Pratiques satellites de la CEC

DU Circulation Extra-Corporelle en chirurgie cardiaque et en suppléances d'organes

10/01/2025

Gaspard Cadier , **Service d'Anesthésie-Réanimation GH Sud**

Conflit d' intérêt

- Aucun

Plan

- Système de récupération sanguine autologue/Récupération de Sang Péri-Opératoire (RSPO)
- Hémofiltration per CEC
- Adsorption per CEC

- Adjonction de CO_2 per CEC

Récupération de sang périopératoire (RSPO)

Permet d'administrer par voie intraveineuse au patient son propre sang récupéré dans le site chirurgical ou la plaie postopératoire lors d'une intervention chirurgicale hémorragique.

Elle fait partie des techniques d'économie du sang qui permettent d'éviter de recourir au sang homologue.

HAS - Service évaluation médico-économique et santé publique – Juillet 2006

Rationnel

- 1)Chirurgie sous CEC: hémorragique
- 2)Transfusion sanguine nocive en elle même, couteuse, stocks limités.

- Limitation des pertes sanguines (et donc de la transfusion) si récupération de celles ci en per opératoire

-Henke PK, McKeown E, et al. A case-cohort study of postoperative myocardial infarction: impact of anemia and cardioprotective medications. Surgery 2014;156
-SHANDER A, HARE GMT. What is really dangerous: anaemia or transfusion ? Br J Anaesth 2011

Principe RSPO per CEC

- **1) Aspiration « directe »**, non lavée ni centrifugée:
  -Cannule du chirurgien directement reliée au bol de CEC, pas de traitement du sang autre qu'une filtration passive (20 à 40µm).
  -Reperfusion du sang total (avec facteurs de coag, plaquettes mais aussi débris cellulaires+++ et facteurs de l'inflammation)

Principe RSPO per CEC

- **1) Aspiration « directe »**, non lavée ni centrifugée
- **2) Aspiration « traitée»**, lavée et centrifugée: deplasmatisation du sang aspiré avec concentration des Erythrocytes, pertes des plaquettes, des facteurs de coagulations mais aussi d'une partie des débris cellulaires.

- Dualité

1) Aspiration directe

- Sang total
- Principalement pour l'extravasation « immédiate »
- Eviter d'aspirer de la « soupe inflammatoire » (ex: sang stagnant dans le médiastin)
- Aspiration sur tubulure de petit calibre responsable en elle même d'une inflammation importante

2) Aspirations lavées/centrifugées Principe

https://www.youtube.com/watch?v=OIQ63oev6kc

2) Aspirations lavées/centrifugées Recommandations

2017 EACTS/EACTA Guidelines on patient blood management for adult cardiac surgery FREE

Domenico Pagano ✉, Milan Milojevic, Michael I Meesters, Umberto Benedetto, Daniel Bolliger, Christian von Heymann, Anders Jeppsson, Andreas Koster, Ruben L Osnabrugge, Marco Ranucci ... Show more

Author Notes

European Journal of Cardio-Thoracic Surgery, Volume 53, Issue 1, January 2018, Pages

The routine use of cell salvage should be considered to prevent transfusions.	IIa	B

RECOMMANDATIONS FORMALISEES D'EXPERTS

Question 2. **L'utilisation d'un système de récupération sanguine préopératoire pendant la chirurgie a-t-elle un impact sur la survenue de complications postopératoires ou sur la durée d'hospitalisation ?**

Experts : Guillaume LEBRETON (SFCTCV, Paris), Bertrand ROZEC (SFAR, Nantes)

R5.2 – Il est probablement recommandé d'utiliser un système de récupération sanguine peropératoire pour limiter la transfusion érythrocytaire en chirurgie cardiaque.
GRADE 2+ (accord FORT)

2021

RFE commune SFAR - SFCTCV
Société Française d'Anesthésie et de Réanimation (SFAR)
Société Française de Chirurgie Thoracique et Cardiovasculaire (SFCTCV)

2) Aspirations lavées/centrifugées Transfusion

- Nombreux essais cliniques

Cochrane Database of Systematic Reviews

Cell salvage for minimising perioperative allogeneic blood transfusion

Cochrane Systematic Review - **Intervention** | Version published: 14 April 2010 see what's new

