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Optimized fluid management improves outcomes of pediatric burn patients

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ABSTRACT

Background: One of the major determinants for survival of severely burned patients is appropriate fluid resuscitation. At present, fluid resuscitation is calculated based on body weight or body surface area, burn size, and urinary output. However, recent evidence suggests that fluid calculation is inadequate and that over- and under-resuscitations are associated with increased morbidity and mortality. We hypothesize that optimizing fluid administration during the critical initial phase using a transcardiopulmonary thermodilution monitoring device (pulse contour cardiac output [PiCCO]; Pulsion Medical Systems, Munich, Germany) would have beneficial effects on the outcome of burned patients.
Methods: A cohort of 76 severely burned pediatric patients with burns over 30% of the total body surface area who received adjusted fluid resuscitation using the PiCCO system were compared with 76 conventionally monitored patients (C). Clinical hemodynamic measurements, organ function (DENVER2 score), and biomarkers were recorded prospectively for the first 20 d after burn injury.
Results: Both cohorts were similar in demographic and injury characteristics. Patients in the PiCCO group received significantly less fluids ($P < 0.05$) with similar urinary output, resulting in a significantly lower positive fluid balance ($P < 0.05$). The central venous pressure in the PiCCO group was maintained in a more controlled range ($P < 0.05$), associated with a significantly lower heart rate and significantly lower incidence of cardiac and renal failure ($P < 0.05$).
Conclusions: Fluid resuscitation guided by transcardiopulmonary thermodilution during hospitalization represents an effective adjunct and is associated with beneficial effects on postburn morbidity.

1. Introduction

One of the major determinants for survival of severely burned patients is appropriate fluid resuscitation during the initial phase after injury [1,2]. It has been shown that unbalanced administration of fluid volume immediately after injury during the acute phase results in significantly higher mortality and complication rates [3]. Over-

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resuscitation leads to dramatic fluid accumulation with edema formation and complications such as abdominal compartment syndrome or cerebral edema [4]. Under-resuscitation is associated with hemodynamic instability and organ hypoperfusion, leading to organ failure and poor clinical outcome [5]. It is therefore imperative to reevaluate strategies to administer the right amount of fluid to maintain vital organ perfusion without causing fluid overload a massive edema formation [6].

The amount of fluid resuscitation is calculated based on burn size, body weight, body surface, and urinary output, which is often inaccurate and leads to failure in resuscitation volume [7–9]. To improve resuscitation, invasive methods to assess the fluid balance such as the measurement of central venous pressure (CVP) and the use of pulmonary artery catheters were introduced, but these methods are not delivering specific parameters [10,11]. In the present study, we therefore examined a novel monitoring device that provides more detailed information, the pulse contour cardiac output (PiCCO) (Pulsion Medical Systems, Munich, Germany). PiCCO uses the technique of thermodilution according to the Stewart–Hamilton method to assess volumetric parameters and allows the intermittent measurement of cardiac output [12]. Additionally, the PiCCO system measures the cardiac index (CI), intrathoracic blood volume index (ITBVI), extravascular lung water index (EVLWI), and systemic vascular resistance index (SVRI). These parameters give specific results of the fluid demands and fluid shifts, and we hypothesized that monitoring and evaluating these data can result in an optimized balance for the patient [12]. The aim of this study was to determine that the use of the PiCCO system and consecutively adjusted fluid management has positive impact on the hospital course, morbidity, and mortality in severely burned children.

2. Materials and methods

This cohort study analyzed 76 pediatric patients with severe burns over 30% of the total body surface area (TBSA) receiving resuscitation guided by transcardiopulmonary thermodilution (PiCCO group) monitoring compared with 76 conventionally (conventional group) resuscitated patients over the first 20 d with similar demographics and injury characteristics. The PiCCO cohort was matched with control patients for age, gender, and injury characteristics. Patients were admitted to the burn unit between March 1998 and June 2008 (control) and December 2005 and August 2008 (PiCCO). All patients were resuscitated according to the Galveston formula with 5000 cc/m^2 TBSA burned + 2000 cc/m^2 TBSA lactated Ringer solution given in increments over the first 24 h. After 24 h, the fluid need was calculated by 3750 mL/m^2 body surface area burn/d + 1500 mL/m^2 body surface area/d in the control group. Resuscitation within the PiCCO group was adjusted by the outcomes of the transcardiopulmonary thermodilution measurements of CI, EVLWI, and ITBVI after the initial 24 h. Therapeutic targets were to reach normal ranges, especially to maintain EVLWI <10. Therefore, the PiCCO-derived parameters were used to guide treatment decisions of the attending physician on the administration of fluids and inotrope substances according to the decision model shown in Fig. 1.

Within 48 h of admission, all patients underwent total burn wound excision, and the wounds were covered by autograft. Any remaining open areas were covered with homograft. This procedure was repeated until all burn areas were covered with autografts and donor sites were healed.

All patients underwent the same nutritional treatment according to a standardized protocol. The intake was calculated as 1500 kcal/m^2 body surface + 1500 kcal/m^2 area burn as previously published [13–15]. The nutritional route of choice in our patient population was enteral nutrition via a duodenal (Dobhoff) or nasogastric tube. Parenteral nutrition was only given in rare instances if the patient could not tolerate tube feeds.

2.1. PiCCO measurements

All patients had a central venous central line and an arterial (mostly femoral artery) access placed on initial admission. Transpulmonary thermodilution measurements were performed using the Pulsiocath 3- or 4-French thermistor–tipped catheters (Pulsion Medical Systems, Munich, Germany). To determine CI, ITBVI, EVLWI, and SVRI, 10 mL of cooled saline solution (0°C–6°C) was injected into the central venous circulation using the venous access. Injections were manual and not coordinated with the respiratory cycle. Measurement procedures of each patient were performed at least twice daily. Each procedure consisted of three injections via the venous access, and all saline boluses were administered

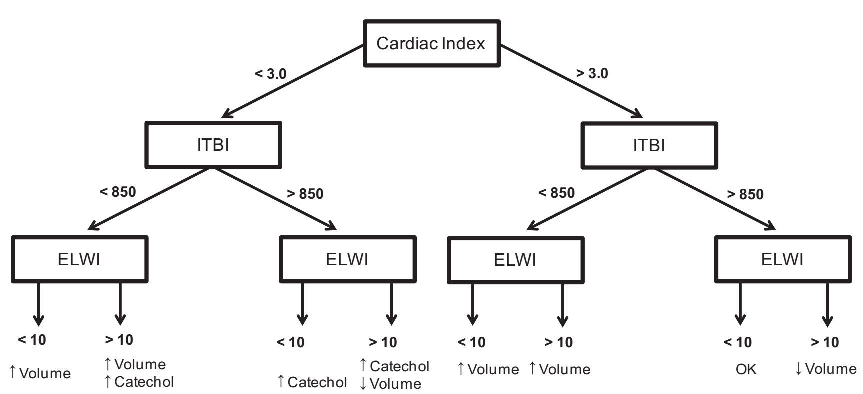

Fig. 1 – Decision tree for the adjustment of fluid and catecholamine therapy according to PiCCO-derived parameters adjusted according to the manufacturer's recommendations [12].