HEMODİNAMİK MONİTORİZASYON

DOÇ. DR. MÜCAHİT EMET
ATATÜRK ÜNİVERSİTESİ
ACİL TIP AD
ERZURUM 201

FM ve Vital Bulgular yeterli mi?

- KH, KB, SS, sat
- Şuur bulanıklığı
- Idrar çıkışı

KKY'de AC Dinleme Bulguları

- Ral (+) ✳ hepsinde wedge basıncı > 18 ✳ çok spesifik
- Wedge basıncı > 18 olanların ≅ %25'de ral (+) ? sensitivite çok düşük
- SONUÇ: KKY'de ral yoksa hastanın sıvı volumü hakkında bişey söyleyemezsin

968

JACC Vol. 22. No. 4
October 1993:968–74

Bedside Cardiovascular Examination in Patients With Severe Chronic Heart Failure: Importance of Rest or Inducible Jugular Venous Distension

SAMUEL M. BUTMAN, MD, FACC, GORDON A. EWY, MD, FACC, JAMES R. STANDEN, MD, KARL B. KERN, MD, FACC, ELIZABETH HAHN, MA
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American Journal of Emergency Medicine (2012) **30**, 954–960

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Brief Report

The inability of emergency physicians to adequately clinically estimate the underlying hemodynamic profiles of acutely ill patients☆,☆☆,★

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Abstract

Objective: Emergency physicians (EPs) estimate the underlying hemodynamics of acutely ill patients and use them to help both diagnose and formulate a treatment plan. This trial compared the EP clinically derived estimates of cardiac output (CO) and systemic vascular resistance (SVR) to those measured noninvasively.

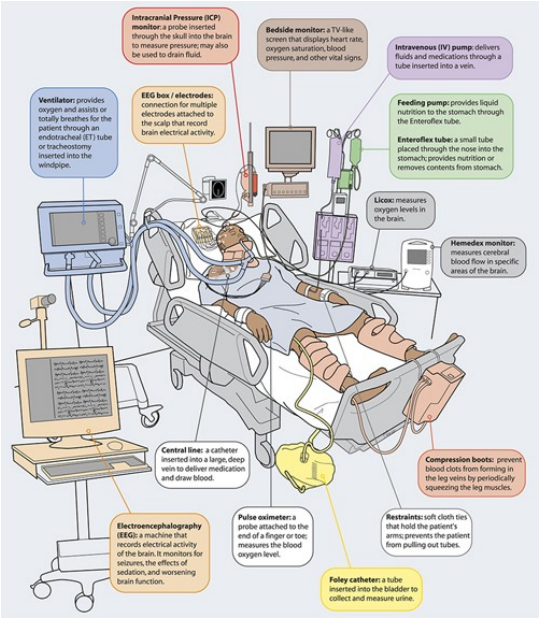
Methods: Forty acutely ill emergency department patients with a broad range of diagnosis and blood pressure (BP) and pulse were monitored for 2 hours using novel noninvasive finger cuff technology (Nexfin; BMEYE, Amsterdam, The Netherlands). The Nexfin device provides continuous BP monitoring and, from the resulting pulse pressure waveform, calculates beat-to-beat CO and SVR. At baseline assessment and after 2 hours of testing and therapy, treating EPs were asked to estimate the CO and SVR (low, normal, or high), and these were compared with Nexfin measurements.

Results: Twenty-five men and 15 women were enrolled with a mean age of 62.2 years (SD, 12.6 years). Eighteen had acute shortness of breath; 11, with probable stroke syndrome; 3, with suspected sepsis; and 8, with a systolic BP greater than 180 or less than 100 mm Hg. Concordance tables showed that there was very little agreement (κ values) between either the compared initial CO (−0.0873) and SVR (−0.0645) or the 2-hour values (−0.0645 and −0.1949, respectively).

Conclusions: Emergency physicians cannot accurately estimate the underlying hemodynamic profiles of acutely ill patients when compared with more objective measurements. This inaccuracy may have important clinical ramifications. Further study is needed to determine how to use these measured continuous CO and SVR monitoring values.

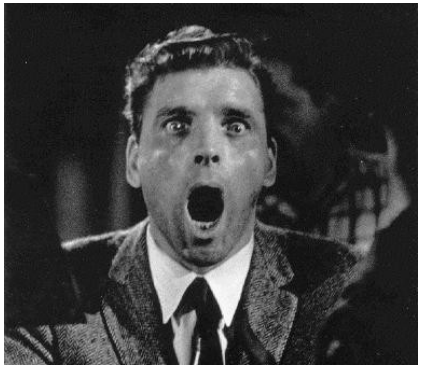
HEMODİNAMİK MONİTORİZASYON AMAÇ

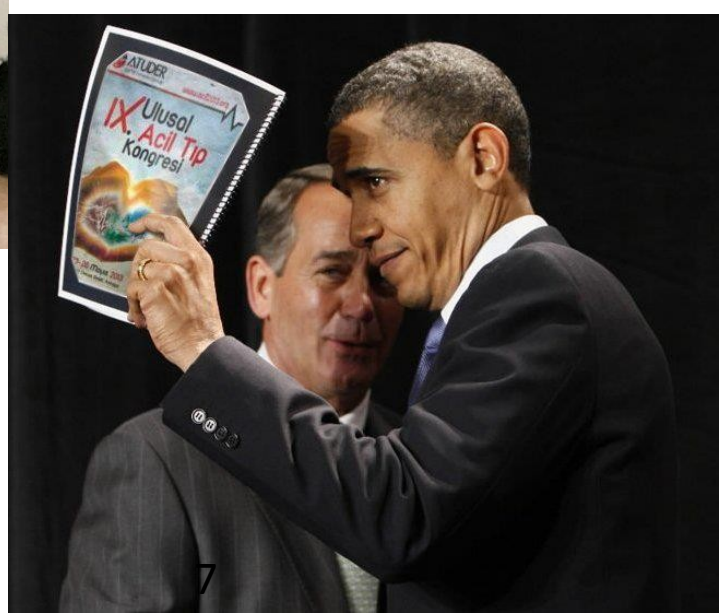
- **Doku perfüzyonunu değerlendirmek**
  - **Oksijenasyon ve dağılım (akım)**
- Hastanın kötüye gidişini erken tesbit etmek



3 önemli Şok Tipi

1. Distributive ✳ Septik
2. Volum ✳ Hipovolemik
3. Pompa ✳ Kardiyojenik





ORIGINAL ARTICLE

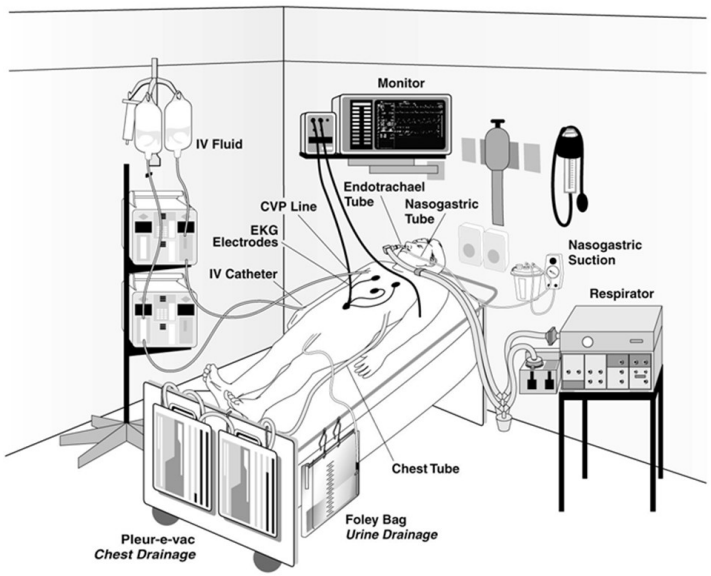
Early Goal-Directed Therapy in the Treatment of Severe Sepsis and Septic Shock

Emanuel Rivers, M.D., M.P.H., Bryant Nguyen, M.D., Suzanne Havstad, M.A., Julie Ressler, B.S., Alexandria Muzzin, B.S., Bernhard Knoblich, M.D., Edward Peterson, Ph.D., and Michael Tomlanovich, M.D. for the Early Goal-Directed Therapy Collaborative Group

N Engl J Med 2001; 345:1368-1377 | November 8, 2001 | DOI: 10.1056/NEJMoa010307

- Acilde santral venöz O2 sat ve arteryel O2 sat ölçerek agresif resutasyon uygulamak septik şoklu hastalarda prognozu iyileştirir

- Vitaller haricinde bazı erken şok parametreleri kullanalım ✳ erken tedaviye başlayalım


Monitor
IV Fluid
Endotrachael Tube
Nasogastric Tube
CVP Line
EKG Electrodes
IV Catheter
Nasogastric Suction
Respirator
Chest Tube
Foley Bag
Urine Drainage
Pleur-e-vac
Chest Drainage

tar


PHILIPS

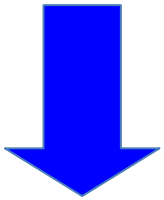
KARDİYAK OUTPUT

- Dk.da LV'den pompalanan kan miktarı
- CO = HR x SV
- N = 4-8 L/min
- CO ↓
  - Sepsis
  - Hipovolemi
  - Kardiyojenik şok

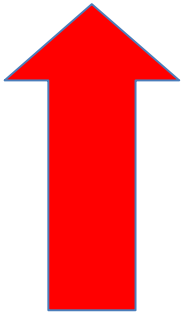
Kardiyak İndeks (CI)

- Perfüzyonu belirtmede daha doğru bir değer
- BSA'yı göz önüne alır
- CI = CO / BSA
- N = 2,5 – 4,2 L /min/ m2

- Hipovolemi
- Artmış direnç



- Septik şok
- Gebelik
- Siroz
- Atletler



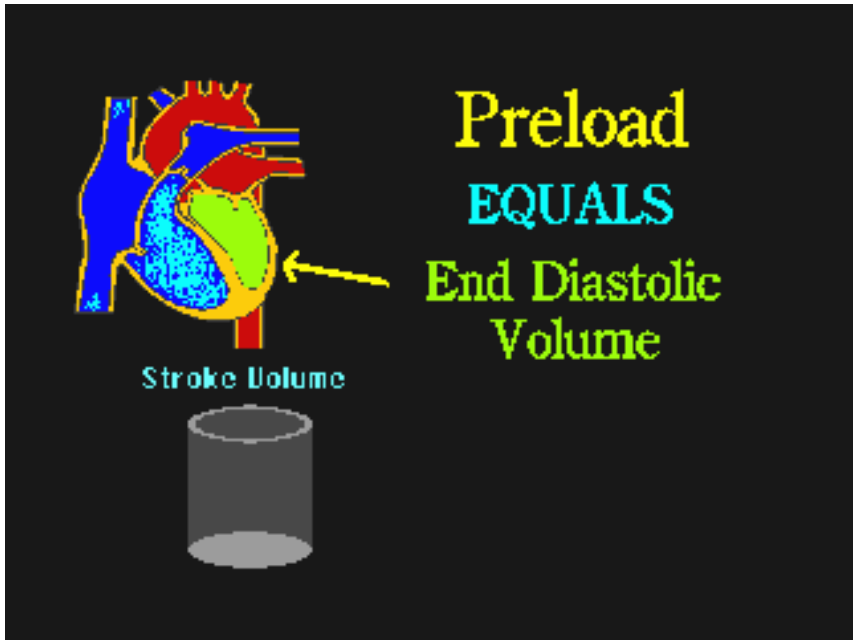
Stroke Volume (Atım Hacmi)

- Her atımda ventrikülden pompalanan kan miktarı
- N = 60 – 130 mL/ atım
- 3 öğeye bağlı

