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# AN ELECTROCARDIOMETRIC EVALUATION OF DYNAMIC CARDIAC PARAMETERS TO ASSESS FLUID RESPONSIVENESS IN MAJOR NON-CARDIAC SURGERY.

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**ABSTRACT** This study was done to assess the fluid responsiveness as per hemodynamic categorisation (fluid responder or non-responder) using electrocardiometry in a tertiary hospital in Central India during major non cardiac surgery. **Methodology:** This study was a prospective observational study done in a tertiary medical college in central India from May 2021-November 2022 on total of 30 patients . **Observation And Results:** In this study, out of 30 patients, 18 patients who had experienced an event of hypotension were hemodynamically categorized into fluid responders and non responders. 10 patients were fluid responders and 8 patients were non responders. ECG, pulse oximetry, and non-invasive blood pressure monitor were applied before induction of anaesthesia while capnography was applied after induction of anaesthesia. ICON monitor measured Heart rate (HR), Stroke volume (SV), Cardiac Index (CI), Stroke volume variation (SVV), Systemic vascular resistance (SVR), Index of contractility (ICON), Thoracic fluid content (TFC) were measured. Mean arterial pressure (MAP), stroke volume (SV), SVR decreased in both fluid responders and non responders after hypotension, while Cardiac index (CI) increased in fluid responders but decreased in non responders after hypotension. ICON decreased in fluid responders but showed an increase in non responders after an event of hypotension. After a fluid challenge Pulse rate ( PR) decreased in both fluid responders as well as non responders. Similarly Stroke volume variation (SVV) decreased in both the groups but was significant in responders. MAP of a responder increased more than that of a non responder, whereas TFC decreased in both the groups. ICON decreased in responder but there was an increase in non responder. Increase in SVR was observed in responder but it decreased in non responder.

**KEYWORDS :** Electrocardiometry, fluid responsiveness.

## INTRODUCTION:

Fluid therapy plays an important and lifesaving role in perioperative management and remains a cornerstone in hemodynamic stabilization in unstable patients [1] [2]. Over the past few decades, there has been continuous debate about the optimum perioperative fluid therapy. This gave rise to three strategies of fluid management: the “liberal”, “restricted”, and “goal-directed” fluid therapy strategy.

Clinical studies have consistently demonstrated that only about 50% of hemodynamically unstable patients are volume responsive. It is therefore essential to have reliable bedside tools to predict the efficacy of volume expansion and distinguish the patients who might benefit from volume expansion from those in whom treatment is likely to be inefficacious [3]. Similarly, in major surgeries, characterized by fluid shifts, inadequate fluid replacement might lead to impaired tissue perfusion and postoperative organ dysfunction and over infusion might lead to tissue edema which would again prove detrimental [3].

A meta-analysis conducted by Sanders et al concluded that monitoring changes in cardiac output is relevant in clinical practice to measure the effect of an intervention and EC fulfils as an acceptable trend monitor despite its inability to measure absolute cardiac output values [4]. A comparative study by Yoshida et al concluded that EC can be a useful gadget for safe delivery management in high-risk pregnant patients [5]. Other studies like Effat et al, Malik et al have proven usefulness of EC though it may not be a replacement of beat-to-beat measurement [3] [6].

In this study, Electro cardiometry was used to assess the fluid responsiveness as per hemodynamic categorization, whether the patient is fluid responder or non-responder.

## METHODOLOGY:

This study was a prospective observational study was carried out prospectively in Department of Anesthesiology in a tertiary care hospital after getting approval from ethical committee of institution during period May 2021-November 2022. Sample size is calculated with taking the proportion of intraoperative hypotension in patients undergoing non-cardiac surgeries [7].

A total of 30 patients were selected amongst the patients admitted via Surgery, Obstetrics and Gynaecology and Otorhinolaryngology posted for major surgery, both Elective and Emergency.

**Inclusion criteria:**

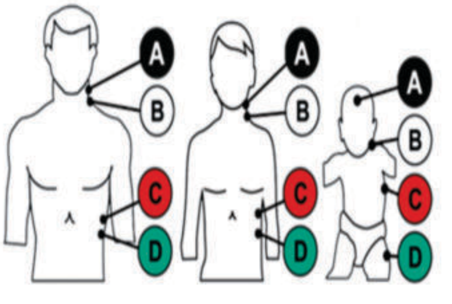
Adult patients of age 18-65 years, ASA grade I-1V and weighing between 50 to 80kg posted for major surgical procedure, either elective or emergency procedures, under general anaesthesia.

