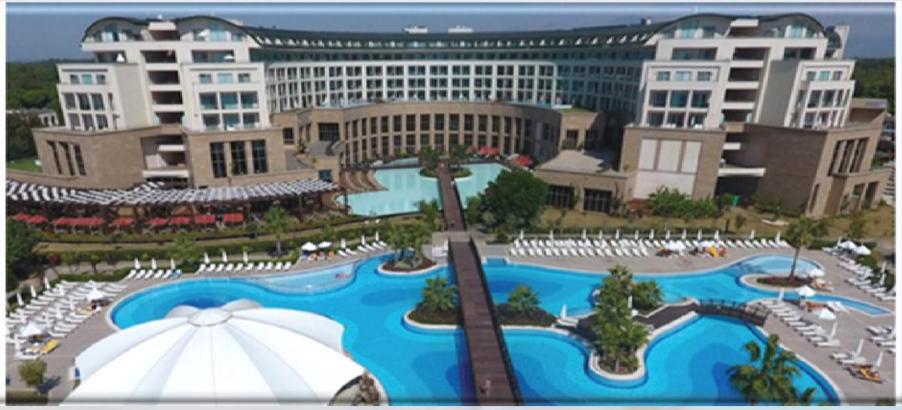
15TH NATIONAL EMERGENCY MEDICINE CONGRESS



6TH INTERNATIONAL CRITICAL CARE AND EMERGENCY MEDICINE CONGRESS

6TH INTERCONTINENTAL EMERGENCY MEDICINE CONGRESS

ATUDER Acil Tıp Uzmanları Derneği

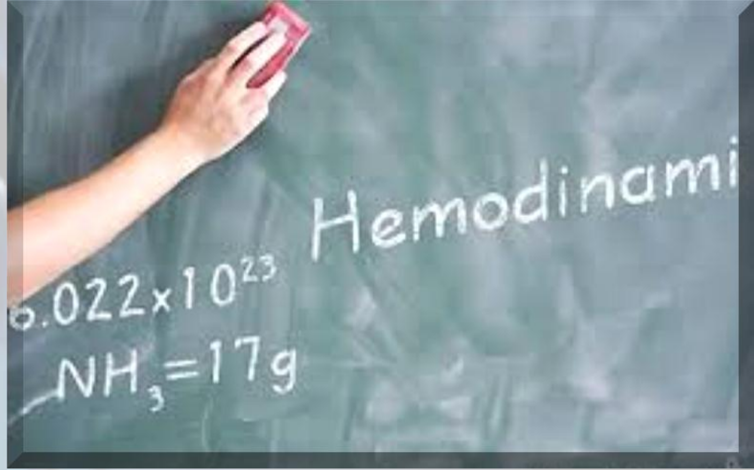
EPAT Emergency Physicians Association of Turkey

# Acilde periferik perfüzyon indeksleri

Doç. Dr. Emine EMEKTAR

SBÜ Keçiören Eğitim ve Araştırma Hastanesi

# Kritik hastalarda Hemodinami yönetiminde amaç




1-İntravasküler volümün korunması

2-Yeterli hücre metabolizmasını sürdürmek için perfüzyon basıncını ve oksijen sunumunu optimize edilmesi

# Perfüzyon bozukluğu olan hastalarda acil serviste gözden geçirilmesi gerekenler

- Doku perfüzyonunu değerlendirmek için global ve rejyonel belirteçler
- Doku oksijenasyonu yeterli mi? (Karışık venöz O2 saturasyonu, laktat vb)
- Kalp debisi yeterli mi? (Atım hacmi? Hasta sıvı yanıtlı mı?)
- Vazomotor tonus ne durumda? (düşük-orta-yüksek, kapiller geri dönüş zamanı?)
- Kalp fonksiyonları ne durumda? (EF? Diastolik disfonksiyon, nonkardiak patolojiler, dolumu bozan kapak patolojileri?)

# Acil serviste

- Kritik hastalarda
- 5 vital parametre

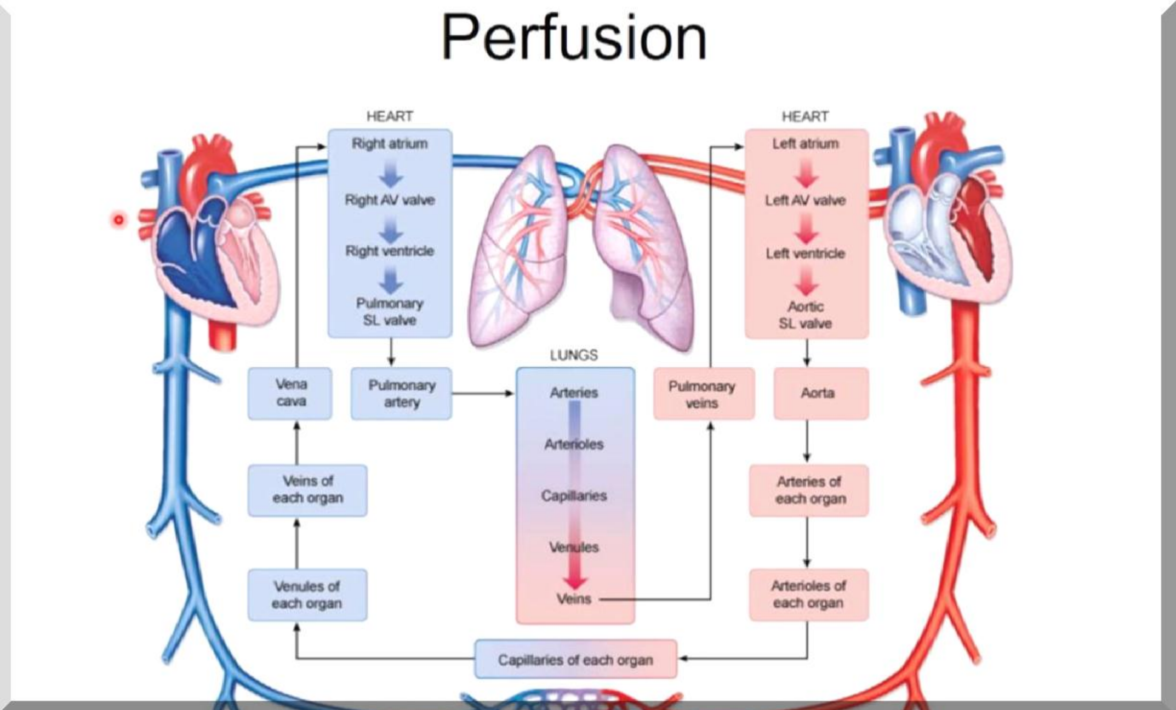
❑Kan basıncı

❑Kalp hızı

❑Solunum hızı

❑Satürasyon

❑Vücut sıcaklığı




- Solunum, dolaşım, renal, hepatik, serebral gibi End–Organ fonksiyonları

1-Neyi monitorize edeceğim?

