SFAR
CONGRÈS
du 23 au 25 Septembre 2021
PALAIS DES CONGRÈS DE PARIS

Hémodynamique en pédiatrie

Quel monitorage en anesthésie pédiatrique ?

Dr Marc Lilot

Département d'Anesthésie-Réanimation Cardio-thoracique Pédiatrique
Hôpital Louis Pradel, Groupement Hospitalier Est
Hospices Civils de Lyon
marc.lilot@chu-lyon.fr ; marc.lilot@univ-lyon1.fr

Université Claude Bernard Lyon 1
UNIVERSITÉ DE LYON
Inserm
lyon cles centre lyonnais d'enseignement par la simulation en santé
Hospices Civils de Lyon

Je n’ai pas de conflit d’intérêt

à déclarer

Faculté de Médecine Lyon Est

HCL HOSPICES CIVILS DE LYON

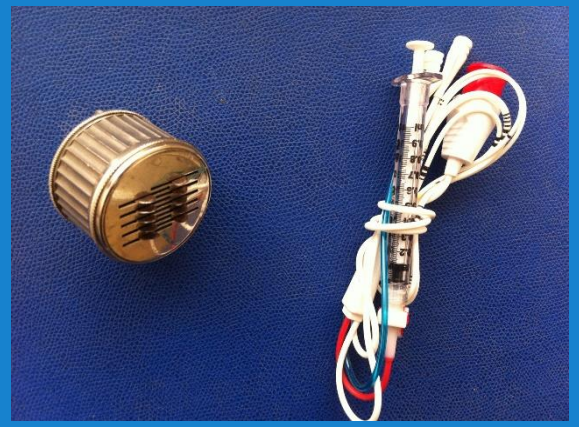
Introduction et monitorage hémodynamique

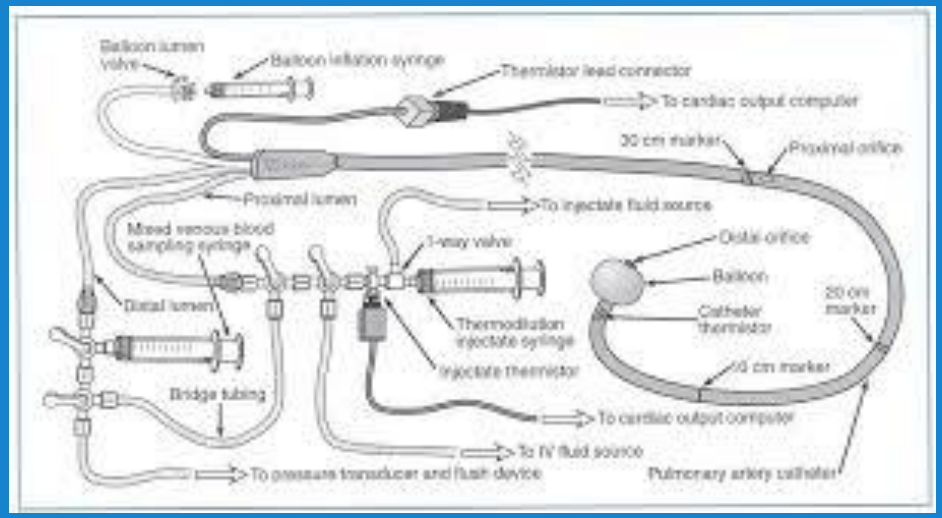
- Changements majeurs des 30 dernières années



Introduction et monitorage hémodynamique

- Changements majeurs des 30 dernières années
- ↘ PAC (Swan-Ganz) ↗ non ou mini-invasif





Introduction et monitorage hémodynamique

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TDTP Pulse contour Bio Imp/Bio react Doppler



Justin J. Skowno, Hemodynamic monitoring in children with heart disease: Overview of newer technologies Pediatric Anesthesia. 2019;29:467–474.

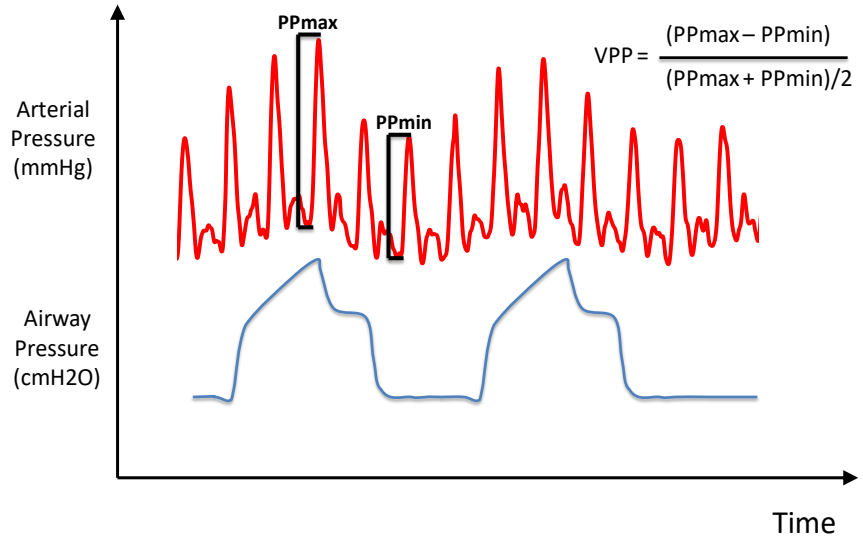
Introduction et monitorage hémodynamique

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- ↘ PAC (Swan-Ganz) ↗ non ou mini-invasif

TDTP Pulse contour Bio Imp/Bio react Doppler

- Monitorage fonctionnel : Stress du paramètre HD





Introduction et monitorage hémodynamique

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- ↘ PAC (Swan-Ganz) ↗ non ou mini-invasif

TDTP Pulse contour Bio Imp/Bio react Doppler

- Monitorage fonctionnel : Stress du paramètre HD

- Concept « Goal Directed Therapy »
  - Paramètre dynamique réponse au remplissage
  - QC-SvO2-RsO2

Introduction et monitorage hémodynamique

- Changements majeurs des 30 dernières années
  - Valeur absolue du débit cardiaque (fiabilité) ?
  - Adéquation aux besoins du patient (DO2/VO2) ?

L'EBM ne nous aidera pas dans ce contexte précis !



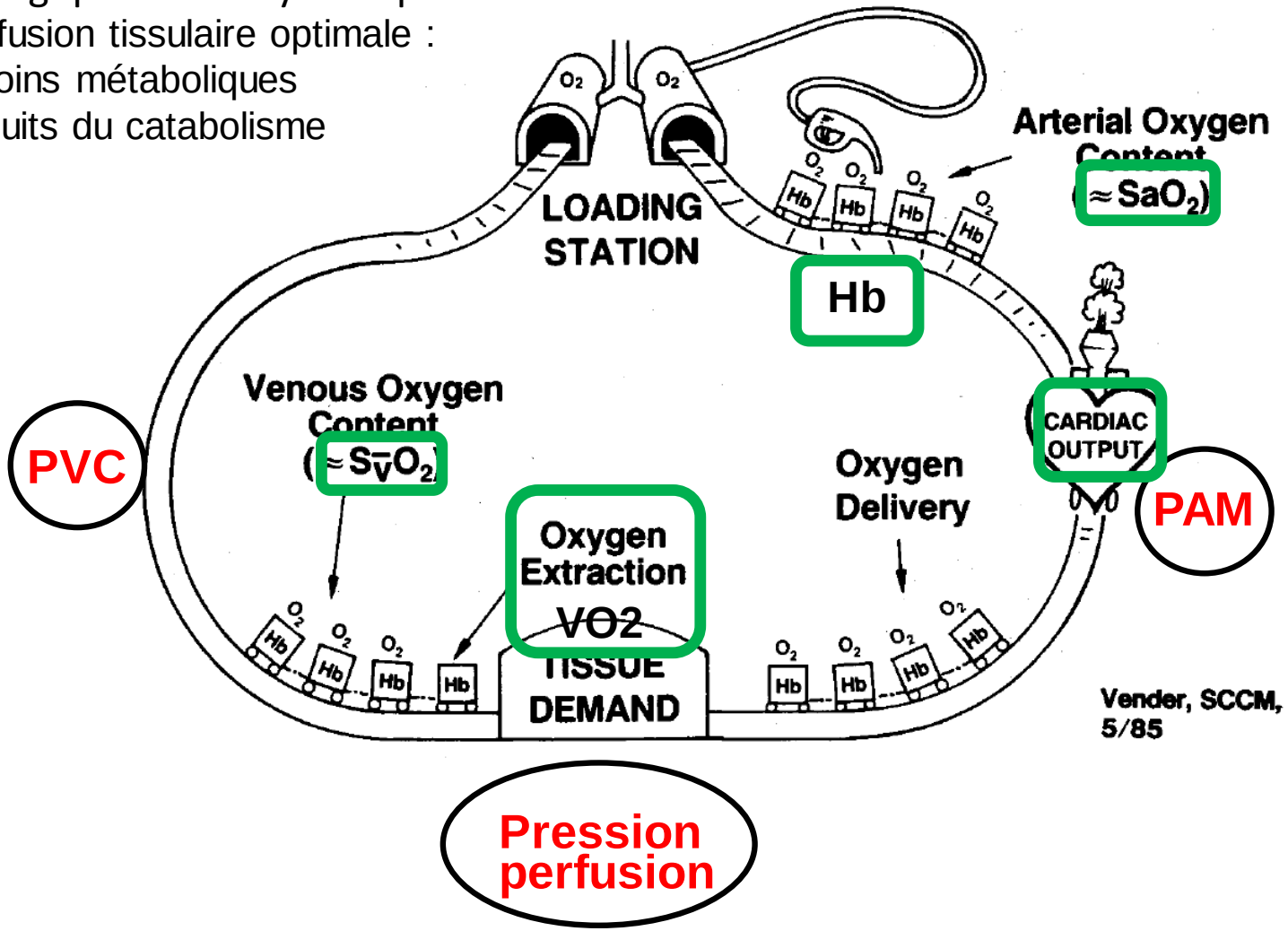
Ce monitor n'est qu'un générateur hasardeux de chiffres sans significations !

Peut-on travailler personnellement et en équipes sur nos propres freins ?

Saugel B, Malbrain MLNG, Perel A. Hemodynamic monitoring in the era of evidence-based medicine. *Crit Care (London, England)*. 2016;20 (1):401.

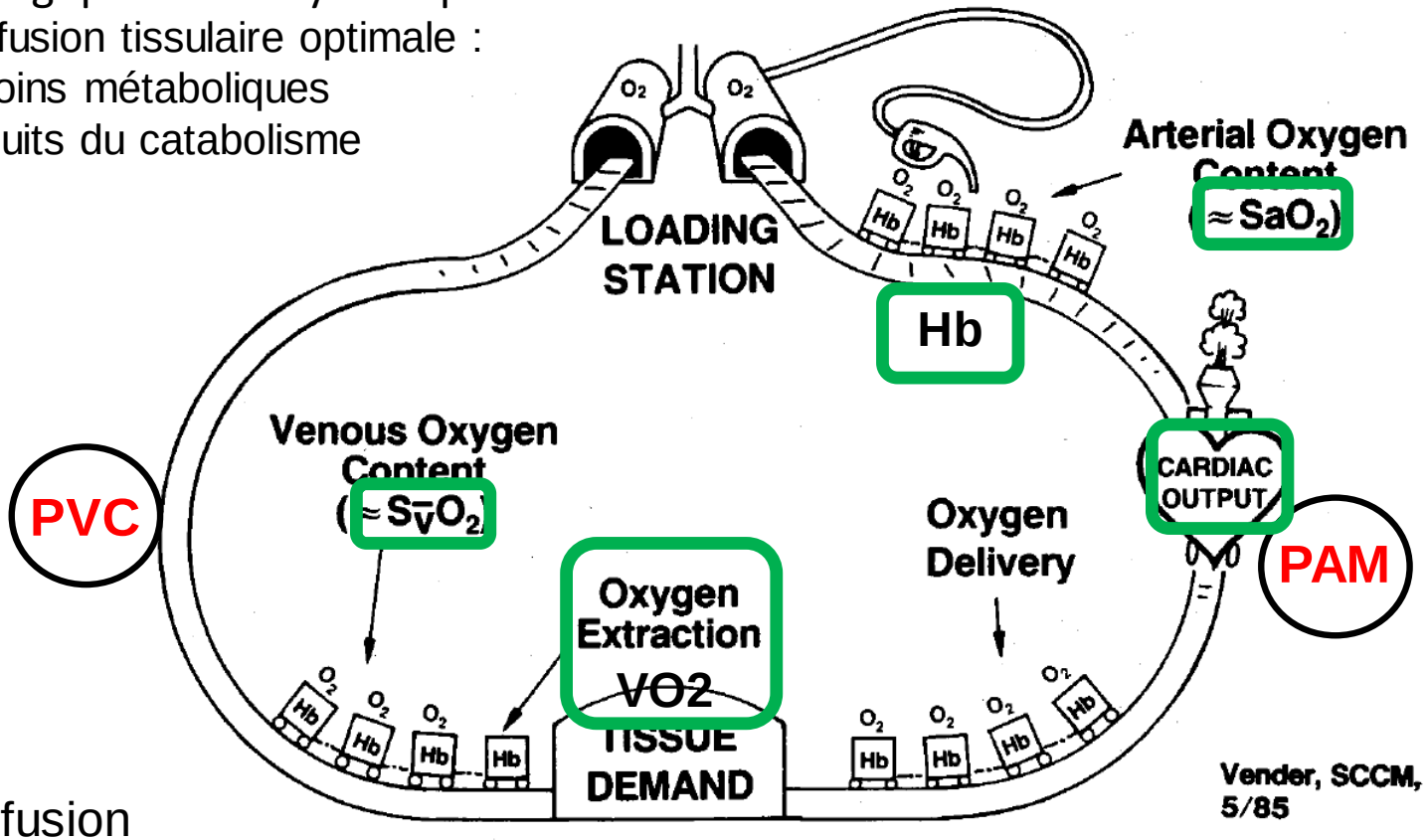
Rappel hémodynamique et expansion volémique

Objectifs physiologiques hémodynamique
Garantir une perfusion tissulaire optimale :
- Couvrir les besoins métaboliques
- Epurer les produits du catabolisme



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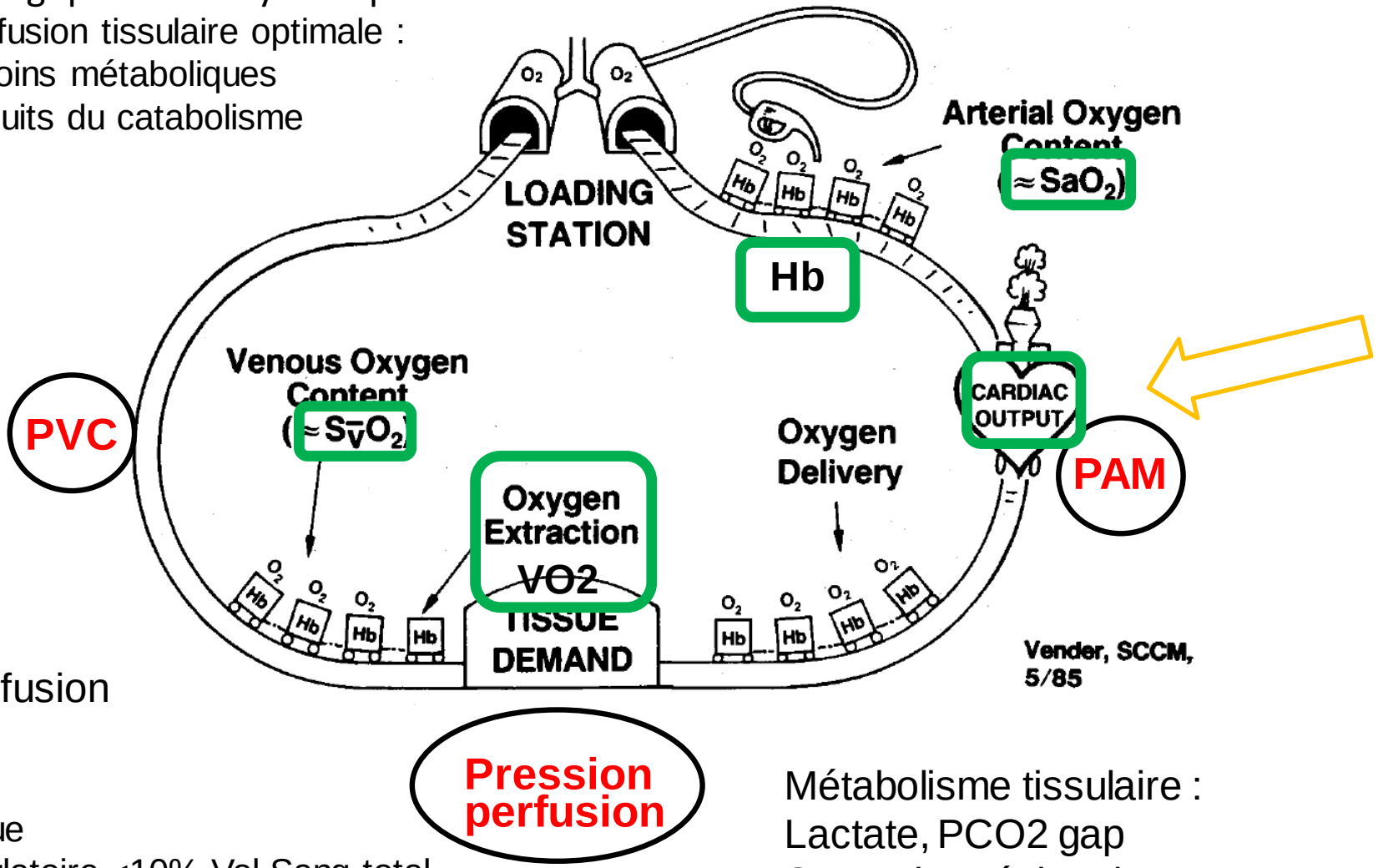
Pression de perfusion (PAM,PAD)

– Débit Systémique
– Débit Microcirculatoire <10% Vol Sang total

Métabolisme tissulaire :
Lactate, PCO2 gap
Saturation régionale

Rappel hémodynamique et expansion volémique

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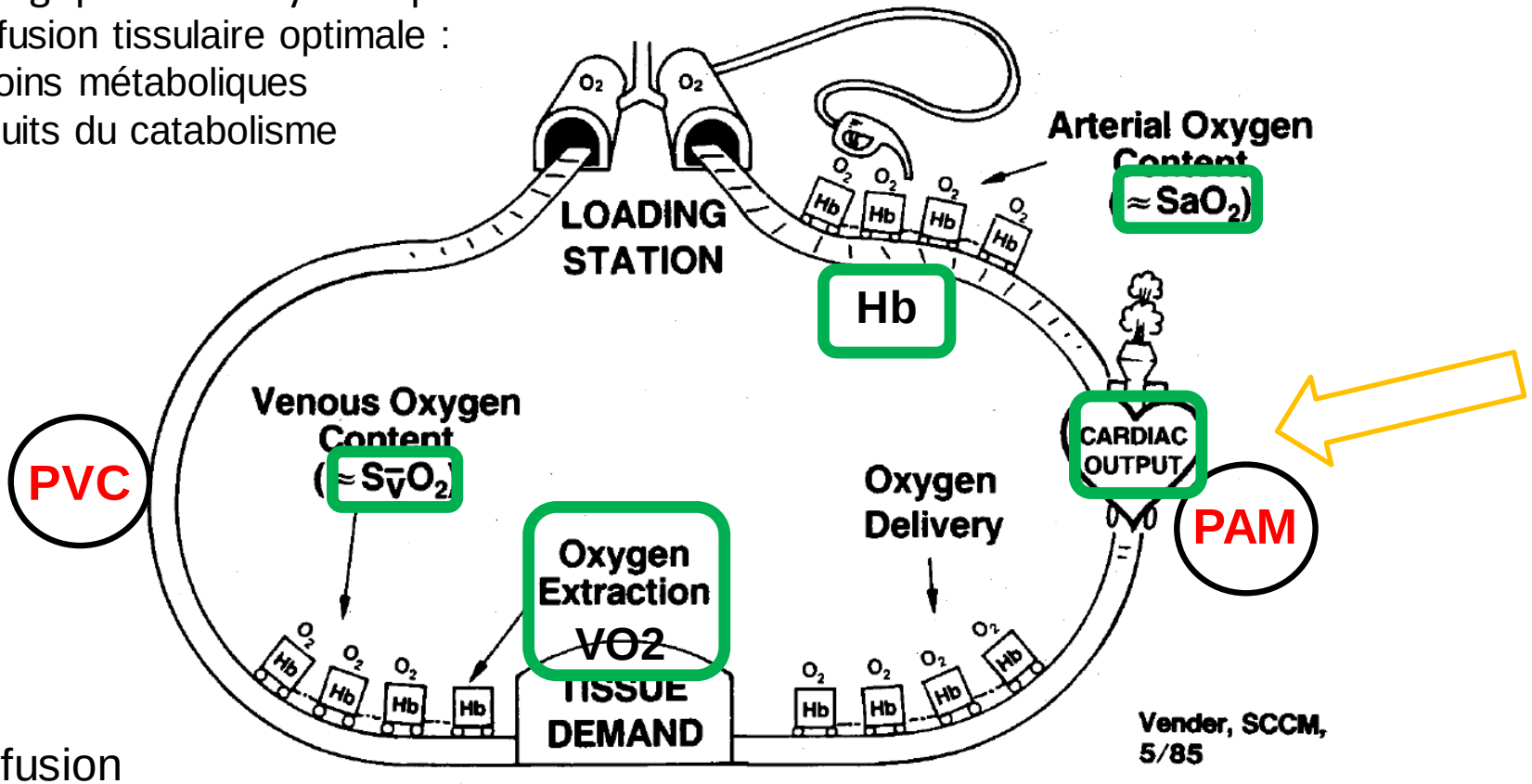
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Pression perfusion

