Journal of Clinical Anesthesia 48 (2018) 62–66

Contents lists available at ScienceDirect

Journal of Clinical Anesthesia

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

Original contribution

Incorporation of point-of-care ultrasound into morning round is associated with improvement in clinical outcomes in critically ill patients with sepsis

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ARTICLE INFO

Keywords:
Point of care ultrasound
Sepsis
Length of stay
Mortality

ABSTRACT

Objectives: Point-of-care ultrasound (POCUS) has been widely used in the intensive care unit (ICU). However, it is largely unknown whether the use of POCUS is associated with improved patient-important outcomes. The study aimed to investigate whether incorporation of POCUS during morning round on a routine basis was able to improve clinical outcomes in critically ill patients with sepsis.
Design: It was a prospective observational study.
Setting: A tertiary care emergency intensive care unit.
Patients: All patients admitted to the emergency ICU from January 2016 to December 2017 were screened for potential eligibility. Sepsis was defined as infection plus signs of organ dysfunction.
Intervention: The intervention group incorporated POCUS during morning round on a routine basis, and a checklist was developed to improve the compliance. The control group did not have the mandates to perform POCUS during morning round, but could use POCUS when necessary.
Measurements: Clinical outcomes of mortality, length of stay in ICU, durations of vasopressors and mechanical ventilation were compared between the intervention and control groups. Multivariable regression model was employed to adjust for confounding factors.
Main results: A total of 129 subjects, including 88 in the control group and 41 in the intervention group, were included for analysis. Univariate analysis showed that the intervention group had shorter durations of mechanical ventilation (MV) (4.5 ± 1.2 vs. 5.7 ± 1.0 days; $p = 0.034$) and more negative fluid balance (−143 vs. 48 ml/24 h; $p = 0.003$) on day 3. In multivariable model, routine incorporation of POCUS was associated with lower risk of prolonged (> 7 days) ICU stay (OR: 0.39, 95% CI: 0.29–0.88; $p = 0.029$).
Conclusions: The study showed that incorporation of POCUS during morning round on a routine basis was associated with shortened duration of MV and length of stay in ICU. The possible mechanism underlying the relationship may be via reduced fluid administration. Future randomized controlled trials are needed to validate current findings.

1. Introduction

Patients with severe sepsis and/or septic shock are at increased risk of death [1,2]. This group of patients usually requires admission to the intensive care unit (ICU) for close monitoring and supportive therapy [3–7]. Point-of-care ultrasound (POCUS) is increasing used in ICU in recent years and has been found to be useful in obtaining valuable information to aid medical decision making [8–10]. It is not simply an extension of physical examination. The American College of Emergency Physicians (ACEP) defines clinical ultrasonography as a diagnostic modality that provides clinically significant data not obtainable by inspection, palpation, auscultation, or other components of the physical examination. There was evidence that ultrasound examination revealed a high prevalence of unsuspected clinical abnormalities, especially in patients with septic shock [11]. However, recent trials used ultrasound in an on-demand pattern. In other words, ultrasound examination was performed for patient only when there were signs and symptoms of hemodynamic and/or respiratory deterioration [12]. Furthermore, current practice typically uses ultrasound when a patient is under unstable stage, but not at late stage when blood pressure and respiratory conditions are stabilized. Thus, we hypothesized that routine POCUS during morning round could help to improve patients'outcomes.

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https://doi.org/10.1016/j.jclinane.2018.05.010
Received 8 March 2018; Received in revised form 2 May 2018; Accepted 3 May 2018

2. Materials and methods

2.1. Patient selection

It was a prospective case-control study. All patients admitted to the emergency ICU from January 2016 to December 2017 were screened for potential eligibility on admission. Patients were prospectively screened and enrolled. In the intervention group, Patients with sepsis were included for routine POCUS examination as described below. Sepsis was defined as infection plus signs of organ dysfunction [13]. The diagnosis was recorded in the electronic healthcare record and data could be extracted for research purpose. ICD-9 code for acute organ failure and infection had been defined elsewhere and we adapted it to the present study [14–16]. Patients were excluded if they fulfil one of the following criteria: 1) pregnancy; 2) advanced stage of malignancy; 3) younger than 18 years old; 4) missing values on mortality outcome; and 5) patients who signed do-not-resuscitate order. The study was approved by the ethics committee of Sir Run-Run Shaw hospital. Informed consent was obtained from providers. The study was reported according to the STROBE checklist.

2.2. Intervention and control group

There were three medical teams in our emergency ICU. There was one attending, two fellows and three residents in each of the three teams. Two teams (control group) did not incorporate POCUS as routine in morning round, but they could use ultrasound as needed during management of some circumstances such as hemodynamic instability and sudden respiratory failure. One team (intervention group) incorporated POCUS as a routine during morning round, irrespective of the condition of the patients.