2-Nasıl monitörize edeceğim?

3- Güvenilir mi?

4- Optimal bir izlem aracı var mı?

5-Non invazif,  kısa zamanda hızlı sonuç veren, yatakbaşı bir cihaz teknik var mı?

| İnvazif teknikler | Minimal İnvaziv Sürekli Arteriyal Nabız Dalga Formu Analizi | Non-İnvazif teknikler |
| --- | --- | --- |
| İnvaziv Arteryel kan basıncı (İAKB) | Pulse contour analiz (PCA) teknolojileri | EKG (ETCO2)Vücut sıcaklığı izlemi |
| Periferik venöz basınç ölçümü | *FloTrac/Vigileo/EV1000 sistemleri (Edwards Lifesciences, Irvine, CA, USA)* | Transtorasik Empedans Kardiyografi<br>Transtorasik Ekokardiyografi /Doppler<br>Transözofajiyal Dopler Ekokardiyografi |
| Santral venöz basınç ölçümü (SVB) | *LiDCOrapid (LiDCO, Cambridge,UK)* | End tidal karbondioksit |
| Pulmoner arter kateterizasyonu | *ProAQT/PulsioFlex (Pulsion/Maquet, Rastatt, Germany)* | Non invasive Blood Pressure; Osilometrik yöntem; Manşonlu otomatik TA ölçümü) ve oskültasyon yöntemi gibi |
| Kardiyak output (KO) ölçümü | *MostCare (Vygon, Vytech, Padua, Italy)* | Nabız oksimetresi (Pulse Oksimetre; SpO2) |
| Karışık (mikst) venöz oksimetre | özofagus Doppler monitörü (esophageal Doppler monitor; EDM) | Perfüzyon İndeksi |
| İntrakraniyal basınç (İKB) monitörü | | Pleth Değişkenlik İndeksi |
| Juguler venöz O2 monitorizasyonu | | Vena Kava Boyutlarındaki Değişimler |
| Mesane kateterizasyonu | | Torasik elektriksel biyoempedans |

# Noninvazif teknikler

- Hızlı
- Yatakbaşı  uygulama
- Kolay uygulanabilir
- Kolay otomatikleşme
- Genellikle doğru sonuç
- Çok düşük infeksiyon riski

# Acil serviste Kullanımı alanları

Kritik hasta sıvı yönetimi
Hipotansiyon
Hipovolemi
Ağrı yönetimi
Sepsis
Mortalite prediktörü

# Perfüzyon İndeksi (PI)


- Kızıl ötesi ışınların vücut üzerinde bağlı olduğu yerdeki sıvıya bağlı fraksiyonu ölçülmesi
- PI değeri, pulse oksimetre ile kızıl ötesi ışınların absorbsiyonuna bakılarak hesaplanan değer
- Parmak ucu, el, ayak parmağı ve kulak.. Periferal vazomotor tonus hakkında da bilgi verir
- PI uygulanan bölgedeki anlık ve belirli bir zaman aralığına ait sürekli dokunun perfüzyon durumunu gösterir
- PI değeri % (0,02 çok zayıf) % 20 (kuvvetli )arasında

**SHOCK,** Vol. 44, No. 6, pp. 554–559, 2015

# EVALUATION OF PERFUSION INDEX AS A PREDICTOR OF VASOPRESSOR REQUIREMENT IN PATIENTS WITH SEVERE SEPSIS

**Islam Rasmy, Hossam Mohamed, Nashwa Nabil, Sabah Abdalah, Ahmed Hasanin, Akram Eladawy, Mai Ahmed and Ahmed Mukhtar**

*Anesthetic Department, Faculty of Medicine, Cairo University, Giza, Egypt*

Received 20 Jul 2015; first review completed 29 Jul 2015; accepted in final form 28 Aug 2015

ABSTRACT—We evaluated the ability of perfusion index (PI) to predict vasopressor requirement during early resuscitation in patients with severe sepsis. All consecutive patients with clinically suspected severe sepsis as defined by the criteria of the American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference were included. Perfusion variables included PI, arterial lactate level, central venous oxygen saturation, and the difference between central venous carbon dioxide and arterial carbon dioxide pressures, and were recorded before resuscitation and 6 h thereafter. We enrolled 36 patients with severe sepsis. Twenty-one patients required vasopressors, whereas 15 did not. The cut-off of the PI value for predicting vasopressor requirement was $\leq 0.3$. This cut-off value had a sensitivity of 100% and a specificity of 93%; the area under the curve was 0.96 (95% confidence interval 0.8–0.99, $P < 0.0001$). The cut-off of the arterial lactate level for predicting vasopressor requirement was $\geq 1.8\ mg\ dL^{-1}$. This cut-off value had a sensitivity of 82% and a specificity of 80%; the area under the curve was 0.84 (95% confidence interval 0.68–0.94, $P < 0.0001$). Other perfusion variables failed to predict vasopressor requirement in patients with severe sepsis. We concluded that PI and arterial lactate level are good predictors of vasopressor requirement during early resuscitation in patients with severe sepsis. Further studies are warranted to investigate whether monitoring PI during resuscitation improves the outcome of patients with septic shock.

KEYWORDS—Central venous oxygen saturation, lactate, mortality, perfusion index, severe sepsis, venous–arterial carbon dioxide pressure difference

ppressor
severe
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J Clin Monit Comput. 2017 Oct;31(5):961-965. doi: 10.1007/s10877-016-9936-3. Epub 2016 Sep 24.

# Evaluation of perfusion index as a tool for pain assessment in critically ill patients.

Hasanin A[1], Mohamed SAR[2], El-Adawy A[2].

Author information

**Abstract**

Pain is a common and undertreated problem in critically ill patients. Pain assessment in critically ill patients is challenging and relies on complex sc … PI) measured by a pulse oximeter (Masimo R … ective observational study was carried out on 87 s … ng, a Masimo pulse oximeter probe was used f … Agitation-Sedation Scale (RASS). The pain in … ents. The PI, arterial blood pressure, heart rate, … anging the patient position) were reported. C … relation between changes in the PI (delta PI) a … osition resulted in a significant increase in … rt rate (99.5 ± 19 vs 92.7 ± 18.2, P = 0.013), … 9] vs 2.2[0.97-3.6], P < 0.001) value compared t … BPS-NI, and RASS at the two measurements. A good correlation was found between the delta PI and delta BPS-NI (r = -0.616, P < 0.001). A weak correlation was observed between the PI and heart rate after the patient positioning (r = -0.249, P < 0.02). In surgical critically ill non-intubated patients, the application of a painful stimulus was associated with decreased PI. There was a good correlation between the change in the PI and the change in BPS-NI values after the application of painful stimulus.