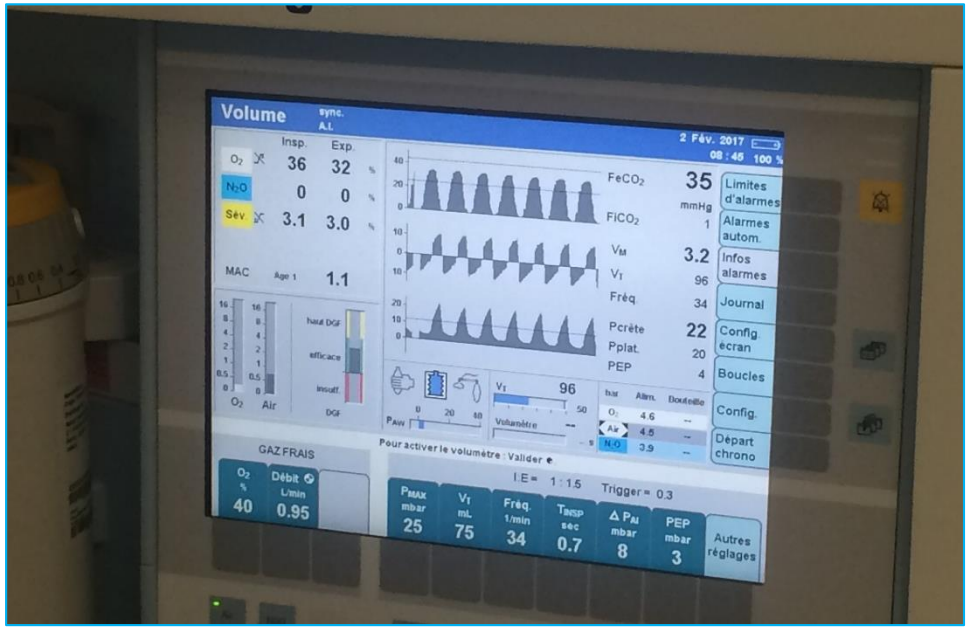
Métabolisme tissulaire :
Lactate, PCO2 gap
Saturation régionale

Eviter :
Insuffisance
Excès d'apport

Monitorage macrocirculatoire

Monitorage hémodynamique simple





Recommandations Nationales

Septembre 2000

Recommandations pour les structures et le matériel de l'anesthésie pédiatrique

Membres du groupe d'experts

C. Ecoffey (Rennes), *coordonnateur*

P. Aknin (Lyon), G. Bazin (Le Mans), J. Bing (Strasbourg), P. Courrèges (Lille), B. Dalens (Clermont-Ferrand), A.M. Devos (Le Havre), E. Giaufré (Marseille), J.P. Guérin (Pau), Y. Meymat (Bordeaux), G. Orliaguet (Paris).

4.1 La fonction cardiovasculaire

La surveillance de l'ECG nécessite d'avoir des électrodes adaptées à la taille de l'enfant.

La surveillance non invasive de la pression artérielle par oscillométrie est possible chez l'enfant, mais nécessite de disposer d'un jeu complet de brassards (taille 1 à 4 et adulte). En pratique, on doit disposer d'un brassard couvrant les 2/3 du bras.

Pour la surveillance invasive de la pression artérielle chez l'enfant, on peut utiliser soit des cathéters veineux courts transcutanés, soit des cathéters spécifiques pour abord artériel.

La surveillance de l'oxymètrie de pouls chez l'enfant nécessite de disposer de capteurs de taille adaptée.

La surveillance de la pression veineuse centrale peut être mesurée après ponction jugulaire, sous-clavière ou fémorale.

Monitorage hémodynamique simple statique

Pression artérielle en pédiatrie

PNI

- Choix brassard de PNI adapté :

  Brassard trop petit → PNI surestimée

- Choix du raccord de PNI adapté :

  Algorithmes ≠

- Corrélation MS-MI

  Moins bonne en péd.



- Complications:

  - Neuropathie tronculaire
  - Ischémie membre

Short JA. Noninvasive blood pressure measurement in the upper and lower limbs of anaesthetized children. Paediatr Anaesth 2000 ;10 : 591-593

Monitorage hémodynamique simple statique

Pression artérielle en pédiatrie

PAI

- Indications :

  Terrains et chirurgies (conséquences ΔPA)

- Vérification qualité du signal

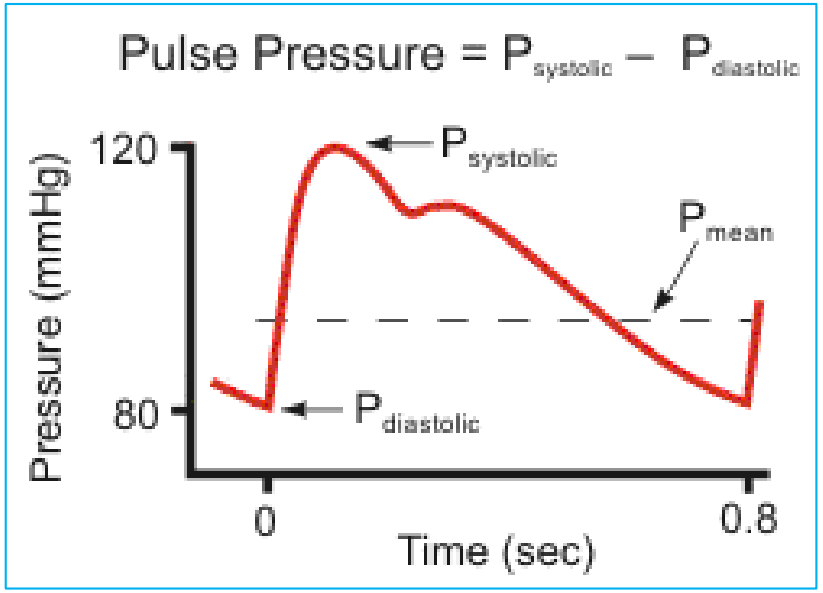
  Niveau zéro

  Gradient aorto-radial + ou –
  (amplification signal)

- Complications :

  - AVC (bulles d'air)
  - Ischémie membre

PAM : P perfusion des organes
PAD : P perfusion du VG et RVS
PAS : post charge VG
PP : VES



Monitorage hémodynamique simple statique

Pression artérielle en pédiatrie

PNI

Joffe et al. Critical Care (2016) 20:177
DOI 10.1186/s13054-016-1354-x

Critical Care

RESEARCH Open Access

The accuracy of blood pressure measured by arterial line and non-invasive cuff in critically ill children

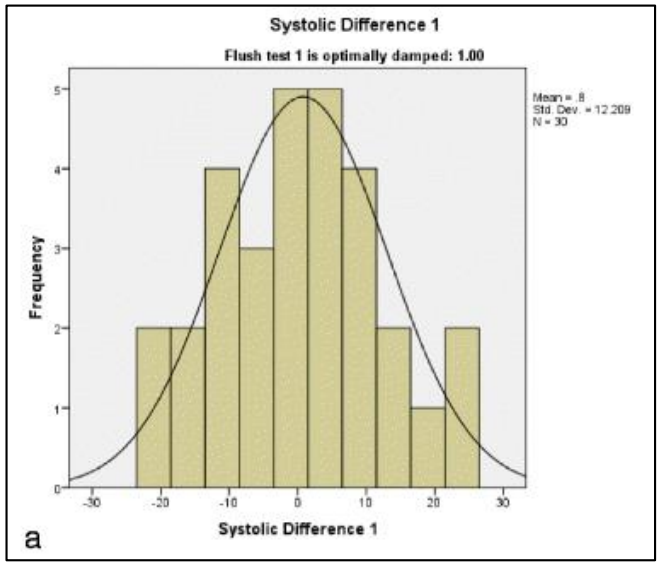
Rachel Joffe[1], Jonathan Duff[2], Gonzalo Garcia Guerra[2], Jodie Pugh[2] and Ari R. Joffe[2,3*]

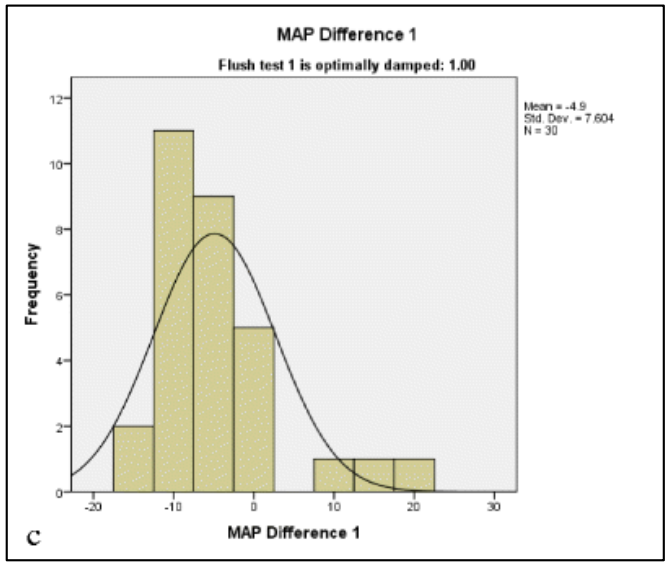
FC plus élevée
PA plus basse

Adulte

PAI

Tracé PAI de haute fidélité





↗ Compliance artérielle
→ PAs plus basse
→ PAd plus élevée
→ PAm plus fiable <6 ans

Curr Opin Anesthesiol 2020, 33:781–787

Monitorage hémodynamique simple statique

Pression artérielle en pédiatrie

- Difficulté de déterminer un seuil pour l'hypotension artérielle

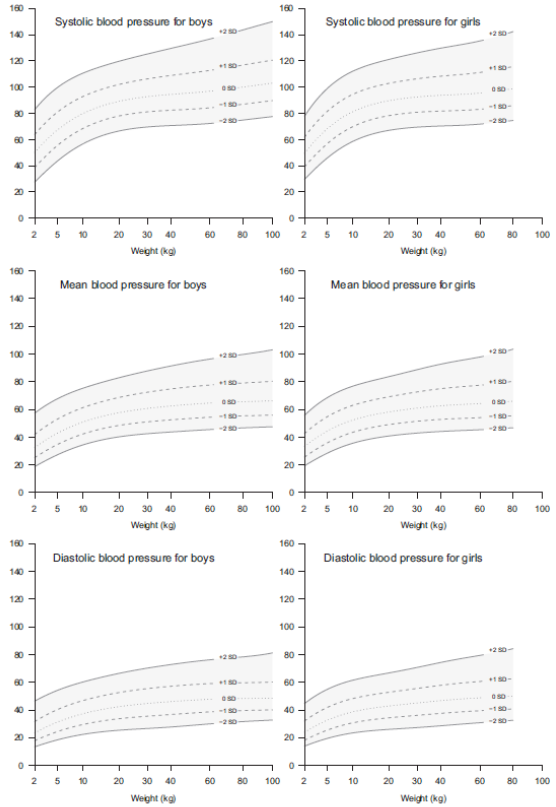


Fig. 4. Reference curves for noninvasive blood pressure for boys and girls during anesthesia during the preparation phase in relation to weight.

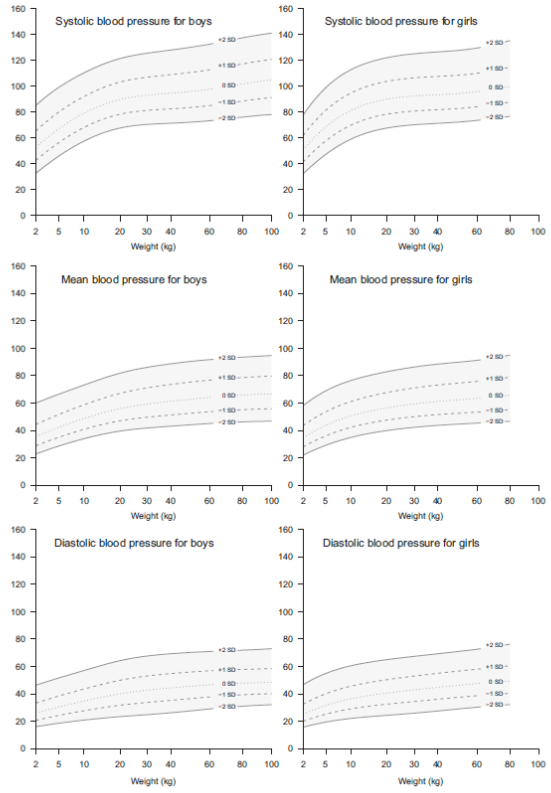


Fig. 5. Reference curves for noninvasive blood pressure for boys and girls during anesthesia during the surgical phase in relation to weight.

Table 1. Baseline Characteristics of Included Pediatric Cases (n = 116,362)

	All Participants	< 2 yr old
Cases	116,362	22,455
Age		
< 2 mo	2,122 (1.8)	2,122 (9.5)
2–12 mo	11,051 (9.5)	11,051 (49.2)
1 yr	9,282 (8.0)	9,282 (41.3)
2–5 yr	28,359 (24.4)	
6–8 yr	16,624 (14.3)	
9–11 yr	13,584 (11.7)	
≥ 12 yr	35,340 (30.4)	
ASA PS		
1	59,581 (51.2)	12,620 (56.2)
2	56,781 (48.8)	9,835 (43.8)
Vital signs available		
Only preprocedure start	22,079 (19.0)	4,220 (18.8)
Only postprocedure start	8,183 (7.0)	1,982 (8.8)
Both	86,100 (74.0)	16,253 (72.4)
Weight (median, IQR)	24.1 (14.0–50.0)	9.1 (6.9–10.9)
Weight known	104,977 (90.2)	20,240 (90.1)
Height (median, IQR)	127 (96–160)	73 (64–79)
Height known	78,242 (67.2)	13,358 (59.5)
Sex		
Male	67,501 (58.0)	15,190 (67.6)
Female	48,861 (42.0)	7,265 (32.4)
Surgical service		
Otolaryngology	21,636 (18.6)	3,255 (14.5)
Orthopedics	20,153 (17.3)	1,246 (5.5)
Urology	16,473 (14.2)	5,871 (26.1)
General	14,577 (12.5)	4,513 (20.1)
Ophthalmology	10,489 (9.0)	2,140 (9.5)
Plastics	7,898 (6.8)	2,125 (9.5)
Other	25,136 (21.6)	3,305 (14.7)

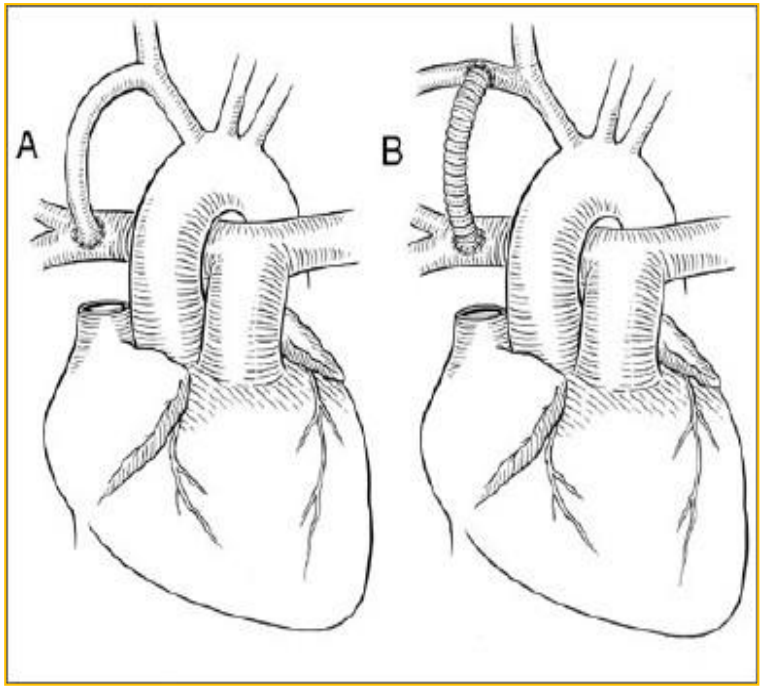
Values are given as the number of cases (n) and percentage of group (%), unless otherwise stated.
ASA PS = American Society of Anesthesia physical status; IQR = interquartile range.

Jurgen C. de Graaff Reference Values for Noninvasive Blood Pressure in Children during Anesthesia. Anesthesiology 2016; 125:904-13

Monitorage hémodynamique simple statique

Pression artérielle en pédiatrie

- Difficulté de déterminer un seuil pour l'hypotension artérielle
- Anastomose systémico-pulmonaire amortissement signal MS



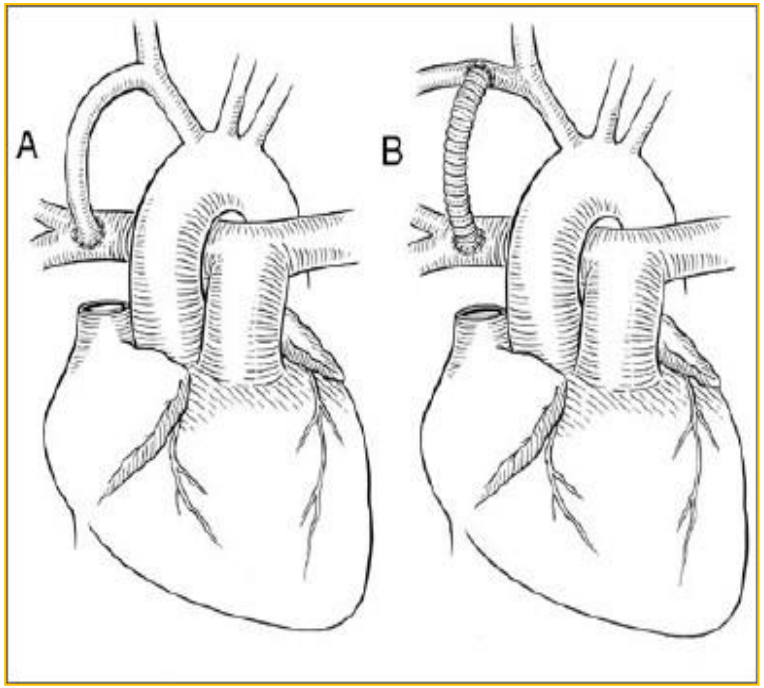
Monitorage hémodynamique simple statique

Pression artérielle en pédiatrie

- Difficulté de déterminer un seuil pour l'hypotension artérielle
- Anastomose systémico-pulmonaire amortissement signal MS

Chez l'adulte l'hypotension artérielle est toujours

- Pathologique
- Grave



Monitorage hémodynamique simple statique

Pression artérielle en pédiatrie

PNI

PAI

PNI : conditions de mesure : bras ++

Pression invasive :

Validité de la mesure

Difficulté en pédiatrie

Interaction cœur – Poumon

Pré-charge dépendance ?

