22. GÖĞÜS KALP DAMAR ANESTEZİ VE YOĞUN BAKIM DERNEĞİ ULUSAL KONGRESİ

Elimizdeki monitorizasyon gereçlerinin sınırlamaları

Doç.Dr.Şaban Yalçın, DESA
Kayseri EAH

Hemodinamik monitörler


EsCCO
130
EKO
USG
Flotrac
PiCCO
ÖD
10


©JAXA/NHK

DR. JEKYLL and MR. HYDE

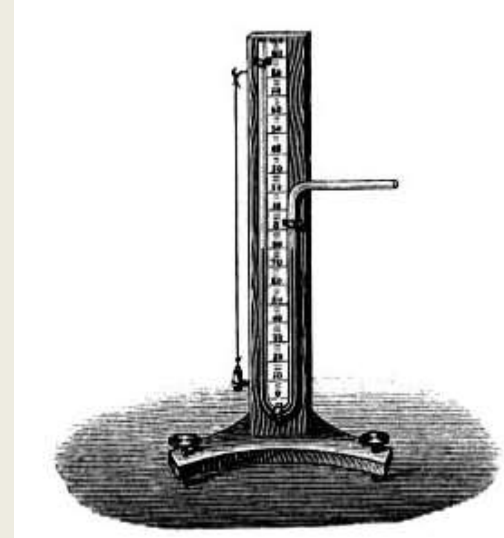
İdeal monitorizasyon aracı

vs.

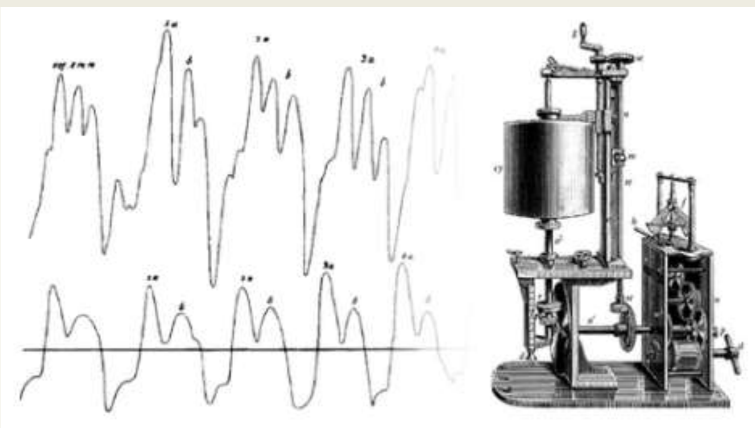
Sunu Planı

- Tarihçe
- Yöntemler ve Limitasyonları

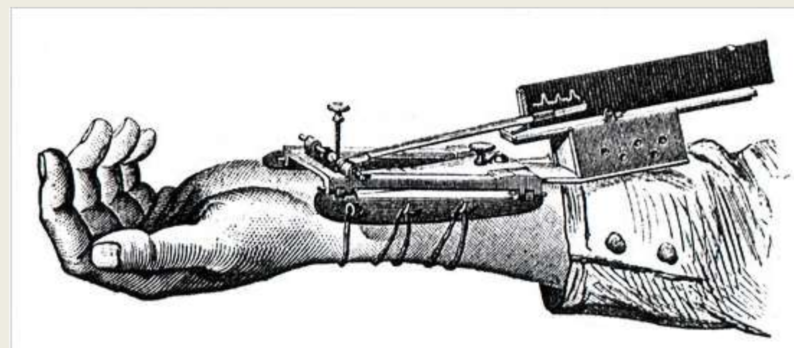
1773 Stephen Hales



1828 Jean Leonard Poiseuille



1847 kimograf Carl Ludwig



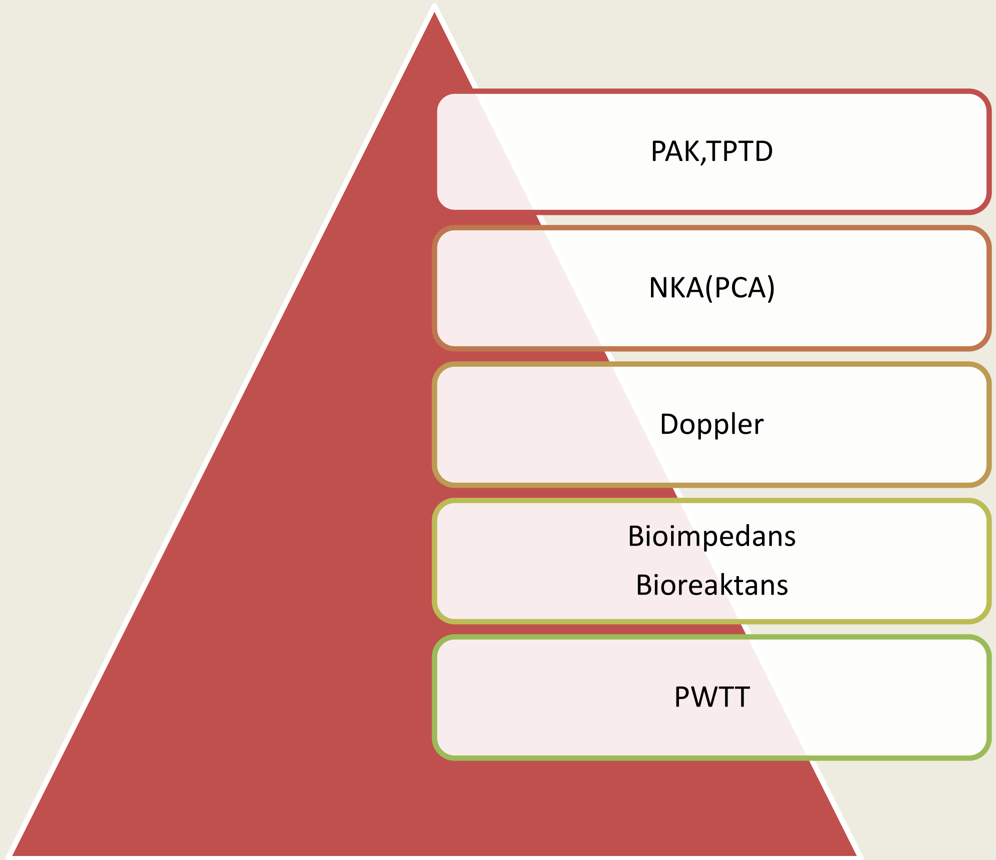
Marey's sphygmograph – note the registration unit at the top right, where one can see the blood pressure waveforms obtained from the set of levers at the wrist

"

The discovery of blood pressure was more important than the discovery of blood.

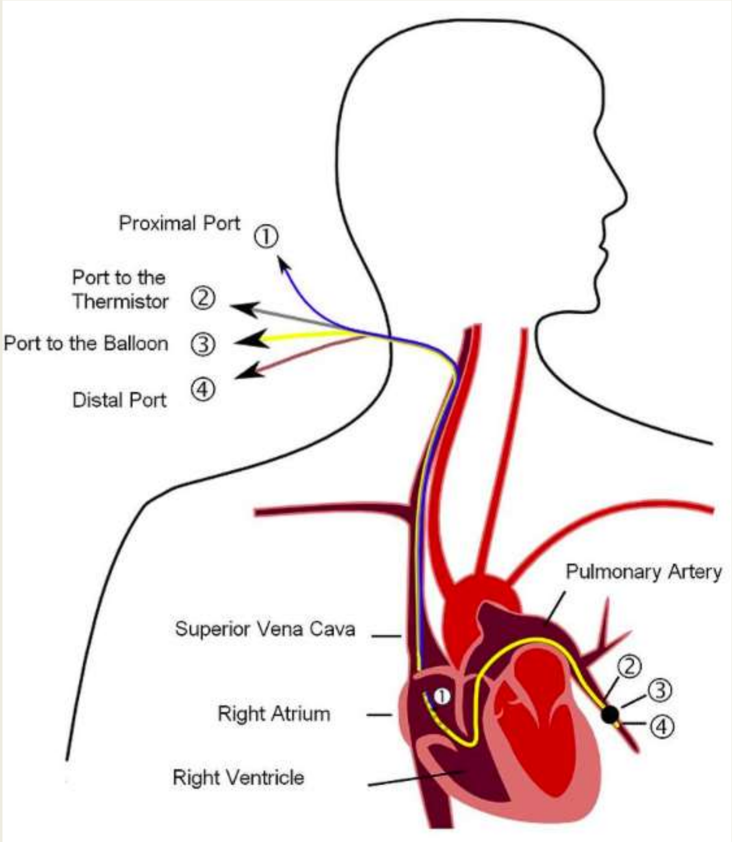
— Johannes Müller

Yöntemler



Pulmoner arter kateteri

- Adolf Fick
- Stewart indikatör dilüsyon
- Fegler termodilüsyon
- Morbidite ile ilişkili



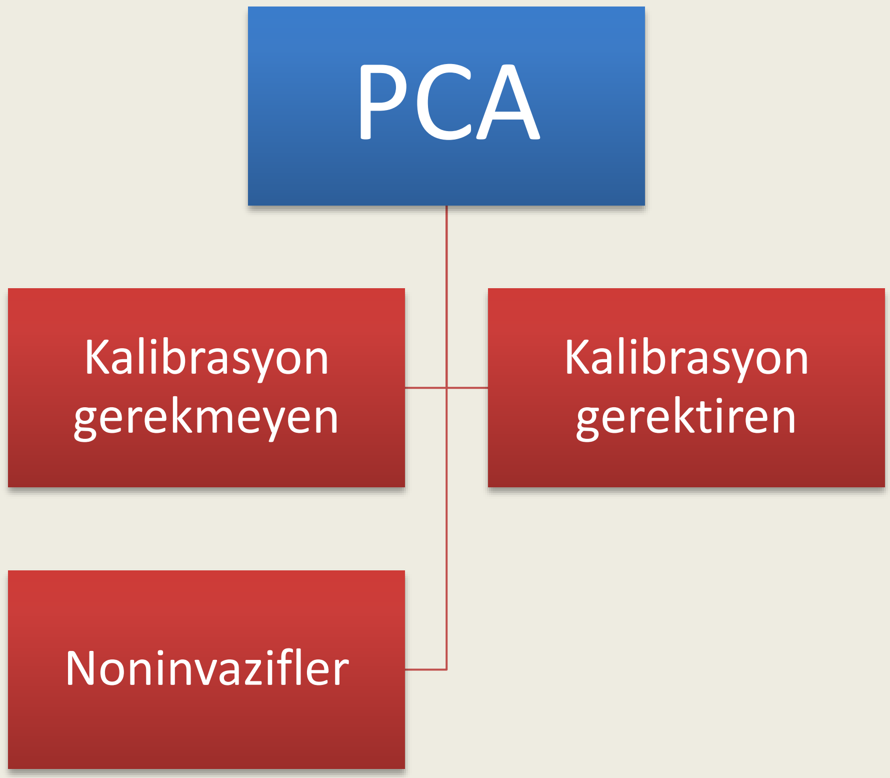
Limitasyonlar

- İndikatör kaybı (enj.öncesi-sırasında-sonrasında)
- Isı volüm
- Resirkülasyon
- Hastanın pozisyon-cerrahi

Limitasyonlar

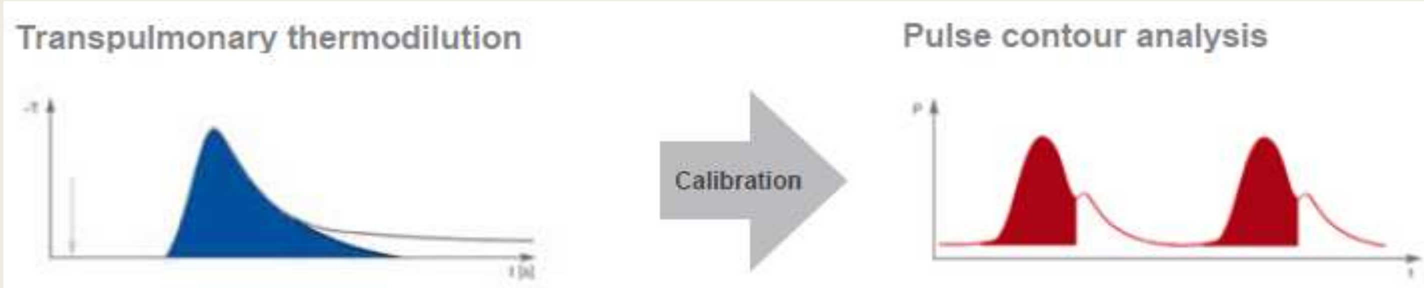
- Vücut ısı değişkenliği
- Sağ kalp outputu
- İnvazif-Komplikasyon
- Tekrarlanabilirlik (%22)
- Devamlı ölçüm yapanlarda-gecikme

