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Fluid Management Using Cardiometry in ARDS Patients

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Fluid management is a complicated subject and one of the most difficult facets of medical care. Fluid balance has been shown to improve respiratory physiology for acute respiratory distress syndrome (ARDS) patients. The aim of this study was to assess the role of electrical cardiometry (EC) in fluid management in ARDS.
Methods: This pilot interventional study was carried on 15 patients who were 18 years or older and fulfill the Berlin definition of ARDS. Fluid management was guided by EC.
Results: ICU stay has a mean value of 13.67 ± 4.58 days and duration of MV has with a mean value of 10.27 ± 4.34 days. Lung injury score decreased significantly at 7, 14, 21, 28 days when compared to baseline. Intravenous fluid intake had significantly decreased in 4,5,6,7 days when compared to the 1st day. Urine output has significantly decreased in 5,6,7 days when compared to the 1st day. Hemodynamic instability was in 20% of patients, heart failure in 13.3% of patients, sepsis in 20.0% of patients and organ failure in 26.7% with no renal failure and no arrythmia.
Conclusions: EC was effective in the fluid management in ARDS as regards decreasing 28th day mortality, LIS, fluid intake, duration of MV and ICU stay.

Keywords: Electrical cardiometry; fluid management; acute respiratory distress syndrome.

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1. INTRODUCTION

Acute respiratory distress syndrome (ARDS) is a life-threatening condition characterized by poor oxygenation and non-compliant or "stiff" lungs. The disorder is associated with capillary endothelial injury and diffuse alveolar damage. Once ARDS develops, patients usually have varying degrees of pulmonary artery vasoconstriction and may subsequently develop pulmonary hypertension [1].

ARDS carries a high mortality, and few effective therapeutic modalities exist to ameliorate this deadly condition. This activity reviews the clinical presentation, evaluation, and management of acute respiratory distress syndrome and highlights the importance of coordinated interprofessional teamwork in caring for patients with this condition [2].

The diagnosis of ARDS depends upon the exclusion of cardiogenic pulmonary edema as well as several other competing etiologies (e.g., acute eosinophilic pneumonia). Similarly, ARDS may be complicated by conditions including pneumothorax, ventilator-associated pneumonia, or pulmonary embolism. Reasonably excluding such etiologies is appropriate before discontinuing LTVV and resorting to additional strategies [3].

Fluid management is a critical aspect of patient care, especially in the inpatient medical setting. What makes fluid management both challenging and interesting is that each patient demands careful consideration of their individual fluid needs [4-6]. Unfortunately, it is impossible to apply a single, perfect formula universally to all patients. However, one general principle for all patient scenarios is to replace whatever fluid is being lost as accurately as possible. These fluid losses can differ depending on patients' medical conditions and differ by both volume and composition [7].

Fluid balance has been demonstrated to benefit ARDS patients' respiratory physiology [8]. However, numerous investigations have demonstrated that these indices are incapable of correctly predicting fluid responsiveness [9]. Instead, while time-varying indicators such as pulse pressure variation, systolic pressure fluctuation, stroke volume variation (SVV), and pleth variability index (PVI) have been acknowledged as efficient predictors of fluid responsiveness for ventilated patients, dynamic indicators like these have been previously overlooked. SVV has been demonstrated to be the most trustworthy of these indicators for determining volume status in chronic patients [10].

Bernstein and Osypka developed and described the technical background of electrical cardiometry (EC), a new model for interpreting thoracic bioimpedance [11]. EC is a technique used to determine the stroke volume (SV),CO, and other hemodynamic parameters in adults, children, and newborns [12].

The aim of this study was to assess the role of EC in fluid management in ARDS.

2. MATERIAL AND METHODS

This pilot interventional study was carried out on 15 patients with ARDS who underwent EC-guided fluid management in Tanta University Hospital - Egypt at surgical intensive care unit (SICU) from January 2020 to December 2020.

Patients included in this study were 18 years of age or older and met the Berlin criteria of mild to moderate ARDS. Hemodynamic instability, vasopressor usage, barotrauma, or organ/s malfunction at presentation or throughout pregnancy were excluded as exclusion criteria.

All patients were ventilated according to basal ventilator strategy of ARDS- network protocol [13] using volume assist-control mode, with tidal volume 4 to 8 mL/kg predicted body weight, an inspiratory plateau pressure < 30 cmH_2O. The ventilator rate was adjusted to achieve a pH >7.25 to 7.44, maximum respiratory rate 35 cycle/min. FiO_2 levels were manipulated to maintain peripheral oxygen saturation between 90 and 95% or PaO_2 between 60 and 80 mmHg. Titration of PEEP according to FiO_2 as recommended by ARDS-network.

