CASE REPORT

A Method for Lung Recruitment in a Quadriplegic Patient: A Case Presentation

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A 21-year old man with cervical spinal cord damage due to diving was admitted in the ICU. Tracheostomy was performed due to prolonged mechanical ventilation. Left lung atelectasis happened frequently. Because of the difficulty of bronchoscopy and failing of recruitment, using a double lumen, two tracheal tubes were guided into the left and right lungs through the tracheostomy stoma site. After 24 hours, the left lung was opened and ventilation was continued with a tracheostomy tube.

Keywords: **spinal cord injury; ventilator dependency; weaning; recruitmen**

Difficult weaning is a problem among patients who have an upper cervical injury, and the majority of these patients become ventilator dependent [1]. Pulmonary functions of these patients may improve as flaccid paralysis of spinal shock change to muscle spasticity [2]. But, delay in weaning from mechanical ventilator can lead to prolonged hospital length of stay, lung injury and increased morbidity and mortality [3].

The leading cause of mortality of these patients is pulmonary complications. So, several protocols for prevention of respiratory involvement and pulmonary hygiene were implemented. Such as: stabilizing the spinal column and changing the position every two hours, intermittent positive pressure ventilation, incentive spirometry and percussion and prescribing bronchodilators. Prescribing bronchodilators and theophyline, monitoring of pulmonary function and fiberoptic bronchoscopy in case of atelectasis are other procedures for these patients [2]. We performed all of these techniques, but weaning was not successful, so we used a new method for weaning from mechanical ventilation.

Case Description

The patient is a 21-year-old man with 120 kg weight and 190 cm height whose cervical vertebrae were damaged and had developed a spinal lesion at C4-C5 level due to diving (Figure 1). After being taken out of the sea, tracheal tube insertion and cardiopulmonary resuscitation were performed and the patient was admitted in the ICU. Tracheostomy was performed due to prolonged mechanical ventilation. Bedsore appeared in the sacral region. Jejunostomy was used for feeding. The patient developed sepsis several times. Left lung atelectasis happened frequently and bronchoscopy and recruitment maneuvers were performed and none were successful (Figure 2-3). The patient was weaned from the ventilator and was transferred to the ward after three months. However, after a few hours, he was attached to the ventilator and transferred to another ICU due to respiratory distress. Diaphragm paradoxical movements were not observed in fluoroscopy; however, compared to the right side, the movements of the left side of the diaphragm were very few. Again, bronchoscopy and recruitment maneuvers were carried out by intensivist and pulmonary diseases specialists, but the procedures were not successful and led to hyper aeration in the right lung. The patient was introduced to anesthesiologists as well as pulmonary diseases and thorax specialists and all believed that the left lung is the source of infection and shunt. They suggested pneumonectomy, for removing of shunt, or discharge with a home ventilator.

Because of the difficulty of recruitment and probable bronchoscopy and suction using a double lumen tube, 7.5 and 7 tracheal tubes were respectively guided by a bronchoscope into the left and right lungs through the tracheostomy stoma site (Figure 4). The right lung was attached to a Bear 1000 ventilator with a synchronized intermitent mandatory ventilation (SIMV) mode and with 5 respirations and tidal volume of 500ml; the left lung was attached to a SERVO I ventilator with a pressure controlled ventilation ventilation (PCV) mode, positive end expiratory pressure (PEEP) of 20 cm H2O, controled pressure of 40 cm H2O (Figure5). In the beginning, the expiratory volume of the left lung was about 10-15cc but it gradually increased. After 24 hours, the chest X-ray indicated the opening of the left lung. The tubes were taken out and ventilation was continued with an 8.5 tracheostomy tube with pressure controlled ventilation (PCV) and then pressure support ventilation (PSV) modes (Figure6). The patient was detached from the ventilator and a 5 size tracheostomy tube was inserted for suctioning the secretions. After blocking the entrance, the patient's nasal respiration continued automatically and without oxygen dependence. Jejunostomy was taken out. The patient stayed in the hospital for another two months for undergoing physiotherapy; his bedsores

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recovered completely. The left hand movement recovered to some extent and the patient was discharged afterwards.

