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Contextualizing Fasting and Fluid Responsiveness: Assessing Fluid Deficits beyond Monitoring Parameters

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Abstract

Background and Objectives: The Pleth Variability Index (PVI) is a noninvasive dynamic parameter to assess fluid responsiveness. It is often utilised in the perioperative period for goal-directed fluid therapy and is believed to be superior to static parameters. This study aims to demonstrate the impact of fasting on baseline and passive leg raising (PLR)-induced changes in PVI in healthy volunteers. This challenges the conventional thinking of substituting fluid for the duration of fasting before a surgical procedure.
Methods: Forty healthy adult volunteers were enrolled and divided into: Group 1 (n = 20, fasted overnight) and Group 2 (n = 20, fed). PVI was recorded using a Masimo Radical-7® Pulse CO-Oximeter® in two scenarios: baseline in the supine position (PVI 1) and post-PLR (PVI 2). The difference between PVI 1 and PVI 2 was calculated. Patient demographics were noted, and a comparative analysis between the groups was performed. Statistical significance was set at $p < 0.05$.
Results: The mean PVI 1 in Group 1 was significantly higher (26.6 ± 3.2) compared to Group 2 (18.2 ± 2.8), $p = 0.0016$. Similarly, the mean PVI 2 was significantly higher in Group 1 (20.9 ± 2.9) than in Group 2 (13.9 ± 2.3), $p = 0.0012$. The PLR-induced changes in PVI were more pronounced in Group 1, indicating greater fluid responsiveness in the fasted state. Box-and-whisker plots demonstrated clear distinctions between the groups.
Conclusion: Fasting significantly impacts PVI readings, with higher baseline and post-PLR values observed in fasted individuals. This underscores the importance of interpreting PVI measurements for fluid responsiveness assessment. Responsiveness does not often translate to deficit.

Keywords: Pleth Variability Index; Fasting; Fluid Responsiveness; Passive Leg Raising; Masimo Monitor

Introduction

Fluid management in the perioperative period has always been a conflicting issue among the practising anaesthesist [1]. 'Liberal' and 'Restricted' fluid approaches are often blanket terms that depict the two extremes of a spectrum. However, often a middle ground is adopted or as we like to call the 'non-extreme fluid approach'. Various monitoring devices,

guidelines, and 'goal-directed' strategies have been tried in the past and continue to evolve in search of 'the one ideal parameter' for guiding fluid administration [2]. Correction of fluid deficit routinely in patients with otherwise normal physiology may not be advocated, on account of fasting overnight before surgery since physiological adjustments to maintain euvolemia take care of the milieu interna. Evidently, fluid administration can improve symptoms related to dehydration [3] and on the downside large volume infusion of crystalloids during surgery can induce endothelial dysfunction and interstitial fluid overload [4]. Hence striking a balance is important. Passive leg raising test (PLRT), a bedside test identifies the subjects who are on the ascending part of the Frank Starling curve [5]. Classically, a 10% increase in the stroke volume using standard cardiac output monitoring is used to evaluate the preload responsiveness of the heart. PVI has been studied and used as a marker of fluid responsiveness in ventilated cardiac and septic patients [2,5-7]. PVI change during PLRT indicates the ability of the heart to increase output with an increase in preload, rather than a deficit in circulating volume necessitating correction [8]. A fall in PVI post-PLRT, may not necessarily signify a need for substituting fluids. Classically a cut-off of 15 for the PVI is taken to decide upon the volume replacement.

Methodology

Study Design and Setting

This prospective observational study was conducted on 40 healthy volunteers divided into two groups based on nutritional status:
Group 1 (Fasted): 20 volunteers who were fasted overnight.
Group 2 (Fed): 20 volunteers who consumed a standard meal two hours before the study.
Written informed consent was obtained from all participants.
Inclusion Criteria:
Healthy adults aged 18–40 years.
Normal body mass index (BMI: 18.5–24.9 kg/m^2).
Exclusion Criteria:
History of cardiovascular, respiratory, or metabolic disorders.
Use of medications affecting hemodynamics or vascular tone.
Pregnancy or lactation.

