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Original Research Article

Intraoperative fluid management in septic shock of abdominal origin guided by Fick´s formula vs ΔPCO2

Vania Romero*, Rosa M. Flores, Hugo E. Meneses

Department of Anaesthesiology, Mexican Social Security Institute, Puebla, Mexico

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***Correspondence:**
Dr. Vania Romero,
E-mail: vann200796@gmail.com

ABSTRACT

Background: In the main causes of morbidity and mortality in world is sepsis. Dynamic evaluations have more accurate predicting fluid response.
Methods: It has made an observational, comparative, prospective, longitudinal and unicentric study. We included both sexes with 30-75 years and diagnosis of septic shock secondary to abdominal surgical pathology requiring surgical intervention. The sample was 36 patients. Two groups were be integrated; one group will be managed with Fick's Formula and the other with ΔPCO2 with an equal number of participants in both groups, were aleatory, each group had 18 patients, three arterial and venous blood gas samples will be taken (pre-anesthetic, trans anesthetic and postanesthetic) to guide fluid management by means of cardiac output. Statistical analysis was made with, descriptive analysis for categorical variables with measures of central tendency and dispersion; inferential analysis for numerical variables with one-way Anova for comparison amount fluid administered guided by the formulas at the beginning, at a one hour and at the end of the surgical procedure subsequently Pearson's correlation was applied.
Results: When evaluating the amount of liquid administered in both groups by one-way ANOVA, no statistically significant difference was found, since the level of significance of both Fick's formula and ΔPCO2 in their three measurements is higher to 0.05. We found for both high correlation with Pearson.
Conclusions: There is no difference between the use of Fick´s formula or ΔPCO2. Regarding the liquids management, it is easier to apply ΔPCO2.

Keywords: Septic shock, PCO2 Delta, Fick´s formula

INTRODUCTION

Septic shock mortality is 20% to >40% in low-income countries for a deficient diagnosis and management.[1] Surgery and anesthesia modify the hemodynamic state and alter the perfusion of target organs. An adequate monitoring allows a reduction in postoperative morbidity and mortality, hospitalization time, costs and it´s also a medical-legal obligation.[2] Fluid administration is essential to improve cardiac output and the optimization continuous as a challenge.[3] Previously Management was guided by serum lactate, ScvO2 and capillary filling. Sepsis-3 in 2016 recommended maintaining MAP>65 mmHg and normalizing lactate. However, they investigated the effectiveness and showed a mortality increase; the administration of boluses, goal therapy or excessive fluids are associated with organ dysfunction and death. Dynamic evaluations are more precise to guide treatment and reducing mortality.[3,4] The ratio of ΔPCO2 over arterial to venous oxygen is a good indicator of tissue hypoxia, a surrogate for CO.[5] Fick´s formula reflects the extraction of oxygen from the systemic circulation and depends of the arterial oxygen levels, pulmonary artery, hemoglobin and the maximum oxygen

consumed in a period.[6] Developing countries struggle with poor access to monitoring equipment and technology. Although there are multiple studies comparing invasive monitoring with indirect measurement tools, few compare the performance of indirect measurement tools between them.[7,8]

The objective of this study is to know which tool between Fick's formula and ΔPCO2 has the best performance to guide fluids administration in patients with septic shock of abdominal origin during the intraoperative period.

METHODS

Study design

An observational, comparative, prospective, longitudinal and single center study was carried out. It was held at IMSS (Mexican Social Security Institute) in the HGZ no. 20 in Puebla.

Study duration

The study period was from March 2023 to October 2023.

Inclusion criteria

Patients between 30 and 75 years of age, of both sexes, with a diagnosis of septic shock of abdominal origin, who required surgical intervention and will have a functional central venous catheter to be able to take samples, were included.

Exclusion criteria

Exclusion criteria avoid patients at the extremes of life such as pediatric and geriatric patients; in order to minimize possible physiological variations in response to the administration of fluids and medications of each age group.

Sample size

Since this protocol was approved by the local health research committee (CLIS), 36 patients were recruited as a minimum sample. The sampling was consecutive, 2 groups were integrated; one group was managed with Fick's formula and the other group with Delta CO2 with an equal number of participants in both groups, each group was made up of 18 patients who were chosen randomly.

Three arterial and venous blood gas samples were taken to guide your fluid management through cardiac output. Both groups had continuous type I monitoring, the vital sings taken at 5 minutes. All patients were managed under balanced general anesthesia; the first radial arterial blood gas analysis was taken when the anesthesia was established with a heparinized insulin syringe, we take 1 ml of blood and 3 ml of blood from a central venous catheter to measure the variables; subsequently repeating this procedure at the time and at the end of the surgical procedure. Fluid management was guided according to the formulas, when cardiac output was increased the fluid administration was decreased and if cardiac output was low the fluids were increased and if was normal the same management continued; at the inverse form with delta Co2 if this increased, we increase the fluids and if it was normal the same management was continued.