1. Preload (Ön yük)
2. Afterload (Art yük)

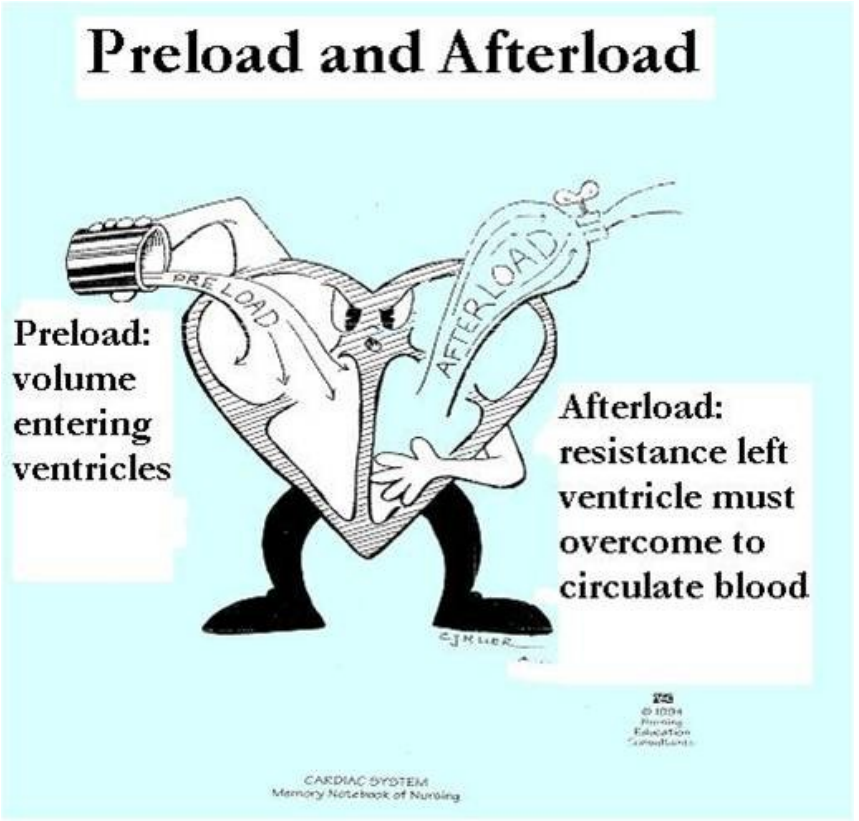
Preload (Ön yük)

- Ventrikülün diyastol sonunda gerilme veya hacim miktarı
- Diyastolik fazda oluşur
- Ventrikülün gerilme ve dolma kabiliyeti
- Damarların kanı getirme kabiliyeti



LV Preload

- LV end-diastolik pressure (LVEDP)
- Diyastol sonunda LV içinde kalan kan miktarı
- PAC ✳ PCWP ile de ölçülür

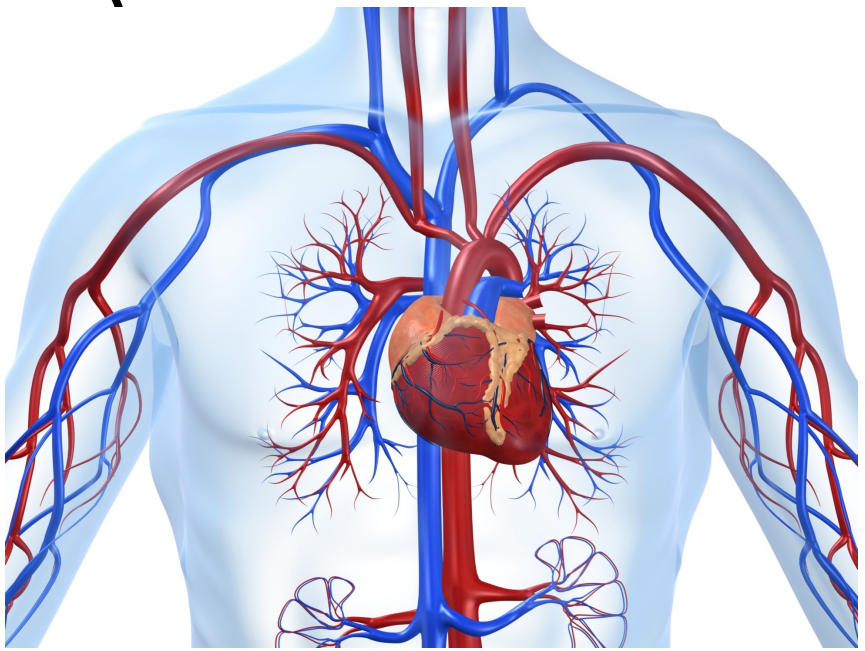


Afterload (Art yük)

- Kanı pompalamak için ventrikülün aşması gereken direnç
- Damar çapı ne kadar fazla ise afterload o kadar düşük
- Kalp kapağını açmak için miyokardın ihtiyacı olan

Afterload – Sistemik vasküler direnç

- LV önündeki damar direnci = SKB / CO
- Aort ve sistemik damarlardan köken alır
- Ateroskleroz, vasküler tonu değiştiren durumlar ve ilaçlardan etkilenir



Kontraktilite

- Kalp kası liflerinin kasılma ve kan pompalama kabiliyeti
- Preload miktarından etkilenir ✳ Starling kanunu denir
- Afterload’dan etkilenir

LV Ejeksiyon Fraksiyonu (EF)

- Kontraksiyonda, V tarafından pompalanan kan %'si
- EF=EDV-ESV/EDV x 100
- Kontraktiliteden etkilenir
- ↑: hiperdinamik durumlar, pozitif inotroplar, vs

SvO2 = Mixed venous oxygen saturation

- Doku hipoksisinin bir göstergesi = Dokuların oksijen tüketiminin göstergesidir
- Pulm art kanda % O2 sat = kalbe dönen kanda Hb üzerindeki O2 miktarı
- **PAC gerekir !**
- N = % 70
- < %60 araştır

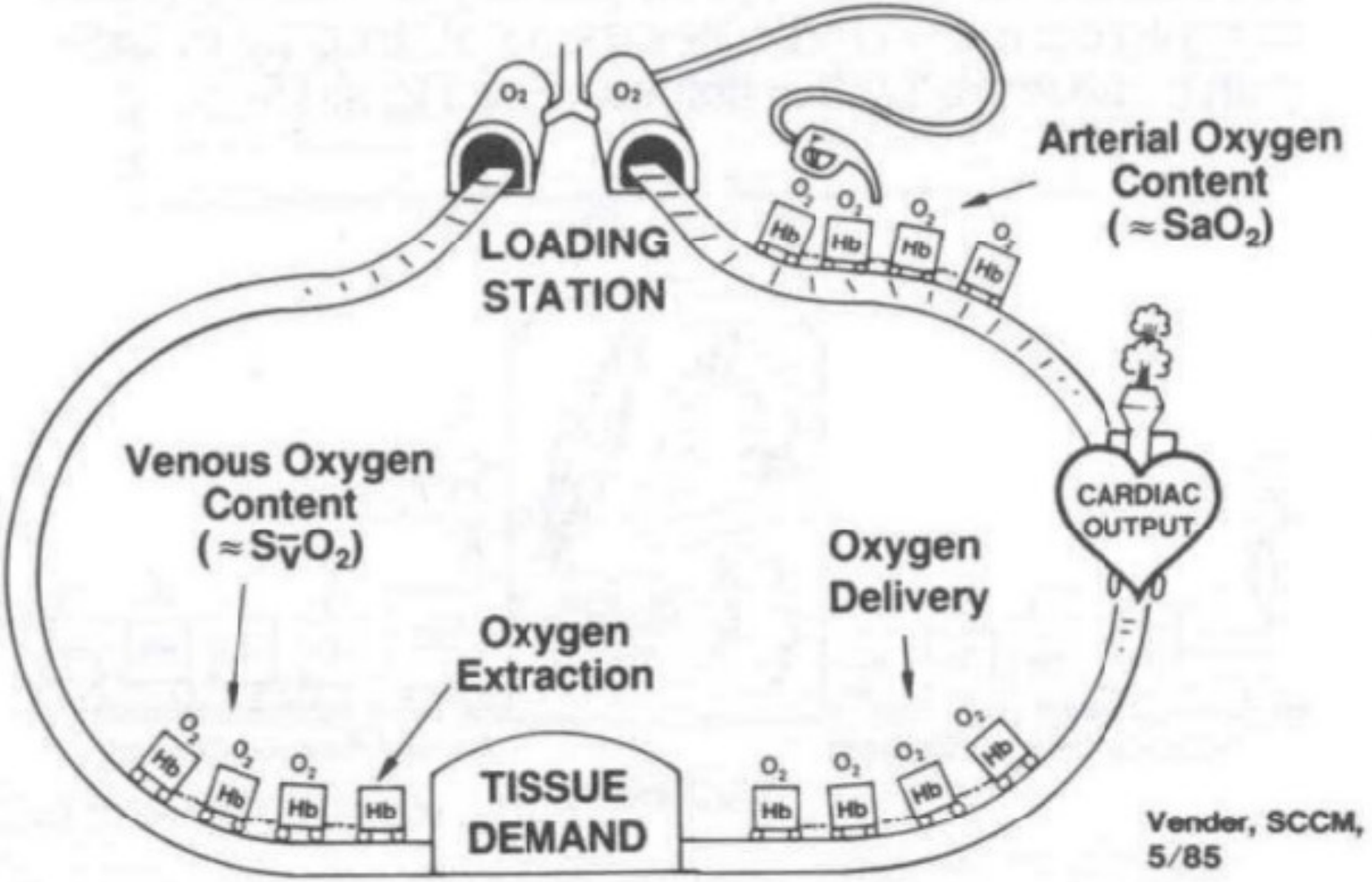


Figure 9d Mixed venous oxygen saturation.

SvO2 = Mixed venous oxygen saturation

- =3 svc + 1 ıvc /4
- VO2 (Oxygen Consumption-harcama) = Cardiac Output x Hb x (SaO2 - SvO2)
- **SvO2 ↓ nedenleri:**
- 1. CO ↓
- 2. Hb ↓
- 3. SaO2 ↓
- 4. O2 taşıması artmadan O2 harcamanın

Mikst Venöz Oksijen Satürasyonu (SvO2)

- Sepsis
- Pankreatit
- CO zehirlenmesi
- Portal kaval şant
- Siyanid zehirlenmesi

