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Perissia Otel - KAPADOKYA
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Pediyatrik Kardiyak Cerrahide Monitorizasyon

Yeni Kuşak Hemodinamik Monitorizasyon

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BURSA

Pediyatrik Kardiyak Cerrahide Monitorizasyon

Standart monitorizasyon

- EKG
- Nabız oksimetri
- Noninvaziv – invaziv ABP
- CVP
- End-tidal gaz analizi

İleri hemodinamik monitorizasyon

- Dolaşımsal durumu değerlendirme
  - **CO ölçümü**
  - **Venöz oksimetri**
- Sıvı tedavisini değerlendirme
  - **Sıvı yanıtı**
  - Akciğer sıvısının saptanması

CO Monitorizasyonu

Kan Basıncı = SVR x CO

HR x SV

- Preload
- Kontraktilite
- Afterload
- Ritim
- Diyastolik fonksiyon

$DO_2 \approx SaO_2 \times Hgb \times CO$

CO Monitorizasyonu

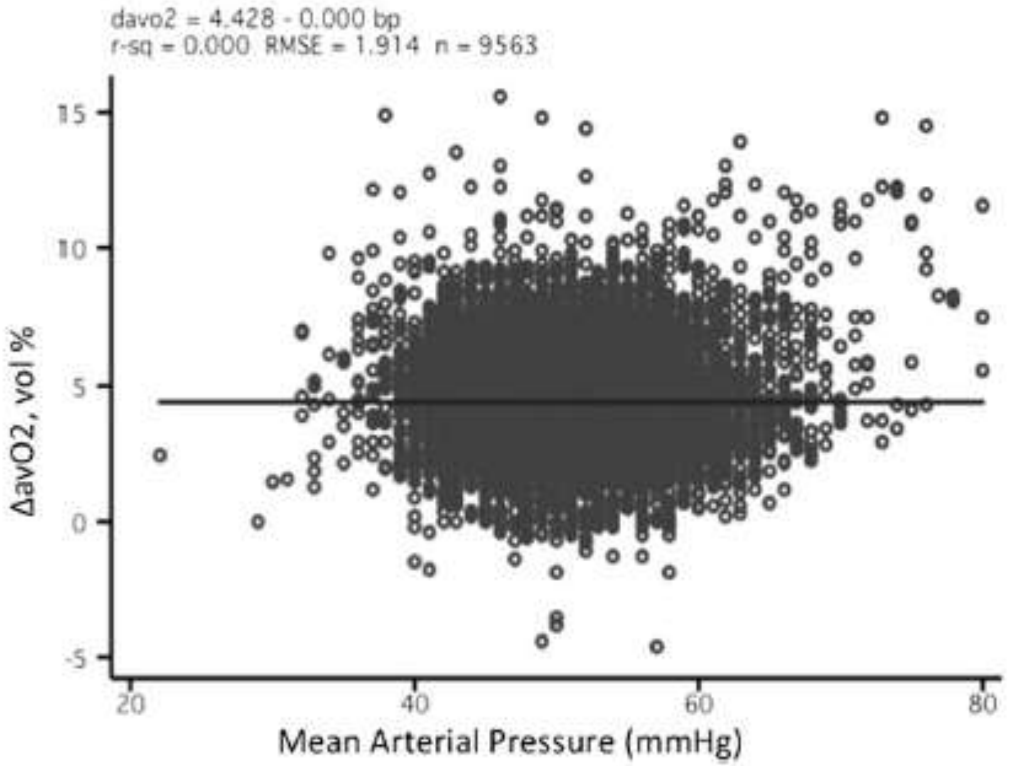


Figure 1 Data from the Children's Hospital of Wisconsin hypoplastic left heart syndrome stage 1 perioperative database comparing mean arterial blood pressure and arteriovenous oxygen content difference. Just under 10,000 hours of data are shown. There is no correlation between blood pressure and cardiac output.

JS Tweddell, et al. Semin ThoracCardiovascSurgPediatrCardSurgAnn 2014;17:81

CO Monitorizasyonu

Klinik göstergeleri

- Nabız ve ortalama kan basıncı
- Kapiller dolum zamanı
- Kan pH, baz defisiti and laktat
- Periferik /santral ısı farkı
- Diürez

PICU (kardiyak / nonkardiyak)

Klinik göstergeler *vs* TPTD $\Rightarrow$ CO (Düşük, Normal, Yüksek) tahmini

- HR
- CVP
- Mental durum

Klinisyen deneyimli de olsa korelasyon zayıf

Tibby SM, et al. Clinicians' abilities to estimate cardiac index in ventilated children and infants. Arch Dis Child 1997;77:516-518

Kardiyovasküler Fonksiyon

CO ölçümü

- Oksijen tüketimi (Fick)
- Indikatör dilusyonu (boya, ısı, lityum)
- Arteriyel basınç dalga formu analizi
- Biyoimpedans/reaktans
- Doppler US

Doku oksijenasyonu belirteçleri

- Laktat düzeyi
- Mikst venöz O_2 saturasyonu (venöz oksimetri)
- Rejyonal O_2 saturasyonu (NIRS)

CO Monitorizasyonu

İdeal monitorizasyon özellikleri

- Ölçüm doğruluğu ve hassasiyeti yüksek
- Hızlı yanıt alınan aralıklı /sürekli ölçüm (beat-to-beat) yapılabilir
- Kullanımı kolay ve kullanıcıdan bağımsız
- Morbiditeye yol açmayan
- Ekonomik, ucuz
- **Her yaştaki hastaya uygun**
- **CO ölçüm sınırları geniş (özellikle düşük değerler için)**
- **Kongenital kalp hastalığı ve kompleks paliyatif/düzeltici cerrahide kullanıma uygun olmalı**

CO Monitorizasyonu

Pediyatrik olguların erişkinlere göre farklılıkları

- Vücut boyutunda yaşa bağlı büyük değişiklikler olması
  - PAK, femoral arter kateteri, özefagial prob büyüklüğü
- Anatomik boyutun hata sınırlarını arttırması
  - Ölü boşluk ↑, damar boyutunun ↓, indikatör hacminin ↓, invaziv uygulamalarda risk ↑
- Fizyolojik değişikliklerin daha hızlı oluşması
- Sık ölçüm ve çoklu kan örneği alınımına toleransın azlığı
- Fizyolojideki önemli farklılıklar
  - Kongenital kalp lezyonu, transizyonal fizyoloji, sepsis fizyolojisi

Pediyatrik Kardiyak Cerrahi

Kalp – miyokardı değerlendirme

1. Kardiyak fonksiyon ?
2. Mevcut klinik duruma göre kardiyak fonksiyon normal mi?
3. Kardiyak fonksiyon normal değilse nedeni?

Ekokardiyografi

Güçlü yönü ⇒ Miyokard fonksiyonunu kalitatif < kantitatif değerlendirmesi

Zayıf yönü ⇒ Ölçüm sürekliliği olmaması, kullanıcı bağımlılığı

Hemodinamik monitor olarak kullanımını sınırlar

Pediatrik Hemodinamik Monitorizasyon

Altın standart

- Pulmoner arter kateteri
  - Güvenliği

Nishikawa T, Dohi S. Errors in the measurement of CO by thermodilution. Can J Anaesth 1993;40:142

  - Komplikasyon
  - Morbidite-mortaliteye etkisi
- Transpulmoner termodilusyon

Tibby S. Transpulmonary thermodilusyon: Finally a gold standard for pediatric cardiac output measurement. Pediatr Crit Care Med 2008;9:341

- Ekokardiyografi

VS

Yeni kuşak hemodinamik monitorizasyon

Michelle S. Chew
Jan Poelaert

Accuracy and repeatability of pediatric cardiac output measurement using Doppler: 20-year review of the literature

Table 1 Accuracy of traditional Doppler CO measurements compared to reference technique in children given as mean difference ±2 standard deviations of differences unless otherwise stated. All measurements were made using the suprasternal approach unless otherwise indicated. (*TED* transesophageal Doppler, *DBD* dual-beam Doppler, *CWD* continuous-wave Doppler, *TEE* transesophageal Doppler, *PWD* pulsed-wave Doppler, *AA* ascending aorta, *DA* descending aorta, *AN* aortic annulus, *leaflet* aortic maximal leaflet separation, *TD* thermodilution, *dye* dye dilution, *NA* not available)

Study	*n*	Method	Site	Reference	CO range	*R*	Difference
Alverson et al. [32]	33	PWD	AA	Fick	0.4–5.54 l/min	0.98	5±27%
Mellander et al. [15]	10	PWD	AA	TD	1–4.5 l/min	0.97	–18.3 to 75.5% range of mean difference
Morrow et al. [18]	12	CWD	AN	TD	1–6 l/min	0.94	–37±43%
Notterman et al. [17]	17	PWD	AN	TD	1.02–6.26 l/min	0.84	12.7% (0.41–102.5%) mean difference (range)
Rein et al. [21]	25	CWD	AN	TD	1.9–5.6 l/min	0.86	1.2±30.3%
Sholler et al. [16]	21	PWD	AA leaflet	Dye	0.5–5.5 l/min	0.930.99	16.3±30.7%–8.1±19.5%
Tibballs et al. [19]	18	PWD	AA	Dye	0.23–5.76 l/min	0.97	7.1±19.6%
Wipperman et al. [20]	18	PWD DBD	AA	TD	0.4–2.2 l/min	NA	1.9±22.4%
Wodey et al. [10]	20	PWD	DA	CWD	2–6 l/min	NA	–0.02±36%
Murdoch et al. [12]	11	CWD (TED) minute distance	DA	TD	2.91–5.02 $l\ min^{-1}\ m^{-2}$	–	–0.5±10%[a]
Tibby et al. [11]	100	CWD (TED) minute distance	DA	TD	1.44–8.97 $l\ min^{-1}\ m^{-2}$	NA	0.87±16.8%[a]

[a] refers to 2 SDD of the*relative change* in minute distance or CO

Intensive Care Med 2003;29:1889

Table 2 Repeatability of traditional Doppler CO measurements in children defined as the coefficient of variation (CV), unless otherwise stated. All measurements were made at the aorta using the suptrasternal approach unless otherwise indicated (*PWD* pulsed-wave Doppler,*CWD* continuous-wave Doppler, *CO* cardiac output, *VTI* velocity time integral*TED* transesophageal Doppler)

Study	*n*	Variable	Reproducibility of measurement V (%)	
			Intraobserver	Interobserver
Childs et al. [26]	72	VTI	0.3–0.8	8
Claflin et al. [24]	10	CO	7.0–12.1	3.1
		VTI	6.6–11.7	2.5
Hanseus et al. [25]	10	VTI	3.5	5.8
		Minute distance	7.5	6.5
Hirsimaki et al. [27]	37	Mean velocity	6.77 (SEM)	–
		Max velocity	5.65 (SEM)	–
Hudson et al. [23]	12	CO PWD	7.9–16.1	14.8
		CO CWD	7.1–18.4	12.6
Mellander et al. [15]	10	Mean velocity	6.4	–
		Max. velocity	4.5	
Mohan et al. [13]	20	Minute distance	16.0	–
Notterman et al. [17]	17	CO	Median 2.5, range 0.34–10.6	–
Rein et al. [21]	25	CO	–	21.7
Wodey et al. [10]	20	Mean velocity	5.0–20.1 (mean difference)	–
		CO	7.0–22.0 (mean difference)	–
Murdoch et al. [12]	11	MD (TED)	2.8–3	–
Mohan et al. [13]	20	MD (TED)	2.1	–
Tibby et al. [11]	100	Minute distance (TED)	Median 3.3, interquartile range 2.1–4.7	–