Medical Devices: Evidence and Research 2019:12 297–303

Monitorage hémodynamique simple statique

Pression artérielle invasive en pédiatrie

Table 1 Recommendations on use of clinical examination and blood pressure measurement in hemodynamic monitoring in critically ill children

Sr No	Recommendation	Level of agreement
Clinical signs		
1.	There is no single clinical parameter that allows to evaluate the global hemodynamic status in children and, therefore, we recommend to analyze several parameters and make frequent assessments.	Strong agreement
2.	We recommend to perform a clinical assessment as the initial evaluation in all patients for the detection of hemodynamic alterations and to evaluate clinical signs periodically together with hemodynamic monitoring parameters in unstable patients.	Strong agreement
3.	We do not recommend to titrate hemodynamic therapy or fluid loading solely based upon clinical signs or a reduced urine output alone in unstable patients with the exception of the initial resuscitation phase.	Strong agreement
Arterial blood pressure		
4.	We recommend the use of intra-arterial blood pressure (IBP) over oscillometric blood pressure (OBP) measurement when a reliable blood pressure (BP) measurement is of importance or when fast changes in blood pressure need to be detected.	Strong agreement
5.	In children over 12 years of age we recommend a target blood pressure of ≥ 65 mmHg MAP (according to adults surviving sepsis guidelines) unless in children known to have prior hypertension.	Strong agreement
6.	We recommend not to use BP as the only therapeutic target in unstable children. The hemodynamic state should be evaluated integrating several clinical and hemodynamic parameters.	Strong agreement
7.	We recommend IBP monitoring in children in shock not responsive to initial fluid therapy or requiring vasopressor treatment, and hypertensive emergencies to control the effect of continuous invasive hypotensive drugs.	Strong agreement

PAI

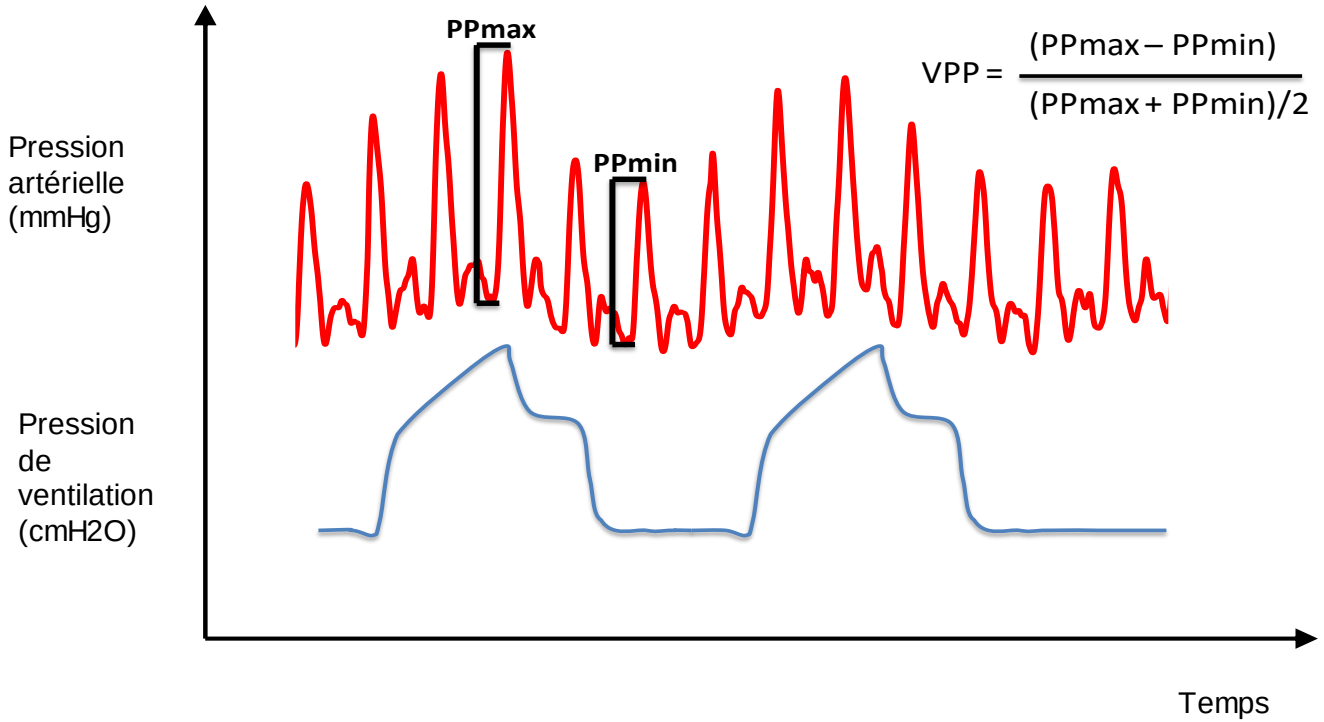
Indication si :
Inotrope IVSE
Vasopresseur IVSE
HTIC et mesure PPC
« major surgery »

Singh Y, Villaescusa JU, da Cruz EM, Tibby SM, Bottari G, Saxena R, Guillén M, Herce JL, Di Nardo M, Cecchetti C, Brierley J, de Boode W, Lemson J. Recommendations for hemodynamic monitoring for critically ill children-expert consensus statement issued by the cardiovascular dynamics section of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC). Crit Care. 2020 Oct 22;24(1):620. doi: 10.1186/s13054-020-03326-2. PMID: 33092621

Monitorage hémodynamique simple dynamique

Variation respiratoire de la pression artérielle pulsée (VPP)

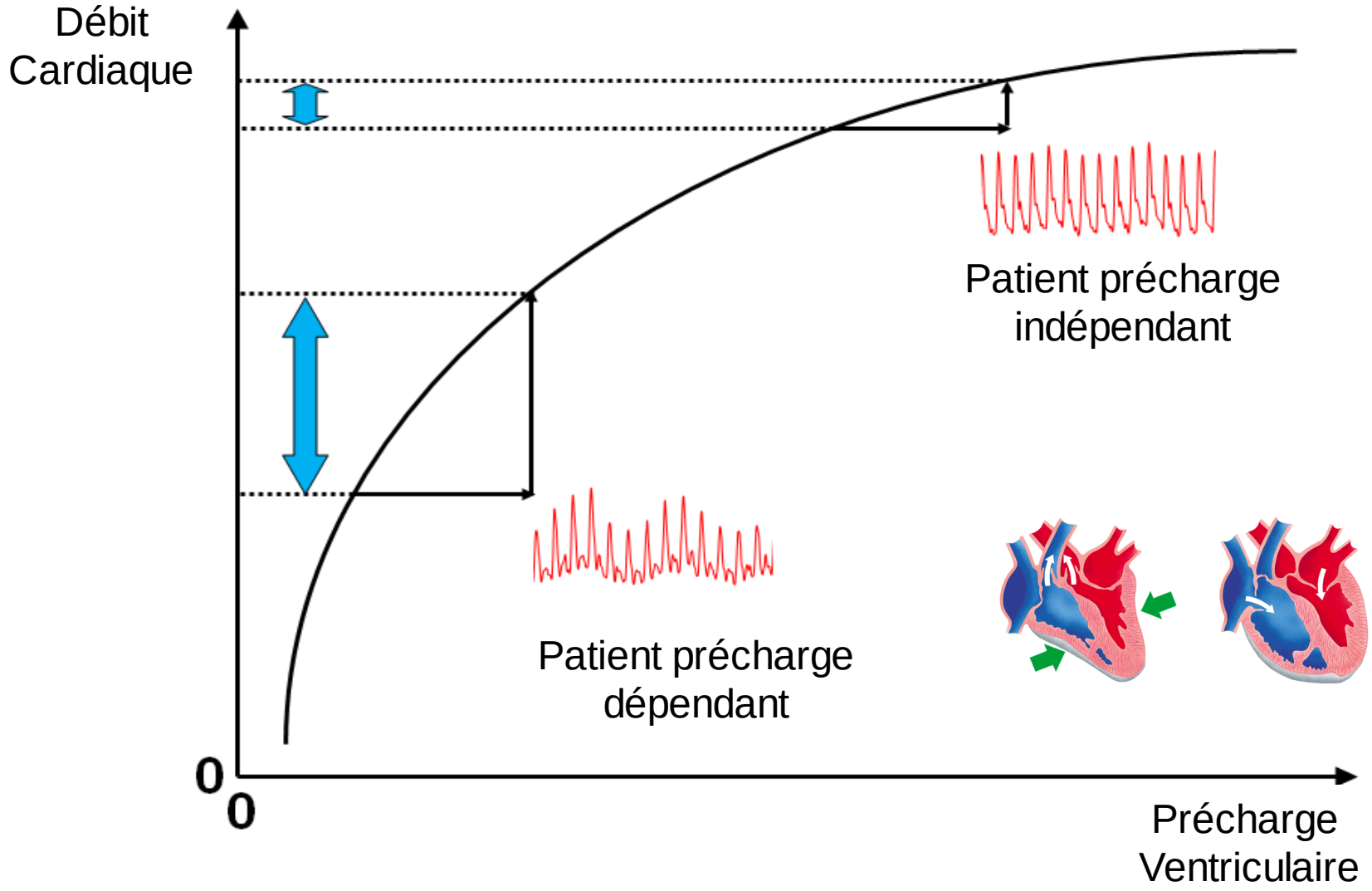
PAI



Les Variations de la Pression Pulsée sont calculées avec les pressions pulsées maximales et minimales à partir de la courbe de la pression artérielle invasive.

Monitorage hémodynamique simple dynamique

Variation respiratoire de la pression artérielle pulsée (VPP)



Monitorage hémodynamique simple dynamique

VPP et Réflexions

Vt < 7 ml/kg	→ Faux Négatif
FC/FR ≤ 3,6	→ Faux Négatif
Thorax ouvert	→ Faux Négatif
Arrhythmie	→ Faux Négatif et Positif
Effort inspiratoire	→ Faux Négatif et Positif
Hypertension intra abdominale	→ Faux Positif
Défaillance ventriculaire droite	→ Faux Positif
PEEP ≥ 5cmH20	→ Faux Positif

Aujourd'hui : Alertes possibles par paramétrages intégratifs

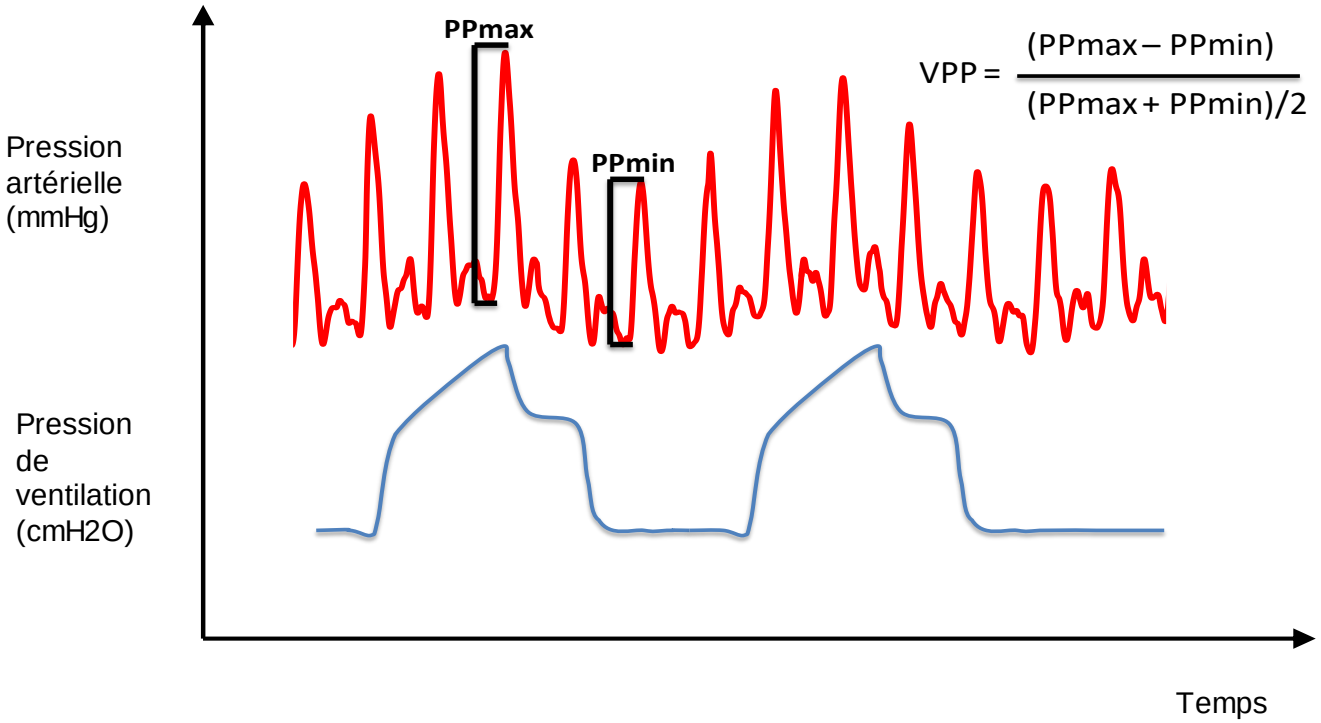
Biais, et al, Anesthesiology 2012; 116:1354 – 61

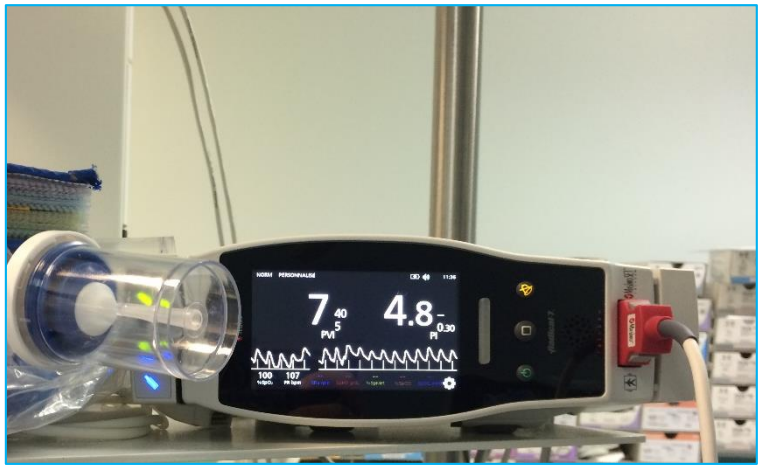
Justin J. Skowno, Hemodynamic monitoring in children with heart disease: Overview of newer technologies Pediatric Anesthesia. 2019;29:467–474.

Monitorage hémodynamique simple dynamique

VPP et compliance vasculaire pédiatrique

PAI





Compliance artérielle vasculaire en pédiatrie invalide le VPP. → Faux négatif ?
Contrairement au VVES : Fort prédicteur de la réponse au RV avec le ΔVPic au doppler œsophagien

Durand et al. 2008; Pereira de Souza Neto et al. 2011; Renner et al. 2011

Monitorage hémodynamique simple dynamique

Mobilisation de volume intravasculaire en pédiatrie

Intérêt des :

- Test de lever de jambe passif : Δ SV > 10% en ETT. Faible volume ?

Si > 5 ans

Lukito V, Djer MM, Pudjiadi AH, Munasir Z. The role of passive leg raising to predict fluid responsiveness in pediatric intensive care unit patients. Pediatr Crit Care Med. 2012;;13((3):):155––160.

El-Nawawy AA, Farghaly PM, Hassouna HM, Accuracy of Passive Leg Raising Test in Prediction of Fluid Responsiveness in Children. Int J Clin Pediatr Dent 2020;24(5):344–349.

Lu GP, Yan G, Chen Y, Lu ZJ, Zhang LE, Kissoon N. The passive leg raise test to predict fluid responsiveness in children—preliminary observations. Indian J Pediatr 2015; 82: 5-12.

- Test de compression abdominale

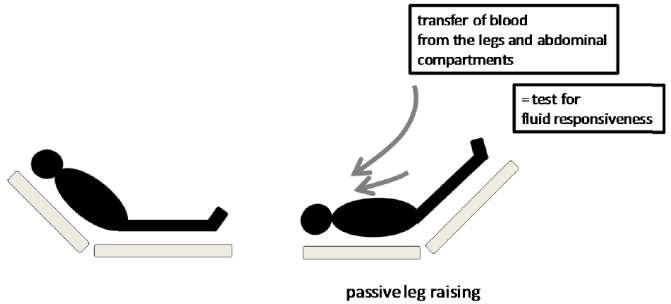


Figure 4 Passive leg raising. The passive leg raising test consists in measuring the hemodynamic effects of a leg elevation up to 45°. A simple way to perform the postural maneuver is to transfer the patient from the semirecumbent posture to the passive leg raising position by using the automatic motion of the bed.

Monitorage hémodynamique simple dynamique

Mobilisation de volume intravasculaire en pédiatrie

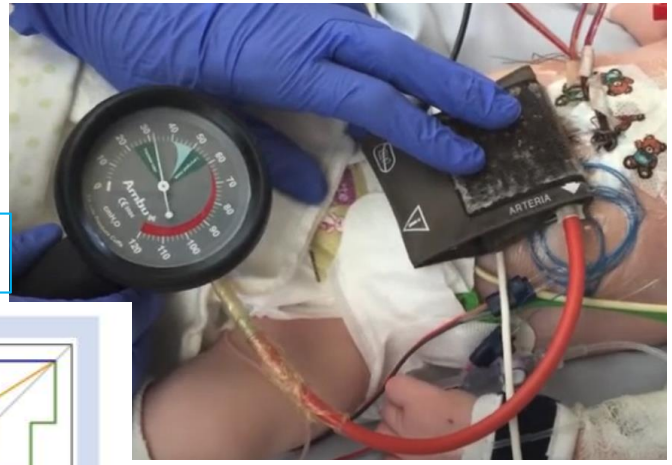
Diagnostic accuracy of a calibrated abdominal compression to predict fluid responsiveness in children

British Journal of Anaesthesia, 121 (6): 1323–1331 (2018)
doi: 10.1016/j.bja.2018.06.030
Advance Access Publication Date: 6 September 2018
Paediatric Anaesthesia

M. Jacquet-Lagrèze[1,5,*], N. Tiberghien[1], J.-N. Evain[2], N. Hanna[1], S. Courtil-Teyssedre[2], M. Lilot[3,5,6,7], F. Baudin[2,5], L. Chardonnal[1], D. Bompard[1], C. Koffel[1], A. Portefaix[4], E. Javouhey[2,5] and J.-L. Fellahi[1,5]

Post op : Défaillance circulatoire

ΔVES : seuil 11% Sp 95% Se 75%



https://www.youtube.com/watch?v=5x3p2hUY7zw&ab_channel=MatthiasJacquet-Lagreze

Table 3 Diagnostic accuracy: characteristics of ΔSVi-CAC, ΔPP-CAC, ΔVpeak and ΔIVC. As ΔSVi-VE is a continuous variable and the choice of the thresholds might be questioned, we report different thresholds in this table (5%, 10%, 15%, and 20%) to define fluid responders. Details of thresholds, specificity, sensitivity, positive predictive value and negative predictive value, are provided when the lower limit of the confidence interval of the ROC_{AUC} is more than 0.5. ΔIVC, respiratory variation of the inferior vena cava diameter; ΔPP-CAC, pulse pressure variation during a calibrated abdominal compression; ΔSVi-CAC, stroke volume index variation during abdominal compression; ΔSVi-VE, stroke volume index variation during volume expansion; ΔVpeak, Respiratory variation of the maximum velocity of the velocity time integral of left ventricular outflow tract; NPV, negative predictive value; PPV, positive predictive value; ROC_{AUC}, area under the receiving operative characteristic curve

	ΔSVi-VE thresholds to define responders	AUC [95% CI]	Best threshold (%)	Specificity	Sensitivity	PPV	NPV	Youden index
ΔSVi-CAC	5%	0.85 [0.71–0.97]	2.7 [−3.5 to 14.4]	0.82 [0.55–1.00]	0.86 [0.71–0.96]	0.95 [0.86–0.95]	0.70 [0.46–0.91]	0.68
	10%	0.86 [0.72–0.96]	2.7 [0.9–15.0]	0.80 [0.60–1.00]	0.88 [0.54–1.00]	0.89 [0.79–1.00]	0.81 [0.56–1.00]	0.68
	15%	0.94 [0.85–0.99]	11.4 [2.0–14.4]	0.95 [0.84–1.00]	0.75 [0.55–0.90]	0.91 [0.75–1.00]	0.90 [0.73–1.00]	0.70
	20%	0.96 [0.90–1.00]	12.1 [8.8–14.4]	0.88 [0.77–1.00]	0.92 [0.77–1.00]	0.85 [0.65–1.00]	1.00 [0.90–1.00]	0.80
ΔPP-CAC	15%	0.63 [0.44–0.81]	–	–	–	–	–	–
ΔVpeak	15%	0.52 [0.32–0.71]	–	–	–	–	–	–
ΔIVC	15%	0.53 [0.32–0.72]	–	–	–	–	–	–

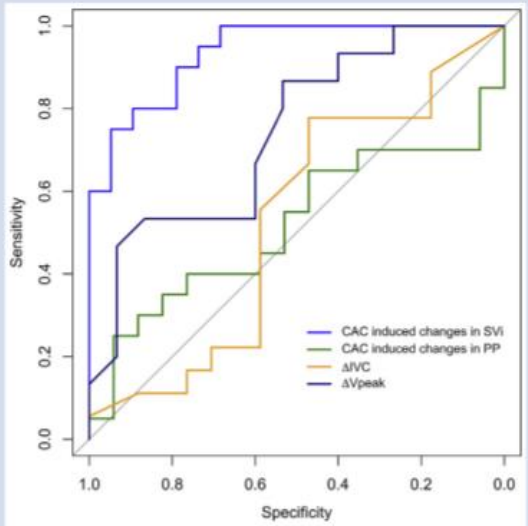


Fig 3. ROC curves showing the discrimination of the different haemodynamic parameters changes during a calibrated abdominal compression to predict fluid responsiveness. CAC, calibrated abdominal compression; SVi, stroke volume index; PP, pulse pressure; ΔIVC, respiratory variability of the inferior vena cava diameter; ΔVpeak, respiratory variability of the left ventricular outflow tract peak velocity; ROC, receiving operative curve.