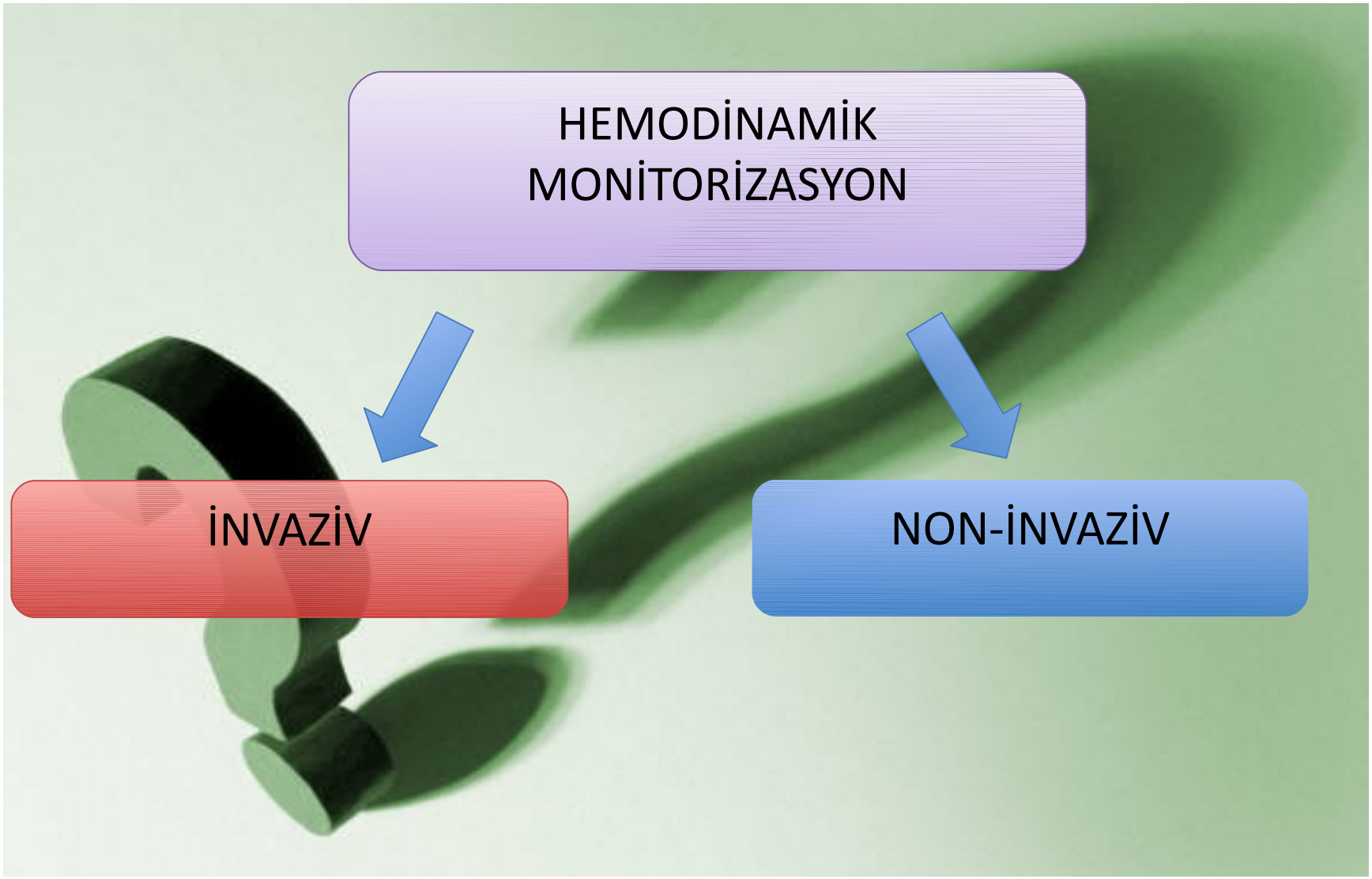
- Ateş
- Hipoksi
- Low CO
- Sol ventrikül yetersizliği
- Artmış metabolizma

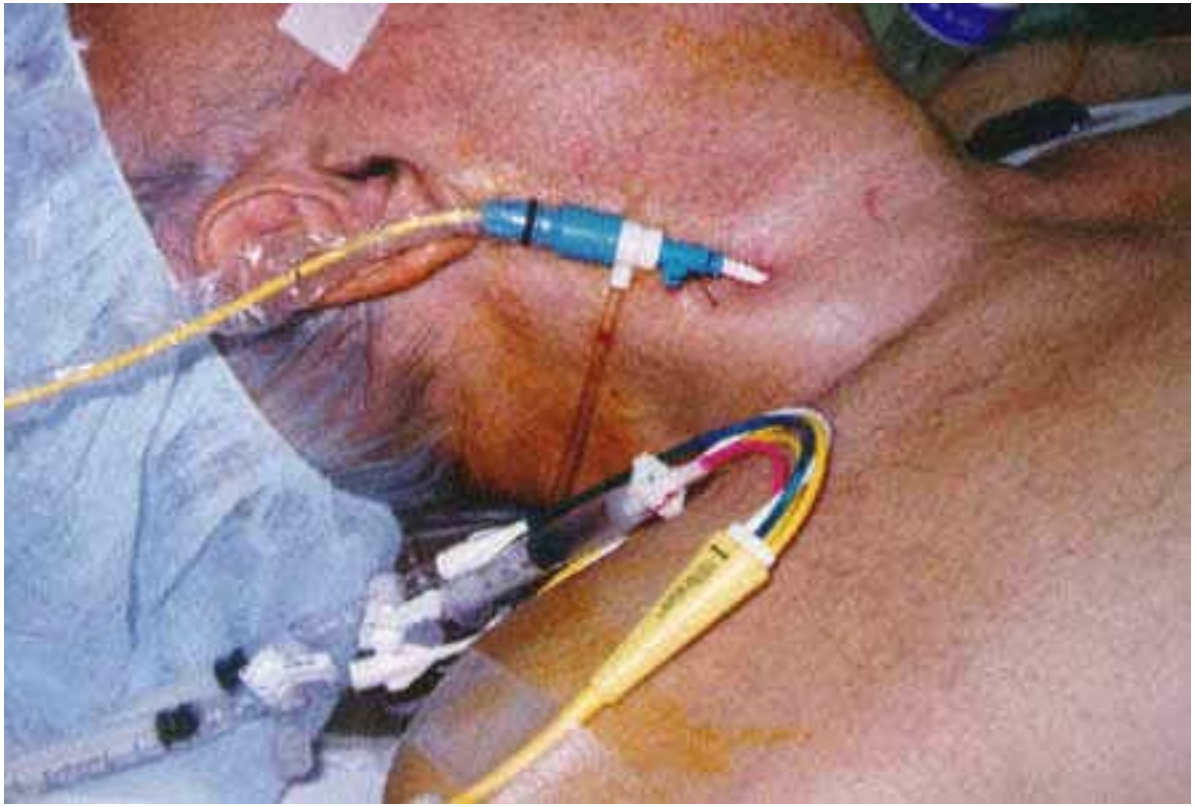
ScvO2 = central venous oxygen saturation

- Üst ekstremitenin O2 rezervi
- **Santral venöz katater gerekir !**
- tipik olarak % 5-13 > SvO2 (ort 7,5)
- N ≥ %70

TABLE 10.1. PARAMETERS OF CARDIOVASCULAR PERFORMANCE

Parameter	Abbreviation	Normal Range
Central venous pressure	CVP	1–6 mm Hg
Pulmonary capillary wedge pressure	PCWP	6–12 mm Hg
Cardiac index	CI	2.4–4.0 L/min/m^2
Stroke volume index	SVI	40–70 mL/beat/m^2
Left-ventricular stroke work index	LVSWI	40–60 g·m/m^2
Right-ventricular		
Stroke work index	RVSWI	4–8 g·m/m^2
Ejection fraction	RVEF	46–50%
End-diastolic volume	RVEDV	80–150 mL/m^2
Systemic vascular resistance index	SVRI	1600–2400 dynes·sec·m^2/cm^5
Pulmonary vascular resistance index	PVRI	200–400 dynes·sec·m^2/cm^5

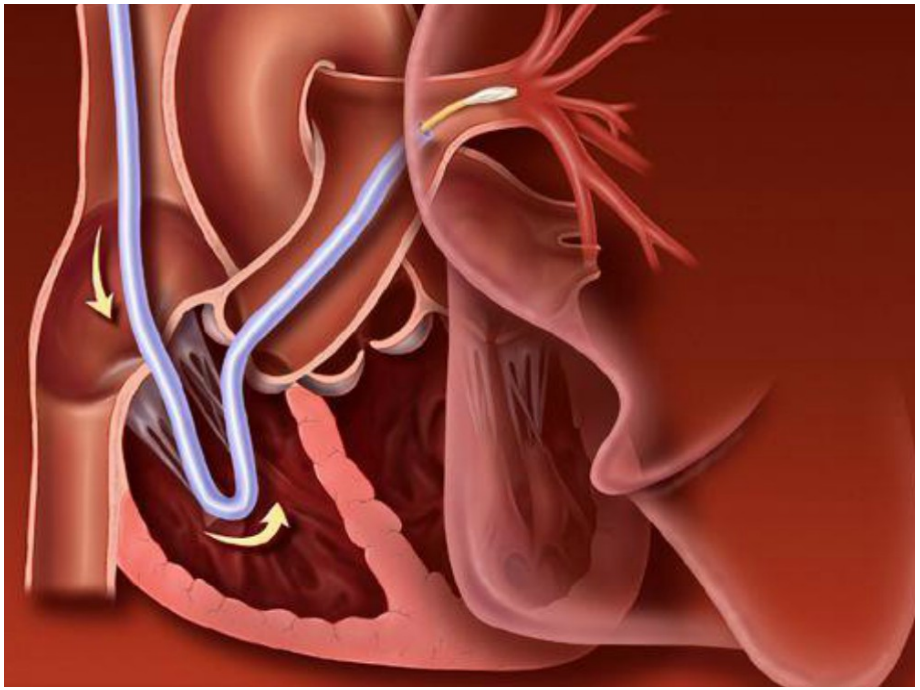

HEMODİNAMİK
MONİTORİZASYON
İNVAZİV
NON-İNVAZİV

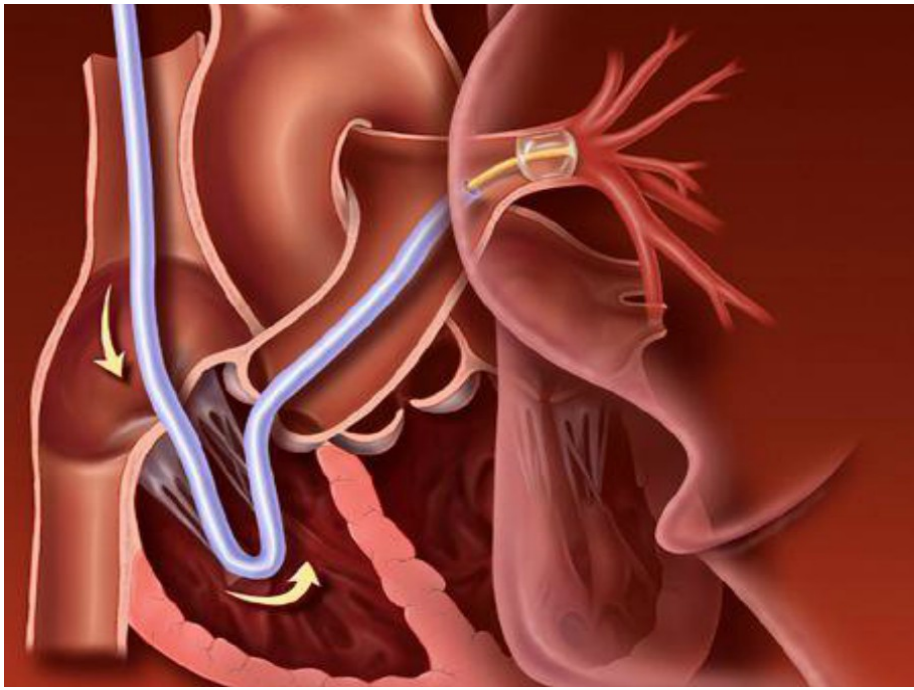


İnvazİv monİtorİzasyon

Pulmoner Arter Kataterizasyonu (PAC)

- Sol atrial basıncın değerini gösterir
- Preload'un değerlendirmesi için altın standart

