International Medical Case Reports Journal

Dovepress
open access to scientific and medical research

Open Access Full Text Article

CASE SERIES

Point-of-Care Ultrasound to Assess Diaphragmatic Paralysis in Resource-Limited Setting: A Case Series

Abduleazize Hussen[1], Menbeu Sultan[2], Muluneh Tufa Kidane[2], Melaku Getachew[1], Temesgen Beyene Abicho[3], Selome F Yewedalsew[4], Getaw Worku Hassen[5]

[1]Haramaya University, Department of Emergency Medicine, Harar, Ethiopia; [2]Saint Paul's Hospital Millennium Medical College Department of Intensive Care Medicine, Addis Ababa, Ethiopia; [3]Addis Ababa University, Black Lion Specialized Hospital, Department of Emergency Medicine, Harar, Ethiopia; [4]SUNY Downstate Medical Center, Department of Medicine, Brooklyn, NY, USA; [5]New York Medical College, Metropolitan Hospital Center, New York, NY, USA

Correspondence: Abduleazize Hussen, Department of Emergency and Critical Care Medicine, Haramaya University, Po Box: 235, Tel +251911192913, Email jhussen81@gmail.com

Abstract: Diaphragmatic dysfunction can arise from various factors, and Guillain–Barre syndrome, characterized by acute inflammatory polyradiculoneuropathy, is one such cause that may result in respiratory failure due to diaphragmatic paralysis. Prompt recognition and timely intervention, including airway protection and addressing the underlying pathology, are crucial for achieving optimal patient outcomes. Point-of-care ultrasound, specifically utilizing the M-mode function, can be employed for individuals displaying symptoms of diaphragmatic paralysis. This diagnostic approach is uncomplicated an effective tool for serial follow-up. In this context, we present a case series involving three patients with diaphragmatic paralysis in a limited-resource setting.
Keywords: diaphragmatic paralysis, point-of-care Ultrasound, resource-limited setting

Introduction

Diaphragmatic paralysis is a disorder that develops when the hemi diaphragms lose control due to a severe injury, systemic illness, or neurological process.[1,2] The diaphragm, a major muscle of respiration, controls about three-quarters of our breathing by enlarging the chest cavity upon contraction, drawing air into the lungs, and relaxing during expiration to allow air expulsion.[3] Diaphragmatic paralysis can be a serious complication of Guillain-Barre syndrome, but with treatment, most patients recover full function within a few months.[4]

To treat diaphragmatic paralysis, early diagnosis is needed to initiate timely treatment, a multidisciplinary approach involving pulmonologists, neurologists, and rehabilitation specialists, mechanical ventilation in severe cases, and phrenic nerve pacing is needed. In addition to this consideration of diaphragmatic plication surgery for patients with unilateral diaphragmatic paralysis who have not responded to conservative treatment, pulmonary rehabilitation in improving respiratory function and overall quality of life, and the generally favorable prognosis for patients with diaphragmatic paralysis who receive prompt diagnosis and appropriate treatment.[5]

Point-of-care ultrasound (PoCUS) facilitates quick patient assessments in various healthcare settings. It is portable and can be utilized as a diagnostic tool by healthcare practitioners.[6,7] PoCUS was first introduced into critical care over thirty years ago. Over the past ten years, its application in prehospital and ambulatory clinical settings has changed.[8]

Case Report 1

A 38-year-old female patient presented with body weakness for five days, initially appearing in the upper extremities and progressing to the lower extremities. The body weakness was associated with easy fatigability, excessive salivation, drooling of saliva, and an inability to hold oral secretion. The patient reported shortness of breath for two days. She has had a recent history of upper respiratory tract infection and was treated in a hospital one week before the current symptom onset. The rest of the review of systems was unremarkable, and he has no known chronic illness. On physical

