CHU
Hôpitaux de
Bordeaux

NIRS
et chirurgie cardiaque congénitale

DIU RCC 2017

Dr N TAFER

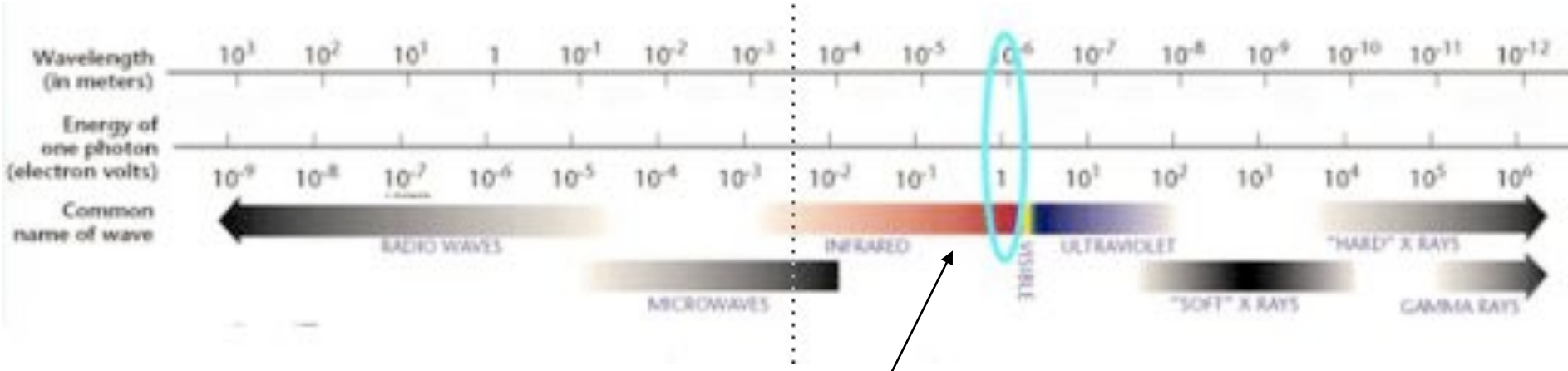
Unité anesthésie réanimation des cardiopathies congénitales

CHU Bordeaux SAR2

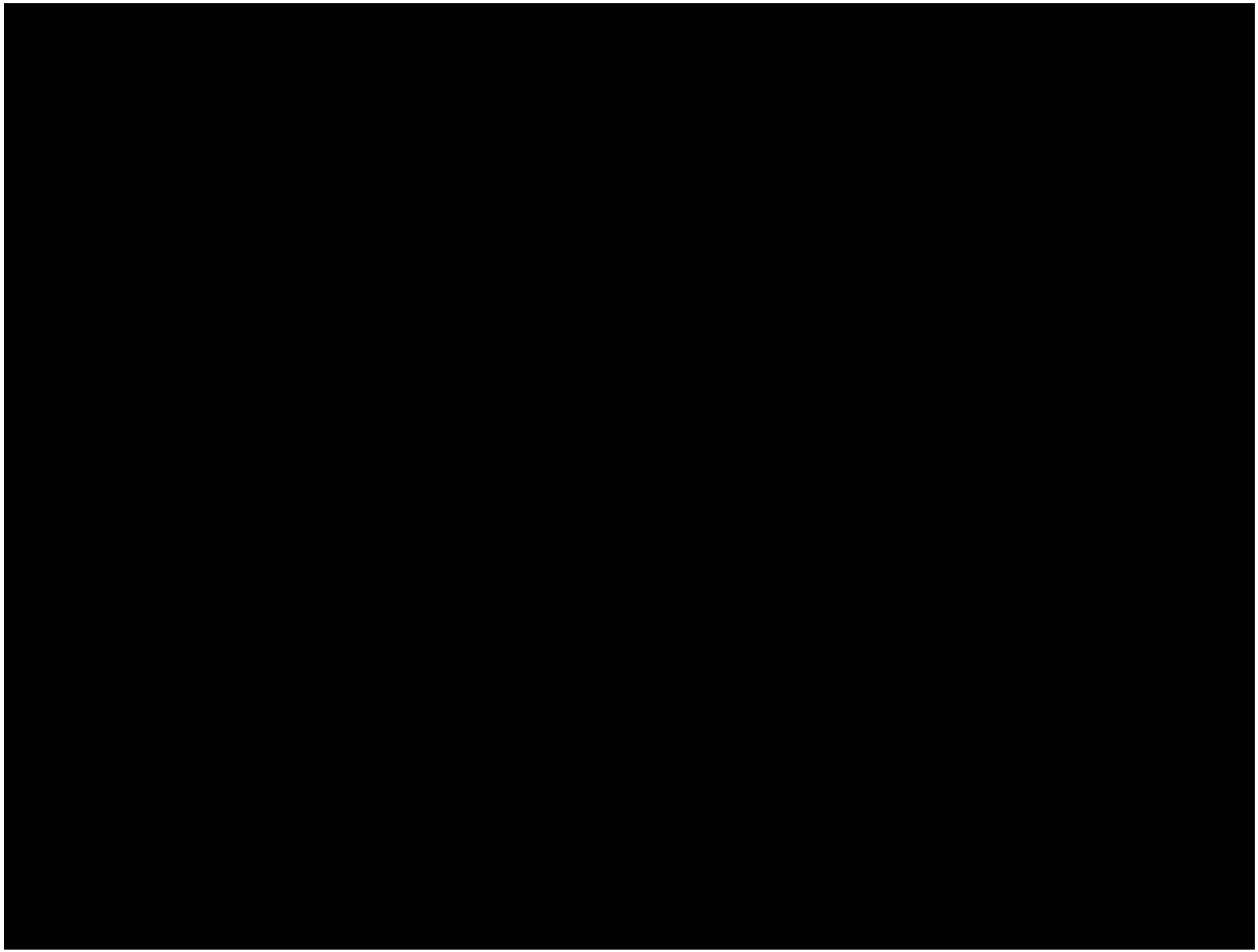
Introduction

- **NIRS** = *near infrared spectroscopy*
- **SPIR** = spectroscopie dans le proche infra-rouge
- La spectroscopie proche IR est une spectroscopie d'absorption dont le principe repose sur l'absorption du rayonnement proche IR par la matière organique.
- Largement utilisée dans l'industrie agro-alimentaire, chimique, plastique, carburants…
- En clinique: Permet de quantifier l'oygénation tissulaire :
- Technique appliquée en médecine **Jobsis FF** Science. 1977 Dec

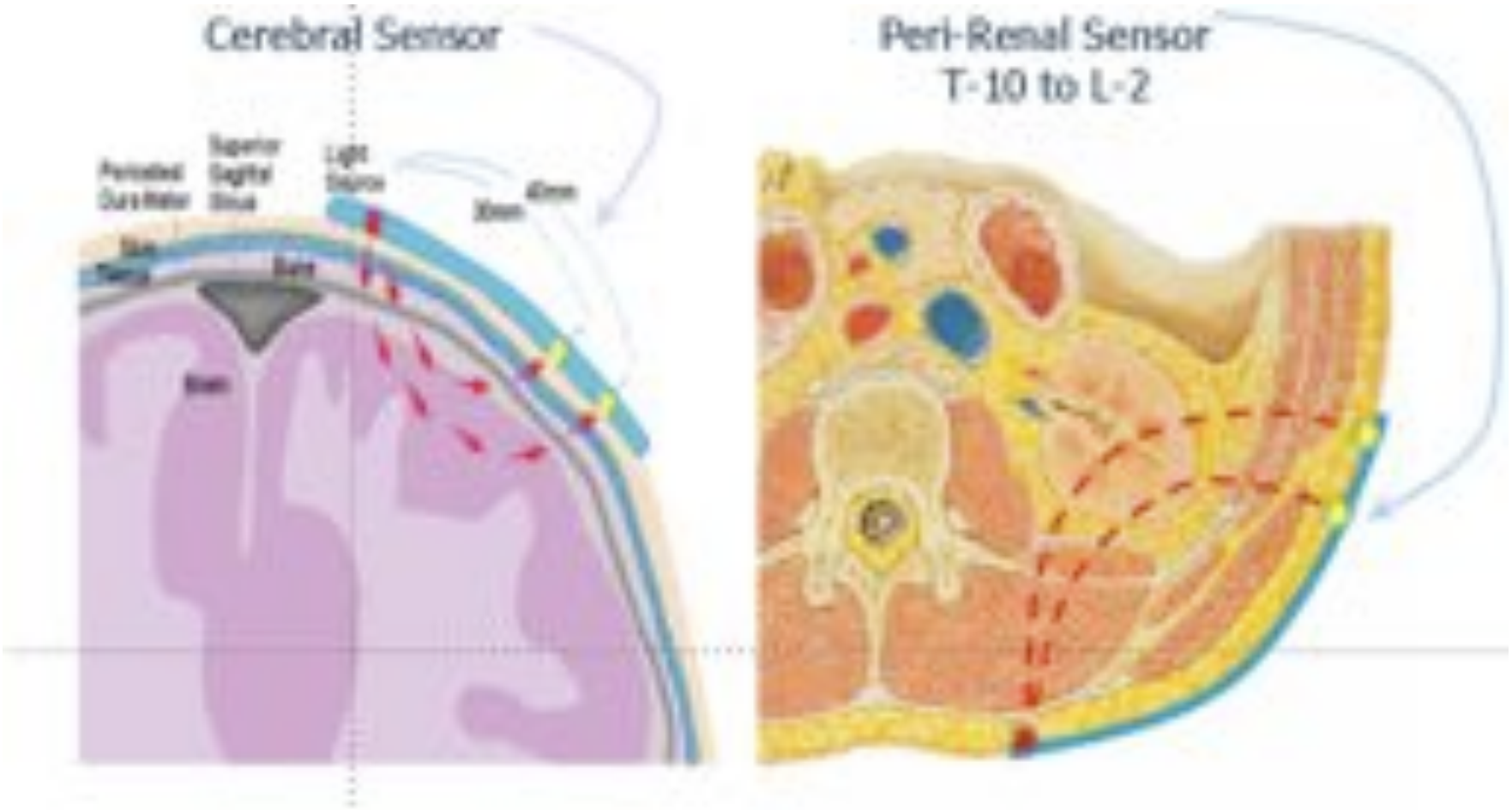
Domaine de longueur d'onde du proche infrarouge



