Case Report

# Ultrasound of the diaphragm in severe hypokalemia induced diaphragmatic dysfunction

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## ABSTRACT

Severe hypokalemia presents with significant muscle weakness and involvement of respiratory muscles. Bedside ultrasonography of the diaphragm is emerging as a noninvasive bedside tool for diagnosis and followup of diaphragmatic dysfunction due to various causes. Here, we present a case of diaphragmatic dysfunction due to severe hypokalemia. The patient presented with acute onset quadriparesis that rapidly improved with correction of hypokalemia. The clinical and laboratory parameters correlated well with the findings of diaphragm ultrasound, both initially and after correction of hypokalemia.

**KEY WORDS:** Diaphragm ultrasound, diaphragmatic dysfunction, hypokalemia

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## INTRODUCTION

Diaphragmatic dysfunction is not uncommon and can present with unexplained dyspnea.[1] Hypokalemic periodic paralysis is a rare disorder that can present with fatal episodes of muscle weakness with the involvement of respiratory muscles.[2] Several tests for the diagnosis of diaphragmatic dysfunction such as chest radiography, fluoroscopy of the diaphragm, pulmonary function test, and measurement of trans-diaphragmatic pressure are either less reliable, not commonly available or are invasive. Ultrasonography of the diaphragm can serve as a reasonable alternative to the invasive tests. It is an easily available and repeatable bedside tool for the diagnosis and followup of diaphragmatic dysfunction.[1]

Here, we present a case of hypokalemic periodic paralysis with quadriparesis. Diaphragm ultrasound at bedside showed diaphragmatic dysfunction. His weakness progressively improved with correction of severe hypokalemia, which correlated with the findings of improvement in diaphragmatic functions, as assessed using ultrasonography.

## CASE REPORT

A 22-year-old male, known case of hypokalemic periodic paralysis, presented with sudden onset weakness of limbs, rapidly culminating in quadriparesis within 3 h of symptom onset. At presentation, motor power was 0/5 in lower extremities and 1/5 in upper extremities. Deep tendon reflexes were absent. However, mentation was intact, and there was no sensory deficit. The patient was tachypneic with a respiratory rate of 28/min, associated with shallow breathing. He required supplemental oxygen at 5 L/min to maintain oxygenation. Arterial blood gas analysis revealed pH of 7.32, $PaCO_2$ of 55 mmHg, $PaO_2$ of 72 mmHg, and $HCO_3$ of 27 mEq/L. Serum potassium level was 1.1 mEq/L. Electrocardiogram showed prominent U waves [Figure 1]. The diaphragmatic

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excursion was measured using ultrasonography through the right anterior subcostal view, using curvilinear transducer C60X (frequency range of 5–2 MHz; MicroMaxx®; SonoSite, USA). M-mode sonography revealed excursion of 1.59 cm [Figure 2], indicating diaphragmatic dysfunction. The patient was continuously observed in Intensive Care Unit for possible deterioration. Noninvasive ventilation was not applied due to nonavailability. Serum potassium was rapidly corrected by intravenous infusion through the central venous catheter. Over next 6 h, motor power progressively improved to 5/5 in lower extremities and 4/5 in upper extremities, $PaCO_2$ normalized to 42 mmHg and serum potassium increased to 2.8 mEq/L. Respiratory rate decreased to 16/min and patient could maintain oxygenation in room air. Ultrasonography revealed improved diaphragmatic excursion to 3.26 cm [Figure 3]. Further correction of potassium was done over next 24 h and patient was discharged home.

## DISCUSSION

Hypokalemic periodic paralysis is the most common form of periodic paralysis, often presenting with sudden onset of weakness ranging from mild transient weakness to severe life-threatening respiratory failure, with the involvement of respiratory muscles.[3] Monitoring respiratory muscle functions is a much-neglected field, due in part to the low reliability or invasive nature of available tests.[1,4] Bedside ultrasonography is a noinvasive technique which is safe, accurate, and easy to use. Diaphragm ultrasound is gaining popularity, especially for bedside evaluation of critically ill patients, where transportation of the patients can be risky.[5]

M-mode ultrasonography for assessment of hemidiaphragm movement has been show to be a reliable and reproducible bedside technique.[6] A Strong correlation was observed between the diaphragmatic excursion measured by ultrasonography and that measured by gold standard radiographic imaging techniques.[7] In patients following cardiac surgery, the best diaphragmatic excursion measured by ultrasonography of <25 mm correlated with sever diaphragmatic dysfunction, indicated by Gilbert index of <0, with an excellent negative likelihood ratio.[8] Sonographic evaluation of the diaphragm has also been used in the diagnosis and followup of diaphragmatic involvement in patients with neuromuscular disorders like amyotrophic lateral sclerosis.[9]

