Case Report

The role of extradiaphragmatic muscles' ultrasound on the diagnosis and follow-up of diaphragmatic dysfunction associated with cervical septic arthritis: A case report and literature review

ABSTRACT

Cervical septic arthritis can lead to complications such as epidural abscess, which may result in respiratory failure. We present a case of a 78-year-old male with cervical septic arthritis complicated by epidural abscess, leading to severe diaphragm dysfunction. Ultrasound evaluation revealed dysfunction of the left hemidiaphragm and compensatory activation of accessory respiratory muscles. Treatment included antibiotic therapy and corticosteroids, alongside respiratory support. After 21 days, improvements were observed in diaphragmatic function and respiratory muscle activation. Our findings highlight the importance of assessing both diaphragm and accessory respiratory muscles in cases of cervical septic arthritis with respiratory complications.

Key words: Cervical septic arthritis, diaphragmatic dysfunction, extradiaphragmatic muscles, ultrasound

Introduction

Cervical septic arthritis is an acute inflammatory condition involving the joints of the neck, often caused by a bacterial infection.[1,2] Typical symptoms include neck pain, stiffness, swelling, fever, and sometimes difficulty in neck movement. In severe cases, the infection can lead to complications such as epidural abscess, as in the present clinical report.[3] Since diaphragm innervation originates from this region, assessment of diaphragm function and extradiaphragmatic muscles via ultrasound might enable the identification of diaphragm dysfunction (DD).[4–6] Here, we report the case of an individual suffering from cervical septic arthritis complicated by epidural abscess, determining severe DD and respiratory failure, detailing the ultrasonographic evaluation of respiratory muscles.

Case Report

LMR, a 78-year-old male, was admitted to the emergency department (ED) after being found unable to get up due to

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weakness in his lower limbs. He had not lost consciousness. Upon admission, his vital signs were stable. His medical history included type II diabetes mellitus, chronic coronary syndrome, and a pacemaker for critical bradycardia. During the examination, the patient was alert, oriented, and cooperative. He complained of neck stiffness. Blood tests were within the normal range except for elevated C-reactive protein 508 mg/L. The chest X-ray at ED did not show pathological findings. He underwent a computed tomography (CT) scan of the head and neck, which under basal conditions did not show significant pathological alterations. Blood samples were collected for blood cultures, which became positive for Streptococcus dysgalactiae after 24 hours. Empiric antibiotic therapy with ceftriaxone and linezolid was promptly initiated. Further investigations did not reveal signs of infectious disease. Consequently, the patient was admitted to the medical ward. During the hospitalization, the patient developed progressively worsening dyspnea. Three days after admission, he experienced left brachio-crural hemiplegia. CT scan and magnetic resonance imaging (MRI) of the head and neck revealed septic cervical arthritis with the presence of two epidural abscesses at C1-C2 anteriorly and C2-C3 posteriorly, causing compression of the spinal cord [Figure 1]. Neurosurgical consultation did not recommend surgical debriding of the abscess. Anti-inflammatory therapy with dexamethasone (8 mg per day) was initiated to reduce local inflammation and pain. Since the patient had developed progressive and worsening dyspnea associated with the inability to adequately clear bronchial secretions, he was transferred to the intensive care unit (ICU) to be assisted with mechanical ventilation. After a brief trial of noninvasive ventilation, invasive support became necessary due to tachy-dyspnea. The respiratory mechanical properties appeared to be preserved with a measurement of respiratory system compliance greater than 60 ml/cmH2O and in the absence of significant hypoxemia (P/F ratio >250) and alterations in carbon dioxide alterations. To further define the clinical picture, the patient underwent a respiratory muscles' ultrasound examination (T1). This investigation revealed a significant dysfunction of the left hemidiaphragm, associated with a compensatory activation of the external and internal oblique muscles and of the transversus abdominis [Table 1]. Differences were noted in the activation of the right and left intercostal muscles, with the latter more active as compared to the contralateral. The same measurements were repeated 21 days after ICU admission (T2), when a progressive improvement in the mobility of the left side of the body was observed along with progression in terms of respiratory weaning [pressure support ventilation (PSV), FiO_2 0.25, PEEP 5 cmH_20 and PS 4 cmH_20]. The completion of respiratory weaning was limited by persistent drooling due to right vocal cord paresis, suggesting the necessity of tracheostomy. After undergoing percutaneous tracheostomy due to the anticipated need for prolonged intubation, prolonged periods of T-Tube were alternated with low-level PSV. The new ultrasound observations of the diaphragm and extradiaphragmatic respiratory muscles were performed, with a significant reduction in the Diaphragmatic Rapid Shallow Breathing Index (DE-RSBI) [Table 1, right side]. The antibiotic and corticosteroid therapy continued for 3 weeks. He was finally transferred to the respiratory rehabilitation ward.

