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Use of bedside ultrasound as a predictive tool for acute chest syndrome in sickle cell patients: A prospective exploratory study

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ABSTRACT

Background: Acute chest syndrome (ACS) is the leading cause of death for patients with sickle cell disease (SCD). Early recognition of ACS improves prognosis.
Objective: Investigate the use of bedside lung ultrasound (BLU) in identification of early pulmonary findings associated with ACS in SCD patients.
Methods: Prospective, observational study of a convenience sample of SCD patients presenting to the Emergency Department (ED) for a pain crisis. BLU interpretations were made by an emergency physician blinded to the diagnosis of ACS, and were validated by a second reviewer. The electronic medical record was reviewed at discharge and at 30 days.
Results: Twenty SCD patients were enrolled. Median age was 31 years, median hemoglobin was 7.7 g/dL. Six patients developed ACS. Five patients in the ACS group had lung consolidations on BLU (83%) compared to 3 patients in the non-ACS group (21%), $p = 0.0181$, (OR = 12.05, 95% CI 1.24 to 116.73). The ACS group was also more likely to have a pleural effusion and B-lines on BLU than the non-ACS group, $p = 0.0175$; 0.1657, respectively. In the ACS group, peripheral and frank consolidations on BLU was 83% and 50% sensitive, 79% and 100% specific for ACS, respectively; whereas an infiltrate on initial chest X-ray (CXR) was only 17% sensitive. BLU identified lung abnormalities sooner than CXR (median 3.6 vs. 31.8 h).
Conclusions: Pulmonary abnormalities on BLU of an adult SCD patient presenting to the ED for a painful crisis appear before CXR, and highly suggest ACS. BLU is a promising predictive tool for ACS.

1. Introduction

1.1. Background

Sickle cell disease (SCD) affects over 5 million people worldwide [1, 2]. Acute chest syndrome (ACS) is a life-threatening complication of sickle cell disease that can rapidly progress to respiratory failure and death [1, 3]. ACS often occurs following or accompanying painful crises [1]. ACS is typically diagnosed when a patient has respiratory symptoms (i.e. cough, dyspnea, hypoxia), and/or fever associated with a new pulmonary infiltrate seen on chest X-ray [3-6]. Early recognition of ACS is crucial so that proper treatment can be initiated [3, 4, 7, 8].

Currently, there is no way to predict the onset of ACS in sickle cell patients until a positive chest radiograph indicates the presence of an infiltration in the lungs. Approximately 18% of all SCD patients admitted to the hospital for acute painful crisis will develop ACS during their hospital stay regardless of respiratory symptoms [9, 10]. ACS is often not diagnosed until 5 or 6 days after admittance via chest radiograph, as many patients will not have symptoms of ACS on initial presentation [7]. Recent studies suggest that bedside lung ultrasound may be a useful tool to detect ACS [11-13]. In a case study published in 2009, ultrasound was successfully used to diagnose ACS in a sickle cell patient without evidence of lung consolidation on chest radiograph [13]. More recently in 2016, Daswani et al. used ultrasound to determine the diagnosis of acute chest syndrome in pediatric sickle cell patients [11]. This sentinel article was the first to demonstrate that point-of-care lung ultrasound was comparable to CXR in identification of pulmonary consolidations in pediatric SCD patients diagnosed with ACS [11].

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1.2. Importance

Bedside ultrasound may offer an alternative, faster, and safer (less cumulative radiation) initial imaging modality to CXR for the diagnosis of ACS that is non-invasive and readily available in most emergency departments (ED). ***Early*** identification of pulmonary abnormalities associated with acute chest syndrome could play a significant role in management, and may help decrease the associated mortality. This is the first study to use ultrasound to assess for ACS in adult sickle cell patients presenting to ED for an acute painful crisis.

1.3. Goals of this investigation

The objective of this exploratory study is to prospectively identify early pulmonary abnormalities of ACS using BLU on adult SCD patients presenting to the ED experiencing pain crisis, and to compare these abnormalities with findings identified on initial CXR obtained in the ED.

2. Materials and methods

2.1. Study design and setting

This is a prospective observational study performed on a convenience sample of adult sickle cell patients presenting to the ED experiencing an acute SCD pain crisis. The setting is the ED of a large urban academic teaching hospital and sickle cell referral center in Chicago, Illinois with over 2000 ED visits per year for SCD related complaints. The study was reviewed and approved by the Institutional Review Board (IRB) of the University of Illinois at Chicago.

2.2. Selection of participants

Patients presenting to the ED for an acute painful crisis from 1 June −30 July 2016 were eligible for this study. Additional inclusion criteria included: 1) age 18 or older, 2) a documented past medical history of sickle cell disease in the EMR, 3) able to provide consent, and 4) hemodynamically stable. Study participants were approached for participation after their initial ED evaluation and treatment plan was started for their acute painful crisis. 21 patients were approached for consent, and there was only one refusal to participate.