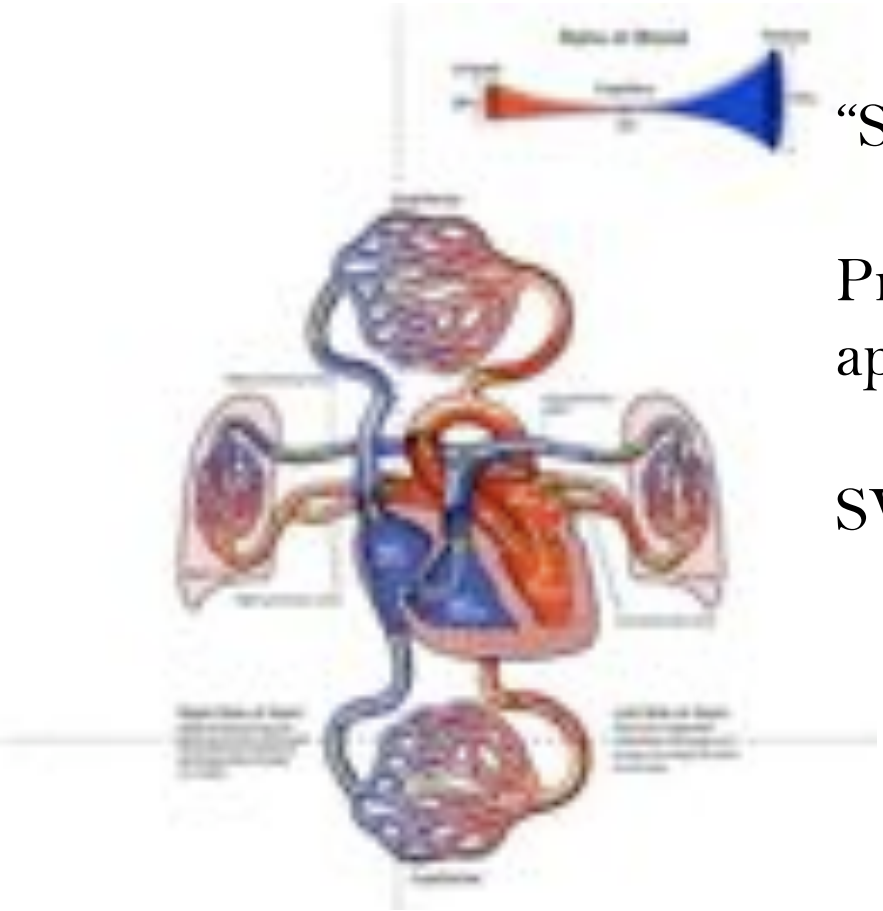
longueurs d'onde du proche infra rouge



NIRS cérébrale et rénale



Interpretation clinique
rSO2: what is it?



rSO2: reflet de l'oxygenation tissulaire de sang veineux et artériel

"SVO2 d'organe"

Principe de FICK completement applicable

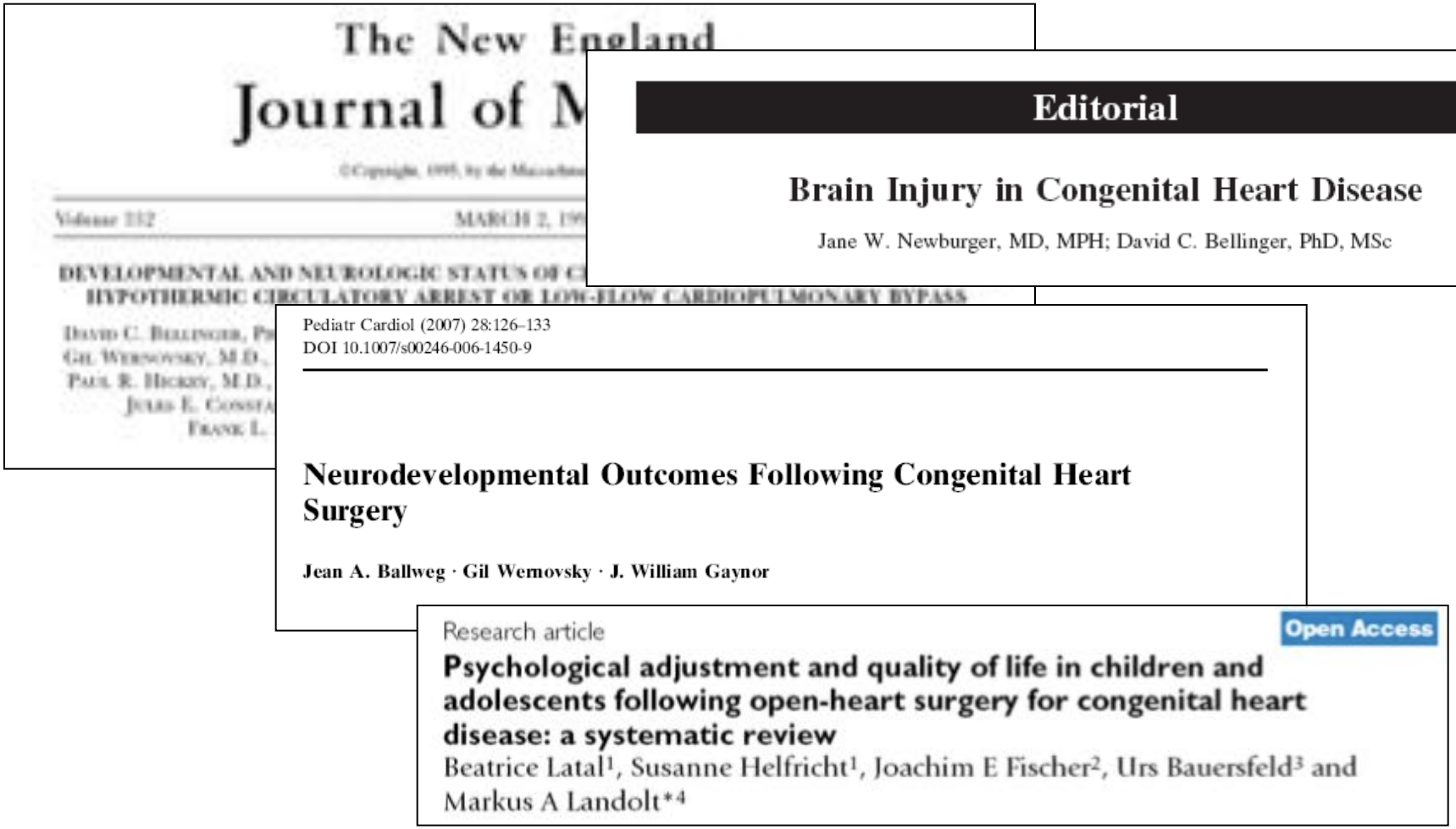
SVO2=SaO2 - VO2/Qc x 1.34 x Hb

- SvO2 = 70%
- renal rSO2 = 90%

region	SaO2	rSvO2	qi	rDO2	rO2ER	rVO2
brain	100%	60%	25	25	0.4	10
heart	100%	50%	20	20	0.5	10
liver	100%	70%	10	10	0.3	3
kidney	100%	90%	15	15	0.1	1.5
intestine	100%	80%	15	15	0.2	3
muscle	100%	80%	15	15	0.2	3
total	100%	70%	100	100	0.31	30.5

D'après G Hoffman ARTECC 2008

Enjeux neurologiques



The New England
Journal of M

DEVELOPMENTAL AND NEUROLOGIC STATUS OF C
HYPOTHERMIC CIRCULATORY ARREST OR LOW-FLOW CARDIOPULMONARY BYPASS

Editorial

Brain Injury in Congenital Heart Disease

Jane W. Newburger, MD, MPH; David C. Bellinger, PhD, MSc

Pediatr Cardiol (2007) 28:126–133
DOI 10.1007/s00246-006-1450-9

Neurodevelopmental Outcomes Following Congenital Heart Surgery

Jean A. Ballweg · Gil Wernovsky · J. William Gaynor

Research article

Open Access

Psychological adjustment and quality of life in children and adolescents following open-heart surgery for congenital heart disease: a systematic review

Beatrice Latal[1], Susanne Helfricht[1], Joachim E Fischer[2], Urs Bauersfeld[3] and Markus A Landolt*[4]