Table 1: Ultrasound variables of diaphragm and extradiaphragmatic respiratory muscle's function

	T1		T2	
	right	left	right	left
DE (mm)	25	10	26	19
DT (mm)	35	31	46	42
DTF (%)	32%	15%	31%	22.5%
DE-DRSBI (breaths/min/mm)	0.96	2.4	0.69	0.95
PIC TF (%)	<5%	12%	6%	<5%
EOM TF (%)	<5%	29	<5%	11
IOM TF (%)	<5%	54	<5%	22
TAM TF (%)	<5%	22	<5%	9

T1: ICU admission; T2: 21 days after ICU admission; DE=diaphragm excursion; DT=diaphragm thickness; DTF=diaphragm thickening fraction; DDRSBI=diaphragmatic dysfunction rapid shallow breathing index; IC TF=intercostal muscles thickening fraction; EOM TF=external oblique muscles thickening fraction; IOM TF=internal oblique muscle thickening fraction; TAM TF=transversus abdominis muscle thickening fraction

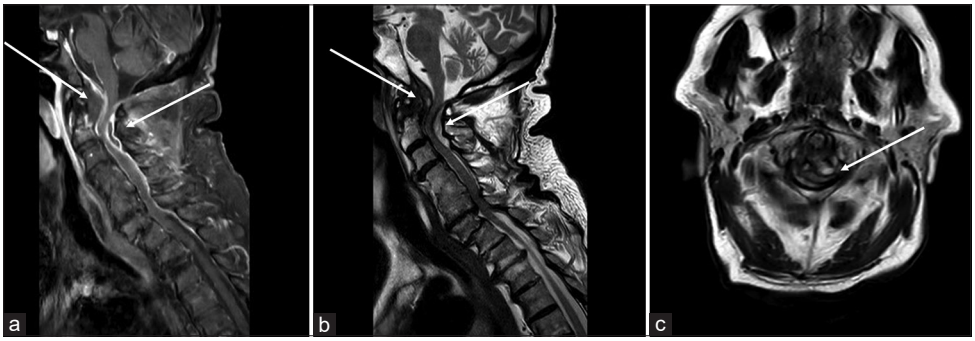

Figure 1: Magnetic resonance images of cervical septic arthritis consisting of epidural abscess (a) MRI sequence in T1 with fat suppression followed by contrast agent administration; the white arrows identify the enhancement of epidural abscess. (b) MRI sequence in T2; (c) sagittal imaging of cervical

Methods

A systematic review of literature was conducted to evaluate published articles documenting cervical spinal injuries ("population") and the development of DD ("outcome"). Six databases were searched: PubMed (1996–present), Embase (1974–present), Scopus (2004–present), SpringerLink (1950–present), Ovid Emcare (1995–present), and Google Scholar (2004–present). The search utilized keywords such as "spinal cord injury," "epidural abscess," "diaphragm," "diaphragmatic dysfunction," "unilateral diaphragm palsy," "hemidiaphragmatic paralysis," and "ultrasound" across these selected databases. Two authors (AM and PF) retrieved full texts of relevant articles. All related titles and abstracts were reviewed, and full versions were obtained. Exclusion criteria included studies involving nonhuman patients, pediatric patients, policy statements, and guidelines. We attempted to extend the search to include evaluation of extradiaphragmatic respiratory muscles, but we found no references, likely because the method is very recent. This is an observational case report study. The "Comitato Etico Lombardia 3" Research Ethics Committee has confirmed that no ethical approval is required. Informed consent was obtained from all individual participants included in the study. The authors affirm that human research participants provided informed consent for publication of the images in Figures 1 and 2.

Results

Four articles met the eligibility criteria: One was an old case series,[7] and three were case reports[8–10] [Table 2]. Initial clinical manifestations included neurological impairment, with diaphragmatic paralysis occurring immediately or within a few hours of the original trauma. DD was diagnosed by ultrasound in only one case.

