygen saturation achieved was 80%, with oxygen saturations in the range of 60–70% for most of the night. High frequency oscillatory ventilation and airway pressure release ventilation modes were trialed with precipitous desaturations to SpO_2 of 30%, requiring hand-bagging. Improved oxygen saturations in the 70–80% range were achieved on a conventional ventilator on pressure control mode of 25, PEEP of 18 cm H_2O, with a respiratory rate of 16, inspiratory time of1.8 seconds, and tidal volume of 370 ml. FiO_2 remained at 100% throughout the night with inhaled nitric oxide at 40 parts per million.

After 6 h of improved hemodynamics and decreasing transfusion requirements, the patient was successfully cannulated for venovenous ECLS via a 27 French Avalon dual-lumen catheter in the right internal jugular vein. Initial flow was 2.5 L/min with a sweep rate of 1.5 L/min. The oxygenation index improved to 12.3 ([100 % × 17 cm H_2O]/102 mmHg). A heparin bolus of 100 units per kilogram was administered during cannula placement. Following the heparin bolus, attempts were made to hold anticoagulation for 24 hours given the patient's traumatic injuries, but clot was noted in the pre-oxygenator tubing after 12 hours and thus systemic heparin was administered. A lower anti-Xa heparin assay range of 0.3–0.5 was subsequently targeted with a heparin drip at 24–27 units/kg/hour. No further clots were noted in the circuit on this low-dose heparin protocol. ECLS settings were titrated to maintain an oxygen saturation greater than 88% and normocarbia. The patient was ventilated at a pressure control setting of 16, with PEEP 12 cm H_2O, at a respiratory rate of 10–16, targeting tidal volumes of 5–6 ml/kg. FiO_2 was maintained at 30%. The patient ultimately remained on ECLS for four days, with dramatic improvement in pulmonary status and chest radiographs during this time (Fig. 2b). He was successfully extubated on hospital day 8 and discharged to acute care rehabilitation on hospital day 16. After 11 days of acute rehabilitation, he was discharged home and was gradually able to return to school.

At two years of follow-up, the patient has fully recovered and returned to his normal activities. His only residual deficits are a mild left sided facial nerve paralysis, which is improving, and left-sided sensorineural deafness, for which he uses a hearing aid.

3. Discussion

The presented case is the first report of a pediatric trauma patient requiring both angioembolization for traumatic hemorrhage and ECLS for post-traumatic respiratory failure. Cannulation for ECLS took place 6 h following angioembolization to ensure that

definitive hemorrhage control had occurred. After the initial heparin bolus, a 24-h period without anticoagulation was attempted. Clot in the ECLS circuit developed requiring heparinization, ultimately without hemorrhagic complications. The polytrauma patient who presents with both hemorrhagic shock and acute respiratory failure requiring extracorporeal support represents a treatment conundrum. Extensive multidisciplinary collaboration is necessary to safely address such time-sensitive factors. Although the patient was safely placed on ECLS 6 h after definitive hemorrhage control, the optimal duration of monitoring prior to ECLS cannulation in the patient who has undergone hemorrhage control procedures is unknown.

The literature available on the use of ECLS in pediatric trauma patients is sparse, with one systematic review identifying four studies that included 58 patients total. The overall survival was 60%, and only five hemorrhagic complications were reported [4]. A review of nearly 590,000 patients in the National Trauma Data Bank (NTDB) found 36 pediatric trauma patients who underwent ECLS, with a 58% survival rate. Most patients in the NTDB cohort were teenagers between 15 and 18 years old, and the most common mechanisms of injury were motor vehicle collisions (44%), gunshot wounds (17%), burns (17%), and drowning (14%) [3]. Since publication of the systematic review, an analysis of pediatric patients enrolled in the Extracorporeal Life Support Organization (ELSO) registry has been performed, reporting on outcomes of 573 pediatric trauma patients in a nearly 30-year period [5]. Patients were young, with a median age of 4.8 years old, and required ECLS primarily after drowning (38.7%), burns (21.1%), or thoracic trauma (17.8%), with an overall survival rate of 55%. The median ECLS duration was 4.8 days, which is similar to the presented case.

The greatest concern in placing trauma patients on ECLS is the risk of hemorrhagic complications. However, only 16.8% of all complications reported in pediatric trauma patients from the ELSO registry were hemorrhagic in nature [5]. Another small case series of six children with severe thoracic trauma who required ECLS had an 83% survival rate. Two of these patients underwent laparotomies prior to ECLS; three had solid-organ injuries ranging from a small splenic laceration to a grade 3 liver laceration, grade 4 renal laceration, and grade 4 splenic laceration. None of these patients suffered from hemorrhagic complications while on ECLS [2].

Interestingly, in a study of 241 pediatric patients on ECLS for non-trauma indications, presence of pre-ECLS coagulopathy was not associated with an increased risk of hemorrhagic complications when compared to patients without pre-ECLS coagulopathy [6]. Heparin-sparing strategies for the management of patients on ECLS have been reported with no difference in hemorrhagic or thrombotic complications when compared to fully anticoagulated patients [7]. However, we were unable to use a heparin-free approach in this patient due to clot in the system, ultimately requiring the use of lower-dose anticoagulation with a lower anti-Xa target level. Fortunately, no hemorrhagic complications occurred.

4. Conclusion

We report the first case of extracorporeal life support in a pediatric polytrauma patient requiring angioembolization for hemorrhage control. No hemorrhagic complications were encountered. Further research is needed to determine the optimal waiting period between angioembolization for hemorrhage control and initiation of ECLS in these critically ill patients.