12 à 27% de complications neuro à 1 an

NIRS et neuromonitoring

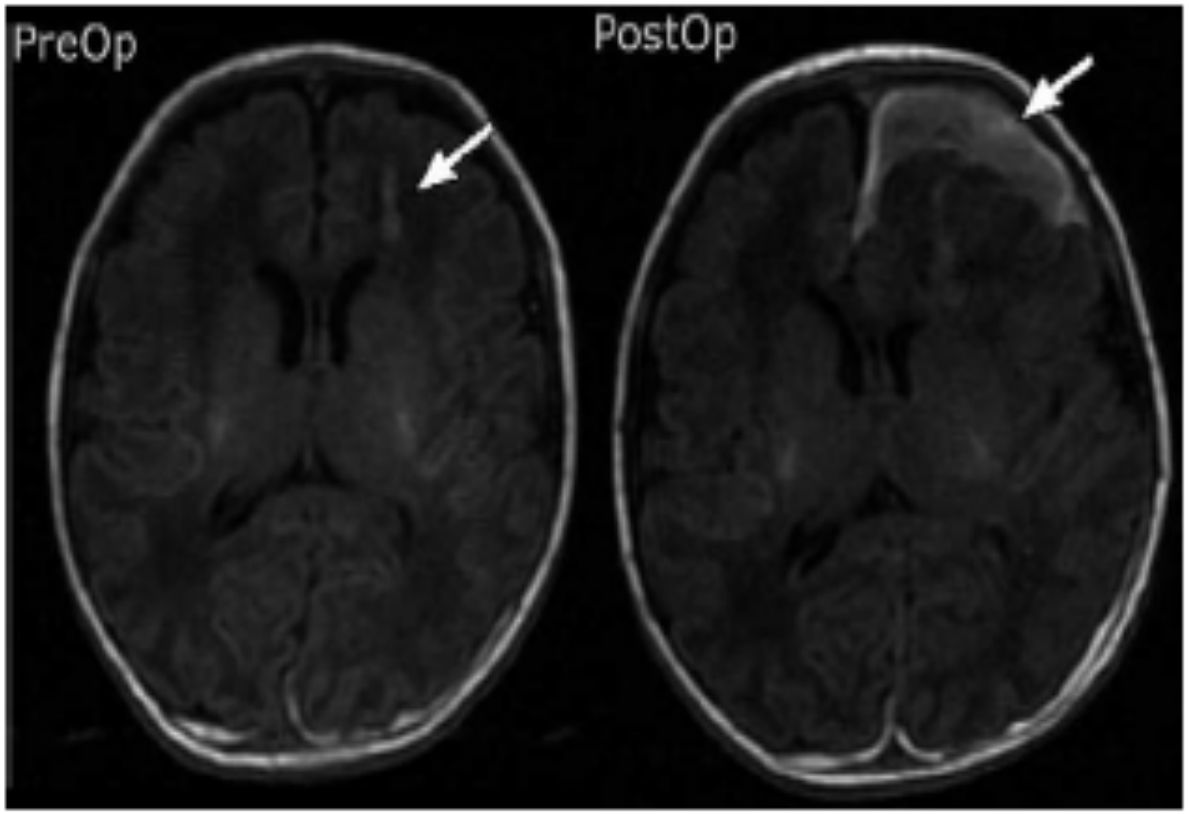
Brain magnetic resonance imaging abnormalities after the Norwood procedure using regional cerebral perfusion

Catherine L. Dent, MD,[a] James P. Spaeth, MD,[f] Blaise V. Jones, MD,[e] Steven M. Schwartz, MD,[a] Tracy A. Glauser, MD,[b] Barbara Hallinan, MD, PhD,[b] Jeffrey M. Pearl, MD,[d] Philip R. Khoury, MS,[a,c] and C. Dean Kurth, MD[f]

The Journal of Thoracic and Cardiovascular Surgery • Volume 130, Number 6

2005

Prolonged low rSO2 values (180 minutes with rSO2 45%) were associated with the presence of lesions on postoperative MRI.



Cerebral Oximetry During Infant Cardiac Surgery: Evaluation and Relationship to Early Postoperative Outcome

ANESTHESIA & ANALGESIA

Vol. 108, No. 4, April 2009

Table 5. Regional Cerebral Oxygen Saturation (rSO_2, %) According to Diagnosis Group

Variable	TGA (n = 43)	TOF (n = 36)	VSD (n = 25)	P
Average rSO_2	80 ± 7	76 ± 8	71 ± 8	<0.001
Postinduction—on CPB	63 ± 10	71 ± 12	62 ± 8	<0.001
Onset cooling—onset last rewarming	85 ± 8	82 ± 9	80 ± 10	0.03
Onset last rewarming—off CPB	88 ± 6	75 ± 11	71 ± 9	<0.001
Off CPB—60-min post-CPB	78 ± 11	73 ± 10	71 ± 11	0.02
Minimum rSO_2	51 ± 12	54 ± 10	50 ± 9	0.28
Postinduction—on CPB	54 ± 11	60 ± 13	53 ± 9	0.04
Onset cooling—onset last rewarming	60 ± 14	69 ± 12	61 ± 14	0.005
Onset last rewarming—off CPB	77 ± 9	64 ± 11	61 ± 9	<0.001
Off CPB—60-min post-CPB	69 ± 13	62 ± 11	59 ± 10	0.004
Decline in rSO_2 ≤45%, n (%)	9 (21)	6 (17)	8 (32)	0.39
Total duration ≤45% (min)	23 (2–64)	9 (1–18)	12 (1–72)	0.10
Longest duration ≤45% (min)	19 (2–32)	8 (1–15)	12 (1–27)	0.12
Integrated rSO_2 ≤45% (min%)	130 ± 117	28 ± 22	61 ± 75	0.12

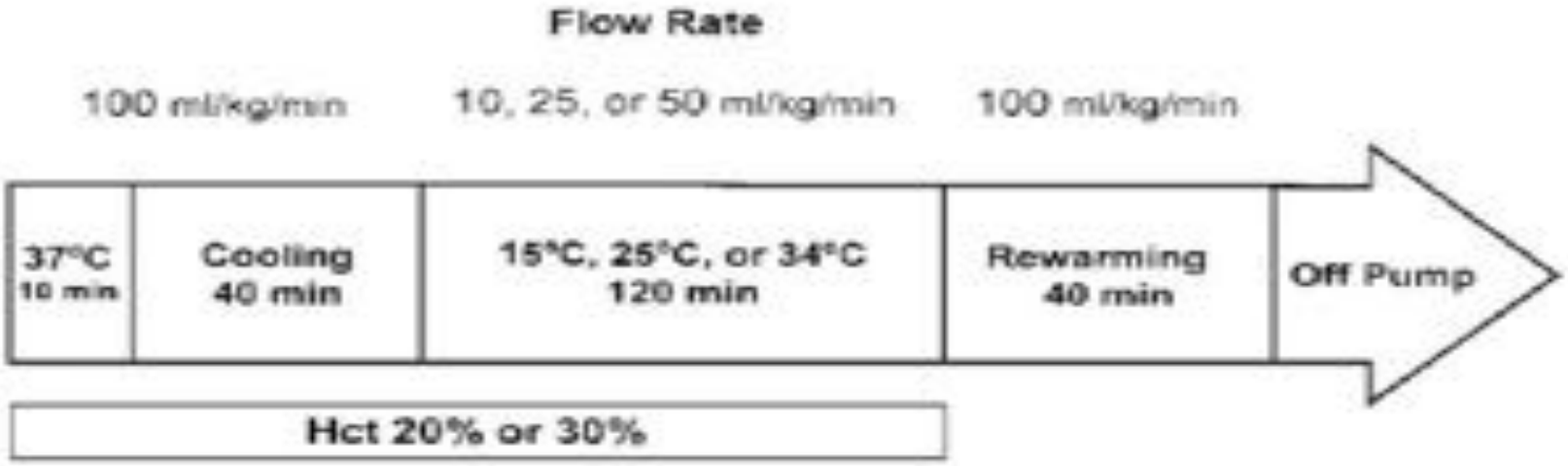
As no patient in this study died or developed clinical seizures, stroke, or choreoathetosis, the relationship between intraoperative NIRS variables and early clinical neurologic outcome could not be determined.

NIRS et CEC

Tissue oxygenation index is a useful monitor of histologic and neurologic outcome after cardiopulmonary bypass in piglets

Ikuo Hagino, MD,[a,d] Vesa Anttila, MD,[a,d] David Zurakowski, PhD,[b,d] Lennart F. Duebener, MD,[a,d] Hart G. W. Lidov, MD,[c,d] and Richard A. Jonas, MD[a]