## 5 Conclusions

In surgical critically ill non-intubated patients, the application of a painful stimulus was associated with decreased PI. There was a good correlation between the change in the PI and the change in BPS-NI values after the application of painful stimulus.

*Denotes statistical significance ($P < 0.05$)

*Denotes statistical significance ($P < 0.05$)

Br J Anaesth. 2013 Aug;111(2):235-41. doi: 10.1093/bja/aet058. Epub 2013 Mar 21.

# Perfusion index derived from a pulse oximeter can predict the incidence of hypotensi spinal anaesthesia for Caesarean delivery.

Toyama S[1], Kakumoto M, Morioka M, Matsuoka K, Omatsu H, Tagaito Y, Numai T, Shimoyama M.

Author information

## Abstract

**BACKGROUND:** Hypotension during spinal anaesthesia for Caesarean delivery is a result of decreased vascular resistance sympathetic blockade and decreased cardiac output due to blood pooling in blocked areas of the body. Change in baseline vascular tone due to pregnancy may affect the degree of such hypotension. The perfusion index (PI) derived from a pulse o used for assessing peripheral perfusion dynamics due to changes in peripheral vascular tone. The aim of this study was to baseline PI could predict the incidence of spinal anaesthesia-induced hypotension during Caesarean delivery.

**METHODS:** Parturients undergoing elective Caesarean delivery under spinal anaesthesia with hyperbaric bupivacaine 10 m µg were enrolled in this prospective study. The correlation between baseline PI and the degree of hypotension during spinal also the predictability of spinal anaesthesia-induced hypotension during Caesarean delivery by PI were investigated.

**RESULTS:** Baseline PI correlated with the degree of decreases in systolic and mean arterial pressure (r=0.664, P<0.0001 a P=0.0029, respectively). The cut-off PI value of 3.5 identified parturients at risk for spinal anaesthesia-induced hypotension of 81% and a specificity of 86% (P<0.001). The change of PI in parturients with baseline PI ≤ 3.5 was not significant during period, while PI in parturients with baseline PI>3.5 demonstrated marked decreases after spinal injection.

**CONCLUSIONS:** We demonstrated that higher baseline PI was associated with profound hypotension and that baseline PI incidence of spinal anaesthesia-induced hypotension during Caesarean delivery.

## Editor's key points

- Hypotension is common during spinal anaesthesia for Caesarean delivery.
- The authors evaluated the relationship of this hypotension with resting vascular tone.
- The vascular tone was assessed by a perfusion index (PI) as derived using a pulse oximeter.
- Importantly, higher PI was associated with increased risk of hypotension.

sion line and the dotted lines represent the 95% CIs.

(AUC=0.696, *P*=0.0529) and baseline HR (AUC<0.5) could not predict hypotension. The baseline PI cut-off point that predicted hypotension as determined by the ROC analyses was 3.5 with a sensitivity of 81% [95% confidence intervals (CI) 58–95%], a specificity of 86% (95% CI 57–98%), a positive predictive value of 89%, and a negative predictive value of 75% (P<0.001).

He et al. Critical Care (2015) 19:330
DOI 10.1186/s13054-015-1057-8

CRITICAL CARE

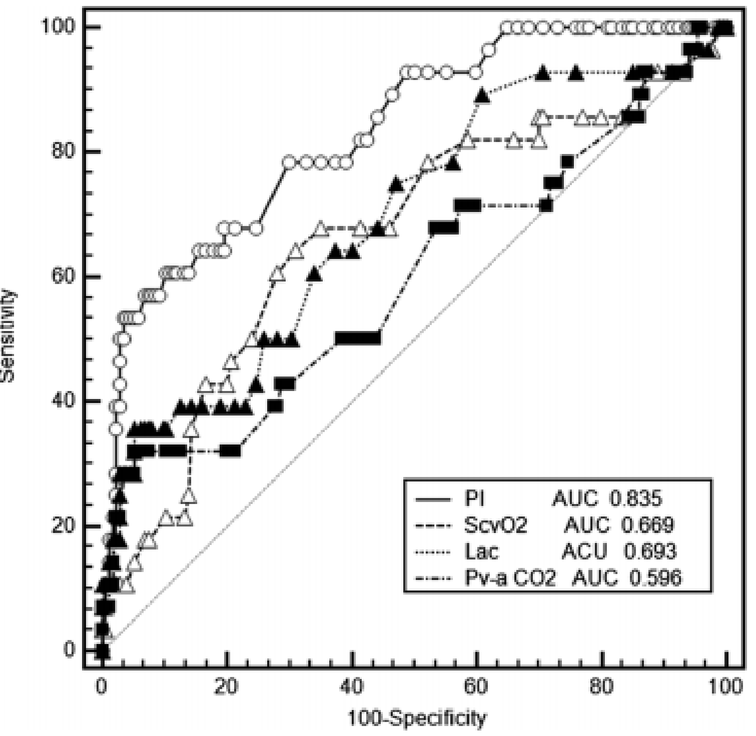
RESEARCH Open Access

# Clinical classification of tissue perfusion based on the central venous oxygen saturation and the peripheral perfusion index

Huaiwu He†, Yun Long†, Dawei Liu*, Xiaoting Wang and Xiang Zhou

## Key messages

- PI is an independent risk factor for 30-day mortality, and a cutoff of PI <0.6 is related to poor outcome following resuscitation
- Pursuing a normalized PI (≥1.4) might not result in better outcomes for mild PI impairment after normalized of $ScvO_2$
- The PI was correlated with lactate, $P(v\text{-}a)CO_2$, and $ScvO_2$ in all of the measurements (n = 404). These relationships seem to be strengthened with abnormal PI (PI <1.4) but not with normal PI (PI ≥1.4).



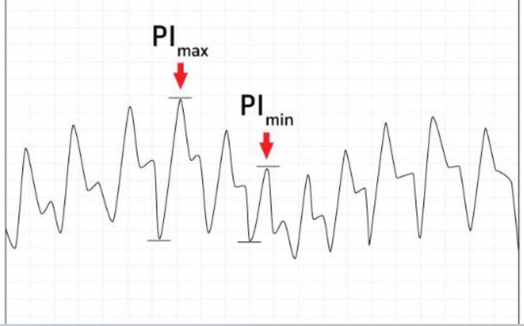

ig. 2 Receiver operating characteristic curves comparing the ability f peripheral perfusion index (*PI*), lactate (*Lac*), difference between entral venous and arterial $PCO_2$ (*Pv-a* $CO_2$) and central venous $O_2$ aturation ($ScvO_2$) to discriminate mortality at day 30 in all the ritically ill patients. *AUC* area under the curve

following: (a) PI is an independent risk factor for 30-day mortality, and a cutoff of PI <0.6 is related to poor outcome following resuscitation; (b) after normalizing $ScvO_2$ (≥70 %), patients with critical PI impairment (≤0.6) had the worst outcome, but there was no difference in outcome between patients with normal PI (≥1.4) and mild PI impairment (0.6 < PI <1.4); and (c) the PI correlated with lactate, $P(v\text{-}a)CO_2$, and $ScvO_2$. In addition, these relationships seem to be strengthened with abnormal PI (PI <1.4) but not with normal PI (PI ≥1.4).