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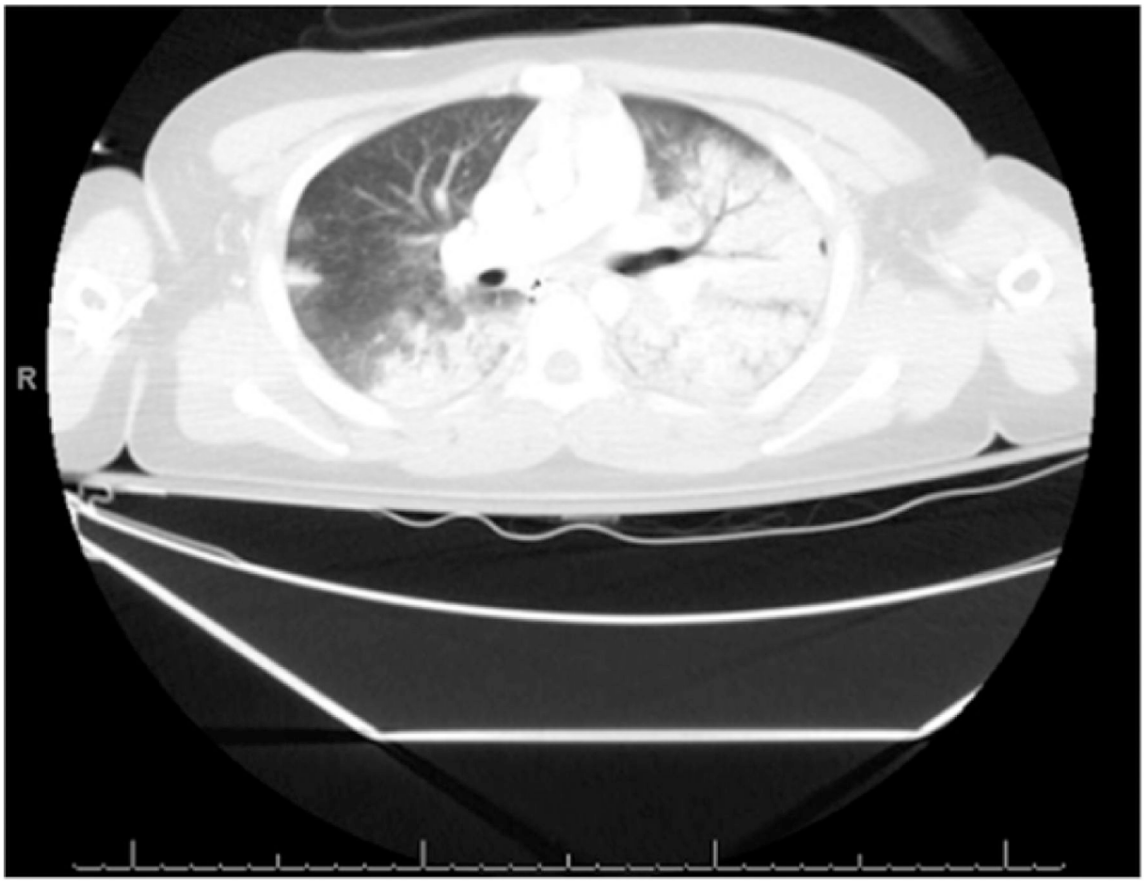

Fig. 1.
Initial chest computed tomography from day of injury showing massive left pulmonary contusion and pneumonitis.

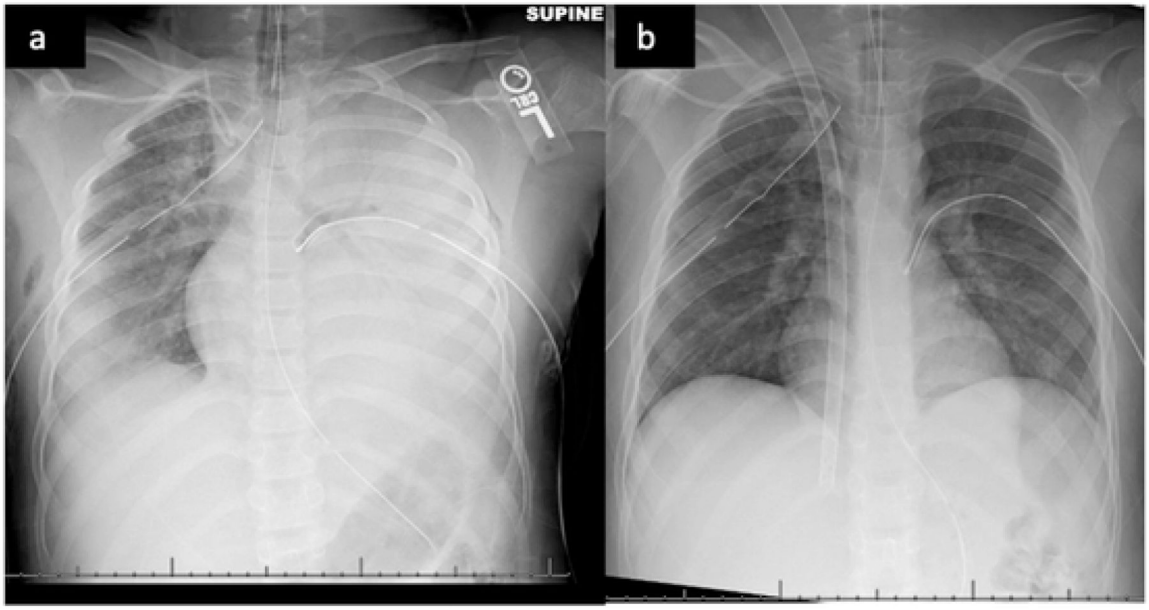

Fig. 2.

a) Chest radiograph at 6 hours after injury showing opacification of the left hemithorax. b) Chest radiograph on day four of ECLS support showing substantial improvement.