Mobile Bedside Ultrasound (mBSUS) and Use of an Artificial Intelligence (AI) Algorithm for Diagnosis of Pediatric Pneumonia in Limited Resource Settings

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Introduction

In low and middle-income countries (LMICs), pneumonia is the leading cause of death in children < 5 years old. A key factor is the challenge of pneumonia diagnosis. Chest X-Ray (CXR) exposes children to ionizing radiation and is restricted to hospital settings. Moreover, only 50% of children meeting the WHO criteria for severe/very severe pneumonia have radiographically confirmed disease. Pneumonia is diagnosed on clinical grounds that fail to recognize many children at risk for death.

Traditional mobile bedside ultrasound (mBSUS) is a radiation-sparing alternative to X-rays but it has the same limitations as CXRs, portability, and the need to interpret images by a trained radiologist. Recent innovations in ultrasound (US) technology and artificial intelligence (AI) applications enable smaller US handheld devices to connect and transmit images to a smart phone or tablet that can fit into one's pocket.

Advances in AI render possible the automated visualization of mBSUS images on a smart phone with the possibility of building algorithms to recognize specific patterns of disease obviating the need to send images for interpretation.

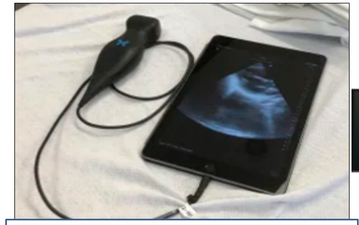


Figure 1. Butterfly device.

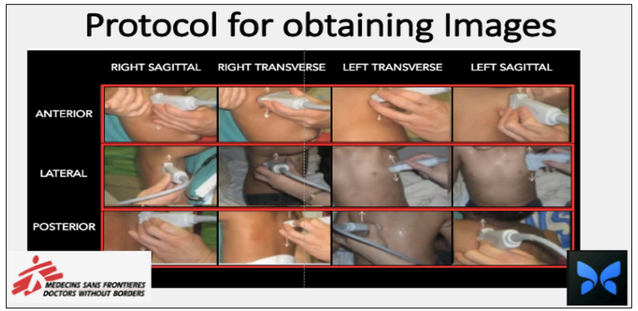
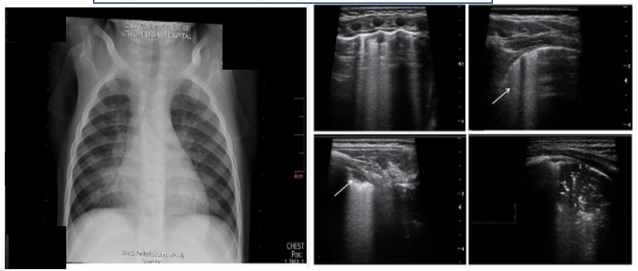


Figure 3. Imaging correlation.

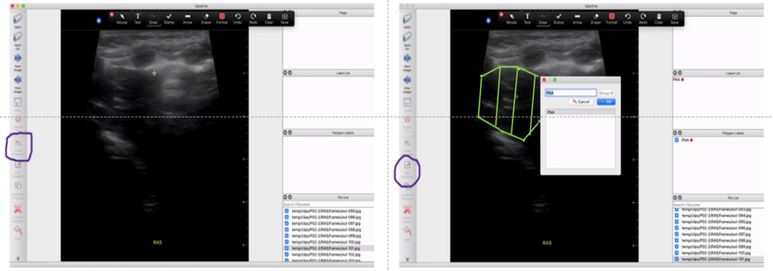


Methods and Materials

We are measuring the accuracy of mBSUS to diagnose pneumonia using chest X-Ray as the gold standard. Children 1-59 months of age at The University Teaching Hospital (UTH) in Lusaka, Zambia and meeting WHO criteria for severe/very severe pneumonia are enrolled to have a CXR and mBSUS. Lung mBSUS images are taken using a butterfly, an innovative handheld US device, they are stored in the butterfly iCloud, a secured/encrypted platform for remote viewing with a Health Insurance Portability and Accountability Act capabilities and transmitted to an iOS phone or tablet. A scanning protocol developed by Médecins sans frontiers (MSF) was used.

Images are extracted from the clips stored in the butterfly iCloud, radiologists annotate the images with abnormal findings and send them to the AI lab; using feature extraction, segmentation, classification and recognition with the use of the application "***label me***", a deep learning algorithm will be created to recognize areas of consolidation representing pneumonia.

Figure 4. Artificial Intelligence Annotation



Results

A complete analysis has finished on 7 patients, 3 (42.8%) had US images that correlated with CXR findings. In another three patients (42.8%), the US showed pulmonary findings not recognized or hardly seen on CXR. In one case, (14.2%), the CXR showed a consolidation not seen on US. The AI lab is building a library of images based on polygons that will be used to recognize similar patterns of consolidation from mBSUS images.

Conclusions

- mBSUS is a feasible, non radiation technique that could be used in limited-resource settings to diagnose pneumonia in children.
- Only a minority of patients had CXR findings not seen on US.
- Images obtained from mBSUS can be used to build a pattern of recognition based on consolidation findings.

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