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Research Article

Comparing transesophageal Doppler corrected systolic flow time versus central venous pressure as a guide for fluid resuscitation in septic shock

Walid Hamimy, Ahmed Mukhtar, Ahmed Zaghloul *, Mahmoud Salem

Department of Anesthesia, Surgical Intensive Care and Pain Treatment, Cairo University, Egypt

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KEYWORDS

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Abstract *Background:* Aortic corrected flow time (FTc) is easily measured by Doppler techniques. Recent data using transesophageal Doppler suggest that it may predict fluid responsiveness in critical care. This use of FTc has not previously been evaluated in septic shock, and only one preliminary study has incorporated transcutaneously measured FTc, denoting its importance in prediction of fluid responsiveness in septic patient. Furthermore, no comparison has been made between transesophageal FTc and central venous pressure (CVP).

Objective: The aim of our study was to compare the impact of using FTc versus CVP as a guide for fluid resuscitation in septic shock on stroke volume denoting cardiac responsiveness for fluid administration.

Methods: This was a prospective study of 46 consecutive adult septic shock patients (in sinus rhythm). 44 patients were mechanically ventilated, treated with intravenous fluid challenge (500 mL over 15 min), guided with CVP in control group and guided by FTC in Doppler group assessment incorporating transesophageal aortic Doppler (CardioQ®) measurements in a surgical tertiary intensive care unit. Stroke volume (SV), mechanical ventilation days, length of stay and mortality of both groups were recorded.

Results: Fourty one patients demonstrated an increase in stroke volume (SV) by more than 10% (fluid responders) while five patients were non responders. There were statistically significant increases in SV after 1 h post resuscitation in the Doppler group as the values were 63.87 ± 25.87 & 81.39 ± 35.02 in the control group and the Doppler group respectively (p value = 0.034). There were statistically significant differences in FTc values after 1 h [397.00 (390.00–404.00) & 362.00 (351.00–377.00)] between non-responders and responders respectively (p value was 0.003) and after 6 h [377.00 (376.00–378.00) & 330.00 (314.00–353.00)] between non-responders and responders respectively (p value was 0.007).

Conclusion: Transesophageal aortic Doppler is a simple, non-invasive tool of guiding fluid therapy in patients with severe sepsis and septic shock. FTC change was a better predictor of fluid responsiveness than CVP in septic shock. There was higher significant difference in SV after resuscitation when using FTC as guidance.

* Corresponding author. Address: 5 Naser street, Fatma Rushdi, AlHaram. Tel.: +20 1001839591.

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1. Introduction

Septic shock is an extremely complex disorder whose deranged hemodynamics results from the interplay of hypovolemia, vasodilatation, peripheral blood pooling, and extravasation of fluid into the interstitial space.

Intravenous fluids remain the cornerstone of treating patients with septic shock. The goal of fluid resuscitation in severe sepsis and septic shock is not merely achieving a predetermined value, but rather optimizing systemic oxygen delivery (cardiac preload, afterload, arterial oxygen content, contractility or stroke volume) [1].

Many factors may contribute to these findings, including physiologic compensatory mechanisms. These mechanisms often mask the true nature of blood flow. For example, whereas a patient may have a significant decrease in cardiac output (CO), the initial compensatory response of reflex vasoconstriction results in increased systemic vascular resistance and a normal blood pressure. The compensatory effects inhibit the clinician's ability to assess decreased blood flow and oxygen delivery accurately [2–4].

Surprisingly, dosing intravenous fluid during resuscitation of shock remains largely empirical. Too little fluid may result in tissue hypoperfusion and worsen organ dysfunction; however, over-prescription of fluid also appears to impede oxygen delivery and compromise patient outcome. Several studies demonstrated that positive fluid balance was associated with increased mortality and the duration of mechanical ventilation [5,6].

In a randomized controlled, single-center study, early quantitative resuscitation improved survival for emergency department patients presented with septic shock [7].

The 2012 Surviving Sepsis Guidelines suggest the infusion of intravenous fluids until achieving a central venous pressure of 8–12 mmHg and raise this target to 12–15 mmHg in patients with mechanical ventilation [8].

However, there are no recommendations as to when it is appropriate to discontinue or to reduce the rate of administration of intravenous fluid.

The measurement of descending aortic blood flow via an esophageal ultrasound probe offers an alternative method of monitoring circulatory status. Measured parameters include peak velocity (PV) and systolic flow time [FTc, corrected for heart rate (HR)]. PV ($cm\ s^{-1}$) is an index of left ventricular contractility while FTc reflects ventricular preload. Concurrent changes in PV and FTc reflect changes in afterload. The technique has been validated extensively compared with pulmonary artery catheters and is now widely used in adult anesthesia and intensive care units practice [8,9].

To the best of our knowledge there is only one published small study on the use of transcutaneous FTc in patients with septic shock [9].

Optimal fluid loading after cardiac surgery or early in the course of septic shock also may ameliorate morbidity and mortality [10].

Taken together, fluid therapy should aim at physiologically and clinically relevant endpoints, in order to improve outcome, but further refinement of these endpoints seems warranted [1].

We tried to compare the impact of using FTc versus CVP as a guide for fluid resuscitation in septic shock on stroke volume denoting cardiac responsiveness for fluid administration.

2. Patients and methods

This study was conducted in the surgical intensive care unit (SICU), at the faculty of medicine, Cairo University (Egypt), from November 2012 to February 2014.

Out of 350 patients admitted to the surgical intensive care unit (SICU), 46 septic patients met the inclusion criteria and were enrolled in the study.

The study was done after approval by local ethics committee and after obtaining written informed consent from the patients' next of kin.

2.1. Study population

2.1.1. Inclusion criteria

1. Ventilated patients who met the criteria of septic shock [8].
2. Mean arterial pressure $\leqslant$60 mmHg after at least a 1000 mL crystalloid bolus.

2.1.2. Exclusion criteria

1. Age less than 18 years.
2. Cardiac rhythm other than sinus.
3. Moderate to severe valvular heart disease.
4. Pregnant patients.
5. Patients who were on hemodialysis.
6. Relative contraindications to the use of the esophageal Doppler probe, such as orofacial and esophageal injury or other known oropharyngeal and esophageal disease.
7. Late stages of sepsis i.e. hypotension persisted >12 h or received previous fluid resuscitation.

2.1.3. Randomization

Patients who met the inclusion criteria were randomly assigned to the protocol group (Doppler) or the control group using computer generated number. Randomization was concealed using sequentially numbered, sealed opaque envelope technique. There were no restrictions or stratification in the randomization process. The allocation envelope was opened by the attending resident at the time of ICU admission. Data were analyzed on an intention-to-treat basis and included all patients who were randomly assigned.

2.2. Study protocol

2.2.1. Control group

The patients received 500 mL of normal saline every 15 min till the CVP reached 12–15 mmHg with maximum administration of 60 mL/kg.

2.2.2. Doppler group

The patient received 500 mL of normal saline every 15 min till the FTc $\geqslant$350 ms with maximum administration of 60 mL/kg

2.2.3. In both groups

If the mean arterial pressure is less than 65 mmHg, norepinephrine was given in a dose of 0.1–0.7 μg/kg/min to maintain a mean arterial pressure of at least 65 mmHg. If the