Assessing Extravascular Lung Water With Ultrasound: A Tool to Individualize Fluid Management?

Journal of Intensive Care Medicine
1-7

DOI: 10.1177/0885066619855000
journals.sagepub.com/home/jic
SAGE

肺超声可很好的反映血管外肺水，避免过量补液，但仍需要大样本临床研究的支持。

Table 1. Select Studies Comparing B-Line Measurements With Other Modalities of Extravascular Water Assessment or Outcomes.

Authors and Year	Study Population and Comparison	Key Findings
Lichtenstein et al, 1997[22]	250 MICU patients, comparing chest X-ray to comet-tail artifacts ("B-lines")	B-lines 93.4% sensitive for alveolar-interstitial syndrome on chest X-ray (93% specific for a clear X-ray)
Jambrik et al, 2004[23]	121 medical inpatients, comparing lung comet score and radiologic lung water score	Number of comet-tails was linearly correlated with radiologic lung water score ($r = 0.78$, $P < .01$)
Agricola et al, 2005[24]	20 cardiac surgery patients, comparing lung ultrasound, chest x-ray, PAC, and EVLW (transpulmonary thermodilution)	Linear correlations between the number of comet-tails and radiologic lung water score, EVLW, PAOP
Volpicelli et al, 2014[25]	73 ICU patients, comparing "A-pattern" (the *absence* of B-lines) with PAOP and EVLW (transpulmonary thermodilution)	A-pattern 85.7% sensitive for PAOP of ≤18 mm Hg (40% specific), 81% for ≤EVLW 10 mL/kg (90.9% specific)
Anile et al, 2017[26]	19 ICU patients, comparing B-line pattern by quadrant with EVLW (transpulmonary thermodilution)	>3 positive quadrants was 100% sensitive and 70% specific for EVLW index of >10 mL/kg
Enghard et al, 2015[27]	50 MICU patients, comparing an ultrasound scoring system with EVLW (transpulmonary thermodilution)	Ultrasound score of >1.5 had a 92.1% sensitivity and 91.7% specificity for EVLW index >7 mL/kg
Zhao et al, 2015[29]	21 patients with ARDS, comparing lung ultrasound score with EVLW	Linear correlation between LUS and EVLW and PaO_2/FiO_2 ratio. Score >16.5 predicted poor prognosis
Miglioranza et al, 2013[30]	97 outpatients with heart failure, comparing clinical assessment, NT-proBNP, lung ultrasound, echocardiography, and chest X-ray	Number of B-lines was significantly correlated with NT-proBNP values ($r = 0.72$), E/e' ($r = 0.68$), CXR ($r = 0.59$), and a clinically validated congestion score ($r = 0.43$)
Maines et al, 2011[31]	23 patients with heart failure with implanted defibrillators, comparing intrathoracic impedance, comet-tails, and noninvasive estimates of PCWP	Lung comets were significantly correlated with PCWP and impedance fluid index ≥5 lung comets was 83% sensitive (91% positive predictive value) for ADHF
Platz et al, 2015[32]	185 symptomatic heart failure outpatients comparing quantity of B-lines with clinical and laboratory markers of congestion and clinical outcomes	Higher number of B-lines was associated with higher NYHA class and NT-proBNP, as well as higher risk of hospitalization and mortality
Donadio et al, 2015[33]	31 hemodialysis patients, comparing lung ultrasound, total body and thoracic bioimpedance analysis, and natriuretic peptide measurements before and after dialysis sessions	Number of B-lines correlated with extracellular water index, thoracic impedance, and BNP ($r = 0.45, 0.30, 0.57$, respectively)
Ciumanghel et al, 2017[34]	45 ICU patients with acute kidney injury, comparing B-line quantity to PaO_2/FiO_2 ratio and BIS	B-line score was negatively associated with PaO_2/FiO_2 ratio. BIS did not differentiate patients with and without respiratory dysfunction

