Dilüsyönel Anemi ve Transfüzyonun Değerlendirilmesinde NIRS Monitörizasyonunun Yeri

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GKDA 2014

Konu başlıkları

1. KPB sırasında değişen fizyopatoloji
2. Transfüzyonun erken ve geç dönem sonuçları
3. Transfüzyondan kaçınma stratejileri

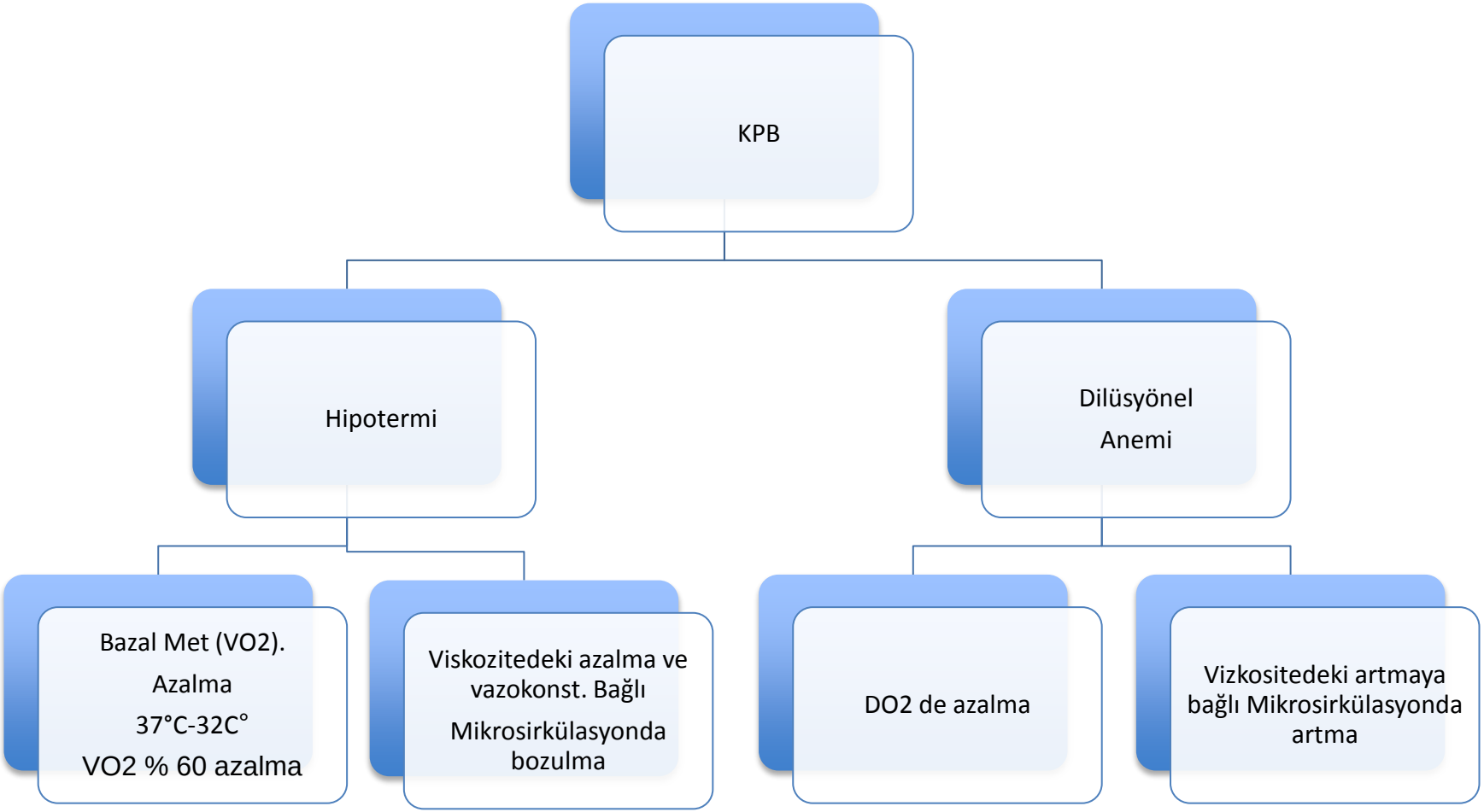
   a) Normovolemik hemodilüsyon

   b) Restriktif transfüzyon stratejisi;

      Anemiye fizyolojik toleransın optimizasyonu

4. Kendi çalışmam

KPB sırasında değişen fizyopotoloji

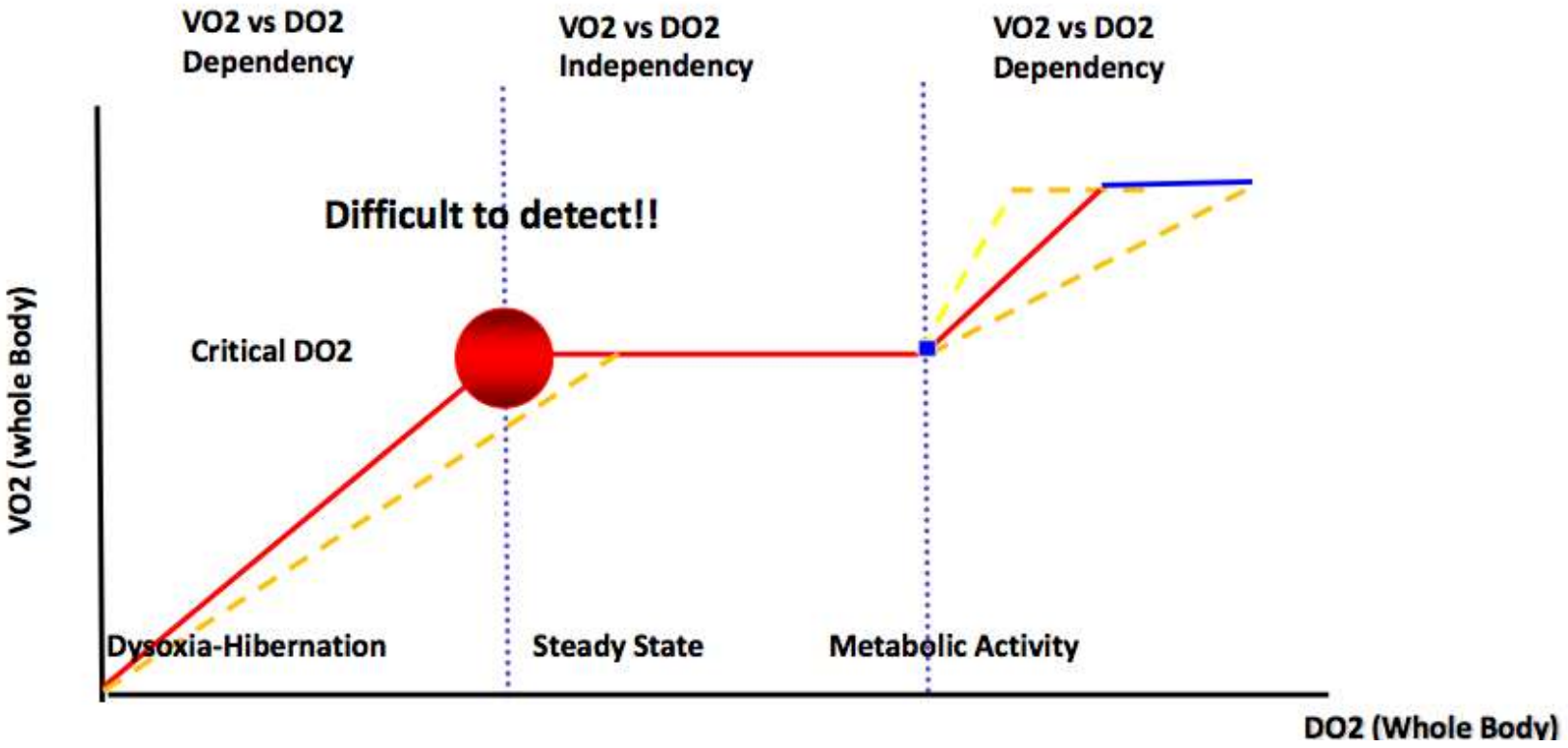


Doku oksijenasyonunun değerlendirilmesinde

- Dokuya sunulan oksijenin (DO2) ve
  - DO_2: CO x 10 x [(Hbx1,34x SaO_2) +(PO_2 x ,0003)]
  - DO2: 980 ml
- Vücudun tükettiği oksijenin miktarının (VO2) belirlenmesi gerekir
  - VO_2: CO x10 (CaO_2-CvO_2)
  - VO2: 230 ml

– OER: %22-24

Doku perfüzyonu



Dilüsyonel Anemi sırasında Temel Hedef

- VO2'nin DO2'ye bağımlı olmamasını sağlayacak minimum DO2 değerini oluşturmak

The oxygen debt during routine cardiac surgery: illusion or reality?

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[1]*Department of Extra Corporeal Circulation, University Hospital Maastricht, Maastricht, The Netherlands;*
[2]*Department of Cardio-Thoracic Surgery, University Hospital Maastricht, Maastricht, The Netherlands*

Background: Patients undergoing cardiac surgery with the use of cardiopulmonary bypass (CPB) are often thought to have tissue hypoxia and intraoperative oxygen debt accumulation despite the lack of sufficient data to support this assumption. Methods and results: Oxygen uptake and related parameters, including the plasma lactate and pyruvate concentrations, were studied during the perioperative period in a group of 15 consecutive patients who underwent coronary artery bypass graft surgery. The actual oxygen uptake (VO_2) and delivery (DO_2) were compared with the individual expected (computed) oxygen transport values. The mean values of DO_2 and VO_2 were in the range of the expected values. Our results demonstrate a leading role for body temperature in perioperative changes of oxygen consumption rate ($r^2 = 0.65$, $p < 0.001$). Plasma lactate and pyruvate did not exceed the physiological range in any patient. However, with initiation of CPB, the lactate to pyruvate (LA/PVA) ratio increased (from 9.87± 2.43 at T1 to 12.08± 1.51 at T2, $p < 0.05$). The mean value of the LA/PVA ratio was elevated during surgery. Later, upon lowering of the plasma lactate concentration in the postoperative period, the LA/PVA ratio decreased to normal values. Without any other evidence of hypoxia, this increase in the LA/PVA ratio could be explained by washout of lactate from previously hypoperfused tissues and intraoperative decrease of lactate clearance. Conclusion: Systemic oxygenation was not impaired during CPB, or during 18 h after surgery in the studied group of patients. *Perfusion* (2002) **17**, 167–173.

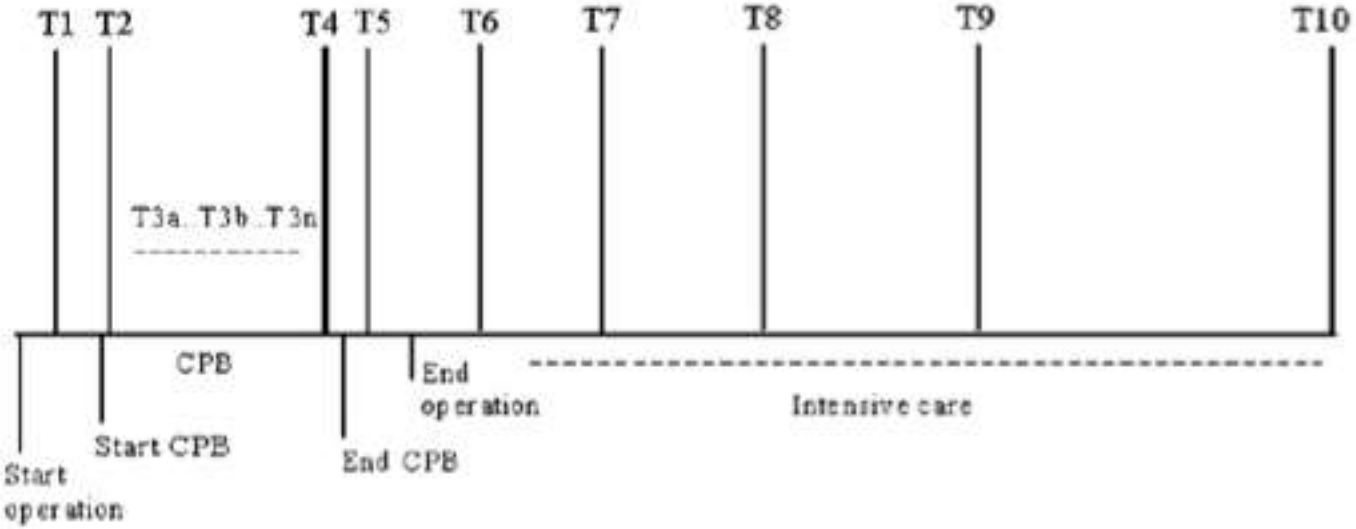

Figure 1 The study stages and their relation to the perioperative events. T1 – before systemic heparinization; start of CPB (T2); every 20 min of bypass (T3a. . .T*n*); before removal of the aortic crossclamp (T4); 15 min after protamine infusion (T5); 2, 4, 8, 12, and 18 h after the end of operation (T6. . .T10).

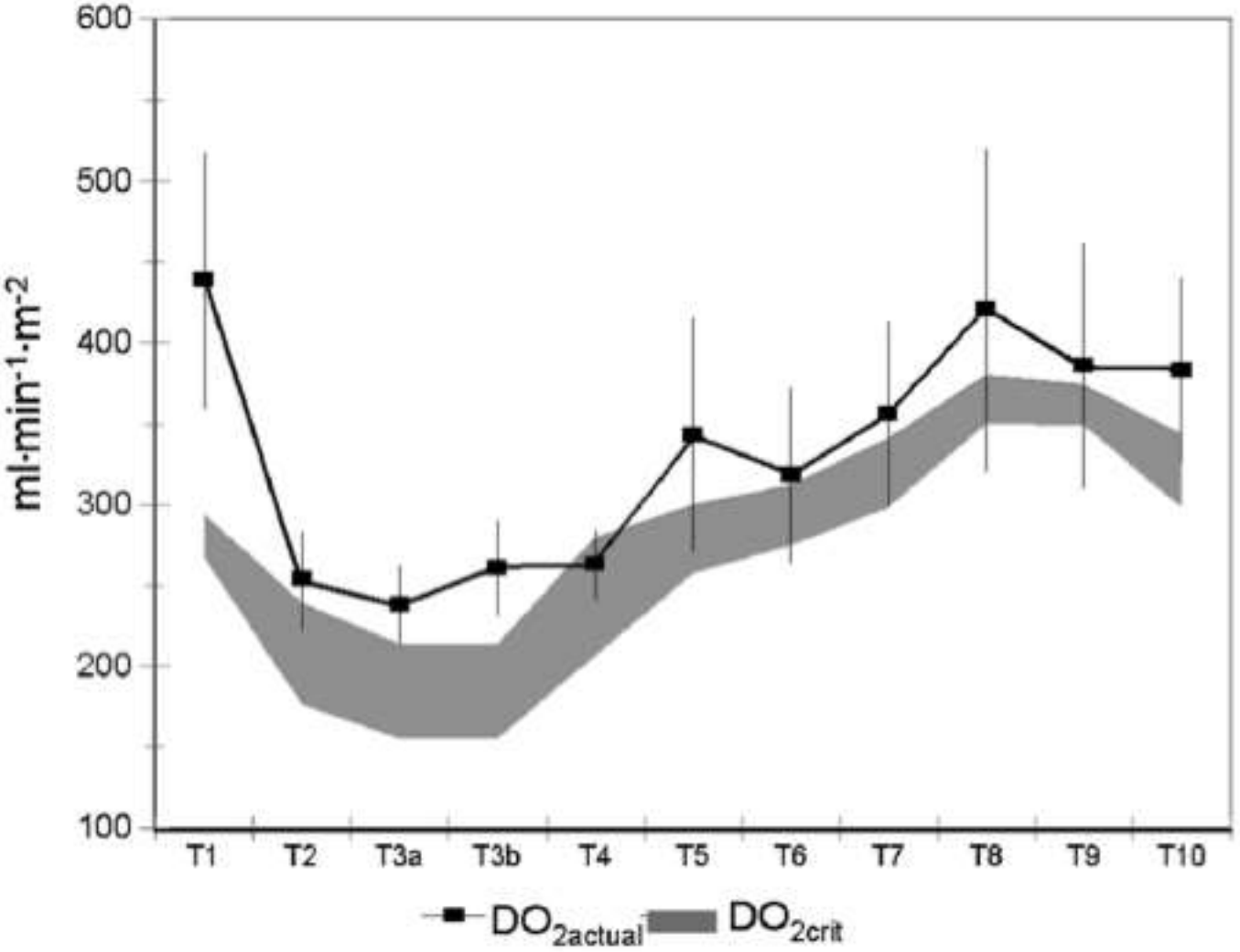

Figure 2 Oxygen delivery before, during, and up to 18 h after coronary bypass operation. The grey area is the critical level of oxygen delivery.