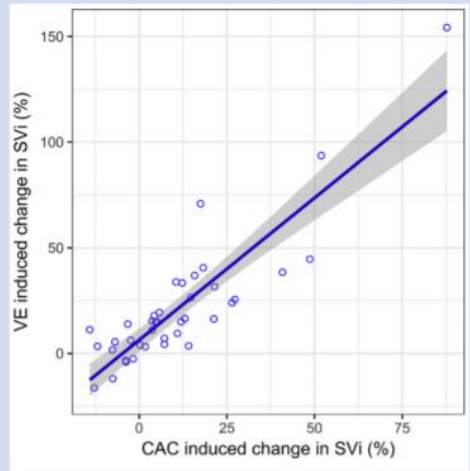


Fig 2. Scatter plot of the variation of stroke volume during abdominal compression *vs* volume expansion. CAC, calibrated abdominal compression; SVi, stroke volume index; VE, volume expansion.

Monitorage hémodynamique simple dynamique

Mobilisation de volume intravasculaire en pédiatrie

Intérêt des :

- Test de lever de jambe passif : Δ SV > 10% en ETT. Faible volume ?

Si > 5 ans

Lukito V, Djer MM, Pudjiadi AH, Munasir Z. The role of passive leg raising to predict fluid responsiveness in pediatric intensive care unit patients. Pediatr Crit Care Med. 2012;;13((3):):155––160.

El-Nawawy AA, Farghaly PM, Hassouna HM, Accuracy of Passive Leg Raising Test in Prediction of Fluid Responsiveness in Children. Int J Clin Pediatr Dent 2020;24(5):344–349.

Lu GP, Yan G, Chen Y, Lu ZJ, Zhang LE, Kissoon N. The passive leg raise test to predict fluid responsiveness in children—preliminary observations. Indian J Pediatr 2015; 82: 5-12.

- Test de compression abdominale
- Test d'occlusion télé expiratoire

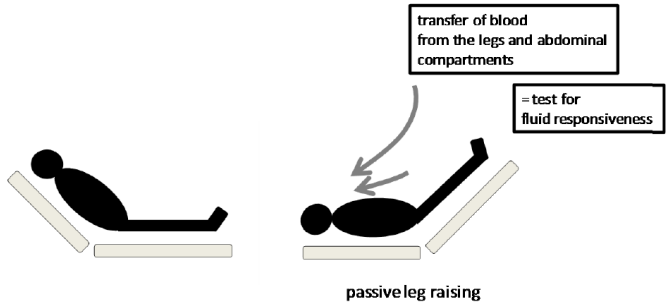


Figure 4 Passive leg raising. The passive leg raising test consists in measuring the hemodynamic effects of a leg elevation up to 45°. A simple way to perform the postural maneuver is to transfer the patient from the semirecumbent posture to the passive leg raising position by using the automatic motion of the bed.

Monitorage hémodynamique simple dynamique

Perfusion de min bolus de volume intravasculaire en pédiatrie

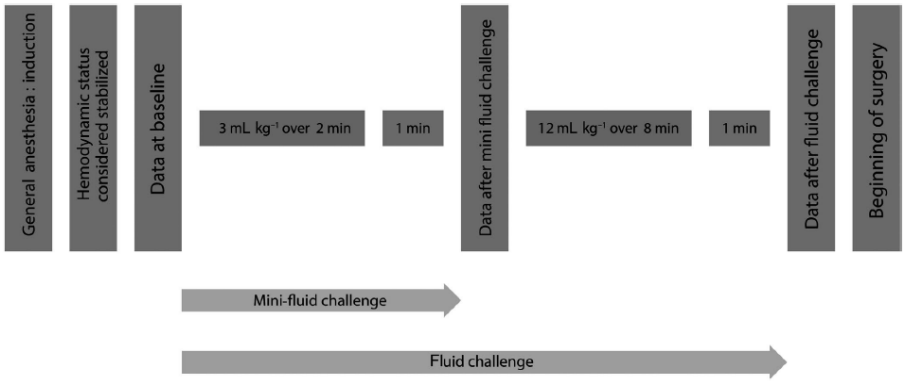


TABLE 2 Hemodynamic and echocardiographic parameters expressed as mean (SD) or median (IQR [range])

Parameters	Responders (n = 43)	Non-responders (n = 12)	Difference (95% CI)	*P*-value
$_{baseline}$ HR (beats min^{-1})	111 (27)	107 (28)	4.23 (−13.3 to 21.8)	.63
$_{baseline}$ SBP (mmHg)	82 (11)	76 (16)	6.73 (−1.48 to 14.9)	.11
$_{baseline}$ MBP (mmHg)	55 (9)	57 (32)	−2.79 (−13.6 to to 8.08)	.61
$_{baseline}$ DBP (mmHg)	44 (9)	40 (11)	3.35 (−2.80 to 9.49)	.28
$_{baseline}$ VTI (cm)	12.4 (2.0)	14.8 (1.2)	−2.42 (−3.66– −1.18)	.0003
ΔHR_{miniFC} (beats min^{-1})	−5.15 (−6.03 to −3.02 [−13.0 to 3.64])	-3.15 (−4.93 to −1.85 [−7.94 to 1.20])	20.4 (−63.3 to 104)	.12
ΔSBP_{miniFC} (mmHg)	0.00 (−0.06 to 0.03 [−0.11 to 13.7])	0.00 (−0.04 to 0.04 [−0.23 to 0.10])	0.35 (−0.87 to 1.57)	.46
ΔMBP_{miniFC} (mmHg)	−3.28 (−7.34 to 5.70 [−22.4 to 13.4])	0.00 (−6.35 to 2.99 [−14.8 to 15.6])	0.20 (−5.41 to 5.81)	.96
ΔDBP_{miniFC} (mmHg)	−4.00 (−9.94 to 4.79 [−34.5 to 28.6])	0.00 (−12.3 to 7.39 [−21.8 to 20.0])	−0.96 (−9.72 to 7.80)	.89
ΔVTI_{miniFC} (cm)	8.00 (3.73 to 12.8 [−5.43 to 43.9])	0.74 (−5.50 to 7.01 [−16.7 to 19.2])	10.3 (2.91-17.8)	.005

Abbreviations: baseline DBP, diastolic blood pressure before fluid challenge; baseline HR, heart rate before fluid challenge; baseline MBP, mean blood pressure before fluid challenge; baseline SBP, systolic blood pressure before fluid challenge; baseline VTI, velocity time integral before fluid challenge; ΔDBP_{miniFC}, changes in diastolic blood pressure after mini- fluid challenge; ΔHR_{miniFC}, changes in heart rate after mini-fluid challenge; ΔMBP_{miniFC}, changes in mean blood pressure after mini-fluid challenge; ΔSBP_{miniFC}, changes in systolic blood pressure after mini-fluid challenge; ΔVTI_{miniFC}, changes in velocity time integral after mini-fluid challenge.

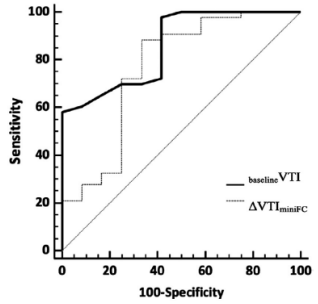


FIGURE 3 Receiver operating characteristics curves were generated for ΔVTI_{miniFC} (changes in velocity time integral induced by a mini-fluid challenge of 3 mL kg^{-1}) and for VTI baseline (velocity time integral before fluid challenge). ΔVTI_{miniFC} was the primary parameter investigated. These curves show the ability of both parameters to predict the effect of a fluid challenge of 15 mL kg^{-1}

$\Delta ITV_{3ml/kg}$: seuil 1,5% Sp 67% Se 88%

LSC : seuil 8%; Sp 77% Se 53%

Background

Very little evidence for predictive markers of fluid responsiveness has been reported in children as compared to adults. The impact of hypovolemia or hypervolemia on morbidity has driven interest in the fluid challenge titration strategy.

Aim

The objective of this study was to explore the ability of a 3 mL kg^{-1} mini-fluid challenge over 2 minutes to predict fluid responsiveness in children under controlled ventilation.

Methods

Children scheduled for surgery under general anesthesia were included and received a fluid challenge of 15 mL kg^{-1} of crystalloid prior to incision administered over 10 minutes in two steps: 3 mL kg^{-1} over 2 minutes then 12 mL kg^{-1} over 8 minutes. Fluid responsiveness was defined as a change of ≥10% in cardiac output estimated by left ventricular outflow tract velocity time integral (VTI) as measured by transthoracic ultrasound before and after the fluid challenge of 15 mL kg^{-1}.

Results

Of the 55 patients included in the analysis, 43 were fluid responders. The increase in the VTI after the mini-fluid challenge (ΔVTI_{miniFC}) predicted fluid responsiveness with an area under the receiver operating characteristic curve of 0.77; 95% CI (0.63-0.87), *P* = .004. Considering the least significant change which was 7.9%; 95% CI (6-10), the threshold was 8% with a sensitivity of 53%; 95% CI (38-68); and a specificity of 77%; 95% CI (54-100).

Conclusion

ΔVTI_{miniFC} weakly predicted the effects of a fluid challenge of 15 mL kg^{-1} of crystalloid in anesthetized children under controlled mechanical ventilation.

Zorio V, Lebreton T, Desgranges FP, Bochaton T, Desebbe O, Chassard D, Jacquet-Lagrèze M, Lilot M. Does a two-minute mini-fluid challenge predict fluid responsiveness in pediatric patients under general anesthesia? Paediatr Anaesth. 2020 Feb;30(2):161-167. doi: 10.1111/pan.13793. Epub 2020 Jan 20. PMID: 31858641.

Monitorage hémodynamique avancé

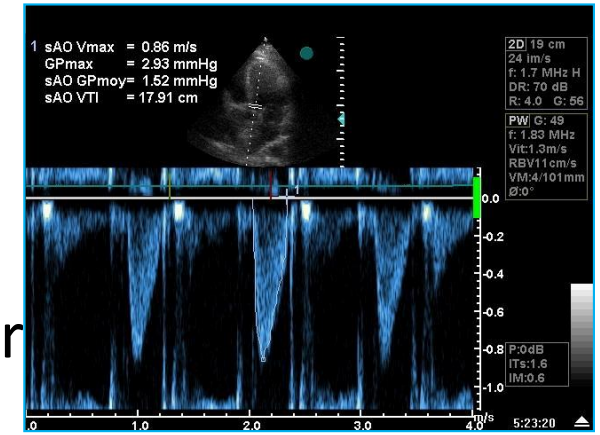
ETT/ETO

Echocardiographie

Technique de comparaison



- Nécessite : Appareil et accès pour mesure
- Intérêt
  - Echogénicité en pédiatrie
  - QC intermittent
  - Morphologie et fonction VD et VG, valves…
  - Précision et informations explicatives



- Limites
  - Complexité pour mesure fiable et interprétation
    - Formation et variabilité Inter et intra observateur
  - ETO à partir de 3 Kg

Monitorage hémodynamique avancé

ETT/ETO

Table 3 Recommendations on the use of cardiac ultrasound and other methods to estimate cardiac output for hemodynamic monitoring in critically ill children

Sr No	Recommendation	Level of agreement
Echocardiography/cardiac ultrasound		
1.	We recommend to use cardiac ultrasound as an adjunct to gain additional information required for making accurate clinical decisions in infants and children with hemodynamic instability but not as a tool for routine hemodynamic monitoring in intensive care setting.	Strong agreement
2.	Cardiac ultrasound can help in diagnosing pulmonary hypertension and assessing severity of pulmonary hypertension, and in detecting cardiac tamponade.	Strong agreement
3.	We recommend monitoring of pulmonary artery pressure (PAP) using ultrasound with refractory shock states to exclude pulmonary hypertension. Cardiac ultrasound may help in identifying underlying pathophysiology of shock and choosing the right intervention based upon deranged hemodynamic physiology (preload, afterload, or cardiac function).	Strong agreement
4.	Cardiac ultrasound may help in assessing fluid responsiveness and we recommend using velocity time integral (VTI) across aortic valve for assessing fluid responsiveness rather than inferior vena cava collapsibility in mechanically ventilated infants and children.	Strong agreement
5.	We recommend using serial longitudinal assessments to assess response to therapy in patients with significant hemodynamic instability.	Strong agreement

Singh Y, Villaescusa JU, da Cruz EM, Tibby SM, Bottari G, Saxena R, Guillén M, Herce JL, Di Nardo M, Cecchetti C, Brierley J, de Boode W, Lemson J. Recommendations for hemodynamic monitoring for critically ill children-expert consensus statement issued by the cardiovascular dynamics section of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC). Crit Care. 2020 Oct 22;24(1):620. doi: 10.1186/s13054-020-03326-2. PMID: 33092621

Monitorage hémodynamique avancé

USCOM

Doppler supra sternal

Technique d'ultrasons

- Nécessite : appareil doppler et accès pour mesure
- Intérêt
  - Flux aortique ascendant par voie supra sternal
  - Non invasif
  - Validé études pédiatrie
- Limites
  - Mesure intermittente
  - Formation nécessaire

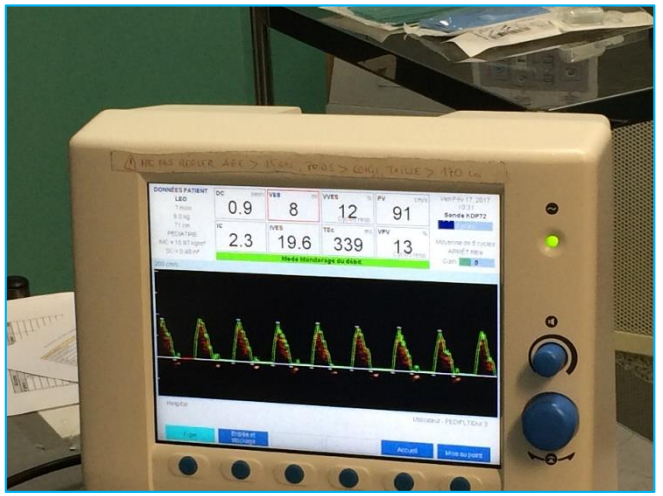


Knirsch et al. 2008.

Monitorage hémodynamique avancé

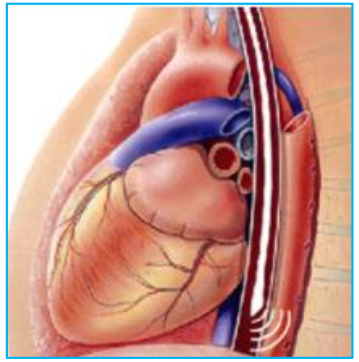
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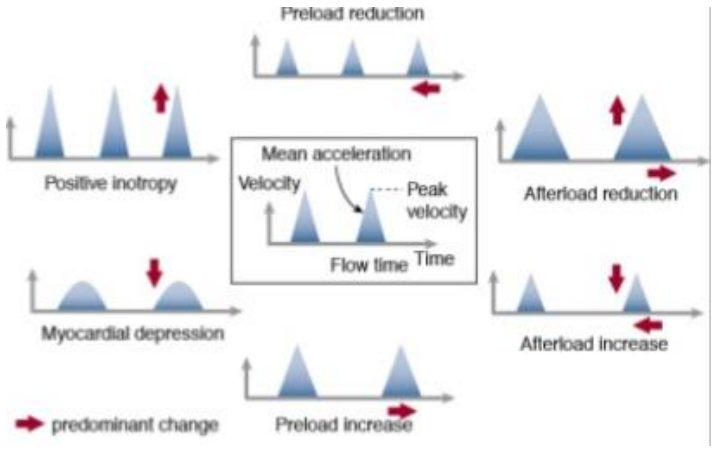
Doppler oesophagien



Technique doppler flux aorte descendante

- Nécessite : appareil et accès (sonde IOT)
- Intérêt
  - Validé et reproductible
  - QC continu et automatisé
  - Précision et informations explicatives
- Limites
  - Formation et angle d'incidence
  - Estimation du VES et répartition QC / âge
  - A partir de 3 Kg / variation Flux Msup / Minf





Tibby et al, Crit Care Med 2000.
Suehiro K, Joosten A, et al. J Clin Monit Comput. 2016;30(5):603-620.

Monitorage hémodynamique avancé

ΔVPeak

RESEARCH Open

Value of respiratory variation of aortic peak velocity in predicting children receiving mechanical ventilation: a systematic review and meta-analysis

Xiaoying Wang[1*†], Lulu Jiang[2†], Shuai Liu[3], Yali Ge[1] and Ju Gao[1*]

Wang *et al. Critical Care* (2019) 23:372
https://doi.org/10.1186/s13054-019-2647-7

Abstract

Background: Accurate volume assessment is crucial in children under fluid therapy. Over the last decade, respiratory variation of aortic peak velocity (ΔVPeak) has been applied in intensive care unit and surgeries to help clinicians guide fluid management. The aim of this systematic review and meta-analysis was to test diagnostic performance of ΔVPeak in predicting fluid responsiveness of ventilated children and to explore the potential factors that influence the accuracy of ΔVPeak.

Methods: We searched PubMed, Embase, and Cochrane from inception to April 2019 that evaluated association between ΔVPeak and fluid responsiveness after fluid challenge in children receiving mechanical ventilation. Data synthesis was performed within the bivariate mixed-effects regression model modified for synthesis of diagnostic test data.

Results: Eleven studies with a total of 302 pediatric patients were included in our meta-analysis. The pooled sensitivity and specificity of ΔVPeak was 0.89 (95%CI = 0.77 to 0.95) and 0.85 (95%CI = 0.77 to 0.91), respectively. The diagnostic odds ratio (DOR) of ΔVPeak was 48 (95%CI = 15 to 155). SROC yielded an area under the curve of 0.91 (95%CI = 0.88–0.93). The ΔVPeak cutoff value was nearly conically symmetrical distribution and varied from 7 to 20%. After excluding several extreme studies, most data were centered between 12 and 13%. The medium and mean cutoff values of ΔVPeak were 12.2% and 12.7%, respectively. In subgroup analysis, compared to total data analysis, ΔVPeak performed weaker in the younger children group (mean ages < 25 months), with lower area under the summary receiver operating characteristic curve (AUSROC) of 0.80 (0.76 to 0.83), but stronger in the older children group (mean ages > 25 months), with AUSROC of 0.96 (0.94 to 0.97).

Conclusions: Overall, ΔVPeak has a good ability in predicting fluid responsiveness of children receiving mechanical ventilation, but this ability decreases in younger children (mean age < 25 months). The optimal threshold of ΔVPeak to predict fluid responsiveness in ventilated children is reliable between 12 and 13%.

Trial registration: The study protocol was registered prospectively on PROSPERO no. CRD42019129361.

