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ORIGINAL ARTICLE

Radiologic diagnosis of hemothorax during neonatal extracorporeal life support

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Abstract. The recognition of a significant hemothorax by chest radiography can be difficult during extracorporeal life support (ECLS) because diffuse pulmonary opacification is typically present. Five newborns who developed hemothoraces after repair of a congenital diaphragmatic hernia while on ECLS were evaluated. The presence of a clinically important hemothorax was suspected when a shift in the position of the ECLS venous cannula was noted on comparable chest films. Four patients required operative evacuation of hematomas and one responded successfully to suction-catheter evacuation of clot through a chest tube. All patients improved in their clinical status without recurrence of the hemothorax. A shift in the position of the ECLS venous cannula may be a radiographic clue that a significant hemothorax exists in newborns on ECLS. Awareness of this finding may allow early recognition and appropriate intervention.

Key words: Extracorporeal support – Hemothorax – Congenital diaphragmatic hernia

Introduction

Extracorporeal life support (ECLS) is a life-saving intervention utilized for neonates with severe respiratory failure due to congenital diaphragmatic hernia (CDH), meconium aspiration syndrome, hyaline membrane disease, sepsis, or persistent fetal circulation [1, 2]. The risk of bleeding as a complication is high in these infants, who are systemically anticoagulated. Hemothorax, in particular, may result from operative interventions that may have occurred prior to or during ECLS. The radiologic recognition of significant bleeding into the thoracic cavity can be quite difficult because diffuse pulmonary opacification is typically present during ECLS [5, 6]. We recently treated five infants who developed bleeding into the thoracic cavity following operative procedures for a CDH while on ECLS. In each case, displacement of the intrathoracic ECLS venous cannula was the initial radiographic clue that led to prompt diagnosis of the unilateral hemothorax and successful surgical treatment.

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Materials and methods

Twenty-three infants required ECLS for CDH and respiratory failure at the Children's Hospital of Philadelphia from April 1990 to June 1993. Retrospective analysis of these patients revealed the development of a hemothorax with mediastinal shift in 5 patients while on ECLS. Daily serial chest radiographs had been obtained in each of these patients over the course of the therapy.

Results

Table 1 shows the data regarding the repair of the CDH and subsequent development of hemothorax in the five patients. Each newborn had undergone the repair while on ECLS. Four patients developed hemothoraces on the side ipsilateral to the repair and one on the contralateral side following chest tube placement for an effusion. Blood transfusion requirements in the 48 h after the procedure were increased from an average of 19 ± 13 ml/kg per day in non-CDH ECLS neonates to 69 ± 48 ml/kg per day ($P < .05$) in the five CDH newborns who developed hemothoraces. Even so, the diagnosis of hemothorax was delayed for 1 to 3 days in these patients. The radiographic clue that suggested the presence of a hemothorax was a shift of the ECLS venous cannula to the side opposite the hemothorax (Figs. 1 and 2). Portable sonograms were obtained in all cases to confirm the radiographic suspicion of hemothorax;

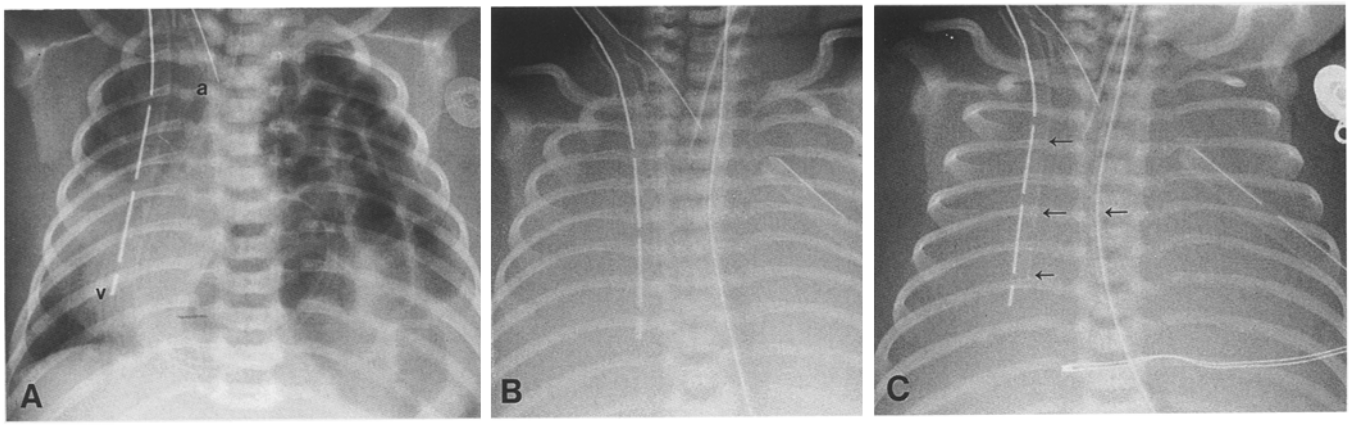

Fig. 1. **A** Pre-repair chest radiograph demonstrating left CDH with internal jugular venous (*v*) and carotid arterial (*a*) ECLS cannulae in place. **B** After CDH repair, diffuse pulmonary opacification present. **C** Subsequent shift (*arrows*) of ECLS venous cannula and nasogastric tube indicating development of left hemothorax