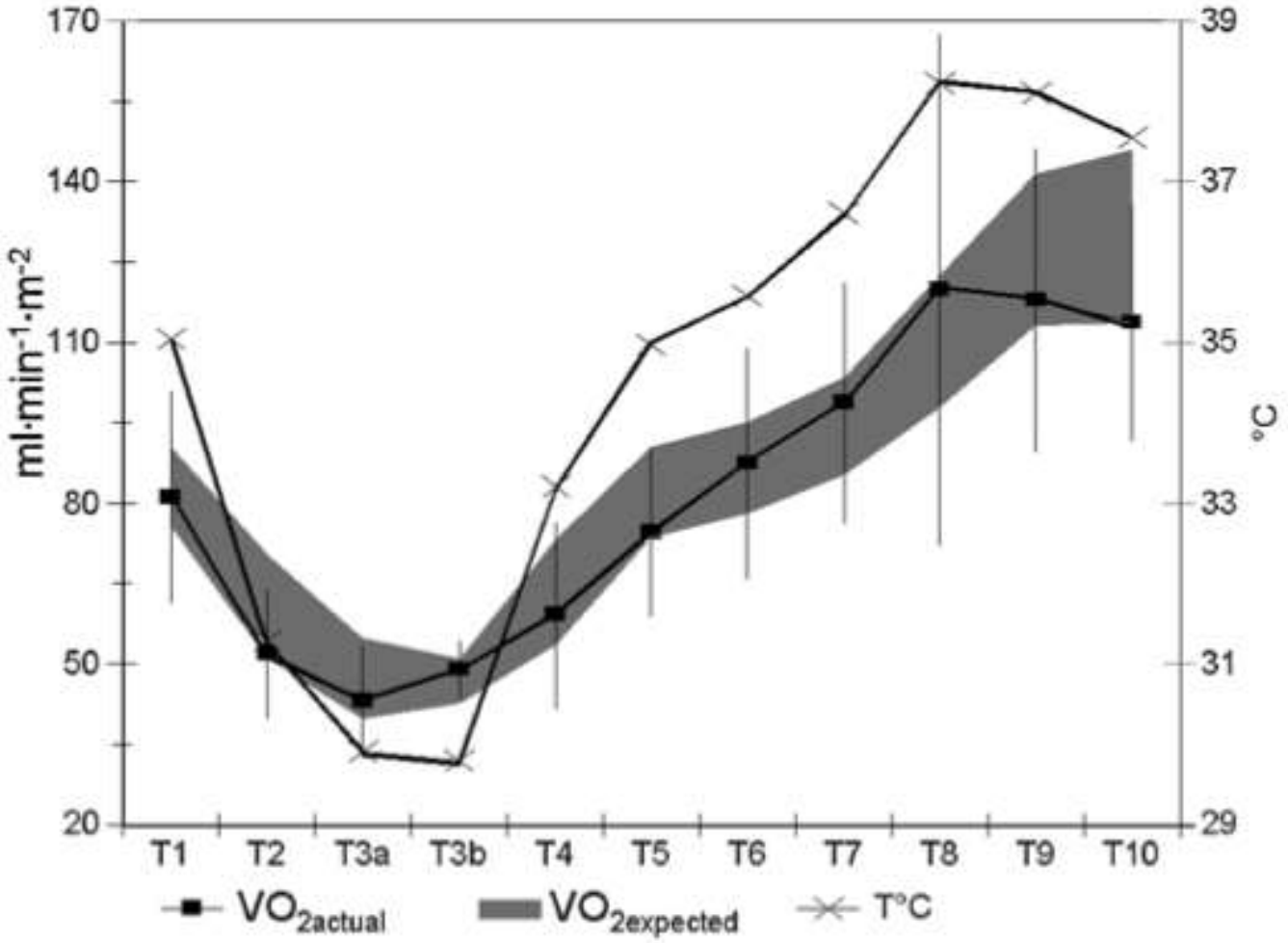

Figure 3 Oxygen consumption before, during, and up to 18 h after coronary bypass operation. The grey area is the expected level of oxygen consumption ($p>0.05$ for all samples points).

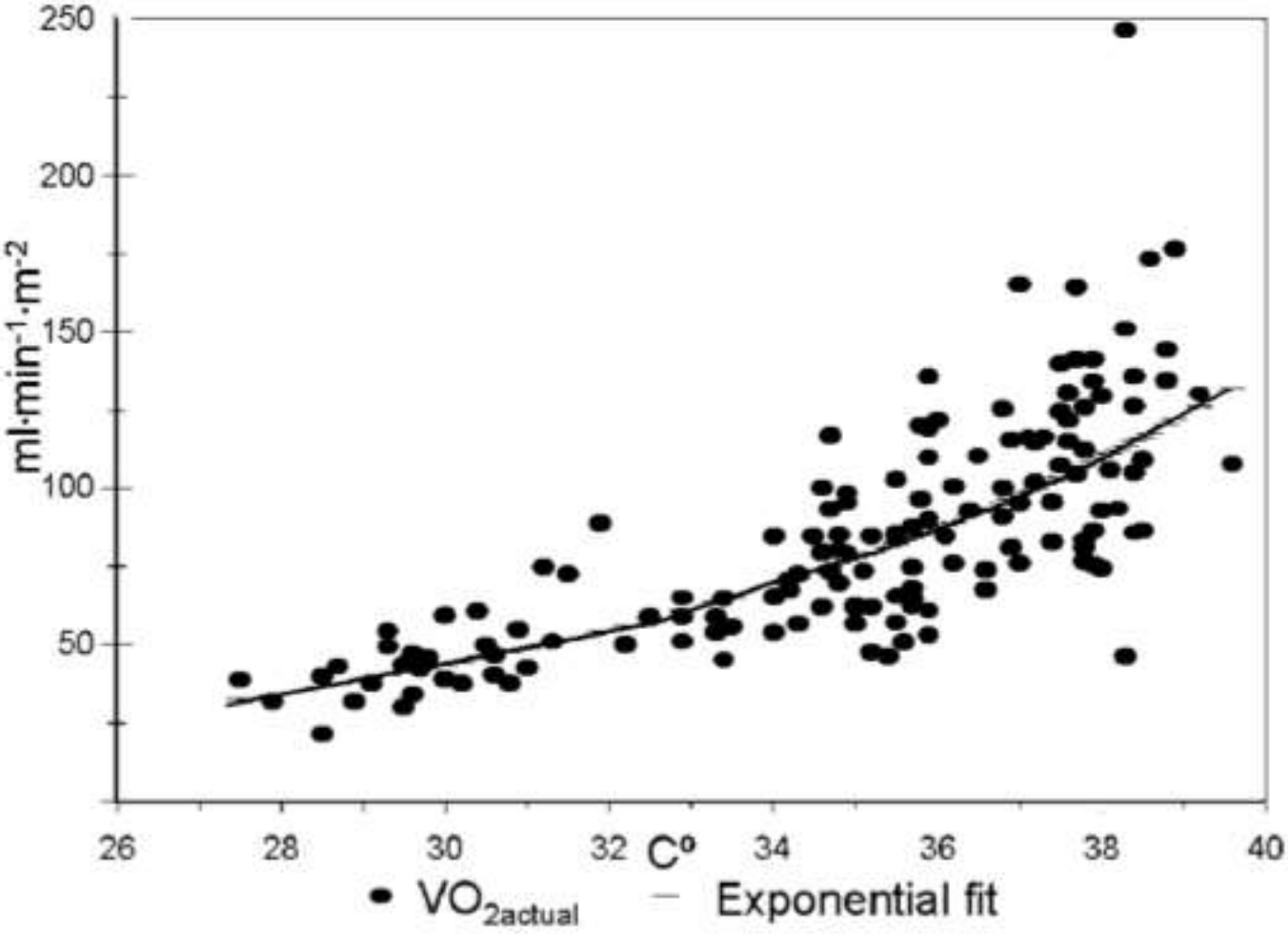

Figure 4 Whole body temperature and oxygen consumption pooled from all study periods (T1...T10).

KPB da oksijen tüketimi

- Normotermide (37 °C)
- VO_2: 95,8±20 ml/dk/m^2 , (Cavaliere F.Perfusion 1998;13:45-51)
- : 96 X 1,7= 163 ml/dk,
- DO_2:5x10x(**8**x1,34x0,99):530 ml, 530/163:3,25
- Hipotermide (30 °C),
- VO_2 :49,9±17,7ml/dk/m^2 (Long C.J Extra Corp Technol 2003;35:13-6)
- : 50 X 1,7= 85 ml/dk 530/85: 6,23
- Yeniden ısınma döneminde
- VO_2 :133±40 ml/dk/m^2,
- : 133 X 1,7= 226 ml/dk, 530/226: 2,3

KPB'da anemi varlığında

- KD :5 lt, Hb:5 gr/dl, normotermide
- DO_2 :CO x 10 x (**Hb**x1,34 x SaO2)
- :5 x 10 x (5 x 1,34 x 0,99):
- :330 ml/dk
- Normotermi Hipotermi Yeniden ısınma

DO_2/ VO_2: 330/163 330/85 330/226 **ml/dk**

- **2** **3,8** **1,4**

DO_2

- DO2’nin kritik değeri ile ilgili klinik uygulamalara baktığımızda

de Somer *et al. Critical Care* 2011, **15**:R192
http://ccforum.com/content/15/4/R192

CRITICAL CARE

RESEARCH Open Access

O_2 delivery and CO_2 production during cardiopulmonary bypass as determinants of acute kidney injury: time for a goal-directed perfusion management?

Filip de Somer[1], John W Mulholland[2], Megan R Bryan[2], Tommaso Aloisio[3], Guido J Van Nooten[1] and Marco Ranucci[3*]

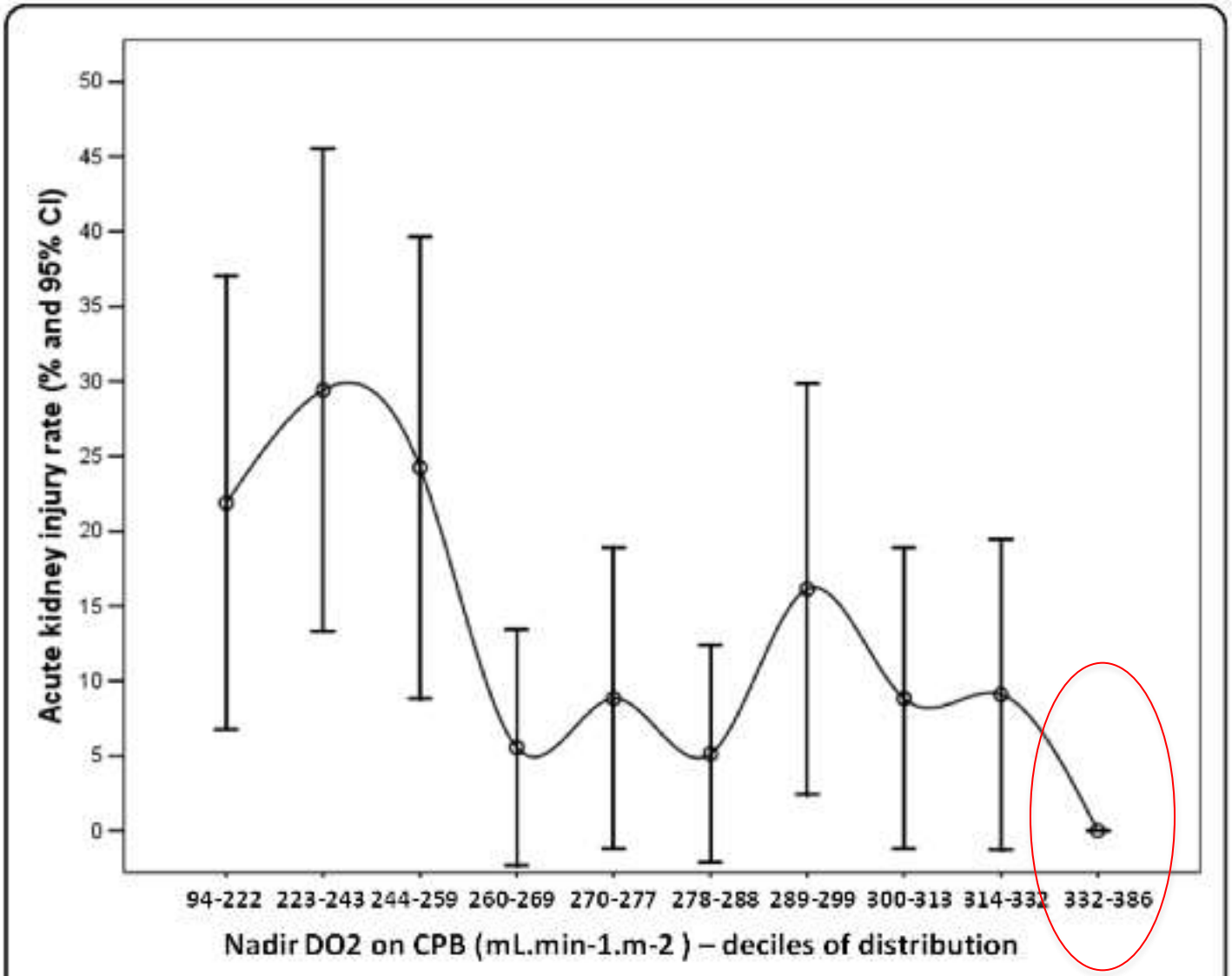

Figure 1 Graph showing acute kidney injury rate according to decile distribution of nadir oxygen delivery (DO_2) level during cardiopulmonary bypass (CPB).