Study Protocol

Participants were positioned in a quiet, temperature-controlled room and allowed to rest for 10 minutes before measurements. A Masimo Radical-7® Pulse CO-Oximeter® was used to measure PVI via a finger probe [9]. Two sets of PVI readings were taken:
Baseline (PVI 1): In the supine position.
Post-PLR (PVI 2): After elevating the legs to 45° for 60 seconds.

Data Collection

Demographics: Age, sex, weight, height, and BMI were recorded.
PVI Measurements: Values were noted for PVI 1 and PVI 2.
Calculated Difference: ΔPVI = PVI 1 – PVI 2.

Statistical Analysis

Data were analysed and continuous variables were expressed as mean ± standard deviation. Group comparisons were made using an independent t-test. Statistical significance was set at $p < 0.05$. Box-and-whisker plots were generated to illustrate group differences.

Results

Demographics

The demographic profiles of both groups were comparable (Table 1). No significant differences were observed in age, sex, weight, height or BMI.

Variable	Group 1 (Fasted)	Group 2 (Fed)	p-value
Age (Years)	28.7±5.6	27.7±7.3	0.646
Male: Female	13.07	12.08	0.747
Weight (kg)	62.06±10.7	56.8±9.49	0.109
Height (cm)	167.4±10.6	161.3±9.8	0.06
BMI (kg/m^2)	23.5±2.7	22.2±2.7	0.09

Table 1: Table showing the mean and standard deviation of the demographic data of the participants in both groups.

PVI Values

Baseline PVI (PVI 1): Mean PVI was significantly higher in Group 1 (26.6 ± 3.2) compared to Group 2 (18.2 ± 2.8), $p = 0.0016$. Post-PLR PVI (PVI 2): Mean PVI was significantly higher in Group 1 (20.9 ± 2.9) than in Group 2 (13.9 ± 2.3), $p = 0.0012$. The change in pleth variability index ΔPVI was comparable in both the groups, irrespective of the fasting status. (Table 2 & Figure 2).

Variable	Group 1 (Fasted)	Group 2 (Fed)	p-value
PVI 1	26.6 ± 9.24	18.2 ± 5.65	0.0016
PVI 2	20.9 ± 7.54	13.9 ± 4.91	0.0012
ΔPVI	5.65 ± 10.0	4.3 ± 5.3	0.601

Table 2: Table showing the mean and standard deviation of the pleth variability index obtained during supine position (PVI1) and post-passive leg raising (PVI 2) in both groups. The change in ΔPVI is also calculated and compared.

Box-and-Whisker Plot

Box-and-whisker plots for PVI 1 and PVI 2 clearly delineated the differences between the two groups, with non-overlapping interquartile ranges indicating statistical significance (Figures 1 & 2).

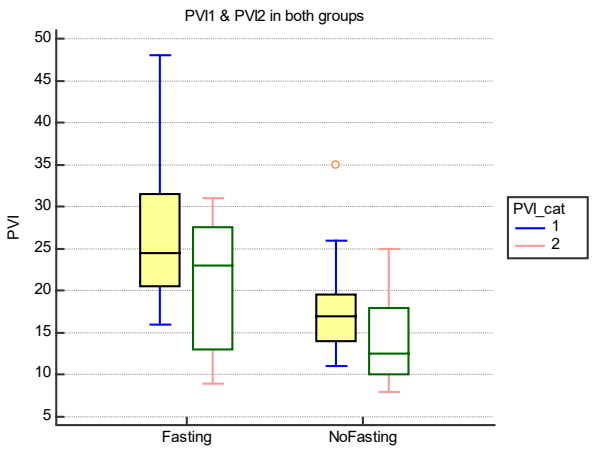

Figure 1: Box and Whisker plot showing the mean and standard deviation of the pleth variability index (PVI) in the two groups, in supine (PVI1) and post-passive leg raising (PVI2).