https://doi.org/10.1002/14651858.CD001888.pub4

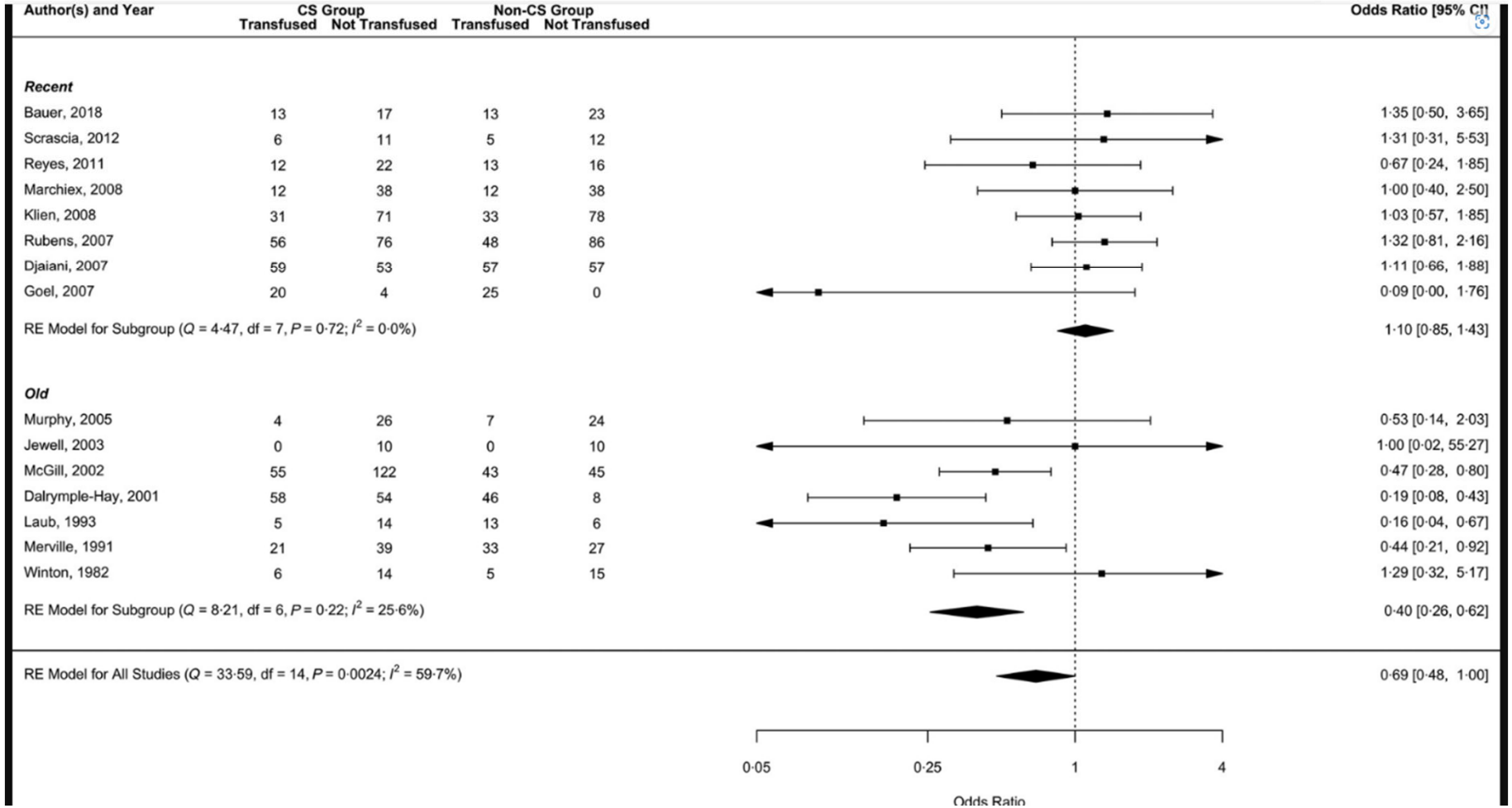
-33 essais de chirurgie cardiaque
-Cell salvage réduirait la transfusion de CGR
-Sans effets secondaires marqués (pas + de reprise chir)
-Etudes méthodologiquement pauvres et hétérogène

- Quelle utilisation per op? de toutes les aspirations? Mediastinales? Circuit de CEC?

Meta-Analysis > Vox Sang. 2019 Aug;114(6):553-565. doi: 10.1111/vox.12824. Epub 2019 Jul 5.

Impact of cell saver during cardiac surgery on blood transfusion requirements: a systematic review and meta-analysis

Murtadha Al Khabori [1], Arwa Al Riyami [1], Mohammad Salman Siddiqi [2], Ziyab Khan Sarfaraz [2], Edem Ziadinov [2], Hilal Al Sabti [2 3]



2) Aspirations lavées/centrifugées Transfusion

Interact Cardiovasc Thorac Surg. 2011 Feb;12(2):189-93. doi: 10.1510/icvts.2010.251538. Epub 2010 Nov 30.

Cell saving systems do not reduce the need of transfusion in low-risk patients undergoing cardiac surgery.

Reyes G[1], Prieto M, Alvarez P, Orts M, Bustamante J, Santos G, Sarraj A, Planas A.

63 patients
Retransfusion CS: 461 +/- 174mL
40 vs 46% de transfusion
Protocoles de transfusion? Taux d'Hb finaux?

Interact Cardiovasc Thorac Surg. 2011 May;12(5):824-6. doi: 10.1510/icvts.2010.249136. Epub 2011 Feb 5.

The use of cell salvage in routine cardiac surgery is ineffective and not cost-effective and should be reserved for selected cases.