Keywords: Aortic, Pediatric, Velocity, Fluid, Ventilation

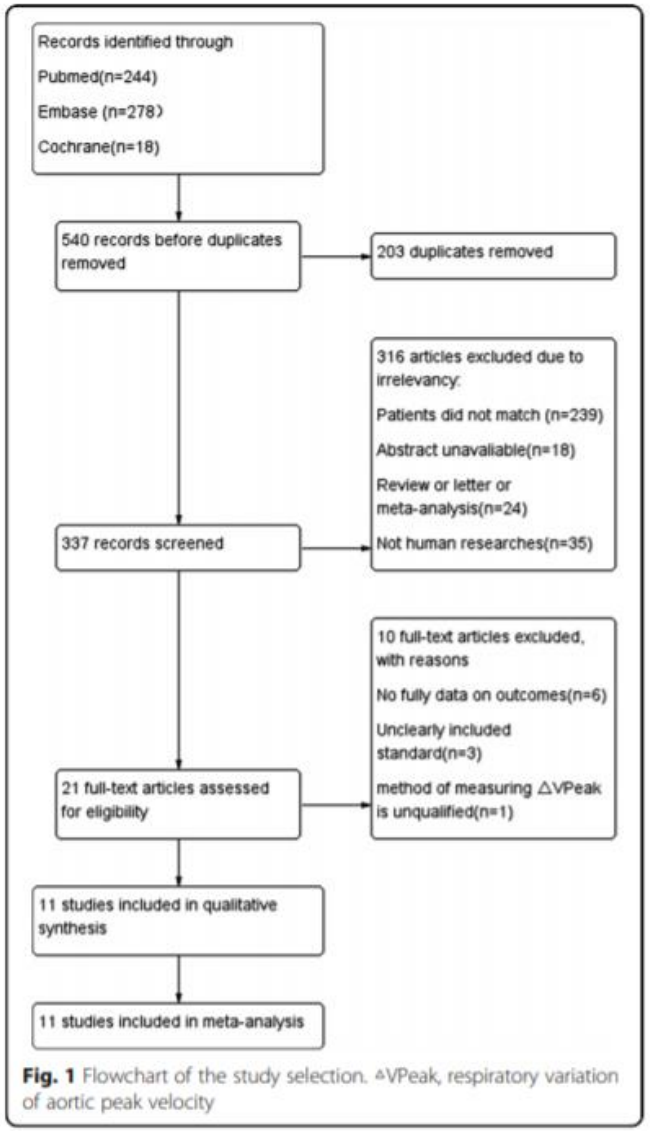


Fig. 1 Flowchart of the study selection. ΔVPeak, respiratory variation of aortic peak velocity

Monitorage hémodynamique avancé

ΔVPeak

RESEARCH Open

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$$\Delta Vpeak\ (\%) = 100 \times (Vpeak\ max - Vpeak\ min) / [(Vpeak\ max + Vpeak\ min) / 2].$$

All diagnostic tests that study ΔVPeak as a predictor of fluid responsiveness of ventilated children were included in our research. The gold standard method of assessing fluid responsiveness was defined as an increase in CO, CI, SV, and stoke volume index (SVI) after volume expansion. And the sensitivity, specificity, and cutoff value of ΔVPeak to predict fluid responsiveness in ventilated children could be found or calculated in the original work.

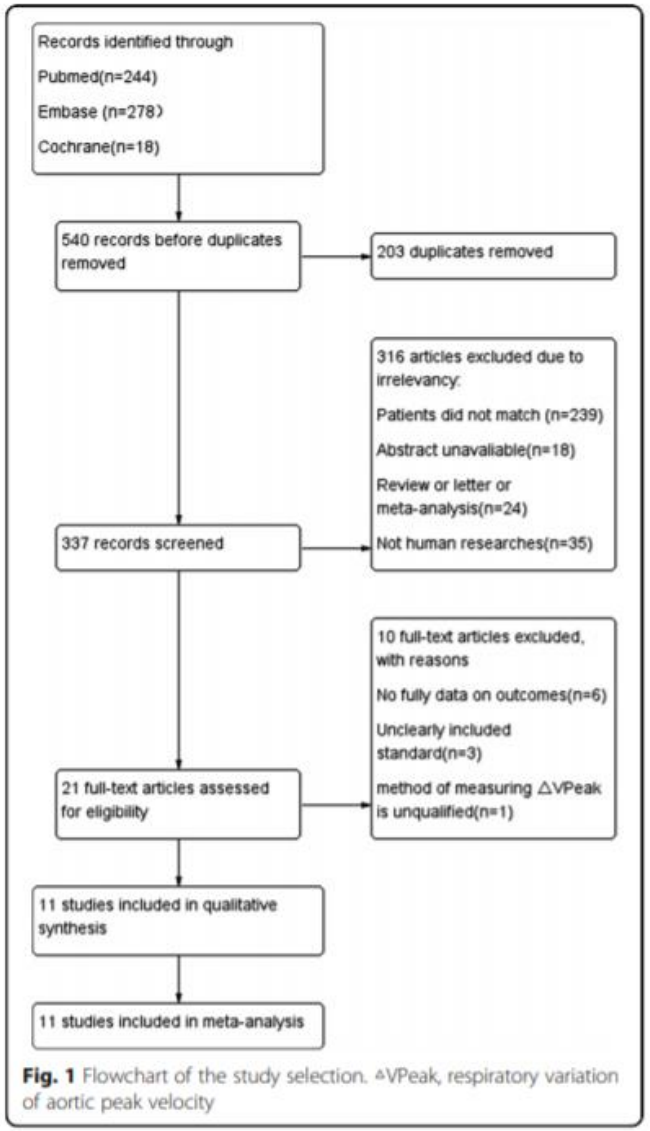


Fig. 1 Flowchart of the study selection. ΔVPeak, respiratory variation of aortic peak velocity

Monitorage hémodynamique avancé

ΔVPeak

Table 1 Selected characteristics of the included studies

No.	Authors/ year	Sample size	Age (months)	Settings or time point of measure	VE	Golden index (responders)	Tool measuring golden index	Tool measuring ΔVPeak	Tide volume (ml/kg)	PEEP (cmH_2O)	Vasoactive drugs
1	Durand 2008	26	*M* = 28.5	ICU	20 ml /kg/6%HES or saline 15–30 min	ΔSV > 15%	TTE	TTE	7.4	4	Yes
2	Choi 2010	21	*A* = 30	VSD repair, 1 h after arriving at ICU	10 ml/ kg/6%HES over 20 min	ΔSV > 15%	TTE	TTE	10	0	Yes
3	Renner 2011	27	*A* = 17	Before cardiac surgery begin	10 ml/ kg/6%HES	ΔSVI > 15%	TOE	TOE	10	3–5	Yes
4	Pereira 2011	30	*A* = 112	Before neurosurgery incision	20 ml /kg/saline over 15 min	ΔVTI > 15%	TTE	TTE	10	0–2	Yes
5	Byon 2013	33	*A* = 72.1	Stable during neurosurgery	10 ml/ kg/6%HES 10 min	ΔSVI > 10%	TTE	TTE	10	0	UC
6	Lee 2014	26	*A* = 28	VSD repair, 30 min after arriving at ICU	10 ml/ kg/6%HES 20 min	ΔSV > 15%	TTE	TTE	10	5	Yes
7	Lee 2015	29	*A* = 13.7	Once sternum closed after VSD repair	10 ml/ kg/6%HES 10 min	ΔSVI > 15%	TOE	TOE	10	UC	Yes
8	Krishna 2016	42	*A* = 76	General endotracheal anesthesia	10 ml/ kg/1%DRL 5-10 min	ΔSVI ≥ 15%	TTE	TTE	10	0	UC
9	Favia 2017	16	*A* = 24.2	Sternal closure in cardiac surgery	10 ml /kg/ crystalloid or blood products	ΔCI > 10%	MostCare™	TOE	8–10	0–10	No
10	Lee 2017	30	*A* = 19.2	After cardiac surgery end before entering ICU	10 ml/ kg/6%HES 20 min	ΔSVI > 15%	TOE	TOE	10	UC	Yes
11	Morparia 2018	22	*A*==69.8	Neurosurgery	10 ml/ kg/ crystalloid	ΔSV > 15%	TTE	TTE	8–10	0–4	sNO

A average age, *min* minute, *M* median age, *VE* volume experiment, *HES* hydroxyethe1 starch, *DRL* dextrose Ringer's lactate, *ΔVPeak* respiratory variation of aortic peak velocity, *VSD* ventricular septal defect, *PEEP* positive end-expiratory pressure, *UC* unclear, *SV* stroke volume, *SVI* stroke volume index, *VTI* velocity-time integral, *TTE* transthoracic echocardiography, *TOE* transoesophageal echocardiography

Monitorage hémodynamique avancé

ΔVPeak

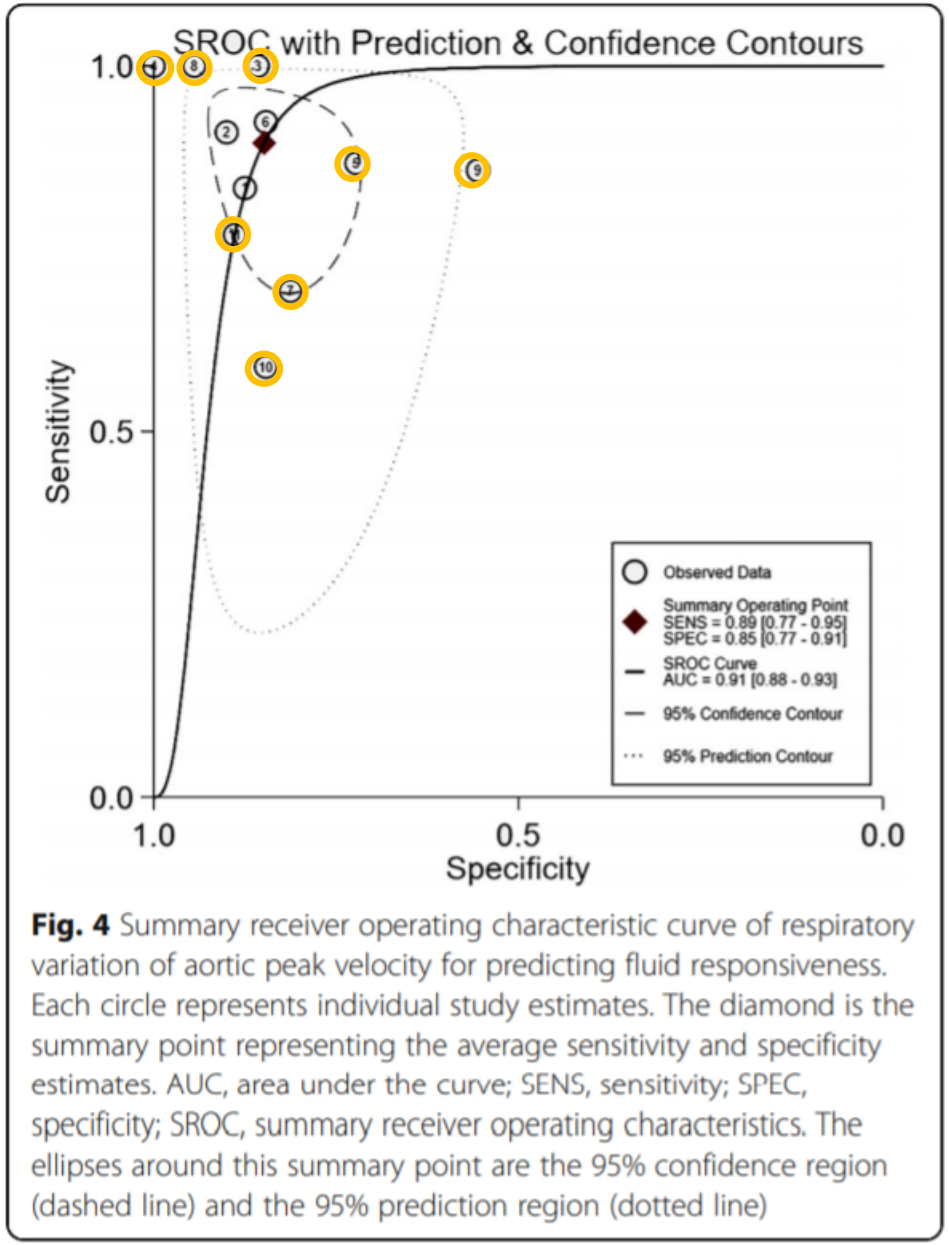


Fig. 4 Summary receiver operating characteristic curve of respiratory variation of aortic peak velocity for predicting fluid responsiveness. Each circle represents individual study estimates. The diamond is the summary point representing the average sensitivity and specificity estimates. AUC, area under the curve; SENS, sensitivity; SPEC, specificity; SROC, summary receiver operating characteristics. The ellipses around this summary point are the 95% confidence region (dashed line) and the 95% prediction region (dotted line)

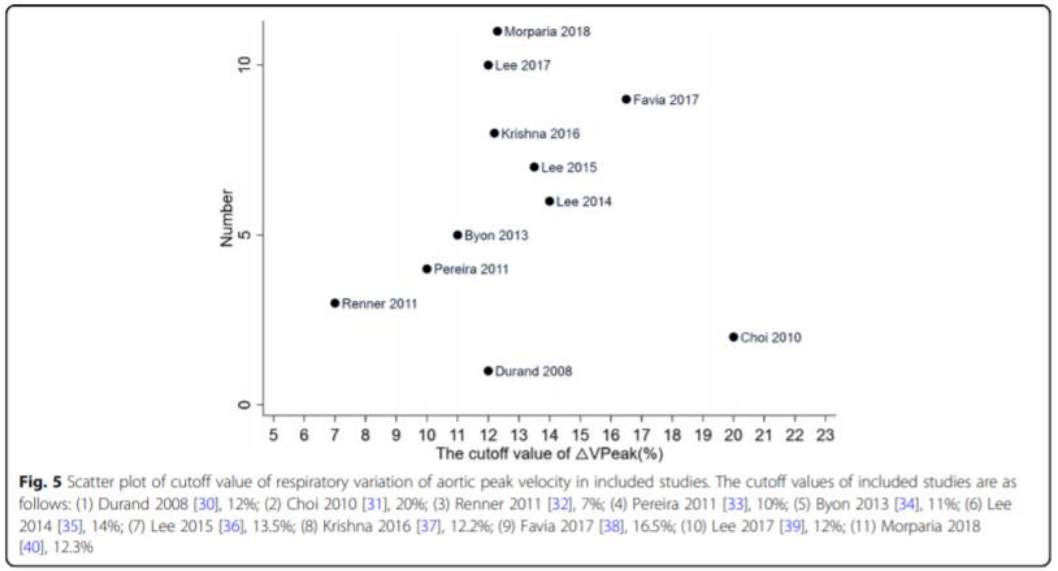


Fig. 5 Scatter plot of cutoff value of respiratory variation of aortic peak velocity in included studies. The cutoff values of included studies are as follows: (1) Durand 2008 [30], 12%; (2) Choi 2010 [31], 20%; (3) Renner 2011 [32], 7%; (4) Pereira 2011 [33], 10%; (5) Byon 2013 [34], 11%; (6) Lee 2014 [35], 14%; (7) Lee 2015 [36], 13.5%; (8) Krishna 2016 [37], 12.2%; (9) Favia 2017 [38], 16.5%; (10) Lee 2017 [39], 12%; (11) Morparia 2018 [40], 12.3%

Durant anesthésie chirurgicale

Monitorage hémodynamique avancé

ΔVPeak

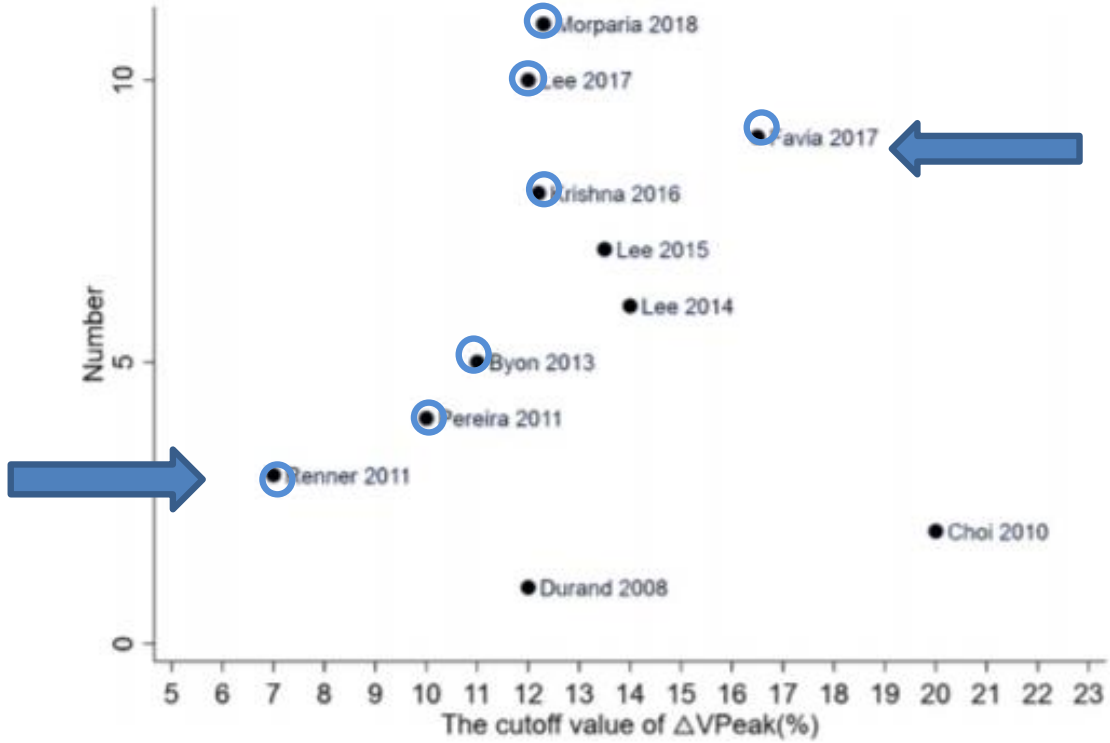


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Monitorage hémodynamique avancé

ΔVPeak

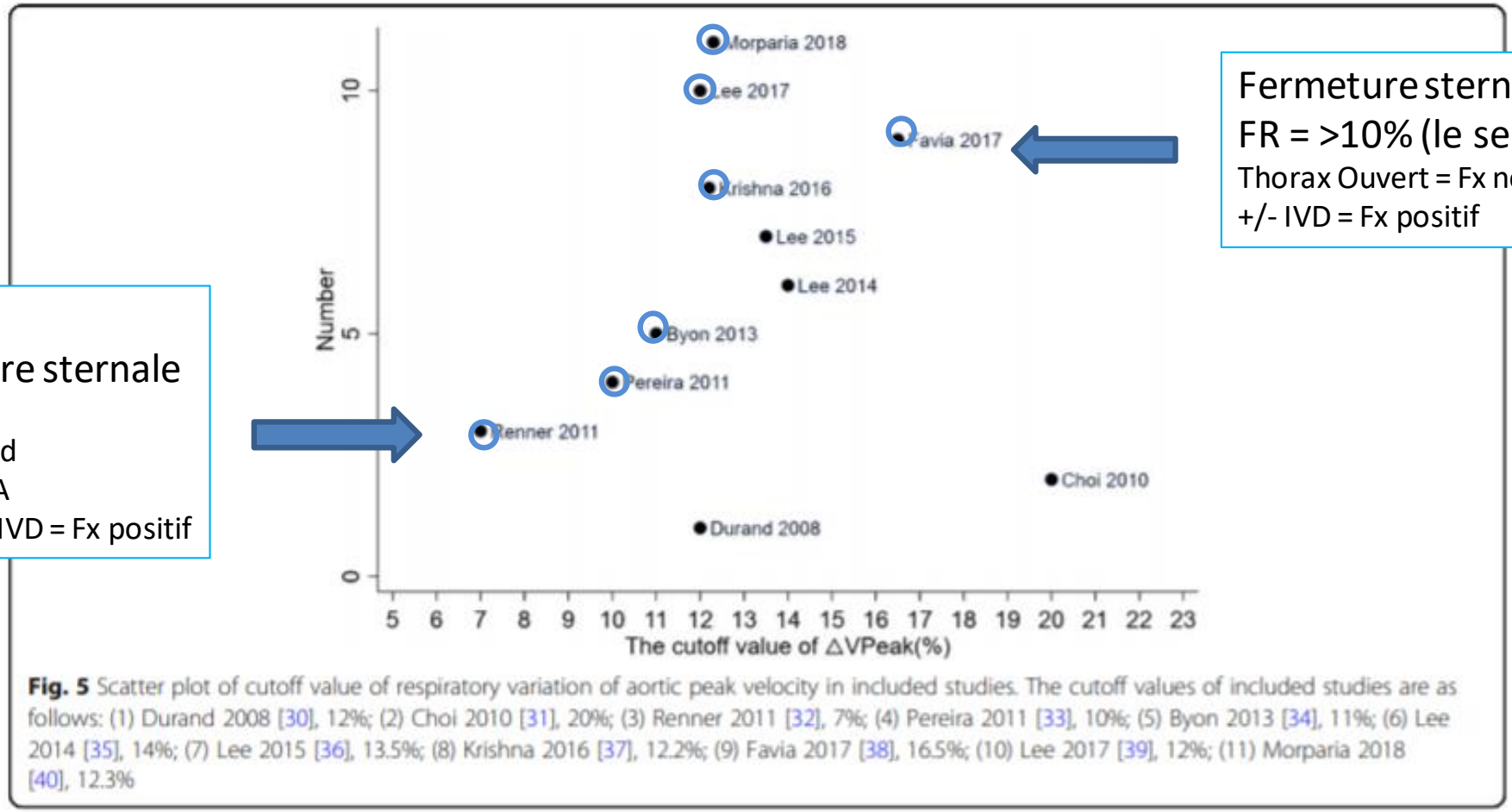


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Fermeture sternale
FR = >10% (le seul)
Thorax Ouvert = Fx négatif
+/- IVD = Fx positif

Avant ouverture sternale
5 DCPT
5 Norwood
15 CIV/CIA
PEEP 3-5, IVD = Fx positif

Monitorage hémodynamique avancé

ΔVPeak

Seuil bas : petite variation Peak ITV = Efficacité du RV pourquoi ?

