Quel objectif de pression artérielle au cours de la CEC ?

DESEBBE Olivier

Département d'Anesthésie , Réanimation, et Médecine périopératoire

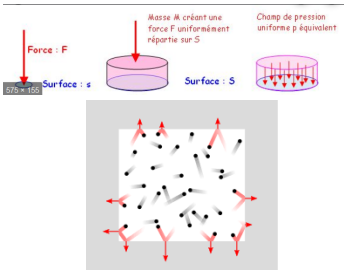
Clinique de la Sauvegarde, Lyon

Conflits d'intérêt

- MEDTRONIC
- BRAINDEX

Définition d'une pression

Pascal ⟵ $P = \frac{F}{S}$ ⟶ Newton / m^2



- Pression = Force exercée sur une surface
- l'agitation incessante des molécules et de leurs collisions, entre elles ou sur des obstacles.
- → transfert de quantité de mouvement dans un liquide et ses effets sur des parois.
- La pression s'exerce naturellement dans toutes les directions.

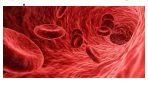
Différentes approches de la PAM

Approche électrique: loi d'OHM

- Gradient de pression motrice ΔP = DC x RVS

RVS = 8 η L / r^4

η = viscosité sanguine L = longueur du réseau r = rayon des



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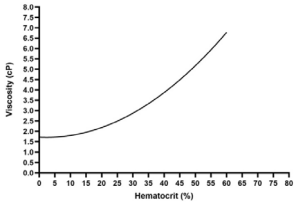
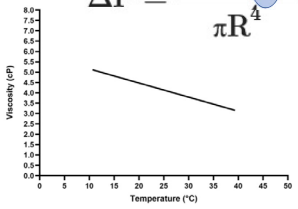
Published online 2023 Jan 19. doi: 10.3390/jcm12030806
PMCID: PMC9918189
PMID: 36769463

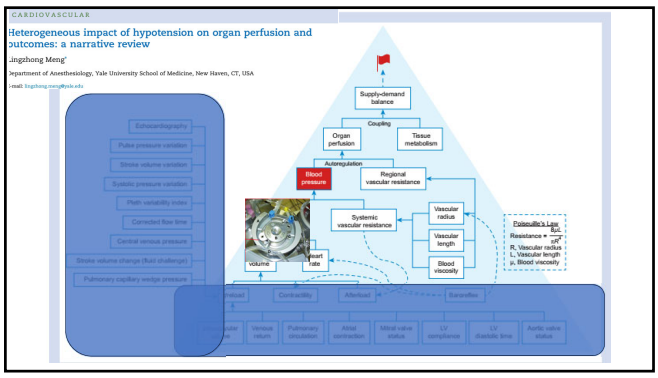
The Conundrum of Systemic Arterial Pressure Management on Cardiopulmonary Bypass

Marco Ranucci,* Mauro Cotza, and Umberto Di Dedda

$$\Delta P = \frac{Q \times 8\eta L}{\pi R^4}$$

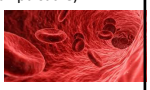


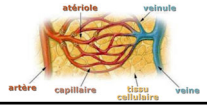




A quoi est du la pression dans un vaisseau? Vision schématique

- **Entrant**: Débit entrant = débit de CEC
- **Contenant**: Paroi des vaisseaux: élasticité, compliance artérielle
  - Élasticité
  - Impedance et inductance aortique (représente la resistance au flux pulsatile)
- **Contenu**: viscosité sanguine et plasmatique
- **Sortant**: Tonus vasomoteur distal: Résistances artérielles périphériques





Thiele A&A 2011

Comment mesurer la pression artérielle?

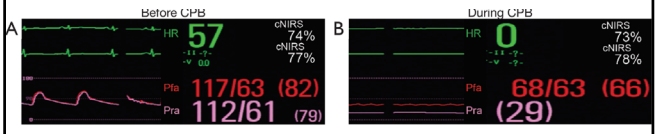
Cathétérisme artériel et mesure invasive de la pression artérielle en anesthésie-réanimation chez l'adulte

Conférence d'experts – SFAR 1994

- Tête de pression en regard de la ligne axillaire moyenne….

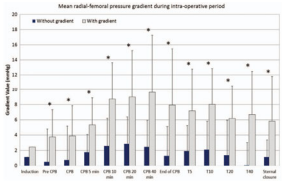
Quel site permet de mesurer la PAM?

- Radial/fémoral?
- PAM radiale < PAM fémorale



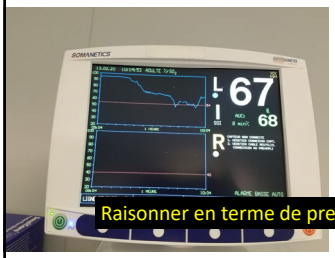
Quel site permet de mesurer la PAM?

- Gradient maximal en fin de CEC et persistant
- Jusqu'à 45% des patients
  - Petite taille
  - HTA
  - procedure longue et complexe



Bouchard Dechene JCVA 2018; Denault, A&A 2016

PAM et pression de perfusion tissulaire



- 74 ans, PAC 4
- Désaturation cérébrale avec débit de CEC et PAM constantes
- Cause?
- PVC 23 mmHg….

Raisonner en terme de pression de perfusion = PAM-PVC

Pression de perfusion tissulaire

Br J Anaesth. 2024 Jun 4;133(2):264–276. doi: 10.1016/j.bja.2024.04.046

PeriOperative Quality Initiative (POQI) international consensus statement on perioperative arterial pressure management

Bernd Saugel [1,2,*], Nick Fletcher [3], Tong J Gan [4], Michael PW Grocott [5], Paul S Myles [6], Daniel I Sessler [7]; PeriOperative Quality Initiative XI (POQI XI) Workgroup Members', , on behalf of the

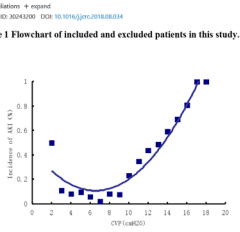
Consensus recommendation 2: We recommend increasing mean arterial pressure targets when venous or compartment pressures are elevated (strong recommendation, moderate-quality evidence).

J Crit Care. 2018 Dec;48:211-215. doi: 10.1016/j.jcrc.2018.08.034. Epub 2018 Sep 4.

High central venous pressure is associated with acute kidney injury and mortality in patients underwent cardiopulmonary bypass surgery

Yanli Yang [1], Jun Ma [2], Liyun Zhao [2]
Affiliations + expand
PMID: 30243200 DOI: 10.1016/j.jcrc.2018.08.034

Figure 1 Flowchart of included and excluded patients in this study.



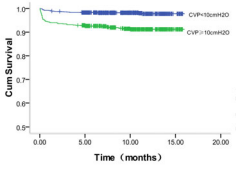


Figure3 Kaplan-Meier Analysis of Survival in two different CVP group

Patients in the high CVP group(CVP≥10cmH₂O) had a low survival rate compare to patients in low CVP group (CVP<10cmH₂O) by Log-Rank test (Chi-square=44.308, P<0.0001). CVP=central venous pressure.

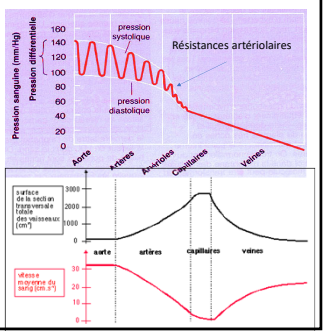
Figure2 Curvilinear Relationship Between CVP at the end of Surgery and Morbidity of AKI

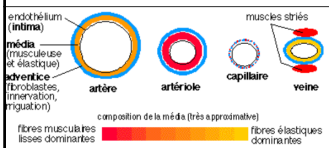
Pour aller plus loin….. Vers la microcirculation

- Théorique
- Domaine physiologique et de recherche
- D'autres pressions sont estimées

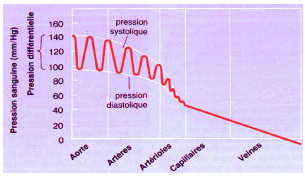
Évolution de la Pression artérielle dans l'arbre vasculaire

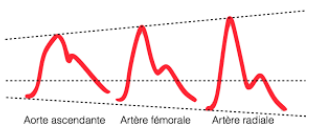
- Gradient de pression selon Résistances et surface endothéliale



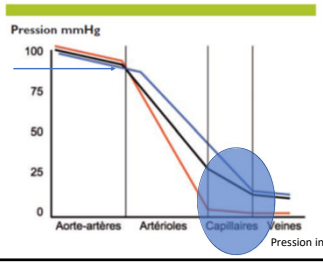


La PAM diminue mais la pression pulsée augmente en circulation pulsatile





Pression de perfusion capillaire
De la macrocirculation vers la microcirculation

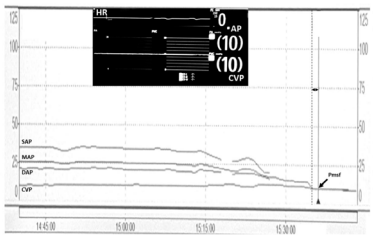


Chute de pression dans les capillaires
Variable selon le tonus vasomoteur, les inotropes, les vasoconstricteurs

Pression intéressante = Pression d'entrée…

Pression systémique moyenne

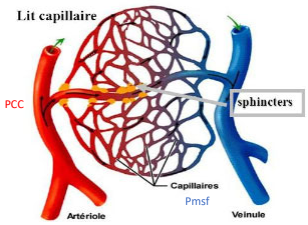
Pression Systémique Moyenne
pression mesurée en l'absence de flux
= Pression dans les veinules postcapillaires (60% de la volémie)
« obstacle aux échanges capillaires »



PAM et pression de perfusion

Gradient de pression motrice ΔP
= PAM – PSM

Lieu d'échanges O2, CO2, nutriments…

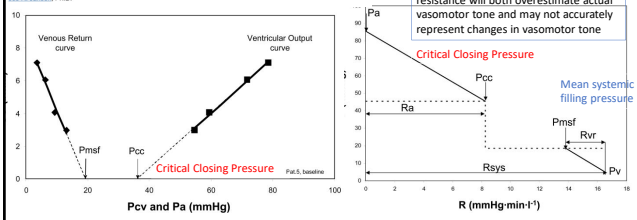


Anesth Analg. Author manuscript; available in PMC 2013 Apr 1.
Published in final edited form as:
Anesth Analg. 2012 Apr; 114(4): 803–810.
Published online 2012 Feb 17. doi: 10.1213/ANE.0b013e318247fa44
PMCID: PMC3310263
NIHMSID: NIHMS352056
PMID: 22344243