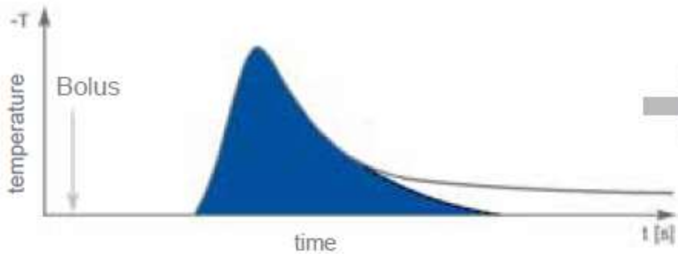
Nabız kontür analizi (Pulse contour analysis)



Kalibrasyon gerektirenler (Transkardiyopulmoner termodilüsyon ve lityum)

Cihaz	Kalibrasyon	Algoritm	Özellik	Dezavantaj
Lidcoplus	Lityum TPD	PulseCO	Arter morfoloji değişikliklerine az hassas	Biraz daha invazif
PiCCO	TPD	Pulse kontür analiz eder, aortik kompliyansa bölerek eğrinin sistolik kısmının alanı ile entegre eder.	Arteryal kompliyans,SVR Gerçek zamanlı KO, PAK ile karşılaştırılmış	Biraz daha invazif Hipotermi? Kalibrasyon?
VolumeView/E1000	TPD	Langewouters	Hiperdinamik, vazoplejik hastalarda geçerli	Biraz daha invazif

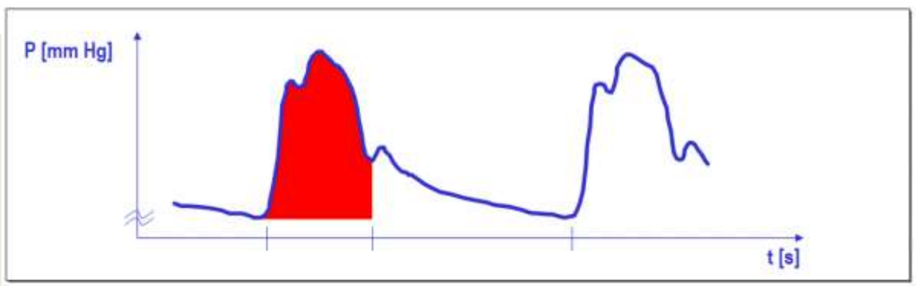




Cardiac output calculation:
Area under the thermodilution curve

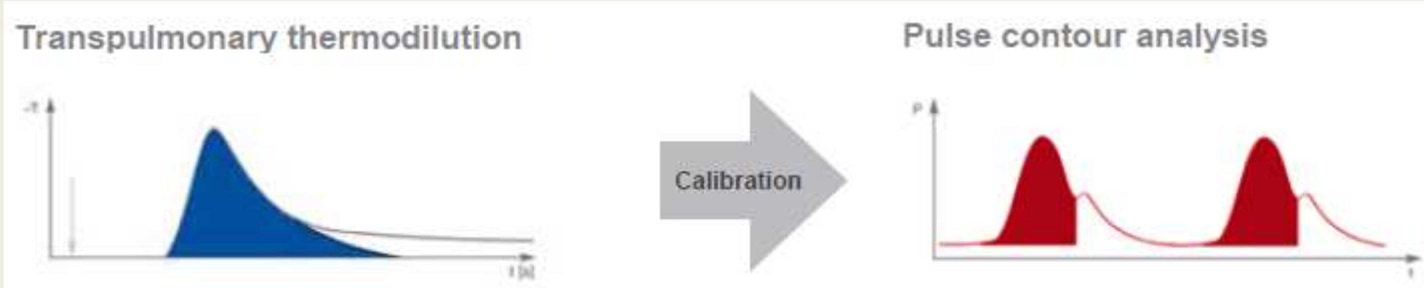
$$CO_{TDa} = \frac{(T_b - T_i) \times V_i \times K}{\int \Delta T_b \times dt}$$

T_b =	Blood temperature
T_i =	Injectate temperature
V_i =	Injectate volume
$\int \Delta T_b \times dt$ =	Area under the thermodilution curve
K =	Correction constant, made up of specific weight and specific temperature of blood and injectate



$$PCCO = cal \cdot HR \cdot \int_{Systole} \left(\frac{P(t)}{SVR} + C(p) \cdot \frac{dP}{dt} \right) dt$$

- cal: Patient-specific calibration factor (determined by thermodilution)
- HR: Heart rate
- $\frac{P(t)}{SVR}$: Area under pressure curve
- C(p): Aortic compliance
- $\frac{dP}{dt}$: Shape of pressure curve



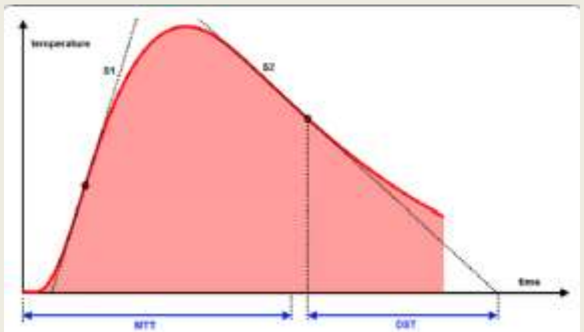
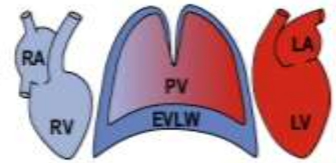


Figure 1 Transpulmonary thermodilution curve. The assessment of global end-diastolic volume (GEDV) by the PiCCO™ system is based on the mean transit time (MTt) and exponential downslope time (DSt), while the assessment of GEDV by the new VolumeView™ method is based on MTt, maximum ascending slope (S1) and maximum descending slope (S2).

1. **Intrathoracic Thermal Volume: ITTV** = CO x MTt
   Definition: Thermal distribution volumes of cardiac chambers plus pulmonary thermal volume



2. **Pulmonary Thermal Volume: PTV** = CO x Edt
   Definition: Thermal distribution volume of the lungs including intravascular, interstitial and alveolar volumes

3. **Global End-diastolic Volume: GEDV** = ITTV – PTV
   Definition: Sum of the end-diastolic volumes of all heart chambers, excluding intrathoracic blood volume

4. **Intrathoracic Blood Volume: ITBV** = GEDV x 1.25

5. **Extravascular Lung Water: EVLW** = ITTV – ITBV
   Definition: Water content outside of the pulmonary vasculature including the pulmonary interstitium plus any alveolar fluid

Limitasyonlar

Daha az invazif ama sağ kalple ilgili veriler yok

Mikst venöz 0_2 saturasyonu yok

Çocuklar için aralıklar uygun değil

Isı, Volüm, İndikatör kaybı, ekstrakorperyal dolaşım, TAV, Pnömenoktomi

Arter, Damping…

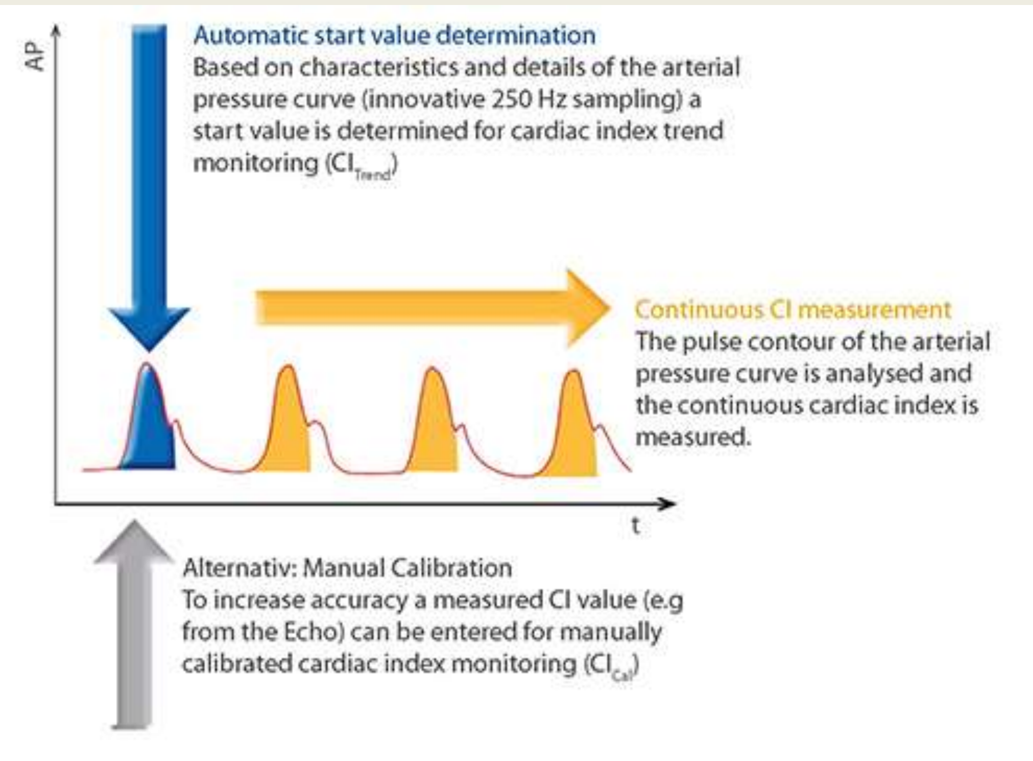
Limitasyonlar

- Lityum tedavisi
- Lityum birikimi
- <40 kg
- İlk trimestr
- Kas gevşeticiler

Kalibrasyon gerekmeyen az invazifler

Cihaz	Algoritm	Özellik	Dezavantaj
Flotrac/Vigileo	Langewouters	En çok çalışma yapılan, Perioperatif dönemde güvenilir	Vazomotor ton Operasyon odası dışında
Lidcorapid	PulseCO	Boy, yaş, ağırlık normogramları	
ProAQT/pulsioflex	Boy, yaş, ağırlık, MAP, HR ile otokalibrasyon	Dalga boyu analizi 250/sn	

ProAQT


AP
Automatic start value determination
Based on characteristics and details of the arterial pressure curve (innovative 250 Hz sampling) a start value is determined for cardiac index trend monitoring (CI_{Trend})
Continuous CI measurement
The pulse contour of the arterial pressure curve is analysed and the continuous cardiac index is measured.
t
Alternativ: Manual Calibration
To increase accuracy a measured CI value (e.g from the Echo) can be entered for manually calibrated cardiac index monitoring (CI_{Cal})


ProAQT

Flotrac/Vigileo

The FloTrac System Algorithm

Formula for Cardiac Output = Heart Rate x Stroke Volume

FloTrac System Cardiac Output = Pulse Rate x [std(BP) *χ]

Pulse Rate [PR]

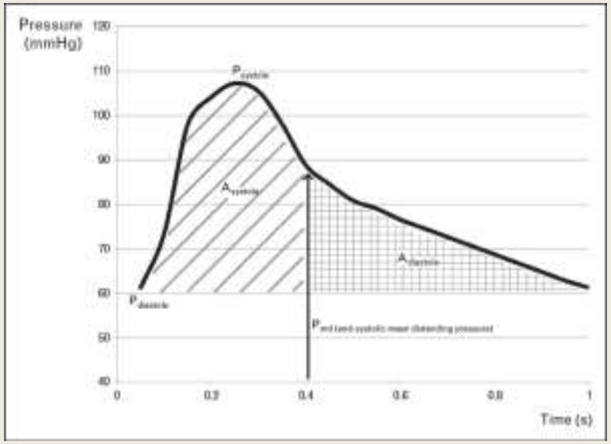
- Measured as beats per minute
- Beats identified by upslope of waveforms
- Advanced beat detection differentiates fully perfused beats
- Computed from 20-second time period of beats

Standard deviation of arterial blood pressure [std(BP)]

- Pulse pressure ∞ SV ∞ std(BP)
- Measured as mm Hg
- Computed on a beat-by-beat basis

The χ factor compensates for differences in vascular compliance and resistance

- Patient-to-patient differences estimated from biometric data
- Dynamic changes estimated by waveform analysis (skewness, kurtosis, of the waveform)
- Measured as mL per beat/mm Hg
- 1-minute average updates



Limitasyonlar

- Algoritmler
- Damping (over-under) rezonans
- Aritmi
- Vasküler tonus değişikliği (NE)
- İABP

Limitasyonlar

- AY
- Perifer arter – arteryal dalga form paterni
- Ameliyatlar
- Farklı hasta grupları

