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Case Report

Lung Herniation After Cardiopulmonary Resuscitation With Mechanical Chest Compression Device: First Case Report and Literature Review

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We reported the first case of lung herniation after cardiopulmonary resuscitation (CPR) with a mechanical chest compression device and a literature review. Older age, long CPR duration, mechanical ventilation, and rib fracture were risk factors. Subcutaneous emphysema was the most common manifestation and indication for further computed tomography to make a definite diagnosis. Despite its rarity, physicians should keep a high awareness of this possible fetal complication. Further studies comparing mechanical and manual CPR for the risk of lung herniation are warranted.

Key words: *cardiopulmonary resuscitation, lung herniation, mechanical chest compression device*

Introduction

Lung herniation after cardiopulmonary resuscitation (CPR) is an extreme complication, which was first documented in 1986.[1] Lung herniation was defined as a protrusion of lung parenchyma with pleural membranes through a defect of the thoracic wall.[2] The main causes of lung herniation are chest trauma including CPR, thoracotomy history, and a congenital chest wall defect.[2] Mechanical chest compression devices are increasingly used because of their high reliability for continuous chest compression even during transportation.[3] The reported complications after the use of mechanical chest compression devices are skin lesions, sternal fracture, rib fractures, mediastinal bleeding, epicardial bleeding, pericardial bleeding, severe cardiac injuries, pneumothorax, lung injury, liver injury, spleen injury, and gastric perforation.[3] However, lung herniation after CPR with a mechanical chest compression device has never been reported.

Case Report

An 86-year-old woman has the histories of hepatocellular carcinoma, diabetes, and hypertension. She was sent to our emergency department because of drowsy consciousness. CPR with a mechanical chest compression device and endotracheal intubation were performed because of pulseless electrical activity. After performing CPR for 60 minutes, return of spontaneous circulation was achieved. She was then admitted to the intensive care unit (ICU) under the impression of cardiac arrest suspected to be caused by chronic obstructive pulmonary disease with acute exacerbation and hypercapnia. The follow-up chest radiograph (CXR) after CPR showed consolidation over left upper lung and suspected left pleural effusion. There was no significant subcutaneous emphysema over the chest wall on the CXR.

On the fifth day of ICU admission, pig-tail drain-

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age was inserted because of increased left pleural effusion. Mechanical ventilation in pressure control mode was used to treat her respiratory failure. On day six, subcutaneous emphysema was found over the left chest wall and on the CXR (Fig. 1A). The subcutaneous emphysema progressed to the right chest wall on day 10 (Fig. 1B). Chest computed tomography (CT) showed herniation of the left upper lobe via the second and third intercostal spaces; fractures of the left second to fifth lateral ribs, right fourth to fifth anterior ribs, and sternal body; left pneumothorax; anterior hemomediastinum; and subcutaneous emphysema (Fig. 2). A chest tube was inserted, and subsequent wedge resection of the left upper lobe and pneumolysis were performed. After 56 days' hospitalization, weaning of the mechanical ventilation failed, and therefore, she was transferred to a respiratory care ward for long-term care.