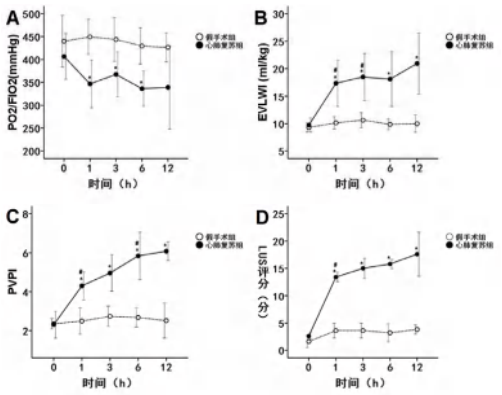
J Intensive Care Med. 2019 Jun 5

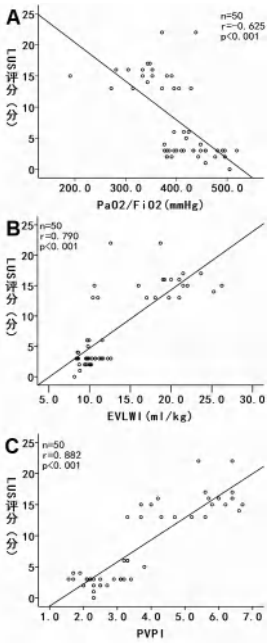
· 论　著 ·

文章编号：1009－4237(2019)07－0487－05

超声在猪心肺复苏后肺损伤评估中的应用价值

吴春双，徐杰丰，陈启江，金晓红，张　茂

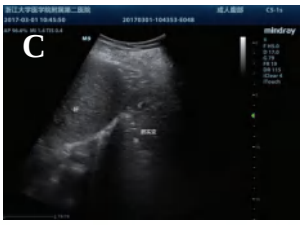


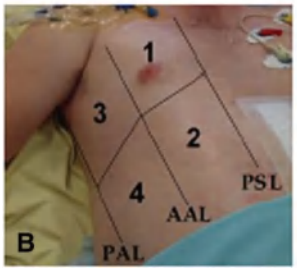


- 在猪心肺复苏模型中，肺超声评分与传统肺损伤指标的相关性较好，可以实时、连续无创地评估复苏后肺损伤的程度。

肺超声评分方法（lung ultrasound score, LUS）

N (0分): 胸膜线和A线，少于3条B线
B1 (1分): 多于3条B线
B2 (2分): 融合B线
C (3分): 肺实变征象

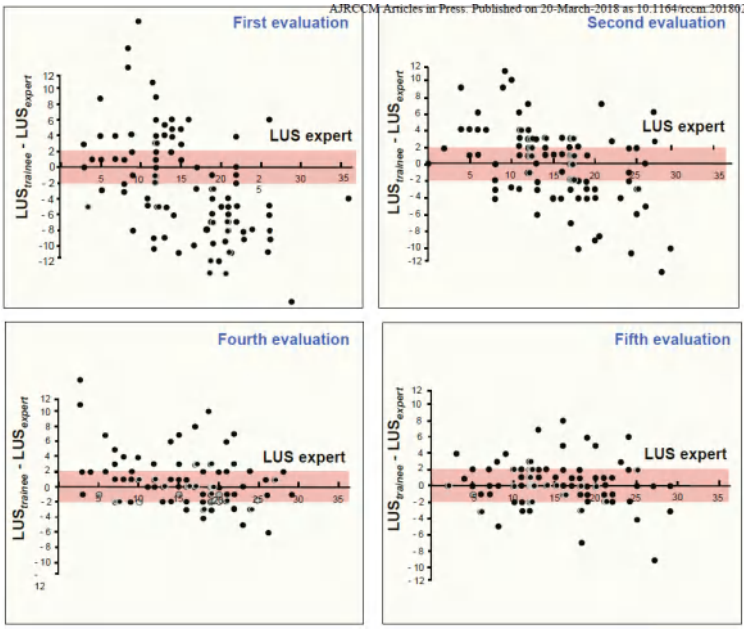


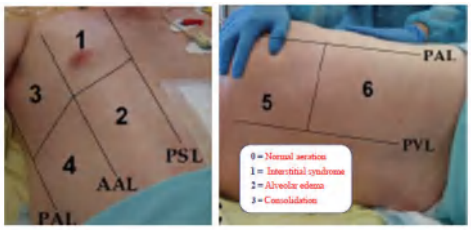


- 病人左右前胸壁、侧胸壁及后胸壁的上下部共12个肺区进行检查，最后将各分区的肺超声评分相加,总分共36分。

Training for Lung Ultrasound Score Measurement in Critically Ill Patients

AJRCCM Articles in Press. Published on 20-March-2018 as 10.1164/rccm.201801





Jean-Jacques Rouby, M.D., Ph.D.
Charlotte Arbelot, M.D.,
Multidisciplinary Intensive Care Unit, Department of Anesthesiology and Critical Care Medicine, La Pitié-Salpêtrière hospital, Assistance Publique Hôpitaux de Paris, University Pierre and Marie Curie Paris 6, France