Non invazif nabız kontür analizi

Volüm klemp yöntemi

- CNAP, Nexfin, Clearsight

Radyal arter applanasyon tonometrisi

- T-Line

Volüm klemp yöntemi

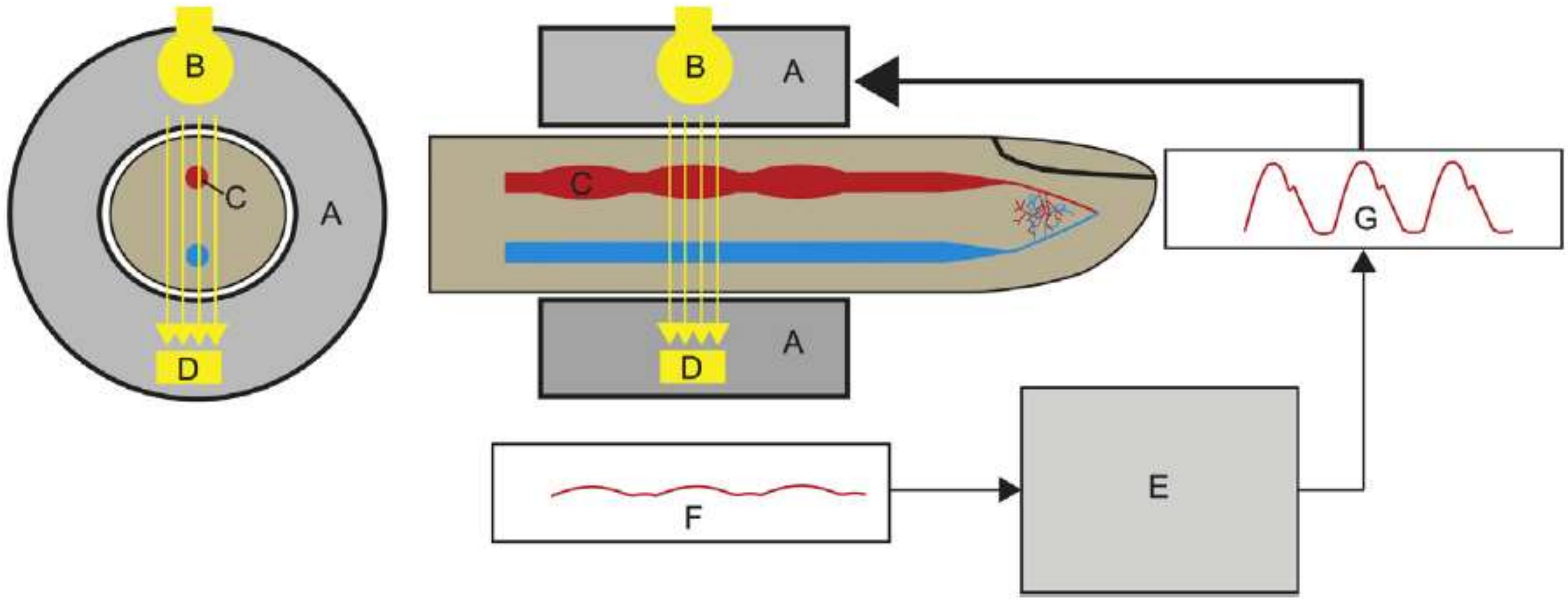


Fig. 3. Schematic illustration showing the theoretical principle of the volume clamp method (also called vascular unloading technique). An inflatable finger cuff (A) applies pressure to the finger and contains an infrared transmission plethysmograph (B) to measure the finger artery's (C) diameter (i.e., blood volume). A light detector (D) that is also integrated in the finger cuff measures the absorption of the infrared light. An increase in artery size because of an increase in blood volume (and subsequently pressure) automatically leads to an increase in cuff pressure with the help of a photo-plethysmographic control system (E) in order to keep the artery diameter constant (and the arterial wall 'unloaded'). Thus, from the pressure needed to keep the volume in the finger artery constant (F) throughout the cardiac cycle, the arterial blood pressure waveform can be derived indirectly (G).

Volüm Klemp yöntemi

Radyal arter aplanasyon tonometrisi

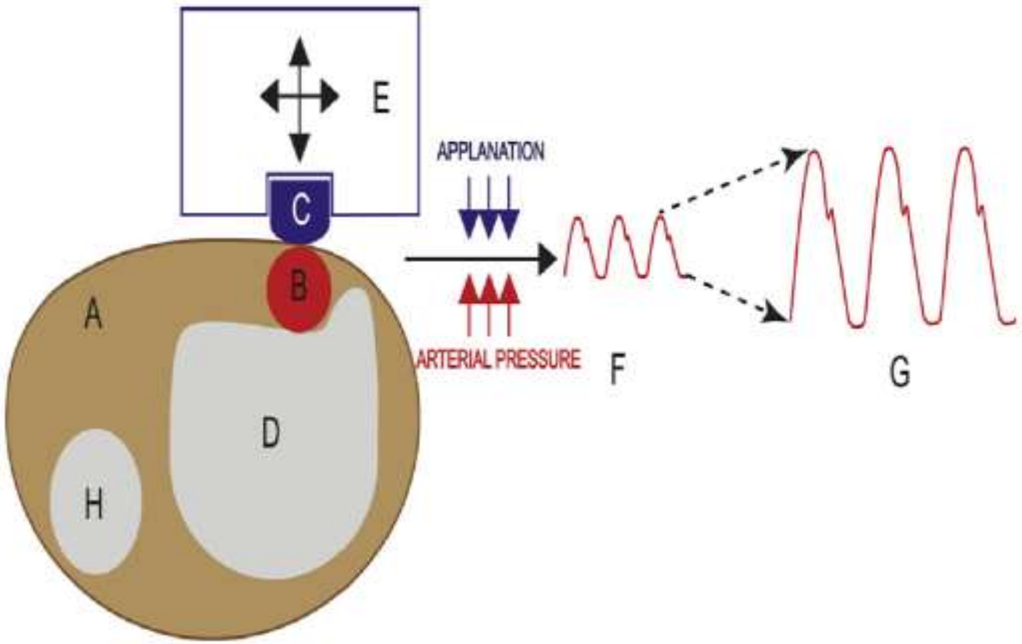


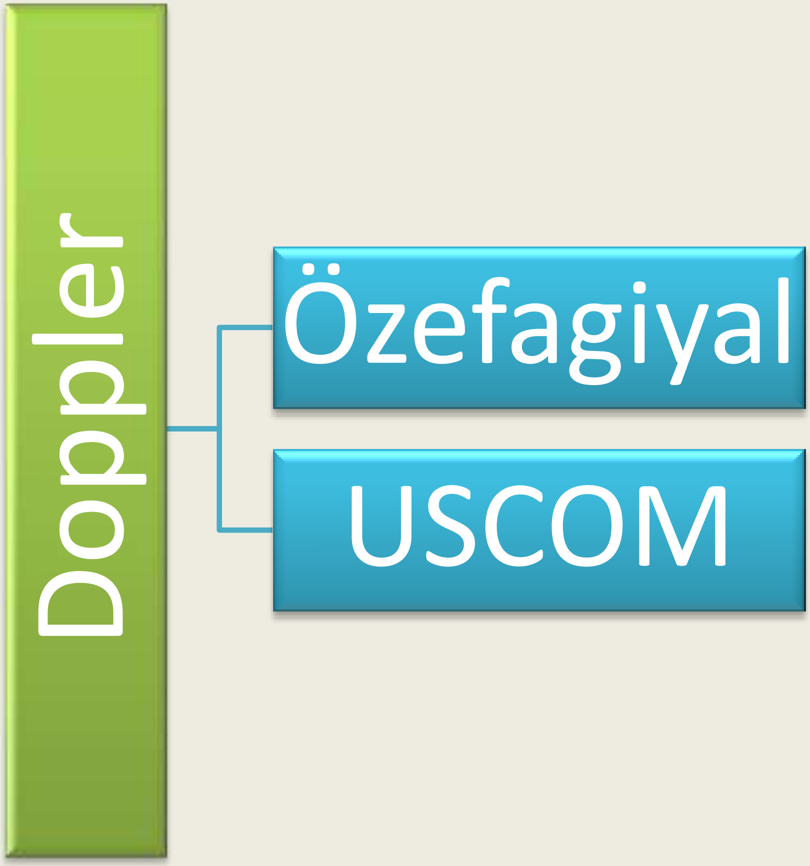
Fig. 4. Cross section of the wrist (A) with a schematic illustration showing the radial artery applanation tonometry technology. The applanation tonometry requires that the radial artery (B) be flattened (applanated) underneath a sensor (C) and be supported by a bony structure (e.g., the radius (D)). The sensor is integrated in a bracelet (E) that also holds the motors to move the pressure sensor laterally for identifying the site of maximum pulsation and up and down for achieving the optimal artery applanation. The maximum pulse pressure (equivalent to the mean blood pressure) can be obtained when the transmural pressure is zero (representing the maximum compliance of the arterial wall). Continuous non-invasive beat-to-beat recording of the arterial blood pressure waveform can thereby be derived (F). Subsequently, the arterial blood pressure waveform is scaled using proprietary signal processing algorithms based on biometric data (G). The ulnar bone is indicated by H.

Limitasyonlar

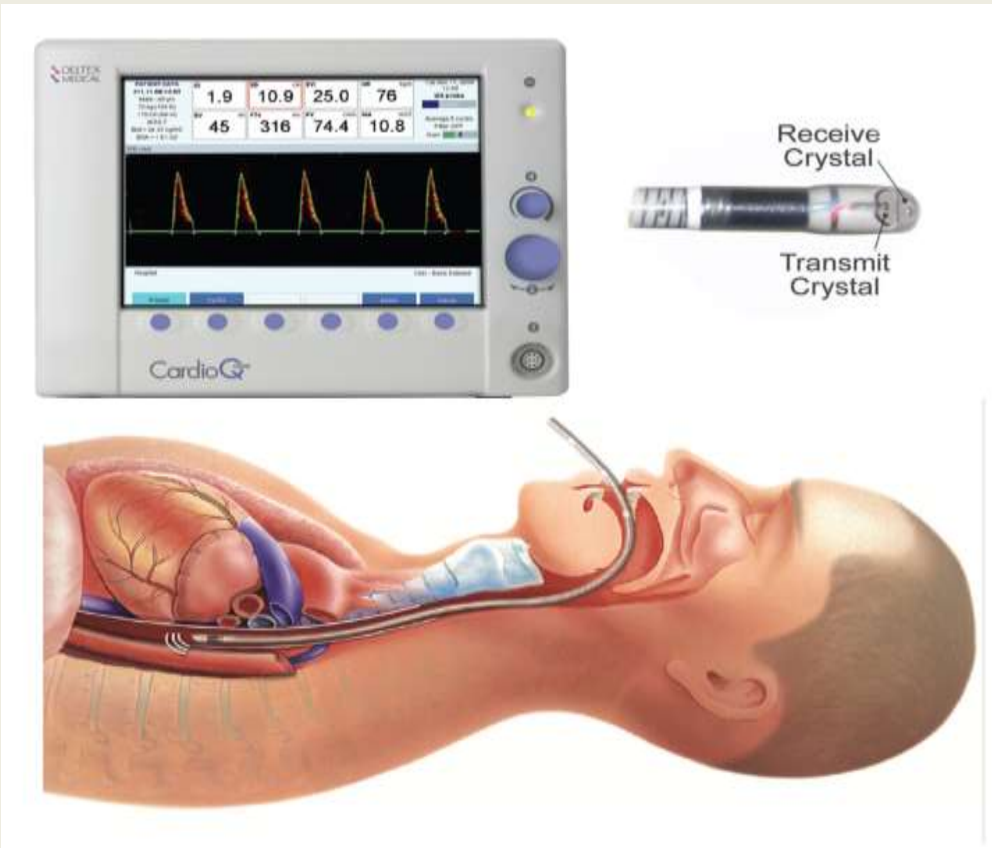
- Algoritmler
- Aritmi
- Vasküler tonus değişikliği
- Hareket artefaktı,Sensör dislokasyonu, Parmak ödemi
- SVR, KO yüksek veya düşük

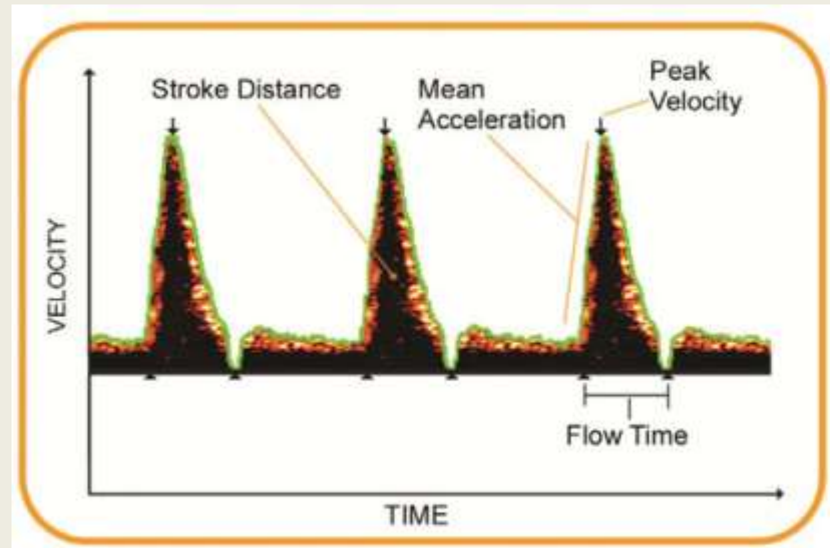
Neyi neyin yerine koymak lazım?