Discussion

Treatment of cervical septic arthritis often requires a combination of targeted antibiotic therapy against the responsible pathogen, and in some cases, surgical intervention may be necessary to repair damage to the joints or surrounding tissues.[11] Since the injury can complicate into abscesses, as in the presented clinical case, it can lead to the emergence of significant respiratory complications that, if promptly recognized, can be appropriately treated. The diaphragm receives innervation from the phrenic nerve, composed of the C3, C4, and C5 cervical nerves. Consequently, as in our case report, patients experiencing motor impairment above the C5 level typically require ventilatory assistance.[12] Ultrasound imaging of the diaphragm provides valuable information about diaphragmatic excursion (DE), diaphragmatic thickness (DT), and thickening fraction (DTF, calculated as the percentage increase in diaphragmatic thickness from end expiration to end inspiration), which reflects diaphragmatic contractile strength. DE is considered pathological with a displacement of less than 10 mm.[4,13–16] Values not falling below this threshold in either spontaneous breathing or mechanical ventilation may still be considered pathological as they depend on different variables such as passive muscle relaxation and ventilatory setting, in contrast with TF, which depends on the muscles' contraction. Several authors have recently begun to suggest the evaluation of extradiaphragmatic muscles, which can be identified in both parasternal intercostal muscles as the inspiratory pathway and abdominal muscles as the expiratory pathway, in conjunction with this method.[17,18] In our case, we documented a case of DD depicted by the reduction in the left DTF, an increment in left PIC TF and abdominal muscles' TF, and an increase in the DE-RSBI. Ultrasound examinations were performed by the same expert trained operator (PF). Measurement of diaphragm variables was conducted on the right and left hemidiaphragms, following established protocols.[16] Similarly, we investigated the parasternal intercostal muscles (PIC),[17] and we measured the abdominal muscles' [the external oblique (EOM), internal oblique (IOM), and transversus abdominis (TAM)] TF by using the same formula.[19] Figure 2 summarizes the main ultrasound findings. In the clinical case presented, we observed how the patient's inability to expectorate was attributed to left DD diagnosed by a DTF $<20\%$ and a DE <10 mm, leading to dyspnea with activation of accessory muscles, in terms of both the inspiratory effort (with a left PIC TF of 12%) and expiratory effort, involving activation of all abdominal extradiaphragmatic muscles. We observed a huge activation of IOM (up to 50% of its TF) normally responsible for forced expiration. Activation of expiratory muscles during breathing occurs when the relative load imposed on the inspiratory muscles' increases. In the presence of an imbalance between load and inspiratory muscle capacity, such as in this case, the expiratory abdominal wall muscles are recruited during expiration according to a

Table 2: List of published articles regarding the association between spinal injury and DD

Reference	Gender	Age	Type of spinal injury	Diagnosis of DD
Carter *et al*.[7]	Male	32 (average)	Traumatic injury	Spirometry (vital capacity)
Hayashi *et al*.[8]	Male	64	Cervical spondylosis	Chest radiography
Manabe *et al*.[10]	Male	70	Cervical spondylosis	Chest radiography, respiratory function tests, and electrophysiologic tests
Charco-Roca *et al*.[9]	Male	65	Traumatic injury	Ultrasound (DTF)