Pediatrik Doppler *vs* TPTD

Precision: %30, Bias (SD): <% 10

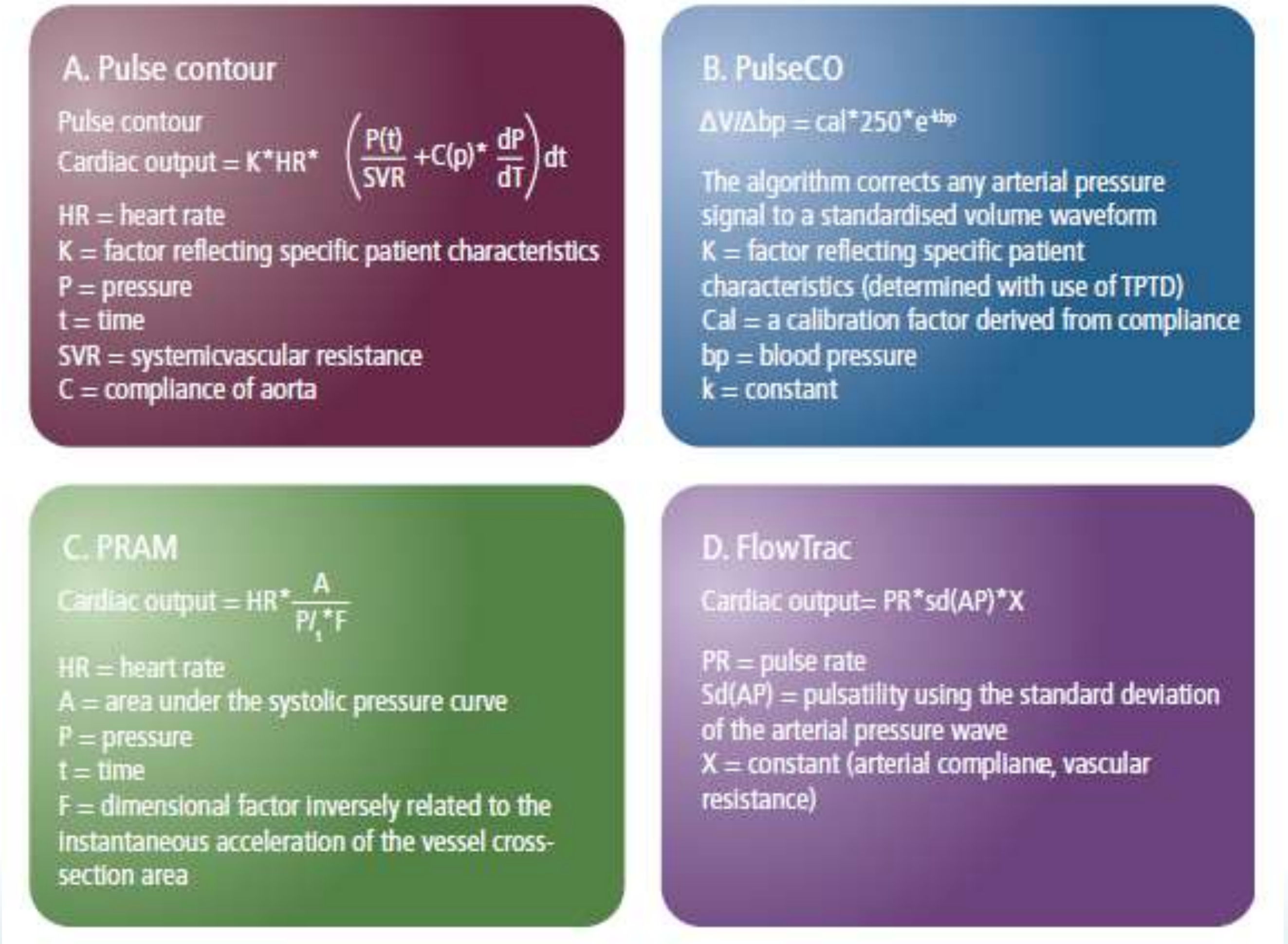
Ölçümün tekrarlanabilirliği: < %1-22

Doppler ile CO ölçümünde değer değil, trend izlendiğinde ve transözefagial yöntem kullanıldığında en doğru sonuç elde edilir

Intensive Care Med 2003;29:1889

CO Monitorizasyonu

- Arteriyel basınç dalga şekli analizi



Hemodynamic monitoring by transpulmonary thermodilution and pulse contour analysis in critically ill children

Table 3. Pediatric animal models evaluating the validity of transpulmonary thermodilution and pulse contour cardiac output

	Population (n)	Methods	R^2	Bias	Limits of Agreement
Lemson et al (19)	Newborn lamb (n = 12)/hypovolemia	TPTD vs pulmonary artery flow probe	0.97	0.19 ± 0.24[b]	−0.04 to 0.43*
Pielh et al (38)	Piglets (n = 10) /hemorrhagic shock	TPTD vs PAC	0.97	0.14 ± 0.47[b]	Not available
		Recalibrated pulse contour cardiac output vs PAC	0.96	0.11 ± 0.45[b]	Not available
Lopez Hercé (41)	Maryland pigs (n = 51)	Pulse contour cardiac output vs TPTD	0.65	0.04 ± 0.55[a]	−0.02 to 0.12[a]
Ruperez et al (39)	Maryland pigs (n = 16) /hemofiltration	TPTD vs PAC	0.89	0.28[a]	−0.34 to 0.93[a]

TPTD, transpulmonary thermodilution; PAC, pulmonary artery catheter.
Bias and limits of agreement are presented in [a]L/min/m² or [b]L/min.

Table 2. Clinical studies evaluating the validity of transpulmonary thermodilution and pulse contour cardiac output

	Population (n)	Methods	R^2	Bias	Limits of Agreement
McLukie et al (5)	Cardiac surgery (n = 10)	TPTD vs pulmonary artery catheter	Not available	0.19 ± 0.21	−0.23 to 0.60
Tibby et al (21)	Cardiac surgery (n = 24)	TPTD vs Fick	0.99	0.02	−0.57 to 0.61
Pauli et al (22)	Cardiac surgery or catheterism (n = 18)	TPTD vs Fick	0.98	0.03 ± 0.17	−0.31 to 0.37
Linton et al (34)	Cardiac surgery or sepsis (n = 17)	Lithium vs TPTD	0.90	−0.17 ± 0.39[a]	−0.86 to 0.31[a]
Fakler et al (36)	Cardiac surgery (n = 24)	Pulse contour cardiac output vs TPTD	0.86	0.05 ± 0.4	−0.75 to 0.85
Mahajan et al (37)	Cardiac surgery (n = 16)	Pulse contour cardiac output vs TPTD	0.72	0.10 ± 0.97	−1.84 to 2.04

TPTD, transpulmonary thermodilution.
Bias and limits of agreement are presented in L/min/m² or [a]L/min.

F Proulx, *Pediatr Crit Care Med 2011;12:459*

Sarena Teng
Jon Kaufman
Zhaoxing Pan
Angela Czaja
Heather Shockley
Eduardo da Cruz

Continuous arterial pressure waveform monitoring in pediatric cardiac transplant, cardiomyopathy and pulmonary hypertension patients

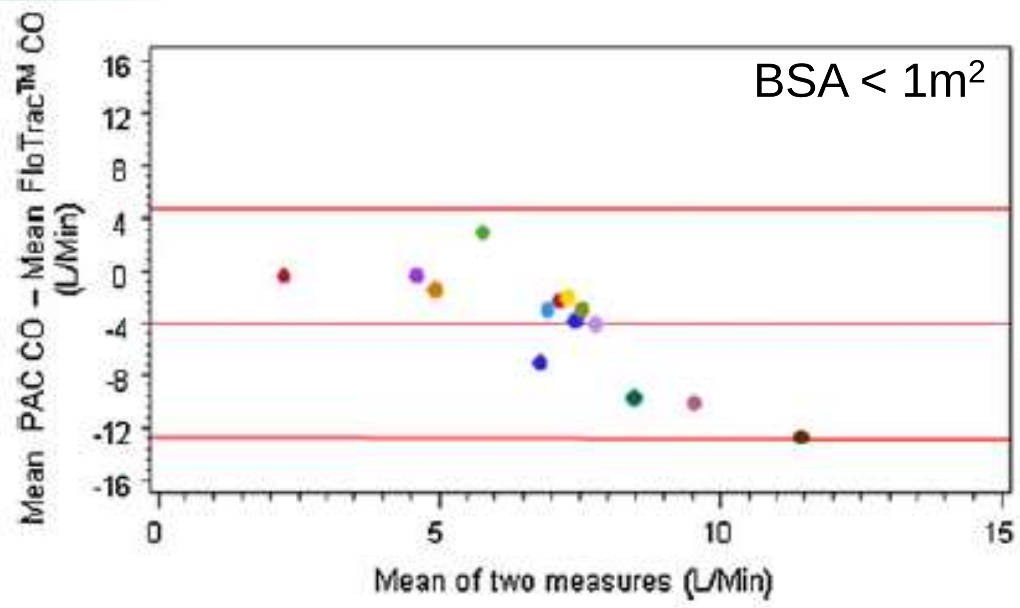
Table 1 Patient characteristics

Characterisitic	No. (%) of patients	Mean	Median	Range
Gender, *n* (%)				
Male	19 (61)			
Female	12 (39)			
Diagnosis				
Pulmonary hypertension[a]	6 (15)			
Orthotopic heart transplantation	26 (63)			
Dilated cardiomyopathy	9 (22)			
No. of measurements per diagnosis				
Pulmonary hypertension		8.6	8	5–13
Orthotopic heart transplantation		3.3	3	2–5
Dilated cardiomyopathy		3.1	3	2–5
Age (years)		8.94	9	0.66–16
BSA (m^2)		1.1	1.04	0.4–1.97
Weight (kg)		33	28.7	8.1–86

[a] Four secondary, two primary

Intensive Care Med 2011;37:129

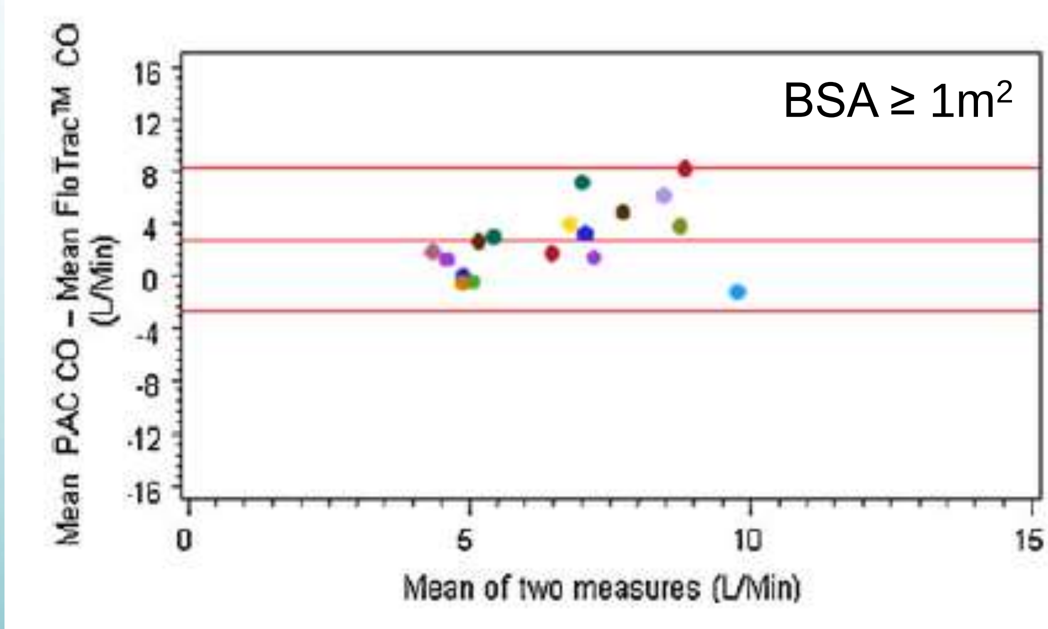
Bland-Altman plot – Ortalama CO değerleri



Limits of agreement: (±8.5 l/min)

Intraclass correlation for

- PAK = 0.929
- FloTrac^{TM} = 0.992



Limits of agreement:

-2.7 to 8.0 l/min (±5.4 l/min)

Assessment of cardiac output in children: A comparison between the pressure recording analytical method and Doppler echocardiography*

Marco Calamandrei, MD; Lorenzo Mirabile, MD; Stefania Muschetta, MD; Gian Franco Gensini, MD; Luciano De Simone, MD; Salvatore M. Romano, PhD