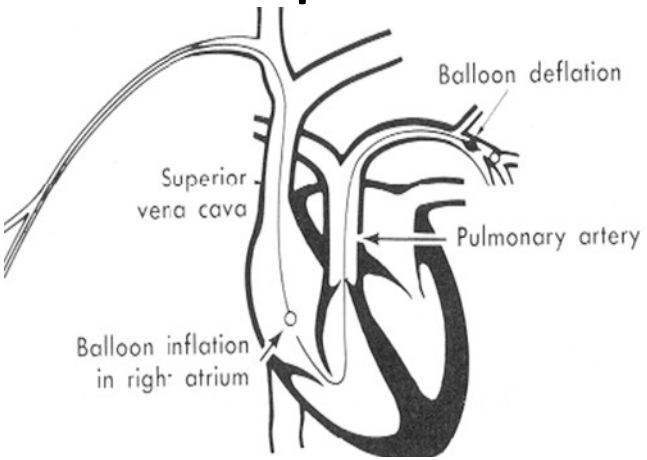




Pulmoner Arter Kataterizasyonu (PAC)

Devamlı ölçüm

- Sıcaklık
- KH
- SvO2= Mixed venöz O2 sat
- CO
- RV EF
- RV end-diyastolik Volüm
- CVP
- …+ non-invaziv pulsoksimetre
- DO2: total body O2 delivery (taşıma)
- VO2: total body O2 consumption



1014 patients at 65 UK institutions: NO DIFFERENCE between PA cath versus no PA cath

Lancet 2005; 366: 472–77

See Comment page 435

Assessment of the clinical effectiveness of pulmonary artery catheters in management of patients in intensive care (PAC-Man): a randomised controlled trial

*Sheila Harvey, David A Harrison, Mervyn Singer, Joanne Ashcroft, Carys M Jones, Diana Elbourne, William Brampton, Dewi Williams, Duncan Young, Kathryn Rowan, on behalf of the PAC-Man study collaboration**

Santral Venöz Basınç (CVP)

- Vena kava süperior veya sağ atrium girişinin basıncı olarak tanımlanır
- N: 3-10 cmH2O
- Kateter RA girişine kadar ilerletilmeli
- RV girildiğinde aşırı yüksek değerler görülür
- İnspiryum ve ekspiryum ile hafif ossilasyonlar

CVP

- CVP sadece normal LV işlevi ile doğrudur ✳ LV disfonksiyonunda mutlaka Pulmoner arter kateterizasyonu gerekir
- Sağ kalp her zaman sol kalp basıncını yansıtmaz
- Santral kateter volum yükleme değil basınç ölçmek için kullanılır !
- CVP'de trend daha önemli

CVP Endikasyonları

- Santral dolaşıma ilaç uygulamak,
- Sağ kalbin basıncını ölçmek,
- T.P.N.,
- Hava embolisini uzaklaştırmak,
- Transvenöz pacing için yol,

Commentary

Hemodynamic monitoring over the past 10 years

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Critical Care 2006, **10**:117 (doi:10.1186/cc3997)

Abstract

Changes in hemodynamic monitoring over the past 10 years have followed two paths. First, there has been a progressive decrease in invasive monitoring, most notably a reduction in the use of the pulmonary artery catheter because of a presumed lack of efficacy in its use in the management of critically ill patients, with an increased use of less invasive monitoring requiring only central venous and arterial catheterization to derive the same data. Second, numerous clinical trials have documented improved outcome and decreased costs when early goal-directed protocolized therapies are used in appropriate patient populations, such as patients with septic shock presenting to Emergency Departments and high-risk surgical patients before surgery (pre-optimization) and immediately after surgery (post-optimization). Novel monitoring will be driven more by its role in improving outcomes than in the technical abilities of the manufacturers.

İnvazİv monİtorİzasyonDA YENİLİKLER NELER?

Arterial pulse contour

(Continuous pulse contour cardiac analysis (PCCO))

- Arteryel nb'dan SV'ü tahmin eder
- Arteryel line'a bağlanır, sürekli ölçüm
- Nb basıncı dalga formundaki değişimleri baz alır
- Kardiyak pre-load ve akciğer sıvısı hakkında fikir

$$PP \propto \frac{\text{Stroke Volume}}{\text{Vascular Compliance}}$$

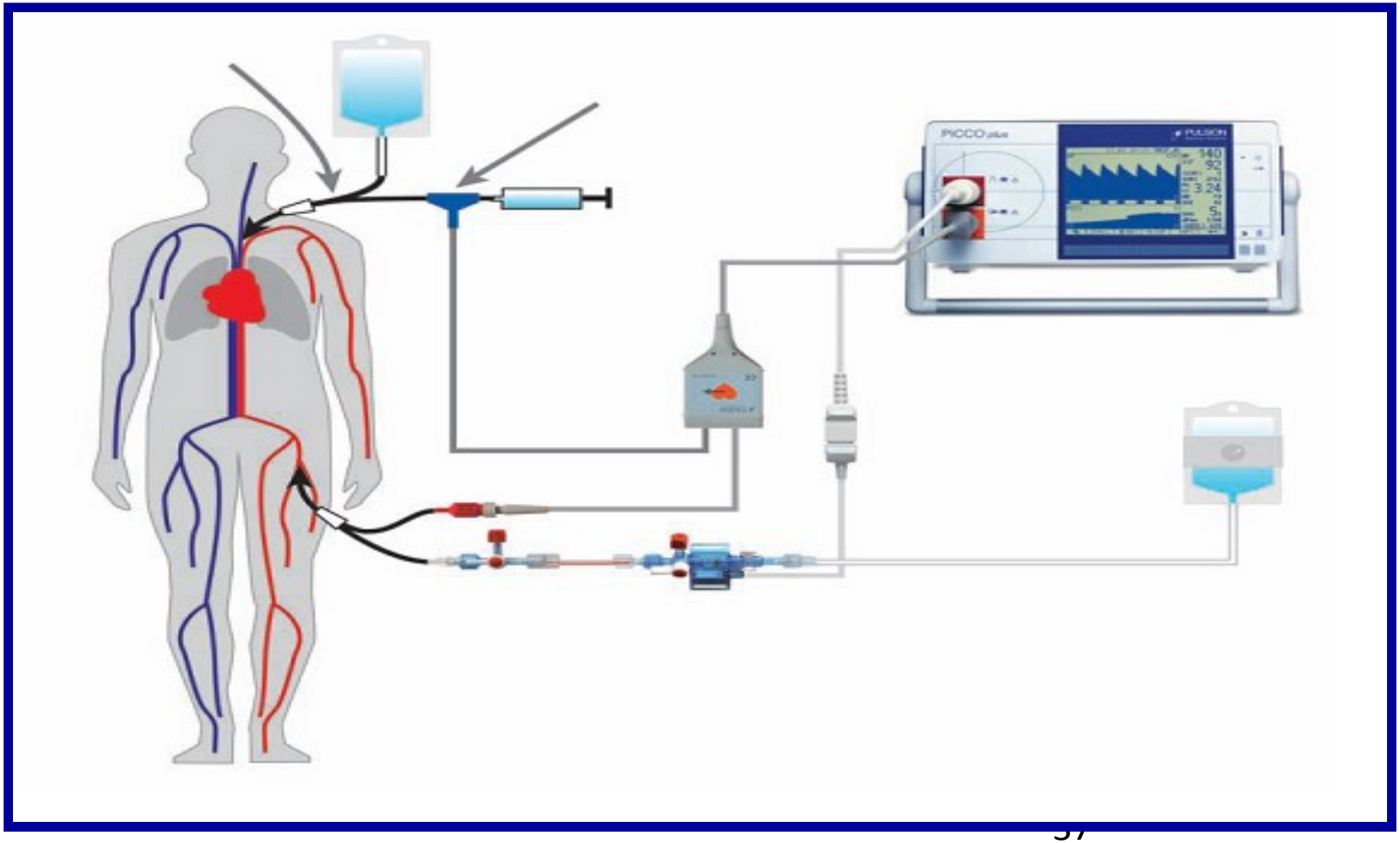
Komplians (uyum) ✳ yaş, cinsiyet, BMI ile hesaplanır

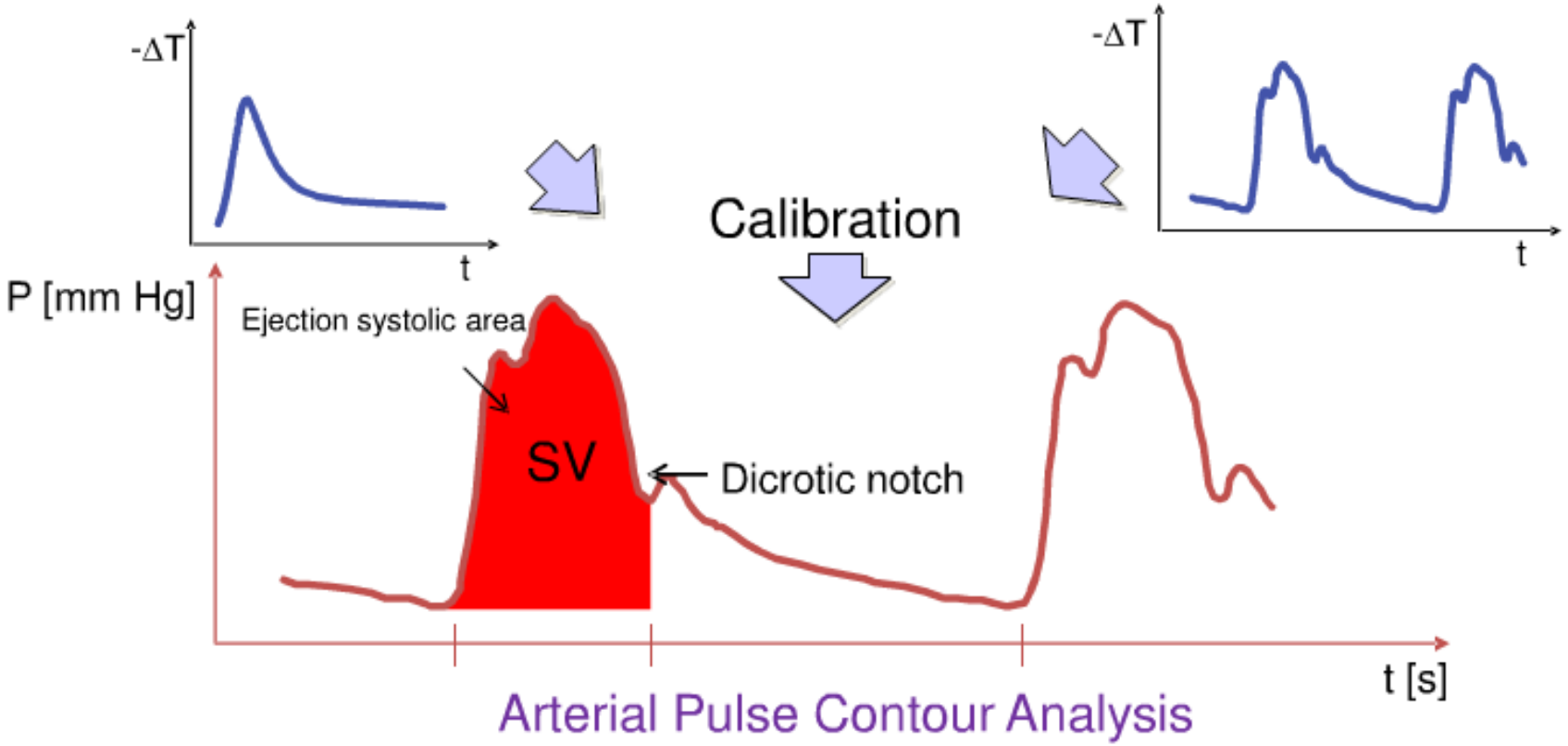
PiCCO Kiti neler içermektedir?

- 1 adet Isı sensörü
- 1 adet Arterial Kateter
- 1 adet Tekli Basınç Seti

Kit hastada varolan en az iki lümenli santral venöz kateteri ile birlikte kullanılmaktadır.