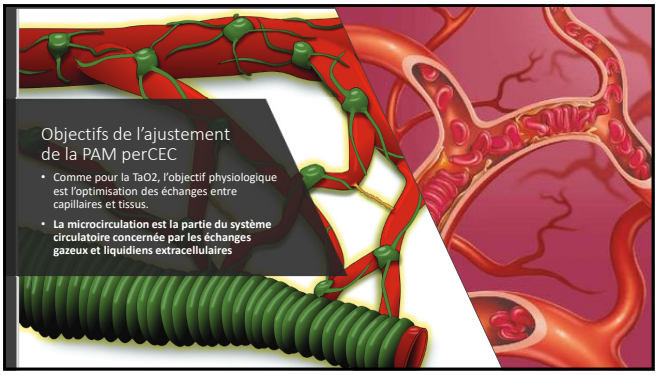
Determination of Vascular Waterfall Phenomenon by Bedside Measurement of Mean Systemic Filling Pressure and Critical Closing Pressure in the Intensive Care Unit

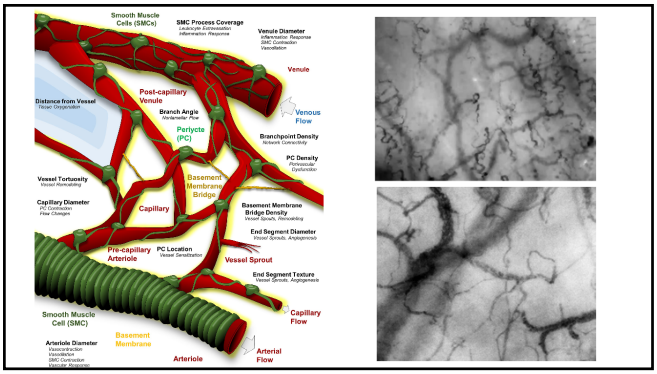
Jacinta J. Maas, M.D., Rob B. de Wilde, Ph.D., Leon P. Aarts, M.D., Ph.D., Michael R. Pinsky, M.D., Dr hc, FCCM, and Jos R. Jansen, Ph.D.

The vascular waterfall is not affected by intravascular fluid administration. Furthermore, because of this vascular waterfall in excess of 25 mmHg estimations of vasomotor tone using calculations of systemic vascular resistance will both overestimate actual vasomotor tone and may not accurately represent changes in vasomotor tone



The pressure gap of 26.8±10.7 mmHg between Pcc and Pmsf indicates that a waterfall phenomenon is likely to be present





PAM et microcirculation

Review Article
Monitoring of the Sublingual Microcirculation During Cardiac Surgery: Current Knowledge and Future Directions

Moritz Flick, MD[a], Jacques Duranteau, MD[b], Thomas W.L. Scheeren, MD[c], Bernd Saugel, MD[a,d,e]

- ? Baisse du lactate
- Amélioration marqueurs de microcirculation?: SDF, ptiO2…
- Pas de marqueurs continus de la microcirculation disponibles pour la CEC

The response of the microcirculation to cardiac surgery

Atila Kara[a,b], Sakir Akin[a,c], and Can Ince[a]

high MAP group, a higher MAP was maintained through administration of higher doses of norepinephrine and repeated bolus injections of phenylephrine. However, there were no differences in any of the microcirculatory variables between the high and low MAP groups.

Holmgaard Microcirculation 2018

Pression systémique per CEC

- Résultante du tonus vasomoteur et du débit de CEC
- Pression modifiable par vasodilatateurs, vasoconstricteurs, modification du nombre de tours/min

Influence du type de pompe sur la PAM en CEC

- principe de l'occlusion plus ou moins complète d'un tube souple par des galets rotatifs
- indépendantes de la postcharge: elles maintiennent leur débit quelle que soit la pression artérielle

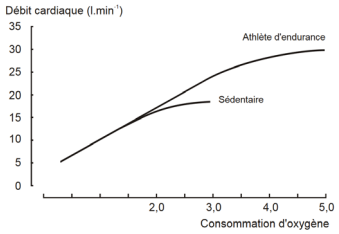
Effet des vasoconstricteurs/vasodilatateurs sur la PAM et pas sur le débit

- turbine rotative à haute vitesse
- sensible à la précharge et à la postcharge car non occlusive

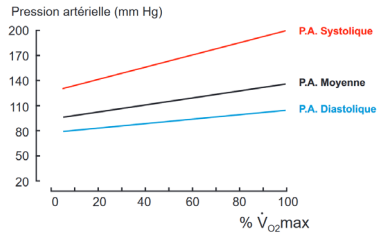
Effet mixte des vasoconstricteurs/vasodilatateurs sur la PAM et sur le débit

Test du tonus vasculaire sur la circulation systémique (DaO2, NIRS, SvO2, VO2…) sera plus difficile à interpréter pour la pompe centrifuge

Relation DC et PA non linéaire



La PA en rapport à l'augmentation du débit augmente peu au cours de l'effort



Quelle PAM pendant la CEC?

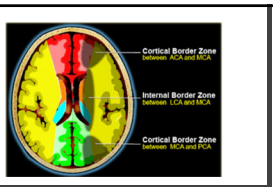
Hypo et hypertension artérielle per CEC

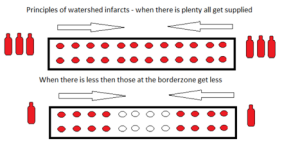
- Vasoplegic syndrome during CPB may derive from
  - the release of proinflammatory cytokines: activation coagulation, inflammation
  - anaesthetic drugs
  - active endocarditis
  - preoperative use of angiotensin-converting enzyme inhibitors and calcium channel blockers.
- Hypertension during CPB may derive from
  - an inadequate level of anaesthesia/analgesia,
  - a release of catecholamines,

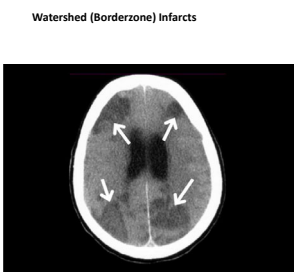
2019 EACTS/EACTA/EBCP guidelines on cardiopulmonary bypass in adult cardiac surgery

Avantages théoriques d'une PAM haute: 80-100

- Meilleure perfusion tissulaire (cerveau, rein, tube digestif) ;
- Meilleure adéquation aux besoins des malades hypertendus, âgés ou diabétiques ;
- Assurance d'un flux satisfaisant lorsque l'autorégulation d'un organe est perturbée ;
- Amélioration du flux collatéral pour les zones tissulaires à risque d'ischémie : « watershed stroke »







Avantages d'une PAM basse

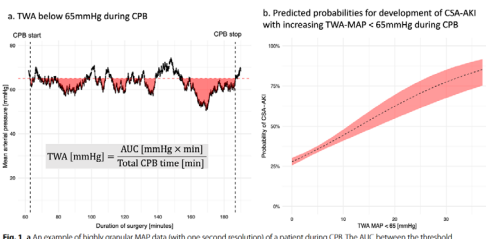
- Moins de traumatisme pour les éléments figurés ;
- Moins d'hémorragie et de retour sanguin par les artères bronchiques
- Moins de volume aspiré et lésé dans les aspirations de cardiotomie ;
- Moins de charge embolique cérébrale ;
- Meilleure protection myocardique (réduction du flux coronarien collatéral).

Pas de vasodilatateur préférentiel

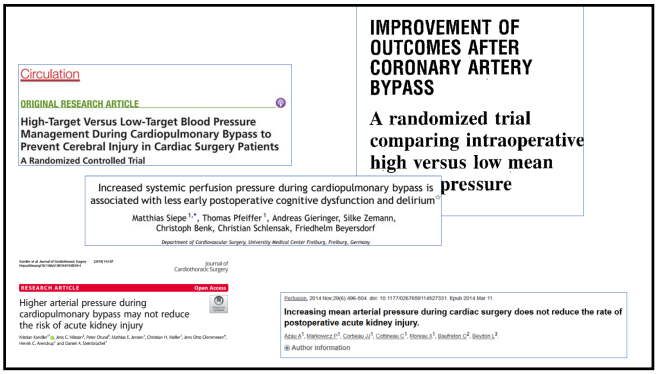
"At present, the existing literature does not contain adequate information to provide recommendations on the choice of vasodilating agents."

Les études: PAM haute ou basse?

Association hypotension et IRA postop

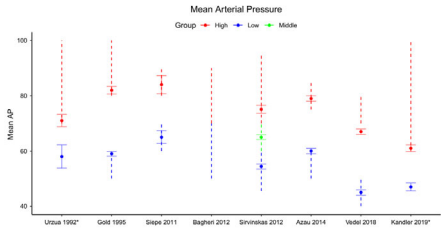


Suivi 9 ans, 2300 patients



Morbidité et mortalité des patients pris en charge avec des cibles élevées ou basses de pression artérielle pendant la chirurgie cardiaque sous circulation extracorporelle : une revue systématique et une méta-analyse d'études randomisées contrôlées

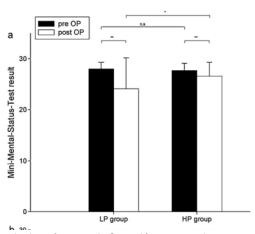
Charlotte C. McEwen, MD · Takhliq Amir, BHSc(Hons) · Yuan Qiu, BHSc(Hons) · 2022

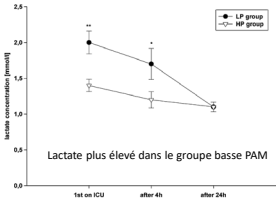


		n	population	Basse PAM	Haute PAM	objectif	résultats
Azau	2014	292	À risque d'AKI	50-60	75-85	Creat > 30%	NS
Siepe	2011	92	Chir coronaire	60-70	80-90	MMSE et délirium à H48	Delirium 13% vs 0%
Gold	1995	248	Chir coronaire	50-60	80-100	Complications neuro et cardiaques	12,9 vs 4,8% 4,0 vs 1,6% décès à 6 mois
Vedel	2018	197	Coronaires + valves	40-50	70-80	Volume total des lésions ischémiques cérébrales IRM POCD à J90	NS
Miao	2022	40	Valvulaire	50-60	70-80	Lactate	3,1 versus 2,1
Kandler	2019	90	PAC Valves	40-50	> 65	AKI	NS

Increased systemic perfusion pressure during cardiopulmonary bypass is associated with less early postoperative cognitive dysfunction and delirium

Matthias Siepe [1,*], Thomas Pfeiffer [1], Andreas Gieringer, Silke Zemann, Christoph Benk, Christian Schlensak, Friedhelm Beyersdorf
Department of Cardiovascular Surgery, University Medical Center Freiburg, Freiburg, Germany





Lactate plus élevé dans le groupe basse PAM

Fig. 2. Postoperative lactate concentration over the time on the intensive care unit. Note that the LP group's lactate rises significantly immediately after surgery (*$p < 0.05$ and **$p < 0.001$ between the groups, error bars indicate standard error of the mean).

Manque de données: Pas de feVG décrite , pas de PaCO2 perCEC, pas de DaO2/débit de CEC delirium 0% dans le groupe traité????