Research

Open Access

The impact of an hematocrit of 20% during normothermic cardiopulmonary bypass for elective low risk coronary artery bypass graft surgery on oxygen delivery and clinical outcome – a randomized controlled study [ISRCTN35655335]

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Critical Care 2006, **10**:R58 (doi:10.1186/cc4891)

Table 1

Basic patient characteristics

Characteristic	Hematocrit 25%		Hematocrit 20%		*p*
	Median	IQR	Median	IQR	
Age (years)	60	55–67	65	58–71	0.10
Gender (male/-female)	28/2		26/0		0.49
Height (m)	1.78	1.73–1.81	1.75	1.72–1.79	0.35
Weight (kg)	93	80–100	87	80–100	0.52
Body mass index (kg/m^2)	27.9	26.0–32.2	28.8	26.7–29.9	0.72
Preoperative hematocrit (%)	41.8	40.2–43.0	42.1	39.4–45.4	0.88
Duration of anesthesia (minutes)	300	290–320	310	290–325	0.26
Duration of surgery (minutes)	190	160–220	205	175–250	0.09
CPB time (minutes)	72	55–83	73	63–81	0.50
Aortic cross clamp time (minutes)	45	33–56	45	38–49	0.93
APACHE II score	14	9–19	16	13–27	0.09

APACHE, Acute Physiology and Chronic Health Evaluation; CPB, cardiopulmonary bypass; IQR, interquartile range.

Figure 1

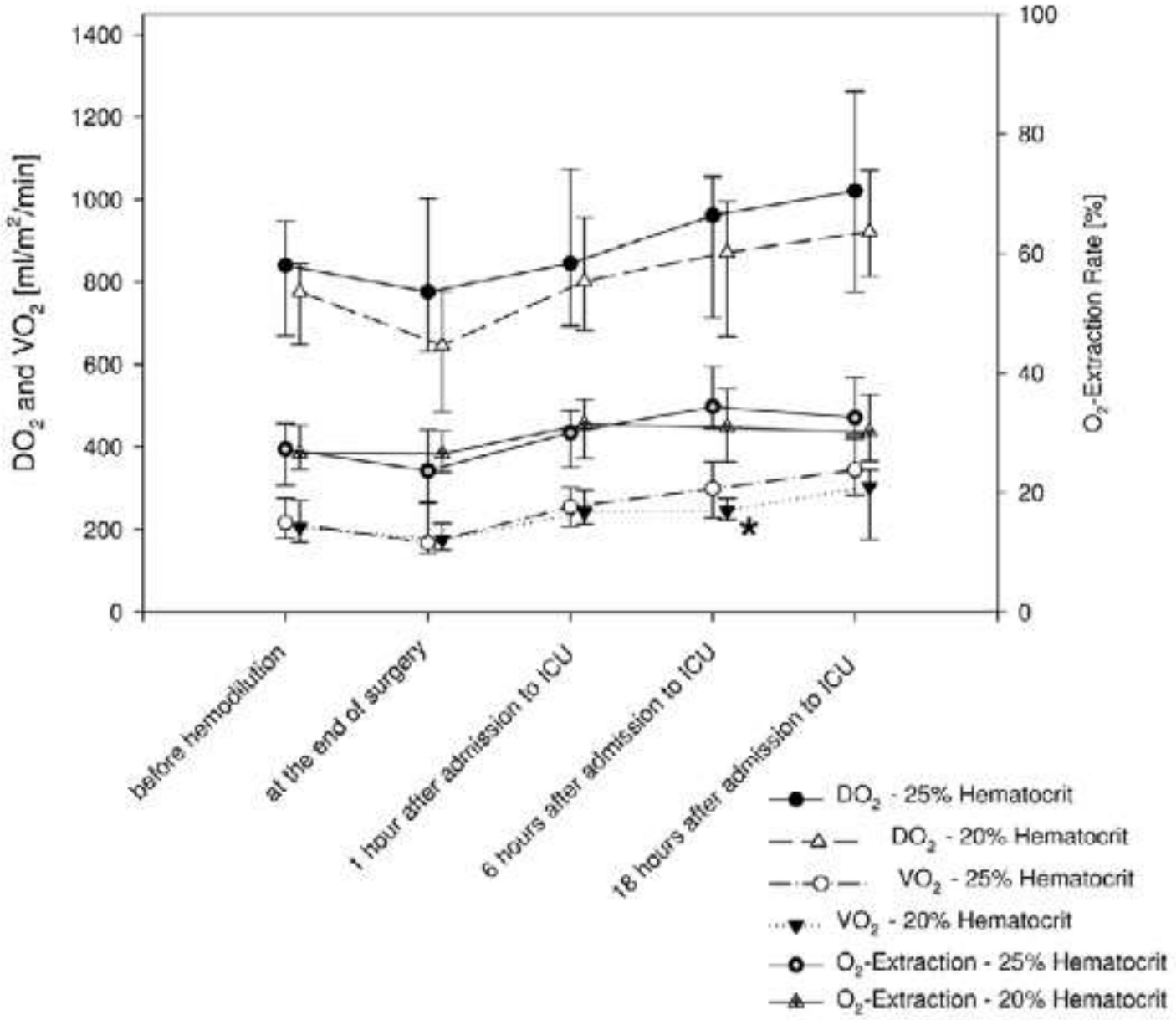
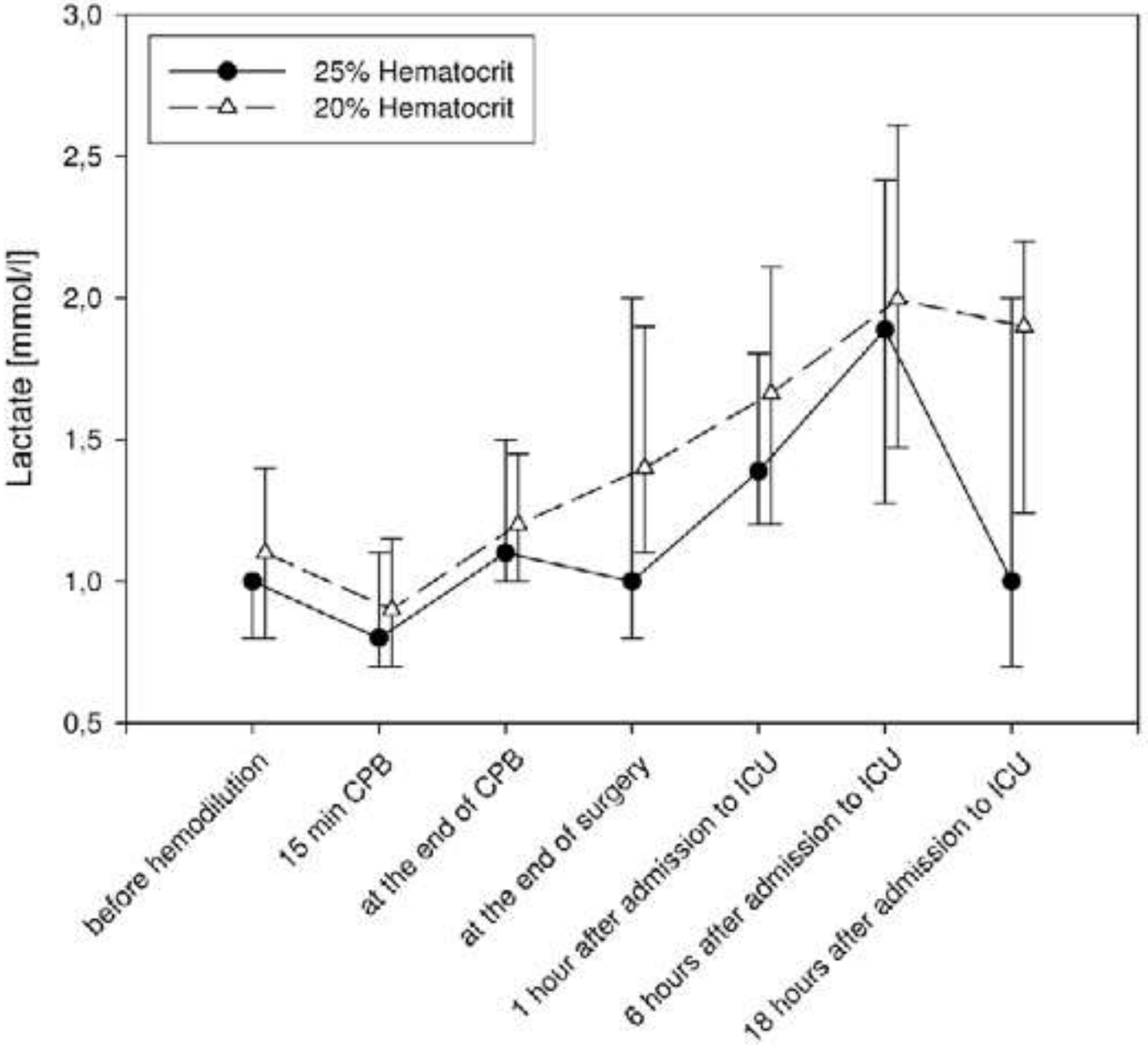

1400
1200
1000
800
600
400
200
0
100
80
60
40
20
0
DO2 and VO2 [ml/m2/min]
O2-Extraction Rate [%]
*
before hemodilution
at the end of surgery
1 hour after admission to ICU
6 hours after admission to ICU
18 hours after admission to ICU
DO2 - 25% Hematocrit
DO2 - 20% Hematocrit
VO2 - 25% Hematocrit
VO2 - 20% Hematocrit
O2-Extraction - 25% Hematocrit
O2-Extraction - 20% Hematocrit

Figure 2


25% Hematocrit
20% Hematocrit
Lactate [mmol/l]
3,0
2,5
2,0
1,5
1,0
0,5
before hemodilution
15 min CPB
at the end of CPB
at the end of surgery
1 hour after admission to ICU
6 hours after admission to ICU
18 hours after admission to ICU

- Yeterli pompa akımı (Debi) varlığında gelişen fizyopatolojik değişiklik böyle
- Anemi, KD (pompa akımı) ve OER ile kompanse edilmekte

- Eğer pompa akımı azalırsa ne olur?

Table 3. Factors Determining Minimal Safe Pump Flow During Cardiopulmonary Bypass

Body Surface Area (BSA)
Degree of hypothermia
Acid-base balance
Whole-body oxygen consumption
Degree of neuromuscular blockade
Oxygen content of blood (hemoglobin concentration and saturation, Pao_2)
Depth of anesthesia
Specific organ ischemic tolerance

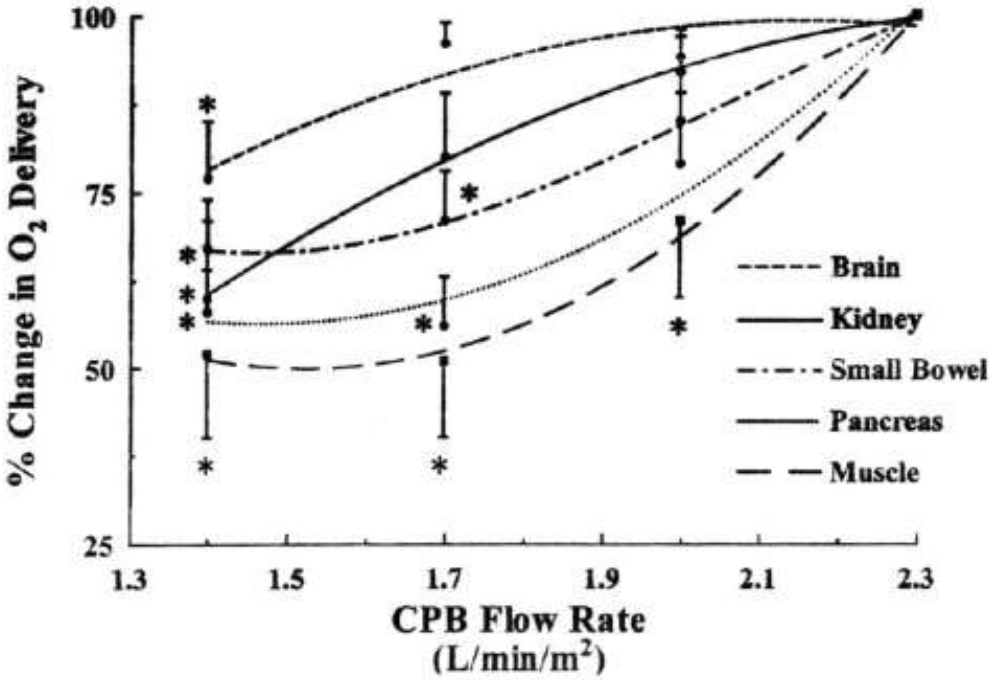


Figure 3. Changes in regional oxygen delivery at varying bypass flow rates. Oxygen delivery to the brain and kidneys was relatively well maintained at flows more than 1.4 $L \cdot min^{-1} \cdot m^{-2}$. However, oxygen delivery to muscle and visceral organs was significantly reduced at higher flow rates (1.7–2.0 $L \cdot min^{-1} \cdot m^{-2}$). Reprinted with permission from Boston US, Slater JM, Orszulak TA, Cook DJ. Hierarchy of regional oxygen delivery during cardiopulmonary bypass. Ann Thorac Surg 2001; 71: 260–4.

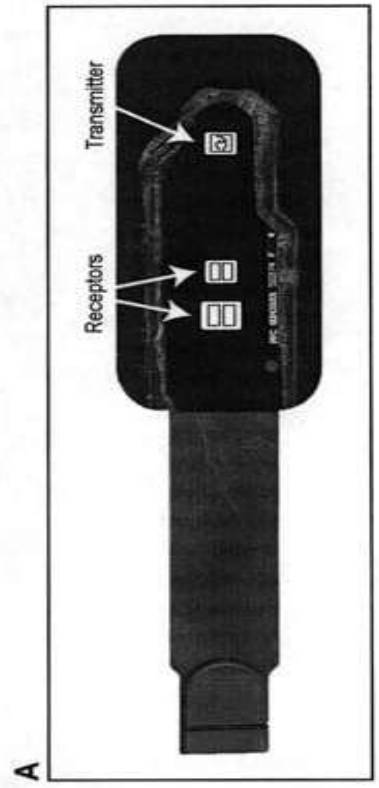
Sonuç

- Tüm bu fizyopatolojik dinamik değişiklikler nedeni ile KPB sırasındaki ideal perfüzyon parametreleri net olarak tanımlanamamıştır
- Bu nedenle end organ venöz oksijen saturasyonunun ölçümü çok anlamlı ve gereklidir.

- End organ venöz oksijen saturasyonunu izleyecek non-invazif cihazlar

- Bugün için NIRS yöntemi ile çalışan cihazlardır

INVOS 5100 C System



Pro: Near-Infrared Spectroscopy Should Be Used for All Cardiopulmonary Bypass

George M. Hoffman, MD

Section Editors' note: The issue of cerebral oxygenation during cardiopulmonary bypass is controversial. There is significant indication in favor of its use, not least of which is its potential for positive cost-to-benefit ratio. Yet, there remains compelling evidence that, although the technique is promising, the limitations must be acknowledged, including the potential for technical difficulties and the lack of evidence regarding long-term outcomes.

With all of this in mind, the Section Editors decided to open the debate regarding the use of cerebral oxygenation monitoring during CPB to a lengthier, more detailed discussion. This Pro/Con will therefore continue the 2-part series begun in the June issue, so that the *Journal* might give this contentious topic the attention it deserves.

of which can be avoided by continuous delivery of oxygenated blood in sufficient quantity to the brain.[3]

The importance of neurologic injury has driven the development and application of monitors to enhance detection and direct treatment of conditions associated with brain injury. Because of the prominence of the potential for hypoxic-ischemic injury during CPB, brain oxygen monitoring has enjoyed persistent development efforts, in the form of intracranial oxygen electrodes, jugular venous saturation monitoring, and various forms of transcranial oximetry via near-infrared spectroscopy (NIRS). NIRS offers the advantages of noninvasive continuous regional tissue (organ) oxyhemoglobin saturation monitoring and is available in Food and Drug Administration–approved, commercially produced forms.