Pediatr Crit Care Med 2008;9:310

N =48, 1 ay – 18 yaş

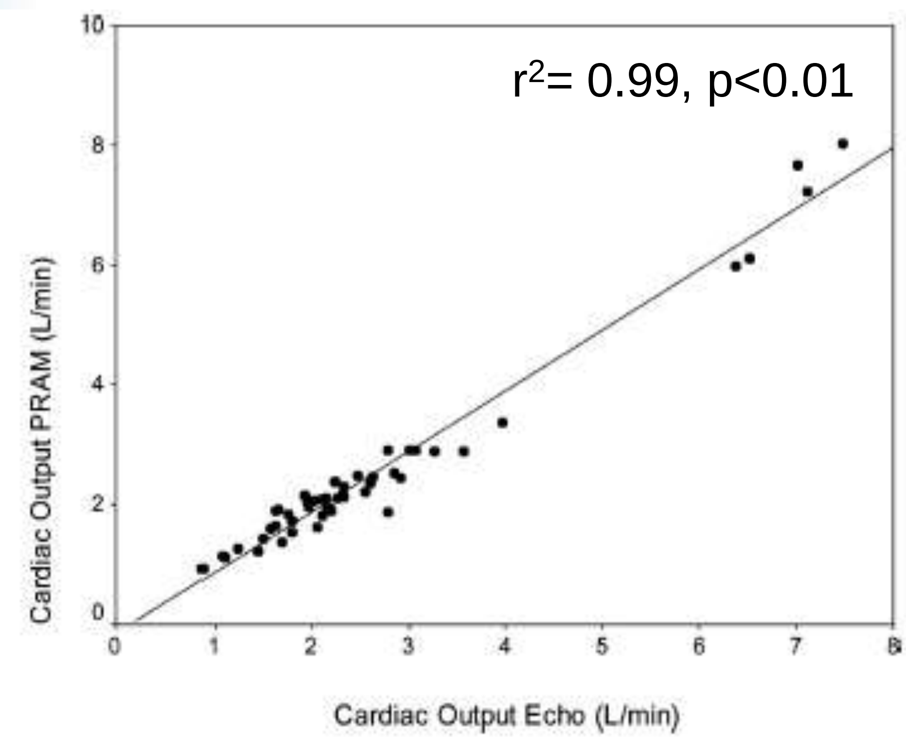
CO_{DOPP}: 2.7 ± 1.6 L/dk (0.92-8.2)

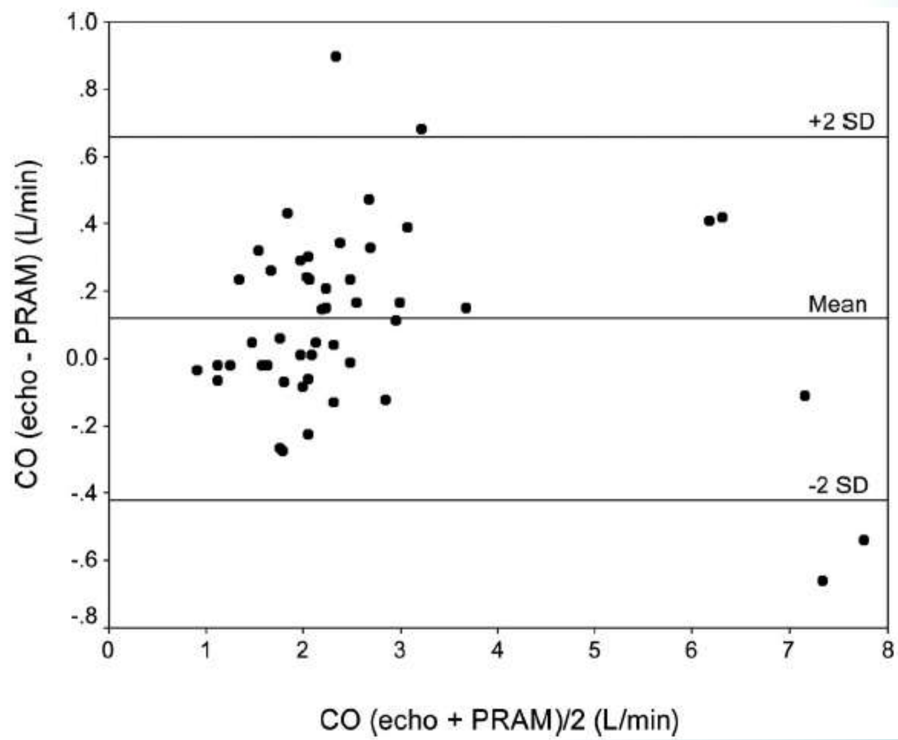
CO_{PRAM}: 2.6 ± 1.7 L/dk (0.89-7.48)

Mean diff: 0.12 ± 0.27 L/dk

CI%95: -0.54-0.77L/dk

P_{error}: %21





Pressure recording analytical method for measuring cardiac output in critically ill children: a validation study

R. Saxena, A. Durward, N. K. Puppala, I. A. Murdoch and S. M. Tibby*

BJA 2013;110:423

N = 48, mekanik ventilasyon, arteriyel ve SVK

PRAM (MostCare®) *vs* Transpulmoner US (CO Status®)

Yaş: 17 (4.5-47.3) ay

VA: 10.7 (5.5-15) kg

İnotrop tedavi: %78

Çalışma dışı:

- Kapak hastalığı
- Ciddi hemodinamik instabilite
- Geniş anatomik şant
- Ciddi aritmi

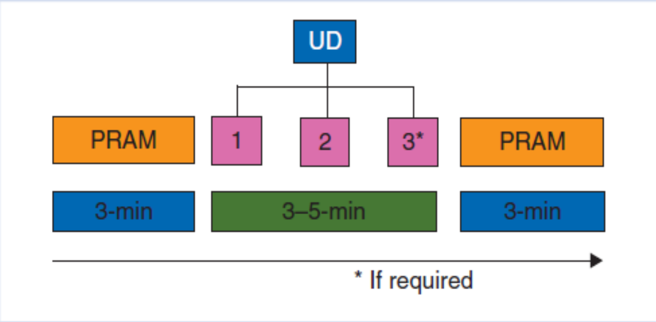


Table 1 Patient diagnostic characteristics. VSD, ventricular septal defect; TCPC, total cavopulmonary connection; AVSD, atrioventricular septal defect; TOF, tetralogy of Fallot; TAPVD, total anomalous pulmonary venous drainage

Diagnosis	Number of patients (%)
Post-cardiovascular surgery	42 (87.5)
VSD	10
TCPC	8
AVSD	3
TOF	3
TAPVD	5
Others	13
Respiratory	2 (4.2)
Sepsis	4 (8.3)

210 eşleştirilmiş ölçüm

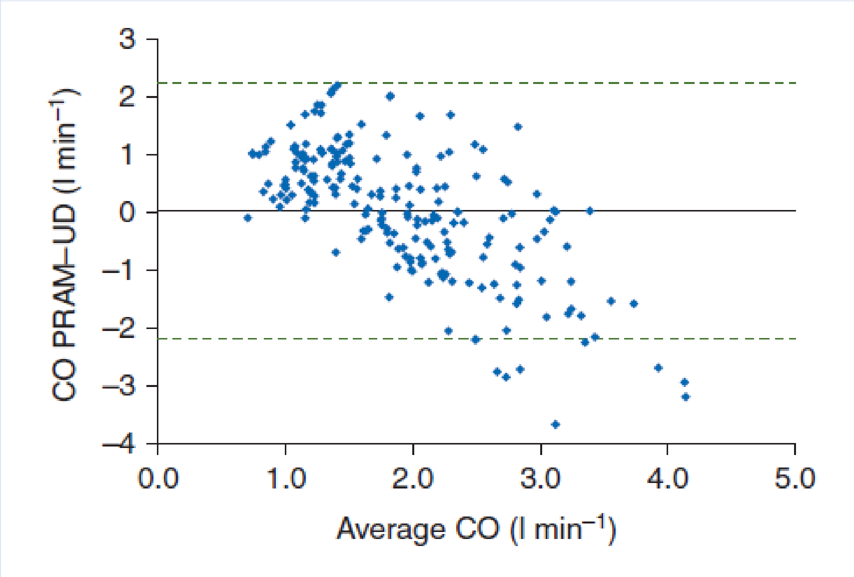
CO_{UD}: 1.9 (1.2) L/dk

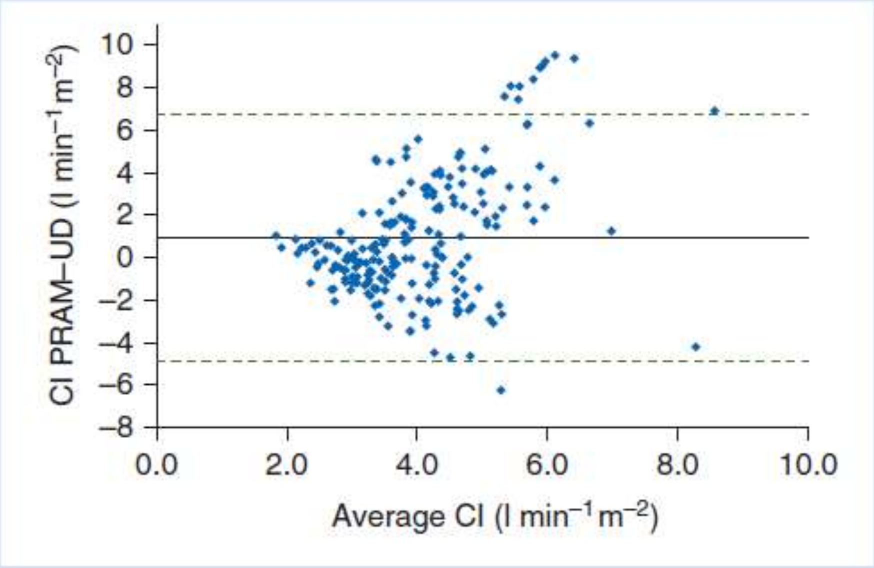
CO_{PRAM}: 1.92 (0.5) L/dk

$Bias_{Mean}$: 0.02 L/dk

LoA: ± 2.21.L/dk

P_{error}: %116





Kritik çocuklarda CO ölçümü için

PRAM'ın uygun bir yöntem olmadığı kanısına varılmış

Pressure recording analytical method and bioreactance for stroke volume index monitoring during pediatric cardiac surgery

Cristiana Garisto[1], Isabella Favia[1], Zaccaria Ricci[1], Stefano Romagnoli[2], Roberta Haiberger[1], Angelo Polito[1] & Paola Cogo[1]

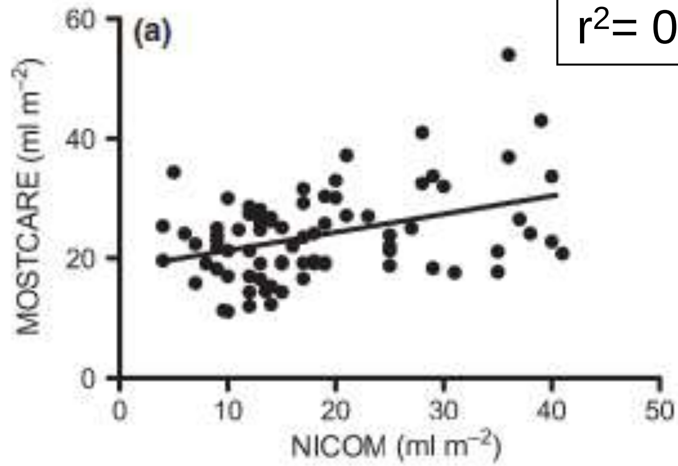
Pediatr Anaesth 2015;25:143

Table 1 Demographic data, diagnoses, and procedures

Total *N*	20
Age (months)	6.0 (3–20)
Weight (kg)	5.3 (4.1–7.8)
BSA	0.31 (0.24–0.37)
CPB (min)	159 (101–213)
XCLAMP (min)	72 (47–115)
Diagnosis	5 Tetralogy of fallot
	1 Pulmonary atresia and ventricular septal defect with multiple aorto-pulmonary collateral arteries
	5 Atrioventricular canal
	2 Univentricular hearts
	1 Transposition of the great arteries
	1 Truncus arteriosus
	2 Aortic valvular stenosis
	2 Atrial septal defect + ventricular septal defect
	1 Total anomalous pulmonary vein drainage
Repair/palliation	18/2
Infant/older	14/6
Cyanotic/Acyanotic	6/14

BSA, body surface area; CPB, cardiopulmonary bypass; XCLAMP, cross clamping time.

