Assessment of Fluid Responsiveness With End Tidal Carbon Dioxide Using A Simplified Leg-Raising Maneuver in Non-Cardiac Patients Admitted in Medical Intensive Care Unit

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ABSTRACT

Objective: To assess the fluid responsiveness with end tidal carbon dioxide using a simplified leg-raising maneuver in non-cardiac patients admitted in medical Intensive Care Unit (ICU).

Study Design: Cross sectional analytical study.

Place and Duration of Study: Intensive Care Unit, Pak Emirates Military Hospital Rawalpindi, form Jun to Nov 2019.

Methodology: A total of 80 cases were included in this study who were admitted in medical ICU and were on ventilator support. A standard 5-minute leg-raising maneuver was applied on all the patients. An increase in cardiac index >15% after passive leg rise was taken as criteria for responders. All echocardiographic evaluations were performed by experienced sonographers.

Results: Mean age of study participants was 47.4 ± 4.421 years, 65 (81.3%) were males while 15 (18.7%) were female patients. Sixty (75%) patients responded to the simplified leg raising maneuver while 20 (25%) did not respond. Mean arterial pressure of the respondents was 92.3 ± 3.26 mmHg while mean arterial pressure of the non-respondents was 83.2 ± 4.57 mmHg. High body mass index and low mean arterial pressure had statistically significant relationship with no response to the maneuver in our study.

Conclusion: Simplified leg raising emerged as an effective maneuver to stabilize the non-cardiac patients hemodynamically inside the setting of critical care unit. Patients with low baseline mean arterial pressure or high body mass index may be considered as high risk for non-response to this maneuver.

Keywords: Cardiac index, Intensive care unit, Leg raising maneuver.

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INTRODUCTION

Critical care is a setting where patients are admitted to get support for their various failing organs.[1] Hemodynamic stability is one of the most important goals for the critical care physicians. Homeostasis of the body cannot be maintained if patient is not stable hemodynamically stable.[2] Sometimes cardiovascular system collapses and is the cause of hemodynamic instability. Therefore, direct support is required but in most cases, non-cardiac patients with other abnormalities have an indirect effect on the fluid and electrolyte balance that if not corrected in time might lead to devastating consequences including the death of the patient.[3]

Central venous pressure (CVP), pulmonary artery occlusion pressure, global end-diastolic volume (measured with transpulmonary thermodilution), flow time of aortic flow (by esophageal doppler) and left ventricular end-diastolic dimensions (measured by echocardiography) have been the few static methods used to assess the hemodynamic changes among the patients with suspicion of hemodynamic instability.[4,5] The method to be chosen to assess and correct the hemodynamic instability among the patients with multiple problems admitted in Intensive Care Unit (ICU) depends upon the type of underlying cause, available equipment and expertise of critical care physician that which.[6,7]

Passive Leg Raising (PLR) maneuver has been in practice for long but advocated more in the recent past as a lot of work has been published in the support of this simple maneuver which is non-invasive and effective. Mackenzie *et al*, in their study done in USA on patients in the emergency department, emphasized that hemodynamic stability is a important factor in predicting mortality and morbidity in the patients inside the emergency department. They concluded that PLR maneuver is the best tool to predict the hemodynamic changes in the patients.[8] A recent Canadian study on cardiac surgery patients concluded that use of a PLR maneuver to induce variation in End Tidal

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Carbon Dioxide ($ETCO_2$) is a non-invasive and useful method to assess fluid responsiveness in paralyzed cardiac surgery patients receiving mechanical ventilation.[9] Study by Young *et al*, has been very important in this regard which clearly showed that PLR maneuver has been superior to mini fluid challenge test in predicting the fluid responsiveness. It was a prospective study comparing the two parameters that generated results with good generalizability.[10]

Limited local data is available on PLR maneuver and its role in predicting the fluid response especially in the non-cardiac patients. We planned this study with the objective to assess the fluid responsiveness with $ETCO_2$ using a simplified leg raising maneuver in non-cardiac patients admitted in medical ICU.

METHODOLOGY

This cross sectional analytical study was conducted at the ICU of Pak Emirates Military Hospital Rawalpindi, from June to November 2019. Sample size was calculated by using the WHO sample size calculator. Population proportion of 3.6% was used to calculate the sample size.[11] Consecutive sampling technique was used to gather the study sample of non-cardiac patients admitted in Critical Care Unit for organ support.

Inclusion Criteria: Patients of either gender, age 18-69 years, admitted in ICU with any non-cardiac cause and on ventilatory support requiring hemodynamic monitoring were included in the study.

Exclusion Criteria: Patients with a definitive cardiac cause for admission in ICU, patients with unclear diagnosis or those who were pregnant, patients with poly trauma whose legs could not be raised were excluded from the study.