TECHNICAL OVERVIEW OF NIRS

Transfüzyonun erken ve geç dönem sonuçları

Patient blood management during cardiac surgery: Do we have enough evidence for clinical practice?

Marco Ranucci, MD,[a] Solomon Aronson, MD,[b] Wulf Dietrich, MD, PhD,[c] Cornelius M. Dyke, MD,[d] Axel Hofmann, ME,[e,f] Keyvan Karkouti, MD,[g] Marcel Levi, MD, PhD,[h] Gavin J. Murphy, MD, FRCS,[i] Frank W. Sellke, MD,[j] Linda Shore-Lesserson, MD,[k] and Christian von Heymann, MD,[l] endorsed by the European Association of Cardiothoracic Anaesthesiologists (EACTA)

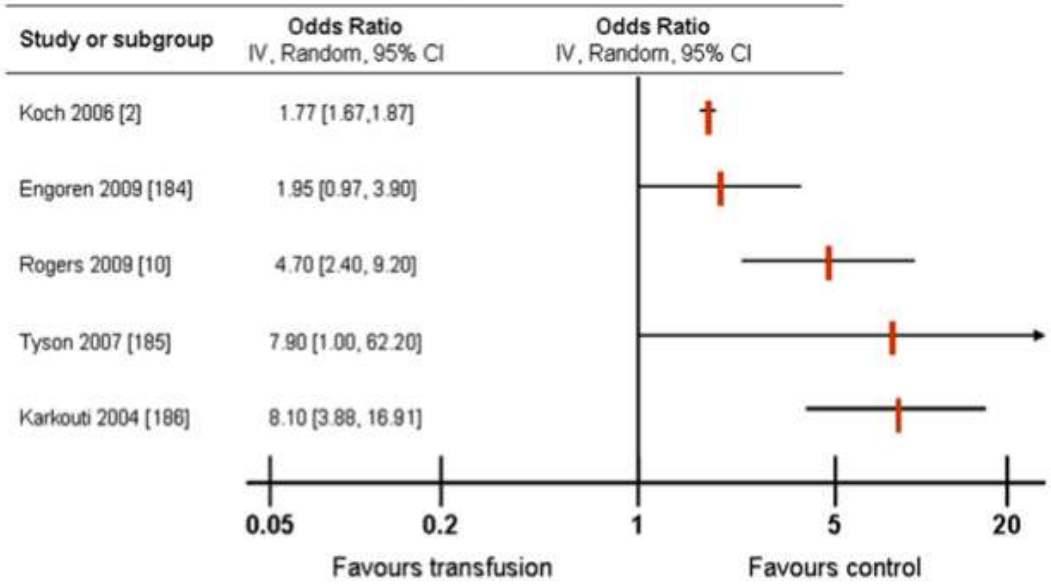


FIGURE 1. Forest plot of studies evaluating the effect of red blood cell transfusion on perioperative mortality (in-hospital or 30-day mortality). *IV,* Inclusive value; *CI,* confidence interval.

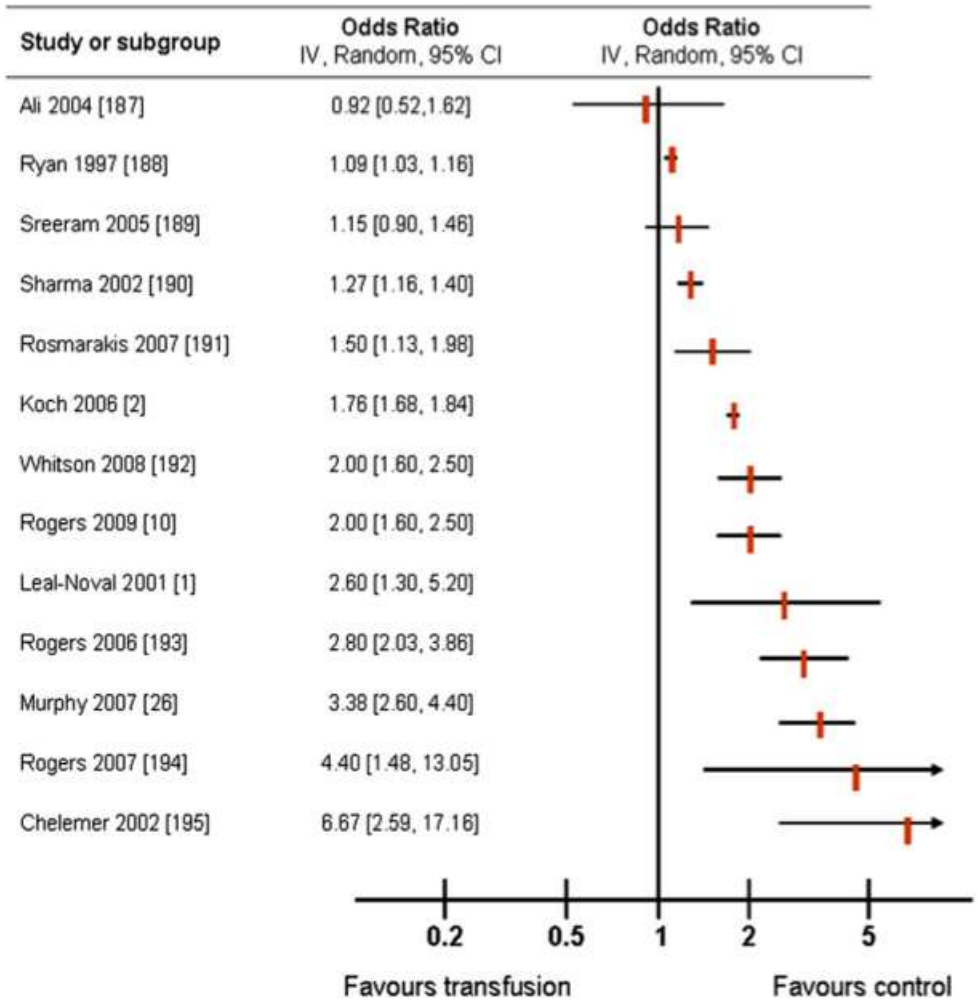


FIGURE 2. Forest plot of studies evaluating the effect of red blood cell transfusion on postoperative infection (sepsis, bacteremia, or any infection). *IV,* Inclusive value; *CI,* confidence interval.

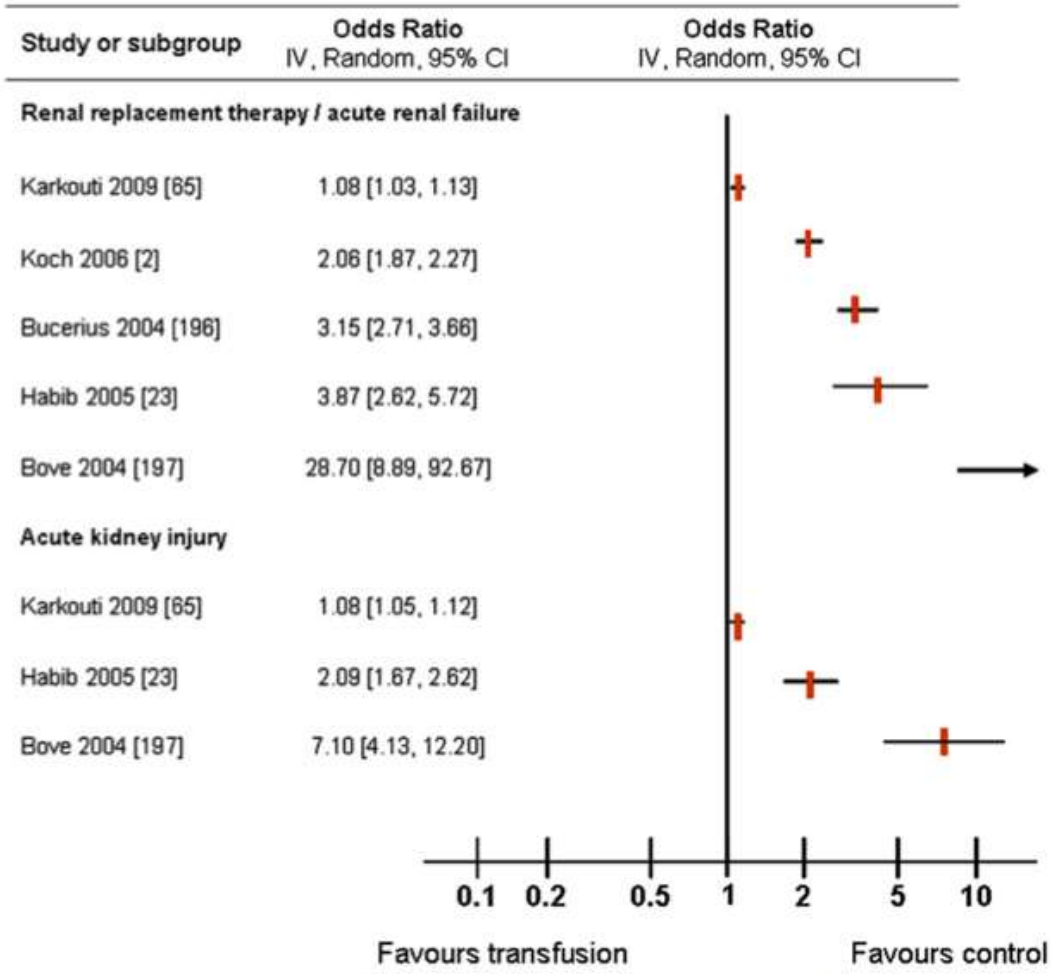


FIGURE 3. Forest plot of studies evaluating the effect of red blood cell transfusion on postoperative acute renal failure or renal replacement therapy and on acute kidney injury. *IV,* Inclusive value; *CI,* confidence interval.

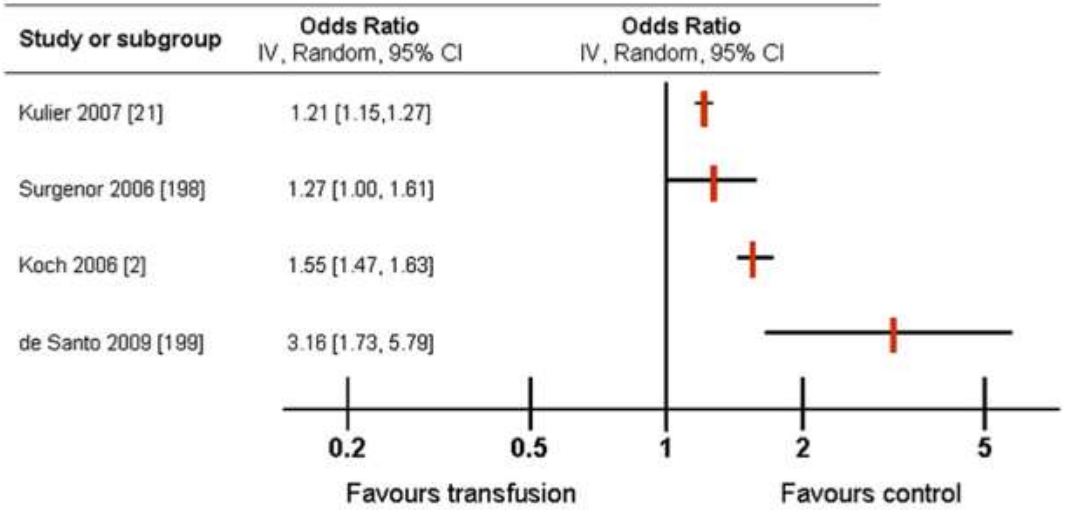


FIGURE 4. Forest plot of studies evaluating the effect of RBC transfusion on postoperative cardiac morbidity (major cardiac complication, low cardiac output). *IV,* Inclusive value; *CI,* confidence interval.

- Transfüzyondan kaçınmalıyız

Transfüzyondan kaçınma stratejileri PBM

1. Hastanın kendi kanının optimizasyonu (preop. aneminin düzeltilmesi)
2. İntraoperatif kan kaybının azaltılması
   - Minimal invazif cerrahi
   - Farmakolojik ajanların kullanımı
3. Restriktif Transfüzyon stratejisinin uygulanması
   - Hb alt eşik değerinin belirlenmesi (PBM)
   - Otolog transfüzyon
   - Normovolemik Hemodilüsyon

CABG Outcomes PBMP vs Non-PBMP

Outcome	PBMP cohort (n=586)	Non-PBMP cohort (n=586)	P-value
% Transfused	10.6%	42.5%	<0.0001
Mortality	0.8%	2.5%	0.02
Serious complication	11.1%	18.7%	0.0002

Moskowitz et al. TheThe impact of blood conservation on outcomes in cardiac surgery: is it safe and effective?
Ann Thorac Surg 2010;90:451-9

ORIGINAL PAPER

doi: 10.1111/j.1368-5031.2004.00120.x

The effect of acute normovolemic haemodilution on cerebral oxygenation

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Department of Anaesthesiology,[1] Hallym University, College of Medicine, Department of Anaesthesiology,[2] Seoul National University College of Medicine, Laboratory of Statistical Information Analysis,[3] Hanyang University College of Natural Sciences, Seoul, Republic of Korea

SUMMARY

Acute normovolemic haemodilution (ANH) may cause an imbalance in cerebral oxygen metabolism because it decreases the arterial oxygen content. This study was designed to investigate the effect of ANH on cerebral oxygenation. By using cerebral oximetry, the regional cerebral oxygen saturation (rSO_2) was monitored during ANH in 26 patients without systemic illness (initial haematocrit = 42 ± 1%). The rSO_2 did not show a significant change until the Hct reached >30%. However, it decreased significantly thereafter to reach 88% of the baseline value when the ANH was completed with a Hct value of 24 ± 1% (before ANH; 71 ± 6% vs. after ANH; 62 ± 4%, $p < 0.01$). In conclusion, an ANH can lead to a reduction in cerebral oxygenation when a patient's Hct goes below 30%.

Keywords: Acute normovolemic haemodilution; cerebral oxygenation; cerebral oximetry

Elektif omuz cerrahisi hastalarında

- ANH$\Rightarrow$ $Ct_aO2\downarrow \Rightarrow$ serebral DO_2 de azalma
- $V = EBV \times (H_i - H_f)/H_{av}$
- İlk 500 ml kan için 500 ml %6 HES
- Geri kalan volum için kan miktarının 3 katı RL veriliyor

Table 1 Patients' clinical characteristics

Sex (M/F)	15/11
Age (years)	59 ± 12
Weight (kg)	63 ± 7
Height (cm)	164 ± 14
Initial Hct (%)	42 ± 1

Data are mean ± SD or number of patients.

Table 2 Physiologic values during the study

	Baseline	V_{25}	V_{50}	V_{75}	V_{100}
HR (rate/min)	69.9 ± 10.4	69.5 ± 9.3	67.3 ± 12.3	70.1 ± 7.5	70.8 ± 6.6
MAP (mmHg)	88.4 ± 8.4	87.7 ± 6.4	84.9 ± 5.8*	82.5 ± 7.0*	81.8 ± 6.8†
CVP (mmHg)	5.6 ± 1.2	5.6 ± 1.2	5.9 ± 1.7	5.4 ± 1.0	5.6 ± 1.3
CO (l/min)	4.7 ± 0.6	4.8 ± 0.7	5.0 ± 0.5*	5.2 ± 0.7*	5.5 ± 0.8†
CaO_2 (vol%)	19.5 ± 1.0	18.4 ± 1.2*	15.4 ± 3.2†	14.1 ± 1.2†	12.0 ± 0.4‡
DaO_2 (ml/min)	927 ± 141	863 ± 150*	761 ± 100†	728 ± 64†	649 ± 86‡

Data are mean ± SD.

