# Comparative Performance of Pulmonary Ultrasound, Chest X-ray, and CT Amongst Patients with Acute Respiratory Failure

SUPPLEMENTAL CONTENT 2 – Additional Methods & Results

## Pulmonary Ultrasound (PU) Exam Detail

The patient was positioned supine with the head of the bed elevated 20 to 40 degrees. All pulmonary ultrasound (PU) examinations were performed with SonoSite EDGE (FUJIFILM SonoSite Inc., Bothell, WA) portable ultrasound systems equipped with a P21 (1 – 5 mHz) phased-array transducer using the abdominal exam preset and oriented in a longitudinal (perpendicular to the rib) orientation. The abdominal exam preset was chosen to best accomplish, with a single preset, the mixed-task of identifying lung sliding, lung artifacts (A-lines and B-lines), pleural fluid, and consolidation/atelectasis. Initial depth was set to 16 cm for all exam points, however, the examining physician adjusted depth at their discretion to further evaluate the area. Surface area examined with ultrasound in each zone was an area in the center of the zone no larger than our hospital ID badge (7.5 x 5 cm).

## Pulmonary Ultrasound Agreement Details and Rationale

Each PU zone was mapped to a single anatomic lung lobe. More than one PU zone may have mapped to the same lobe (i.e. zone 2 and 4 = right middle lobe). The goal of the agreement definitions employed in this study was to mirror the importance of both false positives and false negatives for PU in the *clinical* workflow. The agreement is complex when more than one PU zone maps to the same lobe on CT. An explanation of the various agreement scenarios follows.

*Clinically*, the use of the PU protocol to identify findings present in an anatomic lobe employs an “or” definition such that if consolidation was observed in either zone 2 or 4 on PU exam, a consolidation/pneumonia in the right middle lobe on CT would have been clinically identified. Therefore, the agreement definition for the “lobe-specific” analysis in this *study* environment specified whether pathology was identified in either zone 2 or 4 when it WAS present in the right middle lobe on CT, and if so, resulted in a true positive for the PU exam of the right middle lobe. If the PU exam of zone 2 or 4 did not correctly identify pathology present in the right middle lobe on CT, the PU exam was a false negative.

As a point of emphasis, in a *clinical* workflow using PU, a normal lobe by CT should result in all mapped PU zones for that lobe being normal, or the PU exam gives in a false positive result and potentially leads to inappropriate diagnosis and treatment. Thus, in this *study* environment if pathology was NOT present in a given CT lobe, but either mapped PU zone showed an abnormality, then the PU exam disagreed with that CT lobe (false positive).

The last agreement scenario exists when more than one PU zone is mapped to a lobe on CT (e.g. PU zones 2 and 4 mapped to the right middle lobe), and a finding was present in that lobe on CT (e.g. interstitial). If one mapped PU zone agreed (e.g. zone 2 = B2) and the other disagreed by identifying an incompatible abnormal finding (i.e. not “normal”, but “consolidation”), the PU disagreed with the lobe on CT. This definition is strict, but an incorrect abnormal finding can result in an inappropriate diagnosis and treatment and thus this was treated as a false positive PU exam.

While complex, this agreement algorithm most closely resembled the clinical use scenarios for pulmonary ultrasound and equally weighs the clinical sensitivity and specificity of the protocol for lobe-specific pathology.

In the lung-specific (not lobe specific) agreement definition, when a finding was present in the lung on CT, and a finding of agreement was seen in any ipsilateral zone on the PU, the PU and CT exams were in agreement for that lung. If there were no abnormalities in the lung on CT, and any of the ipsilateral PU zones identified an abnormality, the exam did NOT agree with the lung on CT. Finally, if an abnormal finding was present in a lung on CT (e.g. interstitial) and the ipsilateral PU exam had zones with compatible findings (e.g. B1, B2), but also zones with an incompatible abnormal finding (i.e. not “normal”, but “consolidation”), the results of the PU disagreed with the lung on CT. This lung-specific agreement algorithm again reflects the clinical need for both sensitivity and specificity in order to effectively use PU as a replacement for pCXR and an adjunct or replacement for CT.

**Final Clinical Diagnosis Assignment**

The chart review to assign a final diagnosis responsible for the patient’s acute respiratory failure was performed by 2 study physicians (out of the 4) who had not performed the PU exam and were blinded to the results of the PU exam. The review consisted primarily of extraction of a final diagnosis from text of the clinical team’s discharge summary. When necessary, they subsequently utilized formal imaging reports, labs, and individual clinical notes for clarification. When there was more than one diagnosis present, the predominant diagnosis was chosen. Where there were

sequential diagnoses over the course of a hospital stay, the initial presenting diagnosis was chosen.

The independent assignment of the clinical diagnosis for acute respiratory failure matched between the two physicians in 66 of 67 patients. For 1 patient, they disagreed between the diagnosis of pneumonia and aspiration. Solely for the purpose of final diagnosis percentages in Table 2 of the manuscript, the disagreeing physicians decided on which diagnosis best fit through an open-chart conversation. This adjudication process had no impact on the agreement of PU with final diagnosis as the same findings would have agreed with either aspiration or pneumonia. The 66/67 agreement was likely so high because the diagnosis was usually definitively stated in the discharge summary and recorded as such without in-depth investigation of labs, notes or imaging.