Received: 16 December 2023
Accepted: 27 April 2024
Published: 8 May 2024

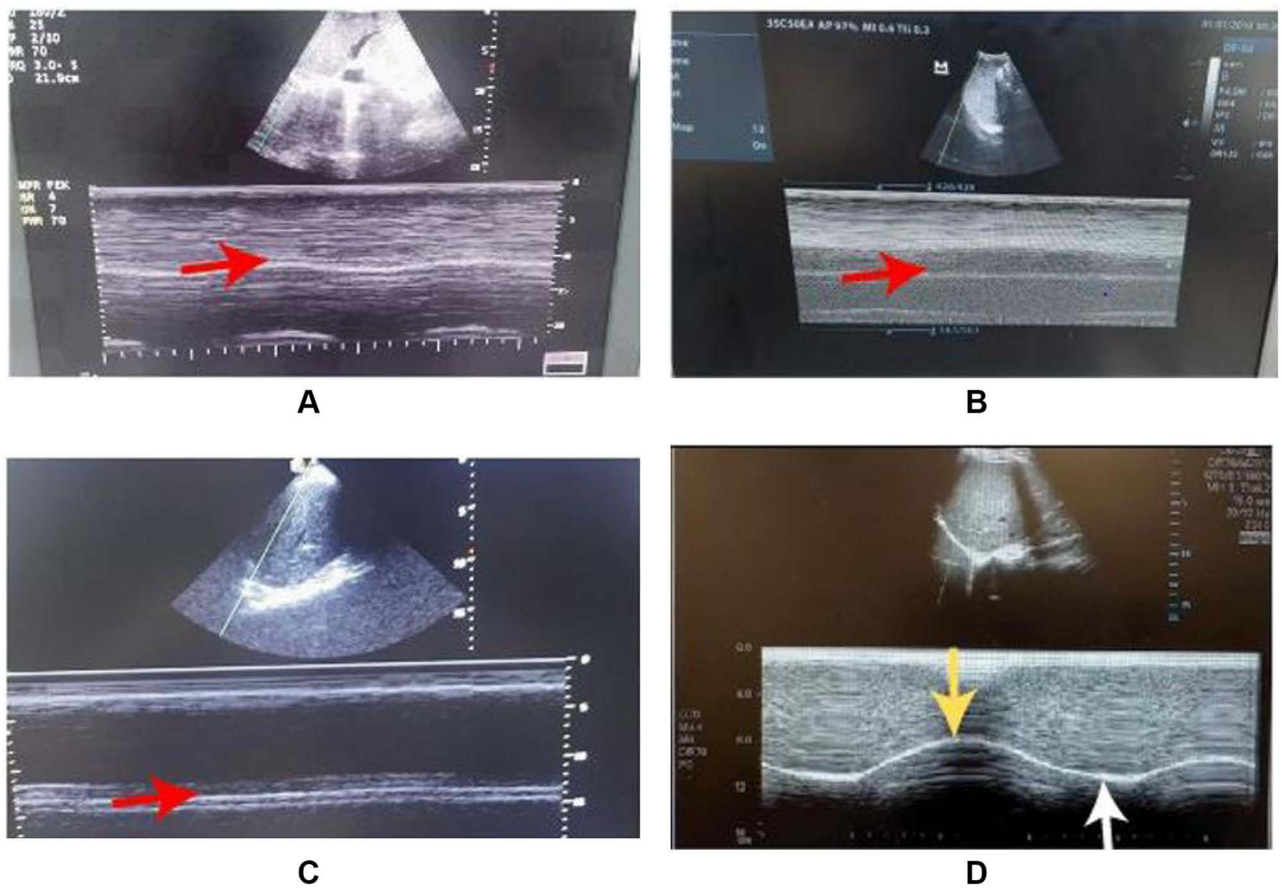

Figure 1 Ultrasound images of the diaphragm and analysis using M-mode. (**A**) M-mode analysis of the diaphragmatic movement of case 1: minimal diaphragmatic movement (red arrow). (**B**) M-mode analysis of the diaphragmatic movement of case 2: no diaphragmatic movement (red arrow). (**C**) M-mode analysis of the diaphragmatic movement of case 3: no minimal diaphragmatic movement (red arrow). (**D**) M-mode analysis of the diaphragmatic movement of normal control: Normal rhythmic/period movement of the diaphragm with inspiration (yellow arrow) and expiration (white arrow).

examination, arrival vital signs were as follows: pulse rate of 136 beats per minute, body temperature of 36.8 °C, respiratory rate (RR) of 36 breaths per minute, blood pressure of 138/80 mmHg, and oxygen saturation of 87% on 15 liters per minute oxygen with face mask. She had crepitation on the right distal 1/3 anterior chest, and dullness was appreciated during percussion. Her Glasgow coma scale (GCS) was 14/15: Eye-opening 4, Verbal 4, Motor 6, pupil reactive and mid-size bilaterally, power 1/5 bilaterally upper extremities, 2/5 bilaterally lower extremities, Tone hypotonic in all extremities, Reflex, plantar reflex down going, Sensory intact.