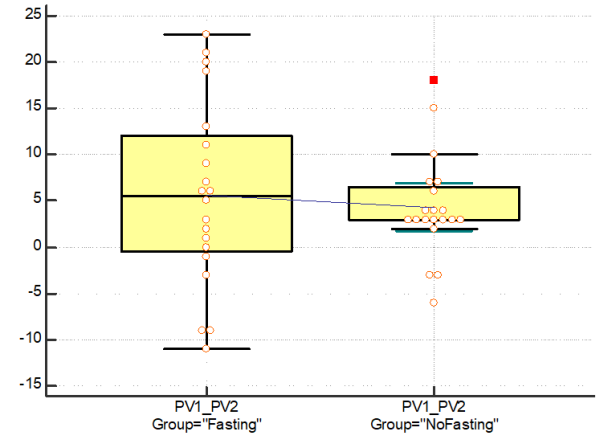

Figure 2: Box & Whisker plot of the change in the pleth variability index (ΔPVI= PVI 1-PVI 2). No difference was noted between the two groups statistically (p=0.6016).

Discussion

Fluid management during the perioperative period is a delicate balance, often teetering between under-resuscitation and fluid overload. While liberal and restrictive fluid strategies have historically been debated, clinical practice has gravitated toward a more nuanced, individualized approach [10]. This study underscores the importance of context when interpreting monitoring parameters, particularly in healthy individuals with overnight fasting.

The findings of significantly higher baseline and post-PLR Pleth Variability Index (PVI) values in the fasted group compared to the fed group emphasize that fasting induces a physiological state that mimics preload sensitivity. However, this does not necessarily equate to a true volume deficit requiring correction. Overnight fasting activates compensatory mechanisms such as shifts in interstitial fluid to intravascular compartments, maintenance of vascular tone, and hormonal regulation to preserve euvolemia. These adaptive processes highlight the body's resilience and ability to adjust to transient fasting states without necessitating external fluid supplementation in most healthy individuals. Replacing fluids without placing context in a patient can lead to unnecessary fluid overload. As noted in the observation, both groups had a significant fall in the pleth variability index values (PVI), however, the degree of change (ΔPVI) in both groups is comparable and does not differ. This marks the heart's ability in a person with normal physiology to pump out blood for the increased preload.

PVI and Its Role in Fluid Responsiveness

PVI is a dynamic parameter influenced by respiratory variations in the perfusion index and is often used as a surrogate for fluid responsiveness. While its utility in ventilated, critically ill patients is well-established, its application in healthy, spontaneously breathing individuals or those in transient fasting states is less straightforward [11,12]. This study's results suggest that a decrease in PVI following PLRT primarily reflects a transient preload responsiveness rather than a true circulating volume deficit. The reliance on PVI alone, without considering the physiological context, may lead to unnecessary fluid administration. This is particularly important in scenarios where patients exhibit an increase in preload responsiveness due to transient conditions, such as fasting, rather than pathological hypovolemia.

Clinical Implications

The key message from this study is that PVI changes during PLRT should not be interpreted in isolation. A decrease in PVI post-PLRT in fasted individuals is not necessarily indicative of a deficit requiring immediate fluid supplementation. Instead, it reflects the heart's ability to utilize an increased preload to enhance cardiac output, which may not always warrant intervention. This can alter with varied physiological states such as age, pregnancy etc [13].

The concept of "goal-directed fluid therapy" should extend beyond monitoring parameters to include a comprehensive

evaluation of patient physiology, surgical requirements, and clinical context [12,13]. This aligns with the broader principles of precision medicine, where individualized care takes precedence over one-size-fits-all algorithms.

Limitations

This study was conducted in healthy volunteers, which limits the direct extrapolation of findings to critically ill or perioperative patients with altered physiological reserves. Additionally, PVI measurements may be influenced by factors such as probe positioning, respiratory effort, and individual variability in vascular tone.

Future Directions

Further studies are needed to validate these findings in diverse populations, including perioperative and critically ill patients. Investigating the integration of PVI with other hemodynamic parameters and clinical indicators may provide a more robust framework for fluid management. Furthermore, exploring the role of PVI in patients with varying fasting durations and comorbidities could offer additional insights into its practical utility.

Conclusion

The interpretation of PVI requires a case-by-case approach. While PVI changes during PLRT can indicate preload responsiveness, they should not be automatically equated with fluid deficits necessitating correction. This study advocates for a more thoughtful application of dynamic monitoring parameters, emphasizing the need to contextualize fluid management strategies within the physiological and clinical milieu of each patient.

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