TIDAL VOLUME CHALLENGE EFFECT ON PULSE OXIMETERY PLETHYSMOGRAPHY WAVE VARIATION TO PREDICT FLUID RESPONIVENESS IN SEPTIC SHOCK PATIENTS

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Introduction

Sepsis is a critical condition caused by a dysregulated immune response to infection, often leading to organ dysfunction and high mortality, especially in intensive care units. Septic shock, its most severe form, involves circulatory collapse and poor tissue perfusion. Fluid resuscitation is vital to restore hemodynamics, but excessive fluids may cause harm. Traditional static measures like central venous pressure (CVP) fail to reliably predict fluid responsiveness. Dynamic indices such as pulse pressure variation (PPV) are more accurate but require invasive monitoring. Pulse oximetry plethysmography waveform variation (POPV) offers a non-invasive alternative, reflecting respiratory-induced changes in ventricular preload. Its accuracy improves with a tidal volume challenge (TVC), a maneuver temporarily increasing tidal volume to enhance cardiopulmonary interactions. Combining POPV with TVC allows accurate, bedside, non-invasive prediction of fluid responsiveness, even under lung-protective ventilation strategies. This approach aligns with precision-guided care, minimizes fluid overload risk, and is feasible in both resource-rich and limited settings.

Aim of the work

The aim of this work is to assess tidal volume challenge effect on pulse oximetry plethysmography wave variation as a non-invasive method to predict fluid responsiveness in septic shock mechanically ventilated patients.

Patients and Methods

This observational prospective cohort study was conducted in the Critical Care Medicine Department of Alexandria Main University Hospital and included 50 adult patients (≥18 years) with septic shock on mechanical ventilation using a tidal volume ≤6 mL/kg predict body weight (PBW). Patients with spontaneous breathing, arrhythmias, open chest, right heart failure, pulmonary hypertension, low HR/RR ratio (<3.6), or pregnancy were excluded. After fluid resuscitation and stable vasopressor dose, patients were assessed for fluid responsiveness. Hemodynamic parameters and pulse oximetry plethysmography variation (POPV) were recorded at four time points: baseline (VT 6 mL/kg), after tidal volume challenge (VT 8 mL/kg), post-return to baseline, and post-fluid bolus. Cardiac output (CO) was measured via Doppler echocardiography. ΔPOPV6-8 was calculated to evaluate fluid responsiveness, defined as ≥15% CO increase after fluid bolus. The study aimed to determine the diagnostic performance of ΔPOPV6-8, including sensitivity, specificity, and optimal cut-off value, for predicting fluid responsiveness in septic shock.

Results

Table (1): Areas under the receiver operating characteristic curves (AUROC) of pulse oximeter plethysmograph variation in predicting fluid responsiveness

	AUROC (95% CI)	Cut-off	Sn.	Sp.	p
POPV					
Baseline-1	0.621 (0.472 – 0.754)	12.1	84.2	38.7	0.142
V_T Challenge	0.877 (0.753 – 0.953)	21.4	100	67.7	< 0.001
Δ POPV					
Absolute difference	0.975 (0.885 – 0.999)	7.6	100	87.1	< 0.001
Relative difference	0.878 (0.754 – 0.953)	0.6	79	83.9	< 0.001

