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## Case report

## Early improvement of respiratory function after surgical plication for unilateral diaphragmatic paralysis

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**Abstract**

We reported an unusual case of symptomatic diaphragmatic paralysis in an elderly patient with progressive respiratory-dependent limitation of her daily activities. Surgical plication of the affected hemidiaphragm resulted in early clinical and physiological improvements. © 1998 Elsevier Science B.V. All rights reserved.

**Keywords:** Surgery; Diaphragmatic plication; Monitoring: spirometry, capnography; Thorax: diaphragmatic paralysis

**1. Introduction**

Unilateral diaphragmatic paralysis resulting from nonmalignant causes is an uncommon and disabling condition in adults. Plication of the paralyzed hemidiaphragm may considerably improve pulmonary functional tests [1,2]. In this case, beneficial effects were already detected by means of intraoperative respiratory monitoring and were manifested by increased functional pulmonary volumes in the early postoperative period.

**2. Case history**

In October 1996, a 75-year-old woman was admitted in the surgical unit with increasing complaints of dyspnea on exertion over the last year. In 1980, she had a triple bypass coronary surgery but recent cardiac investigations were all negative. In 1990, a raised hemidi-

aphragm was incidentally reported on routine chest X-rays but remained non-investigated since the patient was asymptomatic. On admission, decreased breath sounds were heard over the left hemithorax and fluoroscopic examination documented an elevated left hemidiaphragm with paradoxical motion on 'sniffing', consistent with phrenic nerve paralysis. Forced vital capacity (FVC) and forced expiratory volume in 1-s (FEV<sub>1</sub>) were markedly decreased (48 and 38% of predicted values, respectively), with no improvement after inhalation of a  $\beta_2$ -adrenergic agonist.

The decision to proceed to surgical plication was made by considering that, the patient's quality of life was severely limited as a result of a restrictive pulmonary pattern most likely attributed to left diaphragmatic paralysis.

A left double-lumen tube was positioned in the left bronchus and perioperative analgesia was conducted with a thoracic epidural catheter. An in-line respiratory monitor (AS3 Datex Instrum. Corp. Helsinki, Finland) was used for continuous measurements of airway pressure, end expiratory CO<sub>2</sub> concentration ( $P_{ET}CO_2$ ), as well as breath-by-breath calculation of respiratory dynamic compliance.

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A left posterolateral thoracotomy was performed and on examination, the hemidiaphragm appeared flaccid, atrophic and devoid of muscular fibres. The remaining fibrotic hemidiaphragm was plicated by folding its lateral and posterior portions with a series of ten pledgeted 1-0 nonabsorbable sutures until it was tense to palpation. The plicated segment was then oversewn with a continuous monofilament suture. After re-expansion of the collapsed lung, respiratory compliance improved dramatically (36 vs. 26 ml/cm H<sub>2</sub>O before surgical incision) and was accompanied by higher PaO<sub>2</sub>/FIO<sub>2</sub> ratio (79.3 vs. 64.7 kPa before surgical incision) and smaller arterial-to-end expiratory CO<sub>2</sub> gradient.

The patient was extubated in the operating room and the chest roentgenogram taken 2 h postoperatively, showed the left hemidiaphragm in a near normal position. As early as 4 h after the end of surgery, spirometric data recovered baseline values and improved thereafter. Within 6 weeks postoperatively, the patient had recovered the ability to perform her daily activities, FVC and FEV<sub>1</sub> were increased by 33 and 47%, while arterial PO<sub>2</sub> on room air increased from 8.8 to 9.7 kPa (Table 1). After 1 year follow-up, the patient is still doing well and no deterioration have been observed.

### 3. Discussion

The diagnosis of diaphragmatic paralysis was suggested by a raised hemidiaphragm on the chest roentgenogram and was confirmed by observing paradoxical motion on 'sniffing' during fluoroscopy. Confusion with cases of diaphragmatic eventration may occur, but this entity is a congenital anomaly, with passive upward movement of a predominantly membranous hemidiaphragm and no paradoxical motion [1].