Siepe 2011

Table IV. *Cardiac and neurologic outcomes in the two treatment groups (intention to treat)*

	Low MAP (n = 124)		High MAP (n = 124)		Low − high MAP		
	No.	%	No.	%	No.	%	95% CI for % difference
Fatal stroke	2	1.6	0	0.0			
Hemiparesis*	2	1.6	1	0.8			
Aphasia	3	2.4	1	0.8			
Cortical blindness	1	0.8	0	0.0			
Monocular blindness	1	0.8	0	0.0			
Other focal deficit	0	0.0	1	0.8			
Total permanent neurologic complications	9	7.2	3	2.4	6	4.8	−0.5, 11.0
Fatal cardiogenic shock	1	0.8	2	1.6			
Shock	1	0.8	0	0.0			
Myocardial infarction	4	3.2	1	0.8			
Total cardiac complications	6	4.8	3	2.4	3	2.4	−2.2, 7.1
Other death, total (not attributable to cardiac or neurologic causes)	2	1.6	0	0	2	1.6	−0.6, 3.8
Total mortality and major cardiac and neurologic morbidity	16†	12.9	6	4.8	10	8.1	1.0, 15.1

Taux d'AIC dans le groupe low MAP très élevé et grave
Débit de CEC 1,9 à 2,3 l/min/m²

Gold 1995

Miao et al. BMC Anesthesiology (2021) 21:309
https://doi.org/10.1186/s12871-021-01537-w

BMC Anesthesiology

RESEARCH Open Access

Target blood pressure management during cardiopulmonary bypass improves lactate levels after cardiac surgery: a randomized controlled trial

Qing Miao†, Dong Jin Wu†, Xu Chen†, Meiying Xu†, Lin Sun†, Zhen Guo†, Bin He* and Jingxiang Wu*

- Débit de CEC 2,4 l/min/m², hypothermie modérée

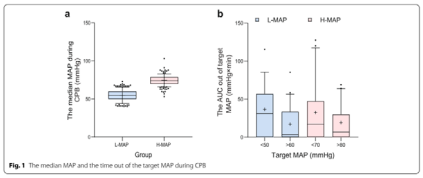


Fig. 1 The median MAP and the time out of the target MAP during CPB

Miao et al. BMC Anesthesiology (2021) 21:309
https://doi.org/10.1186/s12871-021-01537-w

BMC Anesthesiology

RESEARCH Open Access

Target blood pressure management during cardiopulmonary bypass improves lactate levels after cardiac surgery: a randomized controlled trial

Qing Miao†, Dong Jin Wu†, Xu Chen†, Meiying Xu†, Lin Sun†, Zhen Guo†, Bin He* and Jingxiang Wu*

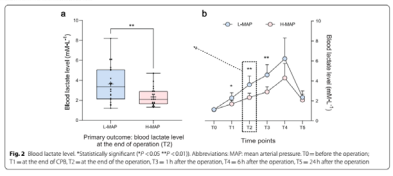


Fig. 2 Blood lactate level. *Statistically significant (*P* < 0.05, **P < 0.01). Abbreviations: MAP: mean arterial pressure, T0 = before the operation; T1 = at the end of CPB, T2 = at the end of the operation, T3 = 1 h after the operation, T4 = 6 h after the operation, T5 = 24 h after the operation

Cr (μM·L⁻¹)			
Baseline	78 [63, 90]	74 [60, 84]	0.558
6 h after the operation	72 [58.8, 88]	79 [52, 93]	0.690
24 h after the operation	75 [57, 91]	75 [63, 86]	0.706

BB (N) (mM·L⁻¹)

Circulation

ORIGINAL RESEARCH ARTICLE

High-Target Versus Low-Target Blood Pressure Management During Cardiopulmonary Bypass to Prevent Cerebral Injury in Cardiac Surgery Patients
A Randomized Controlled Trial

Table 1. Baseline Characteristics

	Low-Target Group (n=99)	High-Target Group (n=98)
Age, y	65.0±10.7	69.4±8.9
Male sex, n (%)	93 (93.9)	84 (85.7)
Nonwhite race, n (%)	2 (2.0)	0 (0)
Previous myocardial infarction, n (%)*	37 (37.4)	37 (37.8)
Recent myocardial infarction (past 2 wk), n (%)	30 (30.3)	25 (25.5)
Aortic valvular disease, n (%)	34 (34.3)	34 (34.7)
Angina, CCS score >1, n (%)†	64 (64.6)	47 (48.0)
Current or previous atrial fibrillation, n (%)	14 (14.1)	13 (13.3)
Hypertension, n (%)	83 (84.8)	87 (88.8)
Diabetes mellitus, type 1 or 2 (insulin treated), n (%)	10 (10.1)	10 (10.2)
Diabetes mellitus, type 2 (non–insulin treated), n (%)	14 (14.1)	14 (14.3)
Chronic lung disease, n (%)	9 (9.1)	12 (12.2)
Current smoker, n (%)	18 (18.2)	15 (15.3)
Current alcohol abuse, n (%)	7 (7.1)	7 (7.1)
BMI, kg/m²‡	27.0 (3.8)	27.6 (4.0)
Left ventricular ejection fraction, n (%)		
>50%	54 (54.5)	50 (51.5)

Circulation

ORIGINAL RESEARCH ARTICLE

High-Target Versus Low-Target Blood Pressure Management During Cardiopulmonary Bypass to Prevent Cerebral Injury in Cardiac Surgery Patients
A Randomized Controlled Trial

	Low-Target Group (n=98)	High-Target Group (n=97)
MAP before anesthesia induction, mm Hg	92.3±15.7	96.9±13.4
MAP during bypass, mm Hg	44.7±4.7	66.8±4.9
Norepinephrine infused in the OR, µg/kg	2.65±6.01	17.43±20.14
Patients receiving norepinephrine in the OR, n (%)	35 (35.7)	90 (92.7)

Circulation

ORIGINAL RESEARCH ARTICLE

High-Target Versus Low-Target Blood Pressure Management During Cardiopulmonary Bypass to Prevent Cerebral Injury in Cardiac Surgery Patients
A Randomized Controlled Trial

Overall, diffusion-weighted imaging revealed new cerebral lesions in 52.8% of patients in the low-target group versus 55.7% in the high-target group (*P*=0.76). The primary outcome of volume of new cerebral lesions was

	Low-Target Group, n		High-Target Group, n		Difference (95% CI)	OR (95% CI)	*P* Value
Complete cases, mean (SD) Volume AVC	89	415 (2682)	80	488 (2539)	8 (−978 to 994)†		0.99‡
Adverse events, n (%)‖							
Death	99	0 (0)	98	4 (4.1)		Inf	0.06
Creatinine, doubling of baseline value, n (%)	2 (2.0)		9 (9.4)		4.93 (1.02–48.12)	0.03	

- PAM basse et moins d'AVC , moins d'insuffisance rénale

Conclusions

No difference in mortality nor in the level of cognitive functioning was found according to blood pressure target during cardiac surgery long-term at 3-year follow-up.

Kandler et al. Journal of Cardiothoracic Surgery (2019) 14:57
https://doi.org/10.1186/s13019-019-0824-4

Journal of Cardiothoracic Surgery

RESEARCH ARTICLE Open Access

Higher arterial pressure during cardiopulmonary bypass may not reduce the risk of acute kidney injury

Kristian Kandler[1*], Jens C. Nilsson[2], Peter Ostrup[3], Mathias E. Jensen[1], Christian H. Møller[1], Jens Otto Clemmesen[4], Henrik C. Ærenlund[1] and Daniel A. Steinbrüchel[1]

90 patients

Table 3 Postoperative data

	CG	HPG	*p* value	95% CI
Delta sCr (mmol/L)	20 (6–51)	25 (10–49)	0.560	−18 to 18
Delta eGFR (ml/min)	−6 (− 15–4)	− 3 (− 13–5)	0.522	−7 to 5
AKI	16 (34%)	19 (44%)	0.447	
Dialysis	4 (10%)	3 (7%)	0.565	
Re-operation	4 (10%)	1 (3%)	0.165	
Stroke	3 (8%)	2 (5%)	0.687	
4 months follow-up				
Change in GFR (ml/min)	−9 ± 12	−5 ± 16	0.288	−13 to 4
> 10% decrease in GFR*	11 (44%)	9 (39%)	0.732	
30-day mortality	3 (7%)	3 (7%)	1.000	
6-months mortality	7 (16%)	8 (18%)	0.763	

Percentages are given as total within group. Continuous data are presented as mean ± SD or median (Interquartile min – max)
AKI Acute kidney injury, *CI* confidence interval, *AP* Arterial pressure, *eGFR* Estimated glomerular filtration rate (calculated using the Cockroft-Gault formula), *GFR* Glomerular filtration rate (estimated by Cr-EDTA clearance), *sCr* Serum creatinine
*Percentages of total of patients at follow-up

2019 kandler

Prévention de l'AKI par la PAM?

SYSTEMATIC REVIEW ARTICLE

Society of Cardiovascular Anesthesiologists Clinical Practice Update for Management of Acute Kidney Injury Associated With Cardiac Surgery

Ke Peng, MD, PhD,*† David R. McIlroy, MBBS,‡ Bruce A. Bollen, MD,§ Frederic T. Billings IV, MD,‖ Alexander Zarbock, MD,¶ Wanda M. Popescu, MD,# Amanda A. Fox, MD, MPH,** Linda Shore-Lesserson, MD,†† Shaofeng Zhou, MD,†† Mariya A. Gasdar, MD, III Fahar Jr, MD, PhD,‡‡ Meena Bhatia, MD,§§ Nanette M. Schwann, MD,§§ Andrew D. Shaw, MD, FCCM, FFCM, FRCA,¶¶ and Hong Liu, MD, PASE*

SYSTEMATIC REVIEW ARTICLE

Table 1. Study Characteristics

Study	Region	Procedure	N	Interventional and control treatments, and main findings on CS-AKI	AKI definition	Journal (IF2020)
Intraoperative target blood pressure						
Asou et al 2014[51]	France	CABG, valve, or aorta, with CPB	292	A high level of MAP (75–85 mm Hg) versus control (MAP 50–60 mm Hg) during normothermic CPB did not reduce the risk of AKI.	30% rise in sCr	Perfusion (1.97)
Kandler et al 2019[52]	Denmark	CABG + valve, with CPB	90	Arterial pressure >60 mmHg versus control (MAP 47 mm Hg) during CPB did not reduce the incidence of AKI or chronic kidney injury at postoperative 4 mo.	RIFLE	J Cardiothorac Sur (1.64)
Vedel et al 2018[53]	Denmark	CABG and/or valve, with CPB	197	A higher MAP (70–80 mm Hg) versus control (MAP 40–50 mm Hg) increased the number of patients with postoperative doubling of sCr.	sCr ≥2 times of baseline	Circulation (29.7)