Attaran S[1], McIlroy D, Fabri BM, Pullan MD.

n <7% of cases the volume of blood loss was sufficient enough to be washed and returned. We conclude that the routine use of cell savers in all cardiac operations affords no benefit and consumes additional revenue……

2) Aspirations lavées/centrifugées Transfusion

J Transl Med. 2016 Jul 29;14(1):228. doi: 10.1186/s12967-016-0986-6.

Impact of intra-operative cell salvage on blood coagulation in high-bleeding-risk patients undergoing cardiac surgery with cardiopulmonary bypass: a prospective randomized and controlled trial.

Shen S[1], Zhang J[2], Wang W[3], Zheng J[4], Xie Y[5].

-110 patients Cell Saver vs Control
-Ac tranex 30mg/kg
-CS: traitement uniquement du sang mediastinal et pre et post CEC (pas de traitement de l'aspi de cardiotomie) VS Contrôle : aspirations jetées
-Protocole de transfu de CGR et PFC et plq (TEG)

2) Aspirations lavées/centrifugées

J Transl Med. 201

Impact of
undergoin
controlled

Shen S[1], Zhang

-risk patients
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-110 p
-Ac tr
-CS: t
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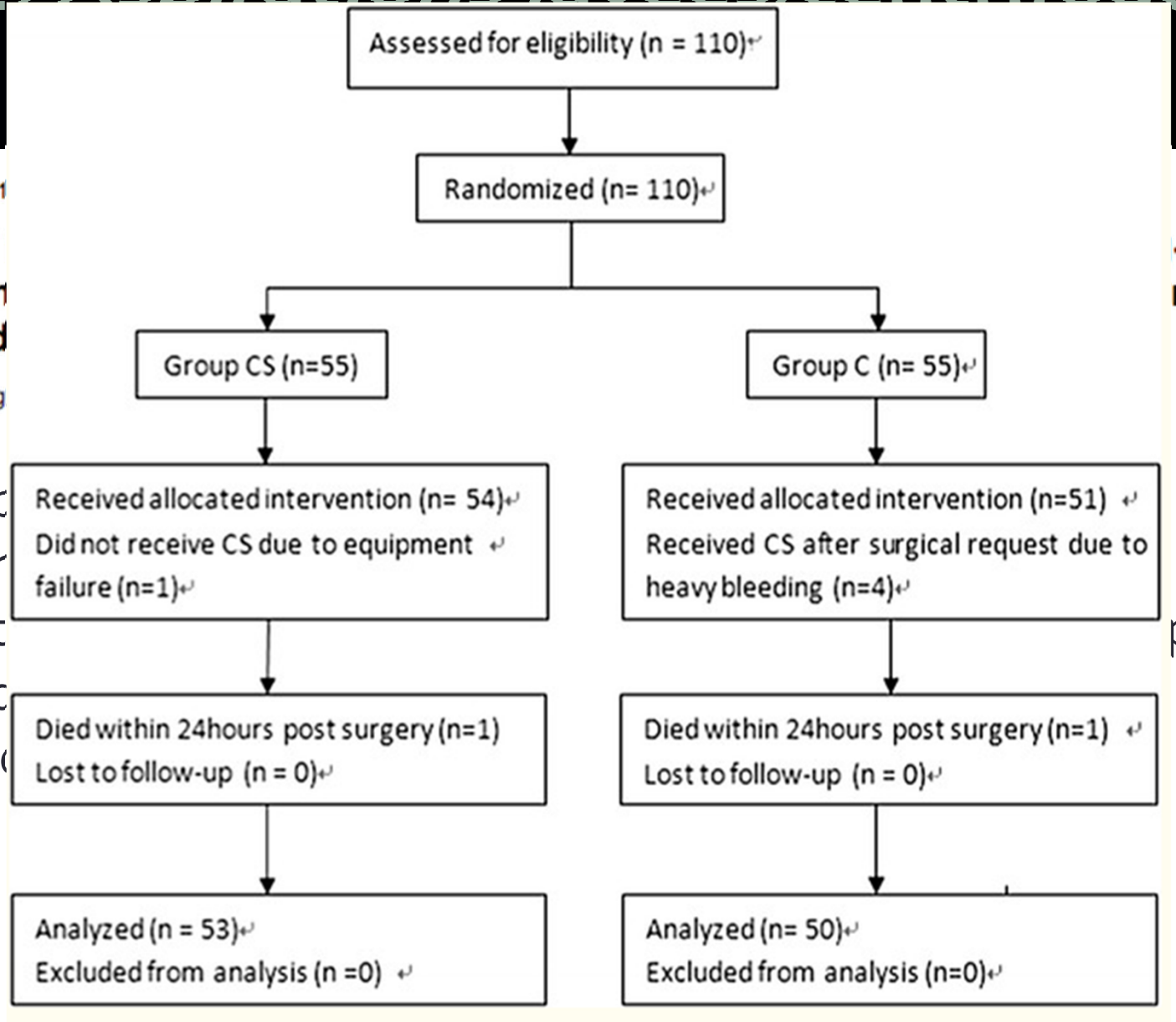
post CEC



2) Aspirations lavées/centrifugées Transfusion

J Transl Med. 2016 Jul 29;14(1):228. doi: 10.1186/s12967-016-0986-6.