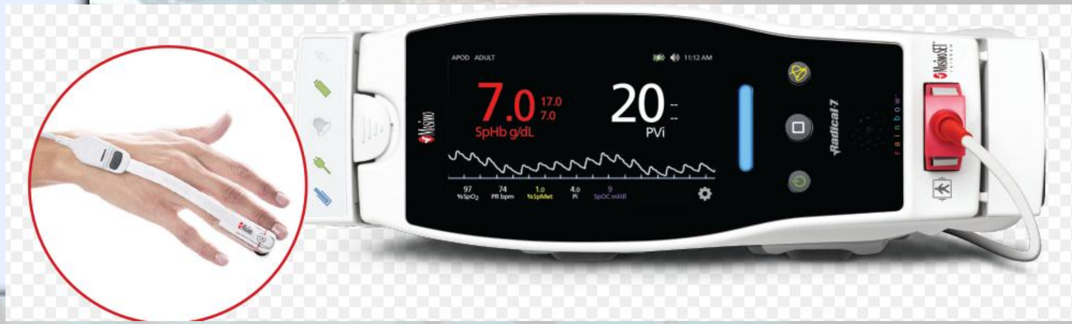
*$P(v\text{-}a)CO_2$*, difference between central venous and arterial $PCO_2$ (mmHg), *PI* peripheral perfusion index measured by pulse oximetry, *$ScvO_2$* central venous $O_2$ saturation
**P* <0.05 for comparison of PI vs $ScvO_2$, P(v-a) $CO_2$, and lactate

# Pleth Değişkenlik İndeksi (PDİ)

$$PVI = \frac{PI_{max} - PI_{min}}{PI_{max}} \times 100$$




- PDI ventilasyonla meydana gelen PI değişikliklerinin en az bir solunum siklusu boyunca hesaplanması
- PDI monitörler üzerinde yüzde ve trend grafiği olarak görüntülenir
- PDI sayısal olarak ne kadar düşükse, solunum siklusu boyunca PI değerinde daha az değişkenlik olduğuna işaret etmekte
- Yüksek PDI değerlerinde volüm replasmanı yapılması sonrası PDI' ın eşik kabul edilen değerlerin altına kadar düşmesi volüm yanıtı pozitif- cevaplı, PDI' in eşik değerin üstünde kalmaya devam etmesi ile volüm yanıtı negatif-cevapsız durum olarak tanımlanmakta
- Kritik eşik diğer çalışmalarda 12-17 arasında tanımlanmış

PubMed ▼ Pleth variability İndex Search

Acta Anaesthesiol Scand. 2018 Jan;62(1):75-84. doi: 10.1111/aas.13012. Epub 2017 Oct 16.

## Pleth variability index can predict spinal anaesthesia-induced hypotension in patients undergoing caesarean delivery.

Kuwata S[1], Suehiro K[1], Juri T[1], Tsujimoto S[1], Mukai A[1], Tanaka K[1], Yamada T[1], Mori T[1], Nishikawa K[1].

⊕ Author information

**Abstract**

**BACKGROUND:** Spinal anaesthesia carries a risk of hypotension. We hypothesized that pleth variability index and perfusion index would assess maternal volume status, and thus, allow identification of patients at higher risk of developing hypotension after spinal anaesthesia for caesarean delivery.

**METHODS:** Fifty patients undergoing elective caesarean delivery were enrolled. All patients received spinal anaesthesia with 0.5% hyperbaric bupivacaine (10 mg) and fentanyl (10 mcg). Blood pressure was measured every minute. Pleth variability index and perfusion index were automatically measured throughout the procedure using pulse oximetry on the index finger. In case of hypotension (systolic blood pressure below 90 mmHg or 80% of the baseline value), ephedrine 5 mg was administered. Receiver-operating characteristic and multivariate logistic regression analyses for spinal anaesthesia-induced hypotension were performed.

**RESULTS:** Hypotension occurred in 32 patients (64%). The areas under the receiver-operating characteristic curve were 0.751 (95% confidence interval: 0.597-0.904) for pleth variability index before anaesthesia, 0.793 (95% confidence interval: 0.655-0.930) for pleth variability index after anaesthesia and 0.731 (95% confidence interval: 0.570-0.892) for perfusion index change (percent change in perfusion index induced by spinal anaesthesia). The optimal threshold value of pleth variability index (after anaesthesia) for predicting hypotension was 18% (sensitivity: 78.1%, specificity: 83.3%). Pleth variability index after spinal anaesthesia was an independent factor for hypotension (odds ratio: 1.21, P = 0.041).

**CONCLUSIONS:** Pleth variability index after spinal anaesthesia was a good predictor of spinal anaesthesia-induced hypotension in patients undergoing caesarean delivery. In addition, perfusion index change after spinal anaesthesia has the potential to predict hypotension.

PLR and ΔCI was found. SVV ( r = 0.850, P = 0.015 ) and PVI ( r = 0.867, P = 0.001 ) before PLR were correlated with ΔCI. It was shown by ROC curve that the area under ROC curve ( AUC ) for SVV fluid responsiveness prediction was 0.948, and cut-off of SVV was 12.4%, the sensitivity was 85.4%, and specificity was 86.6%. The AUC for PVI fluid responsiveness prediction was 0.957, and cut-off was 14.8%, the sensitivity was 87.5%, and specificity was 84.8%. It was higher than other hemodynamic parameters ( HR, MAP, CVP ).

**CONCLUSIONS:** PVI and SVV can better predict fluid responsiveness in mechanically ventilating patients with septic shock after PLR. PVI as a new continuous, noninvasive and functional hemodynamic parameter has the same accuracy as SVV.