A&A 2022

Métaanalyse 2022

Outcome (number of studies)	High MAP target, n/total *N*	Low MAP target, n/total *N*	Relative risk	95% CI	*P* value	I^2 (%)
Dichotomous variables						
Hospital mortality (4)	8/311	6/316	1.1	0.4 to 3.3	0.84	0
30-day mortality (4)	12/334	6/337	1.6	0.6 to 4.36	0.33	0
6-month mortality (3)	15/310	19/309	0.8	0.4 to 1.6	0.55	0
Myocardial infarction (3)	7/367	8/367	0.9	0.3 to 3.2	0.89	18
Delirium (2)	10/142	13/147	0.5	0.03 to 8.6	0.61	75
Cognitive decline (2)	39/190	35/204	1.2	0.7 to 2.1	0.46	35
Stroke (3)	11/261	13/266	1.0	0.2 to 4.9	0.95	65
Hemodialysis (5)	11/368	11/372	1.0	0.5 to 2.3	0.98	0
RIFLE "risk" criteria (4)	120/297	98/303	1.3	0.9 to 1.8	0.25	41
Number transfused (3)	85/227	60/229	1.4	1.1 to 1.9	0.004	0
Outcome (number of studies)	High MAP target, mean (SD)	Low MAP target, mean (SD)	Weighted mean difference	95% CI	*P* value	I^2 (%)
Continuous variables						
ICU LOS in days (4)	2.4 (4.7)	2.6 (5.3)	0.2	-0.4 to 0.8	0.55	29
Hospital LOS in days (4)	10.7 (7.8)	11.1 (9.4)	1.1	0.3 to 1.8	0.006	13
PRBCs transfused/patient (3)	2.1 (2.7)	1.9 (2.9)	0.1	-0.1 to 0.3	0.35	0

CI = confidence interval; ICU = intensive care unit; MAP = mean arterial pressure; LOS = length of stay; PRBC = packed red blood cell; RIFLE = Risk, Injury, Failure, Loss, and End-stage Kidney classification

Review > Cochrane Database Syst Rev. 2022 Nov 30;11(11):CD013494.
doi: 10.1002/14651858.CD013494.pub2.

High versus low blood pressure targets for cardiac surgery while on cardiopulmonary bypass

Yuki Kotani [1], Yuki Kataoka [2 3 4 5], Junichi Izawa [6 7], Shoko Fujioka [8], Takuo Yoshida [9 10], Junji Kumasawa [11 12], Joey Sw Kwong [13]

Affiliations + expand

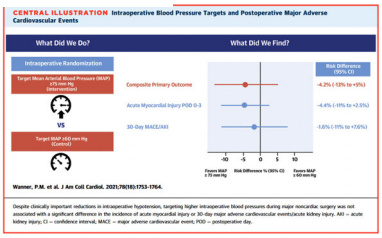
PMID: 36448514 PMCID: PMC9709767 (available on 2023-11-30)
DOI: 10.1002/14651858.CD013494.pub2

Conclusions des auteurs

Une cible de pression artérielle élevée pourrait n'entraîner que peu ou pas de différence dans les critères de jugement relatifs aux patients, y compris les lésions rénales aiguës et la mortalité. Compte tenu de largeur des intervalles de confiance, d'autres études sont nécessaires pour confirmer l'efficacité d'une cible de pression artérielle plus élevé chez les personnes qui subissent une chirurgie cardiaque avec pontage cardio-pulmonaire.

Targeting Higher Intraoperative Blood Pressures Does Not Reduce Adverse Cardiovascular Events Following Noncardiac Surgery

Patrick M. Wanner, MD,* Dirk U. Wulff, PhD,† Mirjana Djurdjevic,‡ Wolfgang Korte, MD,‡ Thomas W. Schnider, MD,‡ Miodrag Filipovic, MD*



Reco EACTS 2024 sur la PAM per CEC

Recommendation Table 29 Recommendations for kidney protection

Recommendations	Class [a]	Level [b]	Ref [c]
Routinely targeting a high MAP using vasoconstrictors is not recommended during CPB to reduce AKI.	III	A	377,378,380,381

Reco EACTS 2024

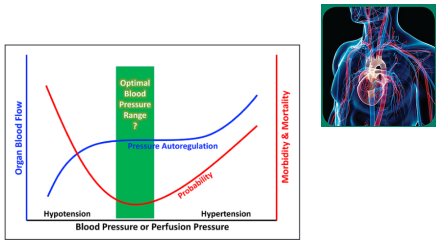
Recommendation Table 40 Recommendations for control of mean arterial blood pressure during cardiopulmonary bypass

Recommendations	Class [a]	Level [b]	Ref [c]
It is recommended that the MAP be maintained between 50 and 80 mmHg with vasoconstrictors and vasodilators if required, having ensured that the depth of anaesthesia and pump flow rate are sufficient.	I	A	381,511
The use of vasopressors to increase the MAP to values above 80 mmHg during CPB is not recommended.	III	B	381,510,517
Targeting the MAP during CPB within the limits of individualized cerebral autoregulation data, measured under normocapnic conditions before CPB, should be considered whenever the technical and human skills are available.	IIa	A	222,519,520
It is recommended that vasoplegic syndrome during CPB be treated with α1-adrenergic agonists and/or vasopressin.	I	C	521,523
In refractory vasoplegic syndrome, alternative drugs (methylene blue or terlipressin) should be considered, alone or in combination.	IIa	B	522,523
Hydroxocobalamin or angiotensin II may be considered to treat vasoplegic syndrome during CPB.	IIb	C	524–527

Titrer la PAM pendant la CEC?

= individualiser pour chaque patient le niveau de PAM selon ses besoins

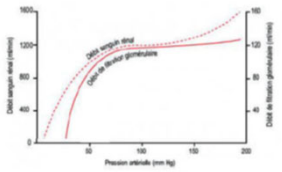
Détermination physiologique de la PAM idéale



Optimisation de la PAM?
Autorégulation de l'organe

Pas de variation du DSR et du DFG pour des variations de pression artérielle moyenne entre 80 et 180 mmHg

Cerveau
Rein
Myocarde (avant/après clampage)
Mésentère?



Titration selon la valeur initiale de PAM?

Improvement of Outcomes after Coronary Artery Bypass II: A Randomized Trial Comparing Intraoperative High Versus Customized Mean Arterial Pressure

Mary E. Charlson, M.D.,* Janey C. Peterson, Ed.D., R.N.,* Karl H. Krieger, M.D.,†

Adaptation PAM per CEC selon valeur basale PAM

- Sédation, pose KT artériel, attente 4 min
- the next 6 mean blood pressures downloaded to the computer from the operating room monitor (at 10 sec intervals) were recorded and an average MAP was taken.

Improvement of Outcomes after Coronary Artery Bypass II: A Randomized Trial Comparing Intraoperative High Versus Customized Mean Arterial Pressure

Mary E. Charlson, M.D.,* Janey C. Peterson, Ed.D., R.N.,* Karl H. Krieger, M.D.,†

- **412 patients**
- **Chir coronaire programmée**
- **80 +/- 20 mmHg,**
- **versus**
- **max 90 (57-90), 88 moy**
- **Complications neuro et cardiaques/cognitives: NS 16,5 vs 14,5%**

- Among those whose average MAP was more than 20 mmHg below their autoregulatory range, the cardiac and neurologic complication rate was double that of patients whose MAP was not that low (15.9% vs. 7.3%).
- 61% adhérence gp PAM préop
- 85% adhérence gp Pam 80
- management at higher MAP on CPB dramatically reduces stroke occurrence in patients with severe aortic atheromatous disease (grade IV and V)

Improvement of Outcomes after Coronary Artery Bypass II: A Randomized Trial Comparing Intraoperative High Versus Customized Mean Arterial Pressure

Mary E. Charlson, M.D.,* Janey C. Peterson, Ed.D., R.N.,* Karl H. Krieger, M.D.,†

Même PAM dans les 2 groupes…

B. Intraoperative Management Pre-bypass	High MAP	Custom MAP	P
Pre-bypass MAP (mmHg)	86 ± 8	85 ± 9	
Pre-bypass cardiac output (L/min)	4 ± 1	4 ±1.	
Bypass Times (min)			
Bypass	74 ± 24	77 ± 22	ns
Cross-clamp	40 ± 15	40.4 ± 14	ns
Pump flows (L/min/m^2)#			
Bypass on—warming (± θ)	2.0 ± 0.3	2.0 ± 0.3	ns
Warming—cross-clamp off (± θ)	2.1 ± 0.3	2.2 ± 0.3	ns
Cross-clamp off—bypass off (± θ)	2.4 ± 0.2	2.34 ± 0.3	ns

observationnel

Difference between pre-operative and cardiopulmonary bypass mean arterial pressure is independently associated with early cardiac surgery-associated acute kidney injury

Delta MAP > 26 mmHg

Hussein D Kanji, Costas J Schulze, Marilou Hervas-Malo, Peter Wang, David B Ross, Mohamad Zibdawi and Sean M Bagshaw

Journal of Cardiothoracic Surgery 2010 5:71
https://doi.org/10.1186/1749-8090-5-71
Received: 7 May 2010 | **Accepted:** 8 September 2010 | **Published:** 8 September 2010

Mesurer en site fémoral si petit gabarit, procédure longue

Position de la tête de pression..

Nonpulsatile pump flow rates were kept at 2.4 L/min/m$_2$

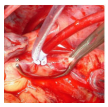
Difference between pre-operative and cardiopulmonary bypass mean arterial pressure is independently associated with early cardiac surgery-associated acute kidney injury

Table 4 Multi-variable adjusted logistic regression model[¶] of association between delta MAP and CSA-AKI

Parameter	Odds Ratio	95% CI	P-value
Male sex	0.7	0.3-1.7	0.49
Age ≥75 years (present)	2.1	0.9-4.9	0.08
BMI ≥25 kg/m^2 (present)	4.2	1.6-11.2	0.0039
Delta MAP ≥26 mmHg (present)	2.8	1.3-6.1	0.009
Flow ≥54 per mL/kg/min (present)	0.3	0.1-0.7	0.004
Side-biting clamp (present)	3.0	1.3-7.1	0.012

Abbreviations: BMI = Body Mass Index; MAP = mean arterial pressure; CPB = cardiopulmonary bypass

Model characteristics: C-statistic = 0.788



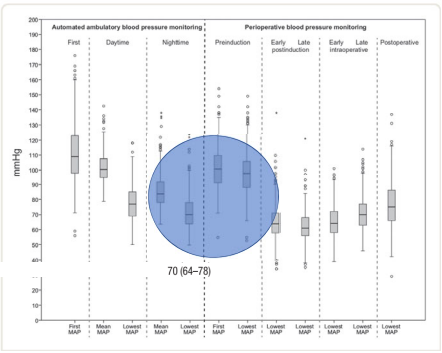
ANESTHESIOLOGY

Automated Ambulatory Blood Pressure Measurements and Intraoperative Hypotension in Patients Having Noncardiac Surgery with General Anesthesia

A Prospective Observational Study

Bernd Saugel, M.D., Philip C. Reese, M.D., Daniel I. Sessler, M.D., Christian Burfeindt, Julia Y. Nicklas, M.D., Hans O. Pinnschmidt, Ph.D., Daniel A. Reuter, M.D., Stefan Südfeld, M.D.

