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Ultrasound-guided perioperative management of 28-month-old patient with congenital diaphragmatic eventration

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Abstract

Diaphragmatic eventration is a rare anomaly. When patients with this condition undergo general anesthesia, anesthetic management should be performed with particular care owing to the risk of diaphragmatic rupture. Such a rupture can be perioperatively diagnosed using multiple tools including lung ultrasonography. This case report describes the anesthetic management of a male infant with osteochondroma in the distal ulna, presenting with diaphragmatic eventration on the right side.

Keywords

Diaphragmatic eventration, anesthesia, pediatric, ultrasonography

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Introduction

Congenital diaphragmatic eventration is an abnormal diaphragmatic elevation caused by insufficient or absent muscularization of the pleuroperitoneal membrane.[1] It is difficult to assess the exact incidence of this abnormality because it is rare and generally diagnosed incidentally on chest radiography. Symptoms of diaphragmatic eventration vary from asymptomatic, mild gastrointestinal disease to life-threatening diaphragm rupture.[2] Both induction and emergence from anesthesia should be smooth to avoid abdominal pressure increase, as this may cause diaphragmatic rupture.[3] If the diaphragm ruptures, it should be rapidly diagnosed and treated. Lung ultrasonography can be used to monitor diaphragmatic movement on a real-time basis.[4] This case report describes the anesthetic management of a pediatric patient with congenital diaphragmatic eventration and perioperative observation of diaphragmatic motion using lung ultrasonography.

Case report

A 28-month-old male (height: 87.8 cm, weight: 11.3 kg) was scheduled for excisional biopsy of osteochondroma on the right distal ulna. The patient had a family history of osteochondroma, and the surgery was planned to prevent further deformity of the right arm. The boy was born at a gestational age of 29 weeks and 2 days with a birth weight of 1400 g. He was transferred to the neonatal intensive care unit (NICU) after birth and remained there for 54 days. Haziness was noted in the right lower lung on chest radiography 30 days after the infant's admission to the NICU (Figure 1(a)). Based on this finding, fluoroscopy was performed and the patient was diagnosed with eventration, which persisted until his discharge. At the time of discharge, no abnormal diaphragmatic movement was observed on fluoroscopy despite right hemidiaphragm elevation. After the patient was discharged from the hospital, his clinical course was uneventful and similar to that of other babies of the same age. As part of the pre-operative evaluation, chest radiography showed an abnormal finding indicating eventration of the right diaphragm (Figure 1(b)). Since no pulmonary symptoms were

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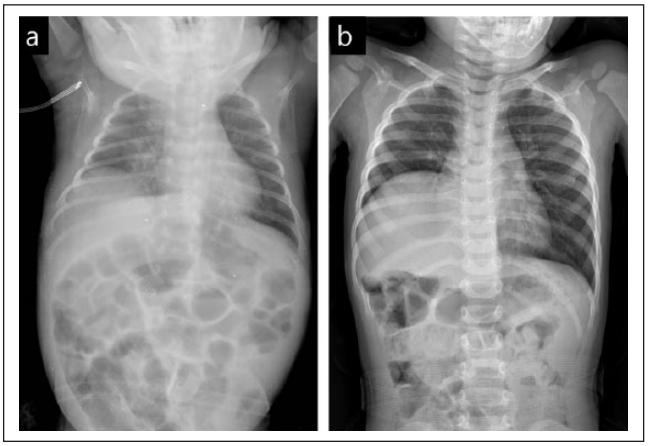

Figure 1. (a) Infantogram at 30th day after birth at neonatal intensive care unit and (b) preoperative chest PA image.

present, the possibility of atelectasis or pneumonic consolidation was ruled out. The patient was already diagnosed with diaphragmatic eventration by fluoroscopy and ultrasonography. Blood test and electrocardiogram results were all within normal ranges.

Because the patient was non-cooperative as a result of his young age, anesthesia was induced with ketamine 1.5 mg/kg before surgery. With the ventilator, spontaneous tidal volume was about 100 mL before intubation. After the administration of 0.8 mg/kg rocuronium as a muscle relaxant, bag-valve-mask ventilation was initiated with pressure less than 15 cmH_2O and tidal volume under 100 mL. Intubation was performed with a cuffed endotracheal tube (size 4.0). Lung sounds were clear on the upper and lower left side. However, on the right side, lung sounds were auscultated only on the upper side, but not on the lower side. Anesthesia was maintained with sevoflurane and remifentanil. Bronchoscopy (3.1 mm diameter, Olympus America, Brooklyn Park, MN, USA) was used to identify three openings on the right bronchus. Initially, volume-controlled ventilation was set at tidal volume 100 mL, respiratory rate 25, fraction of inspired oxygen (FiO_2) 50%, and flow 3 L. With these initial ventilator settings, peak pressure was 25 cmH_2O. Before the initiation of surgery, the zone of apposition was examined using ultrasonography. To prevent an increase in abdominal pressure, the probe was placed on the lateral chest wall instead of the abdomen.[5] Lung sliding and pleural edge were observed in the 8th through the 10th intercostal spaces on the left side and in the 5th through the 7th intercostal spaces on the right side.