PiCCO





Arterial Pulse Contour Analysis

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

- Patient-specific calibration factor (determined by thermodilution)
- Heart rate
- Area under pressure curve
- Aortic compliance
- Shape of pressure curve

PCCO neleri gösterir?

<u>continuous pulse contour analysis İLE</u>

- Continuous pulse contour cardiac analysis (PCCO)
- Arterial blood pressure (AP)
- Heart rate (HR)
- Stroke volume (SV)

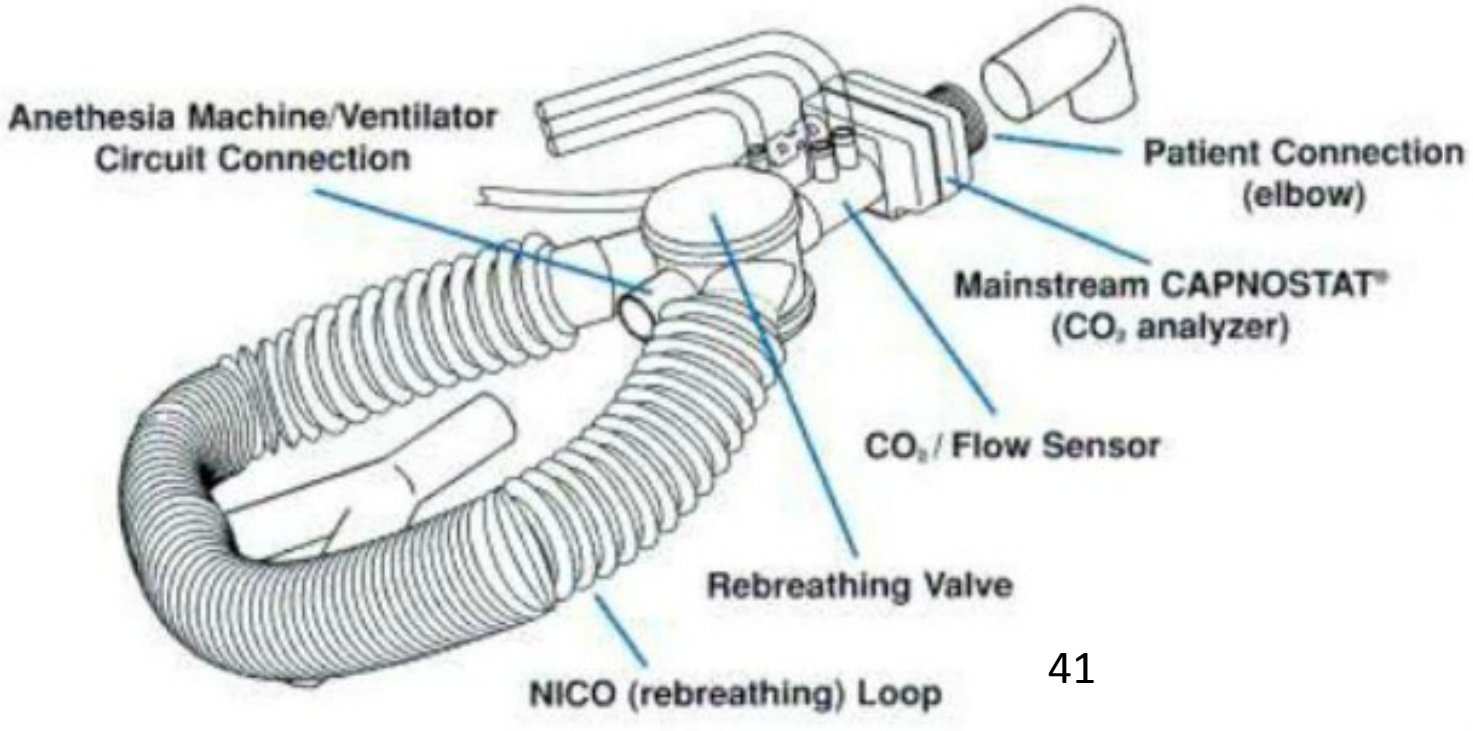
<u>intermittent transpulmonary thermodilution İLE</u>

- Transpulmonary cardiac output (C.O.)
- Intrathoracic blood volume (ITBV)
- Extravascular lung water (EVLW)

NICO = Non- Invasive Cardiac output

- Etkili AC perfüzyonunu temel alarak **CO** hesaplar
- Entübe !
- 3 dakikalık devrelerde ölçme yapar

NICO
Rebreathing valve and loop

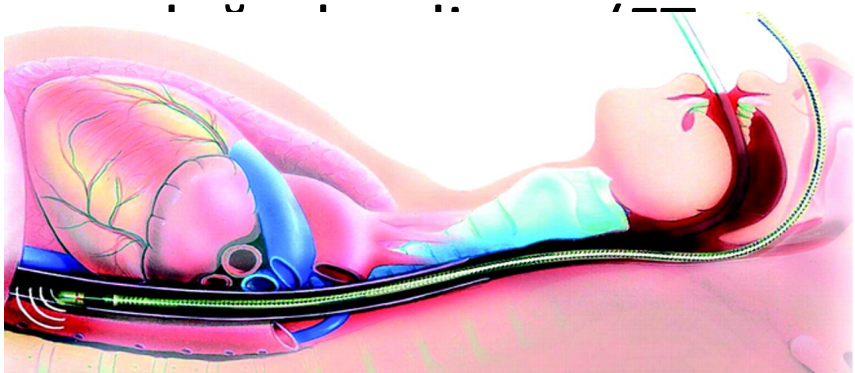


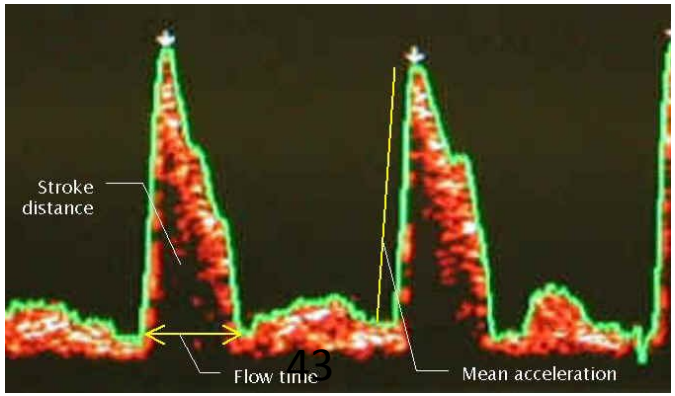
NICO ile edinilen bilgiler

- CO/CI
- SV
- Pulm Capill blood flow
- ETCO2
- İnspired CO2
- RR
- SpO2
- PEEP
- Mean airway pressure
- Minute volume
- Airway resistance
- VS…

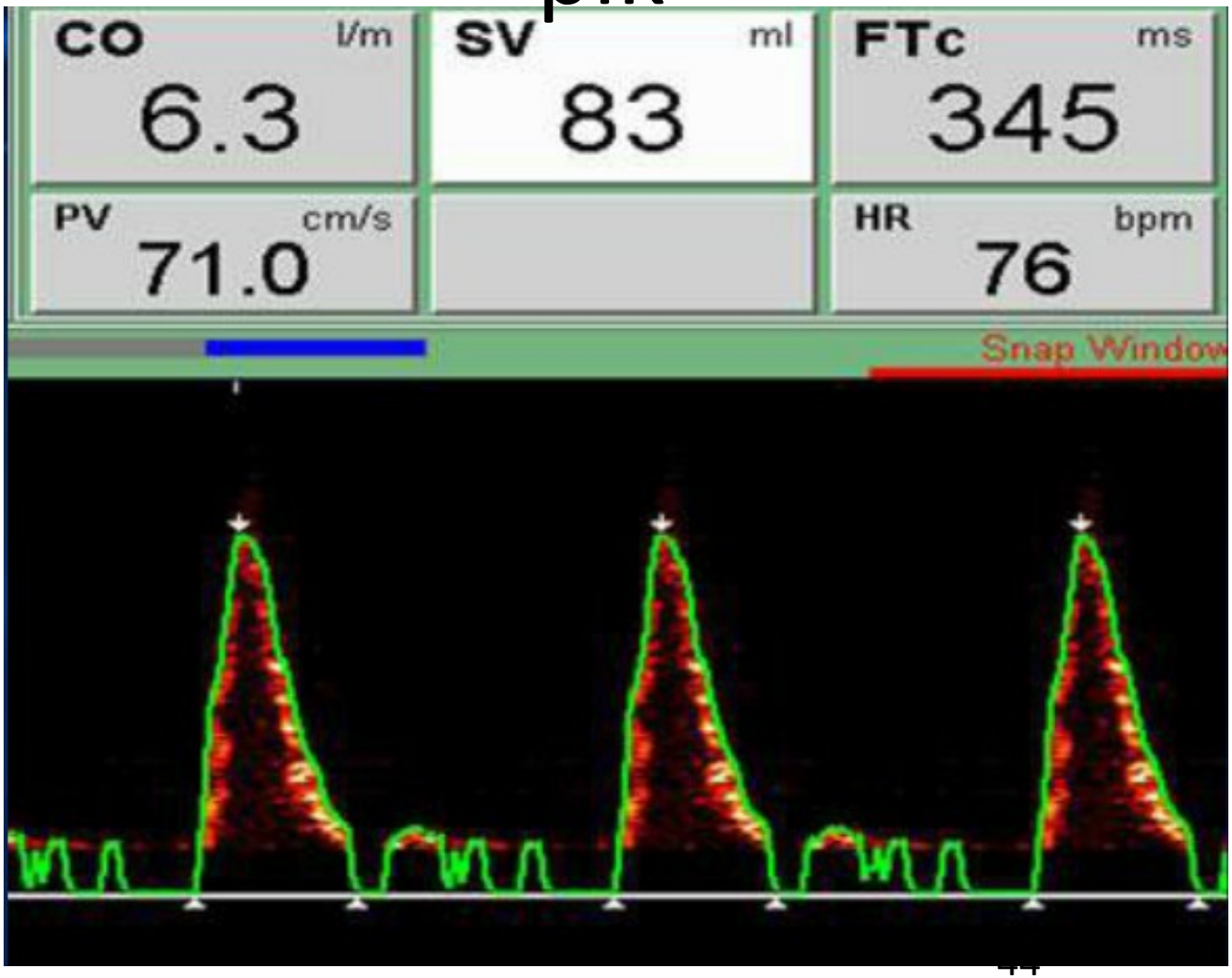
Özofageal Doppler (ED)

- Desendan aortta kan akım hızını ölçer
- Şunlar hesaplanabilir:
  - CO = SV x HR
  - Preload