The patient was intubated due to respiratory failure and for airway protection. The cerebrospinal fluid (CSF) test showed cytoalbuminologic dissociation, suggesting GBS. POCUS of the diaphragm showed no periodic and rhythmic movement (Figure 1A) compared to a wavy white line reflecting the normal rhythmic movement of the diaphragm (Figure 1D).

Case Report 2

A 17-year-old male patient presented with difficulty swallowing for four days. The difficulty swallowing was initially for solids, then progressed to liquid. The patient also reported easy fatigability and a failure to communicate. The patient's symptoms progressed over time, and he developed a descending type of generalized body weakness, which started from the upper extremities and shoulder and then included the lower extremities. The patient had difficulties standing and walking by himself. He also developed excessive salivation, drooling of saliva, an inability to hold oral secretion, and shortness of breath. The rest of the review off systems was unremarkable, and he has no known chronic illness.

On physical examination, his pulse rate was 140 beats per minute, his body temperature was 36.8 °C, his RR was 36 breaths per minute, his blood pressure was 138/80 mmHg, and his oxygen saturation was 85% at 15 liters per minute oxygen with a face mask.

The workup showed reduced amplitude of the left median and right peroneal motor nerves and index motor dominant demyelinating polyradiculoneuropathy likely (AIDP) on the electromyogram (EMG). The PoCUS of the diaphragm showed no periodic or rhythmic movement (Figure 1B) compared to a wavy white line reflecting the normal rhythmic movement of the diaphragm (Figure 1D) (Supplementary Video).

The patient was admitted to the ICU and required 64 days of mechanical ventilation. He'd tried and failed several times to wean himself.

Case Report 3

This is a 29-year-old male patient who presented after experiencing body weakness lasting one day, initially in the upper extremities, then progressed to the lower extremities. Associated with easy fatigability and pain in all her extremities were also reported. After admission to the hospital, he developed excessive salivation and drooling of saliva, was unable to hold oral secretions, and had shortness of breath. The patient has had a history of diarrhea and was treated at a private hospital one week before the symptom's onset. He had no history of chronic illness. On physical examination, his pulse rate was 68 beats per minute; he had a sinus rhythm, a body temperature of had a sinus rhythm, a body temperature of 36.8 °C, an 134/88 mmHg, and an oxygen saturation of 98% in the atmospheric air. The chest was clear. His GCS was15/15: Eye opening 4 verbal 5 motor 6; pupil reactive and mid-size bilaterally; power 2/5 bilaterally upper extremities; 1/5 bilaterally lower extreme; Tone hypotonic in all extremities, Reflex, plantar reflex down going, Sensory intact. The patient was taken to a resuscitation area in the ED, then followed. Still, on the next day, the patient was deteriorating, developed a change of mention, worsened shortness of breath, tachypneic (40), and tachycardic (140), indicating 85%. Airway management started with endotracheal intubation and mechanical ventilation. The patient was transitioned to an intensive care unit (ICU) with an assessment of Type 2 respiratory failure secondary to diaphragmatic paralysis, likely from GBS. Basic routine laboratory examinations for this patient were unremarkable. POCUS showed a flat line reflecting the paralysis of the diaphragm (Figure 1C) compared to a wavy white line reflecting the normal rhythmic movement of the diaphragm (Figure 1D).