**Exclusion criteria:**

Contraindication to fluid challenge, defined as evidence of blood volume overload and/ or hydrostatic pulmonary edema prior to procedure, Active substance abuse (alcohol /tobacco products) and severe depression on medications, Patients with implantable cardiac pacemaker, defibrillator or dysrhythmia, Severe Heart Failure, BMI > 30 Kg/m2.

Electrical cardiometry device (ICON; Cardiotronic, Osypka; Berlin, Germany) was applied to the patient through 4 electrodes at the following sites:

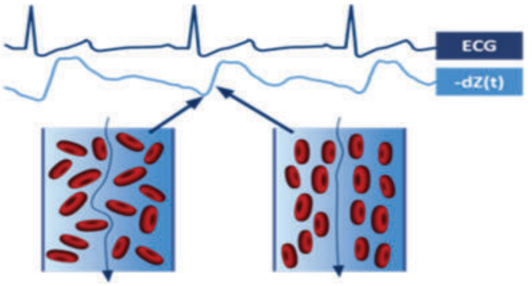
1. below the left ear
2. above the midpoint of the left clavicle
3. left midaxillary line on the horizontal level of the xiphoid process
4. 5 cm below the third electrode.




After entering demographic data and BP, ICON monitor measured HR, SV, CI, SVV, SVR, ICON, TFC. All the data was obtained by averaging data of previous 10 heartbeats as baseline parameters.

It is based on thoracic electrical bioimpedance (TEB). Placement of four skin sensors permits continuous measurement of changes of the thoracic electrical bioimpedance (TEB). By sending a low amplitude, high frequency electrical current through the thorax, the resistance (or impedance) which the current is facing (due to several factors) is measured [6].


It assumes that the underlying phenomenon of the characteristic change in thoracic impedance (or conductivity) during each cardiac cycle is the change in orientation of the erythrocytes (RBCs) when subjected to pulsatile flow [8] [6]. By analysing the rate of change in conductivity before and after aortic valve opening, or in other words, how fast the RBCs are aligning, EC technology derives the peak aortic acceleration of blood and the left ventricular ejection time (flow time) [9][10][11].




**Intraoperative hypotension:**
Patients were considered to be in hypotension when MAP was less than 65 mm hg or 20% below the baseline values. [12] [13]

**Categorization of patients:**
All patients having hypotension were first given a fluid challenge of Ringer lactate at 10 ml /kg over 10 minutes. If the stroke volume, or cardiac index increased by 10-15% after fluid challenge, the patient was considered fluid responder and the remaining ones as non-responders. [14] Stroke volume variation, which is a dynamic parameter was used for the evaluation of fluid responsiveness [15].

Quantitative variables are expressed in term of Mean + Standard deviation and categorical variables were expressed in terms of frequency and percentage. Pearson correlation coefficient was used to find the correlation between two quantitative variables. Mann Whitney U test was used to compare percentage change between fluid responders and non-responders, both during the event of hypotension and post fluid challenge.. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS, IBM Corp., Armonk, NY, USA) version 21.

**Observation (TABLES):**
Mean age was 46.43 +/-13.62 years with majority age group being 31-50 years, Majority of patients weighed between 51-70 kilograms, with mean weight of the patients at 60.03 ± 9.75 kilograms. BMI of the patients ranged from 17.44-29.9 kg/sq. metre, with mean BMI at 24.15 ± 3.73. Study patients had comorbidities, majority having hypertension, diabetes, and some having ischemic heart disease under treatment.

Out of 30 patients, 60% i.e., 18 patients had events of hypotension at various times, amongst which 33.33% i.e., 10 were fluid responders and 26.66% i.e., 8 patients were non fluid responders (Table 1).

After an event of hypotension (Table 2), MAP of a fluid responder decreases by 21.61 % while MAP of a fluid non responder decreases by 24.03%, the difference being not statistically significant.