ANESTHESIOLOGY 2019; 131:74–83



ANESTHESIOLOGY

Automated Ambulatory Blood Pressure Measurements and Intraoperative Hypotension in Patients Having Noncardiac Surgery with General Anesthesia

A Prospective Observational Study

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ANESTHESIOLOGY 2019; 131:74–83

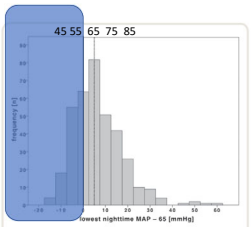
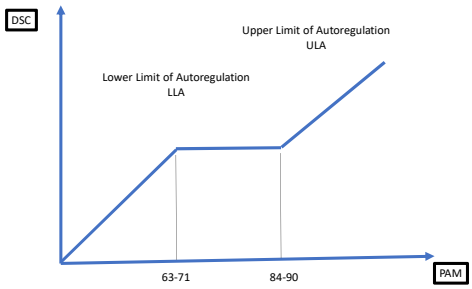
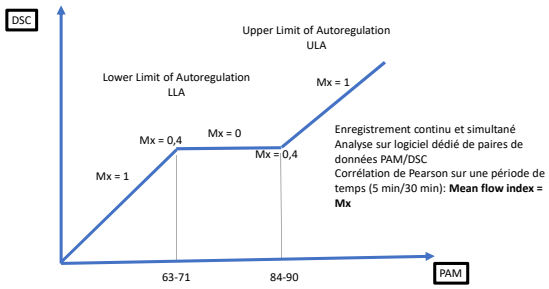


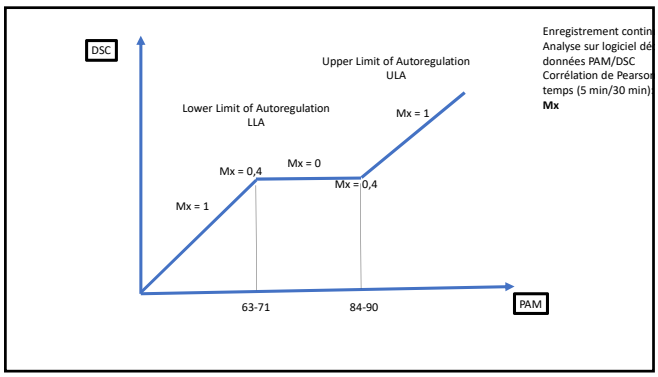
Fig. 6. Difference between lowest nighttime mean arterial pressure (MAP) and a MAP of 65 mmHg. Histogram showing the frequency (n; y axis; n total = 370) of the difference between the lowest nighttime MAP and a MAP of 65 mmHg. The median difference (25th to 75th percentile range) was +5 (−1 to +13) mmHg. The *dotted vertical line* represents the median difference.

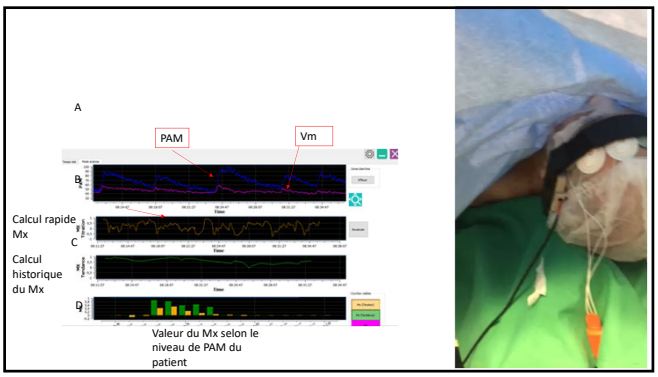
Ajuster la PAM selon la circulation cérébrale?





Enregistrement continu et simultané
Analyse sur logiciel dédié de paires de données PAM/DSC
Corrélation de Pearson sur une période de temps (5 min/30 min): **Mean flow index = Mx**





Optimal blood pressure during cardiopulmonary bypass defined by cerebral autoregulation monitoring

CrossMark

Daijiro Hori, MD,[a] Yohei Nomura, MD,[a] Masahiro Ono, MD,[b] Brijen Joshi, MD,[c] Kaushik Mandal, MD,[a] Duke Cameron, MD,[a] Masha Kocherginsky, PhD,[d] and Charles W. Hogue, MD[c]

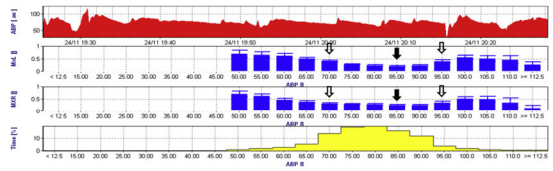


FIGURE 2. Representative graph of cerebral autoregulation monitoring by Mx during CPB. The top graph represents the time-series of ABP, and the bottom bar-graph represents the percentage of the time of the recording spent at 5 mm Hg bin. Optimal MAP (ABP) for the left and right side of the brain was defined as that MAP with the lowest Mx. LLA and ULA were defined as the MAP at which Mx reached 0.4. In this example, the optimal MAP is 85 mm Hg (*black arrow*) and the LLA and ULA are 70 mm Hg and 95 mm Hg, respectively (*black-outlined arrow*). *ABP*, Arterial blood pressure.

Variabilité individuelle de la LLA

Predicting the Limits of Cerebral Autoregulation During Cardiopulmonary Bypass

Brijen Joshi, MD,* Masahiro Ono, MD,† Charles Brown, MD,* Kenneth Brady, MD,† R. Blaine Easley, MD,§ Gayane Yenokyan, PhD,|| Rebecca F. Gottesman, MD, PhD,¶ and Charles W. Hogue, MD*

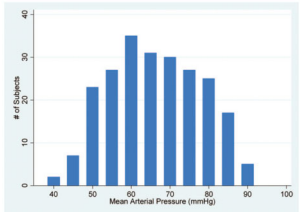


Figure 1. Number of subjects versus the mean arterial blood pressure at the lower limit of cerebral blood flow autoregulation during cardiopulmonary bypass based on the transcranial Doppler-determined mean velocity index.

March 2012 • Volume 114 • Number 3

www.anesthesia-analgesia.org

Détermination du LLA avec l'oxymétrie cérébrale

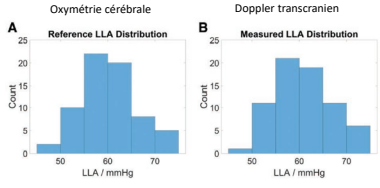


Figure 5. Distributions of LLAs–cotrending algorithm and TCD reference. A, Bland-Altman plot of the data displaying mean bias = 0.22 mmHg, an upper LOA = 10.79 mmHg (95% CI, 10.09–11.49) and a lower LOA = −10.35 mmHg (95% CI, −9.65 to −11.05). B, Scatter plot of individual LLAs over time over all cases (bubble sizes proportional to number of colocated data points). The dashed line in the middle represents the unity line, which indicates a perfect agreement between the method and the reference. CI indicates confidence interval; LLA, lower limit of autoregulation; LOA, limit of agreement.

Les études observationnelles

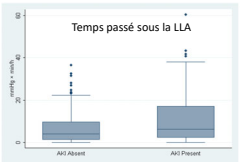
Blood Pressure Excursions Below the Cerebral Autoregulation Threshold During Cardiac Surgery Are Associated With Acute Kidney Injury

Masahiro Ono, MD, PhD[1], George J. Arnaoutakis, MD[1], Derek M. Fine, MD[2], Kenneth Brady,

Published in final edited form as:
J Thorac Cardiovasc Surg. 2014 January ; 147(1): . doi:10.1016/j.jtcvs.2013.07.069.

Duration and magnitude of blood pressure below cerebral autoregulation threshold during cardiopulmonary bypass is associated with major morbidity and operative mortality

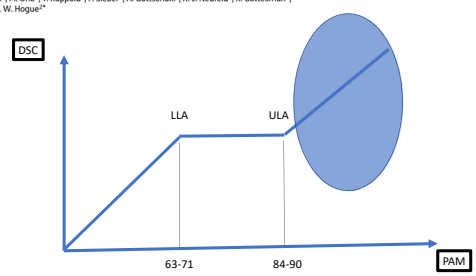
Masahiro Ono, MD, PhD[a], Kenneth Brady, MD[b], R. Blaine Easley, MD[b], Charles Brown,



Variable	No MMOM (n = 354)	MMOM (n = 83)	*P* value
Average MAP during CPB (mm Hg)	74 ± 8 (73–75)	75 ± 9 (72–76)	.203
Average rSO_2	54 ± 11 (52–55)	55 ± 7 (53–56)	.388
Average COx	0.27 ± 0.18 (0.25–0.29)	0.26 ± 0.17 (0.21–0.29)	.749
LLA (mm Hg)	69 ± 14 (67–70)	71 ± 12 (67–72)	.136
$AUC_{MAP<LLA}$ (mm Hg × min/h)	2.4 (1.1–5.7)	6.5 (2.1–15.4)	.017

Arterial pressure above the upper cerebral autoregulation limit during cardiopulmonary bypass is associated with postoperative delirium

D. Hori[1], C. Brown[2], M. Ono[1], T. Rappold[2], F. Sieber[2], A. Gottschalk[2], K. J. Neufeld[1], R. Gottesman[4], H. Adachi[5] and C. W. Hogue[2*]



2 études prospectives

JAMA Surgery | Original Investigation

Effect of Targeting Mean Arterial Pressure During Cardiopulmonary Bypass by Monitoring Cerebral Autoregulation on Postsurgical Delirium Among Older Patients
A Nested Randomized Clinical Trial

Charles H. Brown IV, MD, MHS; Karin J. Neufeld, MD, MPH; Jing Tian, MS; Julia Probert, BA; Andrew LaFlam, BA; Laura Max, MHS, PA-C; Daijiro Hori, MD; Yohei Nomura, MD; Kaushik Mandal, MD; Ken Brady, MD; Charles W. Hogue, MD; and the Cerebral Autoregulation Study Group

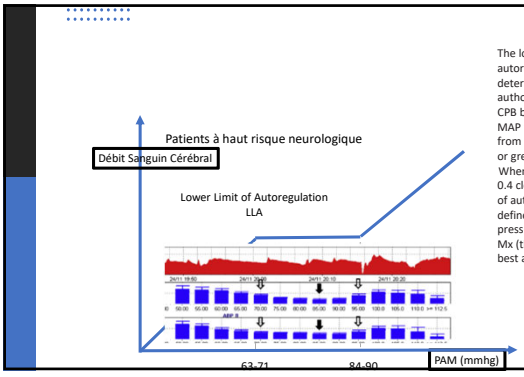
Randomized Controlled Trial › Semin Thorac Cardiovasc Surg. 2021 Summer;33(2):429-438. doi: 10.1053/j.semtcvs.2020.09.032. Epub 2020 Nov 10.