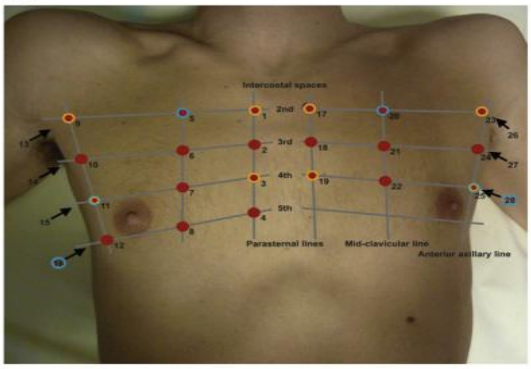
Yuzhi Gao, M.D.
Mao Zhang, M.D., Ph.D.
Emergency Intensive Care Unit, Department of Emergency Medicine, 2nd Affiliated Hospital, Zhejiang University School of Medicine, Institute of Emergency Medicine, Zhejiang University, Hangzhou, China

Am J Respir Crit Care Med. 2018 Mar 20

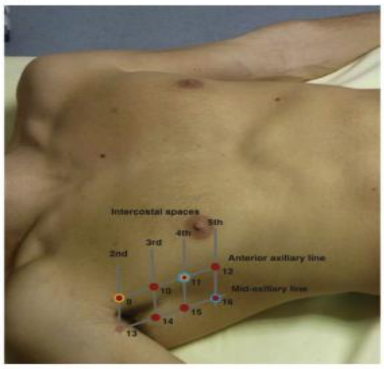
Accuracy of Several Lung Ultrasound Methods for the Diagnosis of Acute Heart Failure in the ED

A Multicenter Prospective Study

A



B



28-point method

8-point method

6-point method

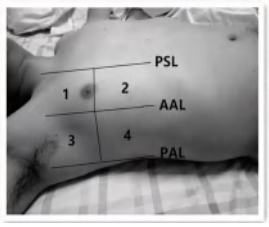
and 4-point method

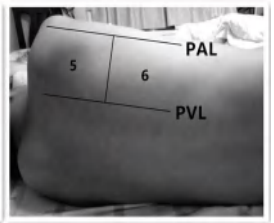
- In patients with diagnostic uncertainty, the 6-point/8-point LUS method (using the 1 bilateral positive point threshold) improves AHF diagnosis accuracy on top of the BREST score