Hospital Ethics Committee granted ethical approval for this study. Baseline hemodynamic variables were recorded including blood pressure, cardiac output and mean arterial pressure. PLR maneuver was performed on all the patients included in the study as per standard technique. Semi recumbent position, total supine position with leg rise at 45° for ninety seconds and then return to the original position.[12] The different hemodynamic variables, including capnography, were recorded at 30, 60, 90, 5, 8, and 10 min after the initiation of the maneuver.[12,13] VTILVOT measurement was taken 90 sec, 5 min, and 10 min after the PLR. End tidal CO2 was measured using Nihon Khoden cap-ONE® TG-920P mainstream CO2 sensor attached in the breathing circuit of the ventilator.[13] Cardiac index was the parameter used in the study to see the response of passive leg raising. It was calculated by dividing cardiac output by body surface area and was calculated by multiplying heart rate with the stroke volume. An increase in cardiac index >15% after PLR was taken as the criteria.[14] All the echocardiographic evaluations were performed by experienced sonographer. It was taken into account that all the evaluations should be performed by one person.

Statistical Package for Social Sciences (SPSS) version 23 was used for the data analysis. Mean and standard deviation were calculated for age, duration in ICU, duration on mechanical ventilation in the ICU and arterial pressure for responders and non-responders. Frequency and percentages were calculated for qualitative variables. Chi-square was applied to look for the association. The *p*-value of ≤0.05 was considered statistically significant.

RESULTS

Eighty non-cardiac patients fulfilled the criteria laid down for this study. Table shows the profile of the study participants in detail.

Table: Profile of the patients admitted in intensive Care Unit (n=80).

Parameters	n (%)
Age (Years)	
Mean + SD	47.4 ± 4.421 years
Gender	
Male	65 (81.3%)
Female	15 (18.7%)
Response to Leg Raising Maneuver	
Responders	60 (75%)
Non- Responders	20 (25%)
Mean Arterial pressure of responders	92.3 ± 3.26 mm Hg
Mean arterial pressure of non-responders	83.2 ± 4.57 mm Hg
Body Mass Index	
<24	55 (68.8%)
>24	25 (31.2%)
Mean Time on Mechanical Ventilation	
Mean ± SD	4.9 (± 2.11) days
Mean Intensive Care Unit Stay	
Mean ± SD	6.1 (± 2.45) days

Mean age of patients inclu-ded in study was 47.4 ± 4.42 years. Out of 80 patients, 65 (81.3%) were males while 15 (18.7%) were female patients. A total of 60 (75%) patients responded to the simplified PLR maneuver and had more than 15% increase in cardiac index while 20 (25%) did not respond. Mean arterial pressure of the respondents was 92.3 ± 3.26 mm Hg while mean

arterial pressure of the non-respondents was 83.2 ± 4.57 mmHg. Chi-square test showed that high body mass index (BMI) and low mean arterial pressure had statistically significant relationship (p-value<0.05) with no response to the maneuver in our study while other demographic characteristics were unrelated.

DISCUSSION

Management of fluid and electrolyte balance has always been a challenge for the physicians. Even patients with trauma and surgery have been referred to the medical specialist for the expertise to manage them hemodynamically.[15] Nephrologist, medical specialist, emergency physician, critical care physician and anesthetist, all have been directly involved to manage the fluid and electrolyte status of the patients with different ailments. Various methods have been used in all parts of the world to assess the hemodynamic status of routine as well as critical patients. This phenomenon takes huge importance in critical or intensive care patients where more than one system has already been failing and hemodynamic instability can add insult to the injury.[16] We therefore planned this study with the rationale to assess the fluid responsiveness with $ETCO_2$ using a simplified PLR maneuver in non-cardiac patients admitted in medical ICU of our tertiary care hospital.

Assadi *et al*, and Fakhari *et al*, in their studies have highlighted the fact that PLR has been an effective and reliable maneuver to assess and achieve hemodynamic stability.[17,18] Fakhari *et al*, included cardiac surgery patients in his study while Assadi *et al*, took only critically ill patients. Findings of our study strengthen the existing literature and come up with a conclusion that PLR maneuver could be used effectively in non-cardiac critically ill patients.

He *et al,* and Jamshaid *et al*, showed a similar phenomenon.[19,20] He *et al*, in a Chinese study discussed adult patients admitted in the ICU while Jamshaid *et al*, discussed pediatric population undergoing cardiac surgery. They showed that PLR maneuver not only confined regarding its effectiveness to a specific age group or population, rather it has emerged as an effective maneuver for all the age groups and can be practiced in almost all types of critically ill patients.

Granados *et al*, in their study concluded that mean arterial pressure was significantly different in the responders and non-responders of PLR maneuver.[21] Illyas *et al*, in a local study concluded that mean arterial pressure has no relationship with hemodynamic response.[12] Our results supported the results of Granados *et al*.

Dong *et al*, in their study on sepsis patients concluded that BMI has no significant role in determining the response to PLR maneouver.[22]

LIMITATIONS OF STUDY

Small study sample is the main limitation of our study. Studies in future with a large sample and involving more techniques to observe the response should be done in order to generate results that could be generalized and local guidelines could be designed for the Intensive Care Units managing hemodynamically unstable patients.

CONCLUSION

Simplified PLR emerged as an effective maneuver to stabilize the non-cardiac patients hemodynamically inside the setting of critical care unit. Patients with low baseline mean arterial pressure or high BMI may be considered as high risk for non-response to this maneuver.

Conflict of Interest: None.

Authors' Contribution

ZH: Direct, IF: Indirect, NA: Indirect, AH: Direct, KS: Direct, AZ: Direct.

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