

# Thoracoscopic approach in management of congenital diaphragmatic hernia

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**Abstract** Thoracoscopic repair is feasible and safe for congenital diaphragmatic hernia (CDH). The operation can be performed with three trocars using carbon dioxide insufflations at a pressure of 4–6 mmHG. From January 2001 to July 2012, we performed thoracoscopic repair for 311 children with CDH including 152 newborns and 159 infants and toddlers. Mean operative time was  $75 \pm 27$  min. HFOV was used in 24 patients. Direct closure of two rims of diaphragmatic hernia was carried out in 175 patients. Closure of two rims of diaphragmatic hernia with the thoracic wall was performed in 136 patients. Prosthetic patches were required in 54 patients. Conversion to open surgery was required in 38 patients (12.2 %). There were no intraoperative deaths. 38 patients died postoperatively (13.5 %).

**Keywords** Congenital · Diaphragmatic hernia · Thoracoscopic

## Introduction

Congenital diaphragmatic hernia (CDH) is a rare and life-threatening condition in children. The reported incidence of CDH is 1 in 2,107 births [1]. Although many advanced technologies have been applied, the mortality rate of CDH is still high.

The conventional surgery has been performed through laparotomy until recently when these were replaced by laparoscopic or thoracoscopic techniques [2–15].

The herniation is located in the left side in 80 % and in the right side in 20 %. Bilateral hernia is rare [16]. In left

diaphragmatic hernia, the hernia usually contains small intestine and colon. The spleen or the stomach or both may be shifted into the hemithorax. The left lobe of the liver and the left kidney are rarely seen in the thorax. In right CDH, a part of the right lobe of the liver is always found in the thorax. Small intestine is occasionally seen in the thorax also.

## Treatment

### Preoperative care

Preoperative care is an essential step in management of CDH. All efforts aim to stabilize the cardiorespiratory system while avoiding even minimal iatrogenic injury. The resuscitation should begin with endotracheal intubation and mechanical ventilation. Pulmonary hypertension is treated by medicaments, high frequency oscillatory ventilation, nitrous oxide, and/or ECMO.

### Timing of surgery

Congenital diaphragmatic hernia is no longer considered an emergency condition. Early surgical intervention is now replaced by delayed surgery. How long is a proper delay? A 100-h delay is recommended by some authors. It could be shorter to reduce the risk of ventilation-associated infection in situation where cardiovascular parameters and blood gaz measurements are relatively stable.

### Anesthesia

Anesthesia with bilateral ventilation is used for newborns, and one-lung ventilation is applied for infant and toddlers.

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Conventional ventilators have been used. High frequency respirators have been used recently for newborns to provide better oxygen [17, 18].

### Thoracoscopic repair for CDH

*Indications* most patients with CDH can be operated by a thoracoscopic approach.

In the past, contraindication for thoracoscopic repair included (1) stomach located in the thoracic cavity, (2) associated cardiac anomalies, and (3) requirement of prosthetic patch.

Recent report no longer considers those conditions contraindications for thoracoscopic repair [6, 13, 19–21].

### Positioning

The patient is placed in the lateral decubitus position with the head elevated. The upper arm is left free.

The surgeon stands at the patient's head, with the monitor positioned at the patient's feet (Fig. 1).

### Procedure

- *Trocar placement* A 5-mm skin incision is made over the third intercostal space at the mid-axillary line. A small clamp is introduced through the intercostal muscle, which is spread out to allow air to the thoracic cavity. A 5-mm trocar is introduced at this site for a thoracoscope. The second trocar is placed in the fourth intercostal space anteriorly, and the third trocar is inserted in the fourth intercostal space behind the scapular tip (Fig. 2).
- Carbon dioxide insufflation is maintained at a pressure of 2–4 mmHg at a flow rate of 1 L/min in the thoracic



**Fig. 1** Patient's position



**Fig. 2** Trocar placement

cavity. Pressure is increased up to 6 mmHg if reduction of herniated organs is difficult.

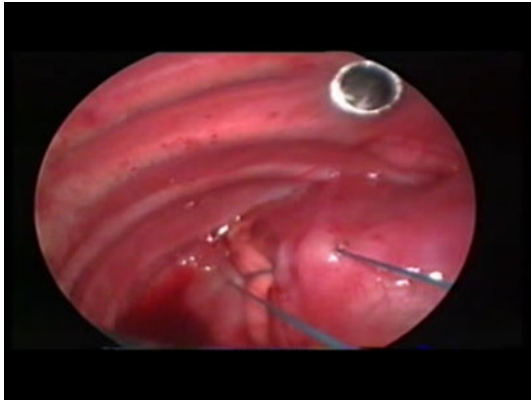
- *Inspection* Identify the herniated organs through thoracoscope and try to identify the orifice of the diaphragmatic defect if possible.
- Reduction of herniated organs is the most difficult step, especially with much small intestine in the thoracic cavity in a low birth weight newborn. The small intestine is gently reduced into the abdominal cavity using blunt graspers. The direction of the reduction is important. It is better if the surgeon can identify the diaphragmatic defect before reducing. The reduction should start with the small intestine, then the colon. Reduction of the spleen is the last step and should be performed carefully. One grasper holds the gastrosplenic mesentery and pushes it to the abdominal cavity. The other grasper is used to push the spleen very gently at the same time.

