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Thoracoscopic Diaphragm Plication in Children and Indications for Conversion to Open Thoracotomy

B. HALUK GÜVENÇ, MD,[1] MEVLIT KORKMAZ, MD,[2] LEVENT AVTAN, MD,[3] REMZIYE SIVACI, MD,[4] CANAN BALCI, MD,[4] and GÜLŞEN EKİNGEN, MD[1]

ABSTRACT

Thoracoscopic plication of the diaphragm has been recently described as an alternative treatment for eventration. It is considered to be much less traumatic than the conventional method. We attempted thoracoscopic diaphragm plication on three patients. Two patients were treated successfully by the minimally invasive technique and were discharged from hospital on the second postoperative day. In the third case, the presence of a mobile intrathoracic kidney due to previous diaphragmatic hernia repair necessitated conversion to open thoracotomy. This patient was discharged on postoperative day six following an uneventful recovery. All patients are well and asymptomatic on followup. We advocate thoracoscopic diaphragm plication in children as a safe procedure with less morbidity and excellent cosmetic results.

INTRODUCTION

EVENTRATION, AN ABNORMAL ELEVATION of the nonfunctioning diaphragm, is defined as paradoxical motion of the affected hemidiaphragm during expiration and inspiration. It may be congenital, or acquired due to phrenic nerve damage. Abnormal development of the muscular portion or central tendon of the diaphragm is considered to be the cause of congenital presentations. Most patients are asymptomatic and require conservative followup. Surgical reconstruction of the redundant diaphragm is necessary in cases where significant respiratory symptoms such as wheezing, repeated respiratory infections, and exercise intolerance develop.[1,2]

The initial report of successful surgical correction of an eventrated diaphragm was by Bisgard in 1947. Bingham performed plication in 1954, followed by other successful techniques.[3] Growing experience with the minimally invasive approach has influenced surgeons to perform thoracoscopic plication. Recent advances in video-endoscopic technologies have made thoracoscopic surgery available in children and infants. In this article, thoracoscopic plication of the diaphragm is emphasized as a safe, feasible, and less traumatic approach with good cosmetic results in children.

MATERIALS AND METHODS

We attempted thoracoscopic plication of the right hemidiaphragm in three patients with eventration (Table 1). All had similar symptoms: respiratory distress, repeated lung infection, and failure to thrive. Chest radiography revealed an elevated right diaphragm in all cases. Fluoroscopic examination and computed tomography confirmed eventration.

Thoracoscopic procedure was applied to all patients. A preanesthetic evaluation of the patients described ASA physical status 1, and the attending anesthesiologist did not suggest premedication. All operations were per-

[1]Kocaeli University Department of Pediatric Surgery; [2]Afyon Kocatepe University Department of Pediatric Surgery; [3]Istanbul University Department of General Surgery; [4]Afyon Kocatepe University Department of Anesthesiology and Reanimation, Turkey.

Table 1. Patient Profiles

N	*Age (months)*	*Sex*	*Defect*	*Etiology*	*Symptoms*	*Extubation (postoperative)*
1	8	F	Right eventration	Congenital	Lung infection and distress	1 day
2	18	M	Right eventration	Congenital	Lung infection and distress	6 hours
3	6	F	Right eventration	Congenital	Lung infection and distress	6 hours

formed under bilateral lung ventilation using sevoflurane and fentanyl in oxygen/nitrous oxide 50/50%, which provided a hemodynamically stable intraoperative course. The heart rate ranged from 111/min to 123/min and the systolic blood pressure from 90 mm Hg to 100 mm Hg. The diastolic pressure ranged between 45 mm Hg and 50 mm Hg. The SpO_2 was almost 99–100% and end-tidal CO_2 ($ETCO_2$) ranged from 36 mm Hg to 55 mm Hg. The airway pressure was 24 mm Hg to 30 mm Hg, breathing rates from 22 to 24, and tidal volume 100ml.

The patients were positioned on their right lateral side and the surgeon and assistant were positioned at the patient's head. A nasogastric tube obtained relief of abdominal pressure and a reversed Trendelenburg position helped in decreasing the intrathoracic pressure. Following skin incision, a clamp was used to produce pneumothorax so as to prevent injury to the lung parenchyma. A 5 mm 0° rigid thoracoscope was inserted through the fourth intercostal space, in the axillary line. Two additional 5 mm working ports were stationed at the 5th or 6th intercostal spaces, in the anterior and posterior axillary lines. An induced pneumothorax at 6 mm Hg pressure CO_2 was enough to obtain an adequate space for working and no lung retractor was needed.