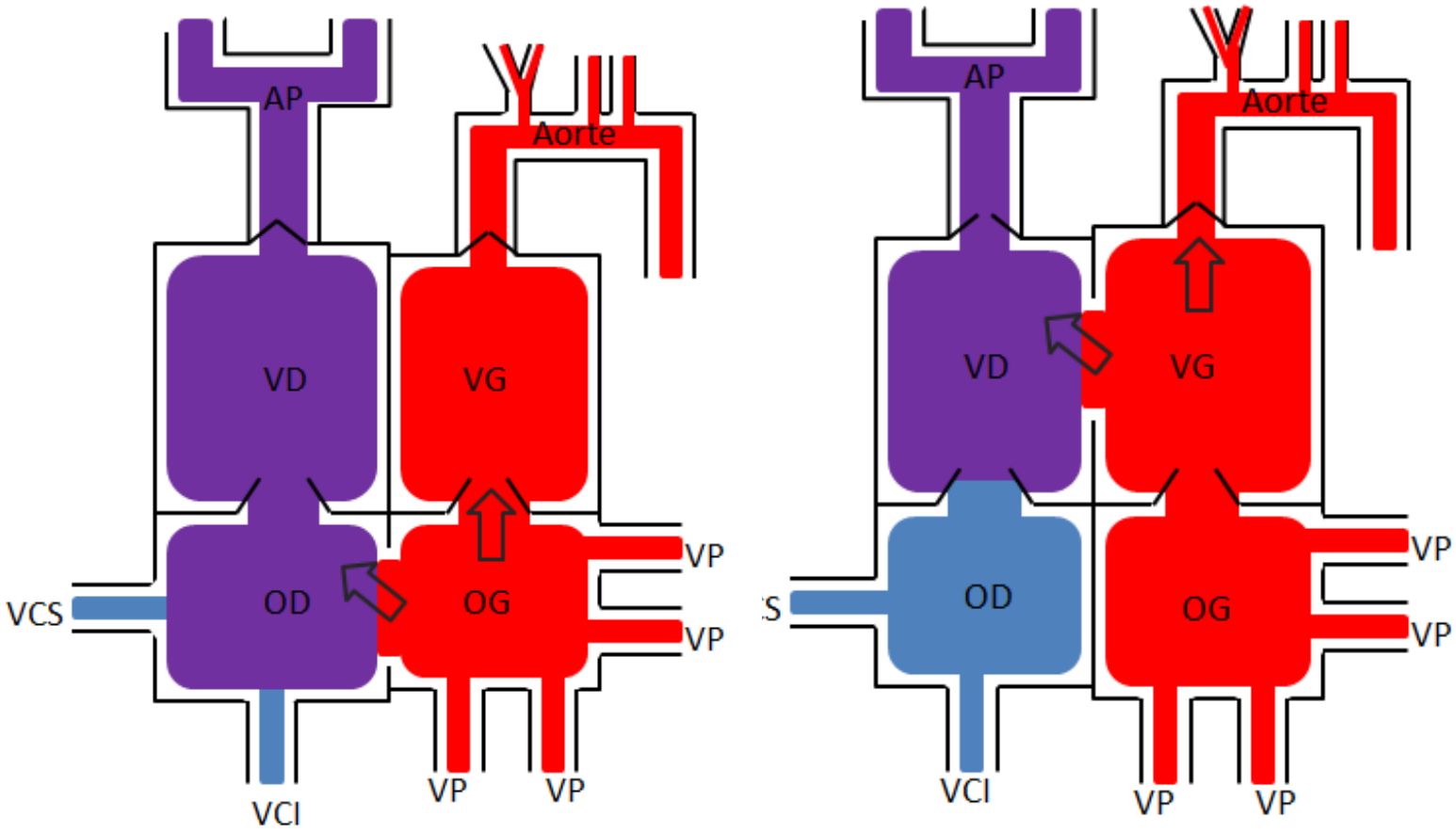
Shunt G-Dt :
- ↘ flux dans l'Aorte
- ↘ ΔVPeak

Ventilation en Pression :
- ↘ flux sanguin Pulm
  = ΔVPeak

Shunt G-Dt
- Hyper QP
- Annule l'effet de la P+

Diurétique +++

↘ seuil à 7% ?



Monitorage hémodynamique avancé

ΔVPeak

Seuil bas : petite variation Peak ITV = Efficacité du RV pourquoi ?

Shunt Dt-G :

2/3 retour Vx systémique non pulsé
(Pas de VD)

Ventilation en Pression :

Flux sanguin Pulm continu
= ↗ ΔVPeak

Mais : Croissance → ↗ RVx syst VCI

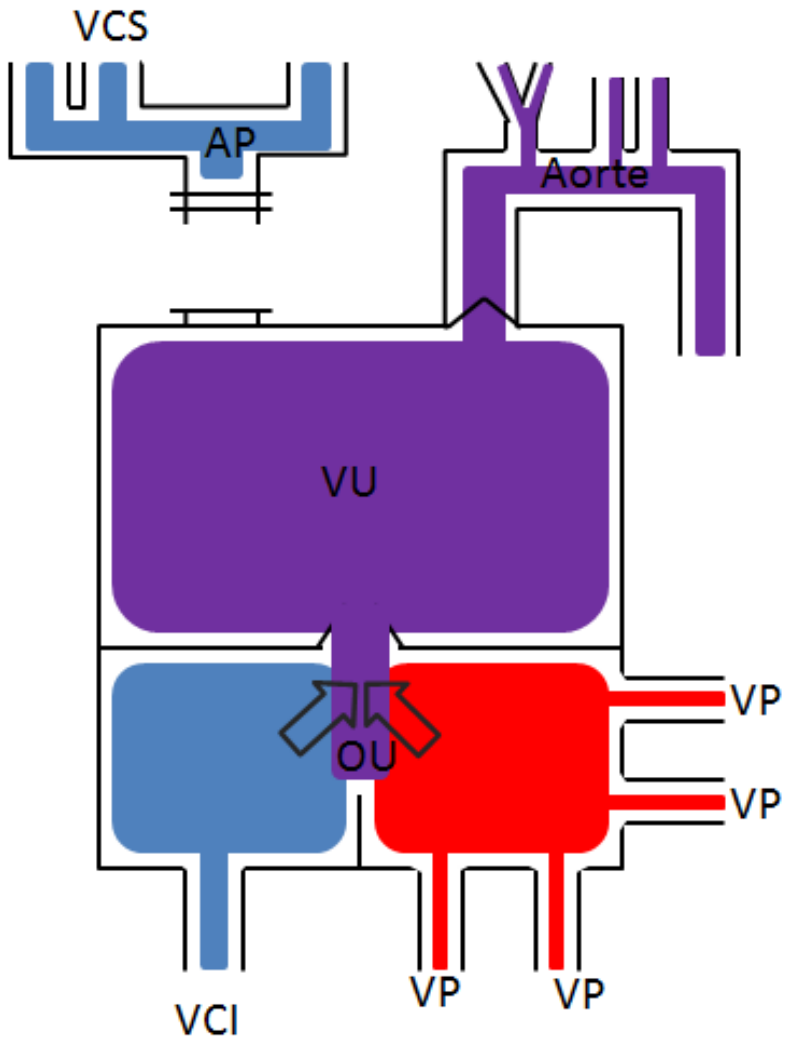
DCPP = Pas de barrage pulm VCI

Si RVP constante

Retour veineux Pulm
→ Volémie
→ Pression intra thoracique

PEEP 3-5 cmH2O

↘ seuil à 7% ?



Monitorage hémodynamique avancé

ΔVPeak

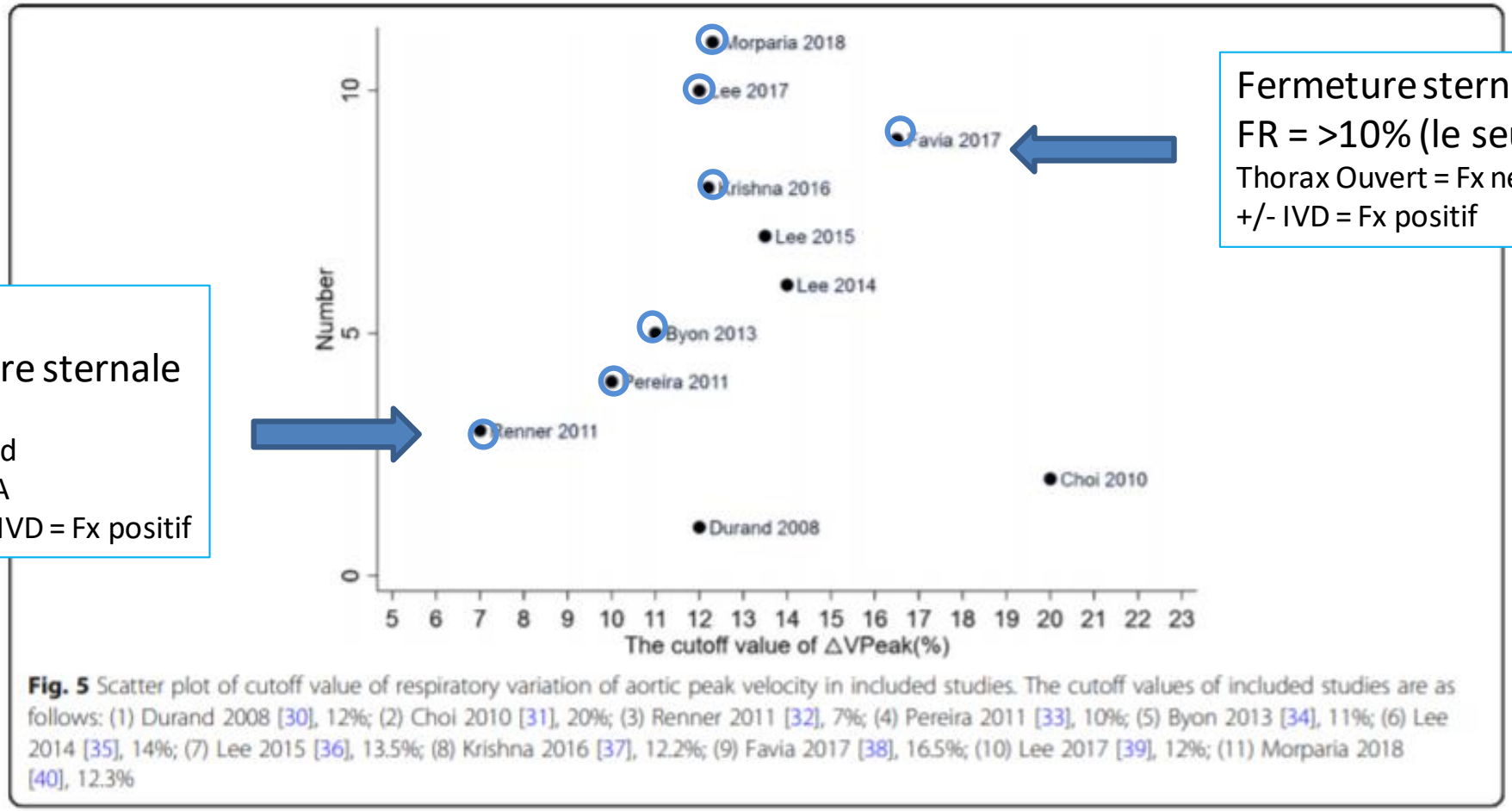


Fig. 5 Scatter plot of cutoff value of respiratory variation of aortic peak velocity in included studies. The cutoff values of included studies are as follows: (1) Durand 2008 [30], 12%; (2) Choi 2010 [31], 20%; (3) Renner 2011 [32], 7%; (4) Pereira 2011 [33], 10%; (5) Byon 2013 [34], 11%; (6) Lee 2014 [35], 14%; (7) Lee 2015 [36], 13.5%; (8) Krishna 2016 [37], 12.2%; (9) Favia 2017 [38], 16.5%; (10) Lee 2017 [39], 12%; (11) Morparia 2018 [40], 12.3%

Fermeture sternale
FR = >10% (le seul)
Thorax Ouvert = Fx négatif
+/- IVD = Fx positif

Avant ouverture sternale
5 DCPT
5 Norwood
15 CIV/CIA
PEEP 3-5, IVD = Fx positif

Monitorage hémodynamique avancé

ΔVPeak

RESEARCH Open

Value of respiratory variation of aortic peak velocity in predicting children receiving mechanical ventilation: a systematic review and meta-analysis

Xiaoying Wang[1*†], Lulu Jiang[2†], Shuai Liu[3], Yali Ge[1] and Ju Gao[1*]

Wang *et al. Critical Care* (2019) 23:372
https://doi.org/10.1186/s13054-019-2647-7

Conclusions

Overall, ΔVPeak has a good ability in predicting fluid responsiveness of children receiving mechanical ventilation and the optimal threshold value of ΔVPeak to predict fluid responsiveness is reliable between 12 and 13%. However, we observed that this ability decreased in younger children, especially mean age less than 25 months; thus, we expect more studies to make a statistic treatment in the future.

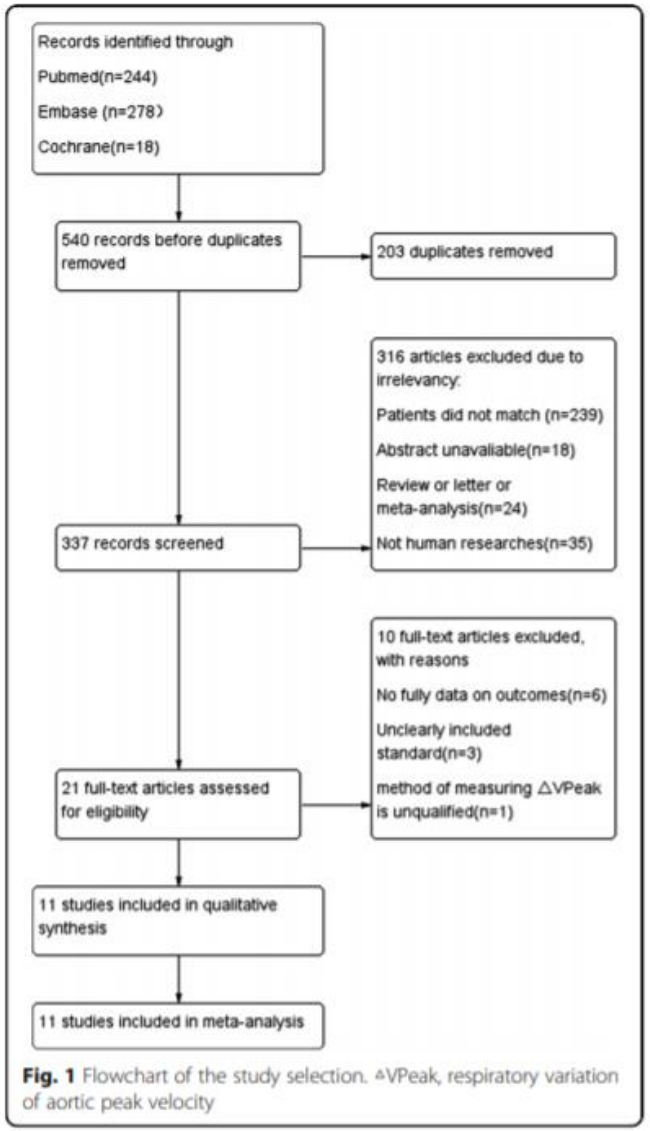


Fig. 1 Flowchart of the study selection. ΔVPeak, respiratory variation of aortic peak velocity

Respiratory Variation of Internal Carotid Artery Blood Flow Peak Velocity Measured by transfontanelle Ultrasound to Predict Fluid Responsiveness in Infants

Eun-Hee Kim, M.D., Ji-Hyun Lee, M.D., In-Kyung Song, M.D., Hee-Soo Kim, M.D., Ph.D., Young-Eun Jang, M.D., Jin-Tae Kim, M.D., Ph.D.

- Etude observationnelle prospective unicentrique janvier 2016- mars 2017
- 30 patients opérés CIA ou CIV *Age moyen : 5 mois Poids moyen : 6 kgs*
- Après fermeture sternale, RV 10ml/kg cristalloïdes
- Référence : Répondeur au RV = augmentation de 15% de VES (ETO)

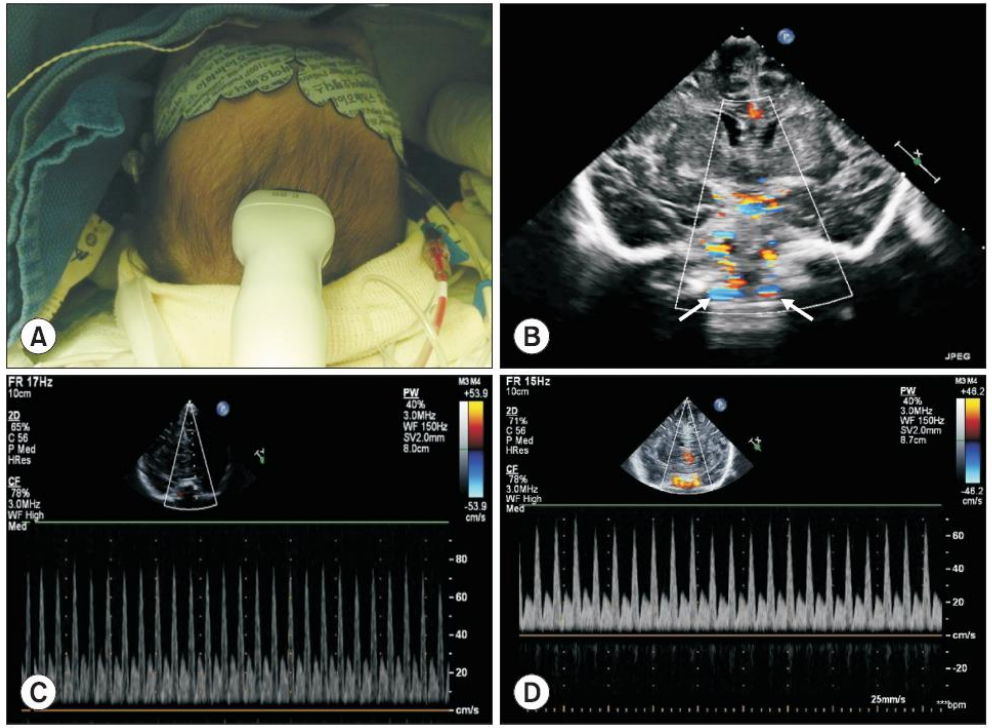


Fig. 4. Measurement of transcranial Doppler via the transfontanelle approach. Respiratory variation carotid blood flow peak velocity is measured using a sector probe via the anterior fontanelle. (A) Probe application on the anterior fontanelle, (B) Coronal view of the brain and the internal carotid artery, (C) Respiratory variation carotid blood flow peak velocity in a fluid nonresponder, (D) Respiratory variation carotid blood flow peak velocity in a fluid responder.

