

Special Edition  
"Revisiting Physical Diagnosis in  
Respiratory Medicine"

## Case Report

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# Diaphragm Ultrasonography as an Important Aid to Diagnose Spinal Cord Injury

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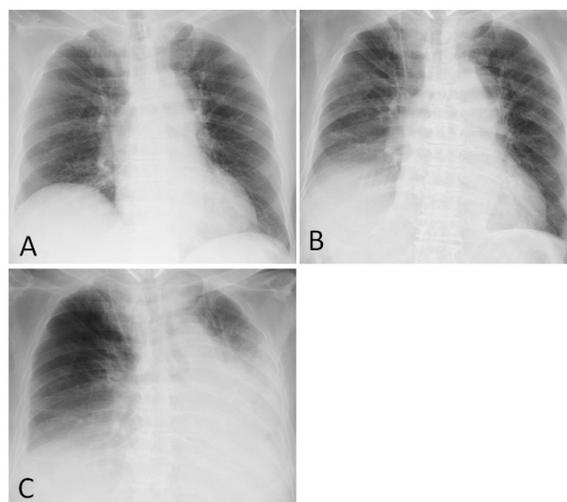
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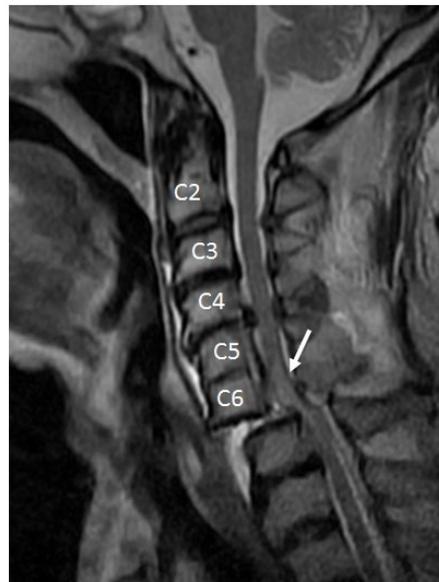
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## CASE REPORT

An 84-year-old man was transferred from a local hospital to our hospital because of a spinal cord injury. He was admitted to the local hospital 4 days prior to the transfer after he tripped and fell, and hit his head in the front. He was immediately taken to the local hospital and was admitted there for observation due to an inability to walk, which was reportedly attributed to his neck pain. His vital signs, including heart rate were reportedly normal and physical examination was unremarkable. Electrocardiogram revealed sinus rhythm with the rate of 74 beats per minute. Chest radiograph was without focal opacities (Figures 1A, 1B and 1C). The patient were treated conservatively with bed rest. The patient, however, developed seizure on the third day of the admission. No intracranial bleeding were noted on head computed tomography (CT). However, CT of the cervical spine demonstrated anterior dislocation at the C6 level (C8 cord level). In addition, magnetic resonance imaging (MRI) with T2-weighted image revealed a vertically spreading high intensity lesion at the C8 spinal cord level (Figure 2). Per record, on neurological examination, including manual muscle testing, the level of spinal cord impairment was considered to be around C5 (Table 1). MRI findings, which were compatible with the anterior dislocation of C6 with possible C8 spinal cord injury (Figure 2), and the neurological findings, which suggested the involvement of higher levels of spinal cord at around C5 to C8 (Table 1) thus had a discrepancy. Therefore, on the 4<sup>th</sup> day of the admission at the local hospital, he was transferred to our hospital for undergoing an urgent posterior cervical spinal fusion (C5-Th1).



**Figure 1:** Chest X-ray on admission to our hospital was normal (A), but the following day after surgery, the silhouette sign of the right diaphragm was positive (B). On the fifth day post operation, left atelectasis was also noted (C).



**Figure 2:** T2-weighted cervical MRI on sagittal view revealed a vertically spreading high intensity lesion at the C6 vertebra, i.e., the C8 spinal cord level (arrow).

Affected part	MMT	Affected cord level
Sternocleidomastoid	un examined	C4
Deltoid	2/2	C5
Biceps	2/2	C5-6
Triceps	1/1	C6-7
Wrist	1/1	C6-8
Trunk	UE	Under Th1
Low extremity	0/0	Under L2
Anal sphincter	no contract, no sensation	

**Table 1:** Neurological findings, which suggested the involvement of higher levels of spinal cord at around C5 to C8.

Few hours after the surgery, the pulmonologists were consulted as he developed further hypoxemia as well as difficulty expectorating sputum. On examination, he was in respiratory distress and was using his accessory muscles to breathe. The respiratory rate was 25 breaths per minute, pulse 49 beats per minute, the temperature 36.6 °C, and the blood pressure 124/68 mmHg. His respiration and oxygenation improved as he was suctioned multiple times by bronchoscopy. He was then placed on nasal high-flow oxygen therapy at flows of 50 L/min with FiO<sub>2</sub> of 40%. He needed frequent suction of sputum by bronchoscopy to maintain adequate oxygenation. Chest radiograph on the following day revealed a positive silhouette sign of the right diaphragm (Figure 1B), implying atelectasis in the right lower lobes possibly due to excessive sputum production.

On the 5<sup>th</sup> day post-operation (8 days after the head injury), the patient complained of severe dyspnea with wheezing. On examination, he was found to be in acute respiratory distress. The temperature was 37.6 °C, blood pressure 111/59

mmHg, pulse 58 beats per minute, respiratory rate 27 breathing per minute, and oxygen saturation 95% while breathing with nasal high-flow mask at flows of 50 L/min with FiO<sub>2</sub> of 40%. Of note, paradoxical respiration, so called rib cage paradox, was recognized (Video 1) together with atelectasis of left lower lobe (Figure 1C).