Reduction of herniated organs is difficult when the orifice of the diaphragm is small. Inspecting and widening the orifice facilitate the reduction.

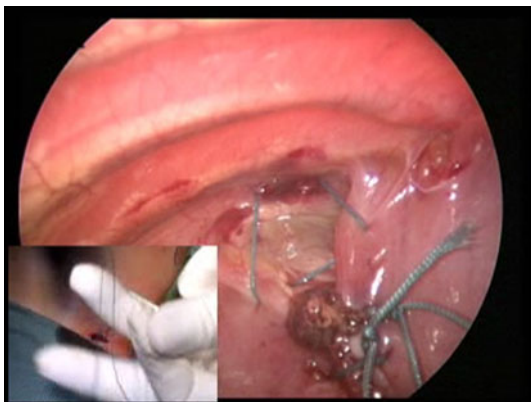
- *Closure of diaphragm defect* If the defect is small, direct closure of the two diaphragmatic rims is carried out. The hernia defect is repaired using nonabsorbable interrupted sutures (Ethibon 2/0 or 3/0) encompassing two borders of the diaphragmatic defect with extra-corporeal knots.

The first stitch is placed at the middle of the hernia defect (Fig. 3), and then the CO<sub>2</sub> insufflation is turned off. Subsequent stitches could be done without insufflation to minimize cardiovascular disturbances.

- *Closure of lateral corner of the defect* It is difficult to close the lateral corner of the diaphragmatic hernia completely when it is large (when the distance between



**Fig. 3** First stitch



**Fig. 4** Closure of the two diaphragmatic defects with thoracic wall

the two diaphragmatic rims is larger than 2 intercostal spaces). This site is a location for recurrent herniation if it is not well managed.

A skin incision is made on the thoracic wall. A needle is passed through the wound to the thoracic cavity, capturing the anterior rim and then the posterior rim and looping back through the thoracic wall. Knot is made extracorporeal, and then the skin is closed over the knots (Fig. 4).

- *Close the diaphragm defect with a patch* If the direct closure of the diaphragmatic hernia is under tension or impossible, a prosthetic mesh is required. Different kinds of prosthetic mesh could be used; however, an impermeable one should be chosen to prevent fluid from the abdominal cavity entering the thoracic cavity due to negative pressure.

One trocar is withdrawn. The mesh was introduced into the thoracic cavity through the trocar wound after it has been appropriately trimmed. The mesh is fastened close to the diaphragmatic rims using intra- or extracorporeal

sutures. Closure of the mesh to the thoracic wall is carried out as previously described.

- *Drainage* Placement of a chest drain is still debated. Many surgeons do not place a chest drain to avoid mediastinal swing. However, we have seen pleural effusion in our patients without a chest drain. We now place a thoracic drain and perform intermittent manual suction every 3 h. The drain is removed after 48 h if the chest X-ray is satisfactory.
- *Surgery in the neonatal intensive care unit and under high frequency oscillatory ventilator (HFOV)* To avoid the stress of transportation, we perform thoracoscopic repair for patients whose cardiovascular system is not very stable or under HFOV. We do not have any special difficulty in performing the operation in this situation.
- *Postoperative management* Ventilation with high frequency and low peak airway pressure is continued. Cardiac echography is routinely obtained to assess pulmonary hypertension, shunt flow, and ventricular performance. HFOV, NO or ECMO is required when pulmonary arterial hypertension is present. Thoracoscopic repair can be carried out successfully in toddlers, infants, and newborns. However in some reports, the conversion rate was from 11 to 42 % [5, 11, 19]. Reasons for conversion included difficulty in reducing herniated organs, oxygen desaturation, cardiovascular system instability, and requirement of prosthetic patch.

We overcome difficulties in reducing herniated organs by some different measures: (1) placing trocars as high as possible to gain enough working space in the thoracic cavity, (2) increasing temporarily CO<sub>2</sub> insufflation pressure, (3) widening the orifice of the diaphragmatic hernia when it is narrow, and (4) using maximal dosage of relaxant medicament.

Oxygen desaturation is a great concern for surgeons who plan to perform thoracoscopic repair for CDH. To ensure oxygen saturation and cardiovascular stability, we now use HFOV instead of conventional ventilator during the operation for newborns.

Thoracoscopic repair is safe. No intraoperative death has been reported in the literature. Injury of intestine or spleen could occur during the reduction of herniated organs. However, the complication rate was low.

## Our results

From January 2001 to July 2012, we performed thoracoscopic repair for 311 children with CDH including 152 newborns and 159 infants and toddlers. Mean operative time was  $75 \pm 27$  min. HFOV was used in 24 patients.

Direct closure of two rims of diaphragmatic hernia was carried out in 175 patients. Closure of two rims of diaphragmatic hernia with the thoracic wall was performed in 136 patients. Prosthetic patches were required in 54 patients. Conversion to open surgery was required in 38 patients (12.2 %). There were no intraoperative deaths. 38 patients died postoperatively (13.5 %).

#### Laparoscopic repair for CDH

Laparoscopic repair is difficult to perform in newborns. However, it could be done in infants and toddlers [22–24]. The rate of conversion in laparoscopic repair is higher than in the thoracoscopic approach. One multicenter study in Europe revealed that the rate of conversion was 41 % in laparoscopic repair versus 27 % in thoracoscopic repair [11].

#### Conclusion

Thoracoscopic repair is feasible and safe for CDH in children.

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