Figure 1- Computerize Tomography shows fracture of cervical vertebrae of the patient following diving

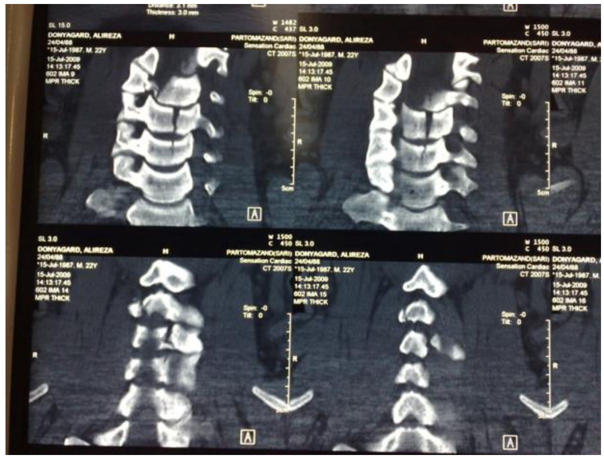


Figure 2- Chest X-ray of the patient before independent lung ventilation shows left side white lung

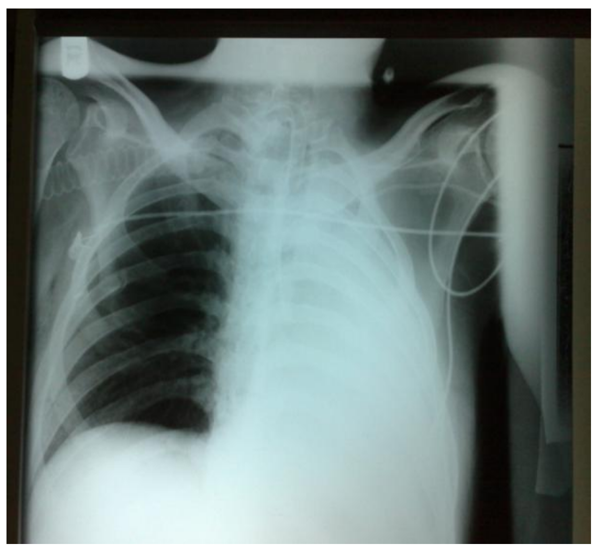


Figure 3- left lung atelectasis, air bronchogram and hyperinflation of right lung in Chest Computerize Tomography Scan of the patient before independent lung ventilation

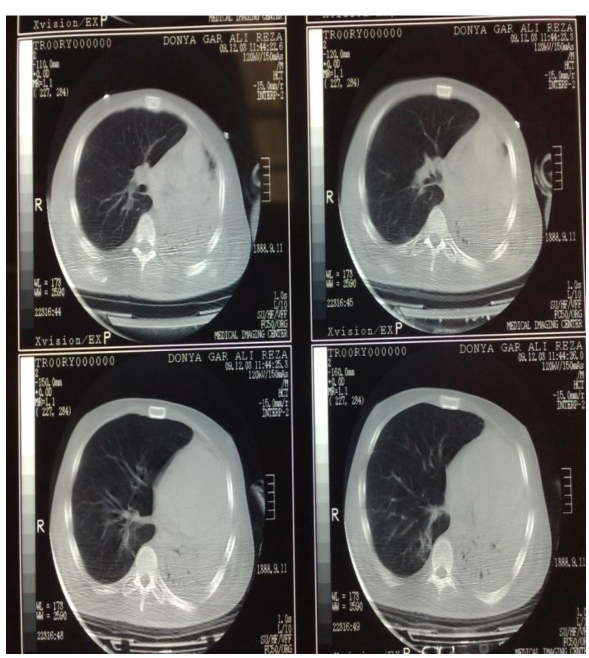


Figure4- The patient connected to the two separate ventilators via two tracheal tubes which inserted through tracheostomy stoma during independent lung ventilation

Figure5- Left lung recruitment in Chest X ray of the patient during independent lug ventilation

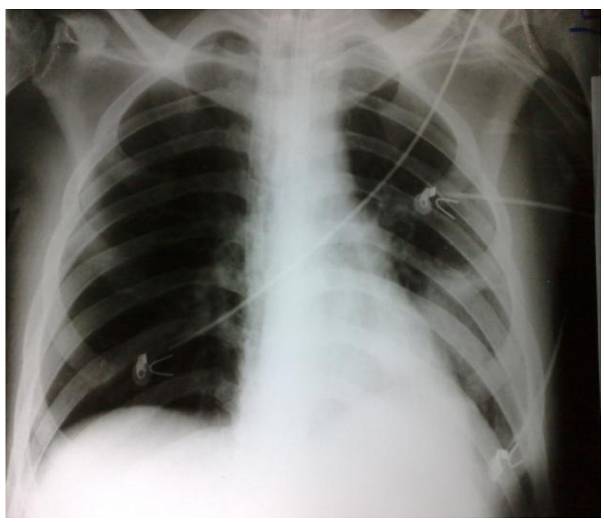
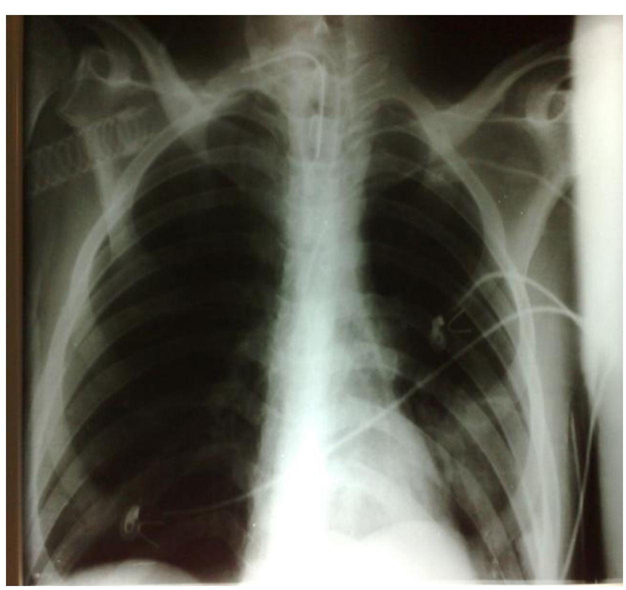