Impact of intra-op… undergoing cardi… controlled trial.

…-bleeding-risk patients …pective randomized and

Shen S[1], Zhang J[2], Wang W…

Allogeneic blood transfusion during peri-op

Variable	Group CS (n = 53)	Group C (n = 50)	P value
RBC			
Proportion	22 (41.51)	39 (78.00)	0.0002
Volume (U)	2.11 (2.66)	5.40 (3.48)	<0.0001
FFP			
Proportion	10 (18.87)	9 (18.00)	0.910
Volume (mL)	118.76 (253.82)	129.00 (284.92)	0.953
PLT			
Proportion	12 (22.64)	10 (20.00)	0.744
Volume (U)	1.81 (3.56)	1.92 (3.94)	0.916

Data are presented as mean (SD) or number (percentage)

2) Aspirations lavées/centrifugées

J Transl Med. 2016

Impact of i
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patients
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Shen S[1], Zhang J

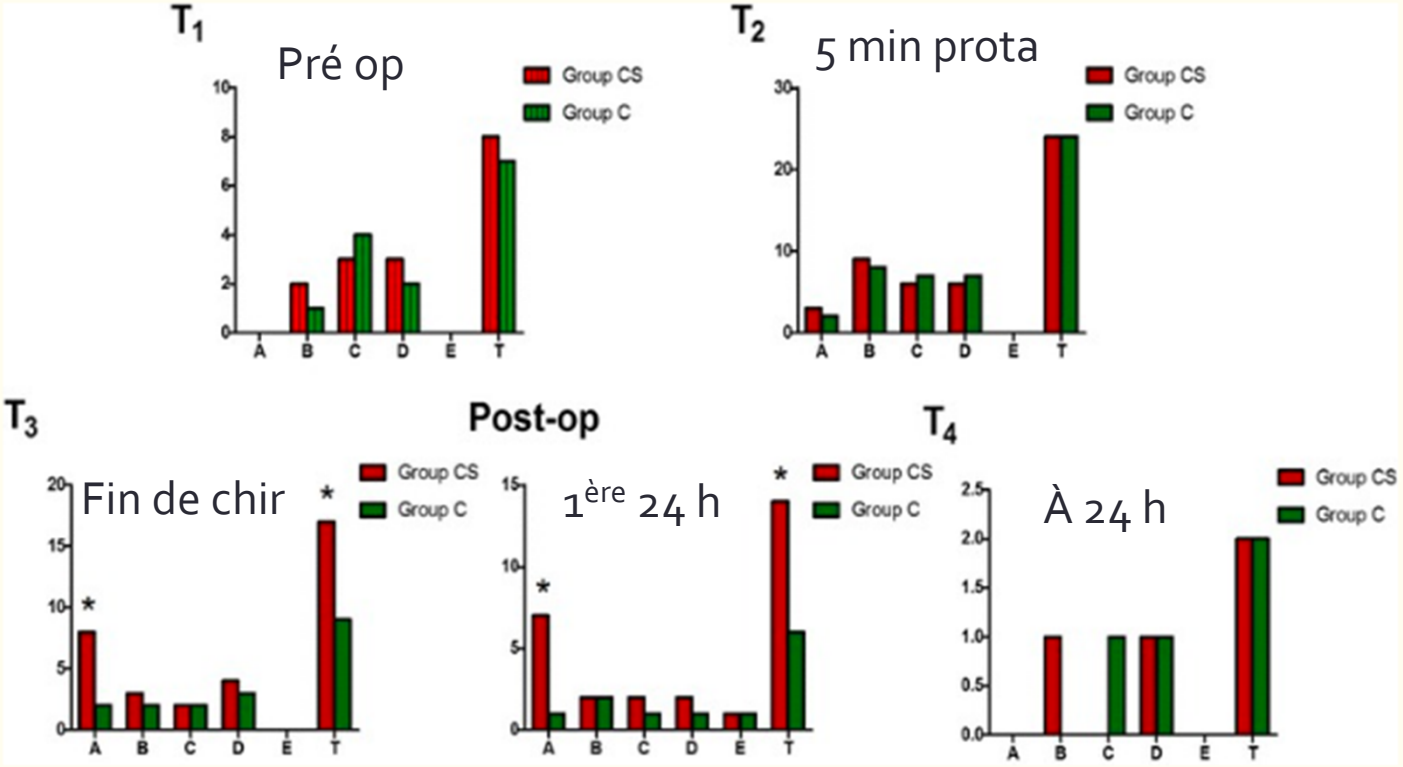


Fig. 4

Comparison of impairment of blood coagulation during peri-op between two groups. *x-axis* type of impairment of blood coagulation, *A* heparin residual, *B* coagulopathy for low PLT, *C* coagulopathy for low FIB, *D* coagulopathy for low clotting factors, *E* hyperfibrinolysis, *T* total (A + B + C + D + E). *y-axis* cases of each type, T_1 at the time of after anesthesia induction and 5 min before surgery, T_2 5 min after heparin was reversed by protamine during surgery, T_3 at the end of surgery, *post-op* during postoperative period, T_4 at the time of 24 h after surgery. *p = 0.024(T_3 − A), 0.043(T_3 − T), 0.010 (post-op − A), 0.040 (post-op − T), respectively