The dome of the diaphragm was put to traction with the grasper to prevent intra-abdominal damage. Continuous zero silk sutures running from the anterolateral to medial direction were placed and tied intracorporeally. Three rows of sutures were sufficient to achieve a tight diaphragm. An additional suture was required to plicate the remaining redundancy in the second patient. Sufficient tension of the diaphragm was shown after decompressing the pneumothorax (Fig. 1). A chest tube was inserted through one of the portholes and left in place until adequate lung expansion was obtained.

The first patient had had diaphragmatic hernia repair at the age of one month. Her right kidney was positioned high in the thoracic cavity on initial admission. The presence of her mobile (ectopic) intrathoracic kidney necessitated conversion to open thoracotomy in this case.

RESULTS

Diaphragmatic plication was performed successfully in all patients. Conversion to open surgery in one case resulted in a prolonged intubation time over 24 hours and hospitalization for six days, whereas the others were easily weaned from ventilatory support, extubated in six hours after operation, and discharged on the second postoperative day. All patients were observed to gain rapid improvement of respiratory condition. Chest radiograms

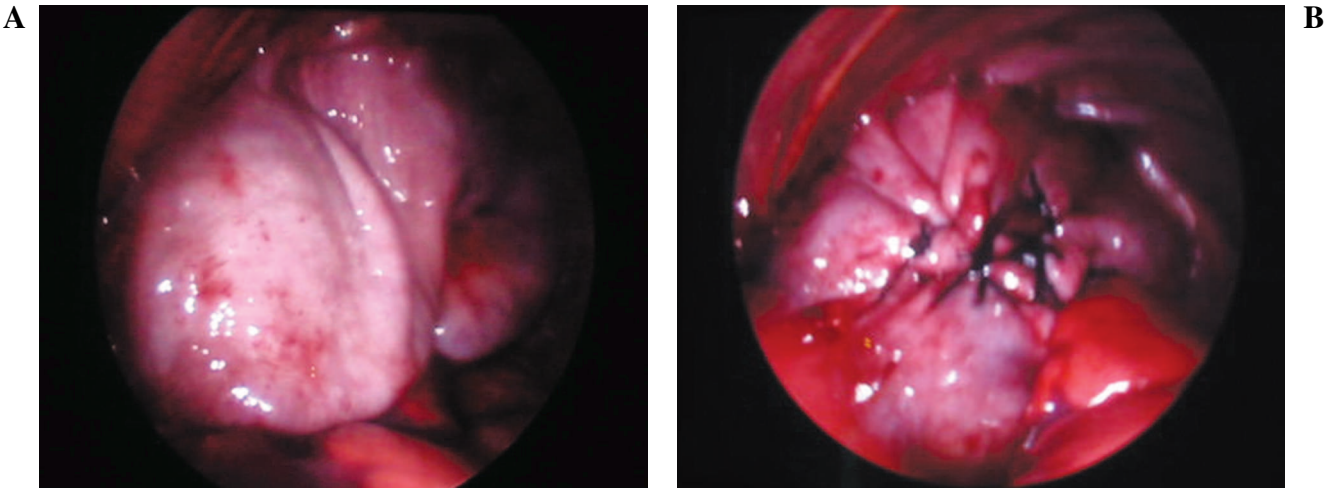


FIG. 1. Intraoperative appearance of the loose diaphragm (A) before and (B) after plication was completed in patient 2.

obtained at the first postoperative month showed normal anatomic position of the affected hemidiaphragm. (Fig. 2).

DISCUSSION

Congenital eventration of the diaphragm is a developmental anomaly characterized by muscular aplasia. In the abnormal area, muscle fibers usually decrease markedly and exhibit a membranous appearance. Congenital eventration may differ from diaphragmatic hernia with a sac or a rim of the diaphragm covering the pleural and peritoneal membrane, but differential diagnosis is sometimes difficult.[4] Acquired eventration, secondary to paralysis of the phrenic nerve, may be associated with the use of forceps during labor, breech presentation, tumors, brachial plexus injury, cephalhematoma, thoracic surgery, or clavicular fractures.[5]

Most children may be asymptomatic, and they may incidentally be seen during a general examination. Without symptoms no therapy is needed. Children under the age of two poorly tolerate loss of functional capacity, which decreases the alveolar to lung mass ratio, which may in turn affect the gas exchange surface. The mobility of the mediastinum in an infant may result in significant respiratory distress. When the normal hemidiaphragm descends during inspiration, the mediastinum shifts to the normal side and the eventrated side paradoxically elevates. This motion further reduces lung volume and decreases tidal volume; the increased breathing effort and extreme respiratory distress may require ventilator support.[6] All of our patients had had respiratory symptoms: cough, respiratory distress, recurrent lung infection and, eventually, failure to thrive.