2.1 Electrical Cardiometry

EC monitor was attached to the sensor cable and patient data were sent into it (ICON Cardiotronics, Inc., La Jolla, CA 92307; Osyka Medical GmbH, Berlin, and Germany, model C3, serial number 1725303). The corrected flow time (FTC) and SV were continuously monitored. Fluids were allowed using the FTc algorithm, and the kind of bolus fluids was decided by the transthoracic fluid content (TFC). Vasopressors and inotropes were given in line with the EC, SVR, and ICON.

2.2 Measurements

Parameters of oxygenation by lung injury score (LIS), total intravenous fluid intake and urine output were recorded at the beginning of the study inclusion, 12 hours post-inclusion, and then on day 1, 2, 3, 4, 5, 6, 7, 14, 21, and 28.

Incidence of mortality at 28th day, duration of MV, duration of ICU stay, weaning categories and adverse effects (such as hemodynamic instability, or organ/s failure) were recorded.

2.3. Statistical Analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric data were presented as mean and standard deviation (SD) and were compared by repeated measured ANOVA. Quantitative non-parametric data were presented as median and interquartile range (IQR). Qualitative variables were presented as frequency and percentage (%).

3. RESULTS

Patients' characteristics of the studied patients. Table 1.

ICU stay has a mean value of 13.67 ± 4.58, duration of MV (days) was with a mean value of 10.27 ± 4.34, MV free days (days) with a median (IQR) 5 (0-6), Weaning categories were simple, difficult and prolonged. Table 2.

Lung injury score decreased significantly at 7, 14, 21, 28 days when compared to baseline Fig. 1.

Intravenous fluid intake had significantly decreased in 4,5,6,7 days when compared to the 1st day. Fig. 2.

Urine output has significantly decreased in 5,6,7 days when compared to the 1st day. Fig. 3.

As regard complication, hemodynamic instability was in 20% of patients, heart failure in 13.3% of patients, sepsis in 20.0% of patients, organ failure in 26.7% with no renal failure and no arrythmia.