2) Aspirations lavées/centrifugées

J Transl Med. 2016 Jul 29;14(1):228. doi: 1

Impact of intra-operative undergoing cardiac surg controlled trial.

Shen S[1], Zhang J[2], Wang W[3], Zheng J

Exessive bleeding:
-bleeding greater than 300 mL in the first hour after surgery
-or greater than 2 mL/kg/h for 3 consecutive hours,

pas de difference sur les reprises sternales

Summary of adverse events during post-op

Variable	Group CS (n = 53)	Group C (n = 50)	P value
Excessive bleeding	17 (32.08)	8 (16.00)	0.038
Resternotomy	3 (5.66)	2 (4.00)	1.000
Cardiovascular failure	6 (11.32)	7 (14.00)	0.682
Severe arrhythmias requiring treatment	4 (7.55)	3 (6.00)	1.000
Myocardial infarction	1 (1.89)	4 (8.00)	0.196
Infection	7 (13.21)	6 (12.00)	0.948
Wound	3 (5.66)	2 (4.00)	1.000
Others	4 (7.55)	4 (8.00)	1.000
Renal failure	5 (9.43)	4 (8.00)	1.000
Respiratory failure	3 (5.66)	2 (4.00)	1.000
Epileptic syndrome	1 (1.89)	1 (2.00)	1.000
Cognitive decline	0 (0.00)	3 (6.00)	0.111
Death	0 (0.00)	0 (0.00)	

Donnée manquante: volume traité??

Data are presented as number (percentage)

2) Aspirations lavées/centrifugées Transfusion

Editorial

More Is Not Always Better: Effects of Cell Salvage in Cardiac Surgery on Postoperative Fibrinogen Concentrations

Journal of Cardiothoracic and Vascular Anesthesia 34 (2020) 2383–2385

"potential harms on the coagulation system when using intraoperative cell salvage. In complex cases, excess cell salvage can only maintain hemoglobinlevels but significantly alters hemostatic function via the elimi-nation of platelets and soluble coagulation factors"

2) Aspirations lavées/centrifugées

Transfus

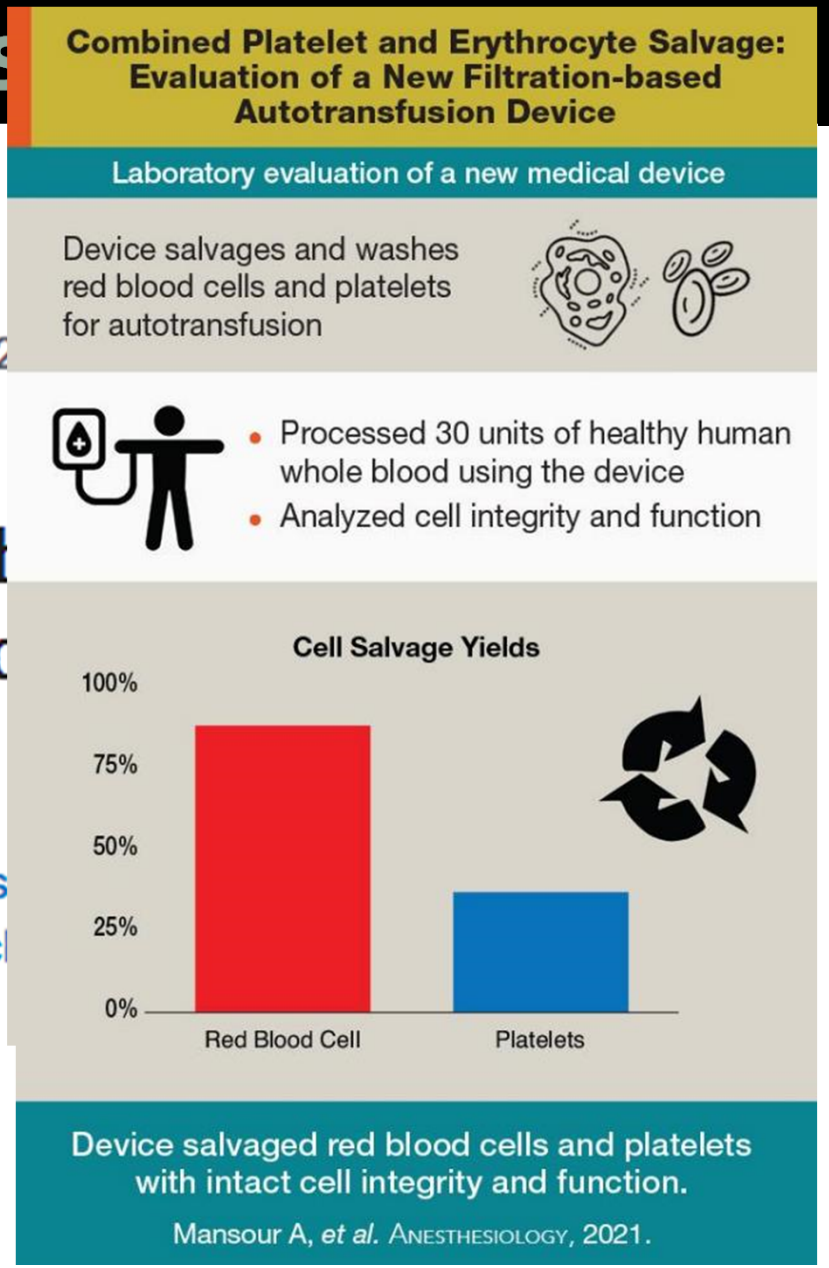
- Futur?