Statistically significant difference was observed in Stroke volume (SV), where a decreases by 7.11 % was seen and decrease by 26.02% was seen in non responder. Cardiac Index (CI) of a fluid responder increases by 4.31 % while CI of a non responder decreases by 1.42%. CI of a non-responder decreases while that of responder increases, difference being significant ($p<0.05$).

ICON of a fluid responder decreases by 4.33 % while ICON of a fluid non responder increases by 6.64% ($p>0.05$). (Table 2)

SVR decreases by 19.91% in fluid responder while it decreases by 27.54% in the other group ($p > 0.05$).

After fluid challenge, (Table 3) Pulse rate (PR) of a fluid responder decreases by 13.43% while PR of a non-responder decreases by 1.64%, difference being statistically significant ($p<0.001$).

MAP of a fluid responder increases by 13.64 % while MAP of a fluid non responder decreases by 0.22%, the difference being statistically significant ($p<0.001$).

SVV of a fluid responder decreases by 28.69% while the SVV of non-responder decreases by 5.86%, the difference being statistically significant ($p<0.001$)

TFC of a fluid responder decreases by 1.02% while the TFC of non-responder decreases by 1.41%.($p>0.05$).

ICON decreases by 1.36% in responders while it increases by 12.95% in non respo nders ($p>0.05$).

SV increases by 16.55% in responders while it increases by 1.99% ($p<0.001$).

CI increases by 12.22% in responders while it increases by 0.82% ($p<0.001$).

SVR increases by 12.90 % while SVR of a fluid non responder decreases by 0.42%. Hence SVR, SV and CI of a fluid responder significantly increases more than that of non-responder ($p<0.001$). (Table 3)

**DISCUSSION:**
Hemodynamic optimization has been shown to improve patient outcome when applied in the perioperative period [16]. Cardiac contractility is the intrinsic ability of heart muscle to generate force and to shorten, ideally autonomously in response to changes in heart rate, preload, and afterload. Contractility increases with an increase in afterload through the Anrep effect. Similarly, contractility increases with an increase in heart rate, through Bowditch effect. So, as the MAP falls there is compensatory rise in HR, contractility increases initially which explains the negative correlation between MAP and ICON [17] [18]. Cardiac index is cardiac output (product of heart rate and stroke volume) divided by body surface area. As the MAP falls initially, there is compensatory rise in heart rate, which is more than decrease in stroke volume, which prevents rapid fall in CI in relation to MAP which explains the negative correlation of MAP and CI [17] [18]. Stroke volume, which is the volume of blood pumped from the left ventricle per beat, naturally decreases with decrease in MAP as there is a decrease in either preload (hypovolemic shock) or due to direct myocardial contractility decrease ( cardiogenic shock ) or due to toxins (septic shock). [17] [18] Systemic vascular resistance is the resistance in the circulatory system which is used to maintain the blood pressure and flow of blood. It is calculated as following; SVR=(MAP-CVP)/CO *80. So CO=MAP/SVR. The body tries to maintain cardiac output in any event of hypotension by compensatory mechanisms, so if MAP falls SVR increase by vasoconstriction in fluid responders but there is a vasodilatory response and decrease in SVR with fall in MAP in non-responders (mainly septic shock). The averaging results of change of SVR in fluid responders and non-responders may be the cause of positive corelation of SVR and MAP where change of SVR was more in non-responders than the responders resulting in net effect of fall in SVR with fall in MAP. [17] [18]

It was found that 18 out of 30 patients had multiple and persistent events of hypotension which was, either BP below 65 mm hg or reduction in BP more than 20% of baseline values. If the stroke volume, or cardiac index increased by 10-15% after fluid challenge, the patient was considered fluid responder and the remaining ones as non- responders.

Out of these 18 patients , SV of 10 patients increased by 16.55 % while SV of 8 patients increased by 1.99%. This difference was statistically significant. ($p<0.001$).

Similarly, CI of same 10 patients increased by 12.22 % while CI of remaining 8 patients increased by 0.82%. This result is statistically significant. ($p<0.001$).

Hence, as per definition of fluid responder set by the study protocol, 18 patients who had experienced an event of hypotension were hemodynamically categorized into fluid responders and non-responders. Out of 18 patients 10 were fluid responders and 8 were non responders.