The amount of volume administered was completely at the discretion of the anesthesiologist, the quantity in milliliters depending on the patient's ideal weight and associated comorbidities guiding this calculation and administration based to obtain optimal parameters (GC 2.6–3.2 l/min/m2 and ΔCO2 <6 mmHg).

Statistical analysis

The statistical analysis was carried out for the sample with, descriptive analysis for categorical variables with measures of central tendency and dispersion; inferential analysis for numerical variables with one-way of Anova for comparison the means of quantity liquid administered guided with ΔPCO2 and Fick's formulas at the beginning and subsequently correlation with P Pearson was applied finding differences of groups.

RESULTS

Descriptive statistics

The sample is made up of 36 eligible subjects with septic shock of abdominal origin at the General Hospital of Zone no. 20 of IMSS in Puebla. The Fick´s method sample had a mean age of 52 years (SD 15.73097), of which seven (38.8%) were male and eleven (61.1%) females.

Cardiac output by Fick´s method with a mean of 6.8 l/min initially and 7.6 at the end with a positive correlation of 0.74 (Table 1). The ΔCO2 method sample had a mean age of 52 years (SD 15.73097), of which twelve (66.6%) were male and six (33.3%) female. The initially mean with ΔCO2 was 8-3 and 5.6 at the end whit a correlation of 0.78; with a minimum reported of 5.6 initially and a maximum of 14 at the end (Table 2).

Unidirectional analysis with ANOVA

Patients were categorized according to the formula applied. Authors categorize the patients according to the applied formula. At the evaluation in both groups for the quantity liquid administration with ANOVA, weren´t find a statistically significant difference, because the significance of both in the tree measurements are 0.5, being the highest value was Fick 1 and Delta 1.

Regarding of the final measurements, the median of Fick´s formula and ΔPCO2 were similar 5.07 and 5.62

respectively with a highest deviation in ΔPCO2 with 2.6 (Table 4, Figure 1).

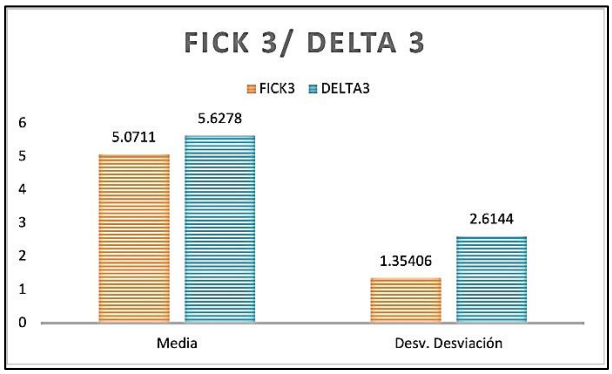

Figure 1: Analysis of mean and deviation of final results in a group of Fick and Delta Co2 patients.

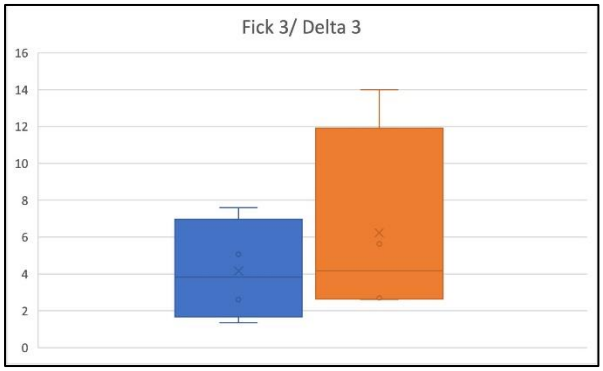

Figure 2: Analysis of mean and deviation of final results in a group of Fick and Delta Co2 patients.

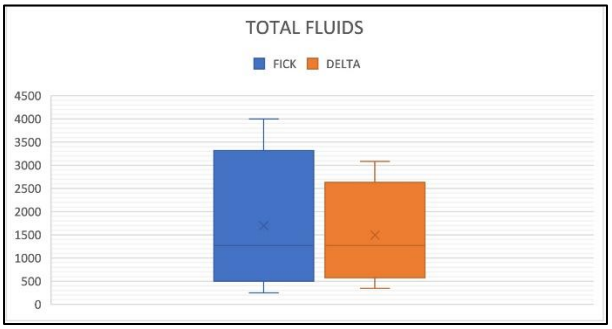

Figure 3: Analysis of total fluids administered to both groups of patients.

In the graphic number two shows like the median despite being similar, are not equal and shows the difference between them in a better way, however, by applying the standard deviation this difference between the two becomes even smaller. Also, it shows two patients from both groups had different behavior from the rest of their group. Failing achieving the objectives (Figure 2). In the following graph shows the total fluids administered to patients in both groups, the median being similar with a significant deviation with a maximum of liquids in Fick of 4.0 liters and in Delta of 3.08 liters (Figure 3).