Chest. 2019 Aug 2

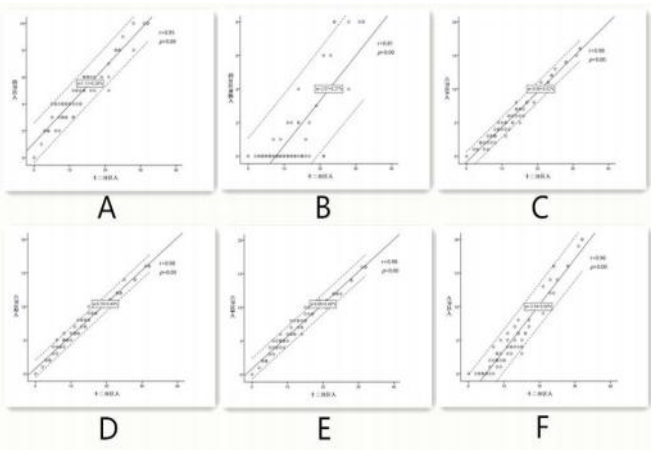
简化肺超声评分在危重病人肺损伤动态评估中的初步评估

[摘要] 目的 探讨肺超声简化分区评分在危重病人肺损伤动态评估中的价值。方法 前瞻性观察浙江大学医学院附属第二医院 2017 年 7~8 月急诊监护室（EICU）收住的 64 例病人，应用多普勒超声进行法国肺十二分区法评分，记录治疗前及治疗后肺超声评分，同时记录氧合指数、ICU 住院时间、APACHE Ⅱ、PEEP。比较各简化肺超声分区与十二分区的相关性，以及治疗前后各观察指标的变化。筛选出与十二分区相关性高，更简易的分区评分方法。结果 64 例病人治疗前及治疗后简化四分区与十二分区相关性高（P<0.05）。其中存活组





	分区部位
八分区	右1、2、3、4，左1、2、3、4
六分区Ⅰ	右1、3、5，左1、3、5
六分区Ⅱ	右1、4、6，左1、4、6
六分区Ⅲ	右2、4、6，左2、4、6
前胸部四分区	右1、2，左1、2
四分区	右1、6，左1、6

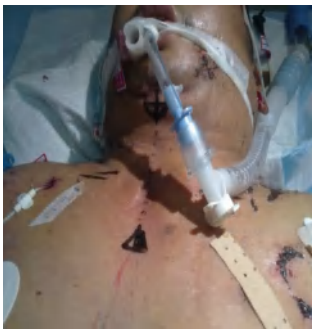


✓ 应用6：协助人工气道建立和定位

ANZICS

Ultrasound may potentially assist by:

- Defining the relevant anatomy;
- Identifying tracheal midline;
- Identifying blood vessels adjacent to the PDT insertion site reducing risk of bleeding;
- Estimating trachea depth from the skin surface and tracheal diameter thus assisting tracheostomy tube size selection;
- Ensuring accurate placement of needle into the trachea; and
- Identifying patients unsuitable for PDT.

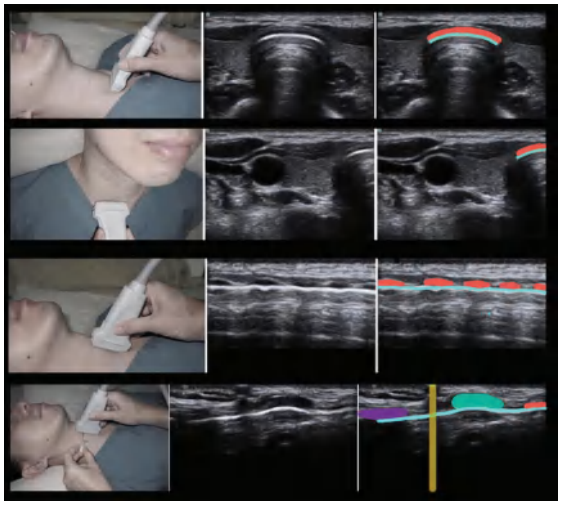


Can J Anesth/J Can Anesth (2018) 65:473–484
https://doi.org/10.1007/s12630-018-1064-8

CrossMark

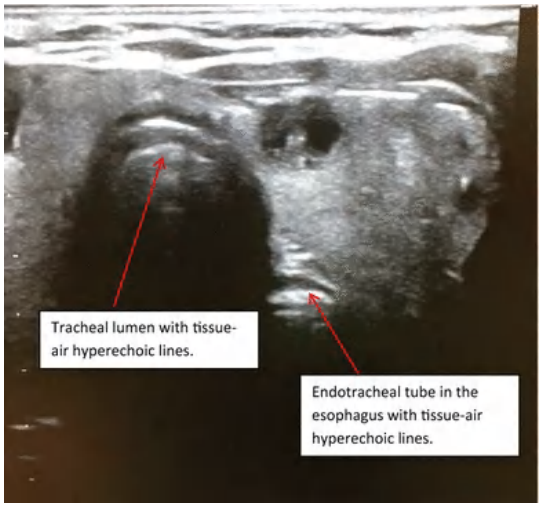
REVIEW ARTICLE/BRIEF REVIEW

Point-of-care ultrasound (POCUS) of the upper airway
Échographie au point d'intervention (PoCUS) des voies respiratoires supérieures