In our patient, the initial clinical scenario of rapid shallow breathing, need for supplemental oxygen to maintain oxygenation, hypercapnia and quadriparesis in the background of severe hypokalemia correlates well with decreased diaphragmatic excursion as revealed by bedside diaphragm sonography. Subsequent rapid correction of life-threatening hypokalemia was followed by dramatic clinical improvement. Correction of hypoxemia and hypercapnia, normalization of respiratory rate and improvement in motor power in the extremities correlated well with the sonographic evidence of improvement in the diaphragmatic excursion.

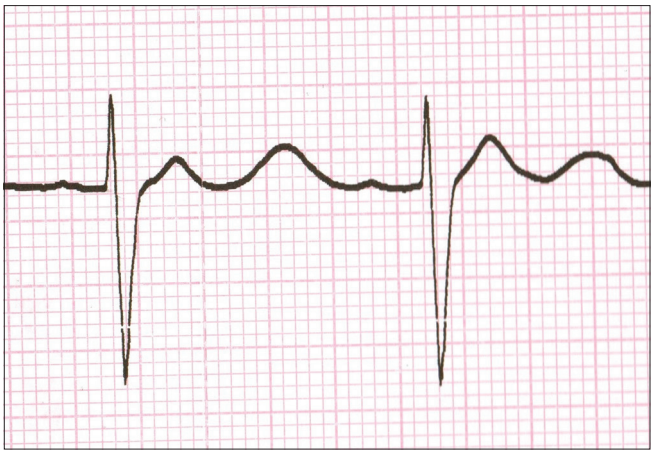

**Figure 1:** Electrocardiogram showing prominent U waves

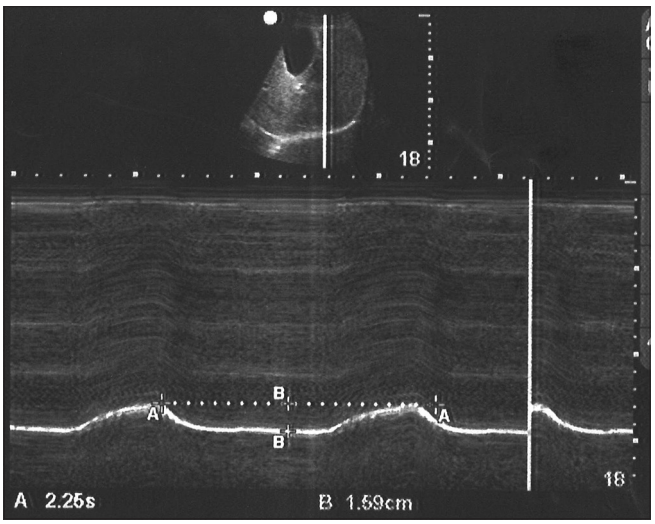


**Figure 2:** Ultrasonography of the diaphragm showing the diaphragmatic excursion of 1.59 cm (indicated by B) and the respiratory rate of around 28/min

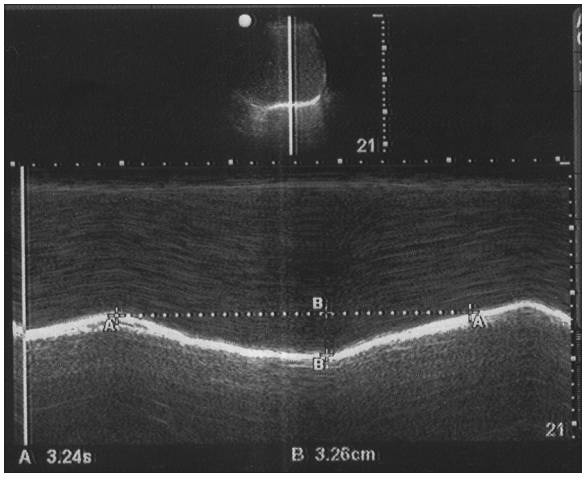


**Figure 3:** Ultrasonography of the diaphragm showing the diaphragmatic excursion of 3.26 cm (indicated by B) and the respiratory rate of around 16/min

To conclude, sonography of the diaphragm can be a valuable noninvasive bedside tool for the diagnosis and followup of diaphragmatic dysfunction in a variety of clinical conditions including severe hypokalemia.

## 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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