Interrater Reliability of Pediatric Point-of-Care Lung Ultrasound Interpretation in the PICU
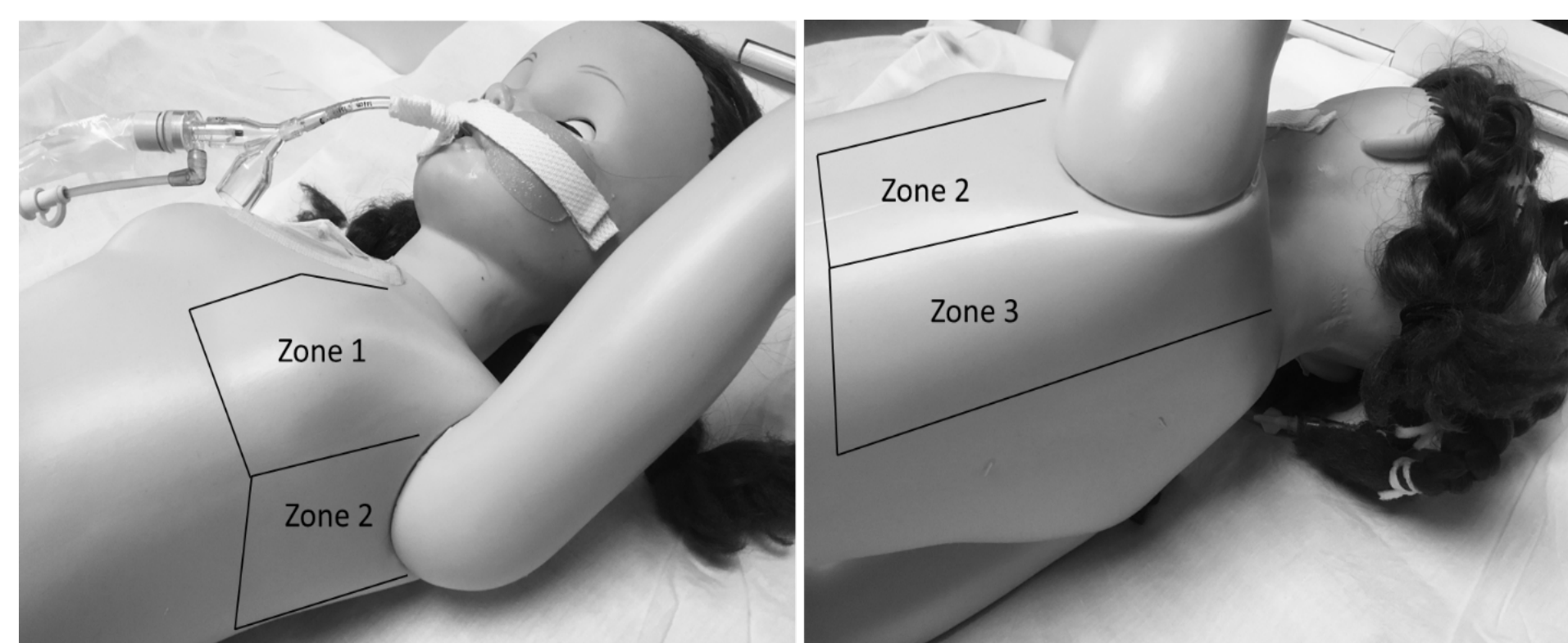
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BACKGROUND

- Point-of-care lung ultrasound (POC-LUS) is a non-invasive, safe imaging technology used to rapidly and accurately differentiate the most common causes of acute respiratory failure (ARF) in adults
- Despite widespread implementation, there remains a paucity of data supporting its use and training in pediatric critical care
- Study objective: determine the interrater reliability of ultrasound interpretation in pediatric ARF among intensivist trained in and experienced in POC-LUS
- Our hypothesis: interrater reliability in POC-LUS interpretation would be >80%