Doppler Teknikleri

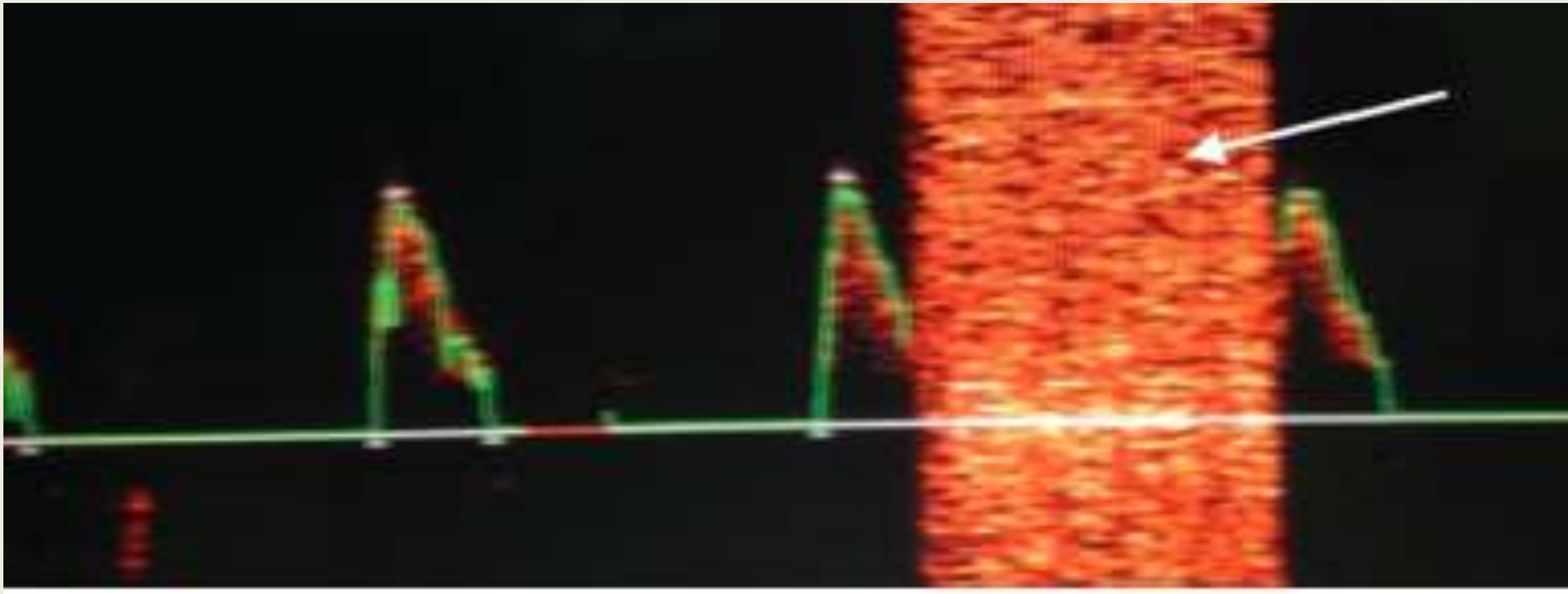


Özefagiyal Doppler EKO






PATIENT DATA
#19.12.08-11.30
Female - 58 yrs
75 kg (165 lb)
167 cm (66 in)
ADULT
BSA = 1.85 m2
CO l/m 3.6
SV ml 39
FTc ms 256
SD cm 4.3
HR bpm 91
PV cm/s 55.5
Fri Dec 19, 2008
11:30
I2S probe
6 hours
Average 5 cycles
Filter OFF
Gain 9
100 cm/s
Snap window
PATIENT DATA
#22.12.08-13.30
Female - 62yrs
72 kg (158lb)
149 cm (59 in)
ADULT
BSA = 1.66 m2
CO l/m 2.9
SV ml 40
FTc ms 363
SD cm 4.5
HR bpm 73
PV cm/s 26.1
Mon Dec 22, 2008
13:30
I2S probe
6 hours
Average 5 cycles
Filter OFF
Gain 9
100 cm/s
Snap window
Hospital
User -Theatre
Run
Take snapshot
Add point to graph
Save screen
Home



Limitasyonlar

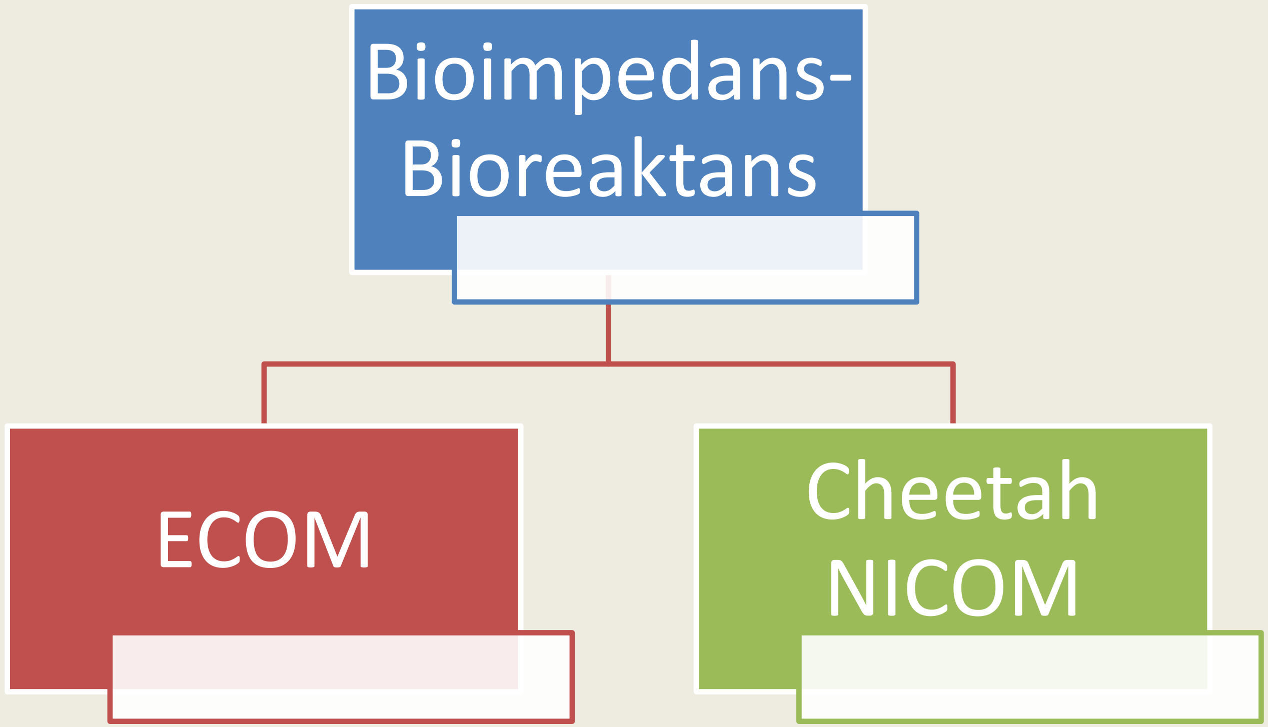
- Semi-invazif, Uyanık hasta?
- Eğitim-Optimal sinyal elde etme
- Desendan aorta-Sefal-Kaudal kan oranını ve Aortun kesitsel alanını sabit kabul eden algoritma
- Aortun çapı-normogram Akımı laminer kabul ediyor. Türbülan?
- Anevrizma, koarktasyon, IABP

USCOM

Limitasyonlar

- Algoritma hasta boyuna göre
- Ağırlık, VYA dikkate alınmıyor
- Doppler teknikleri? PW-CW
- Eğitim

Bioimpedans Bioreaktans ölçümleri



Cheetah NICOM

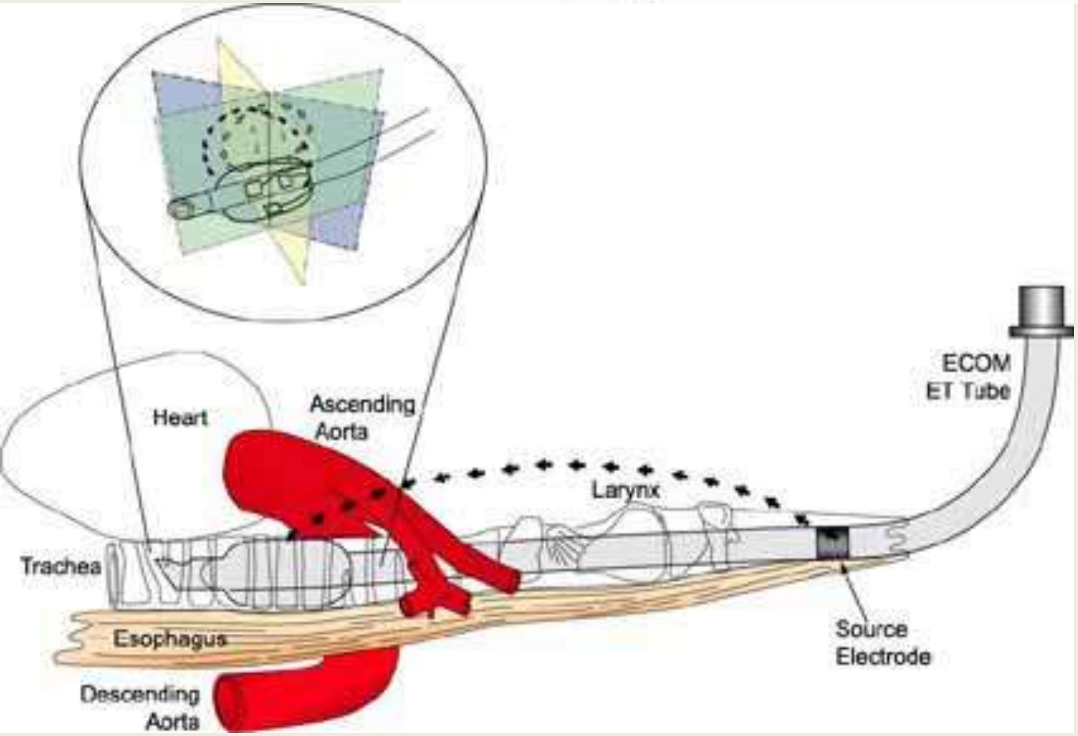
NICOM Completely Noninvasive Cardiac Output Monitor

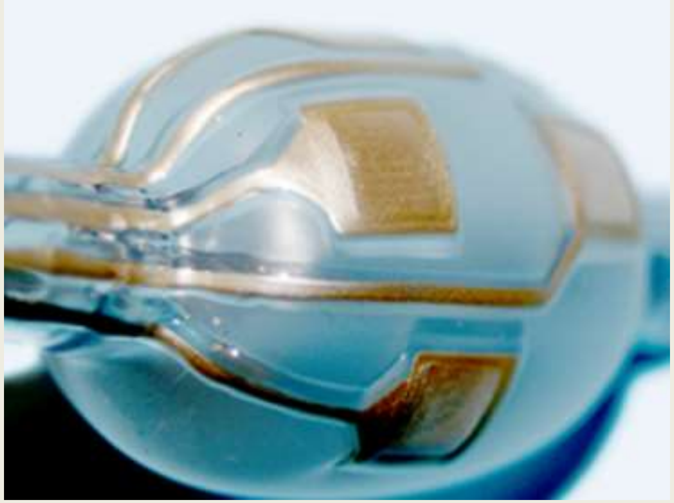
Cheetah NICOM provides continuous, non invasive, hemodynamic insight, delivering real time tracking of Cardiac Output and other key Hemodynamic Parameters.