The Journal of Thoracic and Cardiovascular Surgery • August 2005



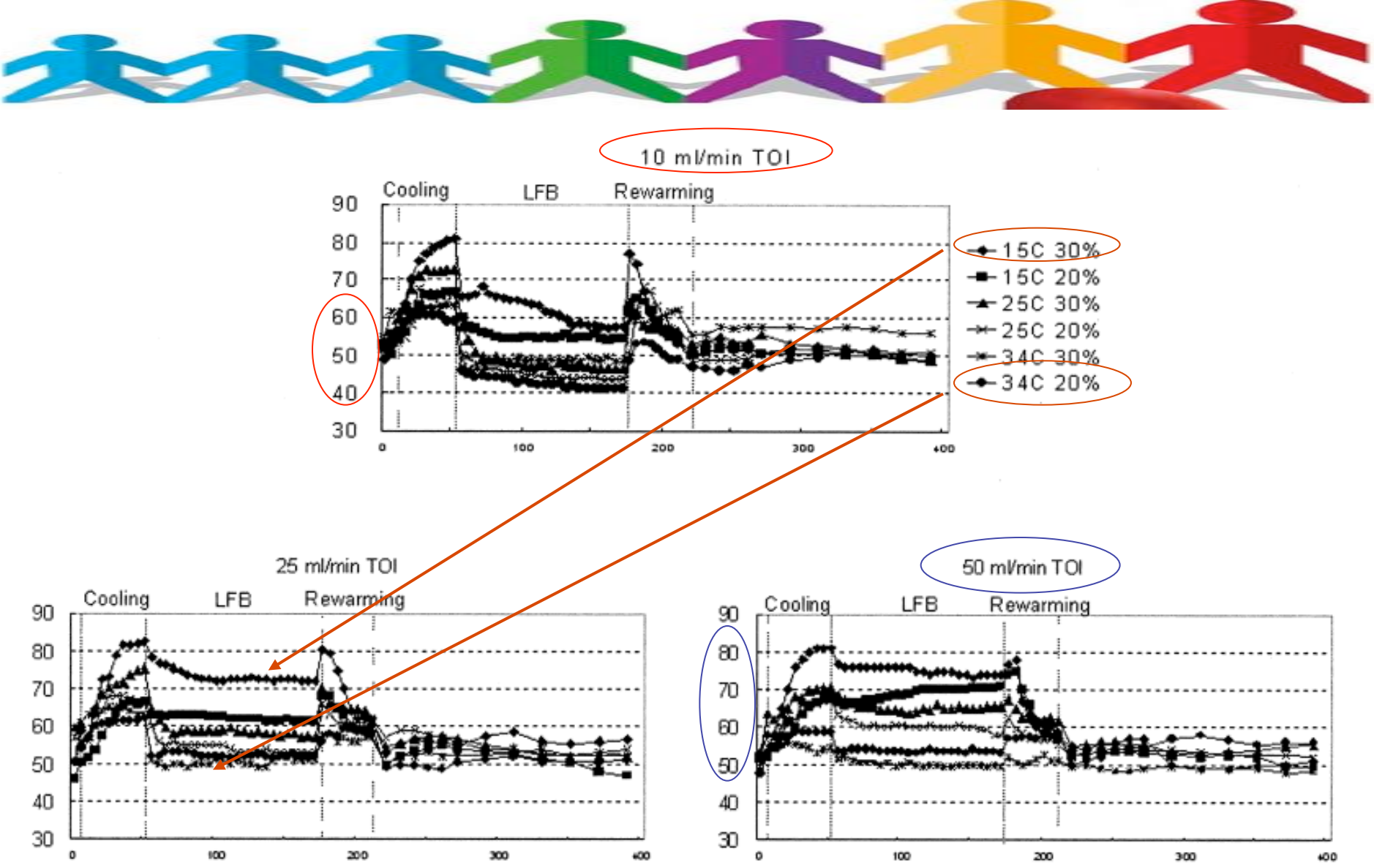


Figure 3. Changes in TOI at 3 different low-flow rates (10, 25, 50 mL · kg^{-1} · min^{-1}). *LFB,* Low-flow bypass.

Positionnement des canules

Pediatric Anesthesia 2006 **16**: 787–789 doi:10.1111/j.1460-9592.2006.

Case report

Bilateral monitoring of cerebral oxygen saturation results in recognition of aortic cannula malposition during pediatric congenital heart surgery

ERIN A. GOTTLIEB MD*, CHARLES D. FRASER JR MD†,
DEAN B. ANDROPOULOS MD* AND LAURA K. DIAZ MD*

Figure 2
Aortic cannula position.

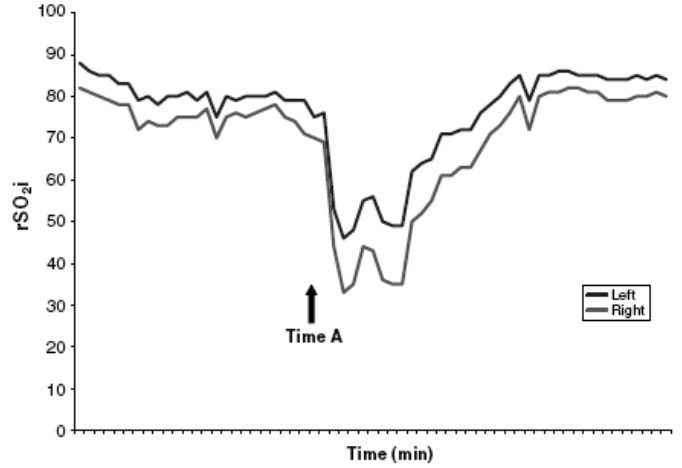


Figure 1
Cerebral oxygen saturation. An abrupt decrease in regional cerebral saturation index (rSO_2i) occurred at the onset of CPB (Time A). After repositioning of the aortic cannula, rSO_2i recovered to baseline levels.

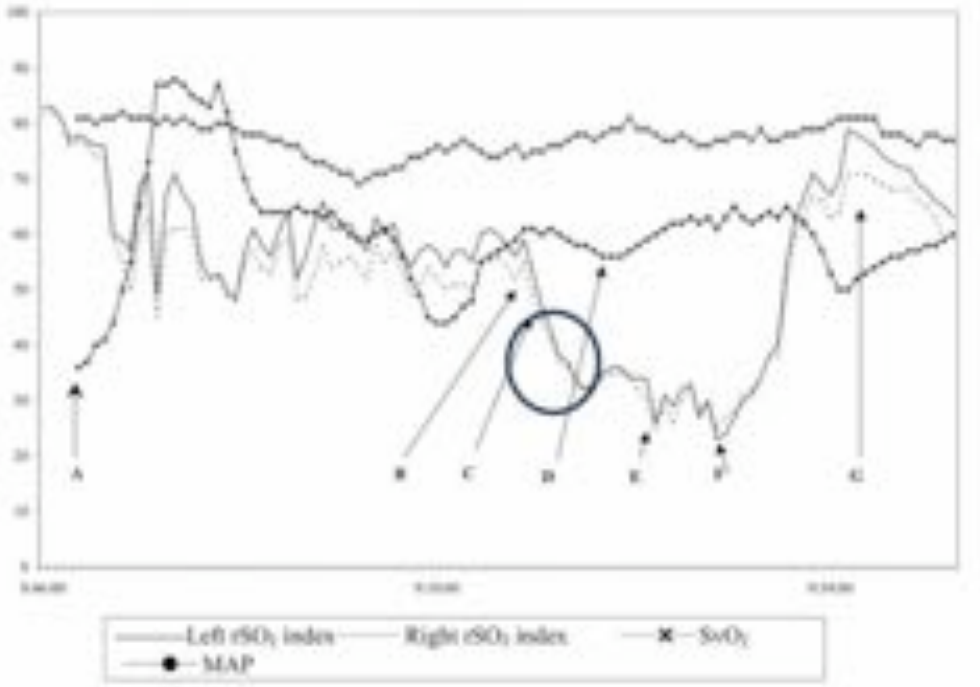
Obstruction de la VCS

1: J Cardiothorac Vasc Anesth. 2004 Aug;18(4):472-4.

Detection of unintentional partial superior vena cava occlusion during a bidirectional cavopulmonary anastomosis.

Ing RJ, Lawson DS, Jaggers J, Schulman S, Shearer IR, Kern FH.

Department of Anesthesiology, Duke University Health System Box 3094, Durham, NC 27710, USA. ing00001@mc.duke.edu



Canulation périphérique

ELSEVIER

European Journal of Cardio-thoracic Surgery 34 (2008) 1253–1254

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

How-to-do-it

Near infrared spectroscopy for controlling the quality of distal leg perfusion in remote access cardiopulmonary bypass

Thomas Schachner *, Nikolaos Bonaros, Johannes Bonatti, Christian Kolbitsch

Innsbruck Medical University, Innsbruck, Austria

Received 13 March 2008; received in revised form 15 August 2008; accepted 22 August 2008; Available online 1 October 2008

11 patients

Chirurgie coronaire assistée par robot

CEC périphérique : canulation veineuse et artérielle périphérique fémorale

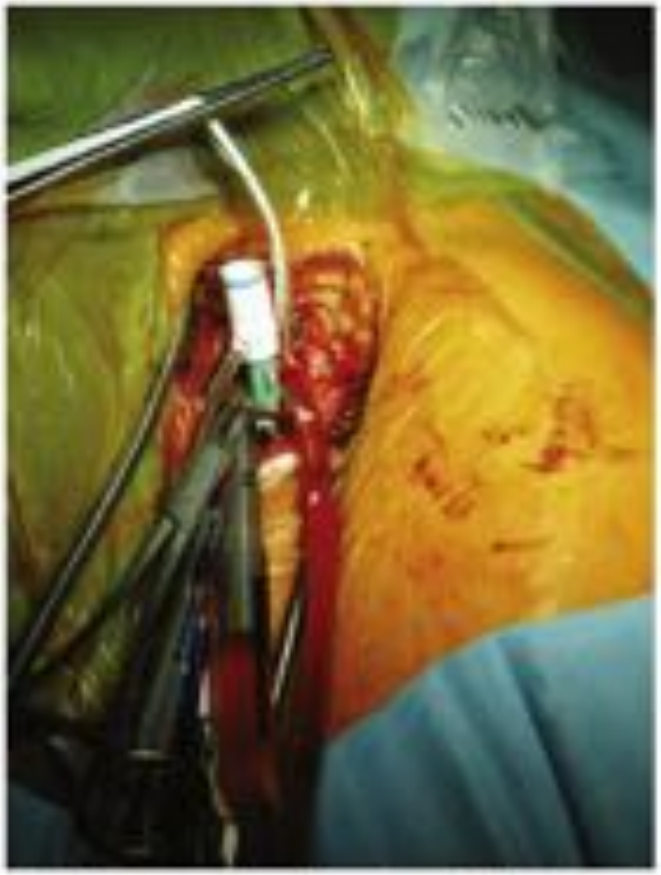


Fig. 1. Retrograde arterial perfusion via femoral access. The femoral artery and vein are cannulated for cardiopulmonary bypass. In addition an arterial access sheath is placed in the femoral artery for distal leg perfusion.