Anatomical structure examined	Clinical indications	Type of study*
Cricothyroid membrane and trachea	Pre-anesthetic airway evaluation to be prepared for emergency front of neck airway access[5,6]	Randomized-controlled trial, prospective cohort, narrative review
	For elective tracheostomy[9] and other kinds of access to the airway via the anterior neck[1]	Randomized-controlled trial, prospective cohort
Tracheal placement of endotracheal tube	Evaluation of the placement of a breathing tube, in trachea, main-stem bronchus or esophagus[10,11]	Randomized-controlled trial, prospective cohort and observational, systematic review, meta-analysis
Trachea	Predicting the optimal size of endotracheal, double-lumen, and tracheostomy-tubes[12-14]	Randomized-controlled trial, prospective cohort and observational, case series
Vocal cords	Identification of vocal cord palsy and other pathology[15,16]	Prospective cohort and observational

超声引导提高经皮气管切开的安全性



Can J Anaesth. 2018 Apr;65(4):473-484

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Point of care ultrasound for orotracheal tube placement assessment in out-of hospital setting☆

Sabina Zadel[a], Matej Strnad[a,d], Gregor Prosen[a,b,c], Dušan Mekiš[d,e,f,*]

	Auscultation	POCUS	Auscultation & POCUS
Sensitivity, % (95% CI)	100 (0.52, 1)	100 (0.52, 1)	100 (0.52, 1)
Specificity, % (95% CI)	90 (0.83, 0.94)	100 (0.96, 1)	100 (0.96, 1)
PPV, % (95% CI)	38 (0.18, 0.62)	100 (0.52, 1)	100 (0.52,1)
NPV, % (95% CI)	100 (0.95, 1)	100 (0.96, 1)	100 (0.96, 1)

PPV, positive predicive value; NPV, netive predicive value; 95% CI, 95% interval of confidence.

Resuscitation. 2015 Feb;87:1-6

✓ 应用7：急性呼吸困难/呼吸衰竭的综合应用

呼吸困难诊断、评估与处理的专家共识

呼吸困难诊断、评估与处理的专家共识组

急性呼吸困难患者

The Speed of Sound | Ultrasound Protocol for Evaluating Acute Dyspnea

中华超声影像学杂志 2018 年 11 月第 27 卷第 11 期 Chin J Ultrasonogr ,November 2018 ,Vol 27 ,No 11