Personalized Blood Pressure Management During Cardiac Surgery With Cerebral Autoregulation Monitoring: A Randomized Trial

Charles W Hogue [1], Charles H Brown 4th [2], Daijiro Hori [3], Masa Ono [4], Yohei Nomura [3], Lauren C Balmert [3], Nina Srdanovic [3], Jordan Grafman [3], Kenneth Brady [3], Cerebral Autoregulation Study Group

Affiliations + expand

PMID: 33186735 DOI: 10.1053/j.semtcvs.2020.09.032

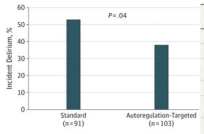


The lower limit of autoregulation was determined by the senior author (C.W.H.) before CPB based on the highest MAP where Mx increased from less than 0.4 to 0.4 or greater.
When Mx did not cross 0.4 clearly, the lower limit of autoregulation was defined as the blood pressure with the lowest Mx (the MAP with the best autoregulation

JAMA Surgery | Original Investigation

Effect of Targeting Mean Arterial Pressure During Cardiopulmonary Bypass by Monitoring Cerebral Autoregulation on Postsurgical Delirium Among Older Patients
A Nested Randomized Clinical Trial

Figure 2. Delirium Incidence by Randomization Group



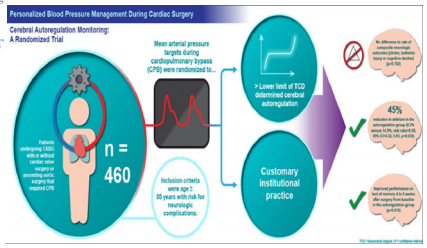
Mean arterial pressure during cardiopulmonary bypass was managed to standard care or autoregulation-targeted goals. Delirium incidence andomization group is shown.

Table 2. Characteristics of Management During Cardiopulmonary Bypass for Patients Randomized to Standard Care vs Autoregulation-Targeted Management of Mean Arterial Pressure

Characteristic of Management	Standard Care (n = 94)	Autoregulation-Targeted (n = 105)	*P* Value
Phenylephrine, median (IQR), mg	1.2 (0.3-2.3)	1.8 (0.5-3.6)	.02
Vasopressin administration, No. (%)	6 (6.4)	9 (8.6)	.56
Cardiopulmonary bypass flow, mean (SD), L/min	4.4 (0.6)	4.4 (0.6)	.92
Isoflurane, mean (SD), %	0.76 (0.27)	0.77 (0.31)	.71
Arterial pressure during cardiopulmonary bypass, mean (SD), mm Hg	71.3 (7.6)	73.9 (6.7)	.01
Arterial pressure at the lower limit of autoregulation, mean (SD), mm Hg	68.7 (11.3)	66.0 (10.9)	.10
Product of the duration of time and mean arterial pressure below the lower limit of autoregulation, median (IQR), mm Hg × h[a]	9.5 (3.7-19.5)	5.3 (2.0-13.4)	.002

Seminars in Thoracic and Cardiovascular Surgery

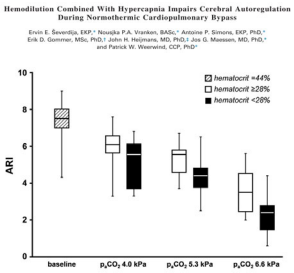
Personalized Blood Pressure Management During Cardiac Surgery With Cerebral Autoregulation Monitoring: A Randomized Trial



AVC, troubles cognitifs

a reduction in the frequency of delirium and better performance on tests of memory 4-6 weeks after surgery

Limites de l'approche de la PAM titrée sur la circulation cérébrale

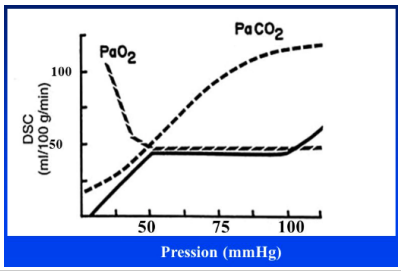


Hemodilution Combined With Hypercapnia Impairs Cerebral Autoregulation During Normothermic Cardiopulmonary Bypass

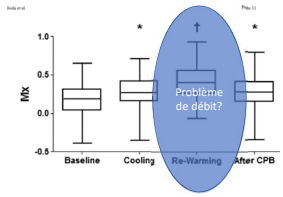
Erwin E. Severdija, EKP,* Nousjka P.A. Vranken, BASc,* Antoine P. Simons, EKP, PhD,* Erik D. Gommer, MSc, PhD,† John H. Heijmans, MD, PhD,‡ Jos G. Maessen, MD, PhD,* and Patrick W. Wiseveld, CCP, PhD*

Fig 1. Cerebral autoregulation as indicated by the autoregulation index (ARI) at baseline, at 3 levels of p_aCO_2, and at 2 levels of hematocrit during cardiopulmonary bypass.

Effet de la PaCO2 et de la PaO2 sur le DSC



Altération de l'AC et réchauffement….



Nonpulsatile CPB with a nonocclusive roller pump was used, and CPB flow was maintained between 2.0 and 2.4 L · min-1 · m-2.

Published in final edited form as:
Anesth Analg. 2010 February 01; 110(2): 321–328. doi:10.1213/ANE.0b013e3181c6fd12.

Impaired Autoregulation of Cerebral Blood Flow During Rewarming from Hypothermic Cardiopulmonary Bypass and Its Potential Association with Stroke

Brijen Joshi, MD*, Kenneth Brady, MD*, Jennifer Lee, MD*, Blaine Easley, MD*, Rabi

Table 5

Neurological Outcomes for Patients with and Without Impaired Cerebral Blood Flow Autoregulation During Rewarming on Cardiopulmonary Bypass

Outcome	No Impairment (n = 68)	Impairment (n = 47)	P
Perioperative stroke	0	7 (14.4%)	0.013
Transient ischemic attack	1 (1.7%)	0	0.483

Limites de l'optimisation de la PAM sur le doppler TC

- Technique à apprendre: ACM?, position
- Matériel spécifique: connecter en continu le signal de PAM et le doppler/NIRS
- LLA évolutive au cours du temps et des conditions: température, pulsatilité, PaCO2, Hte,

Études en cours

Trial to Compare Different Strategies of Mean Arterial Pressure Management During Cardiopulmonary By-pass (MAP)

Integrated University Hospital Trust of Verona

Status

Enrolling

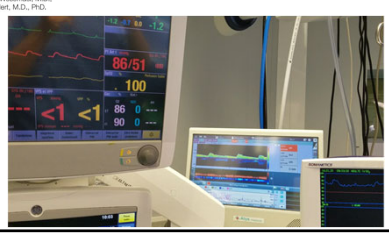
Randomized Controlled Trial · Am Heart J. 2023 Jul;261:10-20. doi: 10.1016/j.ahj.2023.03.005. Epub 2023 Mar 18.

Perioperative individualized hemodynamic optimization according to baseline mean arterial pressure in cardiac surgery patients: Rationale and design of the OPTIPAM randomized trial

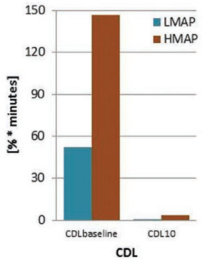
Notre expérience …

Assessment of Cerebral Autoregulation Patterns with Near-infrared Spectroscopy during Pharmacological-induced Pressure Changes

Annelies T. Moerman, M.D., Ph.D., Valerie M. Vanbienvliet, M.D., Astrid Van Wesemael, M.D., Stefaan M. Bouchez, M.D., Patrick F. Wouters, M.D., Ph.D., Stefan G. De Hert, M.D., PhD.



Limites de la NIRS

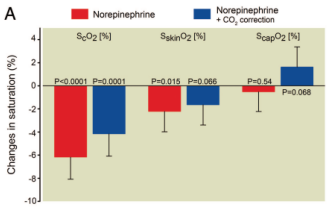


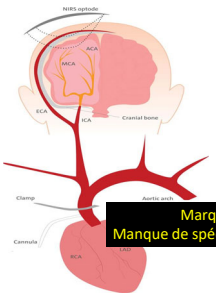
Plus de désaturations cérébrales dans le groupe PAM haute

Impact of 2 Distinct Levels of Mean Arterial Pressure on Near-Infrared Spectroscopy During Cardiac Surgery: Secondary Outcome From a Randomized Clinical Trial

Cutaneous Vasoconstriction Affects Near-infrared Spectroscopy Determined Cerebral Oxygen Saturation during Administration of Norepinephrine

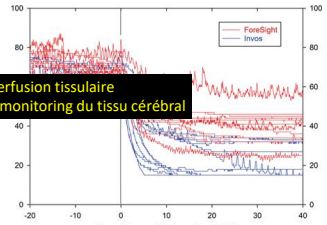
Henrik Sørensen, M.Sc.,* Niels H. Secher, M.D., D.M.Sc.,† Christoph Siebenmann, M.Sc.,‡ Henning B. Nielsen, M.D., D.M.Sc.,§ Matthias Kohl-Bareis, Ph.D.,‖ Carsten Lundby, Ph.D.,# Peter Rasmussen, Ph.D.,**





Mort encéphalique: pas de perfusion sur la carotide interne
Clampage aortique:

Effect of Extracerebral Contamination on Near-infrared Spectroscopy as Revealed during Organ Donation: A Prospective Observational Study in Brain-dead Organ Donors



Marqueur de perfusion tissulaire
Manque de spécificité de monitoring du tissu cérébral

Intégrer le débit de CEC dans la réflexion sur la PAM

- PAM = DC * RVS* k

Cerebral Oximetry and Mean Arterial Pressure: Not a Straight Relationship, the Flow Between?

Desebbe O, et al. Anesth Analg 2019. PMID 31743211

Circulation

ORIGINAL RESEARCH ARTICLE

High-Target Versus Low-Target Blood Pressure Management During Cardiopulmonary Bypass to Prevent Cerebral Injury in Cardiac Surgery Patients
A Randomized Controlled Trial

In 1928, Jarisch is quoted as saying, "It is a source of regret that the measurement of flow [*i.e.*, SV] is so much more difficult than the measurement of pressure. This has led to an undue interest in the blood pressure manometer. Most organs, however, require flow rather than pressure.