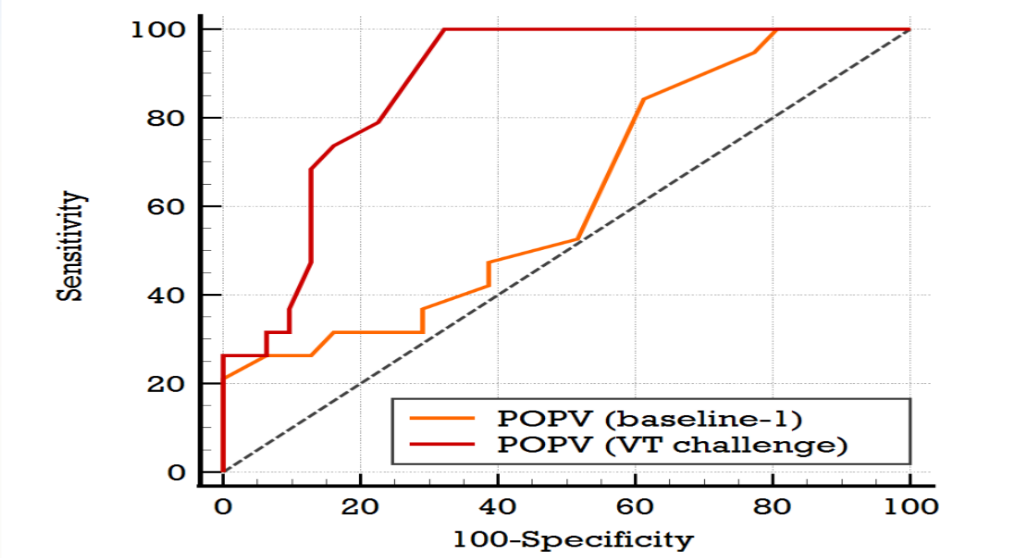

Figure (1): ROC curves comparing pulse oximeter plethysmograph variation (POPV) at baseline-1 and after VT challenge in predicting fluid responsiveness.

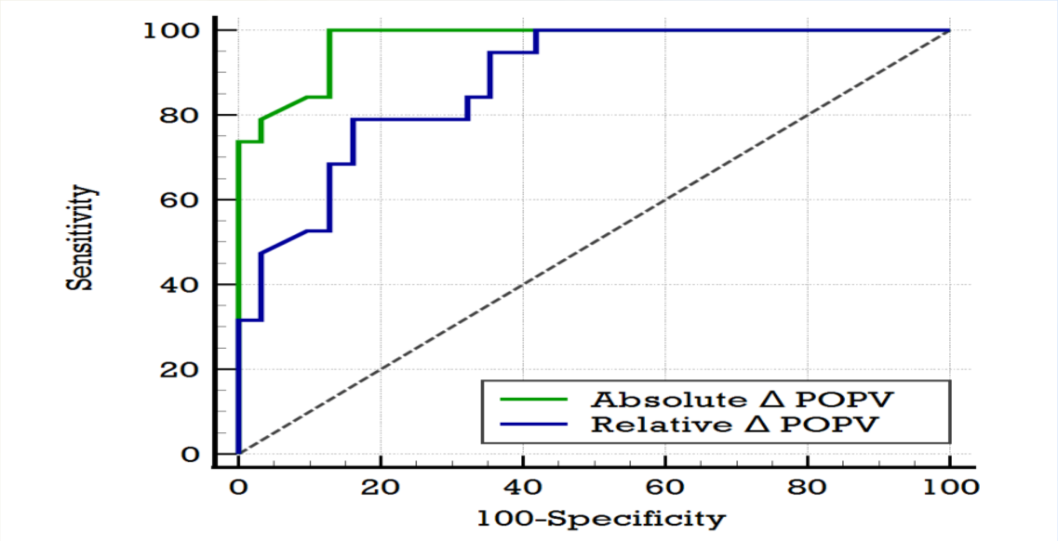

Figure (2): ROC curves comparing absolute and relative difference in pulse oximeter plethysmograph variation between VT challenge and at baseline-1 (ΔPOPV) in predicting fluid responsiveness.

Conclusion

The tidal volume (VT) challenge significantly improves the ability of pulse oximetry plethysmography wave variation (POPV) to predict fluid responsiveness in mechanically ventilated patients with septic shock. After increasing VT to 8 ml/kg, POPV values were notably higher in patients who responded to fluid administration, indicating enhanced sensitivity of this non-invasive measure.

Both absolute and relative changes in POPV after the VT challenge demonstrated superior diagnostic performance. The study identified optimal cutoff values of 21.4% for POPV post-challenge, 7.6% for absolute ΔPOPV, and 0.6 for relative ΔPOPV, supporting the use of VT challenge as a reliable bedside tool to guide fluid management in septic shock.

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