METHODS

- Secondary analysis of an observational study of children admitted to PICU with ARF
- A three zone per hemi-thorax POC-LUS was exam conducted on admission by intensivists with focused ultrasound training
- For each zone, an assessment of lung sliding, pleural line characteristics, and ultrasound artifacts was made & documented
- Findings were grouped into patterns correlating with common, discrete diagnoses of pediatric ARF
- An intensivist experienced in POC-LUS, blinded to all clinical information interpreted the trainee exam & documented in Q-path
- Kappa statistics were used to determine trainee and expert agreement in the interpretation of ultrasound findings
- Final diagnosis determined by blinded review of medical record following discharge

There is moderate agreement between pediatric intensivists training in the use of POC-LUS and an expert POC-LUS intensivist

DISCUSSION

- Training of adult POC-LUS is well established utilizing a combination of classroom based didactic and hands-on ultrasound teaching with longitudinal quality assurance
- Tools have been developed to assess user competence in both the acquisition and the interpretation of adult ultrasound findings
- Over 60% of PICUs utilize point-of-care ultrasound for diagnostic purposes
- Yet established teaching and evaluation tools do not exist in pediatrics
- No studies have evaluated the reliability of POC-LUS interpretation among critically ill pediatric patients

ADDITIONAL KEY INFORMATION

Lung sliding: present   absent
Pleura: thin & smooth   thick & irregular
Pattern: A lines   multiple B lines   confluent B lines   sub-pleural consolidation   lobar consolidation   pleural effusion w/o lung flapping   pleural effusion with flapping

Table 3. Assessment of ultrasound artifacts

Diagnosis	Ultrasound findings
Status asthmaticus	Diffuse, bilateral A lines +/- few B lines limited to posterior lung field
Bronchiolitis Viral pneumonitis	Bilateral areas with sub-pleural consolidation without air-bronchograms OR areas of multiple or confluent B lines +/- thick irregular pleura
Pneumonia	Unilateral or bilateral sub-pleural or lobar consolidation with air-bronchograms AND areas of multiple or confluent B lines
ARDS	Bilateral, sub-pleural or lobar consolidations with air-bronchograms AND areas of focal or confluent B lines +/- pleural effusion
Pulmonary edema	Diffuse, multiple or confluent, bilateral B lines without sub-pleural or lobar consolidation
Pleural effusion	Moderate to large anechoic fluid collection external to lung parenchyma +/- lung flapping
PTX	A lines with absent lung sliding

Table 4. Artifacts supporting etiology of ARF

This study adds to the limited evidence supporting POC-LUS training in the PICU

RESULTS

- Three trainees performed POC-LUS on 50 patients examining 6 zones per patient (300 total zones)
- The cohort included 6 patients with a final diagnosis of status asthmaticus (12%), 28 with bronchiolitis (56%), and 16 with pneumonia (32%)
- Evaluation of agreement between trainee and expert artifact interpretation is displayed in Table 1
- There was moderate agreement between trainee and expert derived diagnoses at 60% (K=0.56, CI 0.031 – 0.80) with comparison in Table 2

Ultrasound Finding	Percent Agreement	Kappa Agreement (SE)	95% Confidence Interval
Lung Sliding	97%	-0.029 (0.008)	-0.045 – -0.012
Normal pleural surface	83%	0.282 (0.099)	0.087 – 0.476
A-lines	83%	0.643 (0.047)	0.550 – 0.736
Multiple B-lines	82%	0.452 (0.063)	0.328 – 0.576
SPC	78%	0.450 (0.071)	0.311 – 0.588
LC	96%	0.648 (0.106)	0.440 – 0.856
Pleural effusion	95%	0.456 (0.154)	0.154 – 0.758

Table 1. Artifact interpretation; SPC = sub-pleural consolidation; LC = lobar consolidation

Diagnosis by Trainee	Diagnosis by Expert		
	Asthma	Bronchiolitis	Pneumonia
Asthma	5	0	0
Bronchiolitis	8	11	3
Pneumonia	2	7	14

Table 2. Diagnostic agreement