Table 2. Intraoperative Management

	Low-Target Group (n=98)	High-Target Group (n=97)
Hematocrit, before start of surgery, %	40.3±5.9	40.6±4.7
MAP before anesthesia induction, mm Hg	92.3±15.7	96.9±13.4
MAP during bypass, mm Hg	44.7±4.7	66.8±4.9
MAP below target during bypass, n (%)*	2 (2.0)	18 (18.5)
MAP above target during bypass, n (%)†	5 (5.1)	0 (0)
Blood flow rate during bypass, L·min^{-1}·m^{-2}	2.69±0.1	2.69±0.1
Hematocrit, mean level during bypass, %	31.5±3.8	33.1±4.2
Nadir hematocrit sampling value during bypass, %	28.7±3.7	29.2±4.0
Surgery time, min	184.9±50.8	194.3±66.6
Bypass time, min	94.0±33.0	105.6±77.4
Cross-clamp time, min‡	63.3±26.9	64.8±32.6
Peak lactate level during surgery, mmol	2.25±0.83	2.16±0.82
Norepinephrine infused in the OR, μg/kg	2.65±6.01	17.43±20.14
Patients receiving norepinephrine in the OR, n (%)	35 (35.7)	90 (92.7)

Improvement of Outcomes after Coronary Artery Bypass II: A Randomized Trial Comparing Intraoperative High Versus Customized Mean Arterial Pressure

Mary E. Charlson, M.D.,* Janey C. Peterson, Ed.D., R.N.,* Karl H. Krieger, M.D.,†

Débits de CEC bas…

B. Intraoperative Management Pre-bypass	High MAP	Custom MAP	P
Pre-bypass MAP (mmHg)	86 ± 8	85 ± 9	
Pre-bypass cardiac output (L/min)	4 ± 1	4 ±1.	
Bypass Times (min)			
Bypass	74 ± 24	77 ± 22	ns
Cross-clamp	40 ± 15	40.4 ± 14	ns
Pump flows (L/min/m²)‖			
Bypass on—warming (± θ)	2.0 ± 0.3	2.0 ± 0.3	ns
Warming—cross-clamp off (± θ)	2.1 ± 0.3	2.2 ± 0.3	ns
Cross-clamp off—bypass off (± θ)	2.4 ± 0.2	2.34 ± 0.3	ns

		n	population	Basse PAM	Haute PAM	Débit (l/min/m²)	particularités
Azau	2014	300	À risque d'AKI	50-60	75-85	2,4 pour SvO2 > 70% 2,57 /2,58	Circuit clot, miniCEC
Siepe	2011	92	Chir coronaire	60-70	80-90	2,6	Troubles cognitifs
Charlson	2007	412	Chir coronaire programmée	80	+/- 20 mmHg, max 90 (57-90), 88 moy	2 à 2,4	61% adhérence gp PAM préop 85% adhérence gp Pam 80 management at higher MAP on CPB dramatically reduces stroke occurrence in patients with severe aortic atheromatous disease (grade IV and V)
Gold	1995	248	Chir coronaire	50-60	80-100	1,9 à 2,3	Niveau de PAM respectés
Vedel	2018	197	Coronaires + valves	40-50	70-80	2,7	

le débit de pompe est primordial

Le débit de CEC avant la pression ?…

Observational Study › J Cardiothorac Vasc Anesth, 32 (2), 684-690 Apr 2018

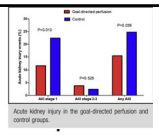
Disturbances in Oxygen Balance During Cardiopulmonary Bypass: A Risk Factor for Postoperative Delirium

Nina Smulter [1], Helena Claesson Lingehall [2], Yngve Gustafson [3], Birgitta Olofsson [4], Karl Gunnar Engström [5], Micael Appelblad [6], Staffan Svenmarker [6]

Ranucci et al — Perioperative Management

Goal-directed perfusion to reduce acute kidney injury: A randomized trial

Marco Ranucci, MD, FESC,[a] Ian Johnson, CCP,[b,c] Timothy Willcox, CCP,[d,e] Robert A. Baker, PhD, CCP,[f]



Acute kidney injury in the goal-directed perfusion and control groups.

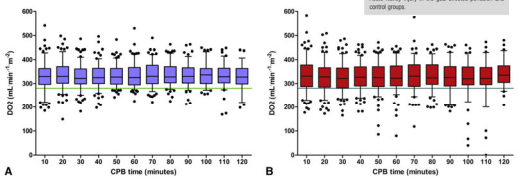


FIGURE 2. Oxygen delivery (DO_2) values in the goal-directed perfusion (*blue*; A) and control (*red*; B) arms during cardiopulmonary bypass (*CPB*). *Boxes* represent interquartile range, lines in the *boxes* represent the median, whiskers are 95% confidence intervals, and *dots* are outliers. The *green line* represents the critical DO_2 value of 280 mL·min^{-1}·m^{-2}. Data are restricted to the first 120 minutes of CPB.

Etude multicentrique,
Valeurs hautes de DaO2 dans les 2 bras…. Et pourtant moins d'Insuffisance rénale Aigue dans le groupe GDP
PAM dans les 2 groupes?

› Jpn J Thorac Cardiovasc Surg, 46 (1), 18-24 Jan 1998

[The Effect of Pump Flow on Cerebral Oxygen Metabolism During Cardiopulmonary Bypass]

[Article in Japanese]
H Sakahashi [1]

2.2-2.5 L/min/m2 in group L and 2.7-3.0 L/min/m2 in group H

It is suggested that cerebral metabolism should be decreased during cooling to 31 degrees C of pharyngeal temperature, 2.2-2.5 l/min/m2 of pump flow was adequate to keep SjO2 stable. On the other hand, it is necessary to increase pump flow to 2.7-3.0 l/min/m2 during rewarming period as

Le débit de CEC doit s'adapter à la demande métabolique

variabilité du débit

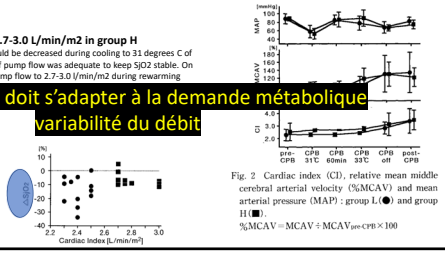


Fig. 2 Cardiac index (CI), relative mean middle cerebral arterial velocity (%MCAV) and mean arterial pressure (MAP) : group L(●) and group H(■).
$\%MCAV = MCAV \div MCAV_{pre\text{-}CPB} \times 100$

Nephrol Dial Transplant (2012) 27: 153–160
Advance Access publication 15 June 2011

Effect of mean arterial pressure, haemoglobin and blood transfusion during cardiopulmonary bypass on post-operative acute kidney injury

Michael Haase[1,2], Rinukka Bellomo[3], David Story[4], Angela Letis[4], Katja Klemz[1], George Matalanis[5], Sivan Seevanayagam[5], Duska Dragun[1], Erdmann Seeliger[6], Peter R. Mertens[1] and Anja Haase-Fielitz[1]

L'anémie est facteur d'I rénale
L'hypotension seule non…

Fig. 3. Time of intraoperative MAP in relation to duration of CPB separated for patients with AKI versus those without AKI.

Etude rétrospective, débit de CEC 2,4 L/min/m²

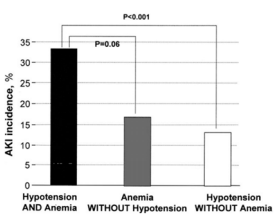
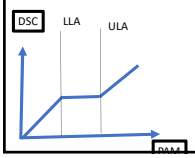


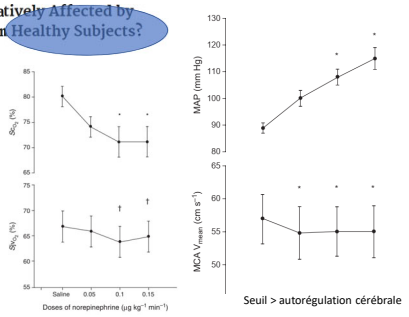
Fig. 4. Cumulative effect of severe hypotension and anaemia during CPB for AKI. Patients with severe hypotension (>75th percentile of AUC MAP <50 mmHg) AND anaemia (lowest haemoglobin concentration <25th percentile); developed more frequently AKI ($N = 24/72$) compared to patients with severe hypotension but WITHOUT anaemia (lowest haemoglobin concentration >75th percentile), ($N = 21/164$); $P < 0.001$ and to patients WITH anaemia but WITHOUT hypotension (<25th percentile of AUC MAP <50 mmHg), ($N = 7/41$); $P = 0.06$ suggesting a cumulative effect of anaemia and hypotension.

Br J Anaesth, 102 (6), 800-5 Jun 2009

Is Cerebral Oxygenation Negatively Affected by Infusion of Norepinephrine in Healthy Subjects?

P Brassard [1], T Seifert, N H Secher
Affiliations + expand
PMID: 19376788 DOI: 10.1093/bja/aep065

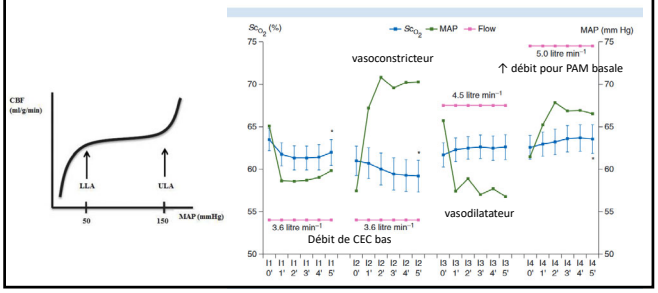




Seuil > autorégulation cérébrale

Influence of variations in systemic blood flow and pressure on **cerebral** and systemic oxygen saturation in cardiopulmonary bypass patients.

Moerman A, et al. **Br J Anaesth** 2013 - *Clinical Trial*. PMID 23740043 Free article.



Essayer de rester physiologique
= s'adapter aux besoins métaboliques

The Journal of Thoracic and Cardiovascular Surgery
Volume 134, Issue 3, September 2007, Pages 587-593

Cardiopulmonary support and physiology

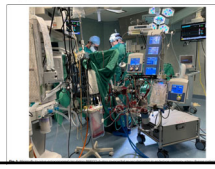
Elevated flow rate during cardiopulmonary bypass is associated with fluid accumulation

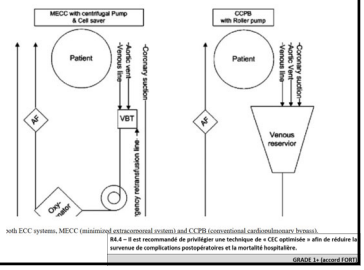
Oddbjørn Haugen MD [a], Marit Farstad MD, PhD [c], Venny Kvalheim MD [b], Olav Bøe DDS, MSc [d], Paul Husby MD, PhD [c]

Type de CEC > à un autre pour préserver la PAM?
Limiter les contraintes vasculaires par la miniCEC?

A combination of MiECC features, such as coating, centrifugal pump, separation of cardiotomy suction blood,
and use of closed systems, should be considered to improve conventional CPB

Journal of Cardiothoracic and Vascular Anesthesia 35 (2021) 1–17





R4.4 – Il est recommandé de privilégier une technique de « CEC optimisée » afin de réduire la survenue de complications postopératoires et la mortalité hospitalière.
GRADE 1+ (accord FORT)

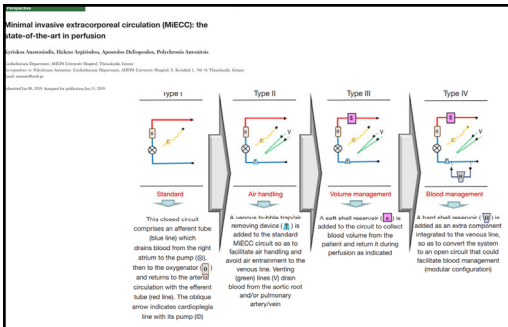


Figure 1 Established classification of MiECCC circuits (3). X, pump; O, oxygenator; C, cardioplegia; T, bubble-trap/air removing device; V, vent (aortic/pulmonary); S, soft-bag/reservoir; H, hard-shell/reservoir; MiECC, minimal invasive extracorporeal circulation.