Figure6- Chest X ray of the patient after lung recruitment and connection to a single ventilator via tracheostomy tube



Discussion

Some patients with upper cervical spine damage may become ventilator dependent. The dependence is undeniably affected by the level of injury. The more rostral the level of the injury, the greater the likelihood that a major respiratory impairment will occur [4]. Motor supply to the diaphragm is provided by phrenic nerve. Diaphragm is mainly innervated from C4 but C3 and C5 are also involved [5]. Patients whose spinal lesions are located in areas higher than C2 would be ventilator dependent for their whole life because of absence of diaphragmatic innervation. Those with C3-C4 injuries can be liberated from the ventilator and the diaphragm activity is continued in them [6].

Patients with C4 and lower cervical spine injuries usually have normal phrenic nerve activity and respiratory drive. However, the activity of accessory and intercostal muscles diminishes and the discharge of their airway secretions becomes difficult. In such patients, lungs mechanics change during time [7]. The prevalence of ventilator dependence in patients with C1-C4 injuries is reported at 40%.The survival rate of cervical spine injury patients with ventilator dependence is about 33% and for those detached from ventilators, it is 84% [1]. The most commone cause of pneumonia in cervical spinal cord injury is mechanical ventilation. Ventilator-associated pneumonia increases 1-3 % per day and is the common cause of mortality and morbidity [8].

The prevalence of pulmonary complications is high during the first weeks following the spinal injury. Groomes and Jackson reported that 63% of people with C1-C6 injuries develop pneumonia and 40% would develop atelectasia. Moreover, many of the patients may develop the complications several times before their discharge [9].

Fishburn et al. reported that 74% of the quadriplegic patients with severe spinal injuries developed pneumonia or atelectasia within the first 8 days of their injury. In 96% of cases, the lower lobe was involved and the left to right lung involvement ratio was 4 to 1. An awareness of these patterns may lead to early diagnosis and effective interventions [10].

Therefore, it is required to detach patients from ventilators as soon as possible. Few studies or case studies have been published on treating pulmonary complications and detaching the patients from ventilator. Peterson et al. suggested the use of high tidal volume in treating C3 or C4 injuries because this shortens the ventilation time. However, this proposal is based on a limited number of patients in only one center [6].

One of the prevalent complications is atelectasia and the treatment methods usually include mechanical ventilation, bronchoscopy and recruitment maneuvers. In the present case, bronchoscopy and recruitment maneuvers were performed for the patient for about ten times but they were not effective. Finally, independent lung ventilation of the patient was carried out using a new approach. Independent lung ventilation was first used by Gale and Waters in thoracic surgery in 1931 and in 1976; it was used in intensive care [11-12].

Anatomic or physiologic separation of lungs is performed during independent lung ventilation by means of one or two ventilator synchronously or by two ventilators, asynchronously. These separations are provided with double lumen tubes, tracheostomy tube or bronchial blockers [13-14]. In this case, for providing a good field of toilet bronchoscopy and recruitment, two 7.5 and 7 tubes were respectively guided with bronchoscope into the right and left lungs. The lungs were separated to prevent a lung from being infected or overinflated.

The purpose of anatomic separation is protection of one lung from contamination by the other injured lung. In massive hemoptysis, great amount of secretions and lavage for pulmonary alveolar proteinosis anatomic separation is indicated. In these situations the lungs were separated transiently and mechanical ventilation provide an opportunity to medical or surgical treatment to take place [14-15]. When the mechanics of two lungs differ from each other such as unilateral paranchymal damage, after unilateral lung transplantation [11] and bronchoplural fistula [16], the lung can be separated physiologically. In this kind of separation each lung can be ventilated by different ventilation methods. Another indication of independent lung ventilation is refractory atelectasia that does not respond to standard ventilation support, bronchoscopy or both [11]. Several open lung maneuvers are reported for recruitment of lungs. In these maneuvers the goal is optimizing gas exchange with the lowest mean airway pressure [17]. In the present case our problem was not difficulty in gas exchange but it was weaning failure.