Prewired sensors

Prewired sensors and bag

Records software


Heart
Ascending
Aorta
Larynx
ECOM
ET Tube
Trachea
Esophagus
Source
Electrode
Descending
Aorta



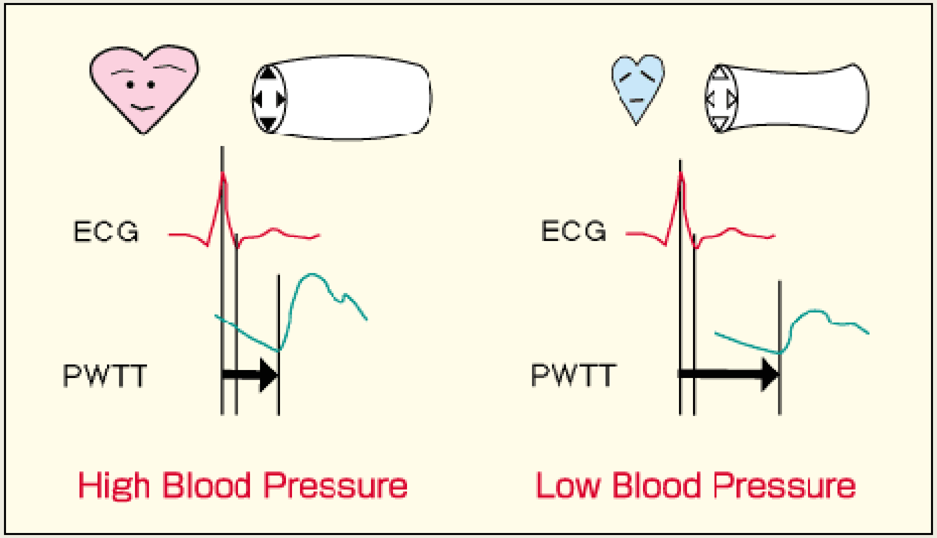
Limitasyonlar

- Büyük sıvı şiftleri
- Pulmoner torasik patolojiler
- Pulmoner ödem efüzyon
- Şant
- Ybc cisim (göğüs tüpü, tel, metal)

Limitasyonlar

- Hareket artefaktı
- Kafın pozisyonu
- Farklı hasta grupları
- Çocuk için elektrot
- Ne kadar gerçek zamanlı?

Nabız dalgası gecikme zamanı (PWTT)



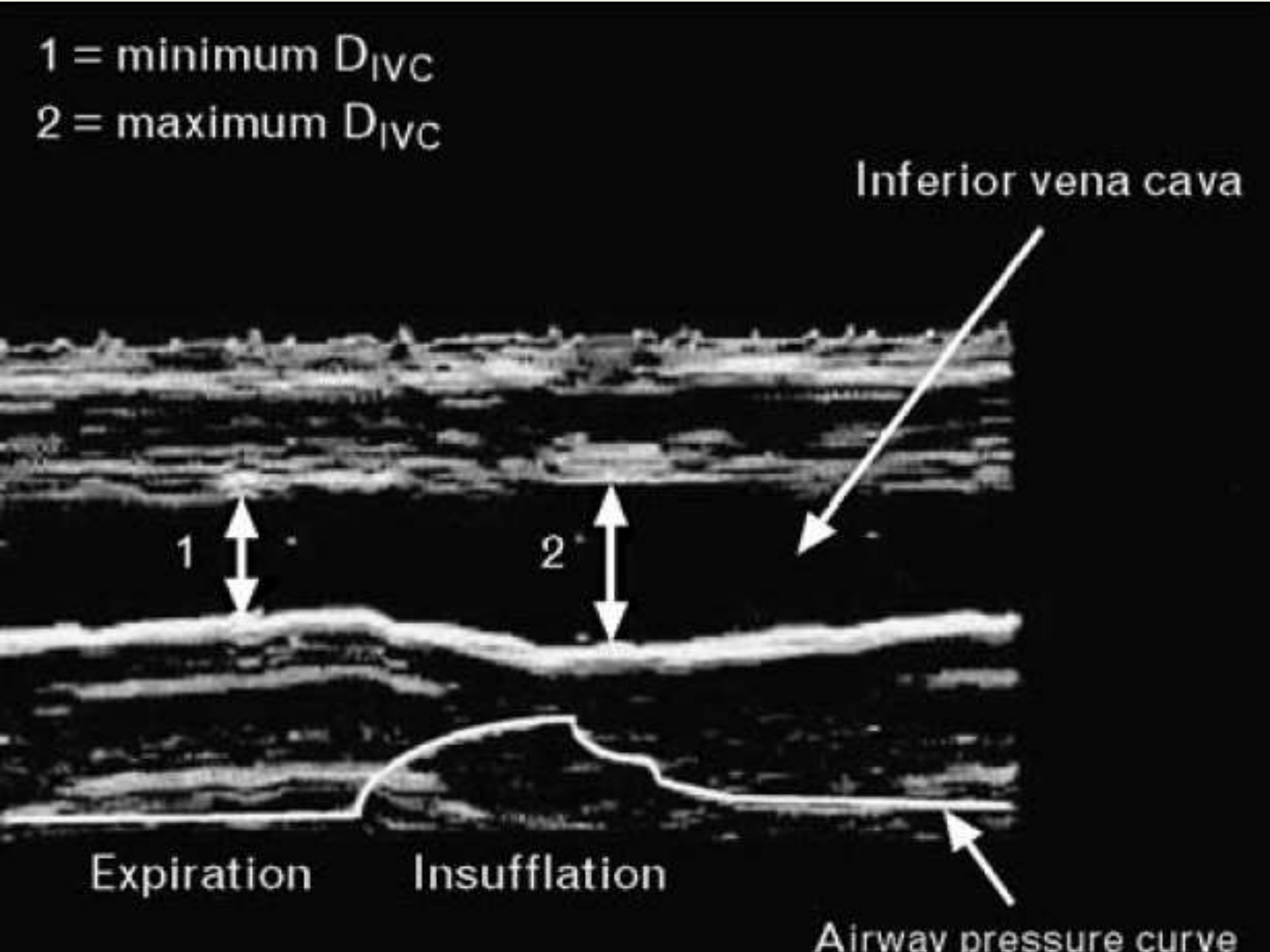
$$CO = K \times (\alpha \times PWTT + \beta) \times HR = esCCO$$

Limitasyonlar

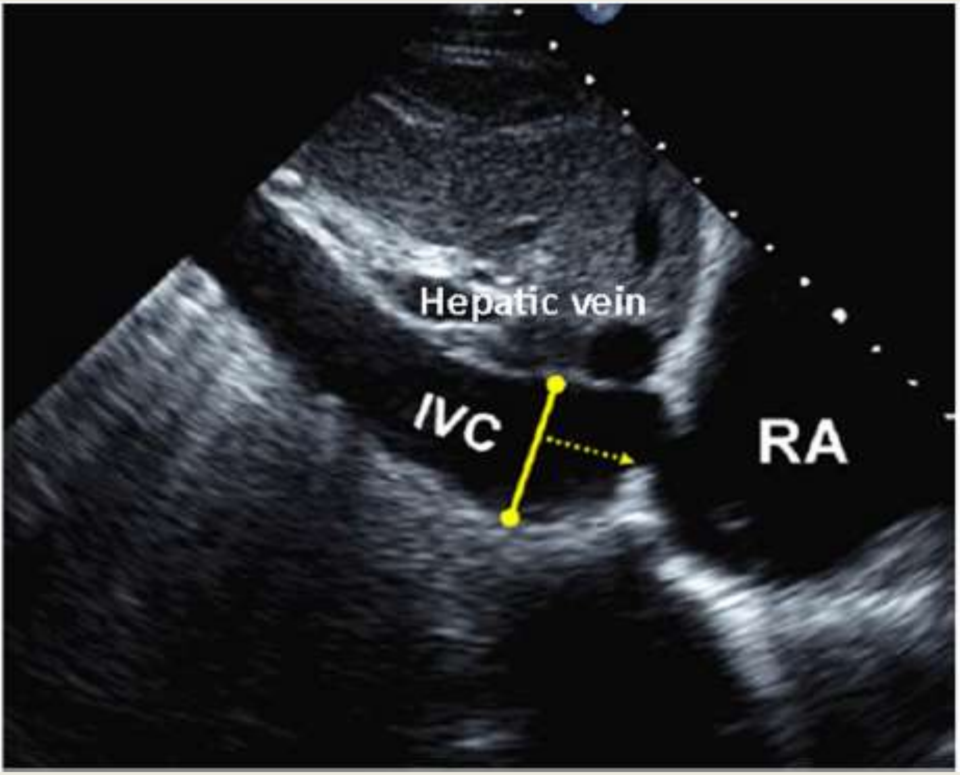
- Başlangıçta kalibrasyon
- Hemodinamik stabilite 3 dk.
- Yeni versiyon morfometrik ölçümler
- Aritmi, Pacemaker, IABP
- Pulse oksimetre (Hipotermi, soğuk çevre)
- Kritik hastalar

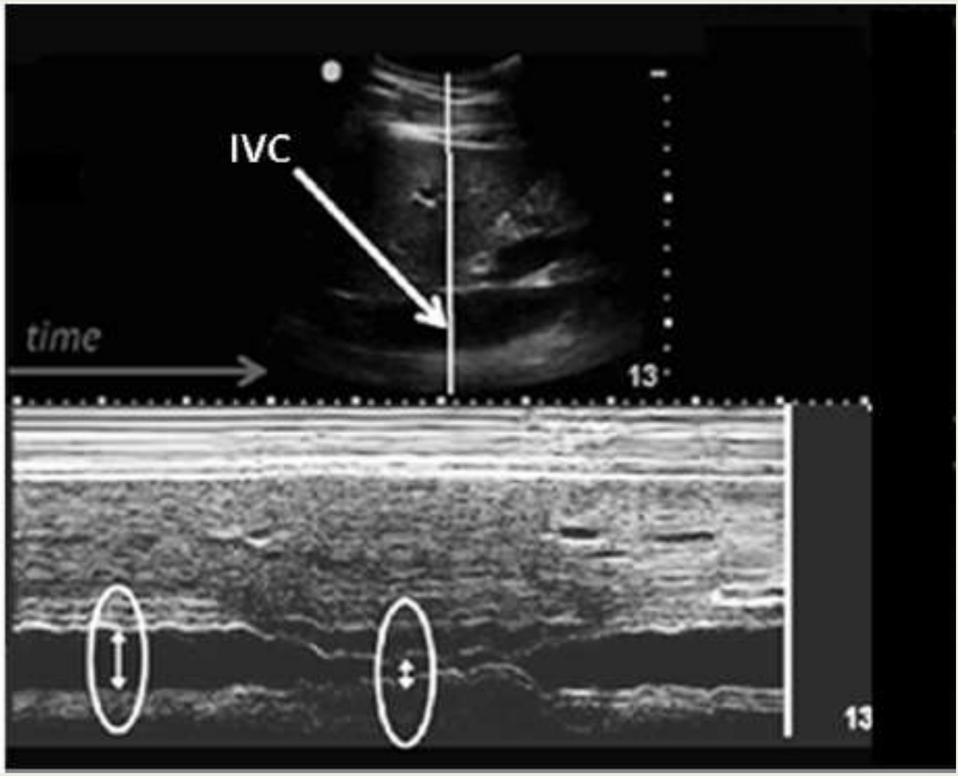
Ultrason

- VCİ çap-kollapsibilite indeksi
- VJİ, VCS



1 = minimum D IVC
2 = maximum D IVC
Inferior vena cava
1
2
Expiration
Insufflation
Airway pressure curve





IVCi-IVCe/IVCi

Guarracino *et al. Critical Care* (2014) 18:647
DOI 10.1186/s13054-014-0647-1

CRITICAL CARE

RESEARCH Open Access

Jugular vein distensibility predicts fluid responsiveness in septic patients

Limitasyonlar

- Pozisyon, Solunum, Diyafram Hareketi, Prob (B line)
- Kişi bağımlı
- İntraabdominal hipertansiyon
- Devamlı?