Mean arterial pressure (MAP), stroke volume (SV), ICON, SVR of the fluid responders decreased and Cardiac index (CI) increased after hypotension while all the parameters showed a decrease in non responders except ICON which showed an increase in the value (Table 2).

After fluid challenge, pulse rate (PR) decreased significantly in responder than in non responder, while MAP increased in fluid responder significantly than in non responder.

Similarly, SVV decreased significantly in responder than non responders.

ICON showed an increase in non responders while decrease in responders.

Thoracic fluid content (TFC) decreased in both the groups which was not significant.

SVR of fluid responders increased while decreased in non responders. SV and CI increased significantly in fluid responders (Table 3).

According to Shaik et al, SVV, has been considered to be a reliable predictor of fluid responsiveness with high sensitivity and specificity in surgical patients [18] [19]. SVV proved to be a surrogate marker of administering intravenous fluids perioperatively as per Ghosh et al. [20] Beat to beat measurement of SVV, which is a dynamic preload parameter has been considered to be a reliable predictor of fluid responsiveness with high sensitivity and specificity in surgical patients. [21] [19]

The study had limitations such as a small sample size, lack of predetermined monitoring events and surgery types for comparison, and failure to compare with other technology to assess superiority.

## CONCLUSION:

Non invasive cardiac output monitor (electrocardiometry) was found to be a simple tool for providing beat to beat estimation of CO in clinical anaesthesia and critical care setup. Measurement of dynamic parameters such as stroke volume , stroke volume variation, systemic vascular resistance etc. can be advocated in a non cardiac tertiary care setup. It also has an upcoming role in obstetric patients with perfusion problems such as preeclampsia, peripartum haemorrhage and sepsis.

**Table 1 showing distribution of patients as per Hemodynamic categorisation**

| Patients with Intraoperative Hypotension | No. of Patients | Percentage |
|---|---|---|
| Fluid Responders | 10/30 | 33.33% |
| Non-Fluid responders | 8/30 | 26.66% |
| Total | 18/30 | 60% |

**Table 2 showing comparison of parameter between Fluid responder and non-responder after Hypotension**

| Parameter | Fluid Responder | | Fluid Non responder | | P value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| MAP | -21.61 | 5.79 | -24.03 | 6.96 | 0.432,NS |
| SV | -7.11 | 14.45 | -26.02 | 6.15 | 0.007,S |
| CI | 4.31 | 14.04 | -1.42 | 12.97 | 0.027,S |
| ICON | -4.33 | 11.23 | 6.64 | 12.20 | 0.065,NS |
| SVV | 12.74 | 32.27 | 42.29 | 29.50 | 0.064,NS |
| SVR | -19.91 | 17.31 | -27.54 | 10.44 | 0.265,NS |

Mann Whitney test is used.

**Table 3 showing comparison of parameter between Fluid responders and Non responders after fluid Challenge**

| Parameter | Fluid Responder | | Fluid Non-responder | | P value |
|---|---|---|---|---|---|
| | Mean (%) | sd.(%) | Mean(%) | Sd.(%) | |
| PR | -13.43 | 3.34 | -1.64 | 2.98 | 0.000 |
| MAP | 13.64 | 7.80 | -0.22 | 1.78 | 0.000 |
| SV | 16.55 | 2.82 | 1.99 | 3.18 | 0.000 |
| CI | 12.22 | 3.53 | 0.82 | 3.45 | 0.000 |
| ICON | -1.36 | 11.08 | 12.95 | 20.06 | 0.07 |
| SVV | -28.69 | 3.70 | -5.86 | 7.10 | 0.000 |
| TFC | -1.02 | 2.56 | -1.41 | 2.73 | 0.926 |
| SVR | 12.90 | 10.81 | -0.42 | 5.95 | 0.006 |

Mann Whitney test is used.

## Abbreviations

BMI – Body mass index
CO - Cardiac output or its index (CI)
HR - Heart rate
ICU - Intensive care unit
ICON - Contractility index
MAP - Mean arterial pressure
PR – Pulse rate
RBC - Red blood cell
SD - Standard deviation
SI - Stroke volume index or SV - Stroke volume
SpO2 - Blood oxygen saturation
SVR - Systemic vascular resistance
SVV - Stroke volume variation
TEB - Thoracic electric bioimpedance
TFC - Thoracic fluid content

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