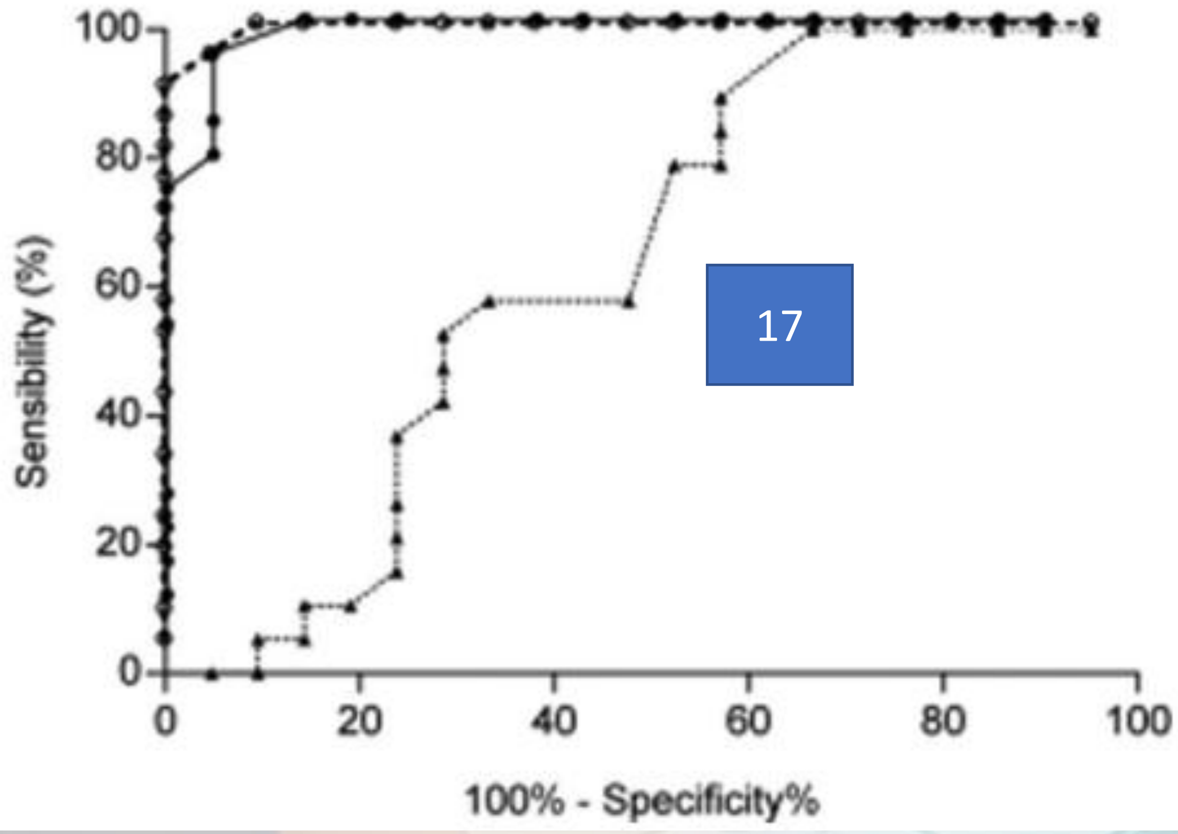
- Anestezi esnasında
- Yoğun bakımlarda
- Sıvı cevaplılığını değerlendirmede

Crit Care Med. 2011 Feb;39(2):294-9. doi: 10.1097/CCM.0b013e3181ffde1c.

# Pleth variability index predicts fluid responsiveness in critically ill patients.

Loupec T[1], Nanadoumgar H, Frasca D, Petitpas F, Laksiri L, Baudouin D, Debaene B, Dahyot-Fizelier C, Mimoz O.

Author information




rial catheter. Our study supports the use of PVI in this setting. Using a threshold value of 17%, the performance of PVI to predict fluid responsiveness was similar to that of ΔPP. Furthermore, PVI was able to quantify the hemodynamic response to volume expansion. However, 17% is probably not a definitive threshold value for PVI in this setting, and as reported for ΔPP (4, 9, 39, 40) further studies may find slightly different values in the future. Identifying the low and high PVI threshold values where volume expansion is not useful or beneficial, as well as a gray zone where other parameters should be taken into account, may help to expand the utility of PVI to guide clinical decisions. Optimizing the patient's hemodynamic state with ΔPP (41–43) or PVI (44) monitoring has potential to decrease duration of hospital stay and mechanical ventilation, postoperative morbidity and costs in patients undergoing high-risk surgery. Whether cardiac preload optimization based on PVI values may improve outcomes of critically ill patients remains to be explored.

Observational Study

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# Accuracy of pleth variability index compared with inferior vena cava diameter to predict fluid responsiveness in mechanically ventilated patients

Özcan Pişkin, MD[a,*], İbrahim İlker Öz, M

**Abstract**

In the intensive care unit (ICU), stable hemodyn
organ failure, such as in tissue hypoxia and
perfusion.

The main objective of this study is to compa
distensibily index (dIVC).

In this study, the hemodynamic measureme
obtained, including, PVI, dIVC, and cardiac inc
and convex probe respectively. The dIVC meas
the inferior vena cava. The PVI was measured
A total of 72 patients were included. The dI
predict fluid responsiveness and was statistical
of >14% provided 95% sensitivity and 81.2%
with an AUC 0.939 (0.857–0.982).

Both PVI and dIVC can be used as a no
responsiveness in all patients with mechanica

**Abbreviations:** BMI = body mass index, CI
vena cava distensibily index, HR = heart rate,
raising, PPV = pulse pressure variation, PVI =
acute physiology score, SOFA = sequential o
ultrasound.

**Keywords:** fluid responsiveness, hemodyna

**Table 2**

**Hemodynamic variables before and after passive leg raising.**

| Variables | Responders (n = 40) | | Nonresponders (n = 32) | |
|---|---|---|---|---|
| | Before PLR | After PLR | Before PLR | After PLR |
| HR, mean ± SD, beats/min | 90 ± 9.42 | 87.6 ± 9.21* | 90.06 ± 11.85 | 89.03 ± 10.46* |
| MAP, mean ± SD, mmHg | 63.83 ± 5.72 | 69.52 ± 6.98* | 70.79 ± 8.78† | 74.32 ± 7.67 |
| CVP, mean ± SD, mmHg | 6.63 ± 2.44 | 8.40 ± 2.16* | 7.66 ± 2.47† | 10.81 ± 2.26 |
| CI, mean ± SD, L/min/m$^2$ | 2.88 ± 0.23 | 3.48 ± 0.26* | 3.19 ± 0.28† | 3.44 ± 0.24 |
| PVI, mean ± SD (%) | 17.28 ± 1.65 | 12.45 ± 1.58* | 12.06 ± 2.82† | 9.66 ± 1.96 |
| dIVC, mean ± SD (%) | 33.38 ± 9.75 | 16.77 ± 7.37* | 14.58 ± 6.22† | 8.70 ± 3.12 |

CI = cardiac index, CVP = central venous pressure, dIVC = caval index, HR = heart rate, MAP = mean arterial pressure, PVI = pleth variability index, SD = standard deviation. Values are expressed as mean ± SD.

* $P < .05$ vs baseline.

† $P < 0.05$ vs 'responders'.