Ekokardiyografi

- Aortik Kan velositesi
- Delta VTI
- SVV, CO
- E/Ea, Sağ ve sol volümler

Limitasyonlar

- Tecrübe
- Uygulayıcı farklılığı
- Hiperinfle akc, amfizem, insizyonlar, dren, yetersiz hasta pozisyonu

Sıvı cevabının değerlendirilmesi

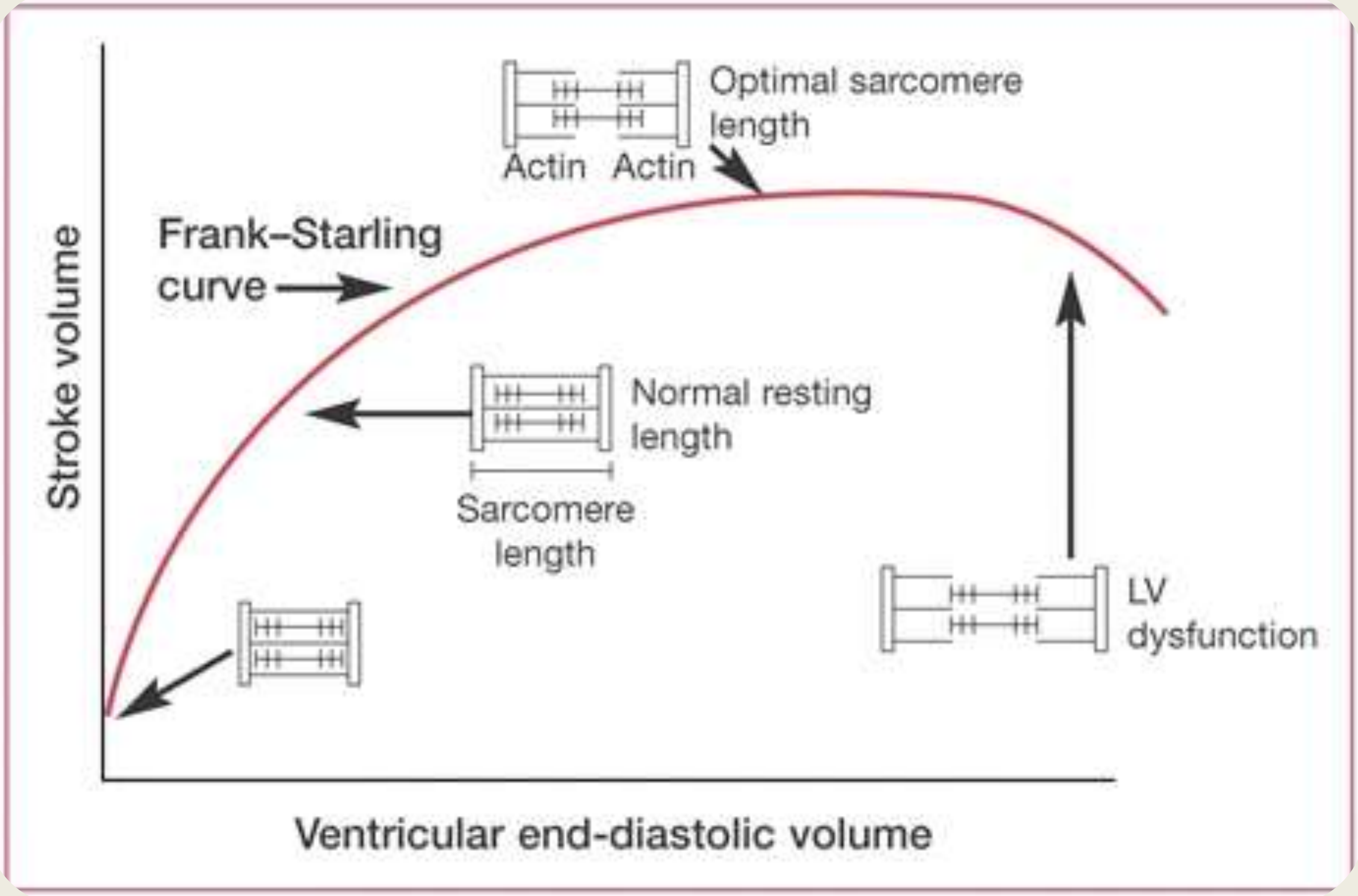
- Kim Cevap Verir?
- Kim Cevap Vermez?
- Her cevap verene sıvı verelim mi?
- Ne zaman Duralım?
- Vazoaktif ajan ?

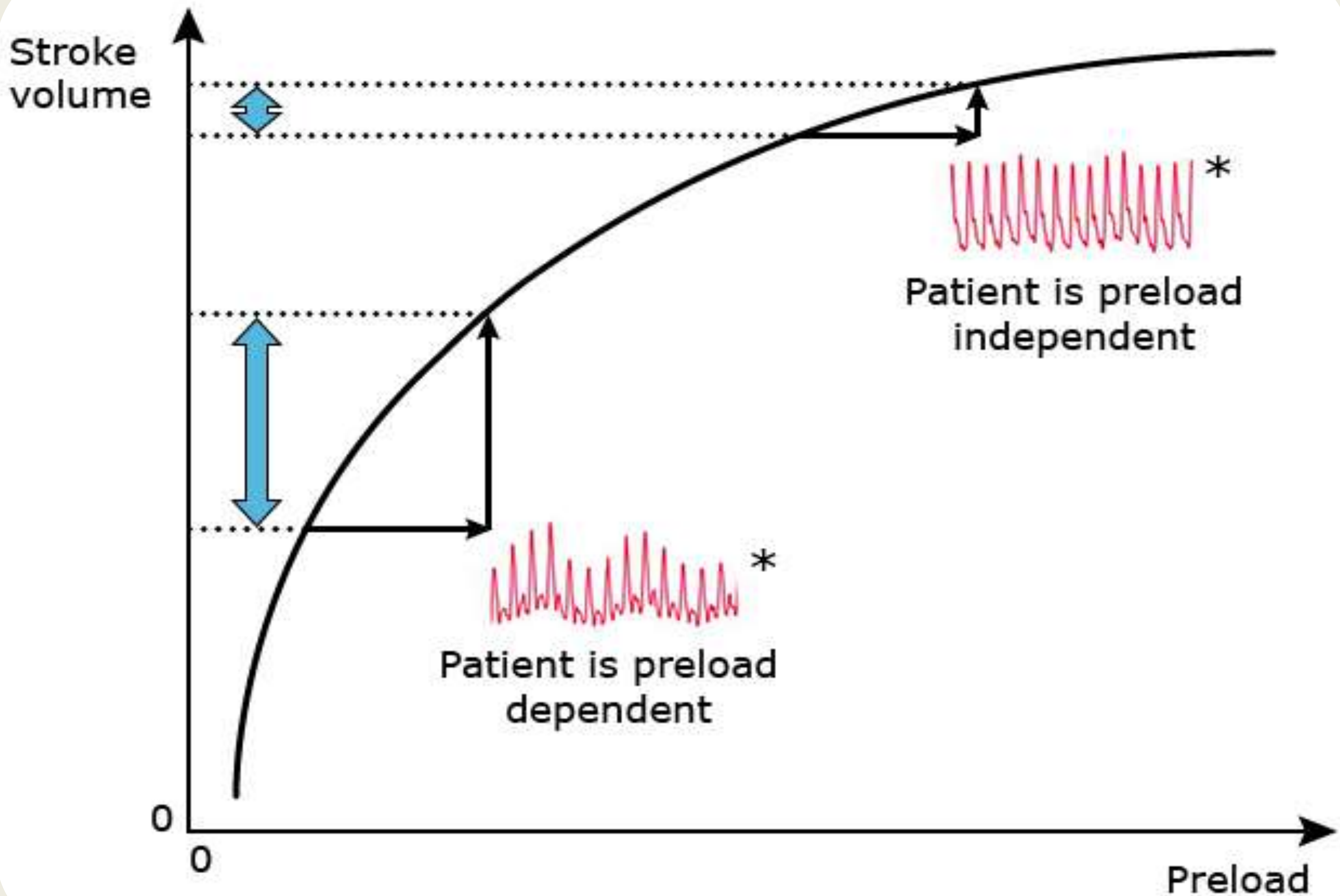

Statik
parametreler

Dinamik parametreler

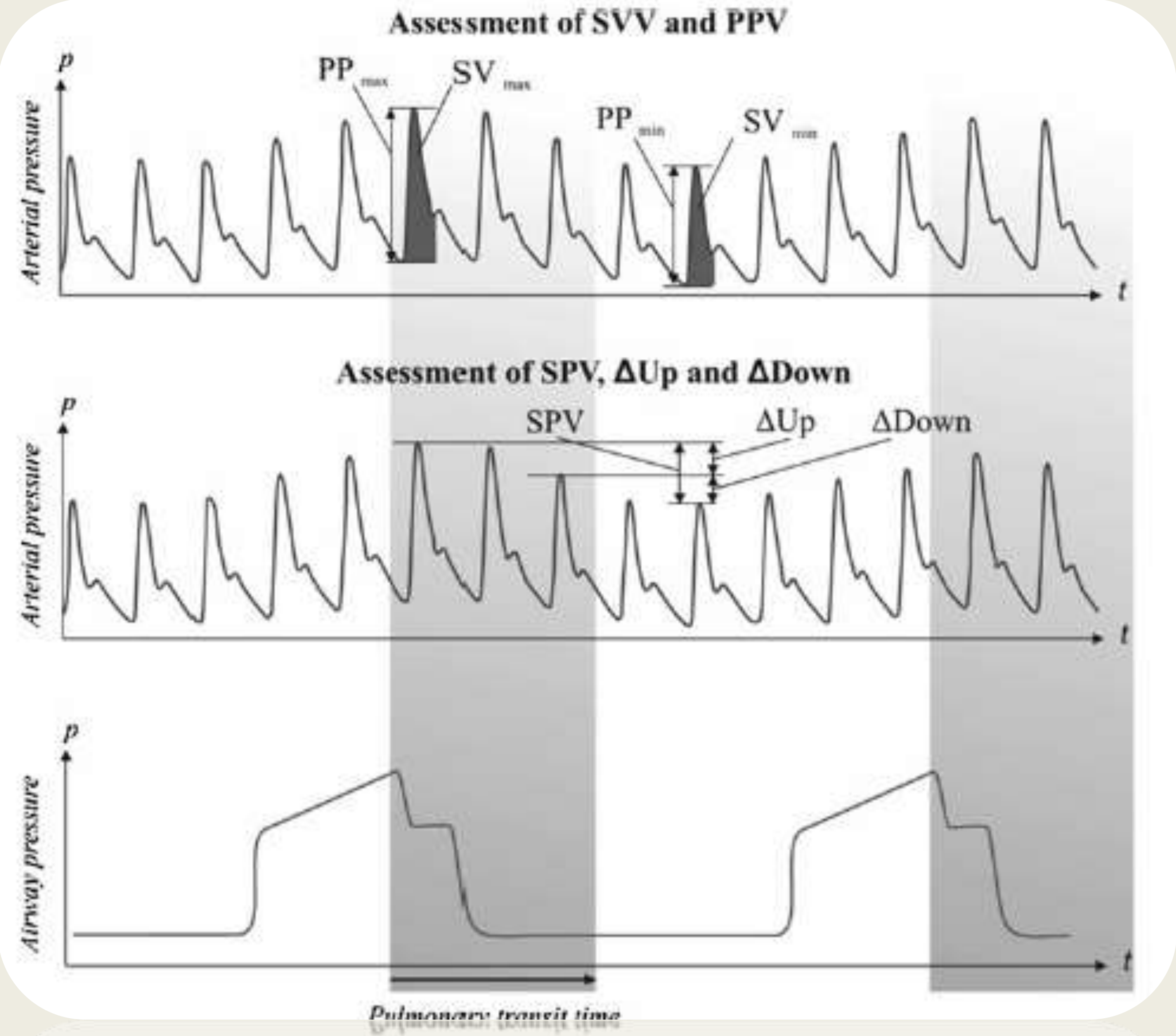
- SVV, PPV, SBV
- PVİ
- EKO (VTİ-Kan velositesi)
- USG (VCİ-VJİ)

Frank-Starling



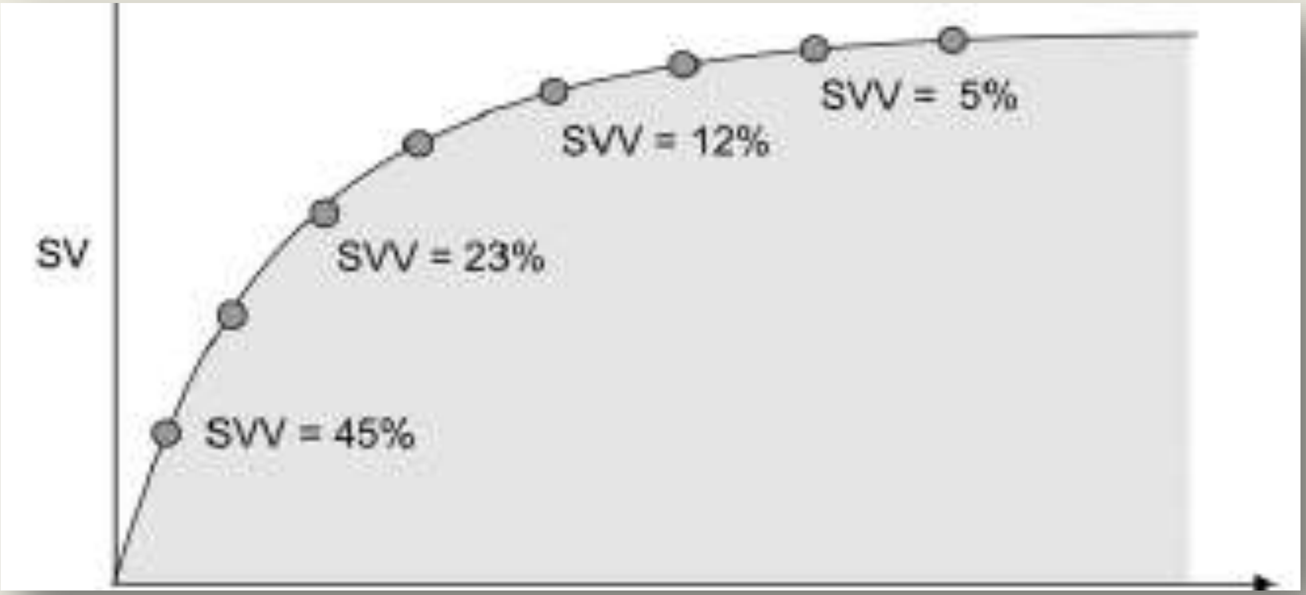


Stroke volume
Patient is preload independent
Patient is preload dependent
*
*
0
0
Preload