A formal power analysis for the current study was not conducted due to its exploratory nature, which was designed to identify potential early ultrasound predictors of ACS from a variety of previously described abnormal lung findings. Preliminary data from this study may provide more of a precise sample estimate for future, multicenter trials.

2.3. Ultrasound protocol

BLUs were performed by the PI or the research associate using a GE Vivid q 3 MHz 4C-RS convex abdominal transducer with tissue harmonics turned off. The low frequency curvilinear probe was selected for its versatility and because it has been previously described in studies identifying pneumonia, alveolar interstitial syndrome, and acute heart failure [14-16]. Longitudinal and transverse six second video clips were recorded at a depth of 15 cm from six locations on the anterior portion of the chest, six locations on the posterior chest, plus a coronal view at each costophrenic angle to provide ample viewing of all 5 lobes of the lung (Fig. 1). For the anterior chest, images were recorded from sonographic windows located along the mid-clavicular line at the first, third, and fifth intercostal spaces with patient lying in a semi-recumbent position at 45°. For the posterior chest, images were recorded from sonographic windows located along the medial scapular line with patient sitting upright arms crossed in front at the second,

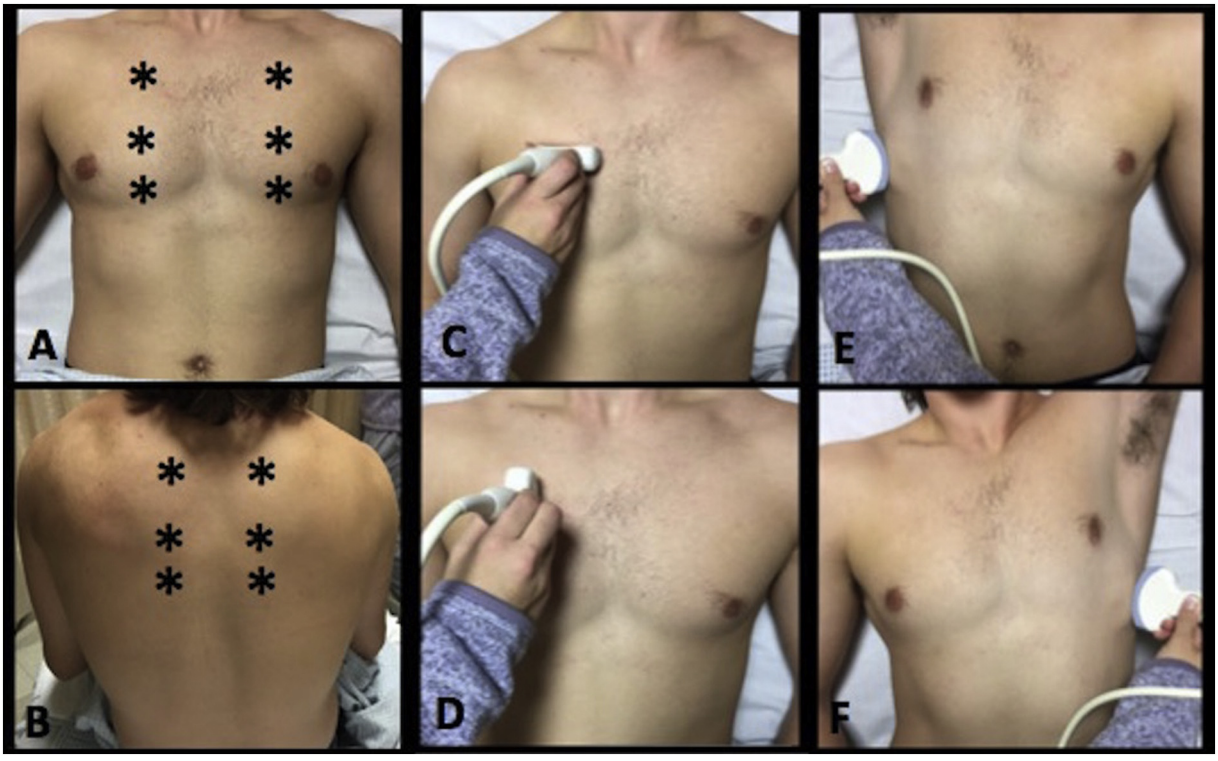

Fig. 1. Bedside lung ultrasound protocol. Location of sonographic windows of anterior chest in the 1st, 3rd, and 5th intercostal spaces along the midclavicular line (A.); Location of sonographic windows on posterior chest in the 2nd, 4th and 6th intercostal spaces along the medial scapular line with patient's arms crossed in front (B.); Images were recorded in the transverse and sagittal plane for each intercostal space (C. and D.); Two additional coronal sonographic window were obtained to better visualize the right and left lung bases and to assess for pleural effusions (E. and F.).

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