**Table 3**

**The comparison of performances between parameters.**

| Parameters | Treshold values | Sensitivity (%) | Specificity (%) | AUC (95% CI) | LR+ | LR− | PPV | NPV | *P* |
|---|---|---|---|---|---|---|---|---|---|
| CVP | ≤7 mmHg | 70 | 53.13 | 0.622 (0.500–0.734) | 1.49 | 0.56 | 65.1 | 58.6 | .066 |
| PVI | >14% | 95 | 81.25 | 0.939 (0.857–0.982) | 5.06 | 0.06 | 86.4 | 92.9 | <.0001 |
| dIVC | >23.08% | 80 | 87.50 | 0.928 (0.842–0.975) | 6.40 | 0.23 | 89.2 | 80.0 | <.0001 |

AUC (95% CI) = area under ROC curve (95% CI), CVP = central venous pressure, dIVC = caval index, LR = likehood ratio, NPV = negative predictive value, PPV = positive predictive value, PVI = Pleth variability index.

Pediatr Emerg Care. 2018 Oct;34(10):702-705. doi: 10.1097/PEC.0000000000000887.

# Using Pleth Variability as a Triage Tool for Children With Obstructive Airway Disease in a Pediatric Emergency Department.

Brandwein A, Patel K[1], Kline M, Silver P, Gangadharan S.

Author information

## Abstract

**OBJECTIVES:** Patients with obstructive airway disease have varying degrees of pulsus paradoxus that correlate with illness severity. Pulsus paradoxus can be measured using plethysmography. We investigated whether plethysmograph (pleth) variability on admission to the pediatric emergency department (ED) could predict patient disposition. We hypothesized that patients with a larger pleth variability would have a higher likelihood of being admitted to a general pediatrics unit or the intensive care unit (ICU).

**METHODS:** We conducted a prospective single-center study of children aged 1 to 18 years who presented to a pediatric ED with a diagnosis of asthma or reactive airway disease. The pleth variability index (PVI) was calculated from their initial plethysmography tracing. Disposition from the ED was recorded as discharge, admission to the floor, or admission to the ICU.

**RESULTS:** A total of 117 patients were included in our study. Forty-eight patients were discharged home, 61 were admitted to the floor, and 8 were admitted to the ICU. The median PVI for each of these groups was 0.27 (interquartile range [IQR], 0.19-0.39) for discharges, 0.29 (IQR, 0.20-0.44) for patients admitted to the floor, and 0.56 (IQR, 0.35-0.70) for patients admitted to the ICU. A Kruskal-Wallis test demonstrated a significant difference in the PVI between each of the groups ($P = 0.0087$).

**CONCLUSIONS:** Our results suggest that PVI may be a useful tool in the triage of children who present to the ED with obstructive airway disease. Further studies should aim to assess the validity of PVI in predicting the response to bronchodilator therapy during the course of a patient's hospitalization.

# End-tidal Carbondioksit, EtCO2

alp debis

septik ha
k için ya
değişikliğ
eşitli araş

AVANTAJLARI

•Non İnvaziv
•Enfeksiyon riski Ø
•Otomatik ve sürekli ölçüm
•Tekniğe bağlı değil
•Kurulumu ve kullanımı basit
•AF'den etkilenmez

SINIRLAMALAR

•PaCO2> 30 mmHg üzerinde kullanılabilir
•Ventilasyon parametrelerindeki herhangi bir değişiklik CO düzeyini etkiler
•Entübe hastalarda kullanılma
•İntravasküler hacim durumunu izlemek için yeterli değil


Intensive Care Med. 2013 Jan;39(1):93-100. doi: 10.1007/s00134-012-2693-y. Epub 2012 Sep 19.

# End-tidal carbon dioxide is better than arterial pressure for predicting volume responsiveness by the passive leg raising test.

Monnet X[1], Bataille A, Magalhaes E, Barrois J, Le Corre M, Gosset C, Guerin L, Richard C, Teboul JL.

⊕ Author information

## Abstract

**PURPOSE:** In stable ventilatory and metabolic conditions, changes in end-tidal carbon dioxide (EtCO(2)) might reflect changes in cardiac index (CI). We tested whether EtCO(2) detects changes in CI induced by volume expansion and whether changes in EtCO(2) during passive leg raising (PLR) predict fluid responsiveness. We compared EtCO(2) and arterial pulse pressure for this purpose.

**METHODS:** We included 65 patients [Simplified Acute Physiology Score (SAPS) II = 57 ± 19, 37 males, under mechanical ventilation without spontaneous breathing, 15 % with chronic obstructive pulmonary disease, baseline CI = 2.9 ± 1.1 L/min/m(2)] in whom a fluid challenge was decided due to circulatory failure and who were monitored by an expiratory-CO(2) sensor and a PiCCO2 device. In all patients, we measured arterial pressure, EtCO(2), and CI before and after a fluid challenge. In 40 patients, PLR was performed before fluid administration. The PLR-induced changes in arterial pressure, EtCO(2), and CI were recorded.

**RESULTS:** Considering the whole population, the fluid-induced changes in EtCO(2) and CI were correlated (r (2) = 0.45, p = 0.0001). Considering the 40 patients in whom PLR was performed, volume expansion increased CI ≥ 15 % in 21 "volume responders." A PLR-induced increase in EtCO(2) ≥ 5 % predicted a fluid-induced increase in CI ≥ 15 % with sensitivity of 71 % (95 % confidence interval: 48-89 %) and specificity of 100 (82-100) %. The prediction ability of the PLR-induced changes in CI was not different. The area under the receiver-operating characteristic (ROC) curve for the PLR-induced changes in pulse pressure was not significantly different from 0.5.

**CONCLUSION:** The changes in EtCO(2) induced by a PLR test predicted fluid responsiveness with reliability, while the changes in arterial pulse pressure did not.

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# Assessment of fluid responsiveness with end-tidal carbon dioxide using a simplified passive leg raising maneuver: a prospective observational study.

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Author information

## Abstract

**BACKGROUND:** Assessing fluid responsiveness is important in the management of patients with hemodynamic instability. Passive leg raising (PLR) is a validated dynamic method to induce a transient increase in cardiac preload and predict fluid responsiveness. Variations in end-tidal carbon dioxide (ETCO2) obtained by capnography correlate closely with variations in cardiac output when alveolar ventilation and carbon dioxide production are kept constant. In this prospective observational study, we tested the hypothesis that variations in ETCO2 induced by a simplified PLR maneuver can track changes in the cardiac index (CI) and thus predict fluid responsiveness.

**METHOD:** A five-minute standardized PLR maneuver was performed in 90 paralyzed hemodynamically stable cardiac surgical patients receiving mechanical ventilation. Cardiac index was measured by thermodilution before and one minute after PLR. End-tidal CO2 measurements using capnography were obtained during the entire PLR maneuver. Fluid responsiveness was defined as a 15% increase in the CI. The Chi square test and Student's t test were used to compare responders and non-responders. Logistic regression analyses were then performed to determine factors of responsiveness.