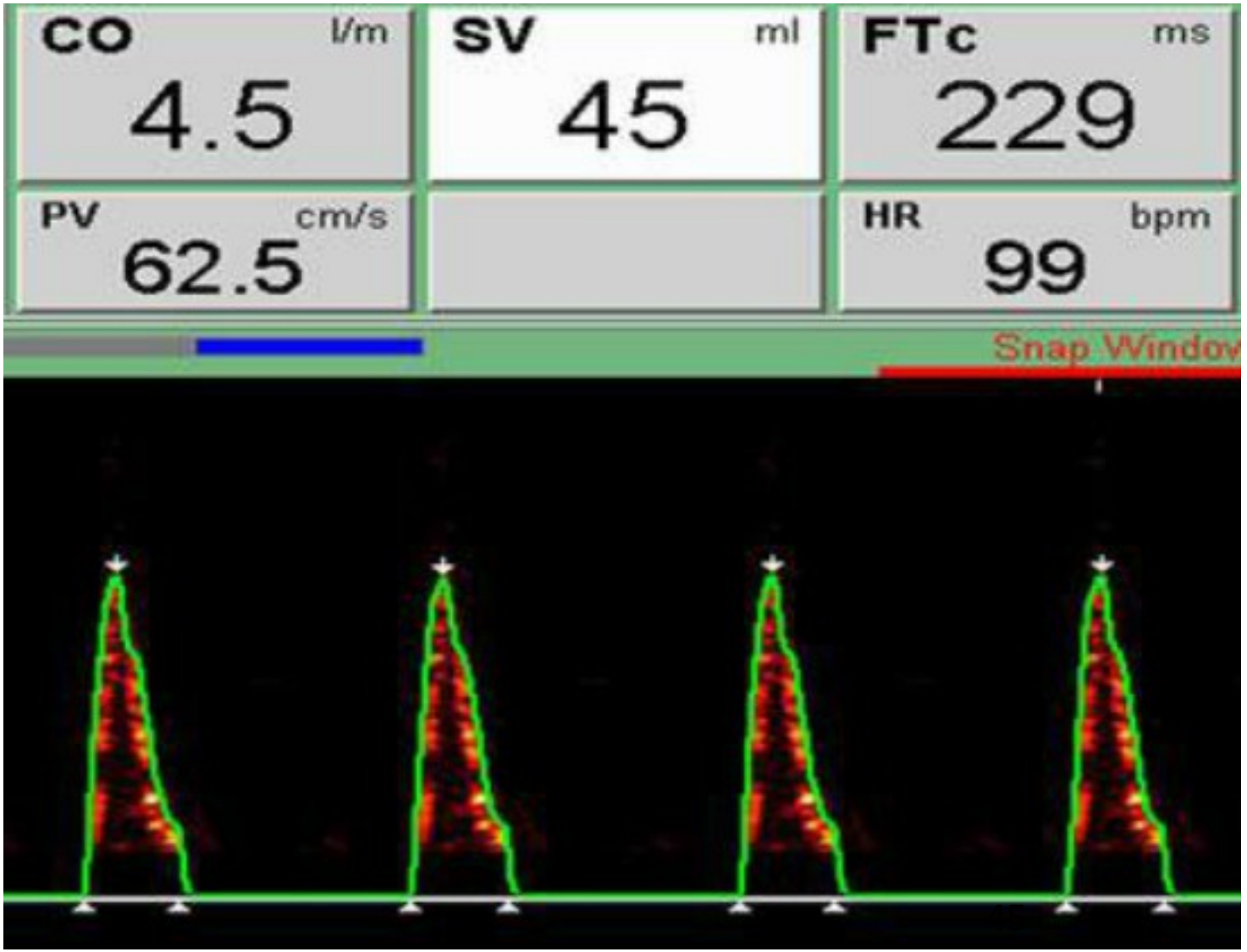




Normovolemi✳ geniş taban, sivri pik

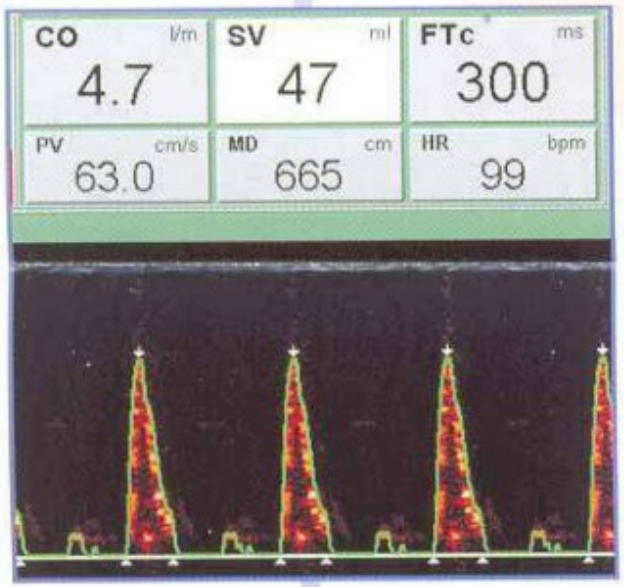


Hipovolemi ✳ dar taban, düşük FTc



Info based management

Base Line

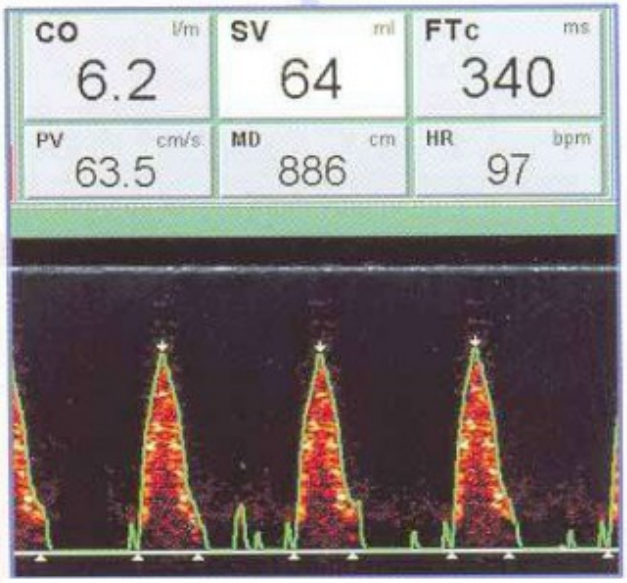


Hypovolaemia.

Narrowed waveform base,
Decreased corrected flow time

FLUID

Favourable Response

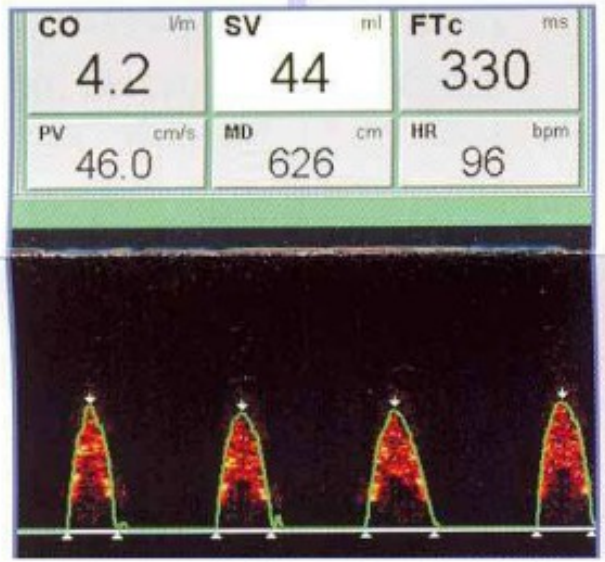


Fluid Repletion.

Waveform base widens,
Increased corrected flow time
Increased SV by more than 10%

Info based management

Base Line



Left Ventricular Failure

Reduced waveform height,
Rounded waveform apex

INOTROPE

Favourable Response

After Inotrope.

Increased waveform height,
Increased Peak Velocity

Normal Range	
Age	Peak Velocity
20 years	90-120 cm/s
50 years	70-100 cm/s
70 years	50-80 cm/s

nON - Invaziv monitorizasyon

Ekokardiografi

- Basınçları değil boyutları ölçer
- CO'u dolaylı olarak değerlendirir

  Preload~LVEDV

  Ejeksiyon Fraksiyonu ~ Kontraktilite
- Kapak işlevleri
- Sağ ve sol kalp performansının ayrıştırılması
- Rejional duvar hareket anomalilerinin saptanması
- Emboli kaynağının belirlenmesi

EKO

Etyolojisi bilinmeyen ve/veya standart tedaviye yanıt vermeyen hemodinamik instabilitenin yönetiminde şiddetle önerilmektedir

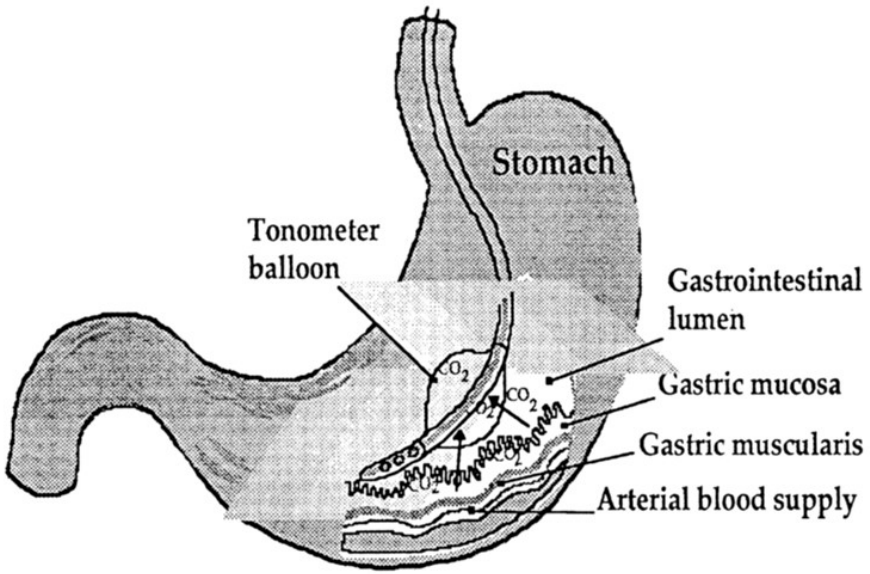
LAKTAT

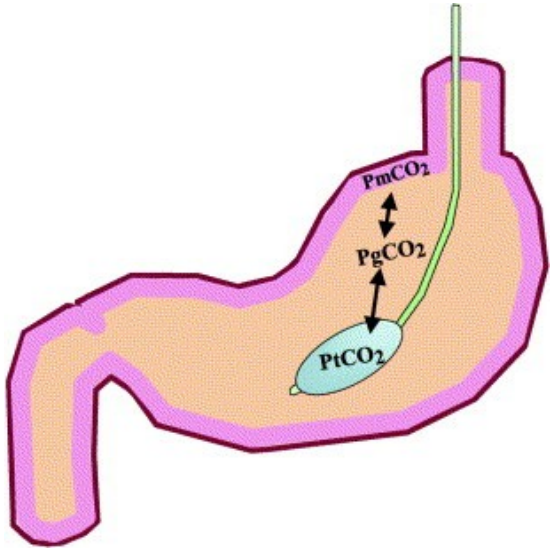
- Hipoperfüzyon şiddet indeksi
- N < 2 mmol/L
- > 4
- > 15 gen ölümcül
- Eğilim daha kullanışlı
- Laktat klirens zamanı< 24 st ise prognoz iyi