Definitive treatment of symptomatic diaphragm eventration is obtained by simple plication of the large paralytic sheet through the conventional transthoracic or transabdominal approach. Most authors favor transthoracic repair.[7] The abdominal approach is preferred in cases with bilateral presentation.[8] Late functional results of plication do not interfere with further development of the diaphragm.[9]

Standard open thoracotomy requires a large incision, rib injury, and results in increased postoperative pain and morbidity. A thoracoscopic approach, on the other hand, produces minimal injury on the thoracic wall, reduces postoperative pain and morbidity, has less adverse affect on lung function, and gives good cosmetic results. Gharagozloo et al.[10] and Sato et al.[11] have published acceptable results with thoracoscopic plication. Recent innovations in the armamentarium have improved the minimally invasive thoracoscopic approach in children and infants as well. An increasing number of pediatric cases are reported in the literature.[12,13]

In the pediatric practice, the initial insertion of a clamp followed by the trocar provides a much safer approach in creating a pneumothorax. This helps to prevent iatrogenic bleeding and internal organ injury in small babies. Although artificial pneumothorax causes an increase in the $ETCO_2$, insufflation of CO_2 at 6 mm Hg pressure is well tolerated in children, and results in a better working space without any need of a lung retractor. Whereas intracorporeal suturing and the limited flexibility of the thoracic cage results in a longer operative time, experience gained by the surgeon will reduce operative times. Rapid

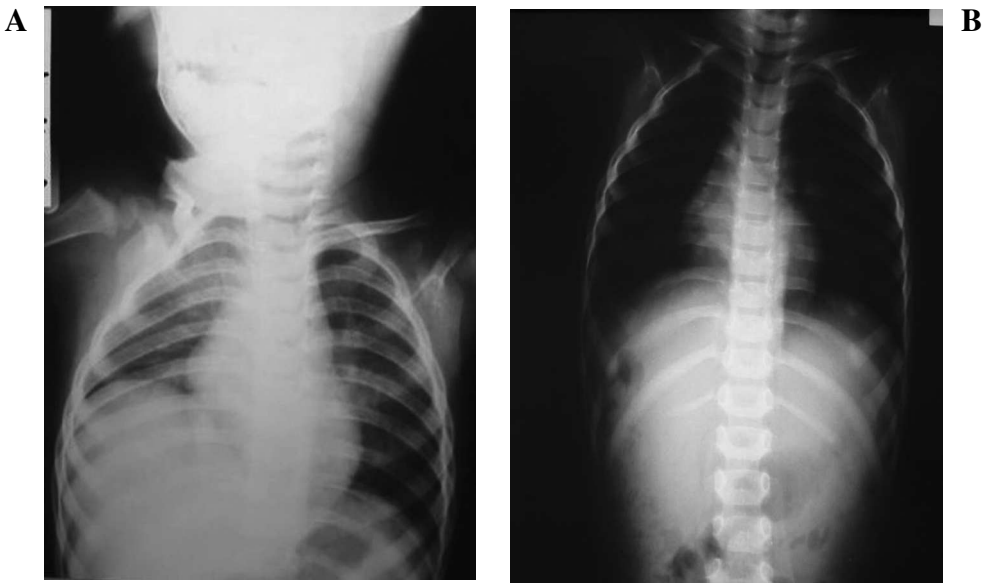


FIG. 2. Chest radiogram obtained (A) preoperatively and (B) at one month followup in patient 2.

postoperative recovery and reduced morbidity are valuable contributions in the treatment of eventration.

Bleeding, organ injury, and gas embolism may result in conversion to open surgery. Furthermore, anatomical abnormalities may also lead to termination of laparoscopy. In our first patient, an ectopic kidney prevented safe suturing and plication, and we completed the procedure by thoracotomy. Even though the end result was identical, conversion to open surgery resulted in a longer hospitalization with increased postoperative pain in this patient.

The advantages of the thoracoscopic approach were clearly observed in our series. We advocate thoracoscopic diaphragm plication in children as a safe procedure with less morbidity and excellent cosmetic results.

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Address reprint requests to:
Mevlit Korkmaz, MD
Afyon Kocatepe University Medical Faculty
Department of Pediatric Surgery
Afyon-TURKEY 03200

E-mail: mevlitkorkmaz@hotmail.com