SVI_{PRAM}: 23 ml/m^2 (19-27), $SVI_{BİOİMP}$: 15 L/dk (12-25), $p<0.0001$

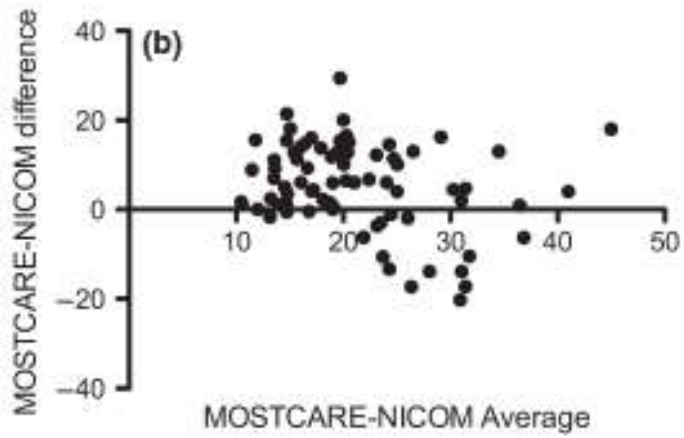


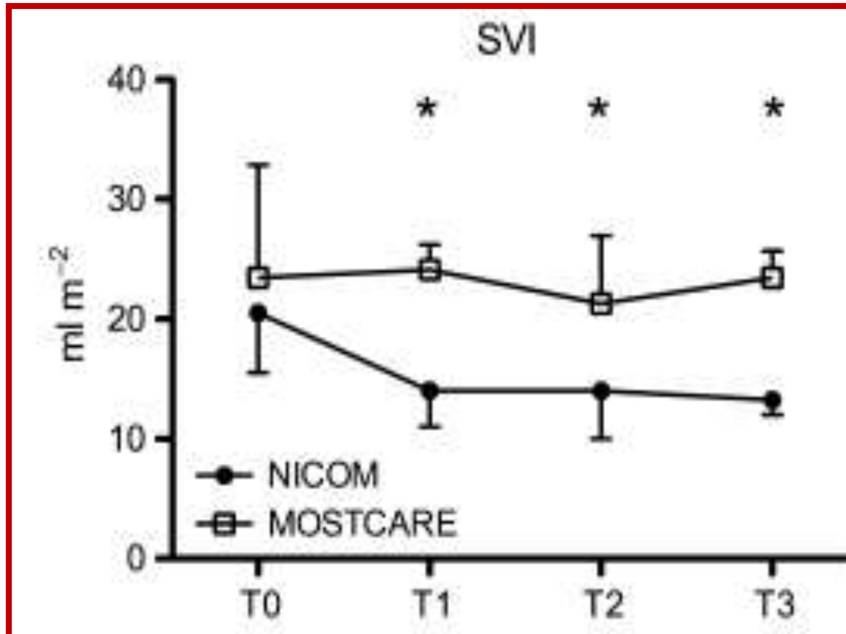
r^2= 0.15, p=0.0003

Mean diff (bias): 5.7 (SD 9.6) ml/m^2

LoA %95: -13 - 24 ml/m^2

P_{error}: %91.7





Yenidoğan - CO Monitorizasyon

Characteristics of various cardiac output monitoring techniques.

Method	Invasive	Catheters	Intermittent	Continuous	Parameters measured/calculated	Feasible in newborns	Validation* in neonates
Fick principle							
Oxygen Fick (O_2-Fick)	+	AC, CVC	+	−	CO, O_2-consumption	+	−
Carbon dioxide rebreathing (CO_2R)	−	−	+	± (3 min)	CO, ventilatory data	−	−
Modified carbon dioxide Fick (mCO_2F)	+	AC, CVC	+	−	CO, ventilatory data	+	−
Indicator dilution							
Pulmonary artery thermodilution (PATD)	+++	PAC	+	+	CO, CVP, PAP, PCWP, $SmvO_2$	−	−
Pulse dye densitometry (PDD)	+	CVC	+	−	CO, IBV	+	−
Lithium dilution (LiDCO)	++	AC, CVC	+	+ (APCA)	CO, SPV, PPV, SVV, HRV, ITBV	−	−
Transpulmonary thermodilution (TPTD)	++	AC, CVC	+	+ (APCA)	CO, GEDV, EVLW, ITBV, PPV, SVV	−	−
Ultrasound dilution (UDCO)	++	AC, CVC	+	−	CO, TEDV, CBV, ACV	+	−
Doppler ultrasound							
Transthoracic echocardiography (TTE)	−	−	+	−	CO, anat. & funct. assessment	+	+[25]
Transesophageal echocardiography (TEE)	+	−	+	−	CO, anat. & funct. assessment	±	−
Transesophageal Doppler (TED)	+	−	+	+	CO, FTc	±	−
Transcutaneous Doppler (TCD)	−	−	+	−	CO	+	+[38]
Arterial pulse contour analysis (APCA)	++/+	AC, (CVC)	−	+	CO, PPV, SVV, HRV	−	−
Thoracic Electrical Impedance (TEI)	−	−	−	+	CO	+	+[39]

*Validated against an accepted reference technology; AC: arterial catheter; ACV: active circulation volume; CBV: central blood volume; CO: cardiac output; CVC: central venous catheter; EVLW: extravascular lung water; FTc: corrected flow time; GEDV: global end-diastolic volume; HRV: heart rate variation; IBV: intravascular blood volume; ITBV: intrathoracic blood volume; PAC: pulmonary artery catheter; PAP: pulmonary artery pressure; PCWP: pulmonary capillary wedge pressure; PPV: pulse pressure variation; $SmvO_2$: mixed venous oxygen saturation; SPV: systolic pressure variation; SVV: stroke volume variation; TEDV: total end-diastolic volume;

Boode W-P, Early Human Development 2010;86:143

Yenidoğan - CO Monitorizasyon

- Transpulmoner indikatör dilusyonu
- Arteriyel basınç dalga şekil analizi
- Torasik elektriksel impedans

+

- TTE (fonksiyonel değerlendirme)

Duktal /arteriyel şant

frontiers in PEDIATRICS

METHODS ARTICLE
published: 25 March 2014
doi: 10.3389/fped.2014.00016

Non-invasive cardiac output measurement in low and very low birth weight infants: a method comparison

- Prospektif, gözlemsel çalışma
- 228 CO ölçümü
- N=28 pre-term yenidoğan
  (17 LBW, 11 VLBW)

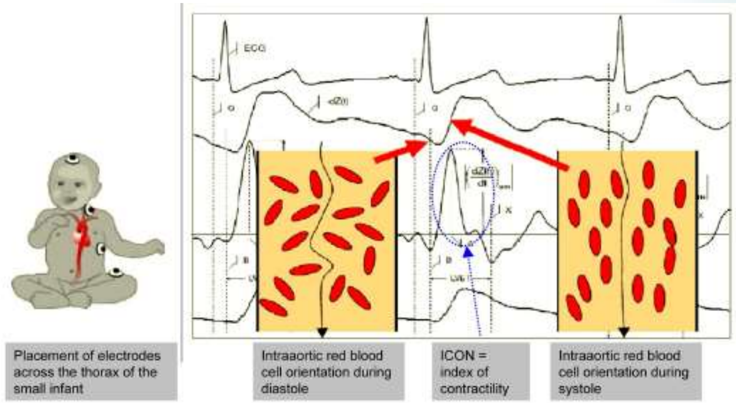


Table 2 | Bland–Altman test for method agreement and coefficient of variations (CV) for precision calculation in all patients, LBW and VLBW infants.

Population	Method	Mean	CV (%)	Agreement (Bland–Altman)				
				Upper limit	Lower limit	% of mean	Bias	% of mean
All patients	TTE	256.4 ± 44.8	8.0	71.6	–53.8	24.0	8.9	3.4
	EV	265.3 ± 48.8	6.3					
LBW infants	TTE	248.3 ± 39.9	8.7	70.9	–50.2	23.9	10.4	4.1
	EV	258.7 ± 44.7	7.1					
VLBW infants	TTE	274.2 ± 53.8	10.5	69.1	–48.4	23.5	5.3	1.9
	EV	268.8 ± 49.0	7.0					

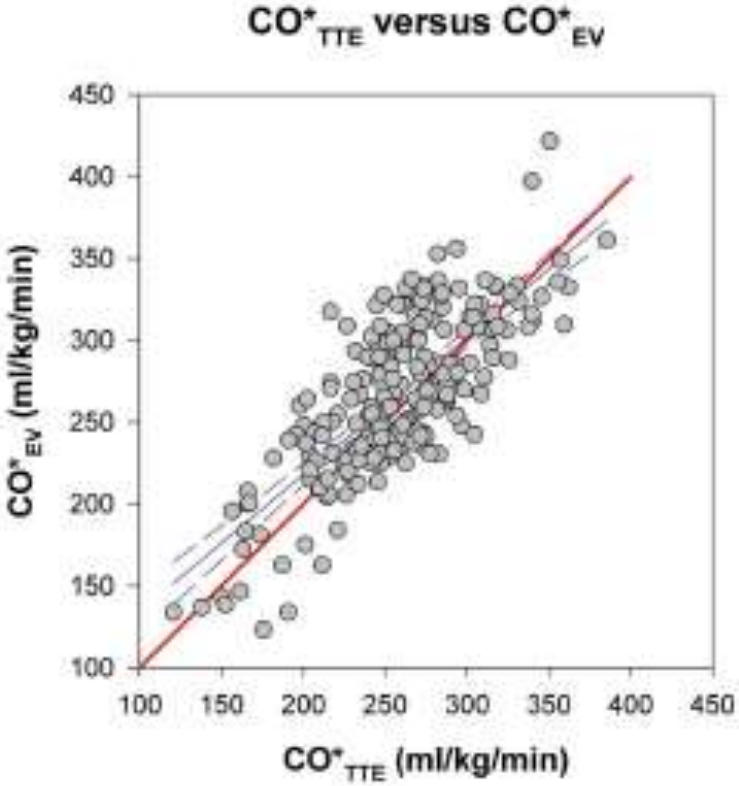
Means, bias, and limits are expressed as absolute values (ml/kg/min), bias and limits also as % of means.

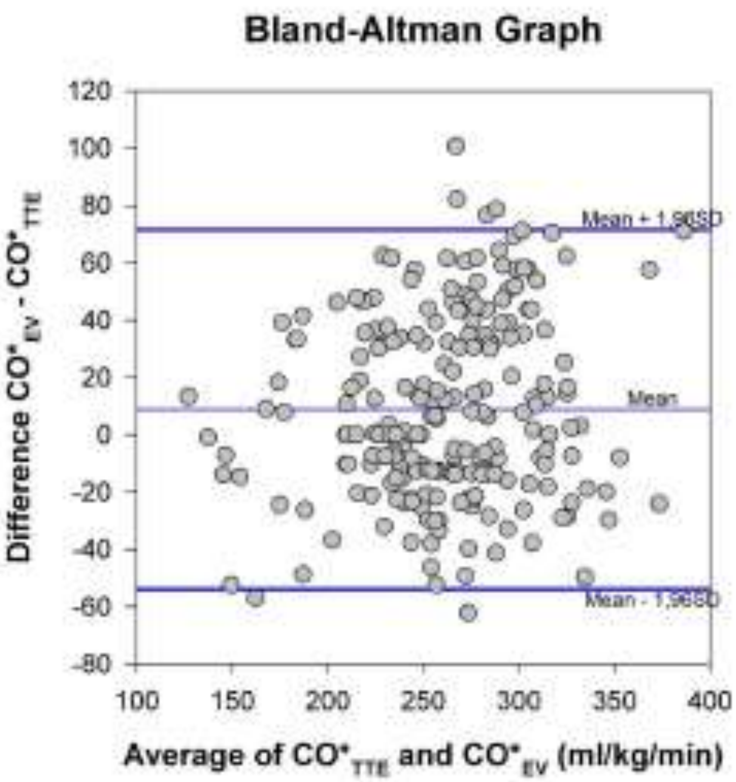
O Grollmuss, et al. 2014;2:16/1-5

Table 3 | Circulatory parameters: Measured SV, body weight indexed SV*, HR, and body weight indexed CO* for all patients, LBW and VLBW.