**RESULTS:** There were no differences between responders and non-responders in demographic and baseline hemodynamic variables. Fluid responsiveness was associated with an ETCO2 variation (ΔETCO2) of ≥ 2 mmHg during PLR [odds ratio (OR), 7.3; 95% confidence interval (CI), 2.7 to 20.2; P < 0.01; sensitivity 75%]. A low positive predictive value (54%) and a high negative predictive value (NPV) (86%) were observed. No other clinical or hemodynamic predictors were associated with fluid responsiveness. A logistic regression model established that a combination of ΔETCO2 ≥ 2 mmHg and a change in systolic blood pressure ≥ 10 mmHg induced by passive leg raising was predictive of fluid responsiveness (OR, 8.9; 95% CI, 2.5 to 32.2; P = 0.005).

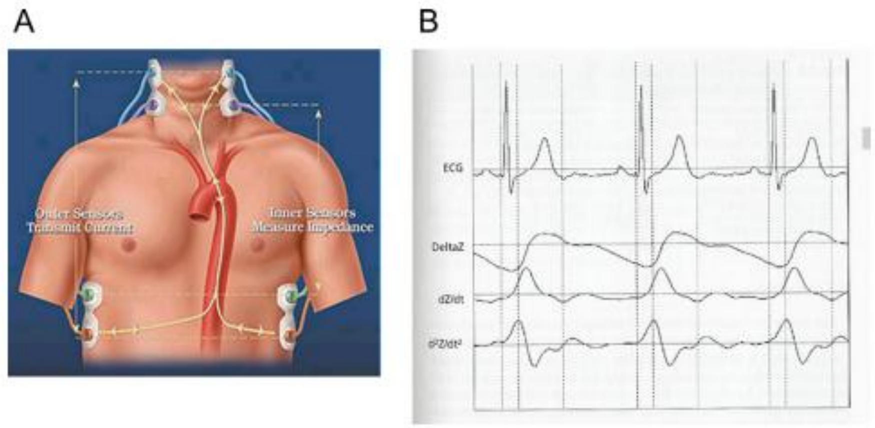
**CONCLUSION:** Use of a passive leg raising maneuver to induce variation in ETCO2 is a noninvasive and useful method to assess fluid responsiveness in paralyzed cardiac surgery patients receiving mechanical ventilation. Given its high NPV, fluid responsiveness is unlikely if a passive leg raising maneuver induces ΔETCO2 of < 2 mmHg.

# Torasik elektriksel biyoempedans

Kısıtlılıklar

- •Obesite
- •Kalp pili
- •Torakotomi
- •Amfizem
- •Pulmoner emboli
- •HR> 250 bpm
- •Septik şok
- •Şiddetli aort yetersizliği
- •Hipertansiyon (MAP> 130)
- •İntraaortik balon pompası sonuçları etkiler






the cardiac cycle. ECG, electrocardiogram; LVET, left ventricular ejection time.

**Table 1. Hemodynamic Parameters Given by Thoracic Electrical Bioimpedance Devices**[11]

| Measured Parameters | Calculated Parameters |
|---|---|
| Heart rate (HR) | Stroke volume (SV) |
| Left ventricular ejection time (LVET) | Cardiac output (SV.HR) |
| Pre-ejection period (PEP) | Systemic vascular resistance (BP/CO) |
| Noninvasive blood pressure (BP) | Left ventricular work index (BP.CO) |
| Acceleration index | Systolic time ratio (PEP/LVET) |
| Velocity index | |
| Intrathoracic fluid content | |

EDITOR'S CHOICE

# Thoracic electrical bioimpedance: a tool to determine cardiac versus non-cardiac causes of acute dyspnoea in the emergency department

Christiane Vorwerk, Hanusha Jeyanithi, Timothy J Coats

**Table 2** Cardiohaemodynamic parameters of cardiac versus non-cardiac patients

| Parameter | Cardiac (n=15) | Non-cardiac (n=36) | p Value |
|---|---|---|---|
| CO (l/min)* | 6.2 (5.2–7.1) | 7.9 (7.3–8.5) | 0.0019 |
| CI (l/min/m$^2$)* | 3.1 (2.8–3.3) | 4.4 (4.0–4.7) | <0.0001 |
| SV (ml)* | 74 (62–87) | 88 (80–96) | 0.0513 |
| SVR (dyne/s/cm$^{-5}$)* | 1227 (1050–1403) | 933 (836–1031) | 0.0023 |
| SVRi (dyne/s/cm$^{-5}\cdot$m$^2$)* | 2403 (2084–2721) | 1681 (1520–1842) | <0.0001 |

*Mean (95% CI).

CI, cardiac index; CO, cardiac output; SV, stroke volume; SVR, systemic vascular resistance; SVRi, systemic vascular resistance index.

**CONCLUSION**

This study demonstrated that non-invasive TEB cardiohaemodynamic parameters can differentiate between cardiac and non-cardiac-related causes of dyspnoea in ED patients presenting with acute breathlessness. A large-scale trial is required to determine if TEB-derived cardiohaemodynamic information can aid ED clinicians in their early clinical decision-making and improve the care and outcome of patients with dyspnoea.

# Near-infrared spektroskopi (NIRS)

- İskelet kası içindeki oksijen satürasyonu ölçen cihaz
- Oksijen iletimi ve tüketiminin dolaylı ölçüsü
- Ortalama doku oksijen satürasyonu yüzdesi (StO2)
- By-pass cerrahisi
- Travma, resüsitasyon
- Organ fonksiyonu
- Mortalite fonksiyonu