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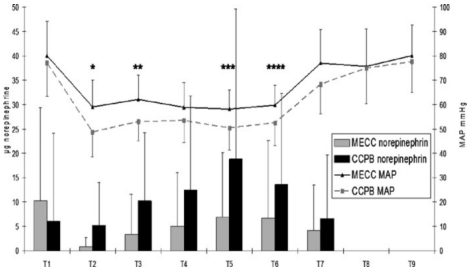
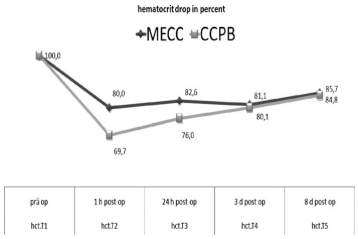
miniCEC et PAM



If the mean arterial pressure decreased, the arterial flow was increased up to a maximum of 120% of the calculated flow. If mean arterial pressure further decreased, a 5 µg norepinephrine bolus was given to raise the MAP on CCPB between 45 and 75 mmHg.

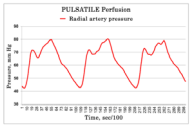
miniCEC et PAM: causes d'une PAM plus élevée?



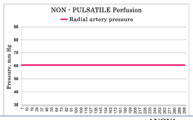
Journal of Clinical Medicine
MDPI
Article

Efficacy of Pulsatile Flow Perfusion in Adult Cardiac Surgery: Hemodynamic Energy and Vascular Reactivity

Mikhail Dodonov [1], Francesco Onorati [1], Giovanni Battista Luciani [1], Alessandra Francica [1,*], Maddalena Tessari [1], Tiziano Menon [1], Leonardo Gottin [2], Aldo Domenico Milano [2] and Giuseppe Faggian [1]



- A new MEDOS Delta Stream DP3 centrifugal blood pump was used during CPB and was set in pulsatile (PP group) or non-pulsatile (NP group) mode.
- In pulsatile mode, the pump was set at maximum rotation speed variation of 3500–8500 rpm with a pulse frequency of 60 bpm; start and stop points of the pulse were set at 20 and 80% of the pulse cycle,
- This model includes the hemodynamic energy gradient as a key point rather than the pressure gradient and it is actually described in terms of energy equivalent pressure (EEP) and surplus hemodynamic energy (SHE). EEP was calculated according to the following formula: EEP =Rtt12 *f pdt*/ Rtt12 *f dt* (mm Hg), where *f* is blood flow, *p* is blood pressure and the product of flow and pressure represents hemodynamic power



		Start CPB	1s of Cross-Clamp	15s of Cross-Clamp	30s of Cross-Clamp	Re-Warming	Cross-Clamp Removal	Means for all CPB Period	ANOVA *p* (Group/Time Interaction)
Post-op CCr, 18 h (mL/min/1.73 m^2)			61 ± 35		47 ± 16 *	0.06			
MAP (mmHg)	PP	57 ± 15	58 ± 14	51 ± 11	58 ± 12	58 ± 14	51 ± 11	56 ± 9.0	0.03
	NP	59 ± 12	61 ± 15	64 ± 19 **	69 ± 19 *	61 ± 18	57 ± 12	62 ± 12 *	

Intérêt d'une CEC pulsatile?

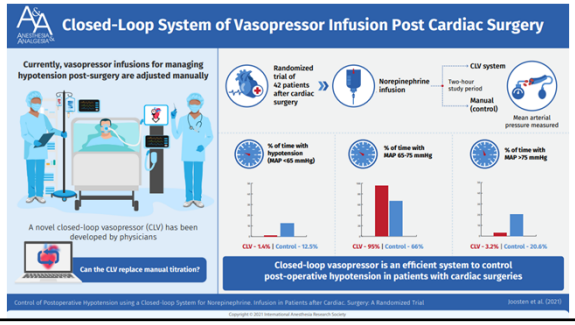
Contents lists available at ScienceDirect
Journal of Cardiothoracic and Vascular Anesthesia
journal homepage: www.jcvaonline.com

Editorial

Guidelines for Conduct of Cardiopulmonary Bypass

- Pulsatile perfusion may reduce postoperative pulmonary and renal complications and should be considered in patients at high risk for adverse lung and renal outcomes (grade B)

Autres voies pour optimiser la PAM en chirurgie cardiaque?



conclusion

- Pas de reco sur ERAS et chir cardiaque sur la PAM et la DaO2 peropératoire

This is a surprisingly strong recommendation that we do not believe is supported by existing evidence. As was true more than 10 years ago, and in our opinion today, an adequate or optimal arterial pressure during CPB has not been resolved with high-level evidence.

patients with postoperative AKI and delirium [193]. Finally, the MAP during CPB is usually accepted in a range of 50–80 mmHg; however, novel approaches to settle the optimal blood pressure have been recently proposed [192].

Clinical Review & Education

JAMA Surgery | Special Communication

Guidelines for Perioperative Care in Cardiac Surgery
Enhanced Recovery After Surgery Society Recommendations

Daniel T. Engelman, MD; Walid Ben Ali, MD; Judson B. Williams, MD, MHS; Louis P. Perrault, MD, PhD; V. Seenu Reddy, MD; Rakesh C. Arora, MD, PhD; Eric E. Roselli, MD; Ali Khoynezhad, MD, PhD; Marc Gerdisch, MD; Jerrold H. Levy, MD; Kevin Lobdell, MD; Nick Fletcher, MD, MBBS; Matthias Kirsch, MD; Gregg Nelson, MD; Richard M. Engelman, MD; Alexander J. Gregory, MD; Edward M. Boyle, MD

European Journal of Cardio-Thoracic Surgery 00 (2019) 1–42
doi:10.1093/ejcts/ezz267

2019 EACTS/EACTA/EBCP guidelines on cardiopulmonary bypass in adult cardiac surgery

Authors/Task Force Members: Alexander Wahba [a,b,c,*] (Chairperson) (Norway), Milan Milojevic [c,d,e,*] (Serbia, Netherlands), Christa Boer [a,*] (Netherlands), Filip M.J. De Somer [f,*] (Belgium), Tomas Gudbjartsson [g] (Iceland), Jenny van den Goor [a,*] (Netherlands), Timothy J. Jones [h,*] (UK), Vladimir Lomivorotov [i] (Russia), Frank Merkle [j,*] (Germany), Marco Ranucci [k,*] (Italy), Gudrun Kunst [m,*,†] (Chairperson) (UK) and Luc Puis [n,*,†] (Chairperson) (Belgium)

SFAR

SFCTCV

Recommandations Formalisées d'Experts

Réhabilitation Améliorée Après Chirurgie Cardiaque adulte sous CEC ou à cœur battant

ENHANCED RECOVERY AFTER CARDIAC SURGERY UNDER CPB OR OFF-PUMP

2021

RFE commune SFAR - SFCTCV
Société Française d'Anesthésie et de Réani
Société Française de Chirurgie Thoracique et Cardi

Pas de recommandations sur la PAM perCEC ou la DaO2

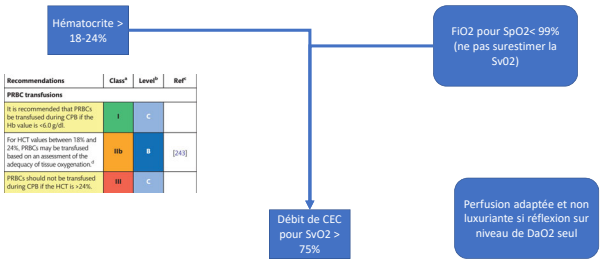
Champ 4. Strategie chirurgicale et gestion de la CEC

4.1	La chirurgie mitrale vidéo-assistée peut être envisagée dans des équipes entraînées	Avis experts	FORT
4.2	Réaliser la CEC en normothermie	1+	FORT
4.3.1	Ne pas réaliser systématiquement les pontages coronariens à cœur battant	1-	FORT
4.3.2	Les pontages coronariens à cœur battant peuvent être discutés en cas d'aorte très calcifiée	Avis experts	FORT
4.4	Utiliser une CEC optimisée	1+	FORT
4.5	Ne pas privilégier une technique de cardioplégie plutôt qu'une autre	2-	FORT

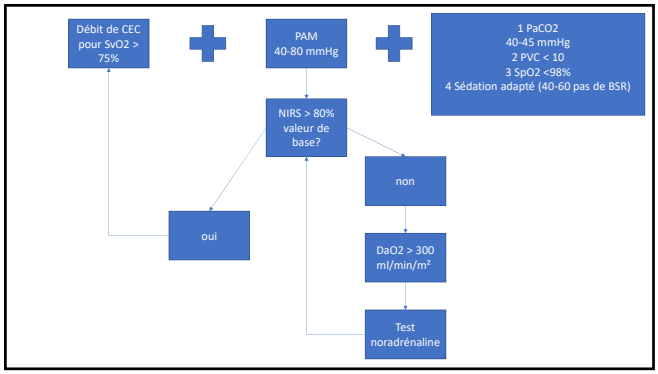
Conclusion

- PAM: un outil de surveillance parmi d'autre: PaCO2, débit CEC, SvO2, Hte
- La PAM est la résultante du Débit de CEC et des RVS :
  - PAM minimale si débit de CEC suffisant +++
  - Coupler la PAM à la DaO2 +++ et à la demande métabolique (test de PAM sur la NIRS, sur la SVO2, pas sur l'exCO2…)
- Modifier les RVS dans un deuxième temps seulement
- Quel vasopresseur idéal?
- Titrer la PAM
  - sur organe « cible », sur microcirculation
  - maintenir PAM > 50 voire 65 mmHg sinon
  - Difficile de proposer une valeur cible de PAM selon PAM préopératoire

Proposition personnelle d'algorithme, en normothermie



Recommendations	Class[a]	Level[b]	Ref[c]
PRBC transfusions			
It is recommended that PRBCs be transfused during CPB if the Hb value is <6.0 g/dl.	I	C	
For HCT values between 18% and 24%, PRBCs may be transfused based on an assessment of the adequacy of tissue oxygenation.[d]	IIb	B	[243]
PRBCs should not be transfused during CPB if the HCT is >24%.	III	C	



Editorial > Br J Anaesth. 2022 Jan 4;S0007-0912(21)00802-3. doi: 10.1016/j.bja.2021.12.013.
Online ahead of print.

High-resolution perioperative cerebral blood flow autoregulation measurement: a practical and feasible approach for widespread clinical monitoring

Eric L Vu [1], Kenneth Brady [1], Charles W Hogue [2]