Providers in the intervention group received a one-week training for the use of POCUS according to the course endorsed by WINFOCUS international. The program includes operation of ultrasound device (M9, Mindray), interpretation of normal and pathological images to assess pleural effusion, hydronephrosis, free peritoneal and pericardial fluid, proximal deep venous thrombosis, pulmonary and first-grade cardiac ultrasound. Lung ultrasound was critical in assessing fluid status of a patient, and the training course included specific signs such as lung sliding, B-line and A-line. These signs were shown to the trainees not only in training materials, but also in real patient. Approximately half of the time was spent performing imaging under supervision. To make sure POCUS was performed routinely during morning round, there was a structured daily goal checklist for the performance of POCUS, which was developed under international guidelines of critical care ultrasonography (Table 1) [17,18]. All items listed in the check list were performed for patients with sepsis in the intervention group. The POCUS findings (images were archived in the ultrasound machine), and relevant changes in treatment were recorded in the progress notes, and were reviewed at 1-month interval in a meeting. Inappropriate changes in treatment according to POCUS findings were discussed to improve the quality of care.

2.3. Variable selection

The Acute Physiology and Chronic Health Evaluation (APACHE) II score measured on the first 24 h after ICU admission was recorded. Demographic data such as age and gender were obtained from electronic healthcare record (EHR). Fluid balance (FB) was calculated as the difference between fluid intake and output. FB for the first 3 days were obtained. Patient type was recorded as whether a patient was transferred to ICU after surgery or not. Infection sites were recorded as lung, blood, abdominal cavity, gastrointestinal tract, urinary tract and others. If there were two infection sites, the primary site as determined by attending physician was used. Mechanical ventilation and vasopressor use were obtained from nursing sheets.

2.4. Outcomes

The primary outcome was hospital mortality defined as the vital status at hospital discharge. ICU length of stay (LOS) was defined as the time interval during one episode of hospital stay. If a patient returned to ICU within 48 h after transferring to floor ward, the two episodes of ICU stays were combined as one. Durations of mechanical ventilation was defined as those with positive pressure support (e.g. including both invasive and non-invasive ventilation). Reintubation within 48 h would be considered as one session of mechanical ventilation when considering duration of mechanical ventilation. Vasopressors include norepinephrine, epinephrine, phenylephrine and dopamine > 5 μg/kg/min [19]. The duration of vasopressor use was the time difference between the initiation and discontinuation of any type of vasopressors. Discontinuation was defined as the cessation of vasopressors for over 48 h without hemodynamic deterioration.

2.5. Statistical analysis

This was an exploratory study that power analysis was not performed. Continuous data were first examined for their distributions. Normal data were expressed as mean and standard deviation, and were compared using student *t*-test between the intervention and control groups. Non-normal data were expressed as median and interquartile range, and were compared using Mann-Whitney *U* test. Categorical data were expressed as the number and proportions, and were compared using Chi-square test [20,21]. Multivariable logistic regression model was built to control for possible confounding factors [22]. Variables considered as potential confounders were APACHE II score, age, use of mechanical ventilation, use of vasopressors, infection site and fluid balance through day 3. The model was not used for prediction purpose,

Table 1
Checklist and daily goal for the performance of point-of-care ultrasound in the intensive care unit.

Regions	Purpose	Daily goal
Pleural cavity	Identify pleural effusion, pneumothorax	Large pleural effusion suspected to compromise respiratory compliance should be drained; pneumothorax should also be drained
Lung parenchyma	B-line; consolidation;	Fluid restriction if cardiac dysfunction and multiple B-lines
Abdomen	Ascites; mechanical causes of Anuria/Oliguria	Paracentesis; urinary catherization; call urologist for mechanical causes of Anuria/Oliguria
Deep vein	Deep vein thrombosis	Call vascular surgeon if necessary
IVC collapsibility	> 15% for mechanically ventilated patients; > 50% collapsibility for non-ventilated patients.	Fluid replacement may be needed, consider with other parameters
LV systolic function	EF > 60% or < 40%	Fluid management to improve systolic function; inotropes
RV function	Acute RV failure due to fluid overload	Fluid restriction; possible inotropes
Pulmonary artery pressure	Identify pulmonary hypertension	Outcome prediction; fluid management goal; PE suspected
Pericardial cavity	Pericardial effusion	Pericardiocentesis if necessary

Abbreviations: IVC: inferior vena cava; LV: left ventricle; EF: ejection fraction; RV: right ventricle.