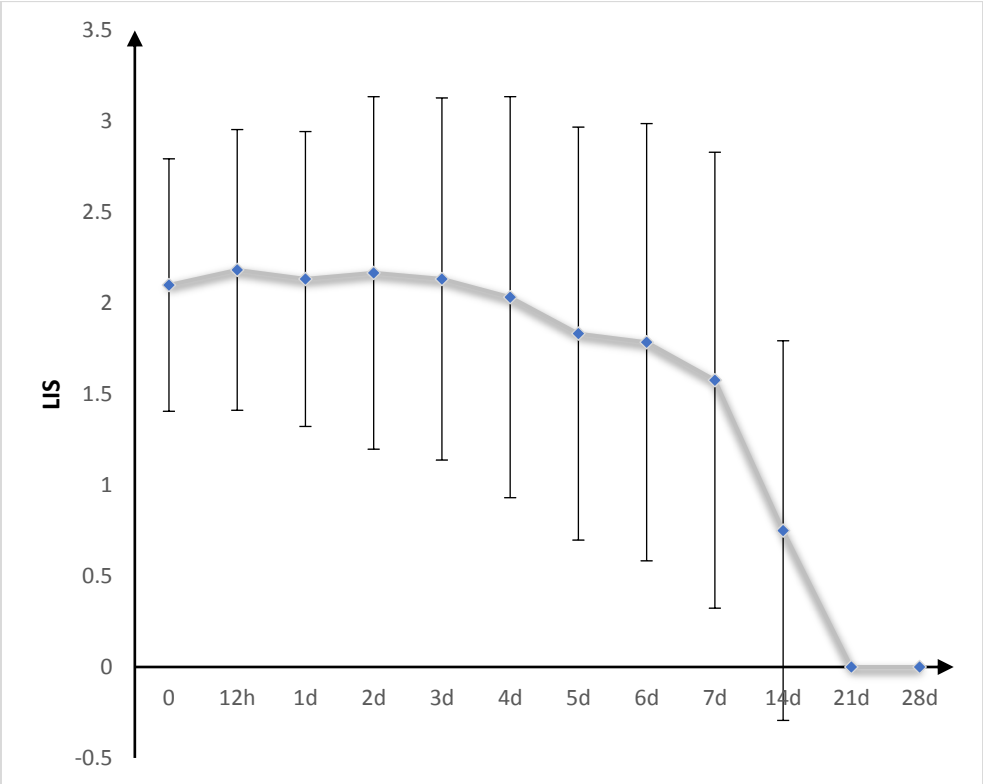

Fig. 1. Lung injury score (LIS) in the studied patients

Table 1. Patients' characteristics

		EC group (n = 15)
Age (years)		48.6 ±11.96
BMI (kg/mm^2)		27.27 ± 3.59
Sex	**Male**	4 (26.67%)
	Female	11 (73.33%)
Cause of ARDS	**Pneumonia**	12 (80.00%)
	Aspiration	3 (20.00%)
Severity of ARDS	**Mild**	9 (60.00%)
	Moderate	6 (40.00%)

Data are presented as Mean ± SD or frequency (percent), BMI: body mass index, ARDS: acute respiratory distress syndrome

Table 2. ICU stay, duration of MV, MV free days and weaning in the studied patients

		EC group (n = 15)
ICU stay (days)		13.67 ± 4.58
Duration of MV (days)		10.27 ± 4.34
MV free days (days)		5 (0-6)
Successful weaning		13 (87%)
Weaning categories	**Simple**	1 (7%)
	Difficult	9 (60%)
	Prolonged	2 (13%)

Data are presented as Mean ± SD or Median (IQR) or frequency (percent), ICU: intensive care unit, MV: mechanical ventilation