Table 1  
Effect of surgical plication on spirometric and arterial blood gas values in one patient with unilateral diaphragmatic paralysis

	Pre-operative		Post-operative	
	-1 day	4 h	18 h	6 weeks
FVC (l)	1.20 (48)	1.20 (47)	1.46 (58)	1.8 (76)
FEV <sub>1</sub> (l)	0.75 (38)	0.81 (39)	0.96 (46)	1.3 (67)
FEV <sub>1</sub> /FVC (%)	62 (83)	69 (92)	66 (88)	72 (98)
PEF (l)	2.3 (39)	2.0 (35)	2.9 (51)	3.9 (66)
PaO <sub>2</sub> /FIO <sub>2</sub> (kPa/%)	8.8/0.2	13.6/0.3	8.3/0.2	9.5/0.2
PaCO <sub>2</sub> (kPa)	6.6	6.9	5.3	5.4

Values in parentheses indicate percentage of predicted. FVC, forced vital capacity; FEV<sub>1</sub>, forced expiratory volume in 1 s; PEF, peak expiratory flow, PaO<sub>2</sub> and PaCO<sub>2</sub>, arterial oxygen and carbon dioxide partial pressures.

In adults, unilateral diaphragmatic paralysis is either idiopathic or related to neoplastic infiltration, viral or bacterial infection, or trauma [1,3]. In this case, chest X-rays was unremarkable before cardiac operation, whereas, a raised hemidiaphragm was noted 7 years postoperatively. After open heart surgery, an elevated hemidiaphragm is encountered in about 25% and may be related to the use of ice/slush topical hypothermia, pleural effusion, operative trauma or jugular cannulation [4]. Unilateral diaphragmatic dysfunction does not dramatically compromise ventilation in patients with normal lung function and it usually recovers within 1–18 months [5]. In 1994, Glassman et al. [6] reported the first case of successful plication for diaphragmatic paralysis and subsequent acute respiratory failure following coronary artery bypass surgery. In the present case, an 'asymptomatic' raised hemidiaphragm was documented following cardiac surgery and the delayed onset of respiratory symptoms was likely explained by an age-dependent decrease in pulmonary reserve capacity.

Some beneficial physiological changes were already detected intraoperatively by continuous spirometry and capnometry. Re-expansion of the left lung following diaphragmatic plication was accompanied by a significant increase in dynamic compliance of the left lung and of the whole respiratory system, as well as by a decrease in arterial-to-end expiratory CO<sub>2</sub> gradient that likely reflected improved ventilation/perfusion matching and greater functional respiratory volumes.

As early as 4 h after thoracotomy, FVC and FEV<sub>1</sub> recovered preoperative values and gradually increased thereafter. Epidural analgesia could hasten the onset of physiological improvements by alleviating pain and suppressing the inhibitory reflexes acting on the right diaphragm [7]. Long term improvements are better explained by structural and physiological reconfiguration of the thoracic cavity and may persist for as long as 10 years after operation [3]. First, enlargement of the hemithorax by fixing the paralyzed hemidiaphragm in a lower position produces greater functional residual capacity. Second, as the intercostal and accessory muscles operate in series with the diaphragm [8], plication of the noncontractile hemidiaphragm attenuates its lengthening during contraction of the other inspiratory muscles. Third, a change in the configuration and position of the left hemidiaphragm allows better recruitment of the ipsilateral inspiratory muscles and the contralateral hemidiaphragm [9]. In agreement with these hypotheses, a significant increase in maximal transdiaphragmatic pressure and greater changes in gastric and esophageal pressures have been observed after plication that are consistent with an improved ability of contractile inspiratory muscles to act as pressure generators [8].

In conclusion, diaphragmatic plication should be considered in adults suffering from immediate or de-

layed respiratory insufficiency following cardiac surgery. Early physiological improvements induced by surgical plication can be detected intraoperatively with in line respiratory monitor and are manifested postoperatively by greater functional lung volumes and better exercise capacity.

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