Parameter population	SV (ml)		SV* (ml/kg)		HR (beats/min)	CO* (ml/kg/min)	
	TTE	EV	TTE	EV	ECG (EV)	TTE	EV
All patients	2.97 ± 0.68	3.04 ± 0.75	1.63 ± 0.27	1.68 ± 0.28	157.7 ± 14.6	256.4 ± 44.8	265.3 ± 48.8
LBW	3.31 ± 0.53	3.46 ± 0.56	1.62 ± 0.25	1.69 ± 0.25	158.2 ± 10.8	247.7 ± 39.8	259.1 ± 44.1
VLBW	2.49 ± 0.58	2.45 ± 0.58	1.65 ± 0.29	1.68 ± 0.31	163.5 ± 12.3	268.8 ± 49.0	274.2 ± 53.8

Measurements performed by TTE and EV.

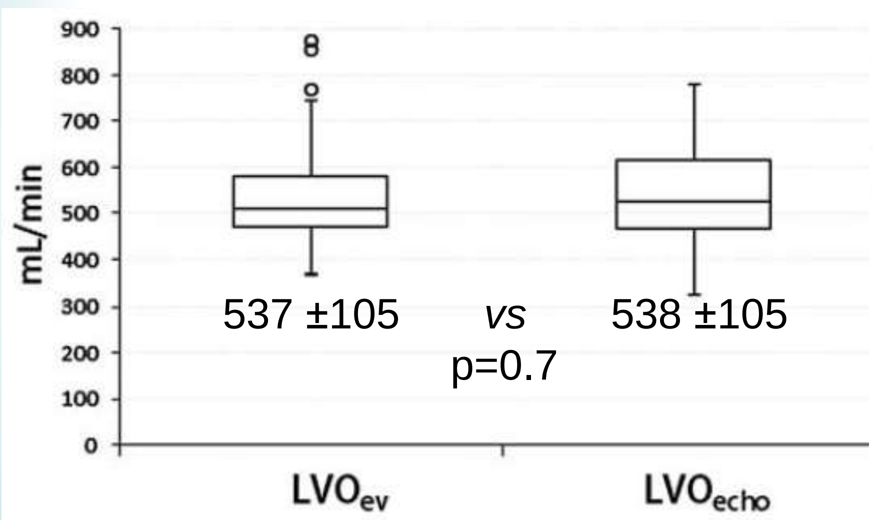


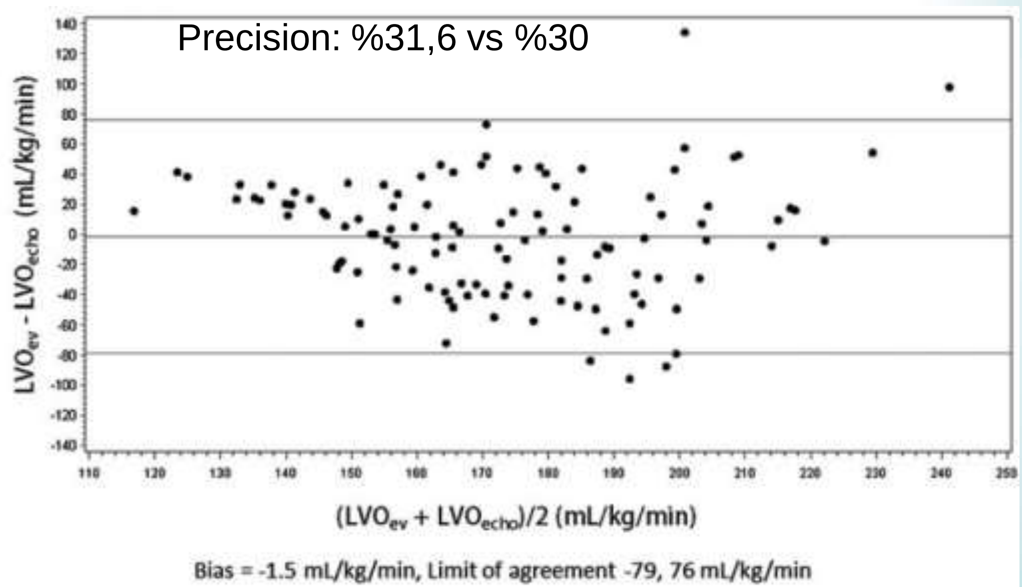


Continuous non-invasive cardiac output measurements in the neonate by electrical velocimetry: a comparison with echocardiography

Shahab Noori,[1,2] Benazir Drabu,[2] Sadaf Soleymani,[1,3] Istvan Seri[1]

N = 20, sağlıklı YD, postnatal 2 gün, 115 ölçüm





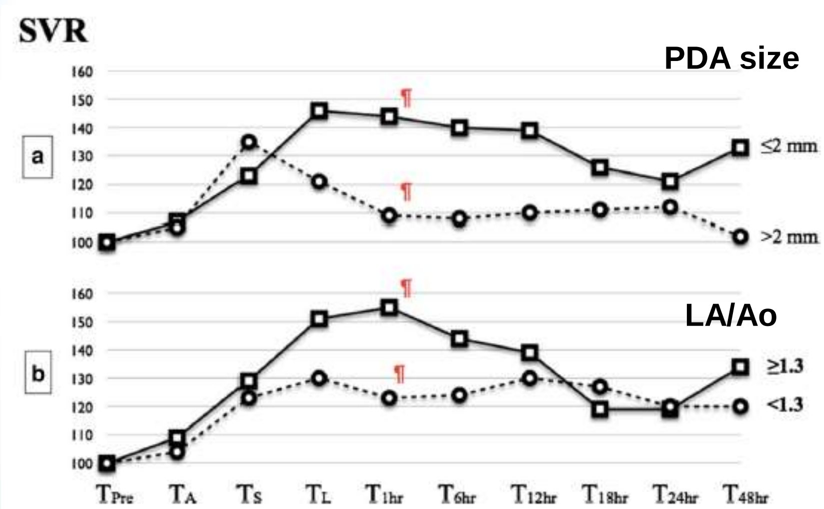
Yenidoğanlarda elektrovelosimetri yöntemi ile ölçülen CO değeri EKO ile belirlenen ile karşılaştırılabilir niteliktedir

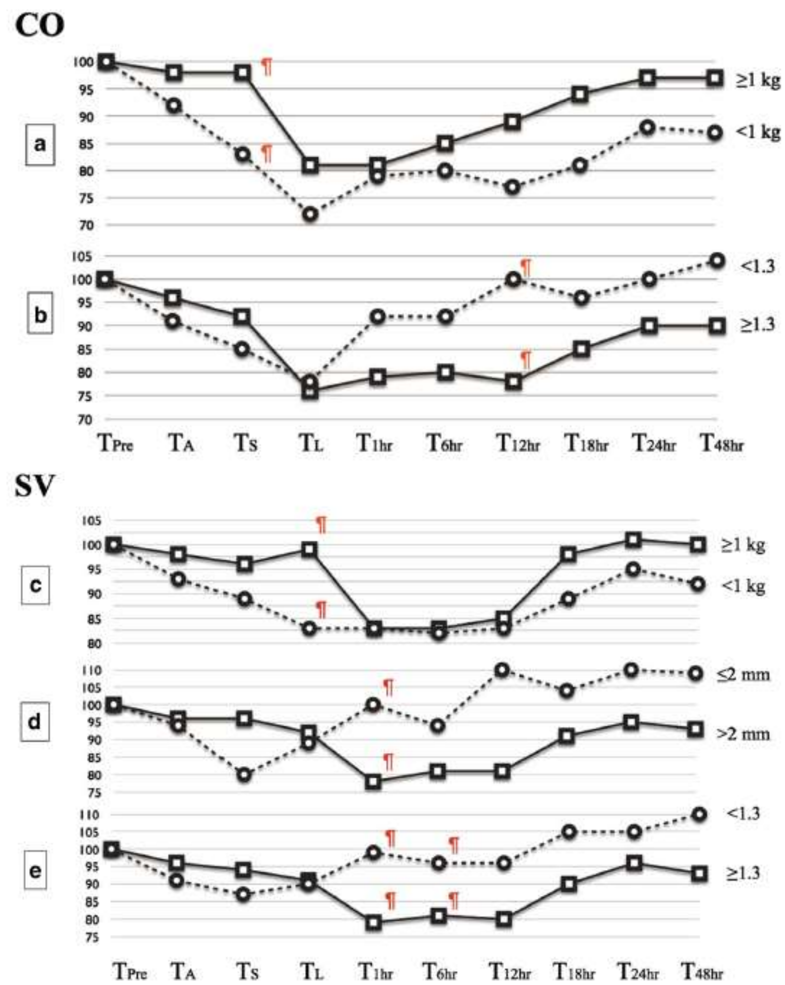
Arch Dis Child Fetal Neonatal Ed 2012;97:F340

Hemodynamic alterations recorded by electrical cardiometry during ligation of ductus arteriosus in preterm infants

Reyin Lien • Kai-Hsiang Hsu • Jaw-Ji Chu • Yu-Sheng Chang

N=30, ≤1500 g, 27.7±2.0 hf, 929±280 g





ÇDDA bebeklerde PDA ligasyonu SV ↓ ve SVR ↑ ile önemli hemodinamik değişikliklere neden olur

Eur J Pediatr 2015;174:543

Experimental paper

Pulmonary arterial thermodilution, femoral arterial thermodilution and bioreactance cardiac output monitoring in a pediatric hemorrhagic hypovolemic shock model☆

Yolanda Ballestero[a,c], Javier Urbano[a,c], Jesús López-Herce[a,c,*], Maria J. Solana[a,c], Marta Botrán[a,c], Diego Vinciguerra[a,c], Jose M. Bellón[b,d]

N=9, immature Maryland domuz (9-12 kg)

Hipovolemi: 30 ml/kg kan → Sıvı tedavisi 30 ml/kg

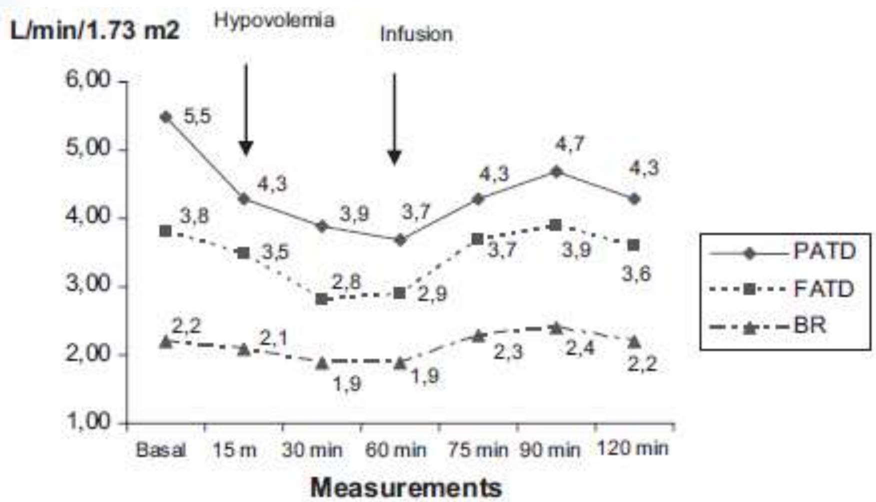


Fig. 4. Changes in the CI measured by pulmonary artery thermodilution (PATD), femoral artery thermodilution (FATD) and bioreactance (BR).