La variabilité respiratoire du pic de vélocité dans l'ACI mesurée par ETF

- Méthode non invasive

- Prédire la réponse au RV

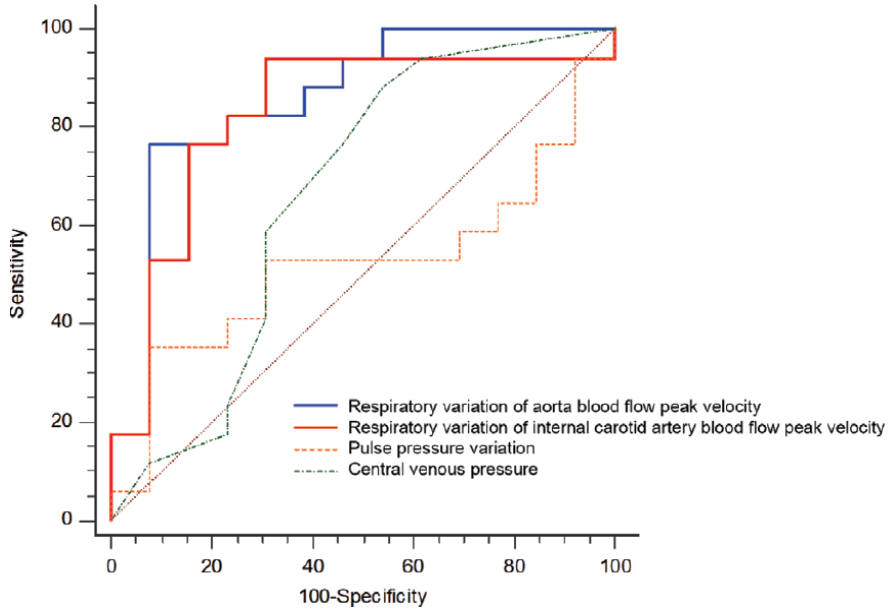
- Limites : un seul anesthésiste, une seul centre, population très spécifique
- Cutoff à définir +++

Kim EH, Lee JH, Song IK, Kim HS, Jang YE, Kim JT. Respiratory Variation of Internal Carotid Artery Blood Flow Peak Velocity Measured by Transfontanelle Ultrasound to Predict Fluid Responsiveness in Infants: A Prospective Observational Study. Anesthesiology. 2019 May;130(5):719-727.

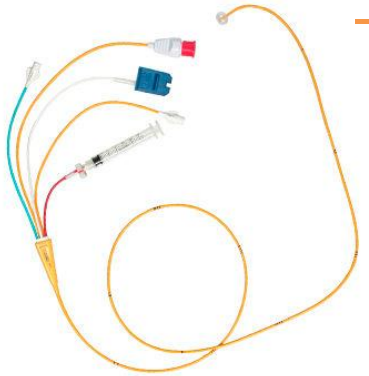
	Before Fluid Administration		
	Responders (n = 17)	Nonresponders (n = 13)	*P* value, 95% CI Differences between Groups
Heart rate (beats/min)	142 ± 16	138 ± 17	0.500, 4.3 (–8.8 to 17.4)
Mean arterial pressure (mmHg)	55 ± 10	61 ± 7	0.097, 5.7 (–1.1 to 12.6)
Central venous pressure (mmHg)	8 ± 2	6 ± 3	0.195, 1.3 (–0.7 to 3.4)
Stroke volume index ($ml \cdot m^{-2}$)	18.2 ± 4.9	20.7 ± 8.1	0.168, 1.7 (–0.8 to 4.4)
Cardiac index ($l \cdot min^{-1} \cdot m^{-2}$)	2.5 ± 0.7	2.8 ± 0.1	0.441, 0.2 (–0.4 to 0.9)
Pulse pressure variation (%)	18.2 ± 2.8	18.5 ± 5.0	0.759, 0.7 (–4.3 to 5.8)
Respiratory variation of aorta blood flow peak velocity (%)	16.0 ± 3.8	10.9 ± 3.5	0.001, 5.1 (2.3 to 7.8)
Respiratory variation of internal carotid artery blood flow peak velocity (%)	12.6 ± 3.3	8.2 ± 3.2	0.001, 4.4 (1.9 to 6.9)

Artère carotide interne :
Cutoff 7,8% (*Se94%, Sp69%*)
AUC 0,83

Aorte :
Cutoff 13% (*Se77%,Sp92%*)
AUC 0,86



Monitorage hémodynamique avancé

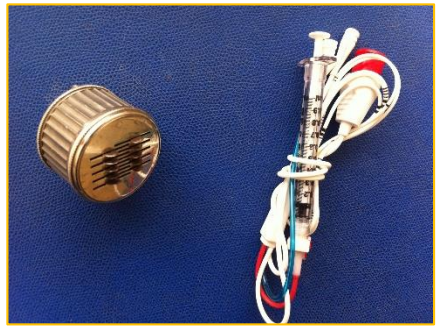


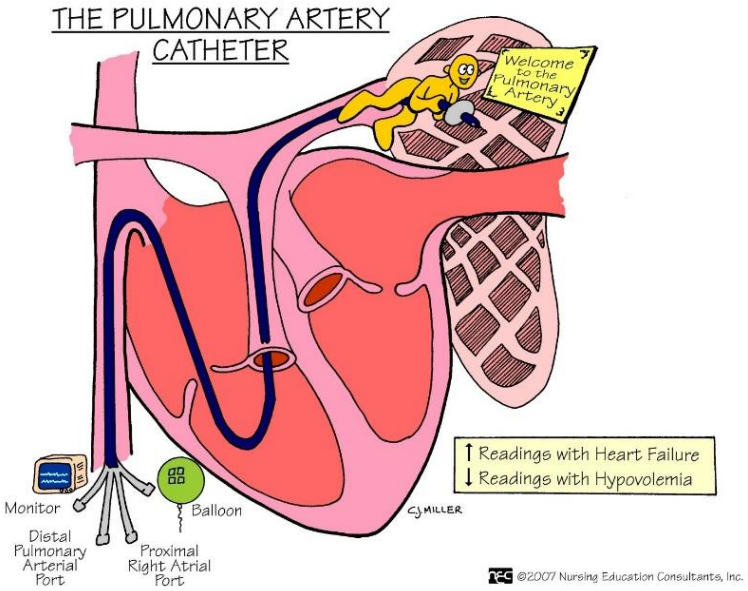
Thermodilution et cathéter artériel pulmonaire

Swan

Gold standard adulte (Stewart Hamilton)

- Nécessite : cathéter AP
- Intérêt
  - Précision
  - SvO2
  - Pression artérielle pulmonaire





- Limites
  - Très invasif min 3-5 kg
  - Retard de mesure du QC
  - Challenge position si < 10 kg

Seule indication: Transplantation cardiaque péd.

Monitorage hémodynamique avancé

Thermodilution et cathéter artériel pulmonaire

~~Swan~~
KT AP
KT OG

Pulmonary artery pressure

11.	We do not recommend to use pulmonary artery catheter (PAC) to measure CO in children. However, monitoring of left atrial pressure only in selected cardiac surgery patients or patients after lung transplant using a surgically inserted catheter can be helpful	Strong agreement

Singh Y, Villaescusa JU, da Cruz EM, Tibby SM, Bottari G, Saxena R, Guillén M, Herce JL, Di Nardo M, Cecchetti C, Brierley J, de Boode W, Lemson J. Recommendations for hemodynamic monitoring for critically ill children-expert consensus statement issued by the cardiovascular dynamics section of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC). Crit Care. 2020 Oct 22;24(1):620. doi: 10.1186/s13054-020-03326-2. PMID: 33092621

Monitorage hémodynamique avancé

Thermodilution transpulmonaire

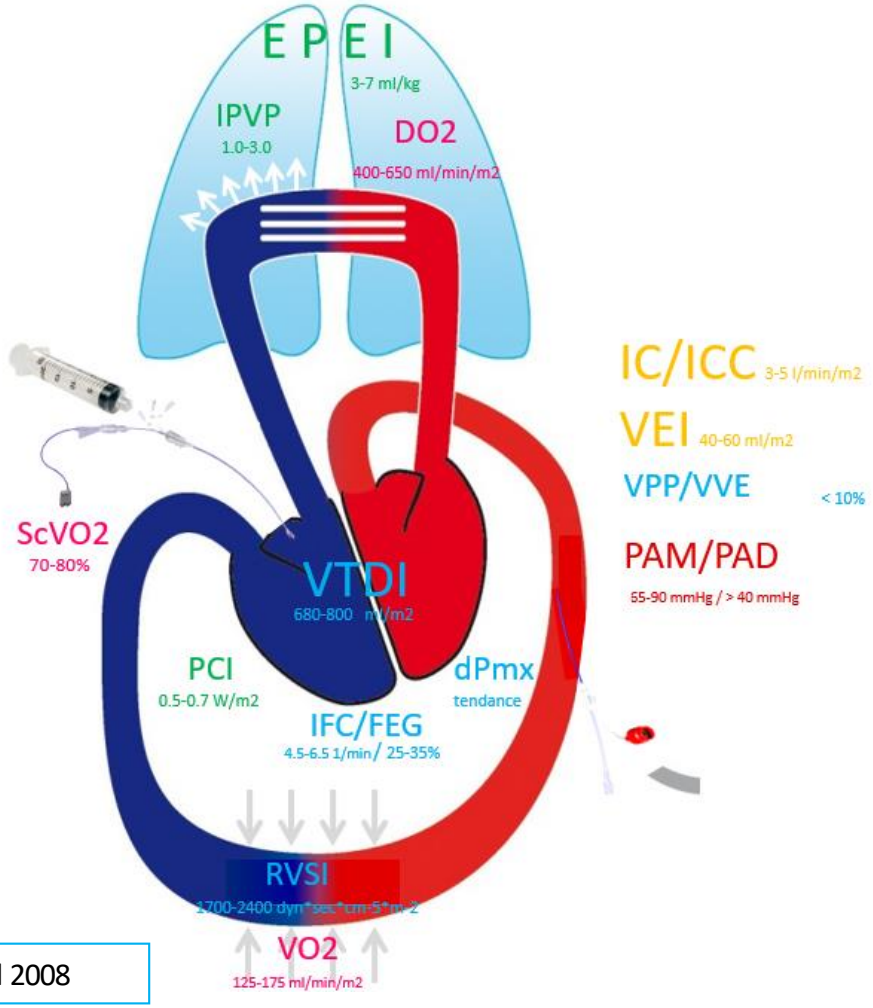
TDTP

Validé en pédiatrie avec résultats favorables

- Nécessite : VVC cave sup et KTA fémoral
- Intérêt (Gold standard en péd.)
  - QC continu calibré (pulse contour)
  - Fiable si RVS inchangée
  - Multiples paramètres HD



- Limites
  - 3,5 kg (3 Fr / 7 cm)
  - mais études sur > 5 kg
  - % erreur important



Intérêt en réanimation péd.

McLuckie et al. 1996; Bajorat et al. 2006; Pauli et al. 2002, Lemson et al. 2009, Tibby, Pediatr Crit Care Med 2008

Monitorage hémodynamique avancé

Thermodilution transpulmonaire

TDTP

Cardiac output measurement and transpulmonary indicator dilution

6.	We recommend to use ultrasound/Doppler-based methods of estimating CO in stable patients, for the initial assessment of unstable patients and to decide if a more invasive method is required. When reliable absolute measurements of CO are deemed necessary, thermodilution (TPD) is the method of first choice.	Strong agreement
7.	In patients with a refractory shock when an accurate measurement of CO is needed, we recommend to use transpulmonary thermodilution (TPTD) or semi-invasive transpulmonary ultrasound dilution (TPUD).	Weak agreement
8.	We recommend to use invasive (and if possible continuous) CO monitoring in unstable post-operative patients after major (cardiothoracic) surgery, multiple trauma injuries or burns or patients with complex cardiopulmonary interactions.	Strong agreement
9.	We recommend against targeting fluid therapy based upon blood volumes measured with TPD or targeting hemodynamic therapy based upon lung water measurement to assess pulmonary edema in critically ill children.	Strong agreement
10.	Because of their intermittent measurement technique, TPD methods are not suitable for the detection of fast changes in CO unless used in conjunction with continuous trend monitoring using pulse contour analysis, calibrated by transpulmonary indicator dilution technology.	Strong agreement

Singh Y, Villaescusa JU, da Cruz EM, Tibby SM, Bottari G, Saxena R, Guillén M, Herce JL, Di Nardo M, Cecchetti C, Brierley J, de Boode W, Lemson J. Recommendations for hemodynamic monitoring for critically ill children-expert consensus statement issued by the cardiovascular dynamics section of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC). Crit Care. 2020 Oct 22;24(1):620. doi: 10.1186/s13054-020-03326-2. PMID: 33092621

Monitorage hémodynamique avancé

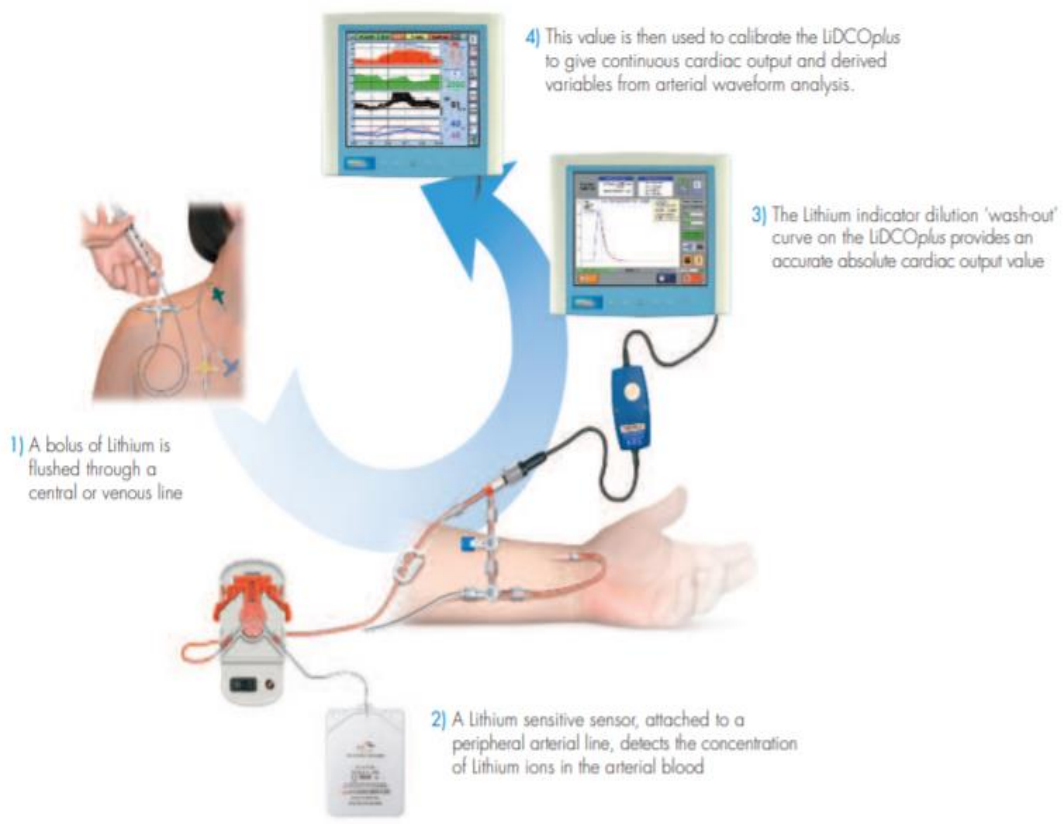
Dilution transpulmonaire de lithium

LiDCo

Technique de dilution au Lithium

- Nécessite : KTA et VVP
- Intérêt
  - QC continu (pulse contour)
  - Calibré au lithium

- Limites
  - CI : traitement lithium et curare
  - Bruit si > 20 mesures (accumulation)
  - % erreur important
  - Testé à partir de 2,6 kg



Kurita et al. 1997; Linton et al. 2000.

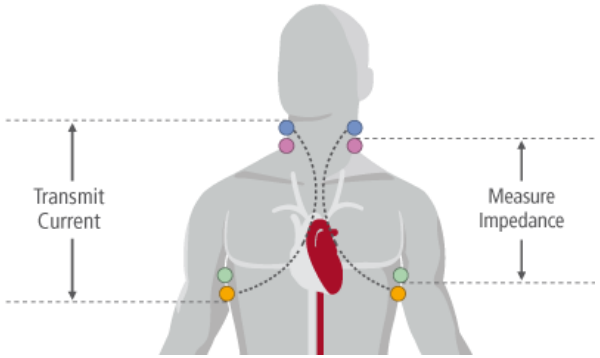
Monitorage hémodynamique avancé

Tech. électrique

Bioimpédance-Bioréactance

Technique de mesure impédance cutanée

- Nécessite : appareil et accès pour mesure
- Intérêt
  - QC continu non invasif
  - Extrapolation du QC par variation cyclique dynamique
    - → impédance électrique du thorax
  - Technologie porteuse d'intérêt



- Limites
  - En cours de validation en pédiatrie
  - Interférence des Turbulences des flux
    - en chirurgie cardio-thoracique



Beck R, Milella L, Labellarte C. Continuous non-invasive measurement of stroke volume and cardiac index in infants and children: comparison of Impedance Cardiography NICaS® vs CardioQ® method. Clin Ter. 2017;168(3):e110-e113.

Monitorage hémodynamique avancé

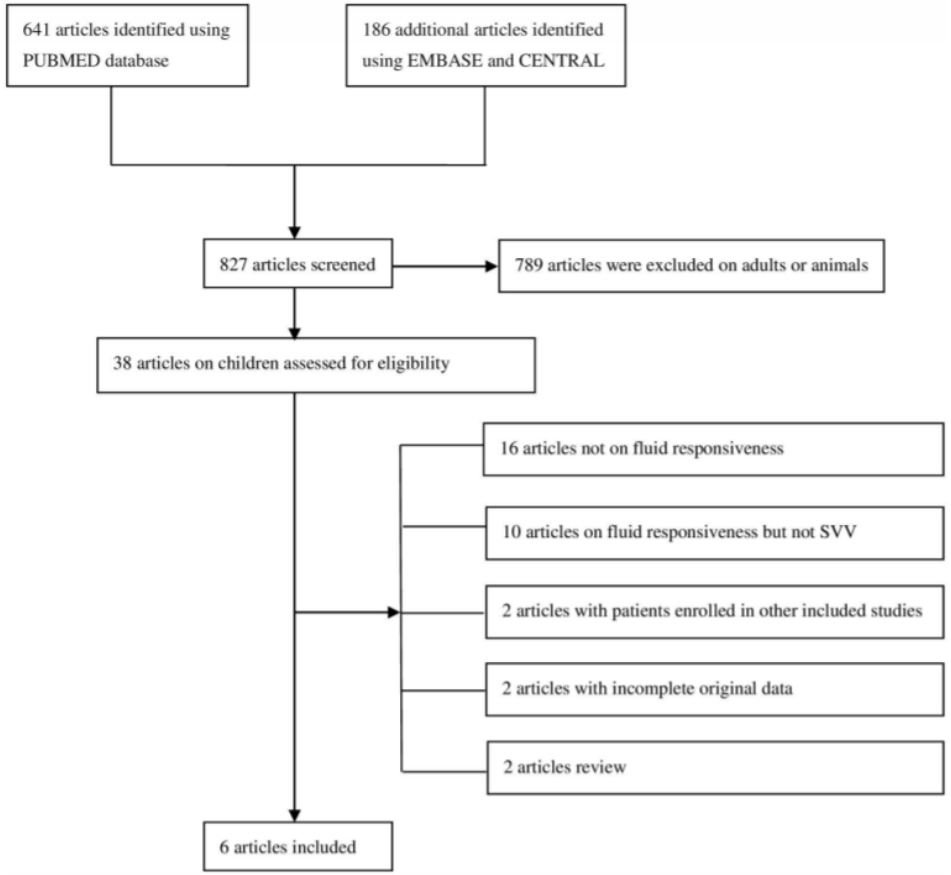
RESEARCH ARTICLE

Does stroke volume variation predict fluid responsiveness in children: A systematic review and meta-analysis

SVV

Ling Yi[1,2☯], Zhongqiang Liu[2,3☯], Lina Qiao[2,3], Chaomin Wan[2,4*], Dezhi Mu[2,4*]

1 National Office for Maternal and Child Health Surveillance of China, West China Second University Hospital, Sichuan University, Chengdu, Sichuan, China, **2** Key Laboratory of Obstetric & Gynecologic and Pediatric Diseases and Birth Defects of Ministry of Education, Sichuan University, Chengdu, Sichuan, China, **3** Department of Pediatric Intensive Care Unit, West China Second University Hospital, Sichuan University, Chengdu, Sichuan, China, **4** Department of Pediatrics, West China Second University Hospital, Sichuan University, Chengdu, Sichuan, China



Objective

Stroke volume variation (SVV) is a reliable predictor of fluid responsiveness in adult patients. However, the predictive value of SVV is uncertain in pediatric patients. We performed the first systematic meta-analysis to evaluate the diagnostic value of SVV in predicting fluid responsiveness in children.