**Figure 1** Near-infrared spectroscopy device measuring tissue oxygen saturation at the thenar eminence.

**Table 1** Published studies of $StO_2$ in sepsis reporting a clinical outcome (organ failure or mortality)

| First author, publication year and country (Ref) | Setting | Participants | Primary outcome measure | Methods | Results |
|---|---|---|---|---|---|
| Shapiro 2011, USA[40] | ED | Sepsis with and without shock (N=168) | SOFA score at 24 h | Comparison of three groups—septic shock, sepsis without shock and ED controls without sepsis. Baseline and dynamic $StO_2$ compared between groups and correlated with organ failure at 24 h. | Mean baseline $StO_2$ in septic shock, sepsis without shock and controls: 76% (±9), 82% (±7) and 79% (±7), respectively. Significant correlation between both occlusion and recovery $StO_2$ slopes and SOFA score |
| Vorwerk 2012, UK[39] | ED | Septic shock (N=49) | 30-day mortality | $StO_2$ measured on arrival in ED and on departure from ED after treatment with oxygen, IV fluid resuscitation and antibiotics. | 24 (49%) patients died. Initial $StO_2$ no different between survivors and non-survivors (mean 72% in each group) but significant increase in $StO_2$ after treatment in survivors. Persistently low $StO_2$ after treatment was associated with RR of death of 2.2 (1.2–3.5). |
| Leone 2009, France[38] | ICU | Septic shock (N=42) | 28-day mortality | $StO_2$ measured after resuscitation with fluids and inotropes compared between survivors and non-survivors | 13 (31%) patients died. Median $StO_2$ significantly lower in non-survivors (73% vs 84%). Area under ROC curve 0.71. |
| Payen 2009, France[41] | ICU | Septic shock (N=43) | 28-day mortality | Ventilated septic shock patients. Continuous $StO_2$ monitoring with four times daily VOT analysed according to outcome. Additional examination of relationships between $StO_2$ and various haemodynamic and metabolic parameters. | 15 patients (35%) died. Baseline $StO_2$ similar between survivors and non-survivors with shock but significantly reduced reperfusion slope in non-survivors (1.88%/s vs 3.98%/s, p=0.003). Impaired $StO_2$ reperfusion slope on day 1 significantly improved predictive value of SOFA and SAPSII scores for mortality. |
| Creteur 2007, Belgium[37] | ICU | Severe sepsis or septic shock (N=72) | ICU mortality | Comparison of static and dynamic $StO_2$ between septic shock, sepsis, ICU controls and healthy volunteers. Measurements were performed in ICU after the initial resuscitation phase. | 35 patients died (49%). Baseline $StO_2$ and recovery slope significantly lower in sepsis compared with controls. Persistent impairment $StO_2$ recovery slope predictive of mortality (ROC AUC 0.797) |
| Doerschug 2007, USA[36] | ICU | Severe sepsis (N=24) | SOFA score at 24 h | Static and dynamic NIRS derived $StO_2$ and THI compared between sepsis subjects and 15 healthy controls. Measurements were taken 24 h after recognition of organ dysfunction and initial treatment. Relationship with organ failure measured in sepsis subjects. | Similar baseline $StO_2$ between sepsis and controls (82% vs 84%) but significant impairment in $StO_2$ recovery slope following stagnant ischaemia associated with degree of organ failure |

AUC, area under the curve; ED, emergency department; ICU, intensive care unit; NIRS, near-infrared spectroscopy; ROC, receiver operating characteristic; RR, relative risk; SAPS, simplified acute physiology score; SOFA, sequential organ failure assessment; $StO_2$, tissue oxygen saturation; THI, tissue haemoglobin index; VOT, vascular occlusion test.

- Sepsisle ilgili  çalışmalar
- Dört tek merkez YBÜ çalışması
- Genel olarak, ortalama StO2 sepsis grubunda kontrollere göre daha düşük
- Septik şoklularda daha düşük
- Tek ölçüm yetersiz
- Dinamik ölçümlerde, St02 eğimi septik şoku olan hastalar arasında bozuk
- Çok fazla çalışmaya ihtiyaç var…..

Hangisi daha üstün?????

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BJA

# Noninvasive continuous cardiac output monitoring in perioperative and intensive care medicine

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## Editor's key points

- The authors review the burgeoning array of non-invasive cardiac output monitors.
- They note the varied limitations of the devices and note the need for appropriate description of device performance.
- The need for uniformity in defining clinically acceptable performance is highlighted.

**Summary.** The determination of blood flow, i.e. cardiac output, is an integral part of haemodynamic monitoring. This is a review on noninvasive continuous cardiac output monitoring in perioperative and intensive care medicine. We present the underlying principles and validation data of the following technologies: thoracic electrical bioimpedance, thoracic bioreactance, vascular unloading technique, pulse wave transit time, and radial artery applanation tonometry. According to clinical studies, these technologies are capable of providing cardiac output readings noninvasively and continuously. They, therefore, might prove to be innovative tools for the assessment of advanced haemodynamic variables at the bedside. However, for most technologies there are conflicting data regarding the measurement performance in comparison with reference methods for cardiac output assessment. In addition, each of the reviewed technology has its own limitations regarding applicability in the clinical setting. In validation studies comparing cardiac output measurements using these noninvasive technologies in comparison with a criterion standard method, it is crucial to correctly apply statistical methods for the assessment of a technology's accuracy, precision, and trending capability. Uniform definitions for 'clinically acceptable agreement' between innovative noninvasive cardiac output monitoring systems and criterion standard methods are currently missing. Further research must aim to further develop the different technologies for noninvasive continuous cardiac output determination with regard to signal recording, signal processing, and clinical applicability.

**Keywords:** cardiac output; intensive care unit; monitoring, intraoperative

key points

es in non-invasive cardiac output technologies
mpler perioperative monitoring, but their accu-
questioned.
eta-analysis found modest agreement and inad-
percentage error for most technologies.
on-invasive cardiac output technologies are typi-
eveloped in relatively healthy populations; their
l algorithms may thus be inappropriate to major
or critical illness.
age error and trending are important variables in
luation of non-invasive cardiac output technologies.

ions

ined that the overall random-effects pooled bias [95%
rcentage error were −0,13 [−2.38 , 2.12] litres min$^{-1}$ and
ctively. Completely non-invasive technologies did not
cceptable level of agreement, although minimally inva-
ologies present a similar PE. The persistent high hetero-
er subgroup analysis and meta-regression could be a
nsufficient data reporting and lack of standardization.
ous methodology and presentation of method-compari-
s could improve the assessment of consistency and
icians to decide better whether non-invasive devices are
eliable.

## ARAŞTIRMA PROTOKOLÜ

**ARAŞTIRMANIN BAŞLIĞI:** Akut gastroenterit hastalarında dehidratasyon şiddetiyle Perfüzyon ve Pletismografik değişkenlik indekslerinin korelasyonu

**ARAŞTIRMANIN YAPILACAĞI MERKEZ:** T.C. Sağlık Bilimleri Üniversitesi Ankara Keçiören Eğitim ve Araştırma Hastanesi Acil Tıp Kliniği

## Comparing Pleth Variability Index (PVI) Variation Induced by Passive Leg Raising and Trendelenburg Position in Healthy Volunteers

Osman Lütfi DEMİRCİ*, Gülşah ÇIKRIKÇI IŞIK, ŞerefKerem ÇORBACIOĞLU, Yunsur ÇEVİK

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## ARAŞTIRMA PROTOKOLÜ

**ARAŞTIRMANIN BAŞLIĞI:** Gönüllü Kan Bağışçılarında bir Ünite Kan Bağışı Sonrası Perfüzyon İndeksi Ve Pletismografik değişkenlik indekslerinin Değerlendirilmesi.

**ARAŞTIRMANIN YAPILACAĞI MERKEZ:**

T.C. Ankara Valiliği İl Sağlık Müdürlüğü Sağlık Bilimleri Üniversitesi Ankara Keçiören Eğitim ve Araştırma Hastanesi Acil Tıp Kliniği

Türk Kızılay'ı Orta Anadolu Bölge Kan Merkezi Ankara


Teşekkürler..

Soru? Katkı?