HR, heart rate; MAP, mean arterial pressure; CVP, central venous pressure; CO, cardiac output; CaO_2, arterial oxygen content; DaO_2, systemic oxygen delivery; V_{25}, when 25% of target volume of blood was withdrawn; V_{50}, when 50% of target volume of blood was withdrawn; V_{75}, when 75% of target volume of blood was withdrawn; V_{100}, when 100% of target volume of blood was withdrawn.

*$p < 0.05$ vs. baseline value.

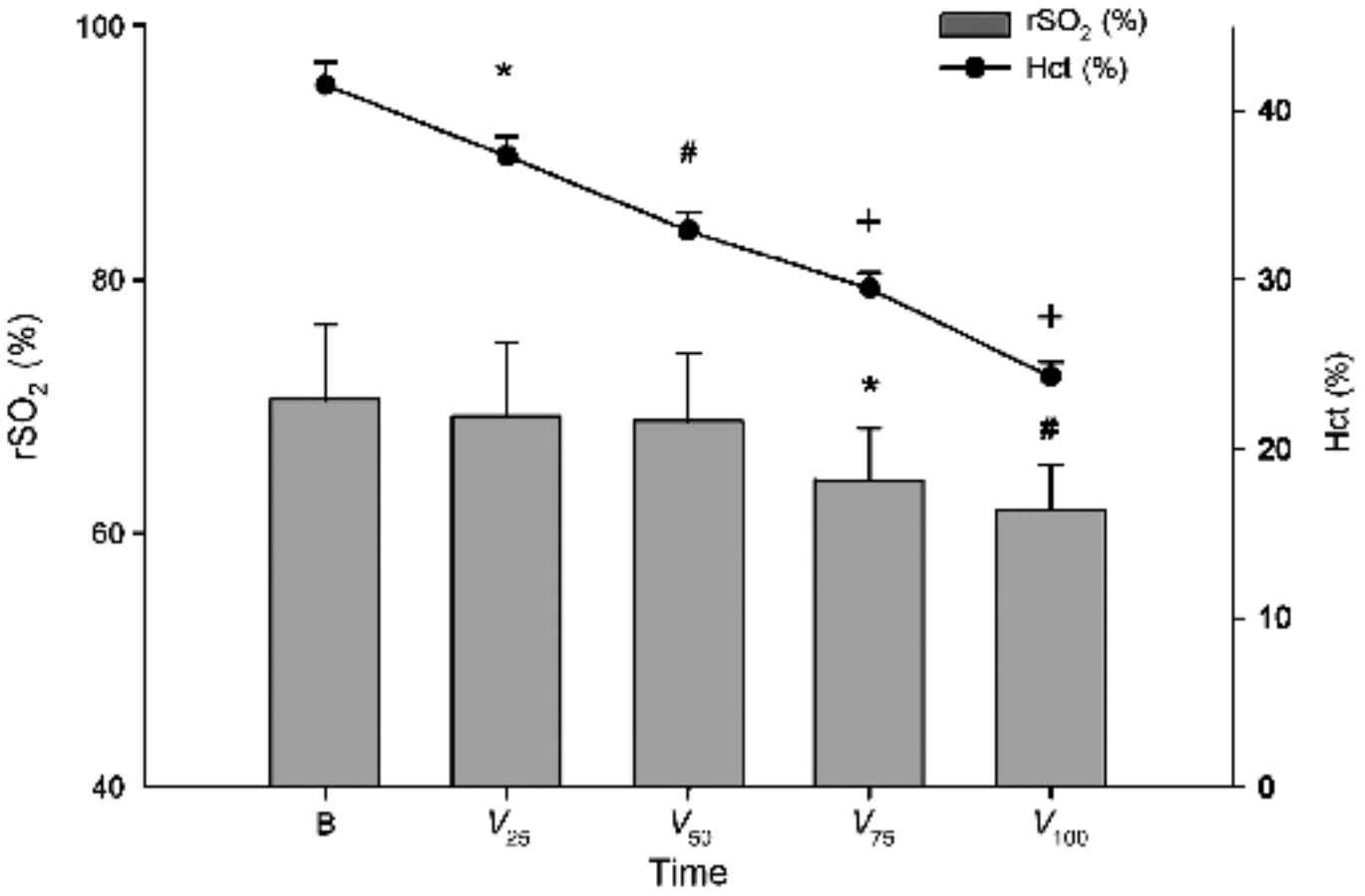
†$p < 0.01$ vs. baseline value.

‡$p < 0.001$ vs. baseline value.

rSO2 % 71 69 64 62

rSO2 değişimi

- Başlangıç rSO2 %71
- $Hct_{(i)}$ %40 dan $Hct_{(f)}$ % 24 düşüyor
- rSO2 değişimi,
  - volüm %50 çekilene kadar anlamlı değil
- Çekilen volüm %75 ulaştığında
  - rSO2% 64 (%10)
- Çekilen volüm %100 ulaştığında
  - rSO2% 62 (%12)


rSO2 (%)
Hct (%)
100
80
60
40
40
30
20
10
0
*
#
+
+
*
#
B
V25
V50
V75
V100
Time

- Sizce ne kadar kan volümü alınmıştır

- 1497 ± 437 ml
- 36 ± 9 dk
- Isı : 36.1 ±0.3˚C - 35.2 ± 0.2˚C , $p < 0.05$).

ANH da anemiye tolerans nasıl belirlenmeli

- Başlangıç Hct değerine göre mi ?
- % değişim oranına göre mi?
  - Hct'in %50 den % 24'e düşmesi ile
  - Hct'in %35 den % 24'e düşmesi ile arasında fark var mı ?

The influence of baseline hemoglobin concentration on tolerance of anemia in cardiac surgery

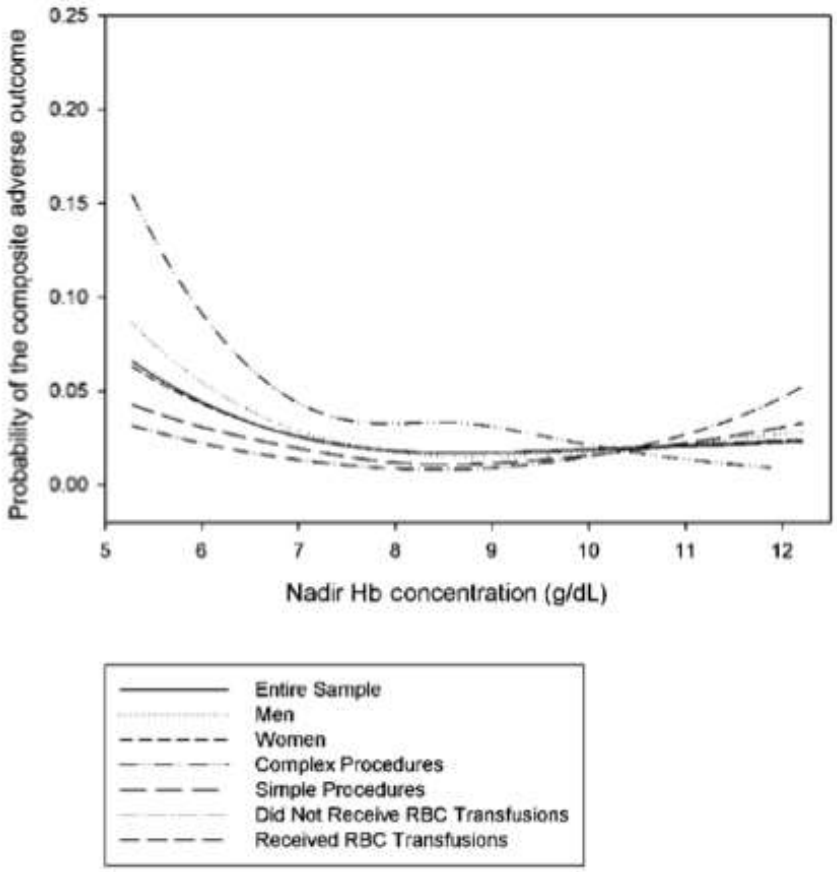
Keyvan Karkouti, Duminda N. Wijeysundera, Terrence M. Yau, Stuart A. McCluskey, Adriaan van Rensburg, and W. Scott Beattie

BACKGROUND: Current red blood cell (RBC) transfusion guidelines assume that most acutely anemic patients can tolerate hemoglobin (Hb) concentrations as low as 6.0 to 7.0 g per dL and recommend that range as the transfusion threshold in patients who have no overt signs of organ dysfunction. Nonetheless, "normal" Hb concentrations vary widely in the population, and this variability may influence patients' tolerance of acute anemia. This retrospective cohort study was carried out to test this hypothesis.

As with other physiologic variables, hemoglobin (Hb) concentration has a relatively wide bell-shaped distribution in the population. The World Health Organization's reference criteria for "normal" Hb concentration is based on the range between the 2.5th and 97.5th percentiles in this bell-shaped distribution; this normal range is 12.0 to 16.0 g per dL in women and 13.0 to 18.0 g per dL in men.[1] This range of apparently normal Hb values then raises the question whether baseline Hb concentration influences the degree of acute anemia that individuals can safely tolerate. This

Materyal-Metod

- 1999-2006
- On pump CABG op olan 10.179 hasta
- Hb: 12-16 g/dl kadın
- Hb: 13-18 g/dl erkek
  - Pompa sırasındaki en düşük Hb ve
  - Başlangıç değerine göre yüzde değişim
  - Sonuç parametreleri üzerine etkisi


Probability of the composite adverse outcome
0.25
0.20
0.15
0.10
0.05
0.00
5
6
7
8
9
10
11
12
Nadir Hb concentration (g/dL)
Entire Sample
Men
Women
Complex Procedures
Simple Procedures
Did Not Receive RBC Transfusions
Received RBC Transfusions

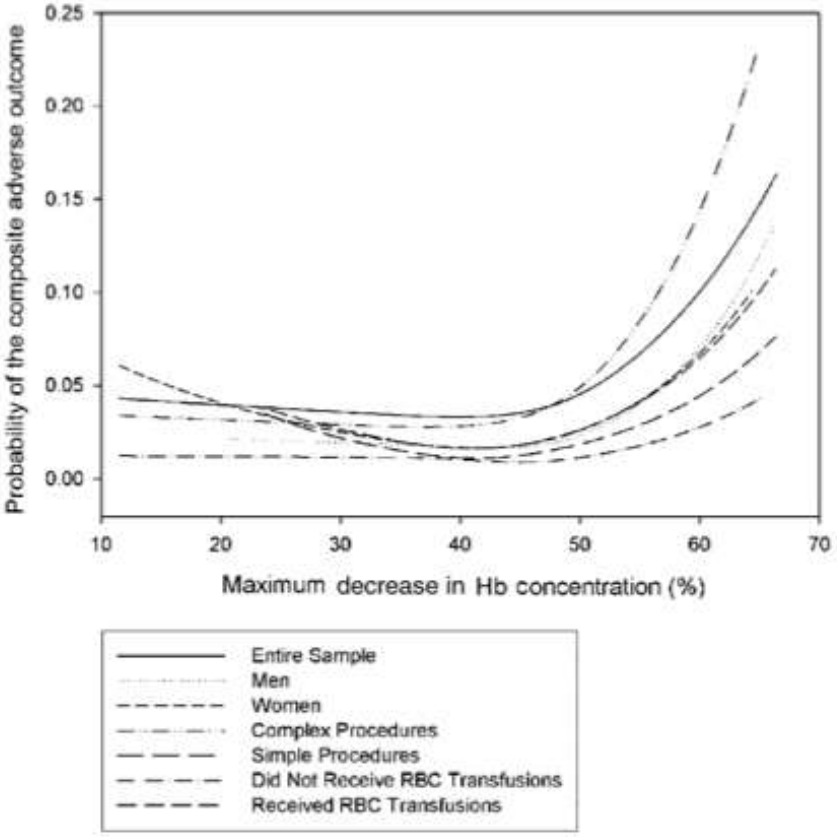
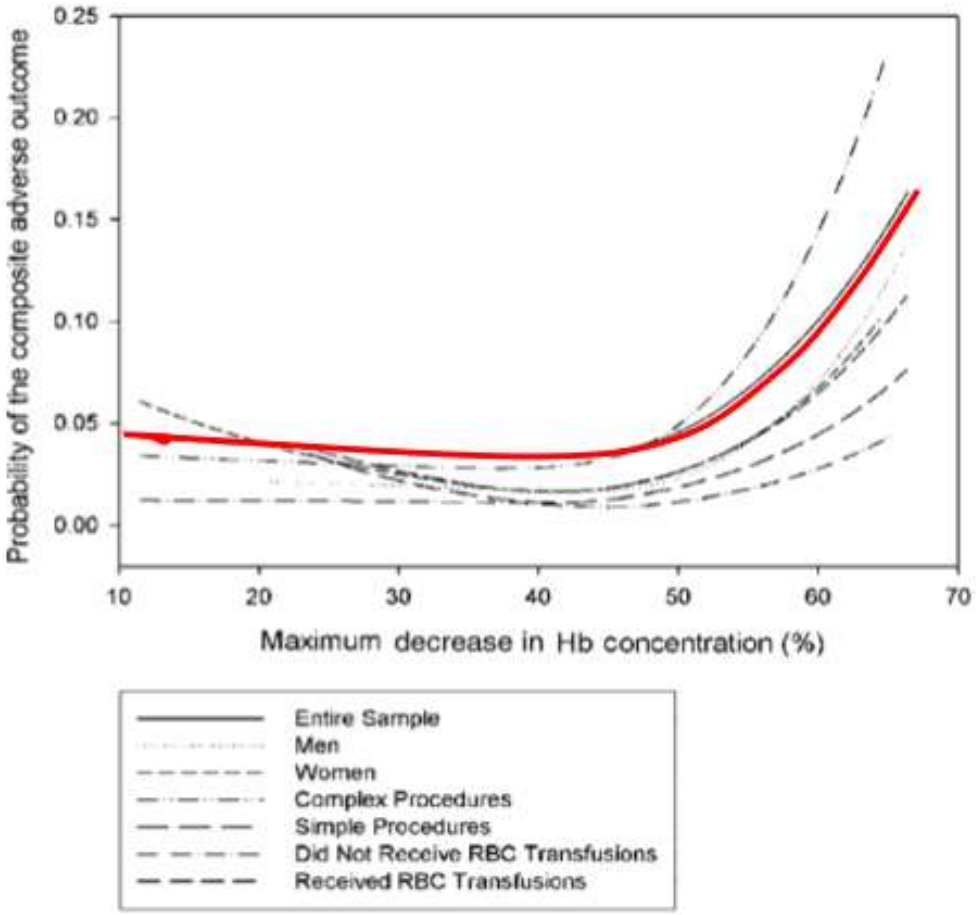

Probability of the composite adverse outcome
0.25
0.20
0.15
0.10
0.05
0.00
10
20
30
40
50
60
70
Maximum decrease in Hb concentration (%)
Entire Sample
Men
Women
Complex Procedures
Simple Procedures
Did Not Receive RBC Transfusions
Received RBC Transfusions

TABLE 3. Details of the logistic regression model for the composite outcome that included lowest CPB Hb as a covariate dichotomized at 7.0 g/dL (< or ≥)*

Variable†	Distribution (unit)	Wald chi-square‡	p Value	OR§	95% CI¶
Low CPB Hb (forced in)	Binomial	0.8	0.4	1.15	0.84-1.56
Age	Continuous (years)	9.5	0.002	1.02	1.01-1.03
Diabetes	Binomial	12.4	0.0004	1.70	1.27-2.29
Cerebrovascular disease	Binomial	8.7	0.003	1.66	1.18-2.31
Kidney dysfunction	Binomial	44.5	<0.0001	2.70	2.01-3.61
CPB duration	Continuous (min)	49.1	<0.0001	1.01	1.01-1.01
Difficult CPB wean	Binomial	75.5	<0.0001	3.74	2.78-5.04
RBC transfusion	Binomial	6.7	0.01	1.61	1.12-2.31
FFP transfusion	Binomial	10.7	0.001	1.74	1.25-2.43

* Hosmer-Lemeshow goodness-of-fit test p = 0.13; area under ROC curve (c-index), 0.83.
† See Table 1 for definitions.
‡ Wald chi-square: the higher the value, the higher the predictive value of the variable.
§ The change in odds of the composite outcome for each unit change of the variable while controlling for other variables in the model.
¶ The 95 percent CI for the estimated OR.