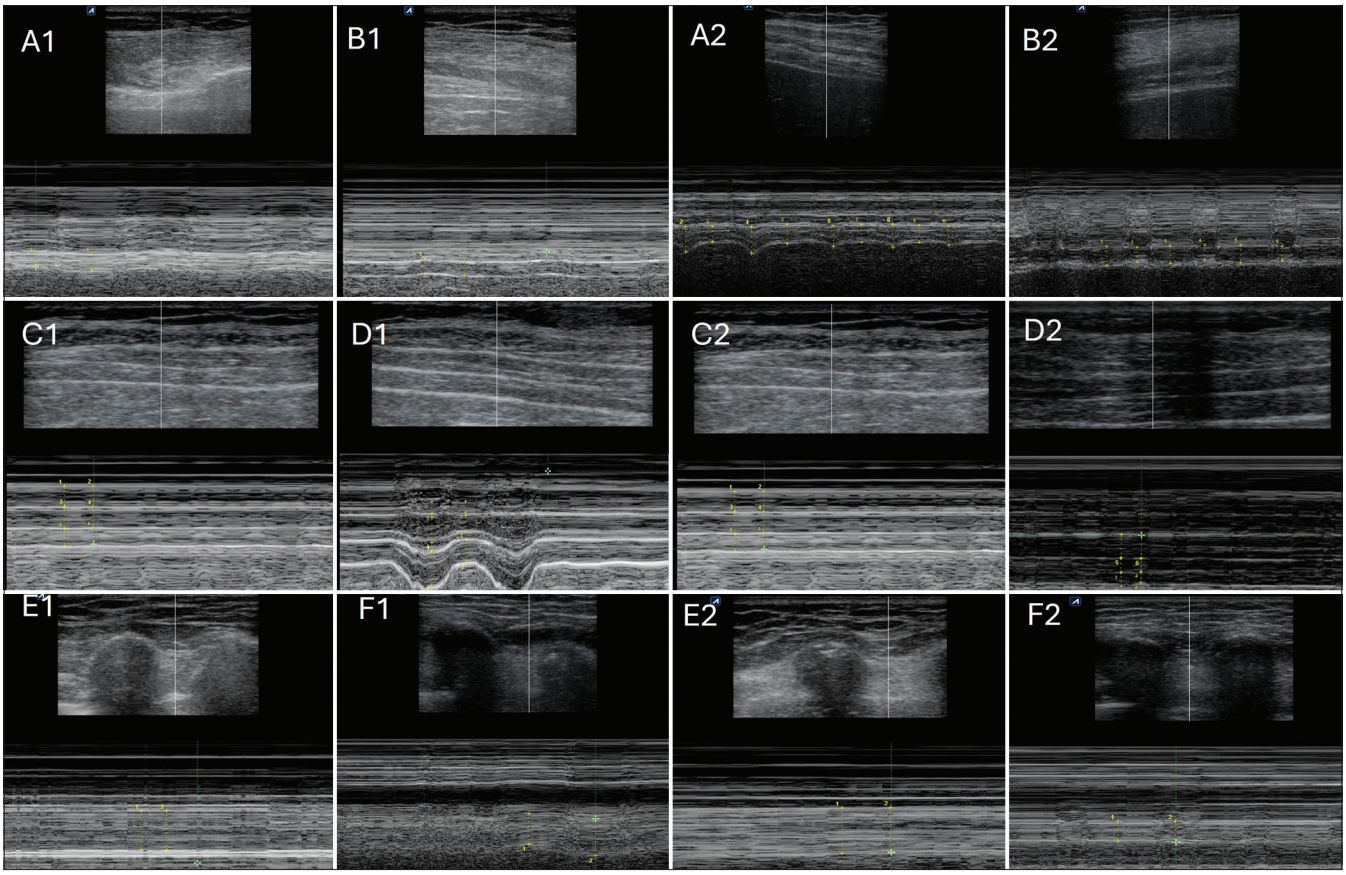

Figure 2: Ultrasound images of diaphragm and extradiaphragmatic respiratory abdominal muscles over the time. The figure depicts ultrasound images of the diaphragm and respiratory extradiaphragmatic muscles. Images depict the TF of each muscle divided in left and right sides and at different time points. A1: Right diaphragm in T1; B1: Left diaphragm in T1; C1: Right external oblique, internal oblique, and transversus abdominis muscles in T1; D1: Left external oblique, internal oblique, and transversus abdominis muscles in T1; A2: Right diaphragm in T2; B2: Left diaphragm in T2; C2: Right external oblique, internal oblique, and transversus abdominis muscles in T2; D2: Left external oblique, internal oblique, and transversus abdominis muscles in T2. E1: Right parasternal intercostal in T1; F1: left parasternal intercostal in T1; E2: left parasternal intercostal at T2; F2: left parasternal intercostal at T2

fixed hierarchy: initially, the transverse abdominal muscle, followed by the internal and external obliques. In this clinical case, DD resulted in the loss of inspiratory effectiveness of the diaphragm itself, and consequently, it may not have balanced the reduction of end-expiratory transpulmonary pressure. Finally, a fundamental role of expiratory muscles is to generate effective cough pressure to facilitate airway clearance in coordination with the diaphragm. In our patient, this effect was not sufficient to generate an effective cough due to the presence of DD. These observations suggest that these muscles compensated during both inspiration and expiration for the significant reduction of diaphragmatic function, contributing to lung ventilation during breathing. This reasoning must consider that in our clinical case, we are dealing with DD affecting only the left side. Moreover, likely global respiratory function had never been deficient in terms of gas exchange or compliance because there was good compensation from the normally functioning right side. After 21 days of treatment, we observed an improvement in both DE (19 mm) and DTF (22.5%), although both remained at the lower limits of normality. Similarly, we observed a normalization of the activity of the intercostal (PIC TF $<5\%$) and abdominal muscles even with a reduction of respiratory support level. This improvement suggests that the treatment implemented had a positive impact on the patient's diaphragmatic function, resulting in improved ventilation and respiratory capacity.

Conclusion

These findings underscore the importance of evaluating not only the diaphragm but also the accessory respiratory muscles during respiratory functional analysis. While our review offered insights on the clinical presentation and diagnostic approaches for DD following cervical spinal injuries, further research is warranted to explore newer diagnostic modalities and their efficacy in diagnosing this condition.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other

clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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