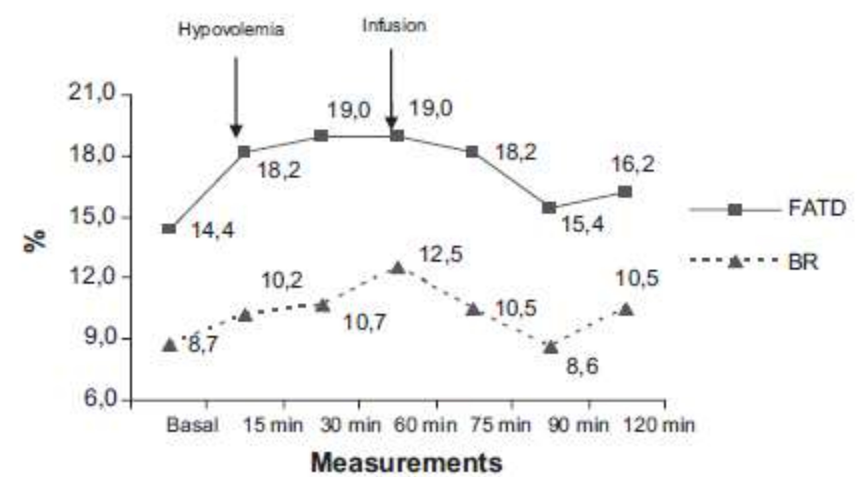


Fig. 6. Changes in the stroke volume variation (SVV %)) measured by femoral artery thermodilution (FATD) and Bioreactance (BR).

Resuscitation 2012;83:125

Experimental paper

Pulmonary arterial thermodilution, femoral arterial thermodilution and bioreactance cardiac output monitoring in a pediatric hemorrhagic hypovolemic shock model☆

Yolanda Ballestero[a,c], Javier Urbano[a,c], Jesús López-Herce[a,c,*], Maria J. Solana[a,c], Marta Botrán[a,c], Diego Vinciguerra[a,c], Jose M. Bellón[b,d]

	PATD-FATD	PATD- BioR	FATD-BioR
Bias	0.84	1.95	1.06
LoA	(−1.87–3.51)	(−1.79–5.69)	(−1.40–3.52)
Korelasyon	r = 0.43	r =−0.018	r = 0.169;
P değeri	**= 0.01**	= 0.9	= 0.22

Conclusions: PATD and FATD measurements showed similar responses to hypovolemic shock and volume expansion. Bioreactance persistently underestimates the CI and is not significantly altered by either inducing hemorrhagic shock, or later, through volume expansion. Bioreactance is not a suitable method for monitoring the CI in pediatric hemorrhagic shock.

Resuscitation 2012;83:125

CO Monitorizasyonu

Kan Basıncı = SVR x CO

↓

SV x HR ←

- Preload
- Kontraktilite
- Afterload
- Ritim
- Diyastolik fonksiyon

↑

$DO_2 \approx SaO_2 \times Hgb \times CO$

Kardiyovasküler Fonksiyon

CO ölçümü

- Oksijen tüketimi (Fick)
- Indikatör dilusyonu (boya, ısı, lityum)
- Arteriyel dalga formu analizi
- Biyoimpedans
- Doppler US

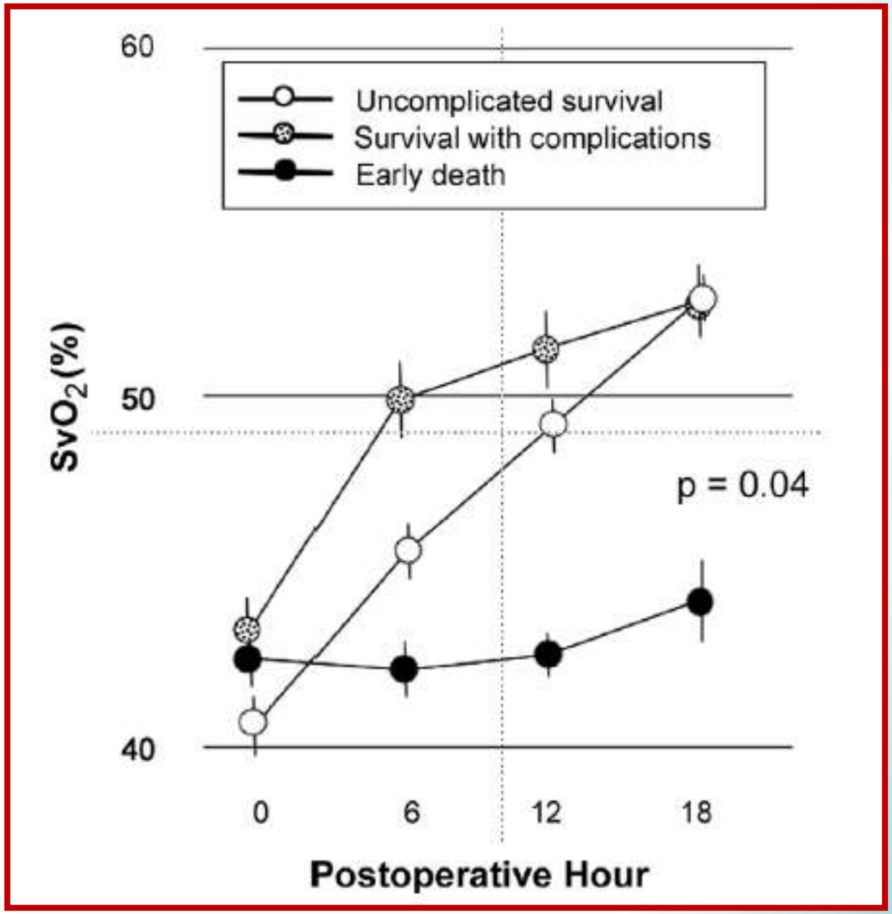
Doku oksijenasyonu belirteçleri

- Laktat düzeyi
- Mikst/santral venöz O_2 saturasyonu (venöz oksimetri)
- Rejyonal O_2 saturasyonu (NIRS)

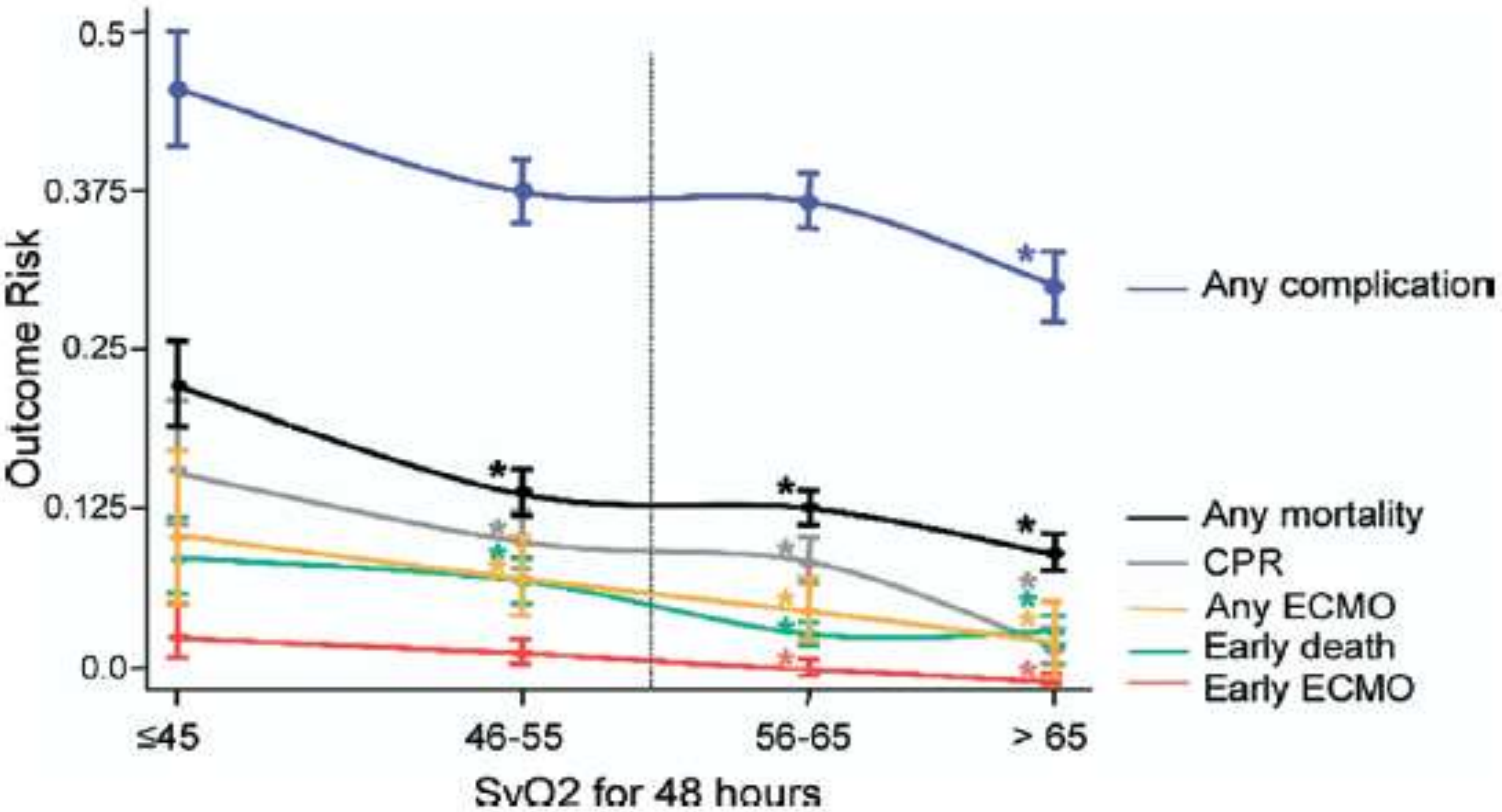
Mixed Venous Oxygen Saturation Monitoring After Stage 1 Palliation for Hypoplastic Left Heart Syndrome

Table 4. Multivariable Analysis of Impact of Factors on Outcome

Factor	Complications $R^2 = 0.29$	Death $R^2 = 0.34$	Ord log model $R^2 = 0.28$
Age (younger)	0.048		0.038
Weight (lower)			
Gestational age			0.024
Aortic diameter			
Phenoxybenzamine			
Additional diagnosis			
DHCA duration			
Total support time (longer)	0.003		0.001
SvO_2 lower	0.022	0.016	0.004
SaO_2 higher	0.04		0.007
ΔAVO_2			
Hemoglobin (higher)			0.015
MAP			
CVP			
Heart rate (lower)	0.03		0.021
Qp/Qs (lower)			0.023
F_{IO_2} (higher)	0.028		
pH (lower)	0.031		0.037
Base Excess			
P_{CO_2}			
P_{O_2}			



Tweddell JS Ann Thorac Surg 2007;84:1301



Tweddell JS Ann Thorac Surg 2007;84:1301

Near-infrared spectroscopy as a hemodynamic monitor in critical illness

Nancy S. Ghanayem, MD; Gil Wernovsky, MD; George M. Hoffman, MD

Background: Near-infrared spectroscopy has moved from a research tool to a widely used clinical monitor in the critically ill pediatric patient over the last decade. The physiological and clinical evidence supporting this technology in practice is reviewed here.

Methodology: A search of MEDLINE and PubMed was conducted to find validation studies, controlled trials, and other reports of near-infrared spectroscopy use in children and adults in the clinical setting. Guidelines published by the American Heart Association, the American Academy of Pediatrics, and the International Liaison Committee on Resuscitation were reviewed including further review of references cited.

Results: The biophysical properties of near-infrared spectroscopy devices allow measurement of capillary–venous oxyhemoglobin saturation in tissues a few centimeters beneath the surface

have been described for normal newborns and infants and children with congenital heart disease and other disease states. The capillary–venous oxyhemoglobin saturation from both cerebral and somatic regions has been used to estimate mixed venous saturation and to predict biochemical shock, multiorgan dysfunction, and mortality in different populations. The relationship of cerebral capillary–venous oxyhemoglobin saturation to neuroimaging and functional assessment of outcome is limited but ongoing. Although there are numerous conflicting reports in small populations, expert opinion would suggest that special use may exist for near-infrared spectroscopy in patients with complex circulatory anatomy, with extremes of physiology, and in whom extended noninvasive monitoring is useful.