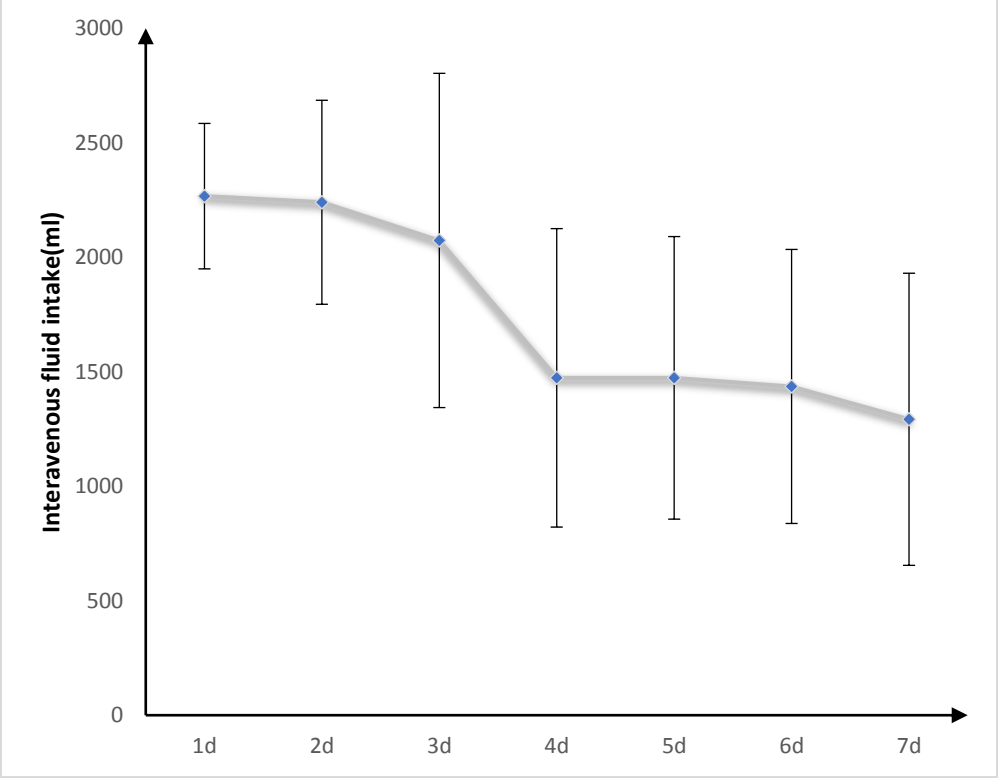

Fig. 2. Intravenous fluid intake (ml) in the studied patients

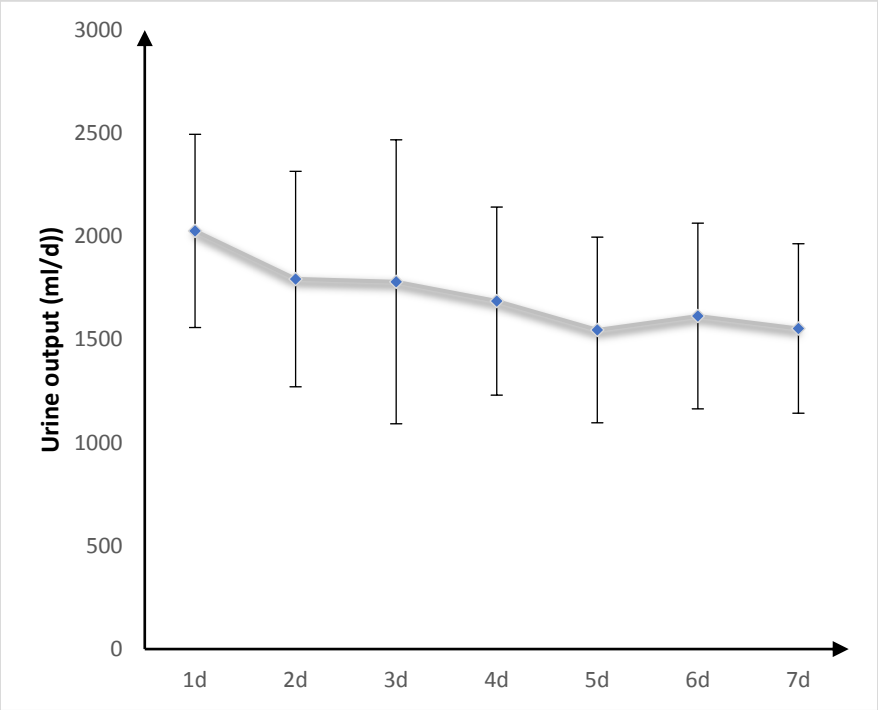

Fig. 3. Urine output (ml/d) of the studied patients

4. DISCUSSION

To our knowledge, this is the first study to examine the role of EC in ARDS patients. The development of a technology for continuous monitoring of SV and CO that is noninvasive, safe, reliable, and easy to use would be a monumental advancement for research and clinical use. The EC shows accuracy and precision in studies of healthy volunteers. However, the reliability of perioperative use is not proven especially with skin incision, which may be a source of error in bioimpedance measurements [14].

EC has been validated to monitor CO and other hemodynamic parameters non-invasively compared to different techniques such as thermodilution technique [15,16], transesophageal Doppler echocardiography and cardiac catheterization including critically ill patients [16,17], intra-operative settings, in pregnant women, in children with congenital heart diseases, even in obese children. Elgebaly et al. [18] For noninvasive continuous CO monitoring after lobectomy or pneumonectomy, EC was compared to transthoracic echocardiography (TTE). In contrast to the TTE, the EC provided accurate and reliable CO, SV, and HR measurements before to and after lung surgery.

However, in disagreement to the accuracy of EC, Cox et al. [14] demonstrated that cardiac index (CI) obtained by continuous pulmonary artery thermodilution catheter and CI obtained by EC are not interchangeable in cardiac surgical patients. This difference may be related to the skin incision done in cardiac surgeries.

The improvement in outcome seen in our study with the EC-guided fluid management patients may be a result of the more restricted fluid intake. Fluid overload has been linked to organ failure and is well recognized as a major predictor of poor outcomes. Consistent evidence indicates that fluid restriction may be associated with better outcomes, especially in critical illness and ARDS [19-21].

This was in accordance with, Afandy et al. [22] compared echocardiography (echo) derived indices to Indicators generated from EC in the therapy of septic patients. The EC-guided treatment group had a substantially lower mortality rate than the Early Goal Directed Therapy (EGDT) group. The EC group, on the other hand, required a longer period to wean off vasopressors and MV, as well as a lengthier stay in the ICU and hospital.

In disagreement to our results, Gerent et al. [23] assessed EC on patients receiving high-risk

surgery for cancer treatment. Between the EC and standard care groups, there were no significant changes in mortality or any of the secondary outcomes (septic shock, ICU readmission, ICU stay) [24-27]. There was no significant difference in ICU or hospital stay, which may be explained by controlling preload through fluid loading until pressure pulse variation (PPV) was 10% in both groups.

The study's limitations include a limited sample size, a single-center design, and a follow-up period of just 28 days.

5. CONCLUSIONS

EC was effective in the fluid management in ARDS as regards decreasing 28th day mortality, LIS, fluid intake, duration of MV and ICU stay.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

Written informed consent had been obtained from the patients' relatives.

ETHICAL APPROVAL

The study was done after approval from institutional ethics committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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