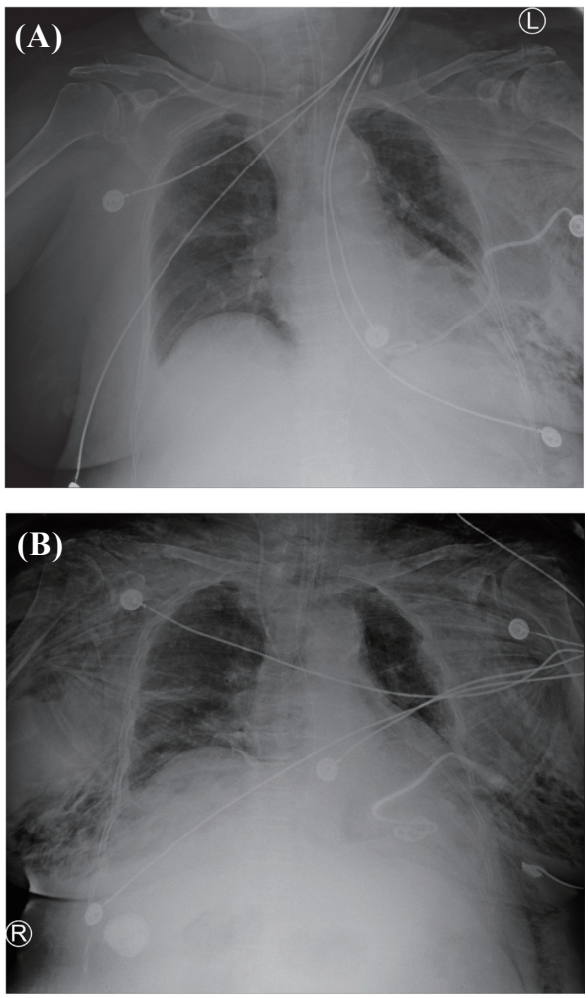

Fig. 1. (A) Subcutaneous emphysema was found over the left chest wall on day six. (B) It progressed to the right chest wall on day 10.

Discussion

The present case is the first report about lung herniation after CPR with a mechanical chest compression device. Based on the clinical manifestation and exclusion of other cause, CPR is suggested to play the major role of lung herniation in this case. After searching using the keywords "lung," "herniation," "cardiopulmonary resuscitation," and "mechanical chest compression" in PubMed and Google Scholar, we identified only 10 cases of post-CPR lung herniation including the present case in the literature (Table 1).[1,2,4-10] In the 10 cases, the sex ratio was nearly equal, and older patients (≥ 65 years) predominated (80%, 8/10). Only two cases were diagnosed with lung herniation immediately on the same day following CPR. Rib fracture, subcutaneous emphysema, and

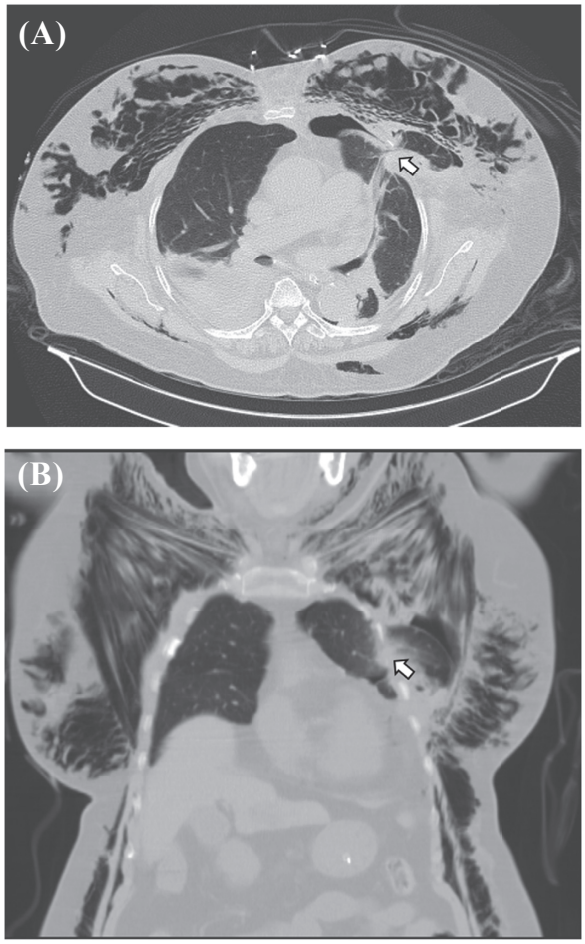

Fig. 2. (A) Axial section of computed tomography (CT) revealed herniation of the left upper lobe via the second and third intercostal spaces (arrow). (B) Coronal section of CT revealed the same finding with the axial section (arrow).