Editorial > Anesthesiology. 2021 Aug 1;135(2):2

doi: 10.1097/ALN.0000000000003820.

Combined Platelet and Eryth
Evaluation of a New Filtratio
Autotransfusion Device

Alexandre Mansour, Benoit Decouture, Mikaël Rouss
Véronique Picard, Alexandre Ouattara, Christilla Bac
Nicolas Nesseler, Isabelle Gouin-Thibault



2) Aspirations lavées/centrifugées Transfusion

ANESTHESIOLOGY

Combined Platelet and Red Blood Cell Recovery during On-pump Cardiac Surgery Using same™ by i-SEP Autotransfusion Device: A First-in-human Noncomparative Study (i-TRANSEP Study)

Alexandre Mansour, M.D., Ph.D., Antoine Beurton, M.D., Anne Godier, M.D., Ph.D., Bertrand Rozec, M.D., Ph.D., Diane Zlotnik, M.D., Fabienne Nedelec, Pharm.D., Pascale Gaussem, Pharm.D., Ph.D., Mathieu Fiore, M.D., Ph.D., Elodie Boissier, Pharm.D., Ph.D., Nicolas Nesseler, M.D., Ph.D., Alexandre Ouattara, M.D., Ph.D.

ANESTHESIOLOGY 2023; 139:287–97

Combined Platelet and Red Blood Cell Recovery during On-pump Cardiac Surgery using same™ by i-SEP Autotransfusion Device (i-TRANSEP Study)

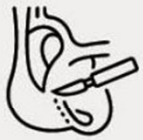
First-in-human noncomparative study of a blood and platelet recovery device in 50 adult patients undergoing cardiac surgery with cardiopulmonary bypass

Hypothesis:

- Red blood cell recovery >80%
- Posttreatment hematocrit >40%
- Removal of >90% heparin
- Removal of >75% free hemoglobin

Observed 50 patients:

- 18 CABG
- 26 valve surgery
- 6 aortic root surgery



	Median (25-75th percentile)
RBC recovery/cycle (%)	86.1 (80.8 - 91.6)
Posttreatment Hct (%)	41.8 (39.7 - 44.2)
Platelet recovery (%)	52.4 (44.2 - 60.1)
Posttreatment platelet concentration (10^9/l)	116 (93 - 146)

In this first-in-human study, the blood and platelet recovery device was able to simultaneously recover and wash both platelets and red blood cells for transfusion during cardiac surgical procedures

Mansour A, *et al.* ANESTHESIOLOGY, 2023.

2) Aspirations lavées/centrifugées inflammation/débris

Ann Thorac Surg. 2010 May;89(5):1511-7. doi: 10.1016/j.athoracsur.2010.02.003.

Cell saver for on-pump coronary operations reduces systemic inflammatory markers: a randomized trial.

Damgaard S[1], Nielsen CH, Andersen LW, Bendtzen K, Tvede M, Steinbrüchel DA.

Eur J Cardiothorac Surg. 2013 Sep;44(3):506-11. doi: 10.1093/ejcts/ezt019. Epub 2013 Feb 12.

Cell salvage of cardiotomy suction blood improves the balance between pro- and anti-inflammatory cytokines after cardiac surgery.

Gäbel J[1], Westerberg M, Bengtsson A, Jeppsson A.

Interact Cardiovasc Thorac Surg. 2016 Mar;22(3):298-304. doi: 10.1093/icvts/ivv355. Epub 2015 Dec 23.

Intraoperative cell salvage during cardiac surgery is associated with reduced postoperative lung injury.

Engels GE[1], van Klarenbosch J[2], Gu YJ[3], van Oeveren W[4], de Vries AJ[5].