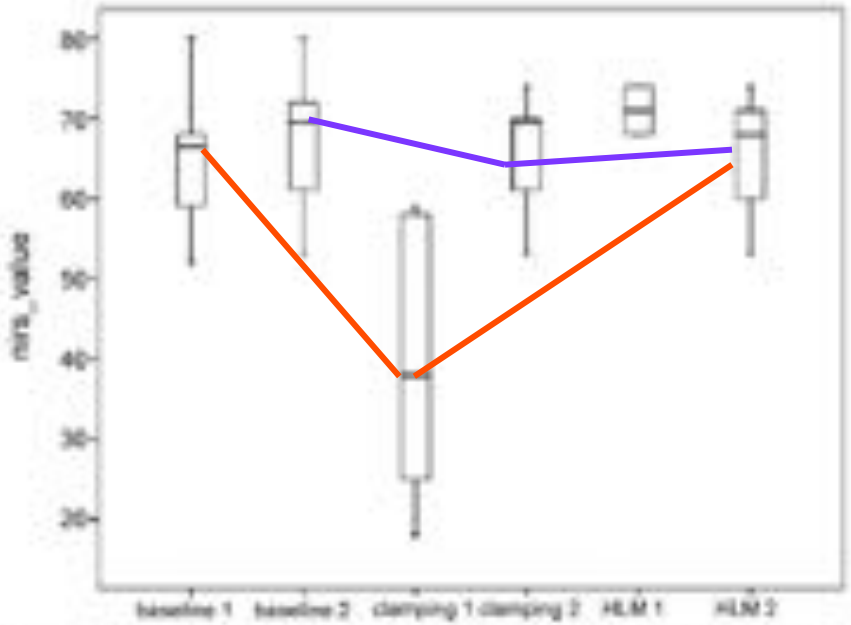
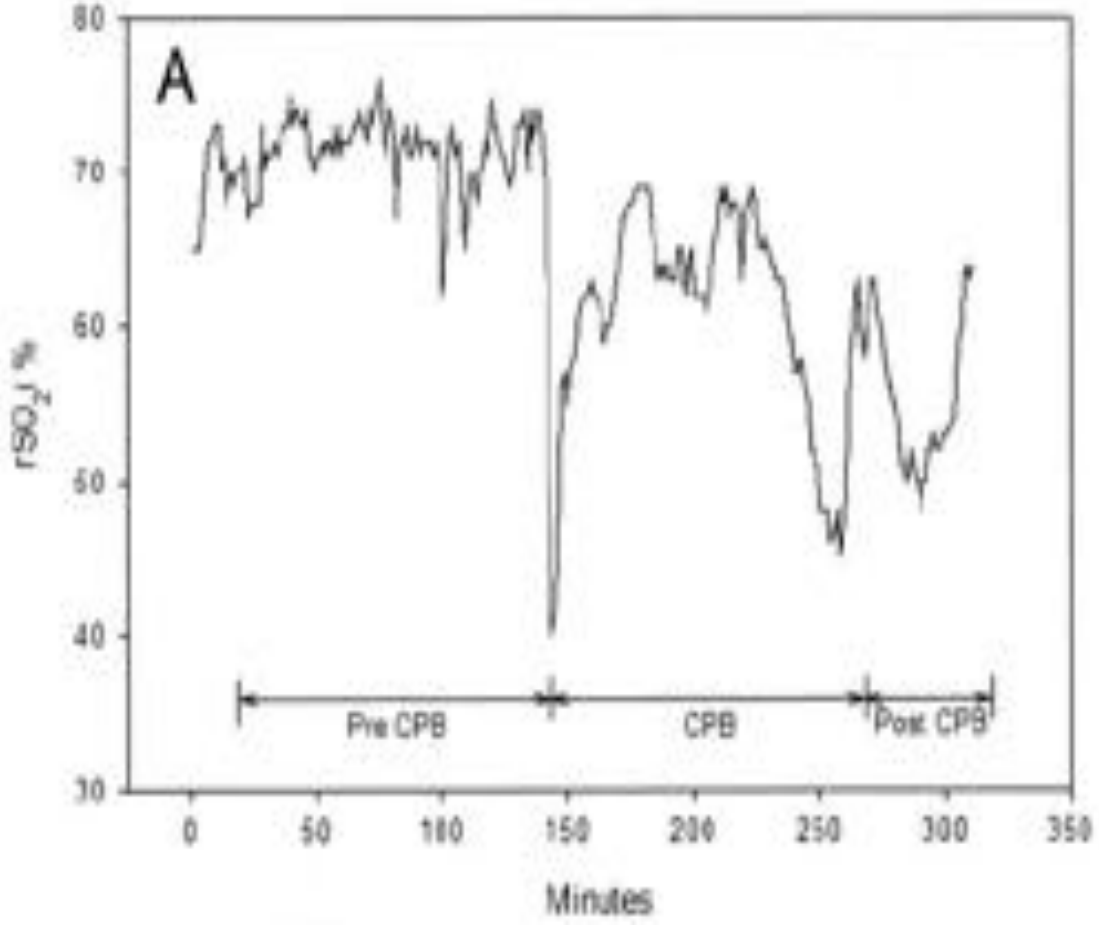


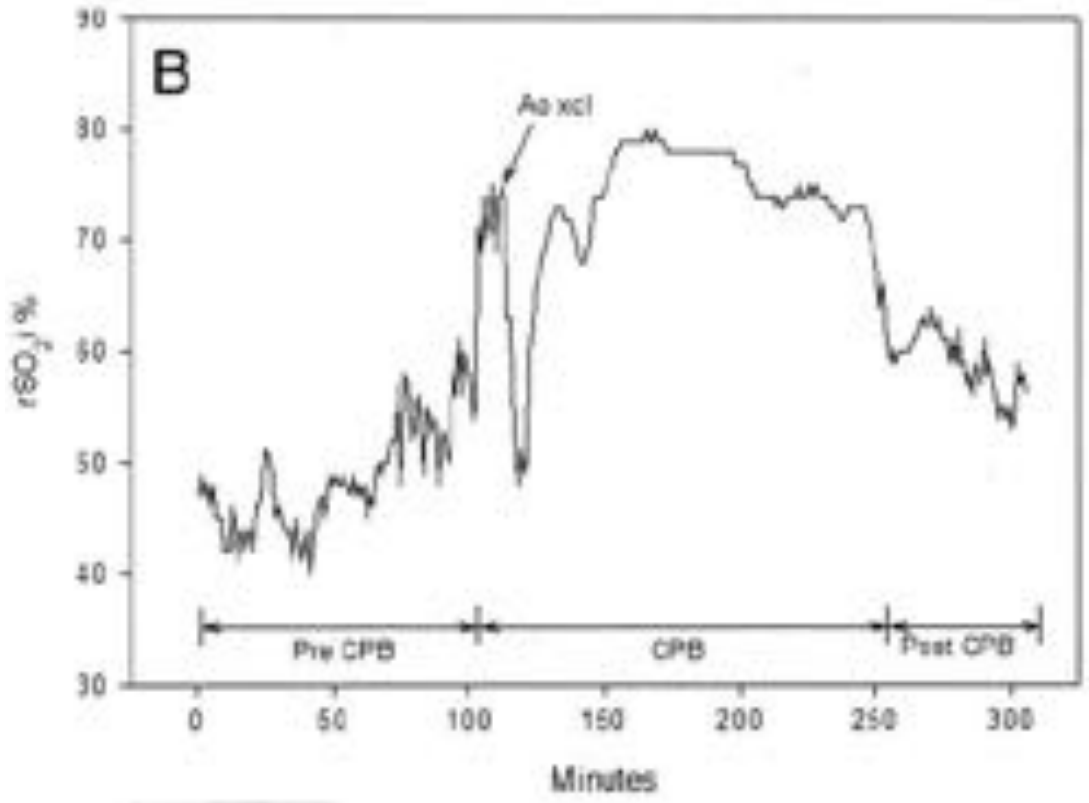
Fig. 2. Values of near infrared spectroscopy (NIRS) measurements on the legs of the perfused side (baseline 1, clamping 1, HLM 1) and contralateral side (baseline 2, clamping 2, HLM 2). Baseline values before femoral cannulation were compared to values after clamping of the femoral artery and values on the heart lung machine (HLM) with distal femoral perfusion on the cannulated side.


90
80
70
60
50
40
30
10:16
2 HEURES
12:16
90
90
40
40
L 83
Avg
80
SSI
R 88
Avg
81
SSI
100
90
80
70
60
50
40
95
90
S1 61
Avg
50
SSI
S2