·综述·

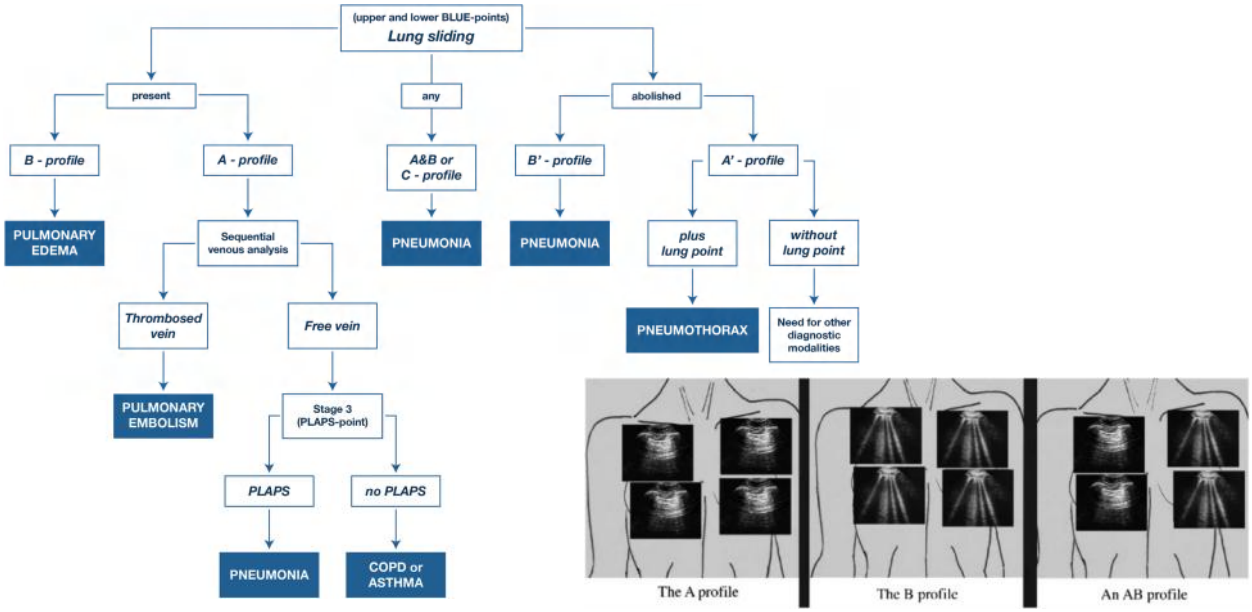
肺超声导向的急性呼吸窘迫综合征个体化诊疗

高玉芝 刘少云 吴春双 卢晓 张茂

Application of lung ultrasound in the individualized diagnosis and treatment of acute respiratory distress syndrome *Gao Yuzhi ,Liu Shaoyun ,Wu Chunshuang ,Lu Xiao ,Zhang Mao .Department of Emergency Medicine ,Second Hospital Affiliated Zhejiang University School of Medicine ;Research Institute of Emergency Medicine ,Zhejiang University ,Hangzhou 310009 ,China*

Corresponding author :Zhang Mao ,Email z2jzk@zju.edu.cn

Relevance of Lung Ultrasound in the Diagnosis of Acute Respiratory Failure *: The BLUE Protocol



CHEST 2008; 134:117–125
Intensive Care Med (2019) 45:1200–1211

Relevance of Lung Ultrasound in the Diagnosis of Acute Respiratory Failure *: The BLUE Protocol

TABLE 2] Accuracy of the BLUE-Protocol

Mechanism of Dyspnea	Profiles of BLUE-Protocol	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Acute hemodynamic pulmonary edema	B-profile	97	95	87	99
Exacerbated COPD or severe acute asthma	Nude profile (A-profile with no DVT and no PLAPS)	89	97	93	95
Pulmonary embolism	A-profile with DVT	81	99	94	98
Pneumothorax	A′-profile (with lung point)	88	100	100	99
Pneumonia	The four profiles	89	94	88	95
	B′-profile	11	100	100	70
	A/B profile	14.5	100	100	71.5
	C-profile	21.5	99	90	73
	A-no-V-PLAPS-profile	42	96	83	78

BLUE = bedside lung ultrasound in emergency; NPV = negative predictive value; PLAPS = posterolateral alveolar and/or pleural syndrome; PPV = positive predictive value. (Adapted from Lichtenstein and Mezière.[61])

CHEST 2008; 134:117–125
Intensive Care Med (2019) 45:1200–1211

Immediate versus delayed integrated *point-of-care-ultrasonography* to manage acute dyspnea in the emergency department

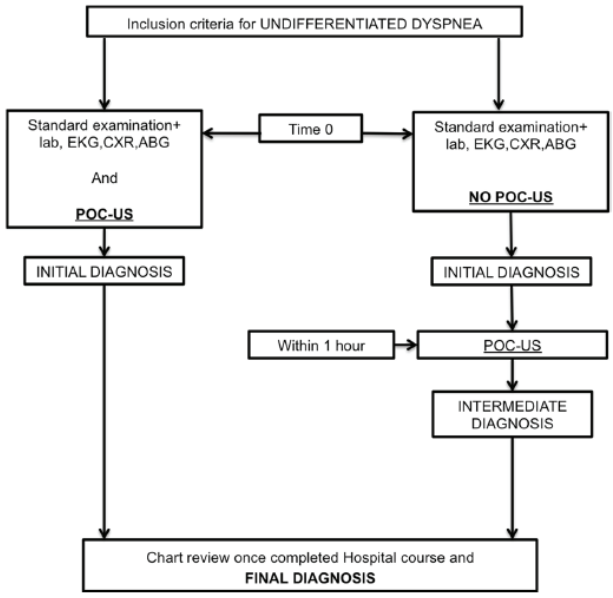


Table 3 POC-US patterns and the corresponding combination of ultrasonography findings