Conclusions: Class II, level B evidence supports the conclusion that near-infrared spectroscopy offers a favorable risk–benefit

Conclusions: Class II, level B evidence supports the conclusion that near-infrared spectroscopy offers a favorable risk–benefit profile and can be effective and beneficial as a hemodynamic monitor for the care of critically patients. (Pediatr Crit Care Med 2011; 12[Suppl.]:S27–S32)

Predicting Fluid Responsiveness in Children: A Systematic Review

Heng Gan, MBBCh, MRCPCH, FRCA,*† Maxime Cannesson, MD, PhD,‡
John R. Chandler, MBBCh, FCARCSI, FDSRDS,§ and
J. Mark Ansermino, MBBCh, MSc (Inf), FFA (SA), FRCPC*†

Anesth Analg 2013;117:1380

12 çalışma, 438 pediyatrik hasta (yaş: 1.0 gün - 17.8 yıl), 501 sıvı bolusu

STATIC		
Clinical	Heart rate	HR
	Systolic arterial blood pressure	SAP
Preload pressure	Central venous pressure	CVP
	Pulmonary artery occlusion pressure	PAOP
Thermodilution	Global end diastolic volume index	GEDVI
Ultrasound dilution	Active circulation volume	ACV
	Central blood volume	CBV
	Total end diastolic volume	TEDV
	Total ejection fraction	TEF
Echocardiography and Doppler	Left ventricular end diastolic area	LVEDA
	Stroke volume index	SVI
	Corrected flow time	FTc
DYNAMIC		
Arterial pressure	Systolic blood pressure variation	SPV
	Pulse pressure variation	PPV
	Stroke volume variation	SVV
	Difference between minimal SAP and SAP at end-expiratory pause	ΔDown
	Difference between maximal SAP and SAP at end-expiratory pause	ΔUp
Plethysmography	Pulse oximeter plethysmograph amplitude variation	ΔPOP
	Plethysmograph variability index	PVI
Echocardiography and Doppler	Respiratory variation in aortic blood flow peak velocity	ΔV_{peak}
	Stroke distance variation	ΔVTI
	Inferior vena cava diameter variation	ΔIVCD
PASSIVE LEG RAISING (PLR)		
Echocardiography and Doppler	PLR-induced change in cardiac index	ΔCI_{PLR}
	PLR-induced change in stroke volume	ΔSV_{PLR}

	Potential predictor	Area under ROC with 95% CI (numerical value on right, vertical line is 0.5)	Fluid bolus, *n*	Setting	Study
Clinical	HR	0.55	33	Neuro OR	Byon[24]
		0.62	19	Neuro OR, 0-6 yrs	Pereira de Souza Neto[6]
		0.66	11	Neuro OR, 6-14 yrs	Pereira de Souza Neto[6]
		0.53	27	Cardiac OR	Renner 2011[8]
	SAP	0.67	33	Neuro OR	Byon[24]
Preload pressure	CVP	0.47	33	Neuro OR	Byon[24]
		0.61	19	Cardiac cath	Chandler[5]
		0.48	21	Cardiac PICU	Choi[2]
		0.61	26	Cardiac OR, ASD/VSD	Renner 2012[7]
		0.69	26	Cardiac OR, closed ASD/VSD	Renner 2012[7]
		0.57	27	Cardiac OR	Renner 2011[8]
		0.41	65	Mixed PICU	Saxena[9]
		0.60	58	Cardiac PICU	Tibby[25]
		0.51	36	General PICU	Tibby[25]
		0.58	44	Cardiac OR	Tran[26]
	PAOP	0.67	19	Cardiac cath	Chandler[5]
Thermodilution & US dilution	GEDVI	0.59	26	Cardiac OR, ASD/VSD	Renner 2012[7]
		0.77	26	Cardiac OR, closed ASD/VSD	Renner 2012[7]
	ACV	0.47	65	Mixed PICU	Saxena[9]
	CBV	0.53	65		
	TEDV	0.44	65		
	TEF	0.45	65		
Echocardiography & Doppler	LVEDA	0.59	19	Neuro OR, 0-6 yrs, TTE	Pereira de Souza Neto[6]
		0.71	11	Neuro OR, 6-14 yrs, TTE	Pereira de Souza Neto[6]
	SVI	0.90	50	General OR, TED	Raux[3]
	FTc	0.54	58	Cardiac PICU, TED	Tibby[25]
		0.76	36	General PICU, TED	Tibby[25]

	Potential predictor	Area under ROC with 95% CI (numerical value on right, vertical line is 0.5)	Fluid bolus, *n*	Setting	Study
Arterial pressure	PPV	0.54	33	Neuro OR	Byon[24]
		0.60	19	Cardiac cath	Chandler[5]
		0.59	26	General PICU	Durand[1]
		0.52	19	Neuro OR, auto PPV, 0-6 yrs	Pereira de Souza Neto[6]
		0.60	11	Neuro OR, auto PPV, 6-14 yrs	Pereira de Souza Neto[6]
		0.71	19	Neuro OR, manual PPV, 6-14 yrs	Pereira de Souza Neto[6]
		0.60	11	Neuro OR, manual PPV, 6-14 yrs	Pereira de Souza Neto[6]
		0.79	26	Cardiac OR, ASD/VSD	Renner 2012[7]
		0.86	26	Cardiac OR, closed ASD/VSD	Renner 2012[7]
		0.61	65	Mixed PICU	Saxena[9]
	SPV	0.58	33	Neuro OR	Byon[24]
		0.65	26	General PICU	Durand[1]
		0.58	65	Mixed PICU	Saxena[9]
		0.74	44	Cardiac OR	Tran[26]
	SVV	0.70	26	Cardiac OR, ASD/VSD	Renner 2012[7]
		0.78	26	Cardiac OR, closed ASD/VSD	Renner 2012[7]
		0.61	65	Mixed PICU	Saxena[9]
		0.74	44	Cardiac OR	Tran[26]
	ΔDown	0.62	33	Neuro OR	Byon[24]
	ΔUp	0.64	33	Neuro OR	Byon[24]

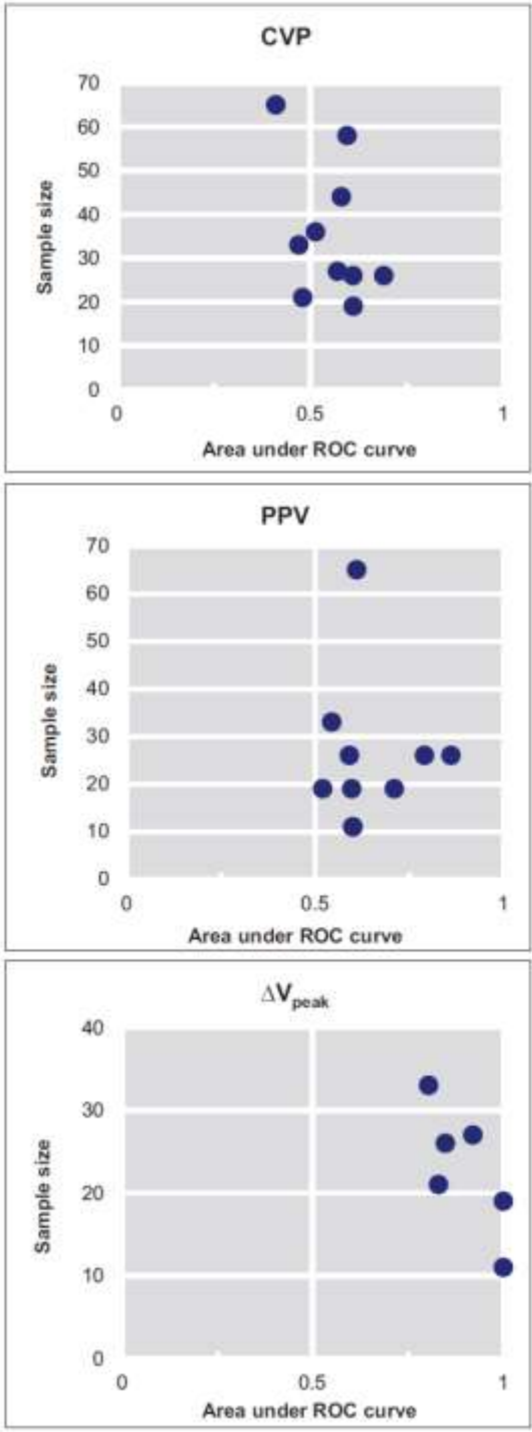
	Potential predictor	Area under ROC with 95% CI (numerical value on right, vertical line is 0.5)	Fluid bolus, *n*	Setting	Study
Plethysmography	ΔPOP	0.56	19	Cardiac cath	Chandler[5]
		0.51	19	Neuro OR, 0-6 yrs	Pereira de Souza Neto[6]
		0.57	11	Neuro OR, 6-14 yrs	Pereira de Souza Neto[6]
	PVI	0.77	33	Neuro OR	Byon[24]
		0.54	19	Cardiac cath	Chandler[5]
		0.63	19	Neuro OR, 0-6 yrs	Pereira de Souza Neto[6]
		0.54	11	Neuro OR, 6-14 yrs	Pereira de Souza Neto[6]
		0.78	27	Cardiac OR	Renner 2011[8]
Echocardiography & Doppler	ΔV_{peak}	0.80	33	Neuro OR, TTE	Byon[24]
		0.83	21	Cardiac PICU, TTE	Choi[2]
		0.85	26	General PICU, TTE	Durand[1]
		1.00	19	Neuro OR, 0-6 yrs, TTE	Pereira de Souza Neto[6]
		1.00	11	Neuro OR, 6-14 yrs, TTE	Pereira de Souza Neto[6]
		0.92	27	Cardiac OR, TEE	Renner 2011[8]
	ΔVTI	0.84	27	Cardiac OR, TEE	Renner 2011[8]
	ΔIVCD	0.37	33	Neuro OR, TTE	Byon[1]
		0.85	21	Cardiac PICU, TTE	Choi[2]
PLR	ΔCI_{PLR}	0.71	40	General PICU, TTE	Lukito[4]
	ΔSV_{PLR}	0.75	40	General PICU, TTE	Lukito[4]

Pediyatrik olgularda sıvı yanıtını değerlendirmede,

- Statik parametreler yetersiz
- Dinamik parametreler
  - Arteriyel kan basıncını baz alanlar

    yol gösterici değildir
  - Pletismografik olanlar için

    kanıtlar henüz yetersiz
  - ΔV peak değeri güvenilir



Çocuklarda
akciğer, vasküler ve kardiyak kompliyansın
erişkinlerden farklı olmasıdır

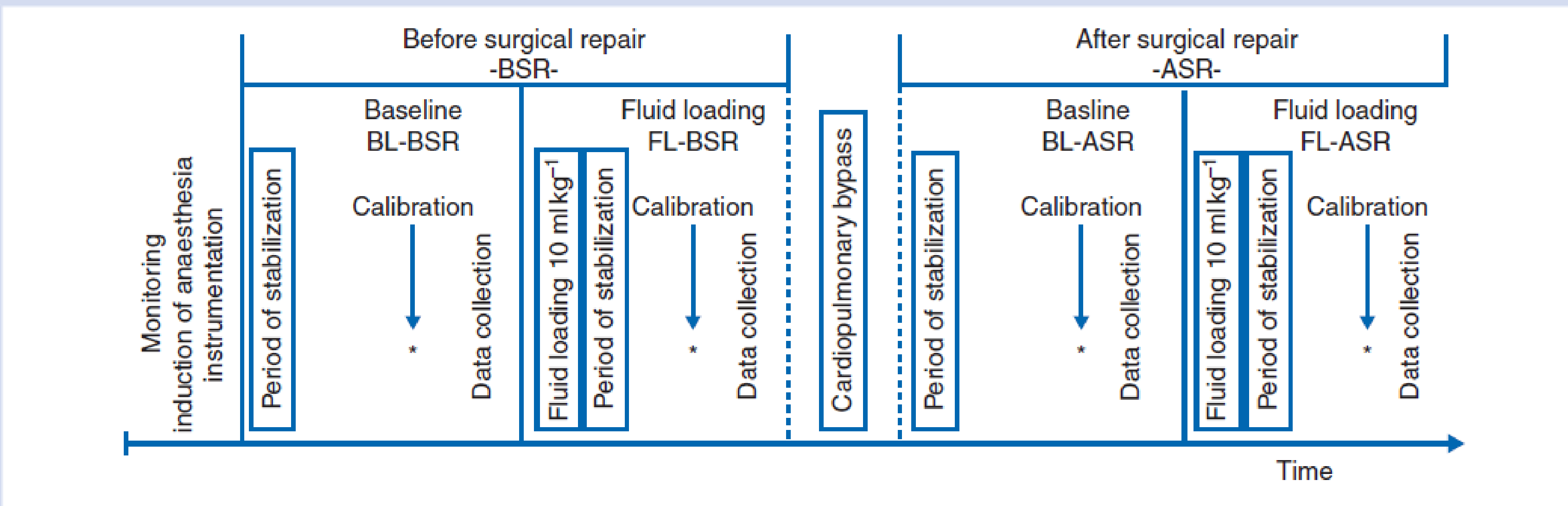
Anesth Analg 2013;117:1380

British Journal of Anaesthesia 108 (1): 108–15 (2012)
Advance Access publication 23 November 2011 · doi:10.1093/bja/aer371