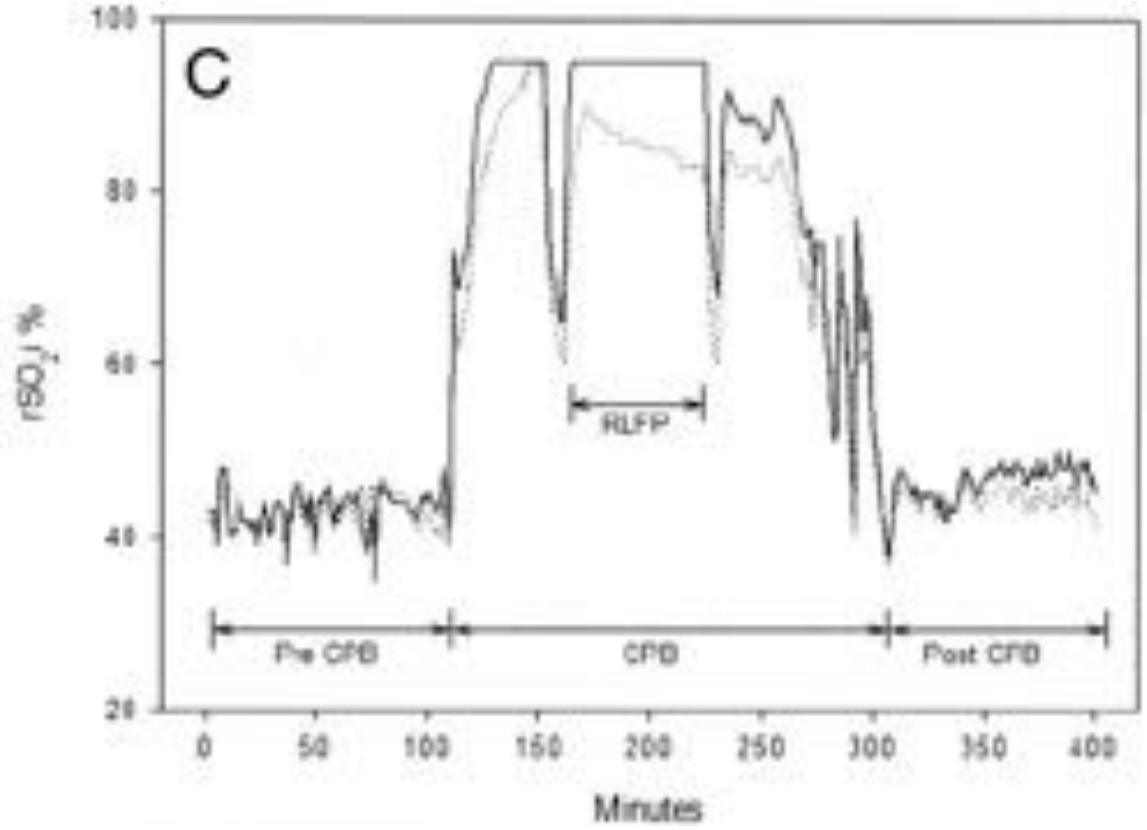
rSo2 c et CEC en normothermie



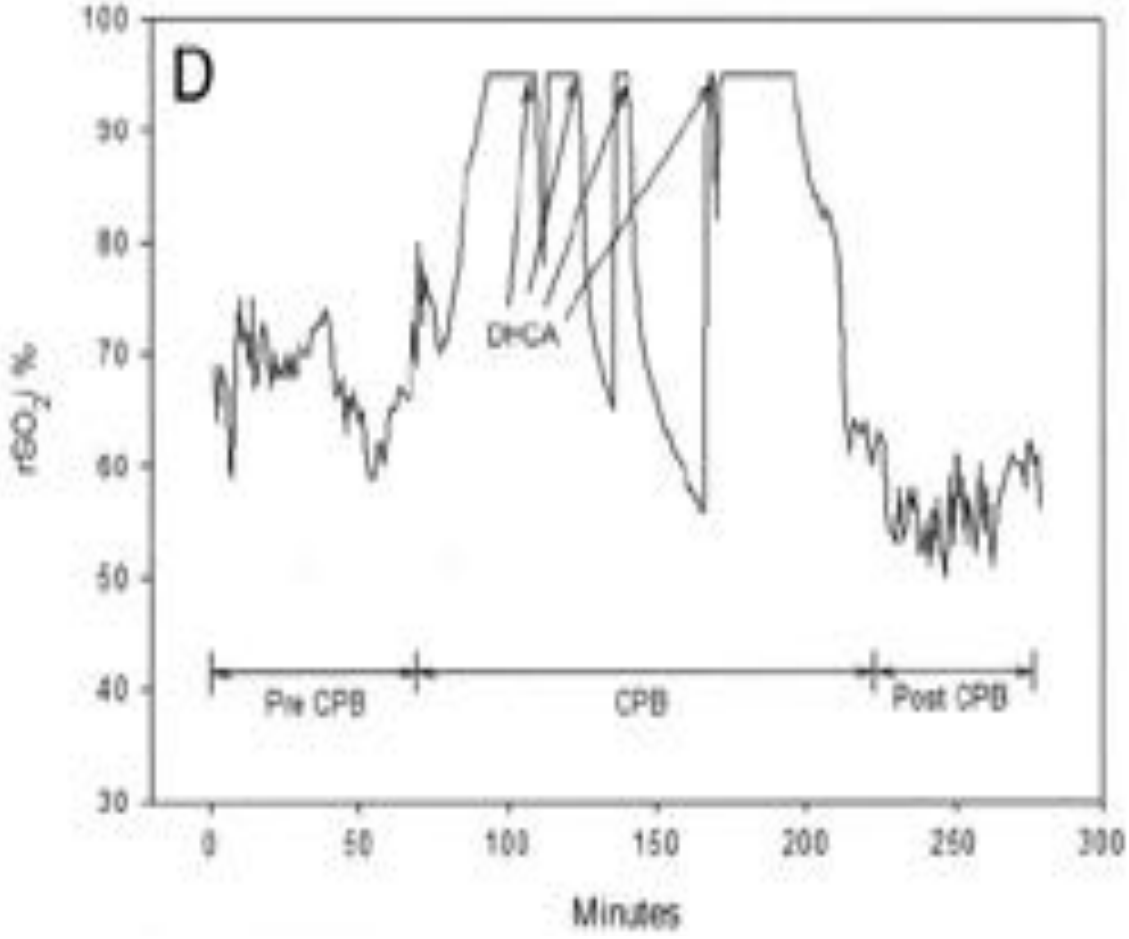
rSo2 c et CEC en hypothermie modérée



rSo2c et CEC en hypothermie profonde et PCS



rSo2 c et ACHP

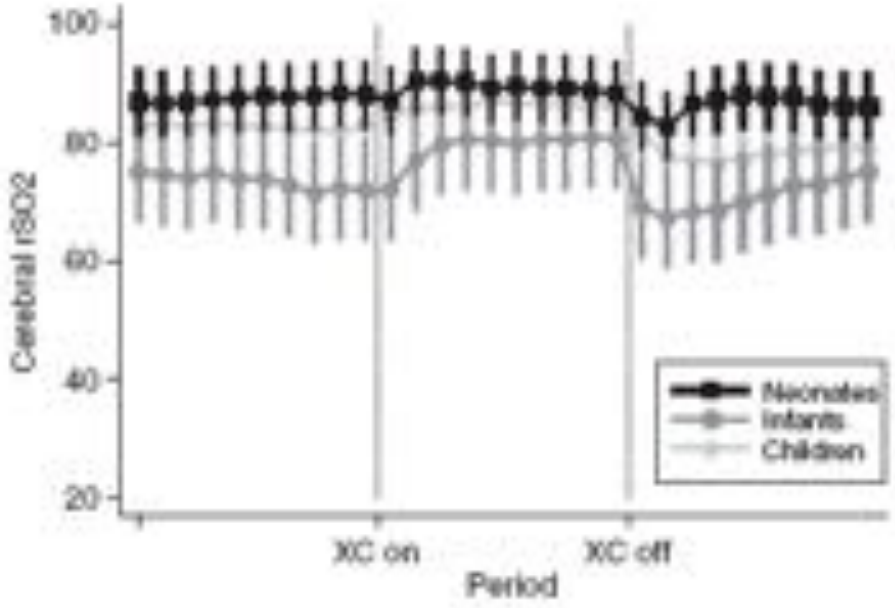


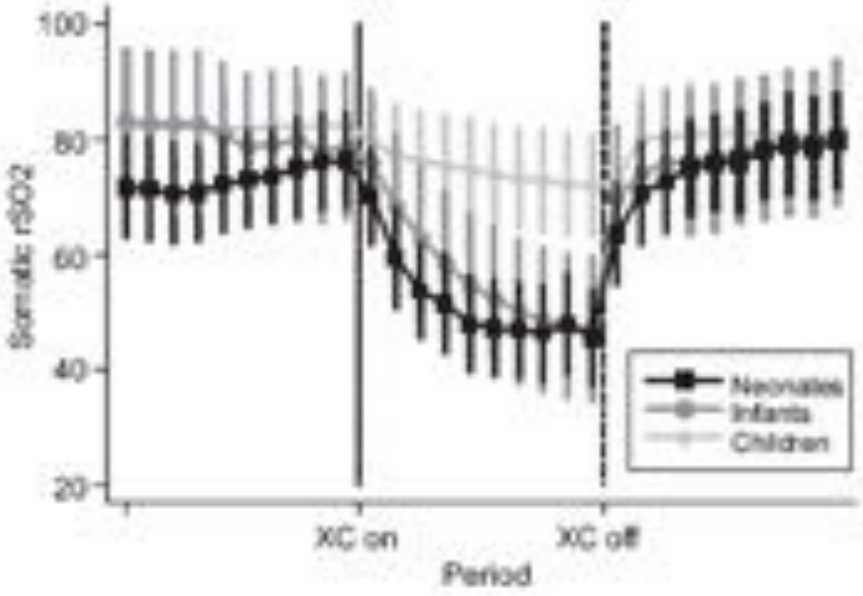
NIRS et Coarctation

Pediatric Anesthesia 2006 **16**: 777–781 doi:10.1111/j.1460-9592.2006.