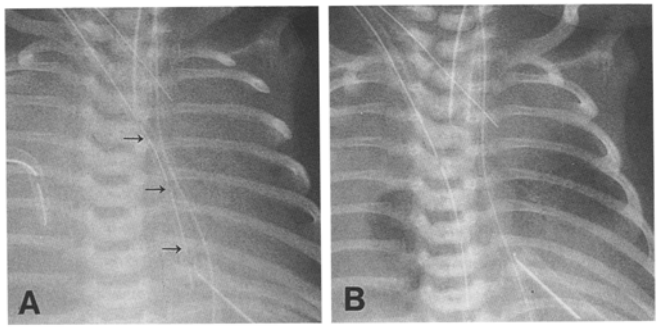

Fig. 2. **A** Chest radiograph following left CDH repair demonstrated shift (*arrows*) of mediastinal cannulae to the left. **B** Right chest tube resulted in development of a right hemothorax

each sonogram demonstrated complex echogenic fluid collections consistent with hematoma on the affected side.

All patients were subsequently treated by decreasing heparin administration and increasing platelet counts via transfusion. Four newborns required an exploratory thoracotomy with successful evacuation of the hemothorax, while one underwent evacuation of the hematoma via a suction catheter introduced through the existing chest-tube site. The shift in the mediastinal catheters resolved after evacuation of the hematoma in all cases. The pulmonary status in each infant subsequently improved, and each was weaned from ECLS without recurrence of the hemothorax. Four patients survived, and one died in the post-ECLS period secondary to severe pulmonary hypertension and respiratory failure.

Discussion

Multiple thoracic procedures may be performed upon patients prior to and during periods of ECLS [7]. Such procedures include CDH repair, thoracotomy tube placement, evacuation of a pneumopericardium, and ligation of a patent ductus arteriosus. As a result of systemic anticoagulation, hemorrhagic complications are a major cause of morbidity and mortality in patients supported with ECLS [3]. The incidence of surgical-site hemorrhage as reported by the National ECLS Registry approaches 14% [7].

Early identification of thoracic bleeding is of paramount importance because of the potential risks of repeated transfusion, consequences of cardiopulmonary compromise, and possible extension of the ECLS course. Zwischenberger et al. identified a constellation of clinical findings that might suggest the presence of a tension hemothorax, tension pneumothorax, or cardiac tamponade during ECLS [8]. However, one would hope to identify a complication of bleeding into the thoracic space prior to the onset of physiologic compromise. The need for repeated blood transfusions may in itself not necessarily raise the suspicion of an occult hemorrhage since multiple transfu-

Table 1. Clinical data from patients with postoperative hemothorax

Patient	Birth weight (kg)	CDH repair (day[a])	Initial cannula shift by CXR (day[a])	Evacuation of hemothorax (day[a])	Survival
T.T.	3.7	4	11	14	Yes
B.G.	3.4	1	7	8	Yes
S.F.	3.7	1	13	14	Yes
M.C.	3.5	11	13	14	Yes
A.C.	3.2	2	4	4	No

[a] day = day of ECLS
CDH = congenital diaphragmatic hernia; CXR = chest radiograph

sions are not uncommonly required during any infant's course of ECLS treatment [4].

ECLS therapy requires surgical placement of vascular cannulae that include a right atrial catheter (via the internal jugular vein) and an aortic arch catheter (via the carotid artery). Serial chest radiographs are obtained to assess the placement of the vascular cannulae and tubes as well as to detect pneumothoraces or worsening pulmonary status. The radiologic identification of a major thoracic hemorrhage is difficult in these infants while on ECLS because diffuse pulmonary opacification typically develops [6], the etiology of which is as yet unclear. Some authors have postulated that it is a manifestation of pulmonary edema and atelectasis, which results from the change from maximal ventilatory support with high distending airway pressures to ECLS with minimal ventilatory settings [5]. In the ECLS patient who has recently undergone repair of a CDH, atelectasis of the ipsilateral, hypoplastic lung along with postoperative effusion also contributes to the opacification of the ipsilateral thorax on chest radiograph. This opacification obscures the detection of bleeding and delays its operative correction.

The position of the vascular cannulae should normally remain stable in these infants. In each of the five patients in whom diffuse pulmonary opacification was present, shift of the ECLS venous cannula occurred away from the site of bleeding. Since the degree of shift may be quite subtle, accuracy in diagnosis requires that serial chest films are comparable, particularly with regard to patient position. If necessary, a portable sonogram may be obtained for confirmation. Evacuation of the hematoma, either by placement of a suction catheter through an existing chest tube site or by thoracotomy, can result in clinical improvement.

In conclusion, diffuse pulmonary opacification, which often occurs during the course of ECLS therapy, may obscure the presence of a large hemothorax. A shift in position of the ECLS venous cannula as seen on comparable chest radiographs should be regarded as an indication that a significant hemothorax is present. Early identification of such complications can allow timely and successful operative intervention.

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