CEP LAKTAT TESTİ

GASTRİK TONOMETRİ

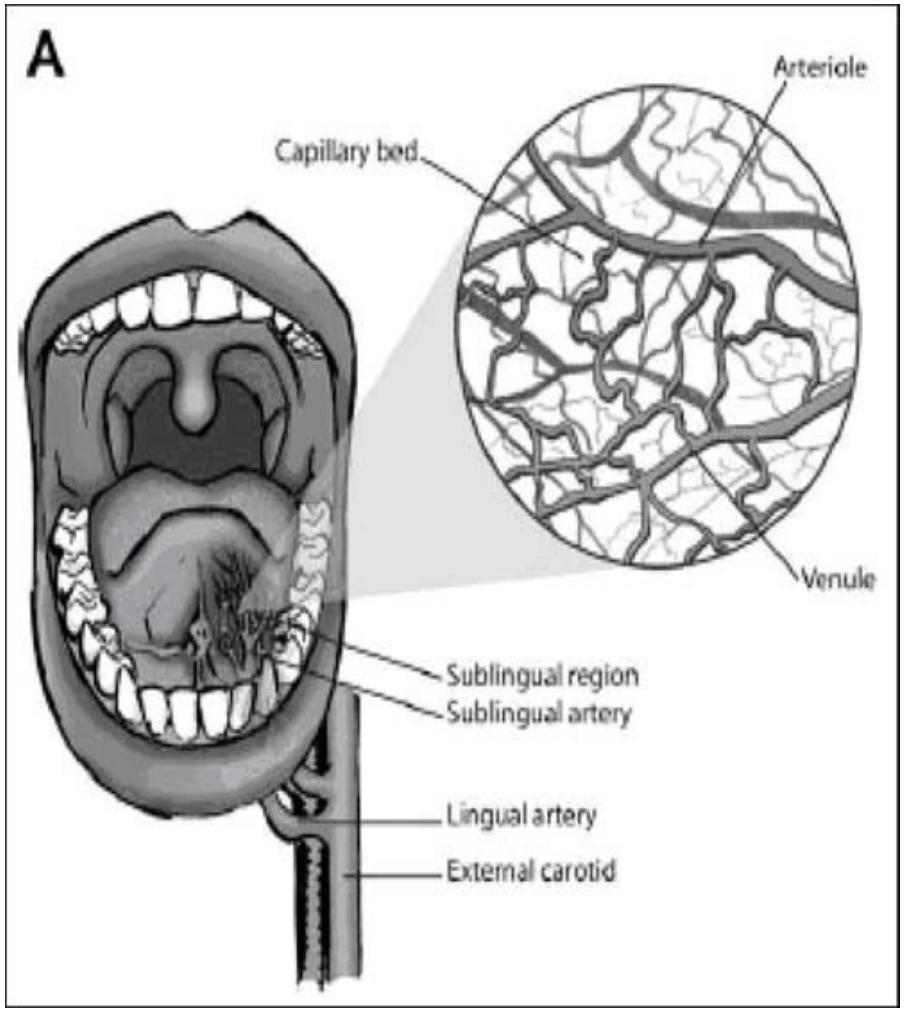
- GİS hipoperfüzyona çok duyarlı
- Mide mukozasının PCO2'ini ölçer
- Bu PCO2 değeri + arteriel HCO3 ✳ gastrik intramukozal pH hesaplanır
- N pH= 7,35-7,45





Sublingual kapnometri

- Dilaltı sensörü
- SL dokuda CO2 parsiyel basıncını ölçer (PslCO2)
- N = 43-47 mmHg
- PslCO2> 70 ✳ ↑ laktat ile ilişkili
- “PslCO2 gap” = PslCO2 - PaCO2
- PslCO2 gap > 25 ✳

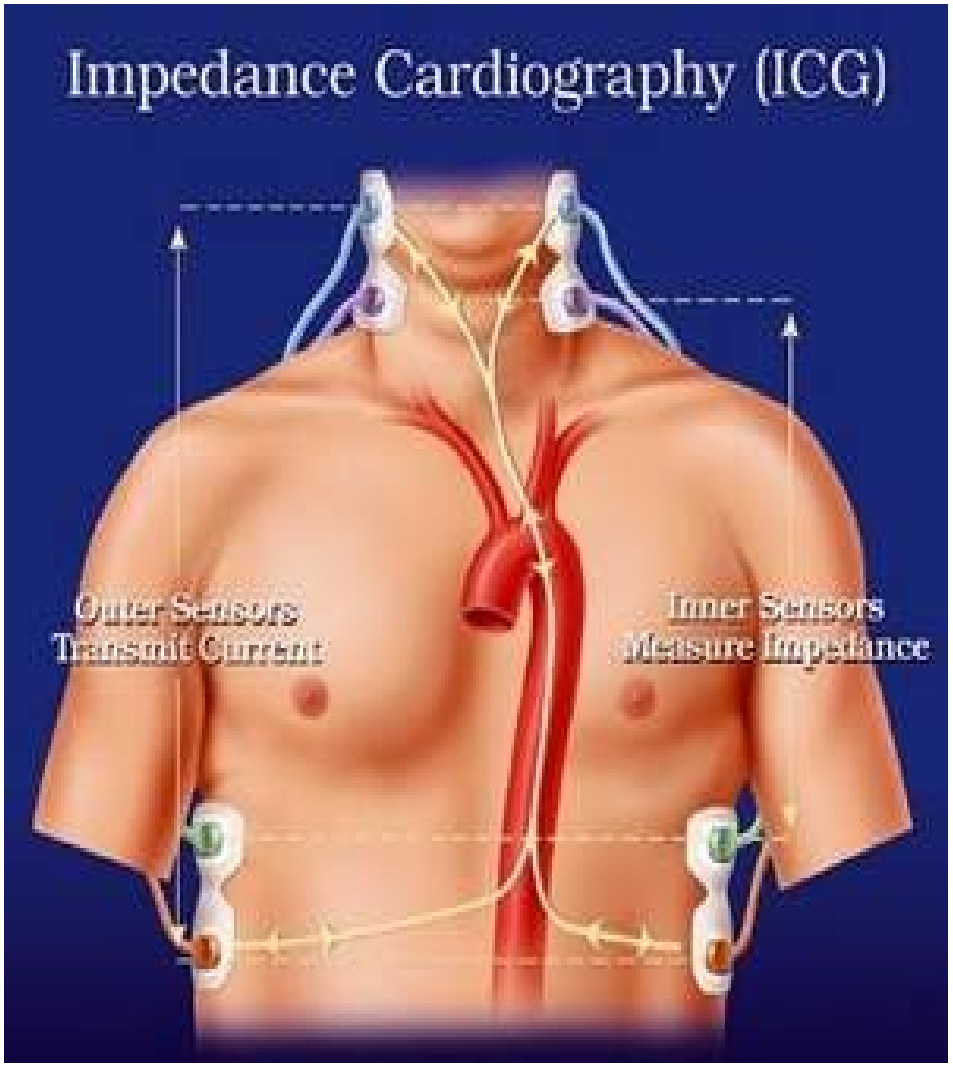


Transkutanöz O2 tansiyonu

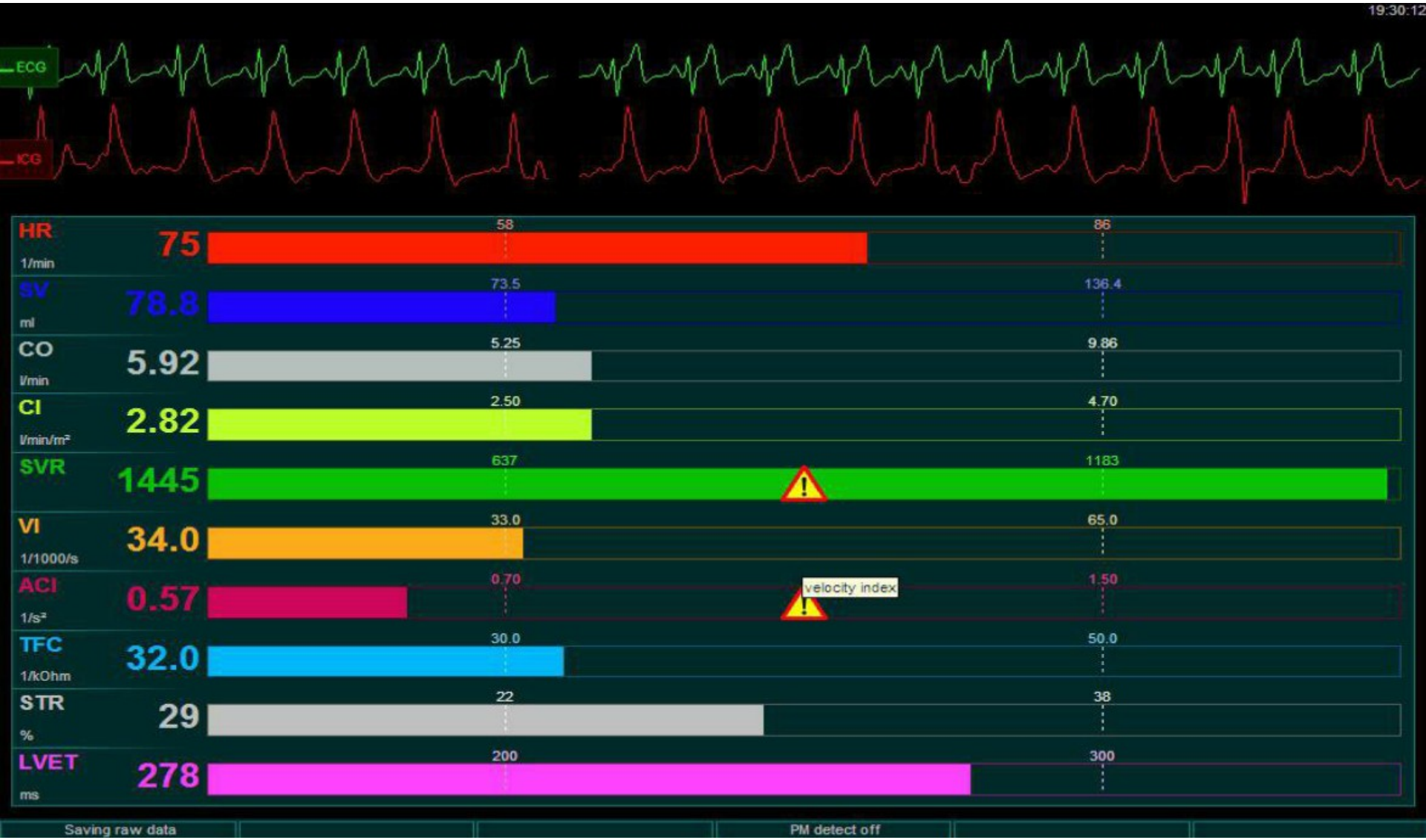
- Transkutanöz O2 veya CO2'yi ölçer
- Isıtılmış probe
- Bölgesel doku hipoperfüzyonunu gösterir
- Düşük Transkutanöz O2 veya Yüksek CO2 ✳ artmış mortalite

Torasik elektriksel bioimpedans

- 4 elektrot toraksa akım gönderir ✳ akım rezistansını ölçer
- Stroke volum,
- ejeksiyon zamanı,
- CO,
- torasik sıvı içeriği,
- acceleration index vs



ICG= İmpedans Kardiografi

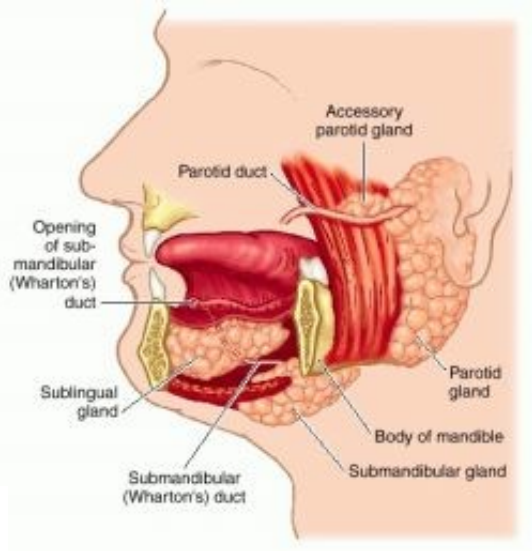

19:30:12
ECG
ICG
HR
1/min
75
58
86
SV
ml
78.8
73.5
136.4
CO
l/min
5.92
5.25
9.86
CI
l/min/m²
2.82
2.50
4.70
SVR
1445
637
1183
VI
1/1000/s
34.0
33.0
65.0
ACI
1/s²
0.57
0.70
1.50
velocity index
TFC
1/kOhm
32.0
30.0
50.0
STR
%
29
22
38
LVET
ms
278
200
300
Saving raw data
PM detect off