The influence of baseline hb concentration on tolerance of anemia in cardiac surgery



The relationship between maximum decrease in Hb concentration and adverse outcomes was independently associated with increased risk!!

Karkouti et al: TRANSFUSION 2008;48:666-672.

TABLE 4. Details of the logistic regression model for the composite outcome that included maximum decrease in Hb as a covariate dichotomized at 50% (> or ≤)*

Variable†	Distribution (unit)	Wald chi-square‡	p Value	OR§	95% CI¶
Maximum decrease in Hb	Binomial	7.3	0.007	1.53	1.12-2.08
Age	Continuous (years)	19.7	0.002	1.02	1.01-1.03
Diabetes	Binomial	12.7	0.0004	1.71	1.27-2.30
Cerebrovascular disease	Binomial	8.6	0.003	1.65	1.18-2.30
Kidney dysfunction	Binomial	46.6	<0.0001	2.77	2.07-3.71
CPB duration	Continuous (min)	50.9	<0.0001	1.01	1.01-1.01
Difficult CPB wean	Binomial	74.0	<0.0001	3.70	2.70-4.98
RBC transfusion	Binomial	5.7	0.02	1.53	1.08-2.16
FFP transfusion	Binomial	10.9	0.001	1.75	1.25-2.43

* Hosmer-Lemeshow goodness-of-fit test p = 0.25; area under ROC curve (c-index), 0.83.
† See Table 1 for definitions.
‡ Wald chi-square: the higher the value, the higher the predictive value of the variable.
§ The change in odds of the composite outcome for each unit change of the variable while controlling for other variables in the model.
¶ The 95 percent CI for the estimated OR.

Sonuç

- KPB sırasında hastanın güvenle tolere edebileceği akut aneminin derecesi, hastanın başlangıç hemoglobin değeri ile ters orantılıdır.
- Ve bu sonuç henüz transfüzyon guidelines için dikkate alınmamaktadır
- Yani; Hb> 16 g/dl den , ANH sonrasi Hb:8 g/dl'ye düştüğünde güvende olmayabiliriz
- Ama Hb:12 g/dl den 8 g/dl düştüğünde daha güvenli olabiliriz
- Bu nedenle NIRS ile venöz oksijen saturasyonu takibi önemli

Pediatr Cardiol (2013) 34:75–80
DOI 10.1007/s00246-012-0389-2

ORIGINAL ARTICLE

Cerebral Oximetry Monitoring During Preoperative Phlebotomy to Limit Allogeneic Blood Use in Patients Undergoing Cardiac Surgery

Elisabeth Dewhirst · Peter Winch · Aymen Naguib · Mark Galantowicz · Joseph D. Tobias

- ANH yapılan çocuklarda, priming solüsyonunun ilavesi ile
- Hb düzeyi istenmeyen sınırlara varabilir
- Bu amaçla;
  - ANH sırasında restriktif sıvı replasmanının uygulanması,
    - Güvenli ve
    - Faydalı olabilir mi?

ANH

- 1:1 kolloid
- 1:3 kristaloid replasmanı yapılmakta
- Bu klasik uygulama yerine,
  - Yeterli doku perfüzyonunu sağlayacak minimal sıvı replasmanı hedef alınmış

Materyal metod

- MAP,HR,rSO2 değerlerinde %20 den fazla değişme olduğunda sıvı replasmanı yapılmış

Sonuç

- Alınan kan volümü ortalaması 9,3 ± 2,9 ml/kg
- Verilen kristaloid miktarı 5,6± 5,1 ml/kg

- 0,6:1 oranında kristaloid verilmiş

Table 2 Hemodynamic changes before and after phlebotomy

Hemodynamic parameter	Before phlebotomy	At completion of phlebotomy	15 Min after phlebotomy	30 Min after phlebotomy
HR (bpm)	95 ± 33	94 ± 36[a]	89 ± 30[a]	87 ± 31[a]
MAP (mmHg)	69 ± 12	60 ± 13[b]	60 ± 14[b]	61 ± 14[b]

HR heart rate, *bpm* beats per minute, *MAP* mean arterial pressure, *NS* not significant

[a] p = NS vs baseline

[b] $p < 0.05$ vs before phlebotomy

Table 3 Lactate and pH changes before and after phlebotomy

Variable	Before phlebotomy	After phlebotomy
pH	7.37 ± 0.06	7.34 ± 0.04[a]
Lactate (mmol/L)	0.9 ± 0.47	1.87 ± 0.88[a]

[a] $p < 0.05$ vs baseline

Table 4 Near-infrared spectroscopy (NIRS) cerebral oximetry (rSO_2) during phlebotomy

	Immediately before phlebotomy	Immediately after phlebotomy	15 Min after phlebotomy	30 Min after phlebotomy
(rSO_2)	74 ± 9	68 ± 10[a]	70 ± 9[b]	68 ± 8[a]

NS not significant

[a] $p < 0.05$ vs baseline

[b] $p =$ NS vs baseline

Table 5 Patients with and without cerebral oximetry (rSO_2) changes after phlebotomy

Variable	Patients with an rSO_2 decrease ≥20 from baseline after phlebotomy	Patients with stable rSO_2 (no value <10 from baseline) after phlebotomy
No. of patients	4	16
Age (years)	2.9 ± 4.7	15.2 ± 2.9[a]
Patients <1 year old	3/4	2/16[a]
Weight (kg)	13.1 ± 12.1	50.3 ± 17[a]
Single-ventricle anatomy	1/4	4/16[b]
Fentanyl dose (μg/kg)	7.2 ± 3.5	5.3 ± 2.8[a]
Received dexmedetomidine	0/4	12/16[a]
Blood volume removed (mL/kg)	13.1 ± 1.6	8.1 ± 2.6[a]
Crystalloid replacement (mL/kg)	6.4 ± 6.6	5.4 ± 4.6[b]
Mean MAP when rSO_2 decreased ≥20 % from baseline (mmHg)	54 ± 15	61 ± 12[b]
No. of patients with ≥20 % decrease in MAP	3/4	7/16[b]
Mean HR when rSO_2 decreased ≥ 20 % from baseline (bpm)	126 ± 48	88 ± 33[b]
No. of patients with ≥20 % increase in HR	0/4	2/16[b]
Mean pH after phlebotomy	7.27 ± 0.05	7.34 ± 0.03[a]
Mean lactate after phlebotomy	1.05 ± 0.4	1.4 ± 1.1[b]
$PaCO_2$ after phlebotomy (mmHg)[c]	48 ± 8	45 ± 7[b]

NS not significant

[a] $p < 0.05$

[b] p = NS

[c] Given the timing of the blood draw, these values do not necessarily coincide with the low rSO_2 value

- NIRS ile ölçülen rSO2 güvenilir mi ?

J Appl Physiol 110: 1691–1698, 2011.
First published March 31, 2011; doi:10.1152/japplphysiol.01458.2010.

Continuous monitoring of absolute cerebral blood flow by near-infrared spectroscopy during global and focal temporary vessel occlusion

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Departments of [1]Medicine, [3]Medical Biophysics, and [4]Anesthesia and Perioperative Medicine, University of Western Ontario, [2]Imaging Division, Lawson Health Research Institute, and [5]Imaging Research Laboratories, Robarts Research Institute, London, Ontario, Canada

Submitted 17 December 2010; accepted in final form 17 March 2011

- Çalışmacıların daha önce geliştirmiş oldukları ve diğer çalışmacılar tarafından da validasyonları yapılmış olan, indocyanine green ile CBF ölçümü ile NIRS'i karşılaştırıyorlar

NIRS’in çalışma prensibi

- Hb difference (HbD) :Oxyhem. con.- Deoxyhem. con.

- HbD: CBF değişim belirteci olarak kullanıyorlar

Çalışma iki aşamalı

1. aşamada; karotid arter oklüzyonunda
  - Klemp öncesi ve sonrası CBF indocyanin ile ölçülüyor ve
  - HbD ile karşılaştırılıyor
  - HbD ile CBF arasındaki ilişki araştırılıyor

2.aşamada: aynı işlemler Middle Cerebral Arter oklüzyonunda yapılıyor

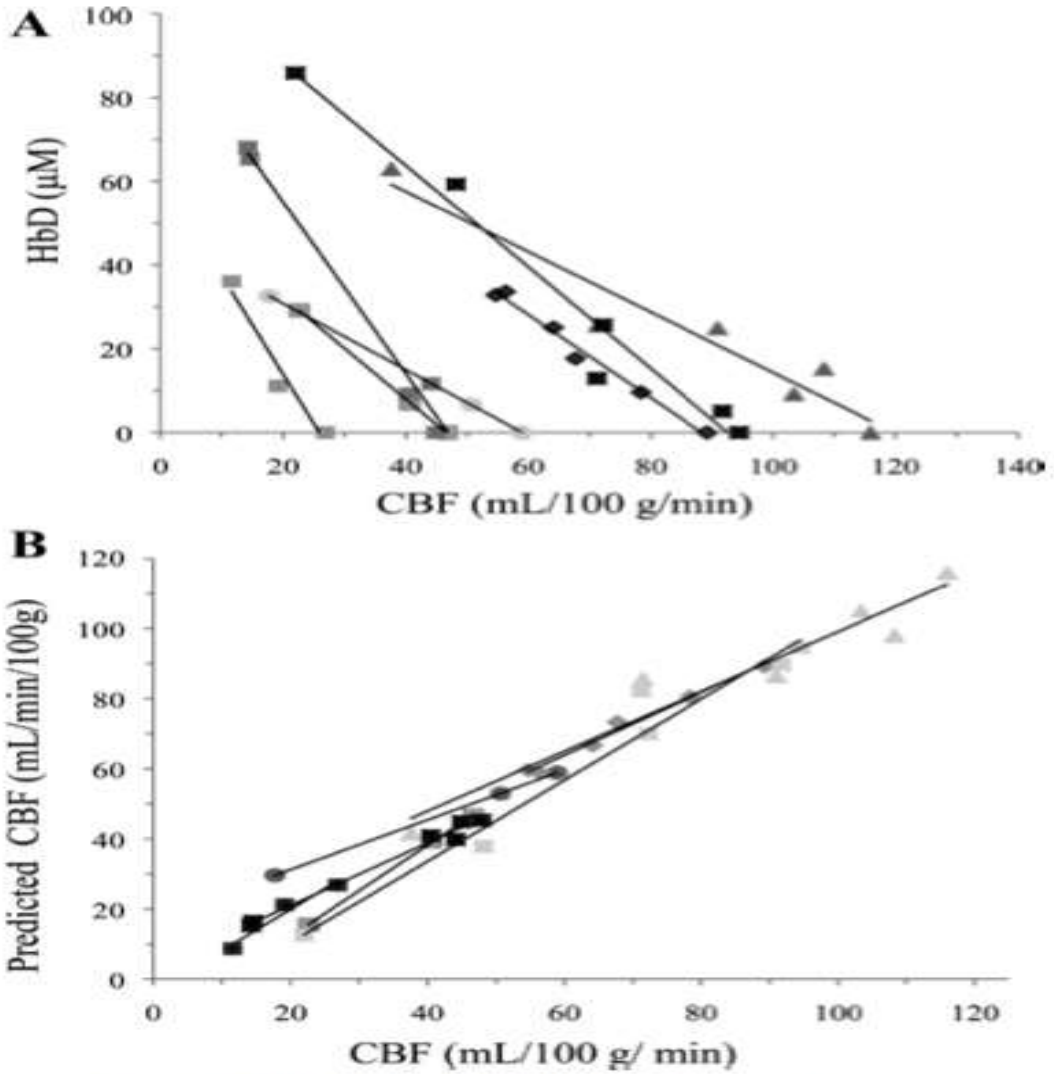

Fig. 1. *A*: change in Hb difference (HbD) plotted as a function of cerebral blood flow (CBF) for each animal in carotid occlusion experiments ($n = 7$). *B*: predicted CBF values derived from HbD plotted as a function of measured CBF. Solid lines represent results of linear regression performed on data from each animal. Each symbol type represents data from a single piglet.

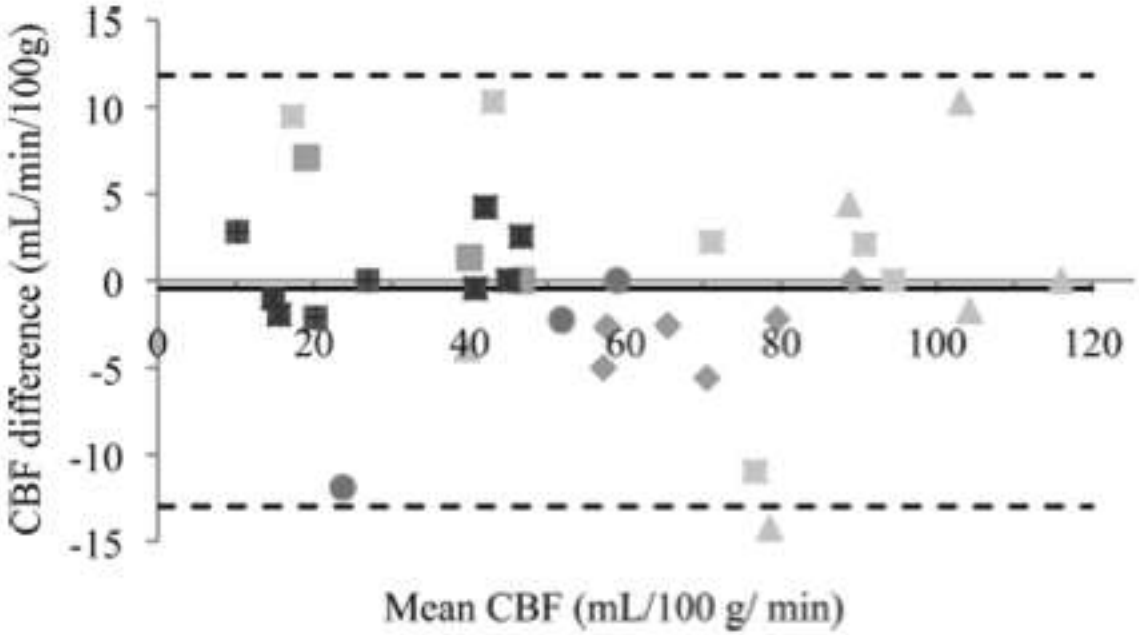

Fig. 2. Bland-Altman plot of predicted CBF values derived from change in HbD and corresponding measured CBF values for carotid occlusion experiments. Solid line, mean CBF difference; dashed lines, 95% confidence intervals. Each symbol type represents data from a single piglet.