Discussion

The diaphragm is the primary respiratory muscle, and breathing depends on its contraction. Diaphragm dysfunction can result from any illness that impairs the diaphragmatic nerve's ability to transmit signals, the contractile muscles' ability to contract, or the chest wall's mechanical attachment.[9] Diaphragm paralysis dysfunction is linked to dyspnea, exercise intolerance, sleep issues, and hypersomnia, all of which may affect survival. The external intercostal muscles help the opposing diaphragm dome compensate for this defect, so respiratory function is not significantly compromised when only half of the diaphragm is involved. The most common cause of diaphragmatic paralysis is phrenic neuropathy, which can be caused by attempting to extend the neck after cardiothoracic surgery, cervical nerve root injury, neuralgic amyotrophy, or infectious agents such as herpes zoster or influenza.[10]

The clinical study's utilization of PoCUS is pivotal in assessing diaphragmatic conditions among patients. It offers a dynamic, detailed evaluation of diaphragmatic impairments, contributing valuable information for a comprehensive understanding of the conditions and potential implications for therapeutic interventions.[11] Supplementary Video demonstrates the normal rhythmic diaphragmatic movement during respiration using the M-mode function. The images resemble a sinus wave, with the convex part representing inspiration and the concave part representing expiration.

Health Care professionals can use portable ultrasonography, a dependable bedside tool, to improve primary and specialty patient careHealthcare.[12] There is an increasing body of literature suggesting that PoCUS can accelerate the diagnostic process, minimize the need for additional imaging tests, decrease patient exposure to ionizing radiation, and ultimately lower overall healthcare costs.[13]

Point-of-care ultrasound has been increasingly used for bedside diagnostic purposes. They provide immediate findings and guide further testing and therapies. Emergency medicine physicians and pulmonary/critical care physicians use POCUS frequently. It is helpful in patients who cannot be easily transported for diagnostic purposes such as CT scans and fluoroscopic tests. Lung and diaphragm POCUS can assist in diagnosing, following up, and evaluating extubating readiness.[14] POCUS of the diaphragm has been conducted on critically ill intubated patients. The ultrasound gives information on the diaphragmatic movement. Information obtained from the POCUS gives information on the status of the diaphragm at the time of the examination.[15–17] Follow-up examinations help indirectly evaluate the progression of the disease and treatment efficacy. Patients with GBS can have diaphragm paralysis that may lead to intubation. Over time, the efficacy of treatment with intravenous immunoglobulin can be assessed by evaluating the diaphragm with POCUS. In addition, intubated patients can be assessed to see if they are ready for extubation. Interactions between the heart, lung, and diaphragm may have an effect/ influence on a patient's ability to be weaned from mechanical ventilation.[18–21] Results of ultrasound examination of these organs may be helpful in detecting dysfunctions potentially leading to weaning failure.

Conclusion

Point-of-care ultrasound presents a more advantageous option for diagnosing and monitoring diaphragmatic paralysis. This approach necessitates minimal training and facilitates regular examinations of critically ill patients at the bedside, eliminating the need for easy transportation to other testing methods. When combined with clinical assessments, the findings from point-of-care ultrasound can contribute to the decision-making process for intubation.

Data Sharing Statement

Data used to support the findings of this study are available from the corresponding author upon request.

Ethics Approval

All patients provided written informed consent for their case details to be published. The college doesn't require IRB approval for case series.

Funding

There is no funding to report.

Disclosure

The authors declare that they have no conflicts of interest in this work.