Table 1: Descriptive statistics of variable age of general hospital of zone no 20. participating patients in this study.

N	N	Mean	Standard deviation
Fick age	18	52.2778	15.73097
Deltas age	18	52.2778	15.73097

Table 2: Descriptive statistics of variable age of patients to whom the delta formula was applied at the general hospital of zone no 20, and average delta at the beginning, 2 hours and at the end of the trans anesthetic.

Significance	
FICK 1	0.055
FICK 2	0.834
FICK 3	0.543
DELTA 1	0.086
DELTA 2	0.558
DELTA 3	0.283

Table 3: Analysis of variance between Fick and Delta of Co2 with ANOVA.

	Minimum	Maximum	Mean	Standard deviation
FICK 3	2.6	7.6	5.0711	1.35406
DELTA 3	2.7	14	5.6278	2.6144

Table 4: Means and deviations of Fick and Delta Co2.

	Minimum	Maximum	Mean	Standard deviation
FICK 3	2.6	7.6	5.0711	1.35406
DELTA 3	2.7	14	5.6278	2.6144

Table 5: Analysis of total fluids administered to both groups of patients.

		Liquidos
FICK 3	Pearson	0.084
	Sig. (bilateral)	0.739
	N	18
DELTA 3	Pearson	0.073
	Sig. (bilateral)	0.774
	N	18
LIQUIDOS	Pearson	1
	Sig. (bilateral)	
	N	36

Correlation analysis

Pearson correlation was applied, finding a high correlation for both, with Fick's method we found a

positive correlation of 0.74 and for ΔPCO2 of 0.78, which means that there was an adequate response to liquids management of both formulas (Table 5).

DISCUSSION

According to the study by Riesbeck et al in 2022 where the Lvad correlation of Hearthmate 3 was compared with Fick's method, there was no significant difference, being like what was obtained in our study. Riesbeck comments that decisions should not be regulated based on any of the two tools, on the contrary should be guided by an invasive method, for example such as the Swanganz; which is optimal for this type of patient, however it is suboptimal in some hospitals because it is not possible to have this type of tools in all hospital units, even if they are tertiary care units and the Swanganz is a static tooling.[9]

During this study we pretending tended to reduce tissue hypoxia with both tools. In this group of patients with septic shock it is possible that in those cases with advanced tissue hypoxia have massive and transcendental decrease in VO2, anaerobic sources of CO2 tend to take on less relevance compared to aerobic sources that are also drastically decreased, which translates into a very important reduction in the VCO2 /VO2 ratio. In Mallat's study refers that elevated ΔPCO2 may not reflect the degree of tissue hypoperfusion, regarding which we disagree because although isn´t a specific parameter of tissue hypoperfusion, this method supports to reflect indirectly the cardiac output and therefore the tissue perfusion that the patient presents at that moment.[10]

In a study by Tsman et al, where they also conclude that ΔPCO2 estimation it´s a feasible technique for continuous and non-invasive perioperative hemodynamic evaluation of patients undergoing cardiac surgery, which extrapolated to patients undergoing non-cardiac surgery where pulmonary and cardiac blood flows, as well as vascular resistance are less compromised, makes the tool a little more precise because don't have those altered variants.[11]

Among the limitations when carrying out this study, it was observed that two patients from both groups behaved differently from the rest. When investigating these events, it was observed that the variable of age and fluids were an important point since one patient was in the extreme age accepted in our study and in another a large amount of fluids had been administered during trans anesthesia.

In addition to possible heart failure that occurred during intraoperative management. All of this is interesting for creating new protocols that further unify the age groups, clinical conditions and, as a curious fact, a correlation study between trends in fluid management and the ages of the anesthesiologists who provided the management.

CONCLUSION

No significant difference was found between the use of Fick´s formula or ΔPCO2 respect to fluid management, this makes the use of these two formulas promising in units that don´t have another type of hemodynamic monitoring, in addition to invasive monitoring also represents certain added risks to the patient or as an alternative in case of failure of invasive monitoring during the trans operative period, since CO monitoring is very important to guide hemodynamic management in unstable patients such as septic shock, reducing the extravasation, damage to the glycocalyx and improving patient survival. However, when using the formulas, ΔPCO2 is more practical as it requires less time to use; time that is not available with these critical patients, who require different management and care during the trans anesthetic period; in addition to its greater ease in learning and remembering the formula.

Finally, we consider more studies are needed compare non-invasive tools and without technology with each other; since all developing countries face various shortcomings in hospital units, however, this should not be a limiting to provide the best management within our reach to patients and improve trans and post-operative morbidity and mortality of critically ill patients.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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