Eur J Cardiothorac Surg. 2003 Apr;23(4):633-6.

A prospective randomised comparison of cardiotomy suction and cell saver for recycling shed blood during cardiac surgery.

Jewell AE[1], Akowuah EF, Suvarna SK, Braidley P, Hopkinson D, Cooper G.

2) Aspirations lavées/centrifugées Contre indication

- Produits que l'on ne voudrait pas retrouver dans la circulation sanguine….
- Antiseptiques iodés, eau oxygénée, alcool, eau stérile, adjuvants de la coagulation, Liquide amniotique ou gastrique….
- Endocardite?
- Néoplasie?

2) Aspirations lavées/centrifugées Endocardite

- Concept de réalisation CEC….
- Que change l'utilisation ou non du cell saver?

2) Aspirations lavées/centrifugées Néoplasie

2011 Update to The Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists Blood Conservation Clinical Practice Guidelines[*]*

Class IIb

Jump to Section Go

1 In high-risk patients with known malignancy who require CPB, blood salvage using centrifugation of blood salvaged from the operative field may be considered since substantial data support benefit in patients without malignancy, and new evidence suggests worsened outcome when allogeneic transfusion is required in patients with malignancy. (Level of evidence B)

2) Aspirations lavées/centrifugées Néoplasie

Medicine (Baltimore). 2019 Jul;98(27):e16040. doi: 10.1097/MD.0000000000016040.

Survival analysis of intraoperative blood salvage for patients with malignancy disease: A PRISMA-compliant systematic review and meta-analysis.

Wu WW[1], Zhang WY[1], Zhang WH[2], Yang L[1], Deng XQ[1], Ou MC[1], Yang YX[1], Liu HB[1], Zhu T[1].

-17 études inclues (1 seule prospective)
-Pas de différence entre utilisation CS vs No CS

2) Aspirations lavées/centrifugées Néoplasie

Medicine (Baltimore). 2019 Jul;98(27):e16040. doi: 10.109

Survival analysis of intraoperativ compliant systematic review and

Wu WW[1], Zhang WY[1], Zhang WH[2], Yang L[1], Deng X

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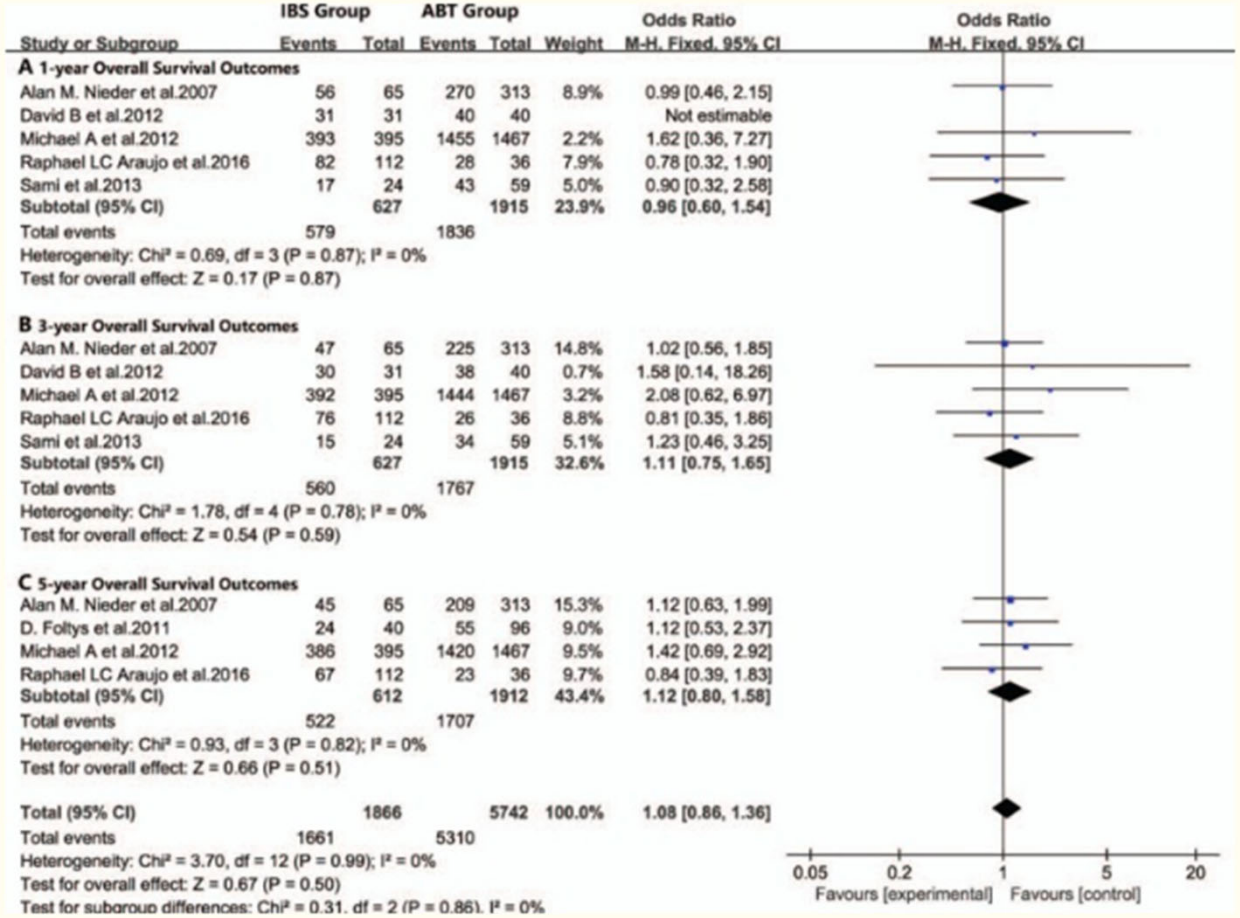

