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Case Presentation

Exercise Therapy for a Patient With Persistent Dyspnea After Combined Traumatic Diaphragmatic Rupture and Phrenic Nerve Injury

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Abstract

We present a case report of a patient with a history of diaphragmatic rupture who had persistent dyspnea for 9 months after primary surgical repair of a right diaphragmatic rupture caused by a car accident. A phrenic nerve conduction study was performed, which demonstrated a rare accompanying ipsilateral phrenic nerve injury with resultant hemidiaphragmatic paralysis. Aerobic exercise therapy for the purpose of improving endurance and dietary modification for weight reduction were prescribed and continued for 6 months. The exercise intensity was prescribed based on the percentage of maximum heart rate as confirmed by an exercise tolerance test. The duration of exercise was gradually increased. In this case, the long-persistent dyspnea was successfully alleviated via nonoperative management to the point that the patient could resume regular activities of daily living.

Introduction

Diaphragmatic paralysis due to diaphragmatic rupture or phrenic nerve injury is a common cause of dyspnea. In cases of diaphragmatic rupture, regardless of the generally positive prognosis after primary surgical repair, complete recovery is achieved in only 43.9% of cases [1]. Moreover, the prognosis for phrenic nerve injury is known to vary with the underlying causal disease or condition. The symptoms of phrenic nerve injury are transient and generally of no clinical significance when they occur after cardiac surgery [2]. However, some cases of hemidiaphragmatic paralysis with persistent respiratory compromise might require diaphragmatic surgery [3]. Reports on separate cases of traumatic diaphragmatic rupture and phrenic nerve injury have been published; however, to the best of our knowledge, this is the first reported case of combined diaphragmatic rupture and phrenic nerve injury. The patient experienced 9 months of continuous dyspnea after a motor vehicle accident. The dyspnea symptoms improved after a regimen of aerobic exercise, dietary modification, and weight reduction, which enabled the patient to resume daily living activities that had been seriously curtailed.

Case Presentation

A 52-year-old woman without any known underlying diseases, including hypertension, heart problems, or metabolic disease, underwent a thoracotomy and primary repair for a right diaphragmatic rupture, a fracture of the seventh rib, and a hemothorax sustained in a car accident. She was hemodynamically stable. Initially, the rupture was successfully repaired without postsurgical complications, and thus satisfactory progress was expected. The initial posteroanterior chest radiograph showed an elevated right diaphragm, and the diaphragmatic height index (DHI) [4] was 2.7 (Figure 1A). One month after surgery, she reported dyspnea. Her Medical Research Council (MRC) dyspnea score was 4. A subsequent contrast-enhanced chest computed tomographic scan revealed an elevated right diaphragm, and no malignant lesion or pulmonary embolism was found. Similarly, an echocardiogram revealed no specific abnormalities. However, posteroanterior chest radiography showed that the right hemidiaphragm was persistently elevated. At that time, the patient's DHI was 2.5. Furthermore, a pulmonary function test revealed a forced vital capacity (FVC) of 2.03 L (67% of the predicted normal value) and a forced

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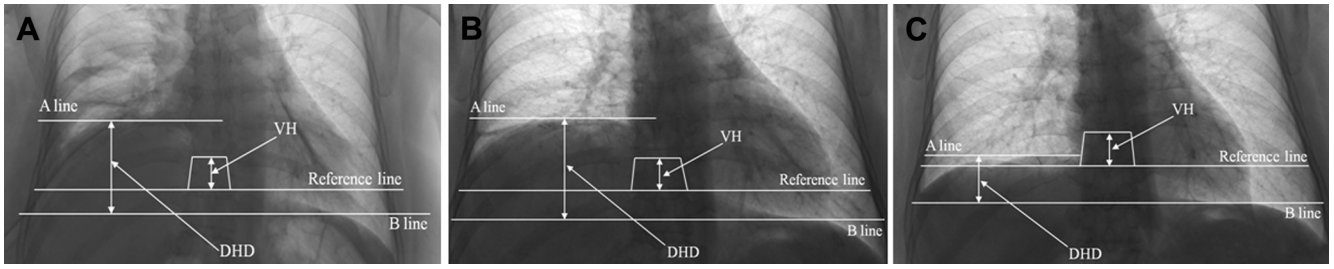