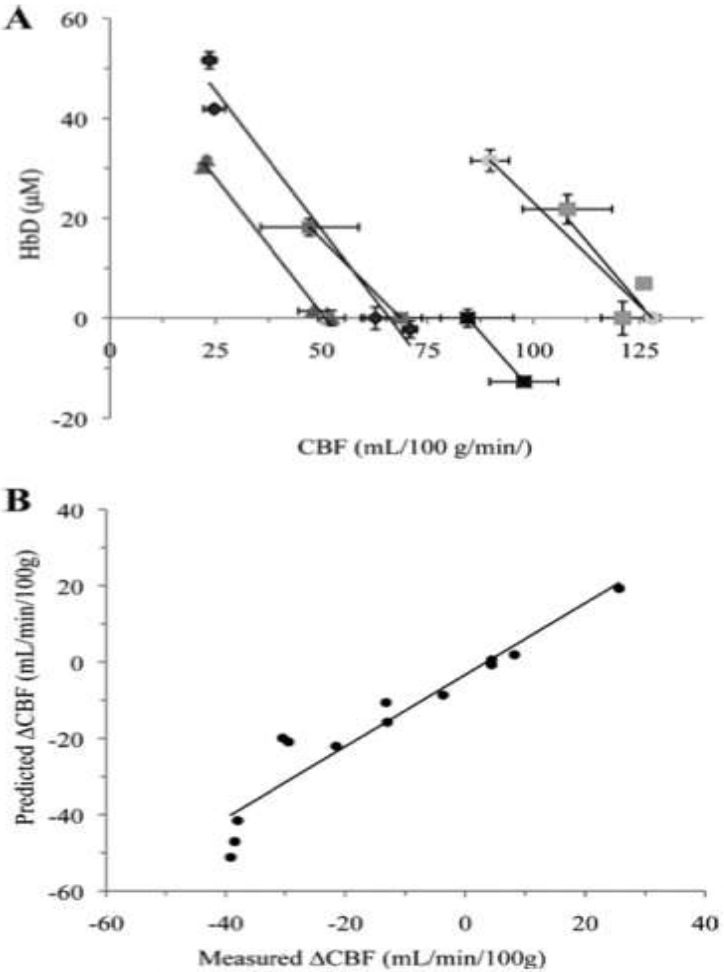

Fig. 4. *A*: change in HbD plotted as a function of CBF for each of 6 animals in the middle cerebral artery (MCA) occlusion experiments. Error bars, SE; solid line, linear regression for each individual animal. *B*: predicted change in CBF (ΔCBF) plotted as a function of corresponding measured change in CBF for all MCA occlusion experiments. Predicted values were determined from change in HbD, and measured values were determined using indocyanine green technique. In both cases, ΔCBF was determined by subtracting each animal's baseline CBF. Linear regression is shown by solid line with slope of 0.939 and *y*-intercept of -3.34 ml·100 g^{-1}·min^{-1} ($R^2 = 0.907$).

Sonuç

- Damar oklüzyonu sırasında değişen HbD (NIRS ile ölçülen) değeri ile
- CBF arasında yakın bir korelasyonun olduğunu ifade ediyorlar (r^2: 0,9)

Vox Sanguinis (2002) **83**, 254–257

ORIGINAL PAPER

Cerebral and peripheral near-infrared spectroscopy: an alternative transfusion trigger?

F. Torella, S. L. Haynes & C. N. McCollum

Academic Surgery Unit, Education and Research Centre, South Manchester University Hospital, Manchester, UK

Vox Sanguinis

Background and Objectives To develop a transfusion trigger based on tissue oxygenation, near-infrared spectroscopy (NIRS) was evaluated in a model of compensated haemorrhage.

Patients and Methods Regional haemoglobin oxygen saturation from the cerebral cortex (CsO_2) and the gastrocnemius muscle (PsO_2) was monitored (using an INVOS 4100 near-infrared oximeter) in 30 patients during acute normovolaemic haemodilution to a target haemoglobin of 11 g/dl. Arterial oxygen saturation, end-tidal carbon dioxide tension, mean arterial pressure and haemoglobin concentration were also measured.

Results During blood collection, CsO_2 and PsO_2 fell by a mean (95% CI) of 8 (5·3–10·7)% ($P < 0·001$) and 5·5 (3·2–7·8)% ($P < 0·001$), respectively. Arterial pressure and oxygen saturation did not change, whilst the end-tidal carbon dioxide tension fell by 2·3 (0·8–3·8) mmHg ($P = 0·004$). Haemoglobin concentration correlated with CsO_2 ($R = 0·76$, $P < 0·001$) and PsO_2 ($R = 0·63$, $P < 0·001$), as did the volume of blood removed.

Conclusions CsO_2 and PsO_2 fell predictably during compensated blood loss. With further research, NIRS may be developed into a transfusion trigger.

Received: 17 April 2002, revised 24 June 2002, accepted 24 June 2002

Key words: acute normovolaemic haemodilution, blood loss, haemorrhage, oximetry, regional oxygen saturation.

Materyal -Metod

- 30 hasta periferik arter cerrahisi
  - 7 Hasta Aorto-bifemoral
  - 23 hasta anevrizmektomi
  - Yaş ortalaması 70 yıl
- Normovolemik hemodilüsyon oluşturuyorlar
  - Boy-kilo göre kan volümü tahmini yapılıyor
  - Tahmini kan volümünün %20 alınıyor
- Ölçümler
  - Başlangıçta
  - Her %2 lik kan alımında ve
  - İşlem sonunda

- Sol frontal lob rScO2
- Sol gastrocnemius muscle (rSmO2).

Tahmini kan volümü (ml)	4719 ± 652
Çekilen kan volümü (Ü) (1ü: 450 ml)	2,2 ± 0,9
Ortalama süre (dk)	30 ± 18

- İşlem sırasında;
  - OAB DA 12 mmHg değişiklik oluyor $p>0,05$
  - $ETCO_2$ de 2,3 mmHg değişiklik oluyor $p<0,05$

	Önce	Sonra	% değişim	p
Hb (g/dl)	14,5 ± 1,36	10,8 ± 0,94	25,5	
rScO2 (%)	74 ± 10	66 ± 9	8	< 0,001
rSmO2 (%)	70 ± 8	64 ± 7	5,5	<0,001

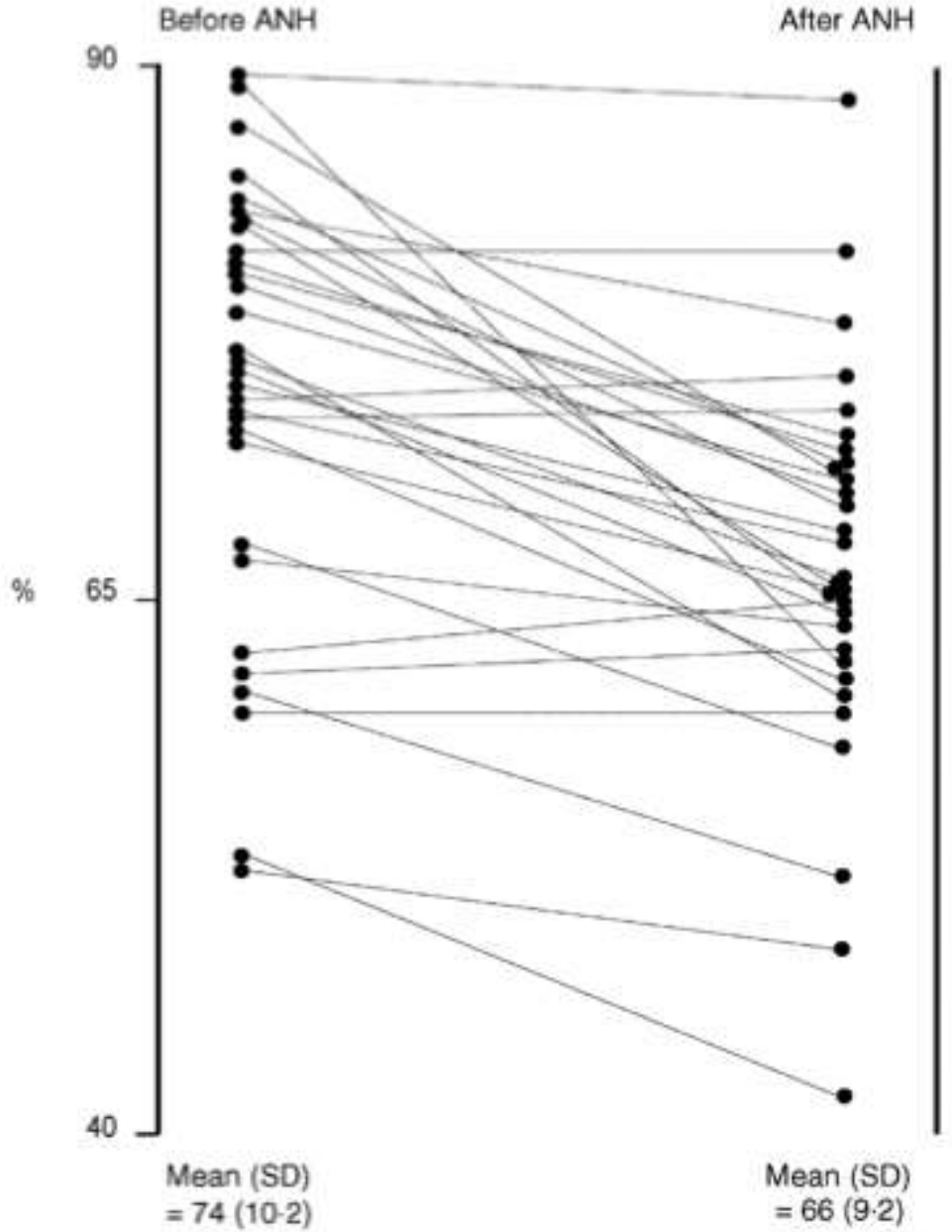

Fig. 1 Changes in regional haemoglobin oxygen saturation from the cerebral cortex (CsO_2) during ANH. The mean fall (95% confidence interval) was 8 (5·3–10·7)%.

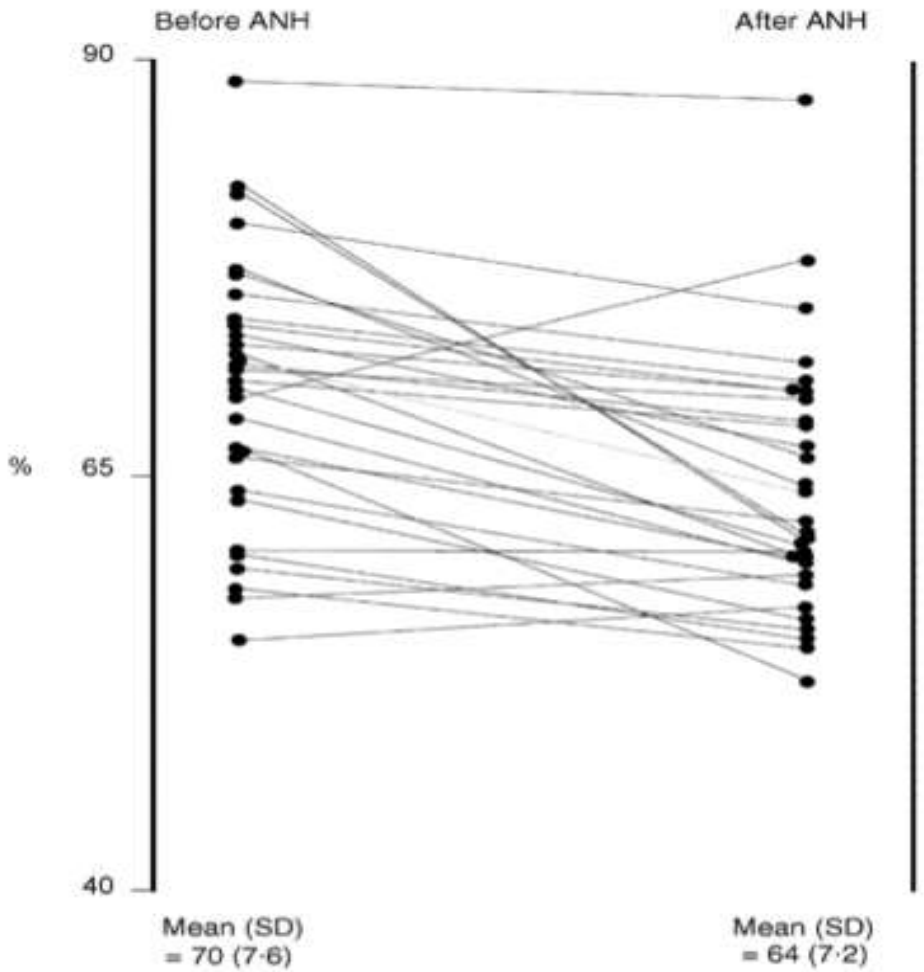

Fig. 2 Changes in regional haemoglobin oxygen saturation from the gastrocnemius muscle (PsO_2) during ANH. The mean fall (95% confidence interval) was 5·5 (3·2–7·8)%.

Hb ile olan korelasyon

	r	p
rScO2 (%)	0,76	< 0,001
rSmO2 (%)	0,63	<0,001

CO2 ayarından sonra Hb ile olan korelasyon

	r	p
rScO2 (%)	0,65	< 0,001
rSmO2 (%)	0,55	<0,001

Alınan kan volümü ile korelasyon

	r	p
rScO2 (%)	-0,48	< 0,001
rSmO2 (%)	-0,75	<0,001
PCO2 ayarından sonra		
rScO2 (%)	-0,61	< 0,001
rSmO2 (%)	-0,52	<0,001

- Kan kaybı takibinin rScO2 ile yapılmasının, PsO2 ile yapılmasından daha uygun olduğunu

rScO2'nin ;

  - Kanamaya bağlı serebral desaturasyonu
  - Non-invazif olarak tespit etmek amacıyla kullanılabileceğini ifade ediyorlar

SHOCK, Vol. 18, No. 5, pp. 440–444, 2002

REGIONAL TISSUE OXYGENATION DURING HEMORRHAGE: CAN NEAR INFRARED SPECTROSCOPY BE USED TO MONITOR BLOOD LOSS?

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Received 3 Aug 2001; first review completed 21 Sep 2001; accepted in final form 12 Feb 2002

ABSTRACT—We investigated whether near infrared spectroscopy could be used to monitor regional tissue oxygenation during uncompensated hemorrhage in man. A Somanetics INVOS 4100 oximeter was used to measure regional hemoglobin oxygen saturation in the cerebral cortex (CsO_2, left frontal area) and from the left calf muscle (PsO_2) in 40 volunteers donating 470 mL of the whole blood. A Critikon 2001 Cerebral Redox Instrument was used to monitor total (tHb), oxygenated (O_2Hb), and deoxygenated (HHb) hemoglobin in the right calf muscle. The oxygenation index, [HbD] = [O_2Hb] – [HHb] was derived. CsO_2 decreased by a mean (95% CI) of 2 (1–3.3%) ($P < 0.001$), PsO_2 decreased by a mean (95% CI) of 3.2 (1.7–4.6%) ($P < 0.001$), and HbD decreased by a median (95% CI) of 6.4 (2.65–10.16) ΔμM/cm ($P < 0.001$) during blood collection. There was an inverse correlation between blood loss and CsO_2 ($R = -0.59$, $P < 0.001$), PsO_2 ($R = -0.61$, $P < 0.001$), and HbD ($R = -0.5$, $P < 0.001$). Regional tissue oxygenation decreases in proportion to uncompensated blood loss. Near infrared spectroscopy may potentially be developed into a transfusion trigger.