Near infrared spectroscopy monitoring during pediatric aortic coarctation repair

RICHARD J. BERENS MCW CHW, ECKEHARD A. STUTH MCW


100
80
60
40
20
Cerebral rSO2
Neonates
Infants
Children
XC on
XC off
Period


100
80
60
40
20
Somatic rSO2
Neonates
Infants
Children
XC on
XC off
Period

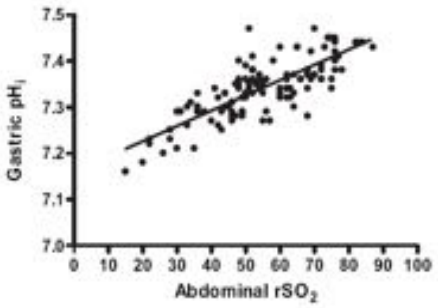
NIRS abdominale et rénale

Correlation of abdominal site near-infrared spectroscopy with gastric tonometry in infants following surgery for congenital heart disease*

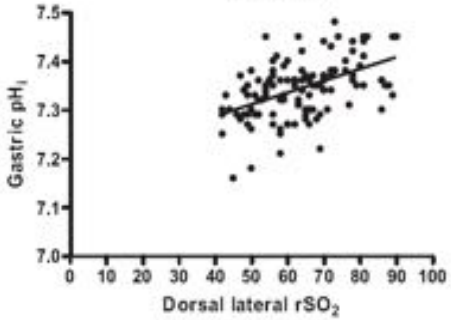
Jon Kaufman, MD; Melvin C. Almodovar, MD; Jeannie Zuk, PhD, RN; Robert H. Friesen, MD

Pediatr Crit Care Med 2008 Vol. 9, No. 1

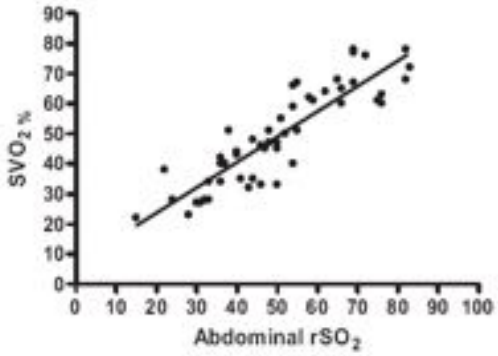
n = 122
r = 0.79
r^2 = 0.63
P < 0.0001



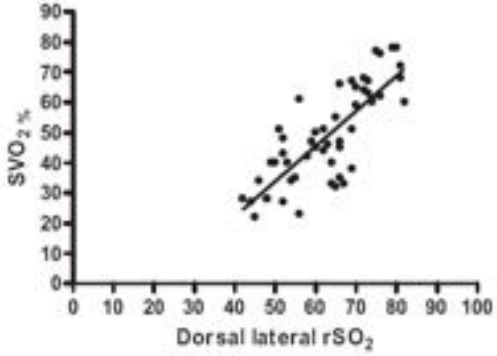
n = 122
r = 0.47
r^2 = 0.22
P = 0.2222



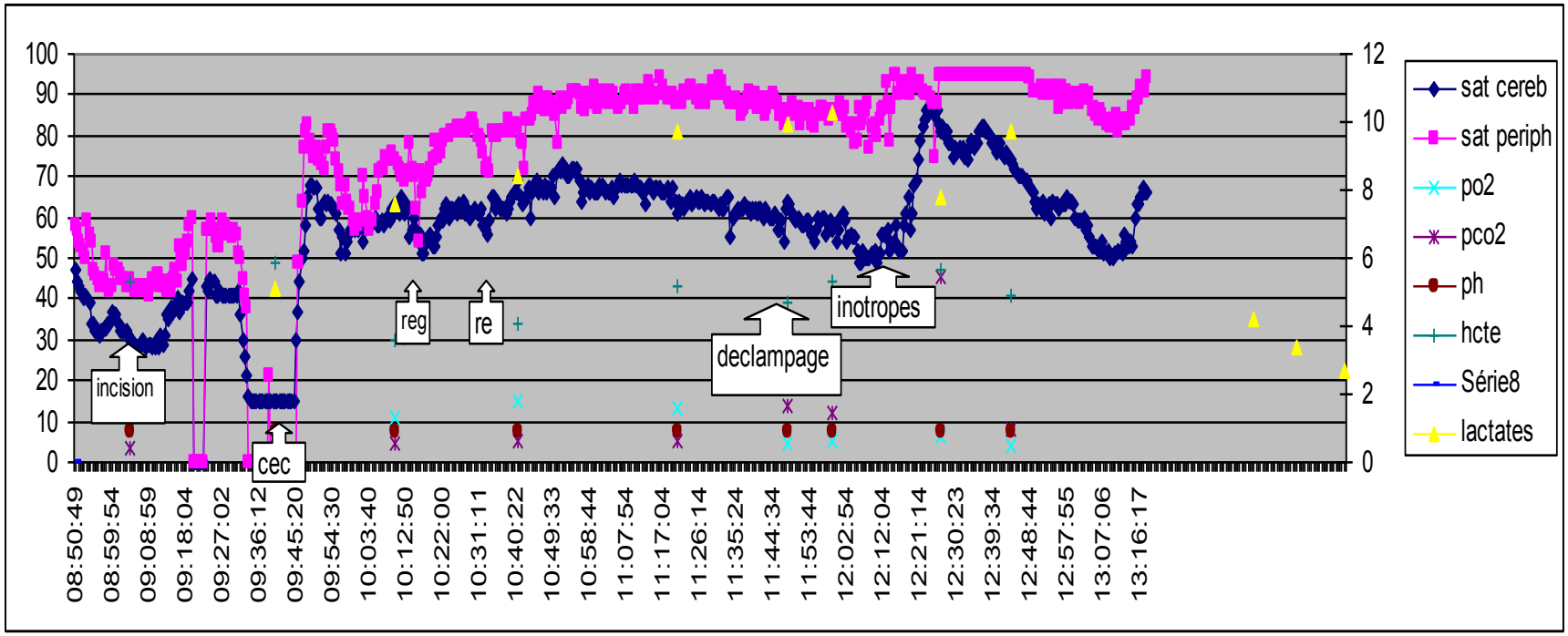
n = 52
r = 0.89
r^2 = 0.78
P < 0.0001



n = 52
r = 0.79
r^2 = 0.64
P < 0.0001



NIRS et switch/CEC

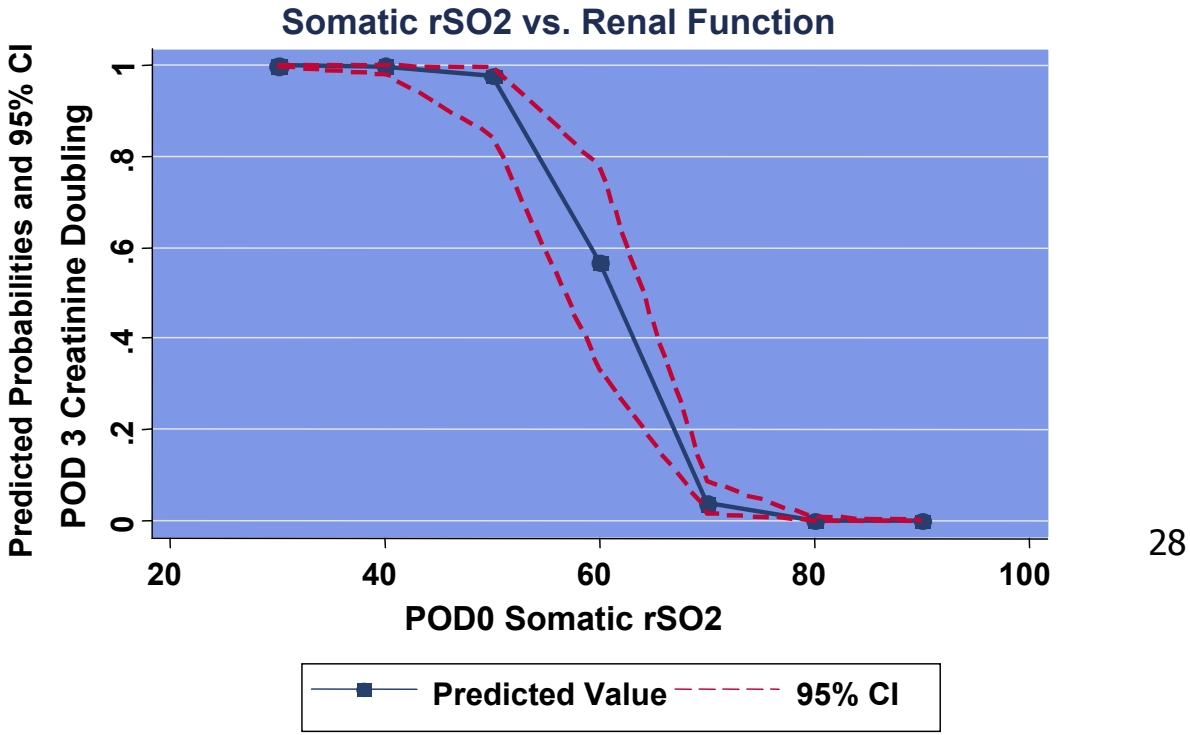


rSO2 rénale et fonction rénale en chirurgie cardiaque

Perioperative Perfusion Assessed by Somatic NIRS Predicts Postoperative Renal Dysfunction

George M. Hoffman, M.D., Nancy S. Ghanayem, M.D., Kathy A. Mussatto, M.S., Ndidi Musa, M.D.
Pediatric Anesthesiology and Critical Care, Medical College and Children's Hospital of Wisconsin, Milwaukee, Wisconsin, United States

Anesthesiology 2005; 103: A1327



ORIGINAL ARTICLE

Low Renal Oximetry Correlates With Acute Kidney Injury After Infant Cardiac Surgery