POC-US pattern	Signs
AHF	Interstitial lung syndrome (the presence of multiple diffuse bilateral B-lines indicates interstitial syndrome) with reduced EF of the left ventricle or preserved EF with diastolic dysfunction
Pneumonia	Subpleural echo-poor region or one with tissue-like echo texture, with additional signs such as air/fluid bronchograms and adjacent B-lines (focal interstitial syndrome)
ARDS	Interstitial lung syndrome (the presence of multiple diffuse bilateral B-lines indicates interstitial syndrome), with non-homogeneous distribution of B-lines and spared areas, and normal systolic and diastolic function of the left ventricle
Massive pleural effusion	Anechoic space between parietal and visceral pleural and respiratory movement of the lung within the effusion
Possible pulmonary embolism	Dilated, hypokinetic RV with systolic septal dyskinesia plus dilated IVC with low collapsibility index (only found in massive or sub-massive pulmonary embolism) and eventually positive CUS of the groin or calf veins

Critical Ultrasound Journal 2014, 6:5

Immediate versus delayed integrated *point-of-care-ultrasonography* to manage acute dyspnea in the emergency department

肺超声大大提高急诊室急性呼吸困难的诊断准确性

Table 5 Sensitivity and specificity of POC-US and standard protocol in diagnosis of acute dyspnea

	After POC-US (G1 + G2)[a]		Standard protocol (G2)[a]		After POC-US (G2)[a]	
Diagnosis	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)
AHF	100	99	78.2	67.7	100	98.4
ECOPD/asthma	93	99	55.5	90.9	94.4	100
Pneumonia	92	98	14.2	97.1	93.3	98.5
ARDS	100	99	16.6	100	100	100
Massive pleural effusion	100	100	16.6	100	100	100
Acute pulmonary embolism	89	100	0	98.8	83.3	100

[a] The diagnosis after POC-US is the initial diagnosis for group 1 (G1) and the intermediate diagnosis for group 2 (G2), the diagnosis after standard protocol is the initial diagnosis for G2. *AHF*, acute heart failure; *ECOPD*, exacerbation of chronic obstructive pulmonary disease; *ARDS*, acute respiratory distress syndrome.

Critical Ultrasound Journal 2014, 6:5

Chest
Volume 151, Issue 6, June 2017, Pages 1295-1301

Original Research: Pulmonary Procedures

Point-of-Care Ultrasonography for Evaluation of Acute Dyspnea in the ED

Table 3. Concordance between US diagnosis and ED diagnosis

Diagnosis	K
Heart failure	0.810
Acute coronary syndrome	0.706
Pneumonia	0.788
Pleural effusion	0.730
Pericardial effusion	0.858
COPD/Asthma	0.845
Pulmonary embolism	0.549
Pneumothorax	0.903
ARDS/ALI	0.294
Other	0.628
Total	0.711

超声应用大大降低急诊室急性呼吸困难的诊断时间

A total of 2,683 patients were enrolled. The average time needed to formulate the ultrasound diagnosis was significantly lower than that required for ED diagnosis (24 ± 10 min vs 186 ± 72 min; *P* = .025). The ultrasound and the ED diagnoses showed good overall concordance (κ = 0.71). There were no statistically significant differences in the accuracy of PoCUS and the standard ED evaluation for the diagnosis of acute coronary syndrome, pneumonia, pleural effusion, pericardial effusion, pneumothorax, and dyspnea from other causes. PoCUS was significantly more sensitive for the diagnosis of heart failure, whereas a standard ED evaluation performed better in the diagnosis of COPD/asthma and pulmonary embolism.