KEYWORDS—Transfusion, regional oxygen saturation, oximetry, INVOS, Critikon

- Sıvı replasmanı yapılmayan kanama durumunda (gönüllü kan verme)

- NIRS ile kan volümü arasınadi ilişki araştırılıyor

- 40 gönüllü kan verici çalışmaya alınıyor
- Sol frontal lob CsO2 (rSO2)
- Sol gastrocnemius muscle (PsO2).
- Boy-kilo göre total kan volümü hesaplanıyor
- Öncesi, işlem sırası ve işlemden 10 dk sonra hemogram bakılıyor
- NIRS ölçümleri her %2 lik volüm alındıktan sonra ve işlem bittikten 5 ve 10 dk sonra
- Oda ısısı 20-23° C
- [HbD] : [O2Hb] − [HHb]), which indicates oxygen extraction, was then calculated.

TABLE 1. **Blood donors.**

*Age (years)	38 (24–53)
Men/women	27/13
§Blood volume (mL)	4800 (826)
§Hemoglobin (g/L)	150 (14.6)
*Blood loss (% blood volume)	10 (9–12)
*Collection time (min)	5.4 (4.6–6.5)

Values are *median (interquartile range) and §mean (standard deviation).

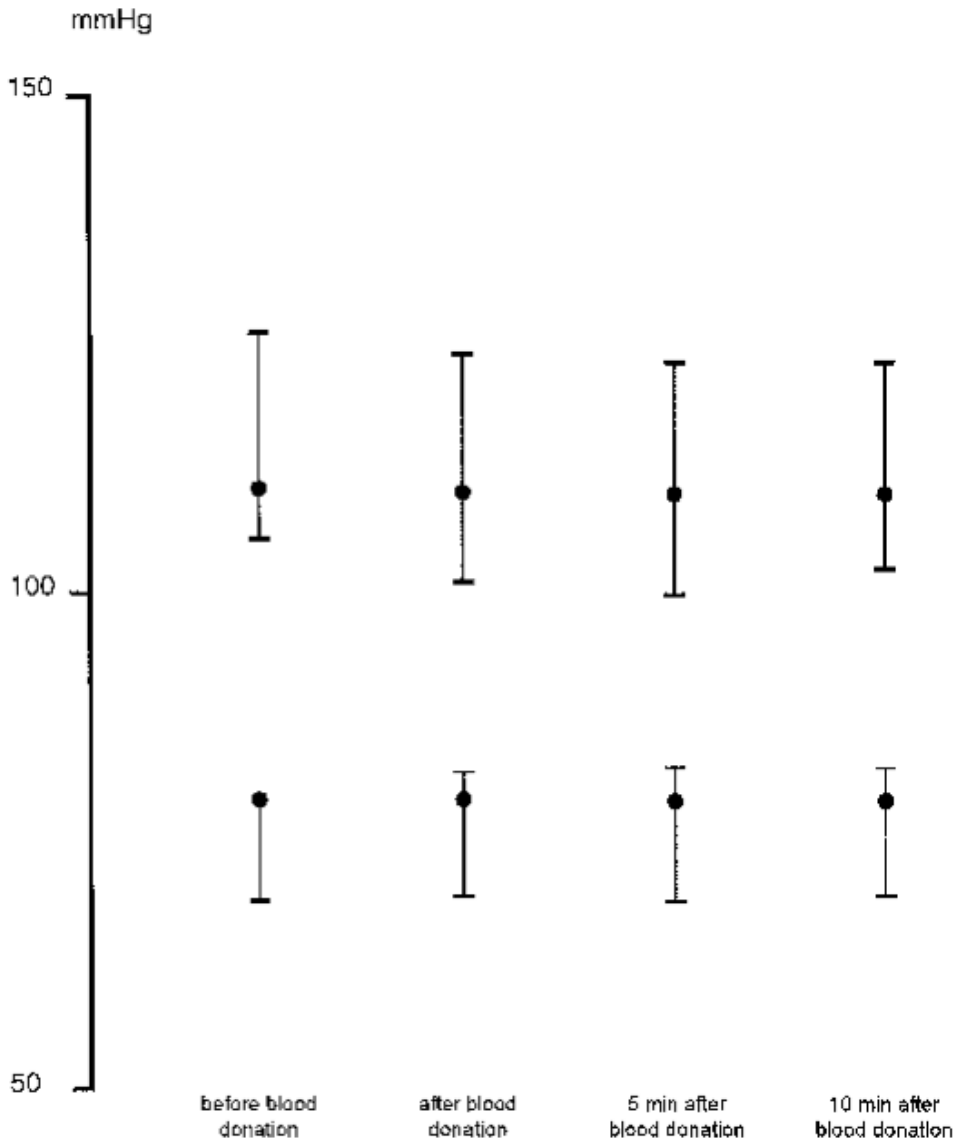

FIG. 1. **Median (interquartile range) systolic and diastolic blood pressure remaining stable during and after blood donation.**

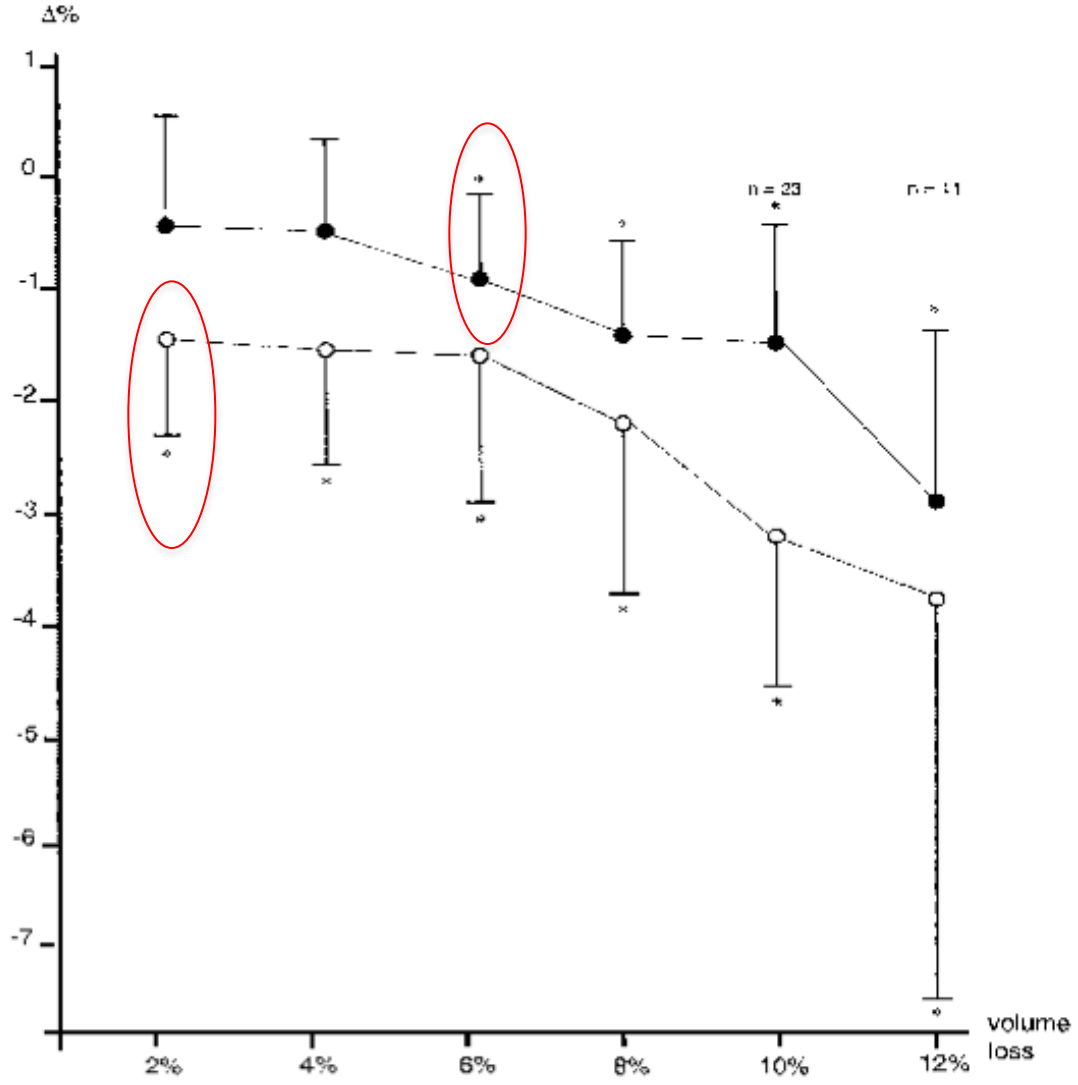

FIG. 2. **Changes from baseline for CsO_2 (⬇) and PsO_2 (↓).** Values are means and 95% CI. Both trends were statistically significant ($P < 0.001$, RM-ANOVA). *$P < 0.05$ on *post hoc* test (RM-ANOVA).

PsO2 falls were more pronounced and showed a better relationship with blood loss than CsO2

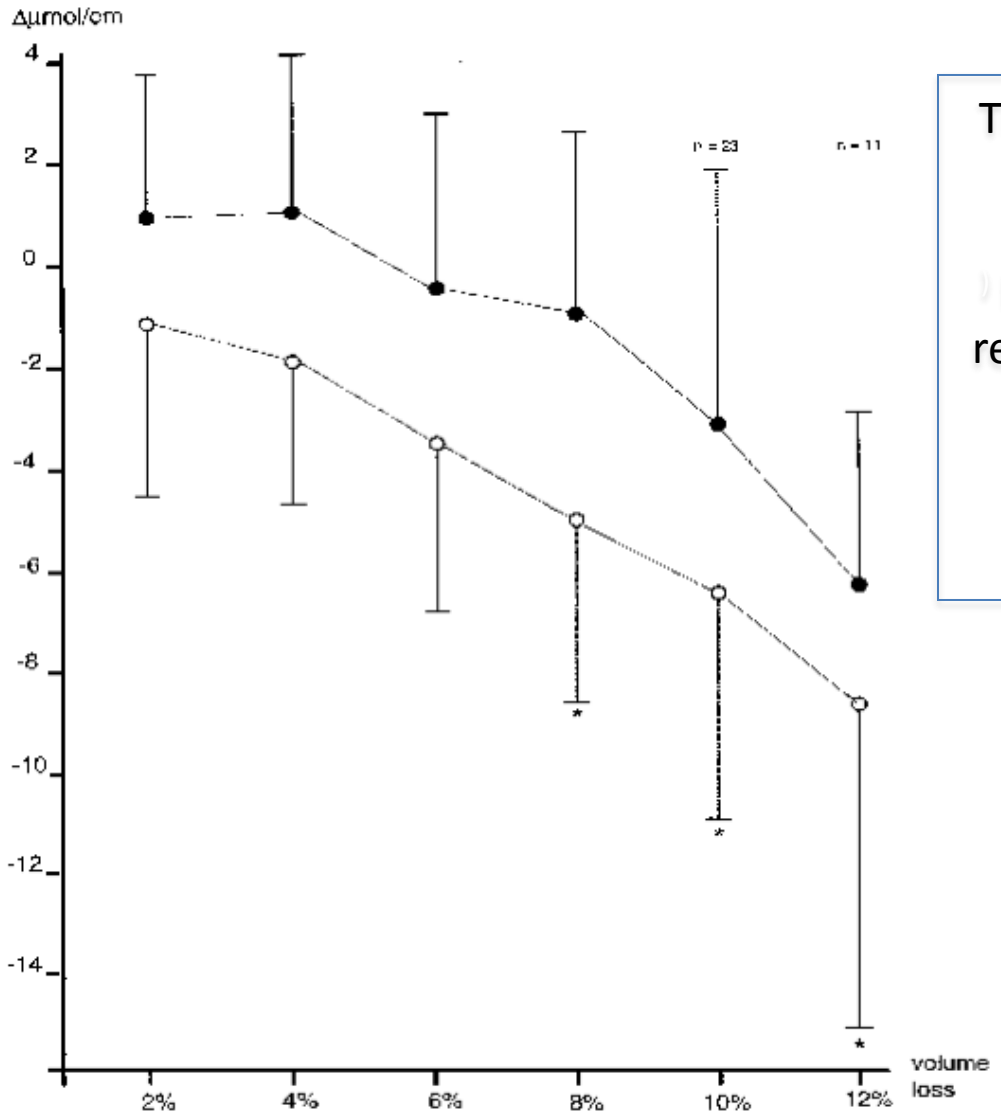

FIG. 4. **Changes from baseline for tHb (⬇) and HbD (↓).** Values are medians and 95% CI. Both trends were statistically significant (tHb, $P = 0.003$; HbD, $P < 0.001$, Friedman test). *$P < 0.05$ on *post hoc* test (Wilcoxon rank sum).

The fall in HbD correlated well with blood loss (R : −0.5, $P < 0.001$ but the volume of blood removed did not correlate with the fall in tHb (R : 0.12; P : 0.088).

Sonuç

- Kan kaybı ile ;
  - rSO2; (R : −0.59; $P < 0.001$) ve
  - PSO2; (R : −0.61; $P < 0.001$).
- Arasında ters yönde güçlü bir korelasyonun olduğunu
- NIRS'in kan kaybının değerlendirilmesinde
- Non-invazif ve
- Etkili bir yöntem olduğunu ifade ediyorlar

KARDİOPULMONER BYPASS SIRASINDA GELİŞEN ANEMİNİN SEREBRAL KORTİKAL OKSİJEN SATÜRASYONUNA ETKİSİ

I’m pleased to advise you that the Editorial Board has completed the review of your manuscript

"EFFICACY OF NEAR-INFRARED SPECTROMETRY FOR MONITORING THE CEREBRAL EFFECTS OF SEVERE DILUTIONAL ANEMIA" (#293).

The Board would like to accept the manuscript for publication in The Heart Surgery Forum

ACIBADEM
ÜNİVERSİTESİ

AMAÇ

- KPB sırasındaki düşük Hb değerlerinin güvenilir olup olmadığını serebral oksijen saturasyonu (rSO_2) takibi ile göstermek

ACIBADEM
ÜNİVERSİTESİ

Materyal-metot

- 32 ° C hipotermik KPB sırasında;
- Anemi grubu: herhangi bir dönemde Hb < 7 gr/dl olan 15 hasta
- Kontrol grubu: en düşük Hb>8 gr/dl olan 15 hasta
- Standart monitorizasyonuna ilaveten, rSO_2 monitorizasyonu

ACIBADEM

Minimum Hb değerindeki Sağ hemisfer oksijen saturasyonu değişimi

	GI (Anemi)	GII (Kontrol)
Başlangıç rSO2 (%)	52 ± 9	66 ± 6
Min Hb (g/dl)	6,2 ± 0,4	10,3 ± 1,3
rSO2(%)	49 ± 7	58 ± 6
Yüzde değişim	% 5,7	% 12

ACIBADEM

Minimum Hb değerindeki Sol hemisfer oksijen saturasyonu değişimi

	GI (Anemi)	GII (Kontrol)
Başlangıç rSO2 (%)	54 ± 6	69 ± 7
Min Hb (g/dl)	6,2 ± 0,4	10,3 ± 1,3
rSO2 (%)	50± 7	58 ± 6
Yüzde değişim	% 7,4	% 11,5

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Sonuç

- KPB sırasında 6 gr/dl ye kadar olan hemoglobin değerlerinde
  - pompa kan akımı,
  - ortalama arter basıncı
  - oksijen parsiyel basıncında yapılan ayarlamalarla ve
  - rSO2 monitorizasyonu ile

  transfüzyona gerek kalmaksızın yeterli serebral oksijenasyonun sağlanabileceği kanısına vardık.

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