Methods

PUBMED, EMBASE, and Cochrane Central Register of Controlled Trials were searched up to December 2016. Original studies assessing the diagnostic accuracy of SVV in predicting fluid responsiveness in children were considered to be eligible. A random-effects model was used to calculate pooled values of sensitivity, specificity and diagnostic odds ratio with 95% CI. The summary receiver operating characteristic curve was estimated and area under the curve was calculated. Quality of the studies was assessed with the QUADAS-2 tool.

Results

Six studies with a total of 279 fluid boluses in 224 children were included. The analysis demonstrated a pooled sensitivity of 0.68 (95% CI,0.59–0.76), pooled specificity of 0.65 (95% CI, 0.57–0.73), pooled diagnostic odds ratio of 8.24 (95% CI, 2.58–26.30), and the summary area under the summary receiver operating characteristic curve of 0.81. However, significant inter-study heterogeneity was found ($p<0.05$, $I^2 = 61.3\%$), likely due to small sample size and diverse study characteristics.

Plos One, 2017 May 12;12(5):e0177590

Monitorage hémodynamique avancé

SVV

Table 1. Characteristics of included studies.

Study	Year	No. of patients	No. of fluid boluses	Patient population	Age	Tidal volume	Fluid bolus	Device	Definition of responders
Renner (14)	2012	26	26	Post cardiac surgery	14±2 months	10 ml/kg	10 ml/kg, colloids	PiCCO	$\Delta SVI_{TOE} \geq 15\%$
McLean (20)	2014	13	26	PICU patients	2months-14years	-	10 ml/kg	USCOM	$\Delta SVI \geq 10\%$
Lee (21)	2014	26	26	Post cardiac surgery	6months-6years	10 ml/kg	10 ml/kg, colloids	NICOM	$\Delta SVI \geq 15\%$
Vergnaud (22)	2015	30	30	Post craniosynostosis repair	0-16years	7–8 ml/kg	20 ml/kg, colloids	NICOM	$\Delta SVI_{TTE} \geq 15\%$
Lee (23)	2015	29	29	Post cardiac surgery	1–36 months	10 ml/kg	10 ml/kg, colloids	NICOM	$\Delta SVI_{TOE} \geq 15\%$
Saxena (13)	2015	100	142	PICU patients	6–48 months	11.9±3.6 ml/kg	10 ml/kg, crystalloids	Mostcare	$\Delta SVI > 15\%$

PICU: pediatric intensive care unit; PiCCO: pulse index continuous cardiac output; USCOM: ultrasonic cardiac output monitor; NICOM: non-invasive cardiac output monitor; SVI: stroke volume index; TOE: transoesophageal echocardiography; TTE: Transthoracic echocardiography.

Conclusions

This work is the first meta-analysis to evaluate the ability of SVV to predict the response to volume expansion in pediatric patients. Our results showed that SVV was of diagnostic value in predicting fluid responsiveness in children under mechanical ventilation. However, high heterogeneity was found between published studies, further studies are needed to confirm the diagnostic accuracy and utility of SVV in predicting fluid responsiveness in children.

Plos One, 2017 May 12;12(5):e0177590

Monitorage microcirculatoire

Monitorage direct : laser doppler, imagerie micro.

Monitorage indirect : NIRS, CO2, lactates.

Microcirculation

5.	Many routinely used parameters like capillary refill, peripheral temperature, lactate, NIRS etc., reflect aspects of the hemodynamic condition, but they do not adequately reflect the microcirculation. Although central venous to arterial CO_2 difference could provide additional insight into the microcirculatory condition, we recommend against its use to guide resuscitation in critically ill children	Strong agreement
6.	We recommend against routine microcirculation evaluation by video microscopy in stable children except those in clinical studies	Strong agreement

Singh Y, Villaescusa JU, da Cruz EM, Tibby SM, Bottari G, Saxena R, Guillén M, Herce JL, Di Nardo M, Cecchetti C, Brierley J, de Boode W, Lemson J. Recommendations for hemodynamic monitoring for critically ill children-expert consensus statement issued by the cardiovascular dynamics section of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC). Crit Care. 2020 Oct 22;24(1):620. doi: 10.1186/s13054-020-03326-2. PMID: 33092621

Monitorage microcirculatoire

Monitorage de l'oxygénation cérébrale régionale

NIRS

Reflet de paramètres macrocirculatoires

Saturation de l'hémoglobine tissulaire rSO2 : SvO2 régionale (70-75%) (75% veineux)

Cardiopathie cyanogène : 46-57%

Quid des valeurs normales ? → Δ rSO2

rSO2 somatique : chute précoce (↗tonus∑)
rSO2 cérébrale : maintien autorégulation

↘ NIRSc de 20% / niveau basal:

Vérifier
- La PAM
- Le débit
- Hb
- PaCO2

- Intérêt
  - Mesures continues faciles et pratiques
  - Nouveau-nés
  - Distribution des flux sanguins régionaux
    → Cardiopathie congénitales (shunt)
  - RCT avec protocole efficace pour ↗ rSO2
- Limites
  - NIRSc basse avec QC normal et hypocapnie ou ischémie vasculaire
  - NIRS haute avec QC et SVO2 basse

Chan MJ, Chung T, Glassford NJ, Bellomo R. Near-Infrared Spectroscopy in Adult Cardiac Surgery Patients: A Systematic Review and Meta-Analysis. J Cardiothorac Vasc Anesth. 2017 Aug;31(4):1155–65. Pediatric Anesthesia. 2019;29:993–1001
Ghanayem NS, Hoffman GM. Near infrared spectroscopy as a hemodynamic monitor in critical illness. Pediatr Crit Care Med. 2016;17(8 Suppl 1):S201-S206

Monitorage microcirculatoire

Monitorage de l'oxygénation cérébrale régionale

NIRS

Near infrared spectroscopy

3.	Trend in NIRS values may provide valuable physiological information in children with hemodynamic instability but routine use in all children with hemodynamic instability is not recommended.	Strong agreement
4.	Near infrared spectroscopy (NIRS) can be useful during the peri-operative period after surgery for congenital heart defects; however, we recommend against the routine use of NIRS during non-cardiac surgery.	Weak agreement

Singh Y, Villaescusa JU, da Cruz EM, Tibby SM, Bottari G, Saxena R, Guillén M, Herce JL, Di Nardo M, Cecchetti C, Brierley J, de Boode W, Lemson J. Recommendations for hemodynamic monitoring for critically ill children-expert consensus statement issued by the cardiovascular dynamics section of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC). Crit Care. 2020 Oct 22;24(1):620. doi: 10.1186/s13054-020-03326-2. PMID: 33092621

Monitorage microcirculatoire

Monitorage de la lactatémie

Lactate

Reflet de paramètres macrocirculatoires

- Intérêt
  - Peu onéreux
  - Rapide
  - Facile
  - Demi vie normale courte (inf à 10 min)
  - Prédictif du devenir
  - Alerte sur le besoin d'intensifier les soins

Attention :
si garrot veineux : max 60 sec

- Limites
  - Certains mécanisme type B (non associé à une hypoxie tissulaire)
    - production endogène, glycolyse aérobie… (B1), ttt ß+… (B2).

Chan MJ, Chung T, Glassford NJ, Bellomo R. Near-Infrared Spectroscopy in Adult Cardiac Surgery Patients: A Systematic Review and Meta-Analysis. J Cardiothorac Vasc Anesth. 2017 Aug;31(4):1155–65..

Choix et rationnel du monitorage

Faible risque : Technologie non-invasive
Haut risque : Technologie plus invasive
→ pour compréhension physiopath. en profondeur



Choix et rationnel du monitorage

Faible risque : Technologie non-invasive
Haut risque : Technologie plus invasive
→ pour compréhension physiopath. en profondeur



PA : information insuffisante

Outils avancé pour débit cardiaque

ScVO2 pour patient cardiopathe ?

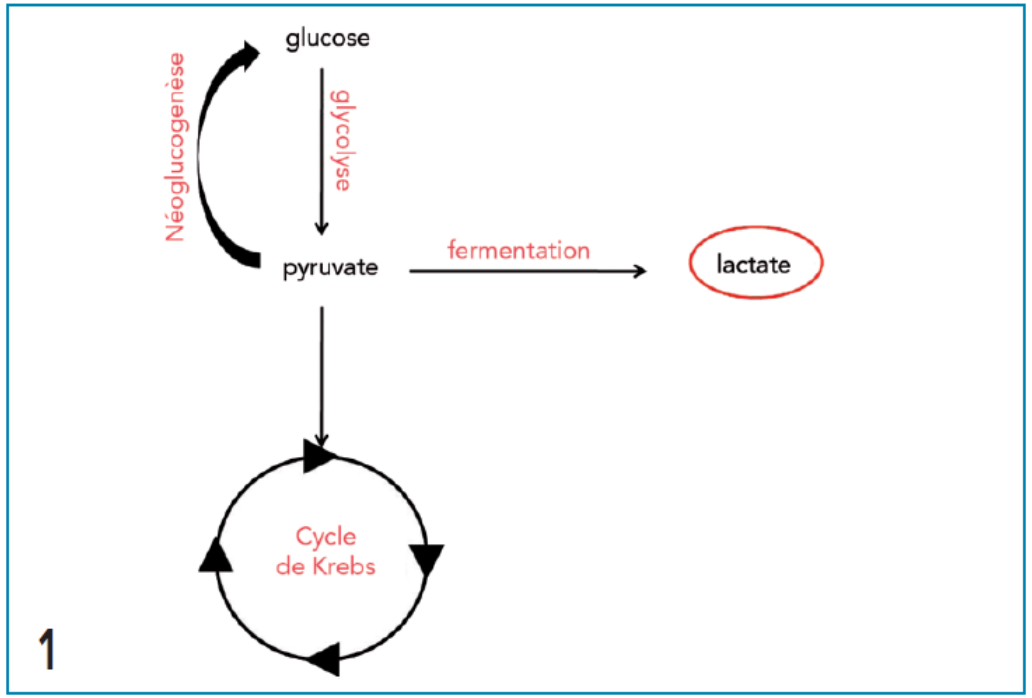
Evolution vers techno.
- moins invasive
- plus fiable

Vers une approche
- Multiparamétrique
- Plus intégrative

Ouverture

Mesure intravasculaire continue

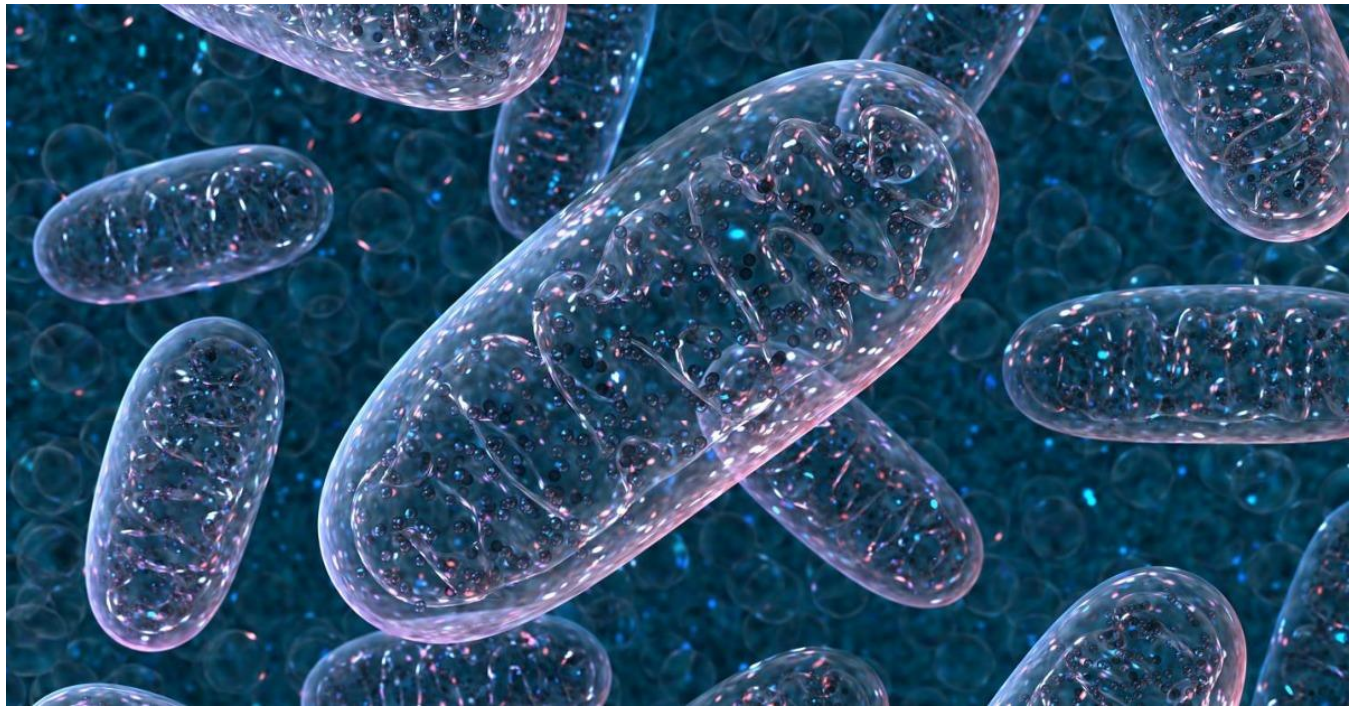
- *PaO2, Lactate*



Ouverture

Mesure intracellulaire

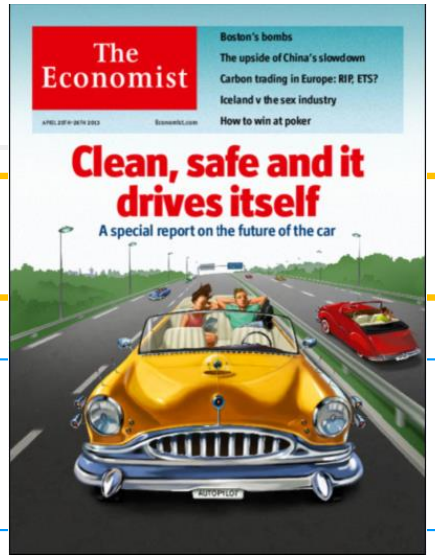
- *Appréciation niveau d'oxygène mitochondrial*
- *Appréciation oxydation cytochromique*



Ouverture

Automatisation

- *Boucle fermée intégrative* :





Fully Automated Anesthesia and Fluid Management Using Multiple Physiologic Closed-Loop Systems in a Patient Undergoing High-Risk Surgery

Alexandre Joosten, MD,* Amélie Delaporte, MD,* Maxime Cannesson, MD, PhD,† Joseph Rinehart, MD,‡ Jean Philippe Dewilde, MD,§ Luc Van Obbergh, MD, PhD,* and Luc Barvais, MD, PhD*

Society for Technology in Anesthesia

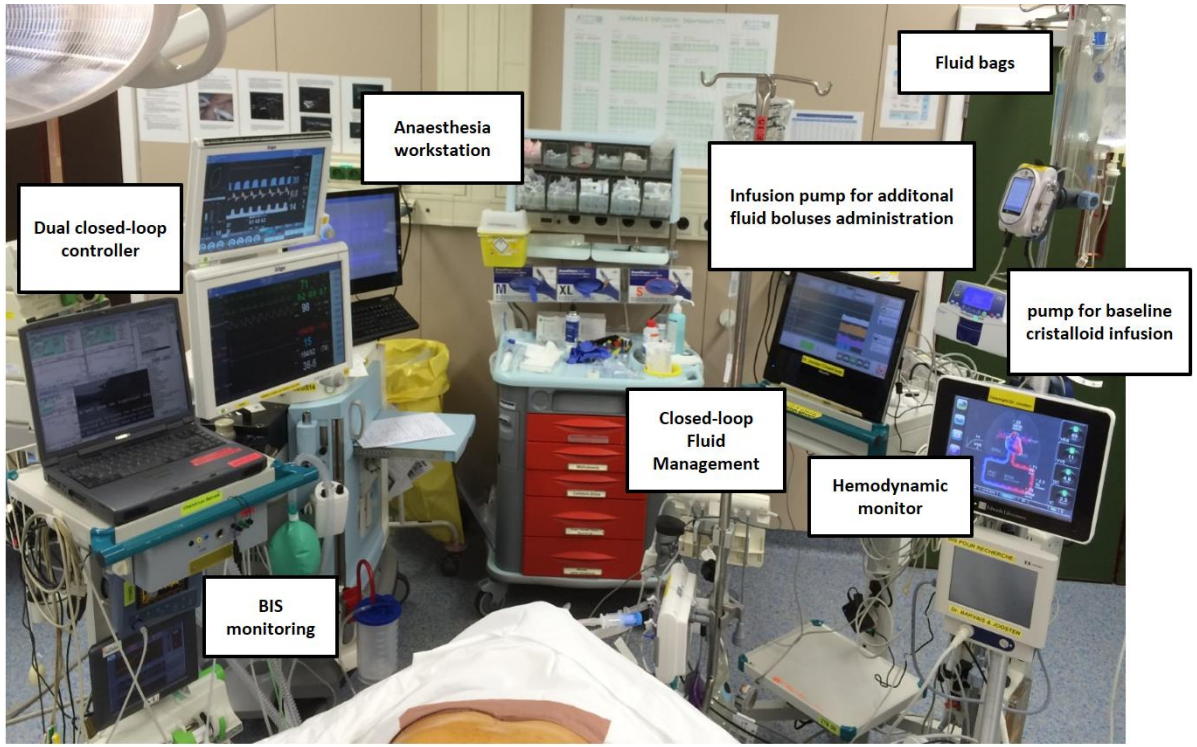
Section Editor: **Dwayne Westenskow**

REVIEW ARTICLE

CME

Closed-Loop Systems in Anesthesia: Is There a Potential for Closed-Loop Fluid Management and Hemodynamic Optimization?

Joseph Rinehart, MD,* Ngai Liu, MD, PhD,† Brenton Alexander, MS,* and Maxime Cannesson, MD, PhD*



Ouverture

Intelligence artificielle , big data et intégration des signaux faibles

- *Integrative Information Processing* :





Conclusion 1

<u>En péri opératoire:</u>

- Maintien d'une pression de perfusion
- Optimisation du débit de perfusion (VES)

- Pour chaque patient : cibler le rationnel

  travail - surcoût / efficacité - risque chirurgical

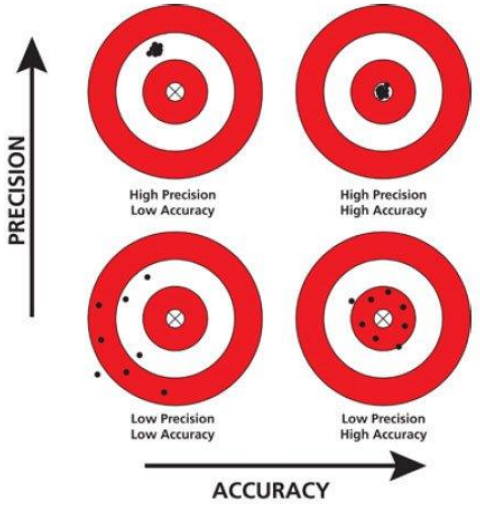
- Pour les patients à haut risque :

  Se donner les moyens de l'optimisation.

Conclusion 2

<u>En pédiatrie :</u>

- Caractéristiques physiologiques = challenge
  - Spectre large (age-taille-poids)
  - Technologies “designée” pour les adultes
  - Paramètres HD plus faible (biais de precision ++)
  - Accès vasculaires complexes
  - Complexité cardiopathie congénitale avec shunt
- Outils disponibles
  - Protocolisation possible



Compliance vasculaire en pédiatrie
Φ méthode périphérique non-invasive
QC
Précharge dépendance

Conclusion 3



<u>En pédiatrie :</u>

Raisonnement clinique multi-paramétrique

- Bloc opératoire
  - QC et surtout ΔQC
  - Remplissage vasculaire
  - Débit-Métabolisme

DO-ETT-ETO

DO-Δvpic-TLJ-CA

SvO2-NIRS-Lactates

- Réanimation

TDTP

Se donner les moyens de l'optimisation (protocolisation)

Sans oublier les objectifs globaux et limites des outils

SFAR
CONGRÈS
du 23 au 25 Septembre 2021
PALAIS DES CONGRÈS DE PARIS

Hémodynamique en pédiatrie

Quel monitorage en anesthésie pédiatrique ?

Dr Marc Lilot

Département d'Anesthésie-Réanimation Cardio-thoracique Pédiatrique
Hôpital Louis Pradel, Groupement Hospitalier Est
Hospices Civils de Lyon
marc.lilot@chu-lyon.fr ; marc.lilot@univ-lyon1.fr

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