Assessment of SVV and PPV
p
PP max
SV max
PP min
SV min
Arterial pressure
t
Assessment of SPV, ΔUp and ΔDown
p
SPV
ΔUp
ΔDown
Arterial pressure
t
p
Airway pressure
t
Pulmonary transit time

SVV



PERIOPERATIVE MEDICINE

Assessing the Diagnostic Accuracy of Pulse Pressure Variations for the Prediction of Fluid Responsiveness

A "Gray Zone" Approach

- %9-13 gri zon
- Hastaların %25 i

Limitasyonlar

- Spontan solunum
- Soluma gayreti-Tetik
- Aritmiler
- Düşük TV (cut of %6,5)

LİmitasyonIar

- Kompliyans 30 ml cmH_2O altında ise
- ARDS yanlış negatif restriktif strateji
- Yüksek frekanslı ventilasyon
- KH/SS<3,6

Lİmitasyonlar

- Artmış intraabdominal basınç
- Yüksek cut-off
- Açık göğüs

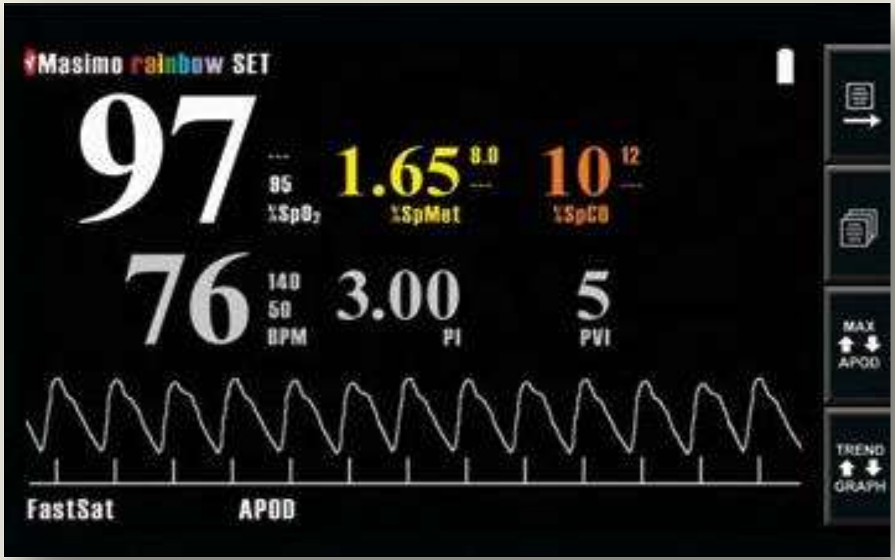
SVV-PPV?

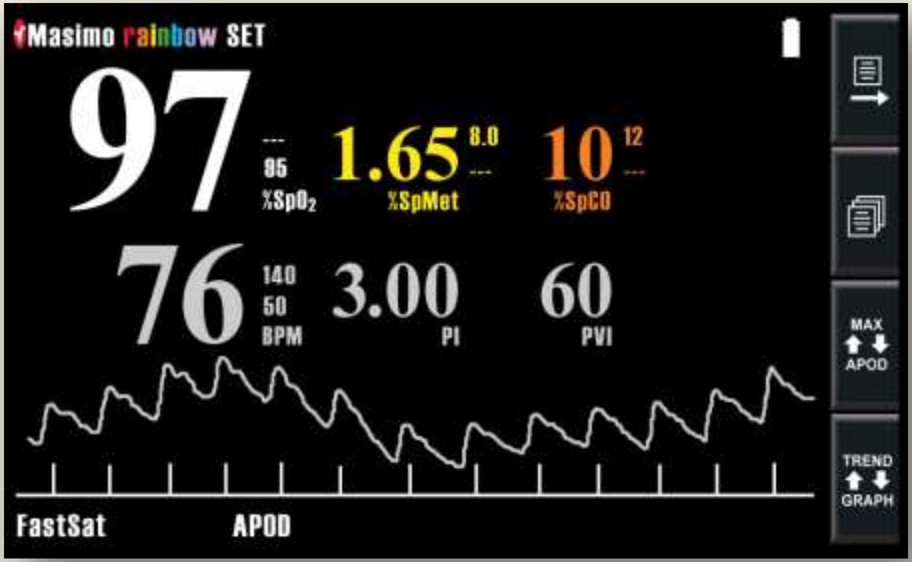
J Clin Monit Comput (2015) 29:197–200
DOI 10.1007/s10877-014-9598-y

LETTER TO EDITOR

Fluid responsiveness is about stroke volume, and not pulse pressure Yogi: the power of Doppler fluid management and cardiovascular monitoring

Pletismografik değişiklikler





Limitasyonlar

- GA-MV-Tetikleme yok
- Aritmi yok –variabilte yok
- TV 8 ml-PEEP 5
- Vazomotor tonus (NE-Ağrı-Şok-Vücut sıcaklığı)
- Hasta hareketi-sinyal kalitesi

End expiratuar oklüzyon testi

ARDS de daha güvenli

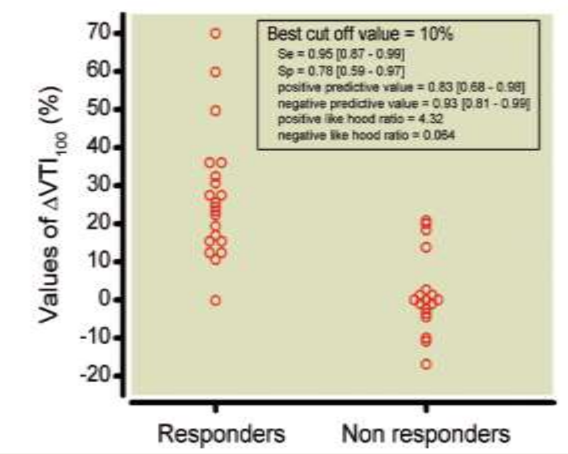
Spontan gayret tetiklerse işe yaramaz

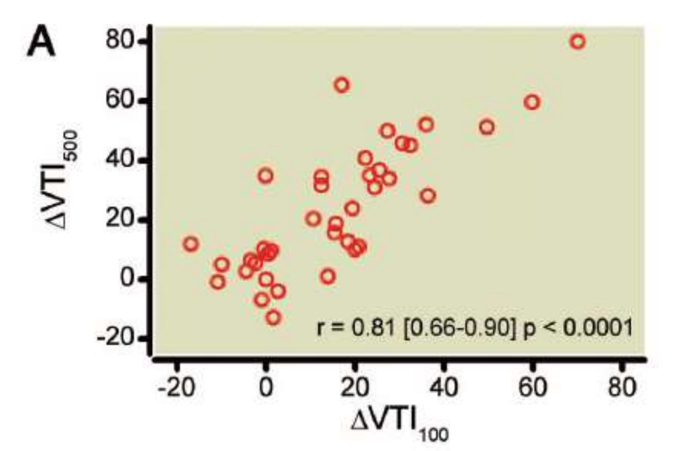
Mini sıvı yükleme (fluid challenge)

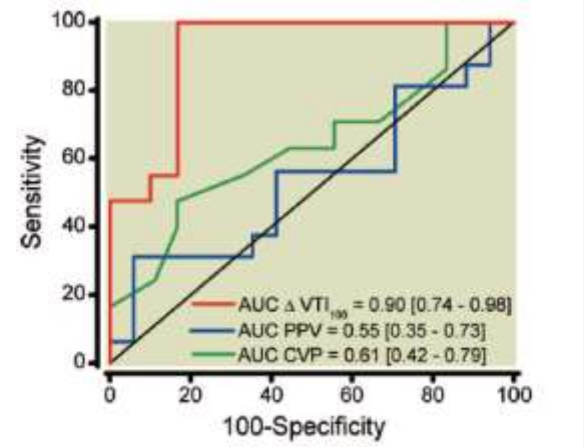
An Increase in Aortic Blood Flow after an Infusion of 100 ml Colloid over 1 Minute Can Predict Fluid Responsiveness

The Mini-fluid Challenge Study

- 39-MV-Yb hastası
- Subaortic VTI - TTE
- 100 ml HES 1 dk., 400 ml HES 14 dk., VTI 100







Anesthesiology 2011; 115:541-7

Wu *et al. Critical Care* 2014, **18**:R108
http://ccforum.com/content/18/3/R108

CRITICAL CARE

RESEARCH Open Access

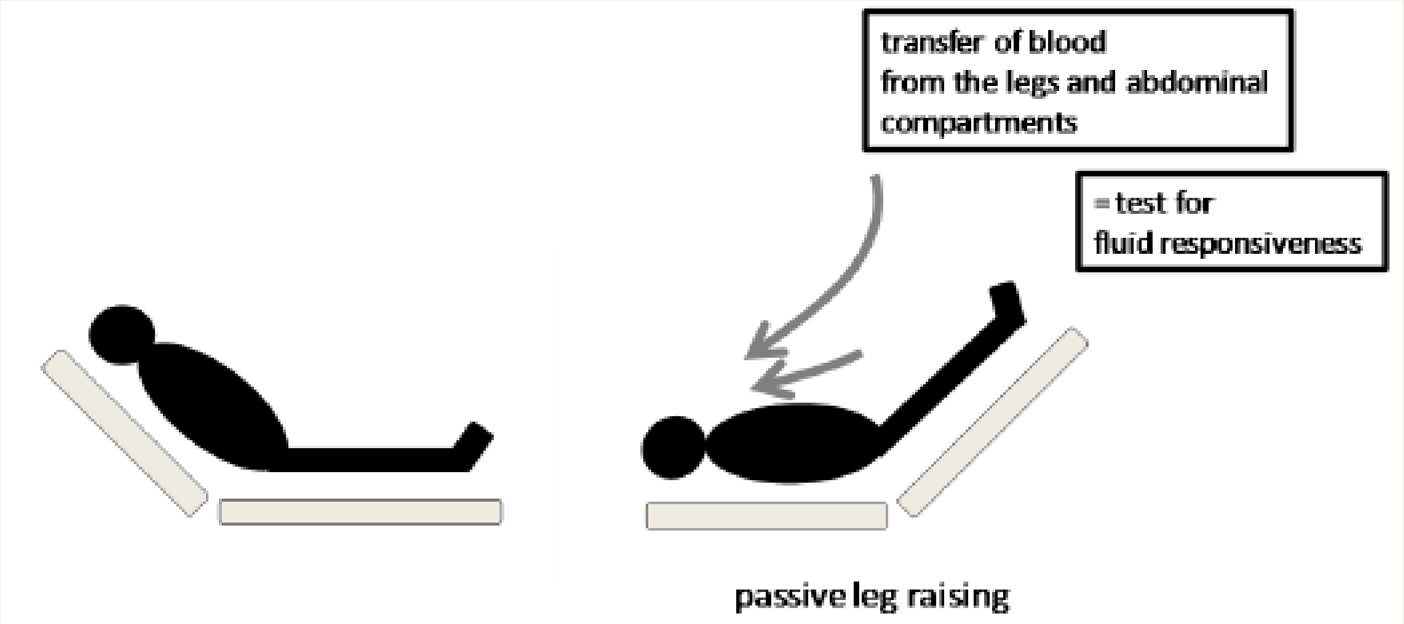
A 10-second fluid challenge guided by transthoracic echocardiography can predict fluid responsiveness

- EKO
- 50-ml kristaloid 10 saniye, 450 ml kristaloid 15 dk.
- SV, aortic velocity time index (VTI), and left ventricular ejection fraction (LVEF)