Urgent diaphragm ultrasonography was performed at the bedside, which revealed dysfunction of the bilateral diaphragm with an impaired contraction (thickness of the right diaphragm [tdi]; Figure 3A: tdi at end-expiration, 1.9 mm; Figure 3B: tdi at end-inspiration, 2.0 mm; Δtdi% of 5.3%). He was thus diagnosed with bilateral diaphragmatic paralysis due to spinal cord injury around the C5 level. The goal of care was discussed with the patient who declined further aggressive intervention, including cardiopulmonary resuscitation. His code status was thus changed to do-not-resuscitate (DNR). The next day (6 days post-operation), he developed further bradycardia and hypotension and expired.

Note: To best view

1. Kindly open the pdf file in Adobe Reader XI version.
2. Please save the pdf file on your local computer.
3. To watch the video kindly install the latest adobe flash player. Click here to download: <http://get.adobe.com/flashplayer/otherversions/>



Video 1: Paradoxical respiration.

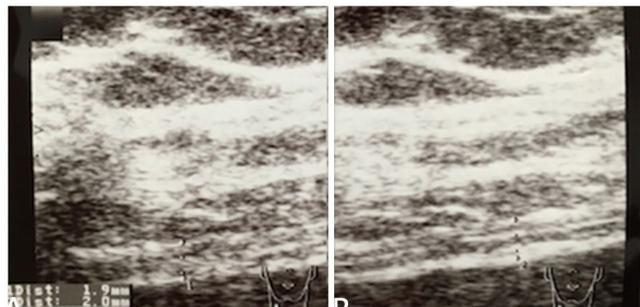


Figure 3: Urgent diaphragm ultrasonography revealed dysfunction of the bilateral diaphragm with an impaired contraction (thickness of the right diaphragm [tdi]; A: tdi at end-expiration, 1.9 mm; B: tdi at end-inspiration, 2.0 mm;  $\Delta$ tdi% of 5.3 %).

## DISCUSSION

Our case demonstrates that accurate determination of the level of spinal cord injury is of crucial importance. Assessment of diaphragm function is an important factor to assess the level of spinal cord injury, since the phrenic nerve emanates from the C3-C5 level. In this case, diaphragm ultrasonography clearly demonstrated bilateral diaphragmatic paralysis possibly due to spinal cord injury around the C5 level, which corresponded to the neurological findings. On further review of the original MRI images, it was suspected that the level of spinal cord injury was in fact higher than it was originally reported, and consistent with our neurological examination and diaphragm ultrasonography findings. The other finding, which implied the presence of spinal cord injury, other than the weakness of extremities, was the presence of bradycardia. Bartholdy et al<sup>1</sup> reported that bradycardia (heart rate of less than 50 beats per minute) was present in 17-35% of the patients with cervical (C1-C8) cord injury within the first 14 days. Indeed, the patient might have had impaired sympathetic innervation given the persistent bradycardia throughout the clinical course.

Kirshblum et al<sup>2</sup> described that 67% of patients with acute spinal cord injury had respiratory complications within the first few days, which might explain the advent of apparent

pneumonia in our patient soon after the operation. While the extent of contribution from diaphragm dysfunction to the respiratory complications in this case is not clear, its presence could certainly augment respiratory failure. Diaphragm function has been traditionally evaluated by fluoroscopy with a sniffing test; however, it may be associated with false negatives, and requires transfer of patients who might be at risk for further spinal cord injury upon moving. This case illuminates the importance and the utility of diaphragm ultrasonography to aid the diagnosis of spinal cord injury. Diaphragm ultrasonography does not require radiation exposure, and can be performed quickly and repeated multiple times as needed. It eliminates the need to transfer patients to the radiology suite.<sup>3,4</sup> Diaphragm ultrasonography could thus be an ideal tool for such patients to aid the diagnosis of spinal cord injury, and should be utilized more frequently.

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

## CONSENT

The patient has provided written permission for the publication of the case details.

## REFERENCES

1. Bartholdy K, Biering-Sorensen T, Malmqvist L, et al. Cardiac arrhythmias the first month after acute traumatic spinal cord injury. *J Spinal Cord Med.* 2014; 37(2): 162-170. doi: [10.1179/2045772313Y.0000000181](https://doi.org/10.1179/2045772313Y.0000000181)
2. Kirshblum SC, Groah SL, McKinley WO, Gittler MS, Stiens SA. 1. Etiology, classification, and acute medical management. *Arch Phys Med Rehabil.* 2002; 83(Suppl 1): S550-S557. doi: [10.1053/apmr.2002.32156](https://doi.org/10.1053/apmr.2002.32156)
3. Minami T. Abdominal ultrasound and genitourinary ultrasound in the intensive care unit. *Respiratory Medicine.* 2014; 249-272. doi: [10.1007/978-1-4939-1723-5\\_12](https://doi.org/10.1007/978-1-4939-1723-5_12)
4. Hardy F, Walker J, Sawyer T. Sonographic measurement of diaphragm movement in patients with tetraplegia. *Spinal Cord.* 2009; 47(11): 832-824. doi: [10.1038/sc.2009.45](https://doi.org/10.1038/sc.2009.45)