Table 1. Comparison of the characteristics among the 10 cases of lung herniation after CPR reported in the literature

Case	Age	Sex	Method of chest compression	CPR cause	CPR duration (min)	Herniation diagnosed post-CPR (day)	Reasons for CT	CPR-related complications
The present case	86	F	Mechanical	COPD with acute exacerbation and hypercapnia	60	9	Subcutaneous emphysema	Rib and sternal fracture, subcutaneous emphysema, pneumohemothorax, hemomediastinum
Oncel et al.[2]	73	F	ND	Hyperpotassemia	Unknown	0	Unknown	Rib fracture, subcutaneous emphysema, pneumothorax
Talebi et al.[4]	86	F	ND	Unknown	Unknown	Unknown	Unknown	Nil
Ojinaga et al.[5]	74	M	ND	Asthma	5	2	Subcutaneous emphysema	Rib fracture, subcutaneous emphysema, pneumothorax, pneumomediastinum
Aggarwal and Loehrke[6]	56	M	ND	Ventricular fibrillation	10	7	Respiratory distress with decelerating oxygen saturation	Rib fracture
Emberger et al.[7]	69	M	ND	Unknown	Unknown	2	Pleural effusion	Rib fracture, hemothorax, injury of an intercostal artery
Ferreira et al.[8]	81	ND	ND	Angioedema	Unknown	4	Stridor with bronchospasm, subcutaneous emphysema	Rib fracture, subcutaneous emphysema
Kottachchi et al.[9]	74	M	ND	Massive variceal hemorrhage	2.5	7	Subcutaneous emphysema	Rib fracture, subcutaneous emphysema, pneumothorax
Sprague and Ferrigni[10]	63	M	Manual	Pulmonary embolism	Unknown	1	Dyspnea, subcutaneous emphysema	Rib fracture, subcutaneous emphysema, pneumopericardium, pneumomediastinum
Batra[1]	65	F	Manual	Unknown	Unknown	0	Soft collapsible swelling over sternal angle, CXR diagnosed	Nil

COPD: chronic obstructive pulmonary disease; CPR: cardiopulmonary resuscitation; CT: computed tomography; CXR: chest radiograph; ND: no data.

pneumothorax were the most common concomitant complications. Five cases received operation for the lung herniation,[5,6,8,10] and two cases were resolved after chest tube insertion.[7,9]

The associated risk factors are intercostal muscle weakness, rib fracture, increased intrathoracic pressure, and CPR duration.[2,5,6,9] Frail older adults such as the present case are prone to have muscle weakness and subsequent complications following CPR.[2] The present case suffered from a rib fracture, CPR for 60 minutes, and mechanical ventilation (i.e., increased intrathoracic pressure), which are also compatible with the risk factors raised in the literature.

There is no evidence that a mechanical chest compression device as used in the present case contributes to increased complications including lung herniation compared with manual chest compression.[3] We reported the first case of lung herniation after mechanical CPR. Because of limited evidence, the differences for lung herniation and benefit between manual CPR and mechanical CPR are not clear. Further studies are warranted for delineating the issue.

CT is the preferred modality for diagnosing lung herniation.[9] The majority of patients with traumatic lung herniation remain asymptomatic.[9] Physical examination may reveal a soft, reducible, bulging mass in the chest wall or neck, which may change in size with the respiratory cycle, coughing, or straining.[9] CXR may show loculated subcutaneous air pockets.[9] In the summary of the 10 cases in the literature, subcutaneous emphysema is the most common manifestation and indication for CT (Table 1). The results of the initial CXR in the present case did not reveal subcutaneous emphysema. We speculate that lung herniation might not have occurred in the initial stage after CPR in the present case. Subsequent mechanical ventilation (i.e., increased intrathoracic pressure) might have aggravated the lung herniation from the injured chest wall.

The managements for lung herniation are based on symptom severity and condition of patients. In asymptomatic patients, conservative treatment is suggested with careful monitoring on the patient's respiratory function and follow-up imaging with CT.[9] For patients on mechanical ventilation with positive end-expiratory pressure such as the present case, surgical intervention is suggested because of the risk of incarceration and strangulation of herniated lung parenchyma and increased risk of pneumothorax.[9]

Conflicts of Interest Statement

The authors declared no conflict of interest.

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