At about 15 min after the initiation of surgery, the peak pressure suddenly rose to 28–30 mmHg. Lung ultrasonography was repeated to determine whether the rise in pressure was due to single lung ventilation and diaphragmatic rupture. In both lung fields, the level of lung sliding motion remained the same as that observed during the initial examination. The diaphragm demonstrated good movement. The sevoflurane concentration was increased to 2.5% to heighten the depth of anesthesia. To prevent diaphragmatic rupture, the tidal volume was lowered to 90 mL. Consequently, the peak pressure dropped to 22 cmH_2O while maintaining end-tidal CO_2 ($ETCO_2$) at about 38 mmHg. Following surgery, the motion of the diaphragm was examined with real-time lung ultrasonographic imaging in the post-anesthesia care unit. It was difficult to observe slow movement of lung sliding because the child was crying. However, the pleural edge moved rapidly in the caudal direction in the zone of apposition when the patient cried, creating effects similar to a sniffing test (see Supplemental Video). Thus, the possibility of diaphragmatic rupture was excluded.

Discussion

Diaphragmatic eventration is so rare that it is difficult to measure the exact incidence. Although there are some reports of the anesthetic management of adult patients with this condition, cases of pediatric patients are limited.[6] The reported incidence of pediatric congenital diaphragmatic eventration is 1/1400,[7] and only one case of spontaneous rupture of a congenital diaphragmatic eventration in an infant has been reported.[8] However, the exact incidence of the condition is unknown in the general population.

Partial diaphragm elevation has generally been found on the anteromedial right hemidiaphragm, while complete elevation has been observed on the left hemidiaphragm.[9] While hypoplastic lung-related diaphragmatic eventration is diagnosed using radiography, fluoroscopy, and computed tomography (CT),[7] it is difficult to count the number of lung lobes on CT images. However, three lobe openings on the right lung were confirmed on bronchoscopy in the present case during general anesthesia. In addition, diaphragmatic motion was noted on fluoroscopy, although congenital eventration of the diaphragm is normally associated with inadequate development of muscles or absence of the phrenic nerve.

Extra precautions are required when administering general anesthesia in patients with diaphragmatic eventration. A sudden increase in intra-abdominal pressure may cause diaphragmatic rupture, especially in patients with an abnormal diaphragm. Therefore, the prevention of severe coughing and bucking in patients should be ensured. If diaphragmatic rupture occurs, cardiac output will decrease with the migration of intra-abdominal organs from the intra-abdominal space to the intra-thoracic space, resulting in compression of the heart, aorta, and vena cava. Thus, it is important to maintain sufficient anesthetic depth during induction and emergence. In addition, low-volume bag-valve-mask ventilation is necessary to prevent peak pressure increase. Moreover, total intravenous anesthesia is preferred to balanced anesthesia with inhalation as the latter causes hypoxic pulmonary vasoconstriction. Peak pressure may rise upon single lung

ventilation or migration of abdominal organs to the thoracic area after diaphragmatic rupture. When the peak pressure does rise, it is important to determine its cause. In addition, lung ultrasonography can be useful to evaluate diaphragm function, although there is no consensus on the sensitivity of ultrasound in this assessment.[10]

Abnormal diaphragmatic motion during breathing can be examined in M-mode ultrasonography.[4] Normal diaphragmatic movement during inspiration shows movement toward the transducer when the transducer is on the right below the normal diaphragm position. When the diaphragm ruptures, the diaphragm may appear to be floating or invisible, or a subphrenic fluid collection may appear on ultrasonography.[11] Ultrasonography may show herniation of the solid abdominal contents, such as the liver, omentum, or a bowel segment with peristaltic activity. If the liver sliding that is hepatic parenchymal movement is shown on the right upper trunk instead of the lung parenchyma, it may indicate liver herniation.[12] Comparison of the amplitude of diaphragmatic movement and the alteration of changes in diaphragm thickness with the contralateral side is also important. In this case, liver and lung diaphragm were found at the locations expected from the results of pre-operative chest posteroanterior (PA) imaging of the right side: five or six rib levels higher than on the left side. When the patient cried, normal diaphragmatic excursion was observed. The fact that diaphragmatic movement in the zone of apposition was observed from the lateral wall of the chest does not necessarily mean the movement was pleural. This is because the movement in the zone of apposition may indicate paradoxical motion induced by the opposite lung.[5] However, paradoxical movement due to the opposite side lung was excluded because caudal moving of the pleural edge and inspiration during snappy crying were observed at the same time. In cases of diaphragmatic rupture, the movement of the diaphragm would be flattening or limited at the zone of apposition. However, in the present case, there was no such abnormal diaphragmatic movement. Indeed, the boundary between the abdominal compartment contents, such as the liver and bowel, and the chest compartment, was in the same position as during the initial examination. The thickness of the diaphragm during contraction was also normal. Thus, we thought the possibility of diaphragmatic rupture was low.

Regional anesthesia can be a safe choice for certain surgical lesions.[13] It is known that peripheral nerve blocks are safe when performed on sedated pediatric patients.[14] For the patient in the present, brachial plexus block (BPB) could not be performed after sedation as it may induce respiration depression, thereby accelerating desaturation owing to the small lung volume. In addition, manual ventilation or airway intubation in an emergency may increase the likelihood of diaphragmatic rupture. Moreover, BPB performed above the supraclavicular level may trigger phrenic nerve palsy. An axillary approach for BPB was also inappropriate in this case as it requires deep sedation to avoid puncture of the surrounding vessels.

Conclusion

When performing mechanical ventilation on patients with congenital diaphragmatic eventration, it is important to prevent the rise of abdominal pressure and peak pressure, as this may lead to diaphragmatic rupture. In addition, perioperative lung ultrasonography may be useful for the rapid diagnosis of diaphragmatic rupture.

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Supplemental material

Supplemental material for this article is available online.

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