Lİmitasyonlar

- Mini sıvı-Mini değişiklik
- Keskin bir yöntem

Pasif bacak kaldırma



CI 2.1 → 2.6 $\Delta \geq 15\%$

$ETCO_2$ 32 → 37 $\Delta \geq 5\%$

CI 2.1 → 2.3 $\Delta \leq 15\%$

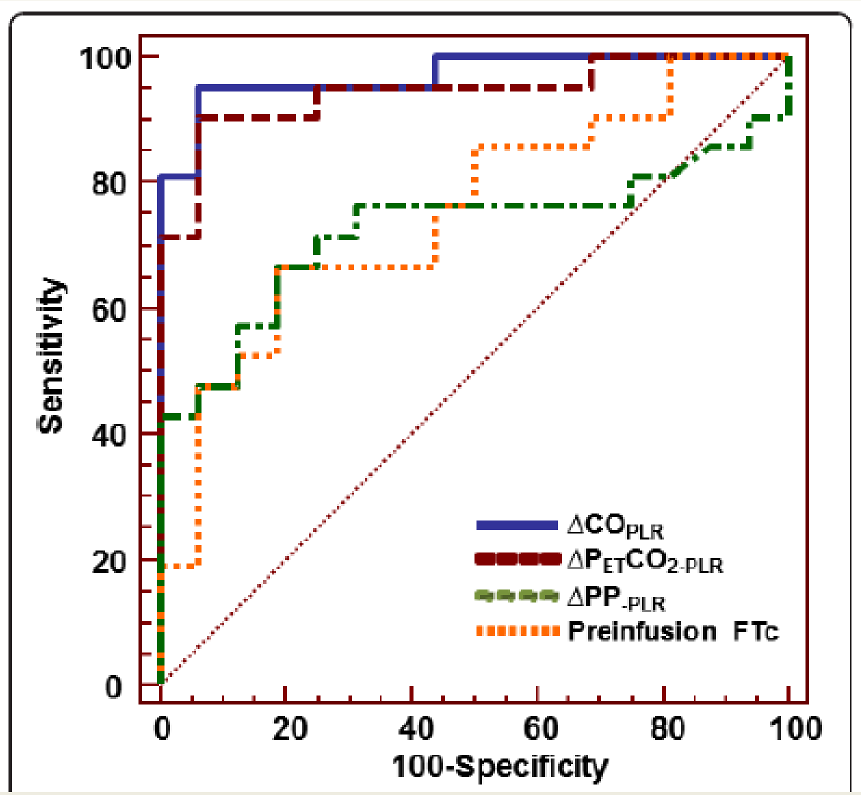
$ETCO_2$ 32 → 32 $\Delta \leq 5\%$

Monge García *et al. Annals of Intensive Care* 2012, 2:9
http://www.annalsofintensivecare.com/content/2/1/9

Annals of Intensive Care
a SpringerOpen Journal

RESEARCH Open Access

Non-invasive assessment of fluid responsiveness by changes in partial end-tidal CO_2 pressure during a passive leg-raising maneuver



Intensive Care Med (2010) 36:1475–1483
DOI 10.1007/s00134-010-1929-y

REVIEW

Fabio Cavallaro
Claudio Sandroni
Cristina Marano
Giuseppe La Torre
Alice Mannocci
Chiara De Waure
Giuseppe Bello
Riccardo Maviglia
Massimo Antonelli

Diagnostic accuracy of passive leg raising for prediction of fluid responsiveness in adults: systematic review and meta-analysis of clinical studies

- Ventilasyon modundan bağımsız
- Kardiyak ritimden bağımsız
- Teknikten bağımsız
- Rutin
- PLR cCO > PLR cPP

Limitasyonlar

Her hastaya uygulanabilir mi? Ampute hasta

Her ameliyatta uygulanabilir mi?

İntra abdominal basınç

İntrakraniyal basınç

ELSEVIER
SFAR
Société Française d'Anesthésie et de Réanimation
Anaesthesia Critical Care & Pain Medicine

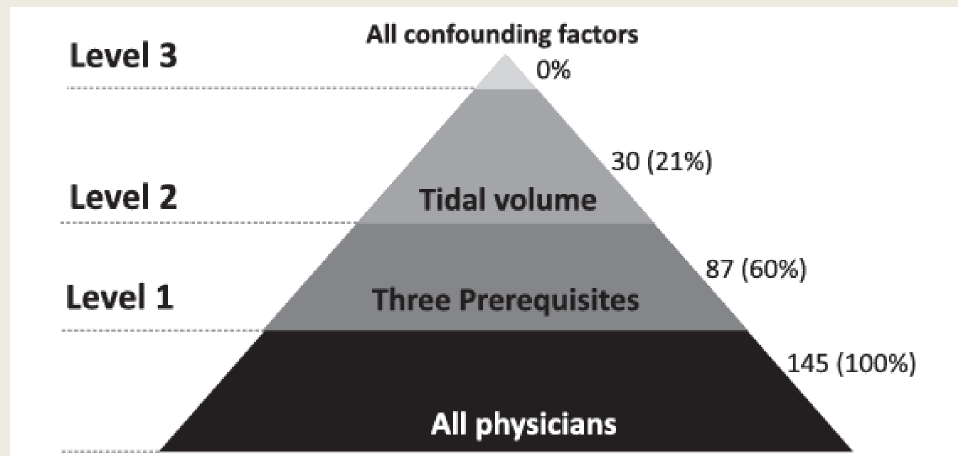
Original article

Evaluation of the knowledge base of French intensivists and anaesthesiologists as concerns the interpretation of respiratory arterial pulse pressure variation

CrossMark

Table 1
Expected answers to clinical cases.

Item	Expected answer
PPV formula	100 × [(PPmax-PPmin)/((PPmax + PPmin)/2)]
PPV physiological support	Respiratory variability of arterial pulse pressure
PPV threshold value	> 13%
Gray zone approach	Area of uncertainty without clinical application
PPV prerequisites	Sinus rhythm, controlled ventilation without spontaneous breathing and continuous arterial pressure monitoring
PPV confounding factors	
Respiratory conditions	Vt ≥ 8 mL/kg, HR/RR > 3.6, low respiratory system compliance (< 30 mL/cmH$_2$O) due to low pulmonary compliance
Cardiac conditions	Absence of RVD (TAPSE > 15 mm)
Abdominal conditions	Absence of intra-abdominal hypertension (< 16 mmHg)



British Journal of Anaesthesia **112** (4): 681–5 (2014)
Advance Access publication 29 December 2013 · doi:10.1093/bja/aet442

BJA

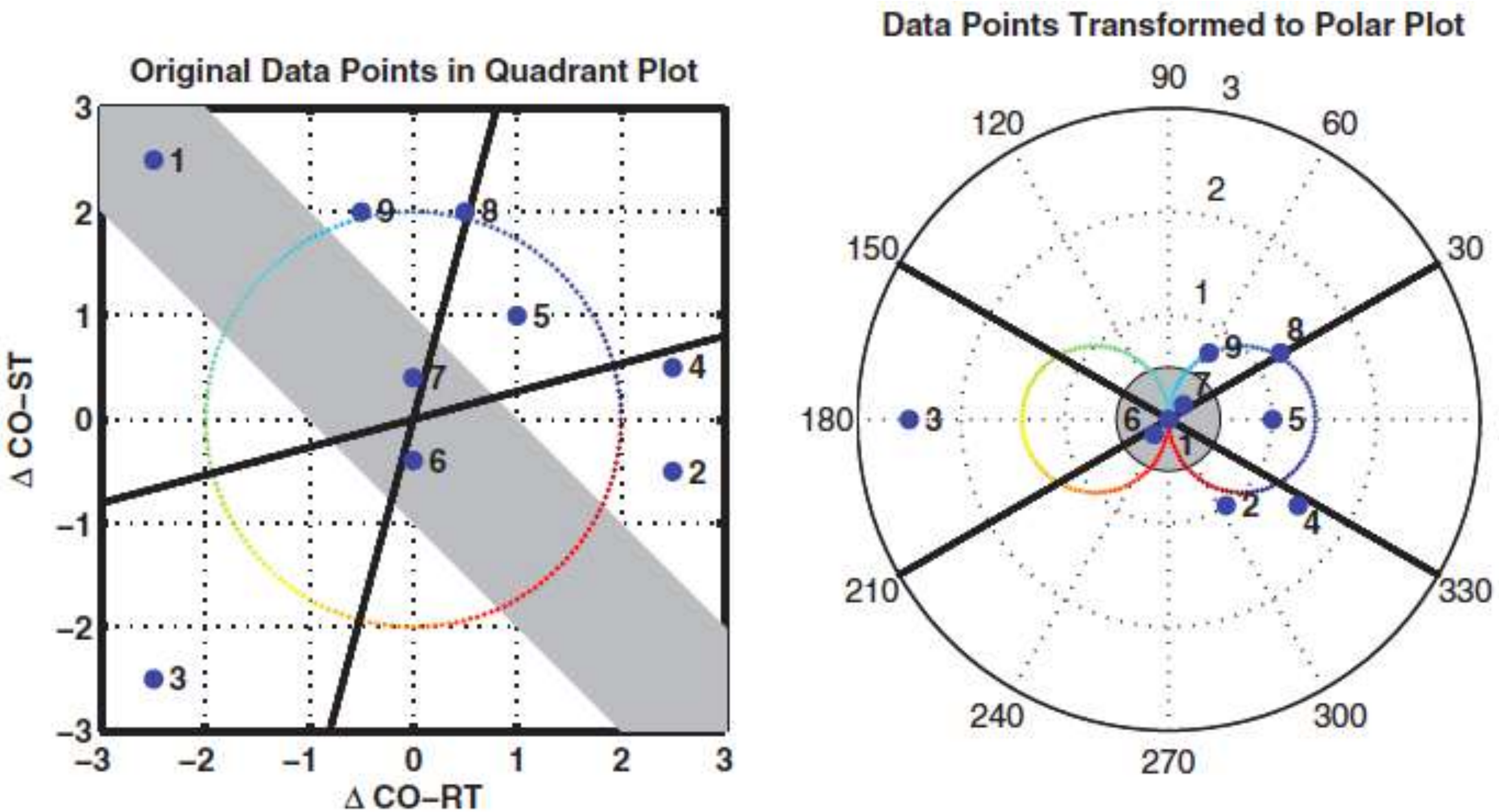
CRITICAL CARE

Evaluation of pulse pressure variation validity criteria in critically ill patients: a prospective observational multicentre point-prevalence study†

Methods. A 1 day, prospective, observational, point-prevalence study was performed in 26 French intensive care units (ICUs). All patients hospitalized in the ICUs on the day of the study were included. The ΔPP validity criteria were recorded prospectively and defined as follows: (i) mechanical ventilation in the absence of spontaneous respiration; (ii) regular cardiac rhythm; (iii) tidal volume ≥8 ml kg^{-1} of ideal body weight; (iv) a heart rate/respiratory rate ratio >3.6; (v) total respiratory system compliance ≥30 ml cm H_2O^{-1}; and (vi) tricuspid annular peak systolic velocity ≥0.15 m s^{-1}.

Results. The study included 311 patients with a Simplified Acute Physiology Score II of 41 (39–43). Overall, only six (2%) patients satisfied all validity criteria. Of the 170 patients with an arterial line in place, only five (3%) satisfied the validity criteria. During the 24 h preceding the study time-point, fluid responsiveness was assessed for 79 patients. ΔPP had been used to assess fluid responsiveness in 15 of these cases (19%).

Tracking Changes in Cardiac Output: Statistical Considerations on the 4-Quadrant Plot and the Polar Plot Methodology



Noninvasive Hemodynamic Monitoring Devices

New Tools or Just Another Toy?

Bizim için bulunan bizim bulmadığımız aletler


PCCI
GEDI
ELWI
Vigileo

EDITORIAL

Goal-Directed Therapy: Time to Move on?

Maurizio Cecconi, MD, FRCA, MD(UK), FICM, and Andrew Rhodes, FRCP, FRCA, FFICM, MD

Yeni sonuçlar?

- Çok şey öğrendik
- Doğru hedef ne?
- Sadece hemodinami-Basit
- Demetler
- ERAS

Hiçbir monitör tek başına outcome

Monitor ihtiyacı zamanla değişir

Herkese uygulanacak optimal hemodinamik değer yok

Verilerin kombinasyon ve integrasyonu

Tahmin edilen ölçülen değil

Tek olay non invaziflik değil

Hastanın tipi, sorulan soru, içinde bulunan durum


F
E
40
80
60


01:33:42
Primus


a
b
c
d
e
f
84
74
87
87
87
64
117
76
99
94
30
130/88
36,4