Gabe E. Owens · Karen King · James G. Gurney · John R. Charpie

Pediatr Cardiol (2011) 32:183–188

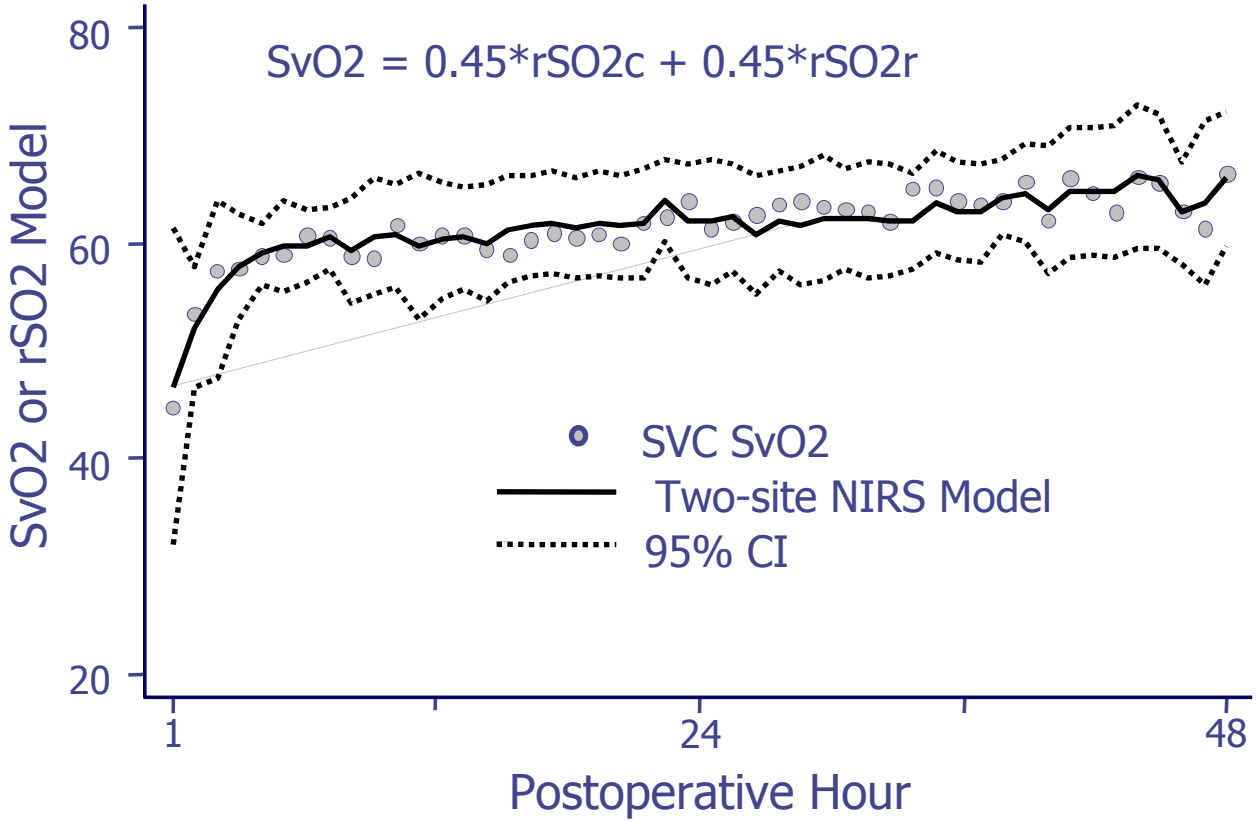
rSo2 <50% 2h

Table 3 Incidence of acute kidney injury (AKI) and evaluation of secondary clinical variables between low and normal oximetry

	Low oximetry ($n = 8$)	Normal oximetry ($n = 32$)	p value[a]
AKI (pRIFLE): n (%)	4 (50)	1 (3.1)	0.003
AKI (ΔCrt >0.4 and >50%): n (%)	5 (63)	5 (16)	0.002
Renal replacement therapy: n (%)	0 (20)	0	0.12
Mechanical ventilation (days)	7.6 ± 3.6	4.2 ±2.9	0.008
Hospital length of stay (days)	15.4 ± 5.7	12.7 ± 11	0.51
Peak creatinine	0.83 ± 0.4	0.52 ± 0.2	0.003
Peak lactate	4.7 ± 4.2	2.9 ± 2.0	0.08
Average lactate	3.0 ± 2.5	1.5 ± 0.7	0.004
VIS peak	23.6 ± 17	13.8 ± 8.8	0.03

Relation SvO2 - 2 sites NIRS

- Précision acceptable en clinique - stable sur la durée
- Hoffman GM, Stuth EA, Berens RJ, et al: Two-site near-infrared transcutaneous oximetry as a non-invasive indicator of mixed venous oxygen saturation in cardiac neonates. Anesthesiology 97:A-1393, 2003



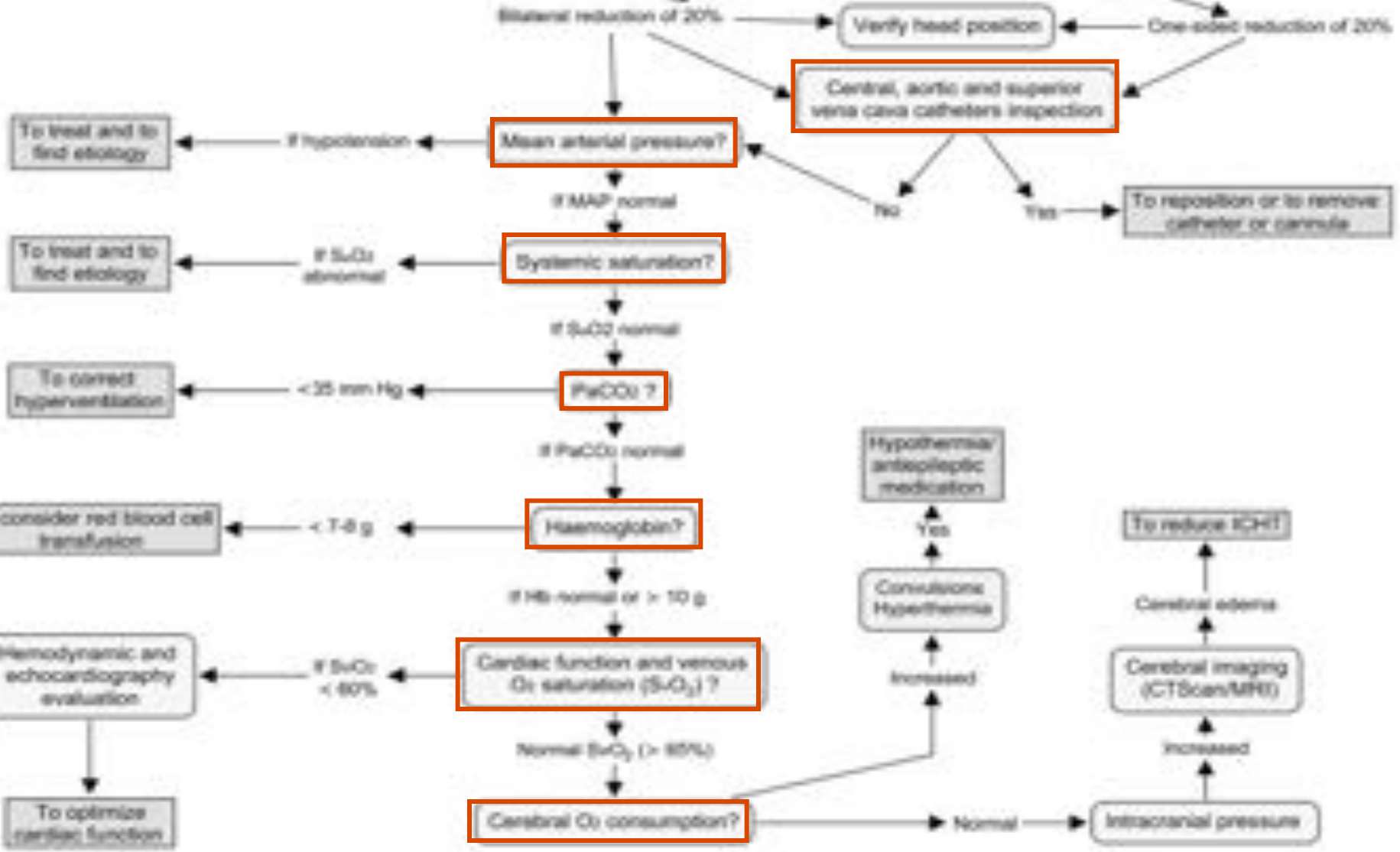
Algorithme décisionnel

A Proposed Algorithm for the Intraoperative Use of Cerebral Near-Infrared Spectroscopy

André Denault, Alain Deschamps and John M. Murkin

Semin Cardiothorac Vasc Anesth 2007; 11; 274
DOI: 10.1177/1089253207311685

Cerebral Saturation



Reversal of Decreases in Cerebral Saturation in High-Risk Cardiac Surgery

Alain Deschamps, PhD, MD,* Jean Lambert, PhD,† Pierre Couture, MD,* Antoine Rochon, MD,* Jean-Sébastien Lebon, MD,* Christian Ayoub, MD,* Jennifer Cogan, MD,* and André Denault, MD, PhD*

Conclusions: **Cerebral desaturation in high-risk cardiac surgery is frequent but can be reversed most of the time resulting in a smaller desaturation load. A large randomized study will be needed to measure the impact of reversing cerebral desaturation on patient's outcome.**

Perioperative cerebral oxygen saturation in neonates with hypoplastic left heart syndrome and childhood neurodevelopmental outcome

George M. Hoffman, MD,[a,b] Cheryl L. Brosig, PhD,[a,b,c] Kathleen A. Mussatto, BSN, PhD,[a,c,d] James S. Tweddell, MD,[a,b,c] and Nancy S. Ghanayem, MD[a,b]

The Journal of Thoracic and Cardiovascular Surgery • November 2013

Conclusions: Neurodevelopmental performance was related to demographic, neonatal perioperative physiologic, and later factors. Perioperative cerebral oxygenation assessed by near-infrared spectroscopy can detect hypoxic-ischemic conditions associated with injury and reduced neurodevelopmental performance and was the most significant physiologic factor identified. These data suggest that efforts to avoid cerebral hypoxia are likely to improve the outcomes in this high-risk population. (J Thorac Cardiovasc Surg

Conclusion

- **Optimiser la perfusion d'organe est l'objectif principal de la CEC**
- **Peu de monitoring permettent de l'évaluer**
- **La NIRS donne directement la SO2 régionale de façon non invasive**
- **Permet de reconnaître rapidement une hypoxie tissulaire et de la corriger**