References

1. Ko MA, Darling GE. Acquired paralysis of the diaphragm. *Thorac Surg Clin*. 2009;19(4):501–510. doi:10.1016/j.thorsurg.2009.08.011
2. Hannan LM, De Losa R, Romeo N, Muruganandan S. Diaphragm dysfunction: a comprehensive review from diagnosis to management. *Intern Med J*. 2022;52(12):2034–2045. doi:10.1111/imj.15491
3. Kocjan J, Adamek M, Gzik-Zroska B, Czyżewski D, Rydel M. Network of breathing. Multifunctional role of the diaphragm: a review. *Adv Respir Med*. 2017;85(4):224–232. doi:10.5603/ARM.2017.0037
4. Shahrizaila N, Lehmann HC, Kuwabara S. Guillain-Barré syndrome. *Lancet*. 2021;397(10280):1214–1228. doi:10.1016/S0140-6736(21)00517-1
5. O'Toole SM, Kramer J. *Unilateral Diaphragmatic Paralysis*. Treasure Island (FL): StatPearls Publishing; 2023.
6. Sorensen B, Hunskaar S, Azil A, Wahab SFA. Point-of-care ultrasound in primary care: a systematic review of generalist performed point-of-care ultrasound in unselected populations. *Ultrasound J*. 2019;11(1):1–29. doi:10.1186/s13089-019-0116-9
7. Myklestul H-C, Skonnord T, Brekke M. Point-of-care ultrasound (POCUS) in Norwegian general practice. *Scand J Prim Health Care*. 2020;38 (2):219–225. doi:10.1080/02813432.2020.1753385
8. Tanael M. *Point-of-Care Ultrasonography, Primary Care, and Prudence*. Vol. 173. United States: Annals of internal medicine; 2020:650–651.
9. Law SM, Scott K, Alkarn A, et al. COVID-19 associated phrenic nerve mononeuritis: a case series. *Thorax*. 2022;77(8):834. doi:10.1136/thoraxjnl-2021-218257
10. Shahid M, Ali Nasir S, Shahid O, Nasir SA, Khan MW. Unilateral diaphragmatic paralysis in a patient with COVID-19 pneumonia. *Cureus*. 2021;13(11):e19322. doi:10.7759/cureus.19322
11. Lloyd T, Tang YM, Benson MD, King S. Diaphragmatic paralysis: the use of M mode ultrasound for diagnosis in adults. *Spinal Cord*. 2006;44 (8):505–508. doi:10.1038/sj.sc.3101889
12. Maw AM, Huebschmann AG, Mould-Millman NK, Dempsey AF, Soni NJ. Point-of-care ultrasound and modernization of the bedside assessment. *J Grad Med Educ*. 2020;12(6):661–665. doi:10.4300/JGME-D-20-00216.1
13. Van Schaik GWW, Van Schaik KD, Murphy MC. Point-of-Care Ultrasonography (POCUS) in a community emergency department: an analysis of decision making and cost savings associated with POCUS. *J Ultrasound Med off J Am Inst Ultrasound Med*. 2019;38(8):2133–2134.
14. Al-Husinat L. The role of ultrasonography in the process of weaning from mechanical ventilation in critically ill patients. *Diagnostics*. 2024;14. doi:10.3390/diagnostics14040398

15. Boussuges A, Bregeon F, Blanc P, Gil JM, Poirette L. Characteristics of the paralysed diaphragm studied by M-mode ultrasonography. *Clin Physiol Funct Imaging*. 2019;39(2):143–149. doi:10.1111/cpf.12549
16. Boussuges A, Gole Y, Blanc P. Diaphragmatic motion studied by m-mode ultrasonography: methods, reproducibility, and normal values. *Chest*. 2009;135(2):391–400. doi:10.1378/chest.08-1541
17. Boussuges A, Rives S, Finance J, Bregeon F. Assessment of diaphragmatic function by ultrasonography: current approach and perspectives. *World J Clin Cases*. 2020;8(12):2408–2424. doi:10.12998/wjcc.v8.i12.2408
18. Gok F, Mercan A, Kilicaslan A, Sarkilar G, Yosunkaya A. Diaphragm and lung ultrasonography during weaning from mechanical ventilation in critically ill patients. *Cureus*. 2021;13(5):e15057. doi:10.7759/cureus.15057
19. Santangelo E, Mongodi S, Bouhemad B, Mojoli F. The weaning from mechanical ventilation: a comprehensive ultrasound approach. *Curr Opin Crit Care*. 2022;28(3):322–330. doi:10.1097/MCC.0000000000000941
20. Santana PV, Cardenas LZ, Albuquerque ALP, Carvalho CRR, Caruso P. Diaphragmatic ultrasound: a review of its methodological aspects and clinical uses. *J Bras Pneumol*. 2020;46(6):e20200064. doi:10.36416/1806-3756/e20200064
21. Scarlata S, Mancini D, Laudisio A, Benigni A, Antonelli Incalzi R. Reproducibility and clinical correlates of supine diaphragmatic motion measured by M-mode ultrasonography in healthy volunteers. *Respiration*. 2018;96(3):259–266. doi:10.1159/000489229