The high PEEP is used in the involved lung aiming at re-expansion without the risk of the opposite lung over-expansion and intra-thorax pressure increase. In some studies, the high PEEP is used in the mechanical ventilation of both lungs synchronously and asynchronously. In a collapsed lung, PEEP; 10-30 Cm H2O was used while a 0-10 Cm H2O was the choice in healthy lung. In other studies, continuous positive airway pressure (CPAP); 20-30 Cm H2O was placed in a damaged lung without ventilation. Miranda et al. used CPAP 30 Cm H2O through Double Lumen Tube (DLT) for expanding the lung and after the opening of the lung, PEEP 25 Cm H2O was used for ventilation in order to improve gas exchange. Millen et al. used CPAP 60-70 Cm H2O using cuffed fiberoptic and the results were satisfactory. Narr et al. used CPAP 80Cm H2O for expanding an asthmatic lung which had collapsed during pleurodesis and then, the independent ventilation of both lungs was continued asynchronously with few respirations to prevent pulmonary expansion. There has been no report on pulmonary damage despite the temporary use of high pressure for pulmonary expansion [11]. In the present case, low volume and few-respiration with SIMV mode along with PCV mode with PEEP 20Cm H2O and PC; 40Cm H2O were used for 24 hours in the right and collapsed lungs, respectively. Then, ventilation was continued in PCV mode with PEEP 8Cm H2O and PC; 25Cm H2O for both lungs through tracheostomy tube. Although new generation ventilators and recruiting modes such as airway pressure release ventilation (APRV) are claimed to be beter for recruiting the lung [18], but lack of these facilities is not a good excuse for hopeless decisions.

References

1. Wicks AB, Menter RR. Long term outlook in quadriplegic patients with initial ventilator dependency. Chest. 1986; 90(3):406-10.
2. Mansel JK, Norman JR. Resiratory complication and management of spinal cord injuries. Chest. 1990; 97(6):1446-52.
3. Macintyre NR. Evidence-based assessments in the ventilator discontinuation process. Respir Care. 2012; 57(10):1611-8.
4. Zimmer MB, Nantwi K, Goshgarian HG. Effect of Spinal Cord Injury on the Respiratory System: Basic Research and Current

Clinical Treatment Options. J Spinal Cord Med. 2007; 30(4):319-30.
5. Standring S. Gray's Anatomy. Churchill Livingstone Elsevier, 40th ed, section 6, page 1010 2008.
6. Peterson WP, Barbalata L, Brooks CA, Gerhart KA, Mellick DC, Whiteneck GG. The effect of tidal volume on the time to wean persons with high tetraplegia from ventilators. Spinal Cord. 1999; 37(4):284-8.
7. Ball PA. Critic Care of spinal cord injury. Spine. 2001; 26(24 Suppl):S27-30.
8. Evans LT, Lollis SS, Ball PA. Management of Acute Spinal Cord Injury. Neurosurg Clin N Am. 2013; 24(3):339-47.
9. Jackson AB, Groomes TE. Incidence of respiratory complications following spinal cord injury. Arch Phys Med Rehabil. 1994; 75(3):270-5.
10. Fishburn MJ, Marino RJ, Ditunno JF Jr. Atelectasis and pneumonia in acute spinal cord injury. Arch Phys Med Rehabil. 1990; 71(3):197-200.
11. Tuxen D: Independent lung ventilation. Principles and Practice of Mechanical Ventilation. Tobin MJ (ed). McGraw-Hill; 2006:573-593.
12. Glass DD, Tonnesen AS, Gabel JC, Arens JF. Therapy of unilateral pulmonary insufficiency with a double lumen endotracheal tube. Crit Care Med. 1976; 4(6):323-6.
13. Ost D, Corbridge T. Independent lung ventilation. Clin Chest Med. 1996; 17(3):591-601.
14. Hillman K, Barber JD. Asynchronous independent lung ventilation (AILV). Crit Care Med. 1990, 8(7):390-5.
15. Claypool WD, Rogers RM, Matuschak GM. Update on the clinical diagnosis, management, and pathogenesis of pulmonary alveolar proteinosis (phospholipidosis). Chest. 1984; 85(4):550-8.
16. Carvalho P, Thompson WH, Riggs R, Carvalho C, Charan NB. Management of bronchopleural fistula with a variable-resistance valve and a single ventilator. Chest. 1997; 111(5):1452-4.
17. Miranda D, Diederik G, Burkhard L. Open Lung Management in Mechanical Ventilation. Clinical Applications and Pathophysiology. Sauders Elsevier 2008, 276-285.
18. Maung AA, Kaplan LJ. Airway Pressure Release Ventilation in Acute Respiratory Distress Syndrome. Crit Care Clin. 2011; 27(3):501-9.