Chest. 2017 Jun;151(6):1295-1301

四、展望：肺超声与人工智能

Brusasco et al. Critical Care (2019) 23:288
https://doi.org/10.1186/s13054-019-2569-4

Critical Care

RESEARCH Open Access

Quantitative lung ultrasonography: a putative new algorithm for automatic detection and quantification of B-lines

Claudia Brusasco[1], Gregorio Santori[2], Elisa Bruzzo[3], Rosella Trò[3], Chiara Robba[4], Guido Tavazzi[5], Fabio Guarracino[6], Francesco Forfori[7], Patrizia Boccacci[3] and Francesco Corradi[8,7*]

Localizing B-lines in Lung Ultrasonography by Weakly-Supervised Deep Learning, *in-vivo* results

Ruud JG van Sloun, *Member, IEEE* and Libertario Demi, *Member, IEEE*

Auto B-line:
Highlights and counts B-lines in real-time, tracks segmental lung assessment and shows trends in response to therapy.

Auto VTI:
Helps assess flow through the left ventricular outflow tract by calculating the velocity time integral and cardiac output in a single step.

Auto IVC:
Measures IVC diameter changes and displays real-time results of respiratory cycles.

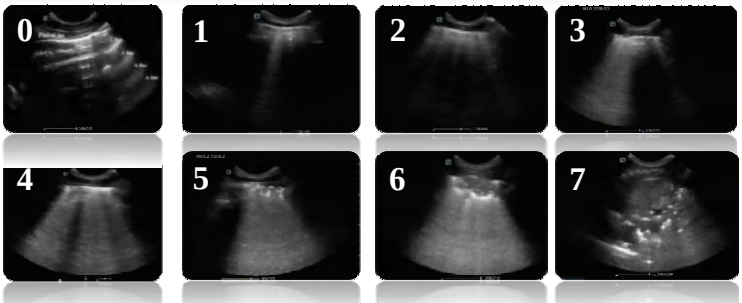
Crit Care. 2019 Aug 28;23(1):288.
IEEE J Biomed Health Inform. 2019 Aug 19

肺冲击伤超声评估标准及人工智能辅助诊断的研究

超声图像采集和记录

手持超声机

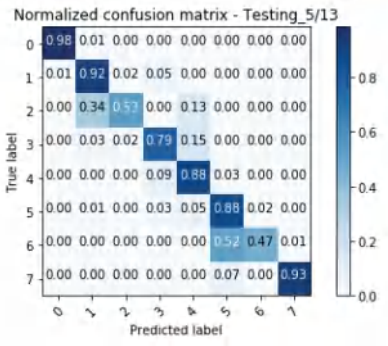
专家评价



细化肺超声评分

初步结果：

- 算法框架：Resnet 50，可初步建立肺超声人工智能辅助诊断的优化模型，实现对肺超声图像自动识别和量化评分 ；
- 以超声专家团队对肺超声图像的评分作为金标准，评价模型的总体诊断准确度达89.6%。




```
Testing_Err_rate_0_5/13: 0.015426497277676976
Testing_Err_rate_1_5/13: 0.08134490238611713
Testing_Err_rate_2_5/13: 0.46808510638297873
Testing_Err_rate_3_5/13: 0.20833333333333337
Testing_Err_rate_4_5/13: 0.11612903225806448
Testing_Err_rate_5_5/13: 0.12347560975609762
Testing_Err_rate_6_5/13: 0.5348837209302326
Testing_Err_rate_7_5/13: 0.0714285714285714
Overall_Testing_Err_rate_5/13: 0.10311011487811717
Overall_Testing_Accuracy_5/13: 0.8968898851218828
```

第四次训练模型测试结果

- ◆ 超声的优势促使在急性呼吸衰竭中应用
- ◆ 要熟悉肺超声的基本征象
- ◆ 肺超声基本征象组合有助于呼吸衰竭评估
- ◆ 肺超声与人工智能技术结合是发展趋势