Figure 1. Posteroanterior chest radiograph. Diaphragmatic height index (DHI) = diaphragmatic height difference (DHD)/vertebral height (VH). Upon the initial chest radiograph (A), DHD = 60.30, VH = 22.3, and DHI = 2.7. At the time of rehabilitation evaluation (B), DHD = 49.55, VH = 20.81, and DHI = 2.4. After treatment (C), DHD = 32.45, VH = 21.52, and DHI = 1.5.

expiratory volume in 1 second (FEV1) of 1.55 L (66% of the predicted normal value; Table 1).

Nine months after surgery, the patient's MRC dyspnea score was, surprisingly, still 4, and she was referred to the Department of Rehabilitation Medicine for a phrenic nerve conduction study and further management. Posteroanterior chest radiography showed that the right hemidiaphragm was still elevated. The DHI was 2.4 (Figure 1B), the FVC was 1.99 L (66% of the predicted normal value), and the FEV1 was 1.55 L (66% of the predicted normal value; Table 1). The phrenic nerve conduction study was performed according to the method detailed by Markand et al [5] and revealed that a right compound muscle action potential (CMAP) was not evoked; needle electromyography of the diaphragm was not performed. Based on these results, the diagnosis of accompanying right diaphragmatic paralysis due to phrenic nerve injury was confirmed. Although an exercise tolerance test conducted at that time revealed a maximal oxygen consumption (V_{O_2} max) of 14.9 mL/kg/min, which was close to the normal value (18.7 $\pm$ 5.5) specified for the patient's age group [6], the metabolic equivalent of task score was 4.3 and indicated severely restricted daily living activities. The peak respiratory exchange ratio was 0.95 beats/min (Table 1), which might indicate a submaximal effort. She was able to perform self-care, such as lightly washing herself and dressing, but she found it difficult to climb the stairs and go shopping. Moreover, she was not able to participate in any recreational or leisure activities.

To alleviate the patient's symptoms and enable the resumption of daily living activities, aerobic exercise therapy and dietary modification were prescribed. Accordingly, the patient exercised 5-6 times per week on a treadmill preceded and followed by 5-minute warm-up and cool-down periods under a health professional's supervision at the local public health center. The exercise intensity was prescribed based on the percentage of maximum heart rate as confirmed by an exercise tolerance test. The level of intensity began at 60% to 85% of the maximal heart rate and increased by 5% every month. The exercise durations were tolerable and were gradually increased. The initial 10- to 15-minute exercise duration was, after the first 4 weeks, augmented to a minimum of 30 minutes (Table 2). The patient was instructed to stop the exercise if she experienced dizziness, dyspnea, chest pain, or lower extremity pain. The patient exhibited very good compliance, performing the exercise as scheduled

Table 1
Physiological changes before and after exercise therapy

	1 Month After Surgery	Before Exercise Therapy	6 Months After Exercise Therapy
MHR, beats/min		143	179
Peak RER		0.95	1.25
V_{O_2} max, mL/kg/min		14.9	28.6
MET		4.3	8.2
CMAP of right phrenic nerve		not evoked	not evoked
Pulmonary function test			
FEV1, L	1.55	1.55	1.77
FEV1, % predicted	66	66	76
FVC, L	2.03	1.99	2.36
FVC, % predicted	67	66	80
FEV1/FVC	0.76	0.78	0.75
FEV1/FVC, % predicted	101	104	100
DHI	2.5	2.4	1.5

MHR = maximum heart rate; RER = respiratory exchange ratio; V_{O_2} max = maximal oxygen consumption; MET = metabolic equivalent of task; CMAP = compound muscle action potential; FEV1 = forced expiratory volume in 1 second; % predicted = percentage of predicted normal value; FVC = forced vital capacity; DHI = diaphragmatic height index.