BJA

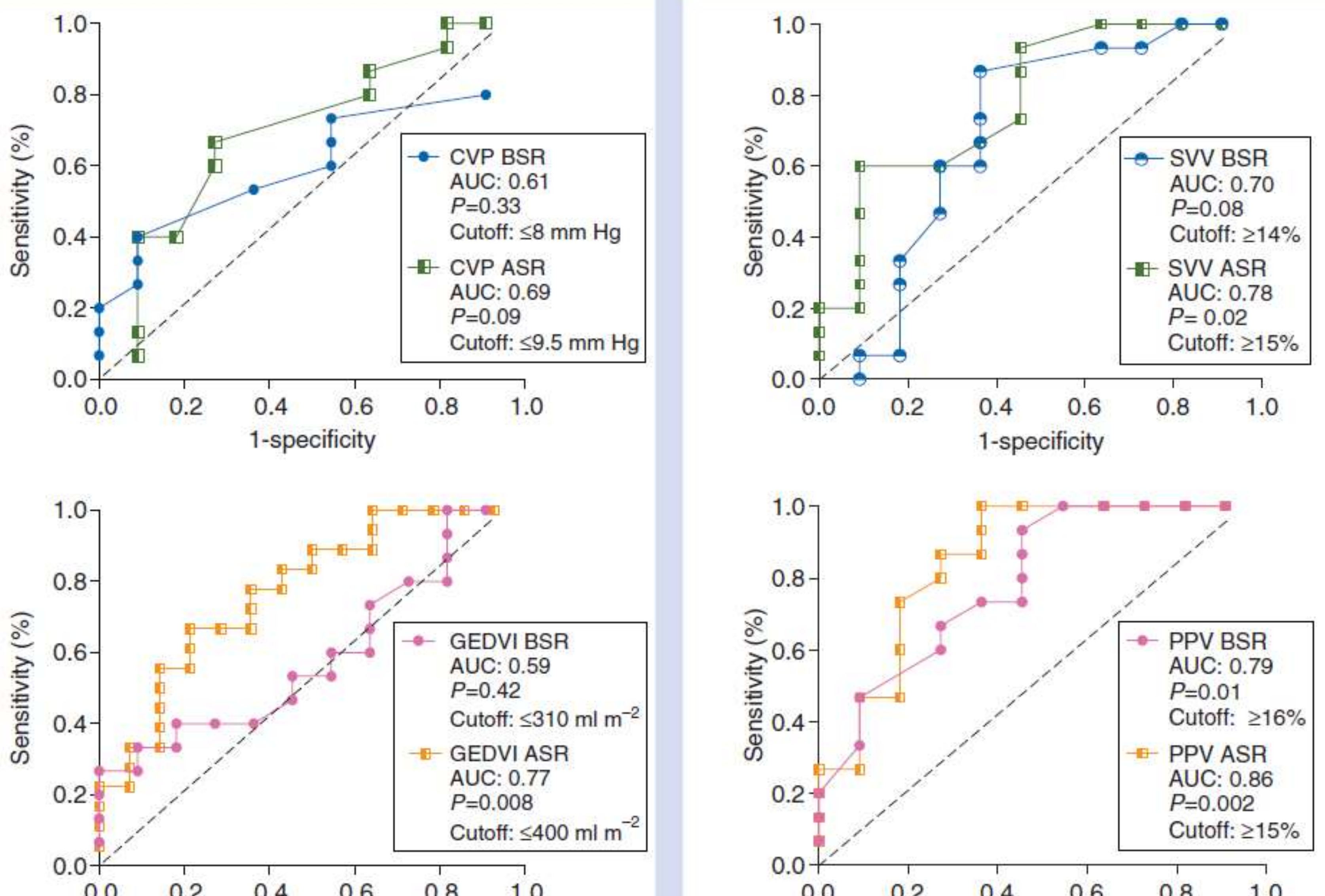
Prediction of fluid responsiveness in infants and neonates undergoing congenital heart surgery

J. Renner[1*], O. Broch[1], P. Duetschke[1], J. Scheewe[2], J. Höcker[1], M. Moseby[1], O. Jung[3] and B. Bein[1]



N = 26, mekanik ventilasyon
ASD, VSD
Yaş (ort (SD): 14 (12) ay
VA (ort (SD): 9.7 (4.3) kg

Preload variables	BSR		ASR	
	r	*P*-value	*r*	*P*-value
CVP (mm Hg)	−0.17	0.42	−0.03	0.81
GEDVI (ml m^{-2})	−0.13	0.52	−0.64	0.0005
PPV (%)	0.54	0.004	0.73	<0.0001
SVV (%)	0.30	0.14	0.57	0.02

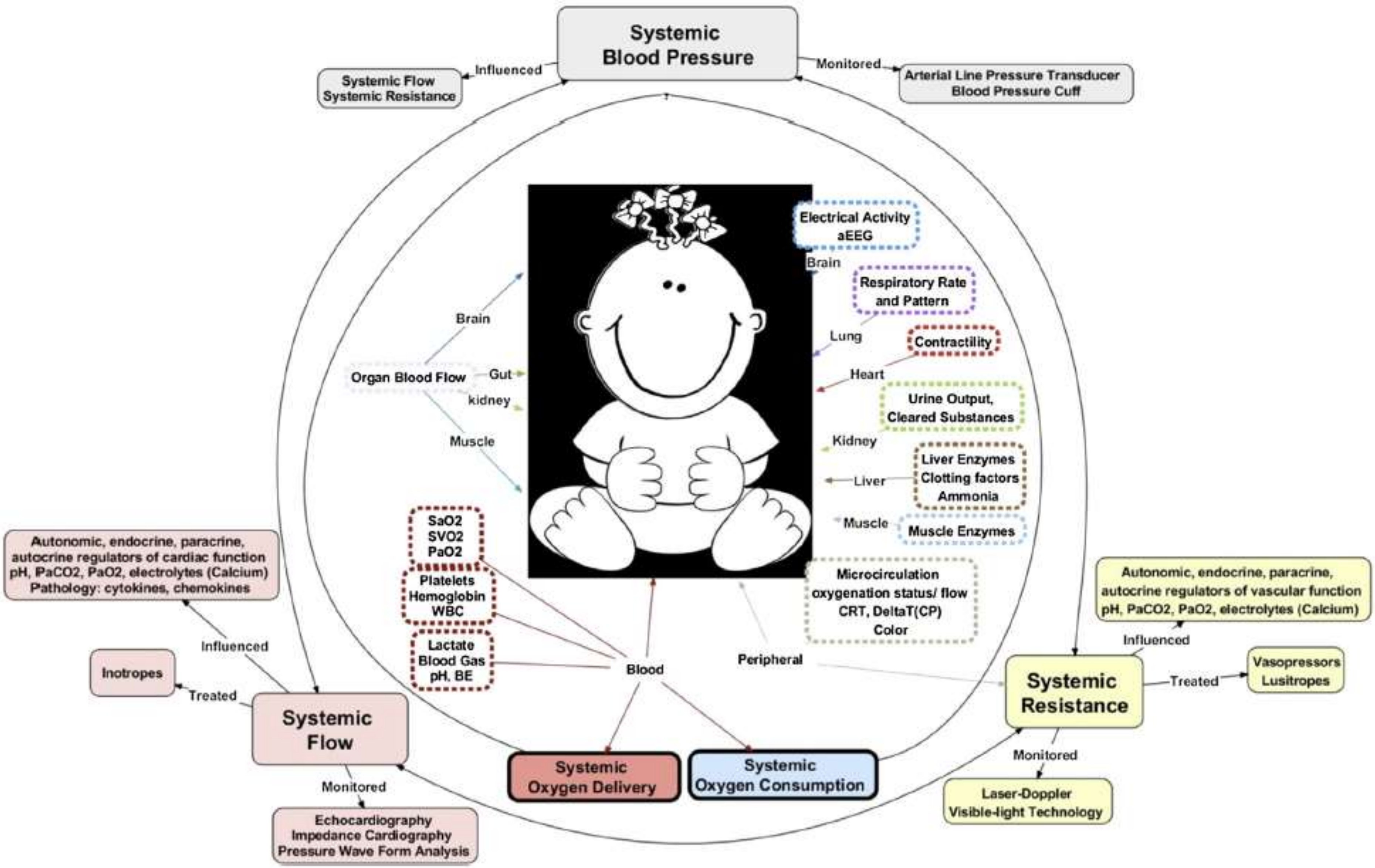


Kongenital kalp hastalıkları cerrahisi geçiren infantlarda PPV cerrahi onarım öncesi ve sonrası sıvı yanıtını gösterirken, SVV, CVP ve GEDVI göstermemektedir

Pediatric Cardiac Surgery Annual

All This Monitoring...What's Necessary, What's Not?

James S. Tweddell,[a,b,c] Nancy S. Ghanayem,[a,b,d] and George M. Hoffman[a,b,e]



Azhibekov T Seminars in Fetal &Neonatal Medicine 2014;19:45

Pediyatrik Kardiyak Cerrahide Monitorizasyon

1. Standart temel monitorizasyon
2. İnvaziv basınç ölçümü
3. Laktat ve $ScvO_2$
4. Ekokardiyografi
   - Özellikle açıklanamayan, ani klinik/hemodinamik kötüleşme

Değişimin izlenmesi – TREND önemli

CO Monitorizasyon Yöntemleri

Metot	Teknik	İnvaziv	Teknik Zorluk	Süreklilik	Doğruluk	Boyut Limiti
Termal	PA TP	Orta Orta	Fazla Orta	Aralıklı Aralıklı	Yüksek Yüksek	5-10kg 3kg
Lityum	LİDCO	Düşük	Orta	Aralıklı	Yüksek	-
US	Ekokardiyografi Özefagial doppler	Düşük Düşük	Fazla Düşük	Aralıklı Sürekli	Yüksek Yüksek	- 3kg
ABD şekli analizi	PİCCO	Düşük	Düşük	Sürekli	Orta	-
Elektriksel	Bioimpedans/reaktans	Noninvaziv	Düşük	Sürekli	Düşük	- -
Venöz oksimetri	Fiberoptik	Orta	Düşük	Sürekli	Orta	-
NIRS	INVOS/NIRO	Düşük	Düşük/orta	Sürekli	Orta	-

Pediyatrik Kardiyak Cerrahide

Yeni kuşak hemodinamik monitorizasyon

- Yeni yöntemlerin özellikle pediyatrik olgularda doğruluğunu ve değerini gösteren daha fazla çalışmaya
- Farklı klinik durumlardaki değişimleri (örn. kardiyak cerrahi ve postop. dönem, şok) araştırılmaya gerek vardır

Ancak bu verilerden sonra tedavide yol gösterici, olabilir ve klinik sonuca olumlu etki sağlayabilirler


23 NİSAN
ULUSAL EGEMENLİK VE ÇOCUK BAYRAMI
KUTLU OLSUN