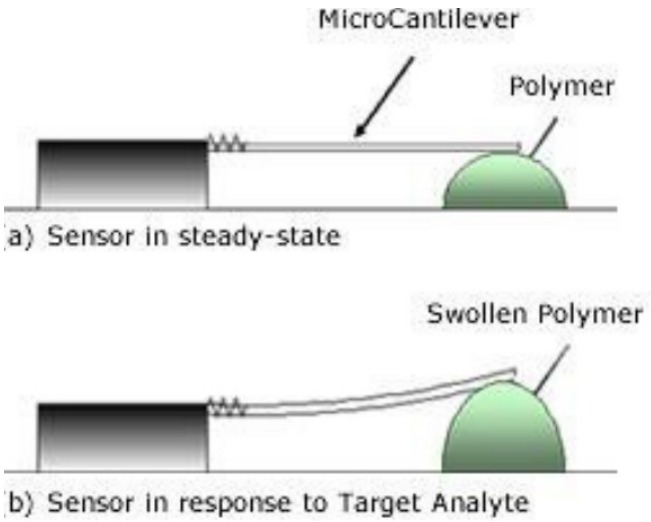

08:33:34
ECG
ICG
HR
1/min
75
SI
ml/m²
36.6
VI
1000/s
33.6
SVRI
3060
STR
%
32
ETR
%
35
Heather
Ohm/s²
9.8
MAP
[mmHg]
150
140
130
120
110
100
90
80
70
60
50
SVRI
LCVM
2.0
3.0
4.0
5.0
6.0
7.0
CI
[l/min/m²]
Thoracic fluid content
220 %
200 %
180 %
160 %
140 %
120 %
100 %
80 %
60 %
40 %
20 %
Saving rawdata
BP manual
PM detect on
Demo-Mode
F3 Set marker
F4 Extern Values
F5 Freeze
F6 Print
F7 PM Config
F8 Enter BP
F9 Patient data
F10 Monitor
F11 Curves

Tükrük ozmolalitesi

- Hidrasyon durumunu gösterir

$$2 \times Na^+ (mEq/L) + \frac{BUN\ (mg/dL)}{2.8} + \frac{Glucose\ (mg/dL)}{18}$$





Principle of Operation

Salivary Osmolality Sensor

Prehosp Emerg Care. 2012 Jan-Mar;16(1):128-35. doi: 10.3109/10903127.2011.614044. Epub 2011 Sep 27.

Use of salivary osmolality to assess dehydration.

Smith DL, Shalmiyeva I, Deblois J, Winke M.

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Abstract

OBJECTIVE: To investigate the ability of salivary osmolality to assess dehydration while subjects perform alternating work/rest cycles in personal protective equipment (PPE).

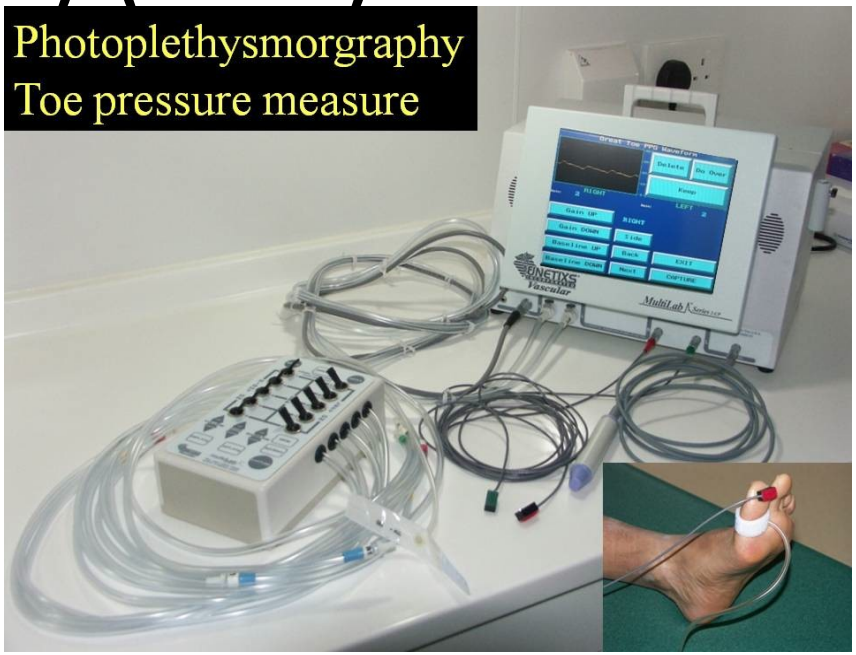
METHODS: Eight healthy men (mean ± standard deviation age: 23.5 ± 4.9 years; body fat: 17.8% ± 5.0%; maximum volume of oxygen consumption [VO(2max)]: 57.2 ± 5.5 mL·kg(-1)·min(-1)) performed two exercise trials: one while wearing shorts and a T-shirt (EX) and one while wearing firefighting PPE (EX+PPE). Saliva samples were taken before exercise, at minutes 40, 80, and 120 of the exercise trial, and during recovery.

RESULTS: Percent body mass loss (BML) was significantly greater while the subjects were wearing PPE (2.18% ± 0.54% vs. control 0.81% ± 0.30%). Salivary osmolality increased significantly in both trials (73.4 ± 12.4 to 125.1 ± 30.3 mOsm·kg(-1) and 70.1 ± 12.5 to 83.6 ± 17.7 mOsm·kg(-1)); however, the increase in the EX+PPE trial was significantly greater than the increase in the EX trial. Plasma osmolality did not change significantly in either trial, whereas urinary osmolality increased significantly in both trials. Changes in salivary osmolality were strongly correlated with percent BML ($r = 0.80$; $p < 0.01$).

CONCLUSION: Salivary osmolality may be a sensitive indicator of moderate dehydration under carefully controlled conditions.

Fotopletisismografi (Pleth waveform) (PPG)

- Parmak, kulak vs uçlar
- Mikrovasküler yatakta kanın pulsatil akımını inceler
- Hastanın sıvı hacim durumunu gösterir



Sıvıya cevaplı hasta ne demek?

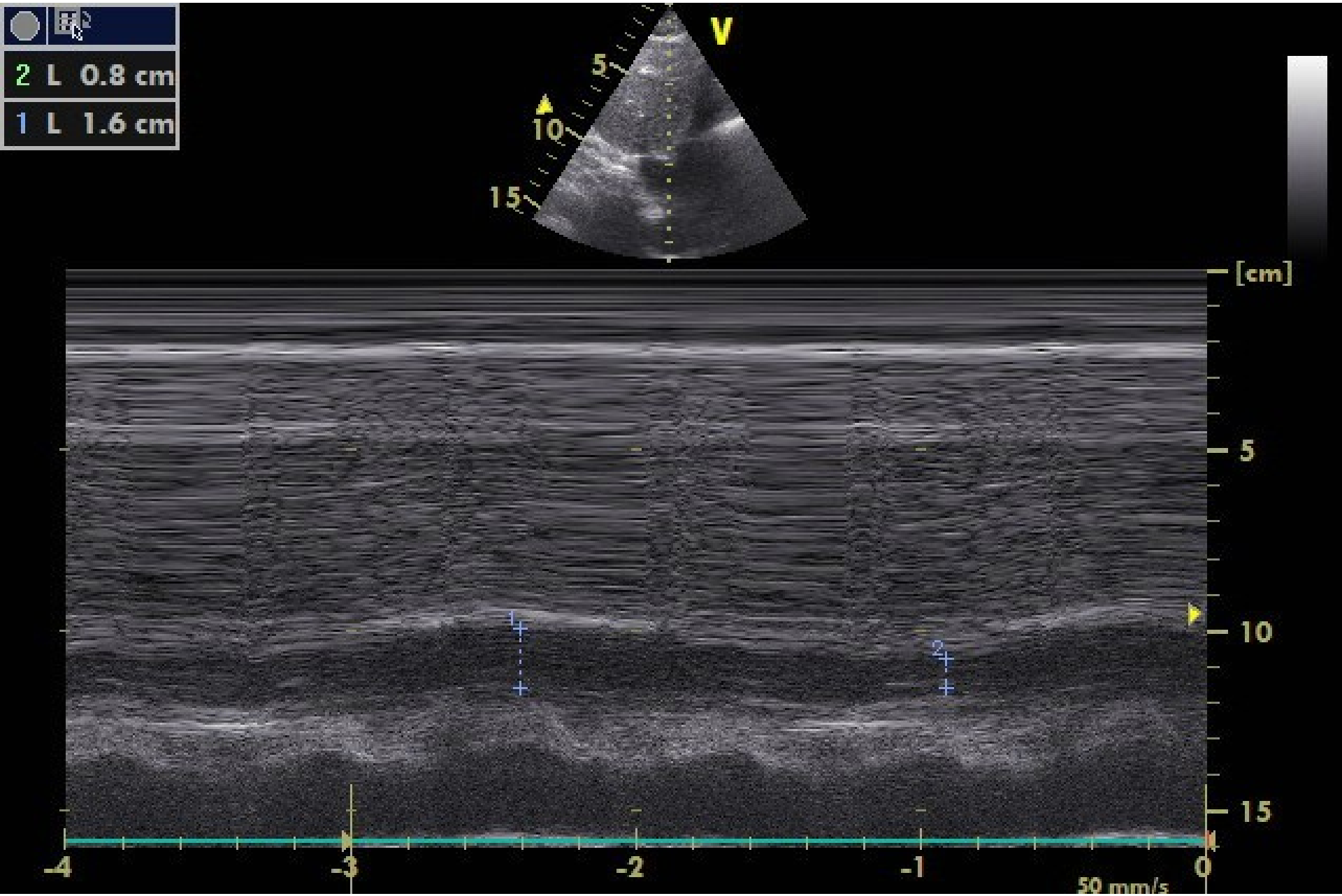
-Fluid (or preload) responsive-

- Şoktaki bir hastaya sıvı infüzyonu yapıldığında CO artıyorsa (düzeliyorsa), sıvıya cevaplı hasta denir
- Kritik hastaların sadece %50'si sıvıya cevaplıdır
  - Vena cava kollapsibilite indeksi
  - Pasif bacak kaldırma testi (PLR)

Sıvıya cevabı belirleme

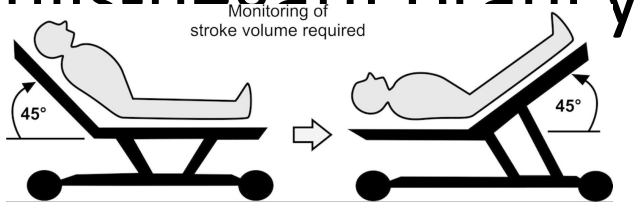
- VCS kollapsibilite indeksi
- TEE ✳ M Mode (2 boyut)
- Diameter max – min / Diam max x 100
- %36 üstü ✳ sıvı ihtiyacı var !
- Sensitivite %90

- VCI kollapsibilite indeksi
- TTE ✳ M Mode
- Diameter max – min / Diam max x 100
- %15 üstü ✳ sıvı ihtiyacı var !
- Sensitivite %90
- Spesifite %90


2 L 0.8 cm
1 L 1.6 cm
V
5
10
15
[cm]
5
10
15
-4
-3
-2
-1
0
50 mm/s

Pasif bacak kaldırma testi (PLR)

- Bacaklar 30 derece kaldırılarak hızlı hacim genişlemesi sağlanır
- SV %12 üzerinde artış olduğunda pozitif kabul edilir
- Hem MV, hem de spontan solunumlu hastalarda kullanışlı
- Intra-abd. Hipertansiyonlu (> 16 mmHg) hastalarda yanlış-negatif oranı yüksek



Teşekkür ederim