Figure 1

Meta-analysis forest plot of the overall survival outcomes. (A. 1-year overall survival outcome, B. 3-year overall survival outcome, C. 5-year overall survival outcomes).

2) Aspirations lavées/centrifugées Néoplasie

Medicine (Baltimore). 2019 Jul;98(27):e16040. doi: 10.1097/MD.0000000000016040.

Survival analysis of intraoperative bloo[illegible] for patients with malignancy disease: A PRISMA compliant systematic review and meta

Wu WW[1], Zhang WY[1], Zhang WH[2], Yang L[1], Deng XQ[1], Ou M

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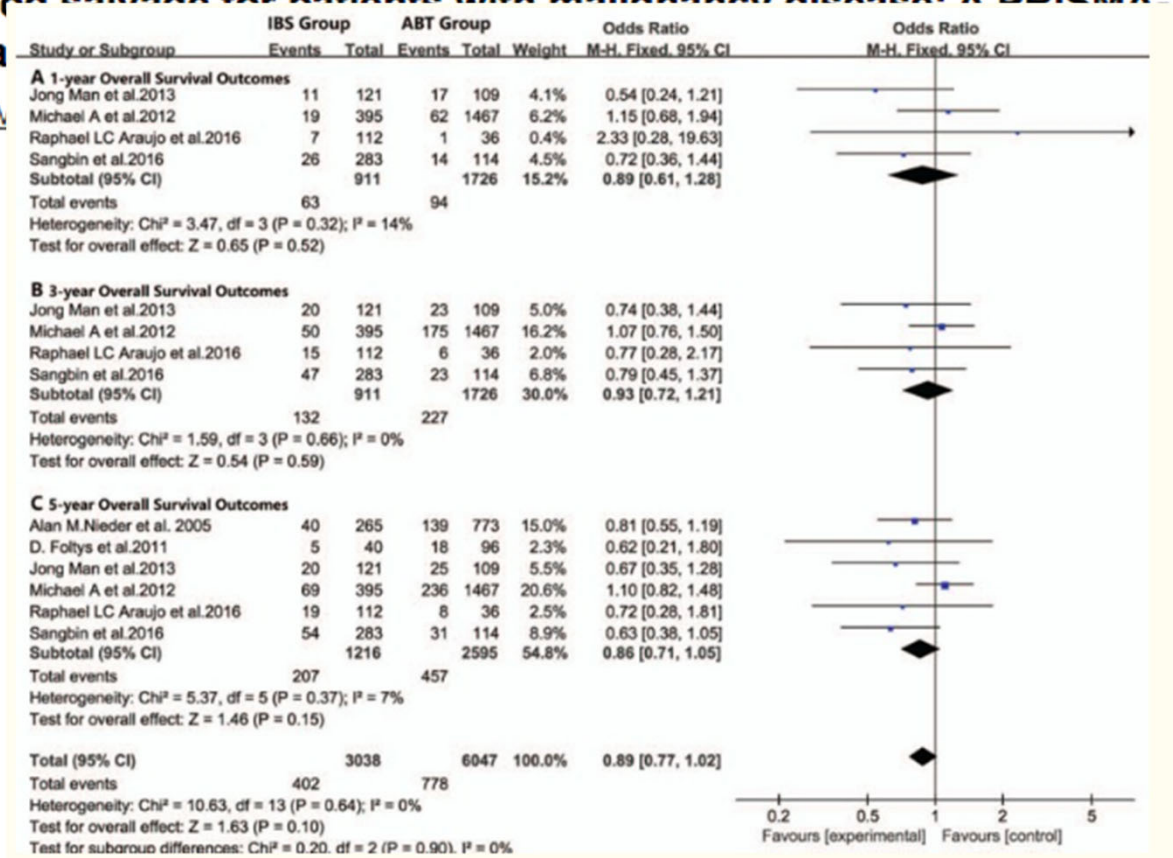


Figure 3

Meta-analysis forest plot of the recurrence rate. (A. 1-year recurrence rate, B. 3-year recurrence rate, C. 5-year recurrence rate).

En pratique Cell saver

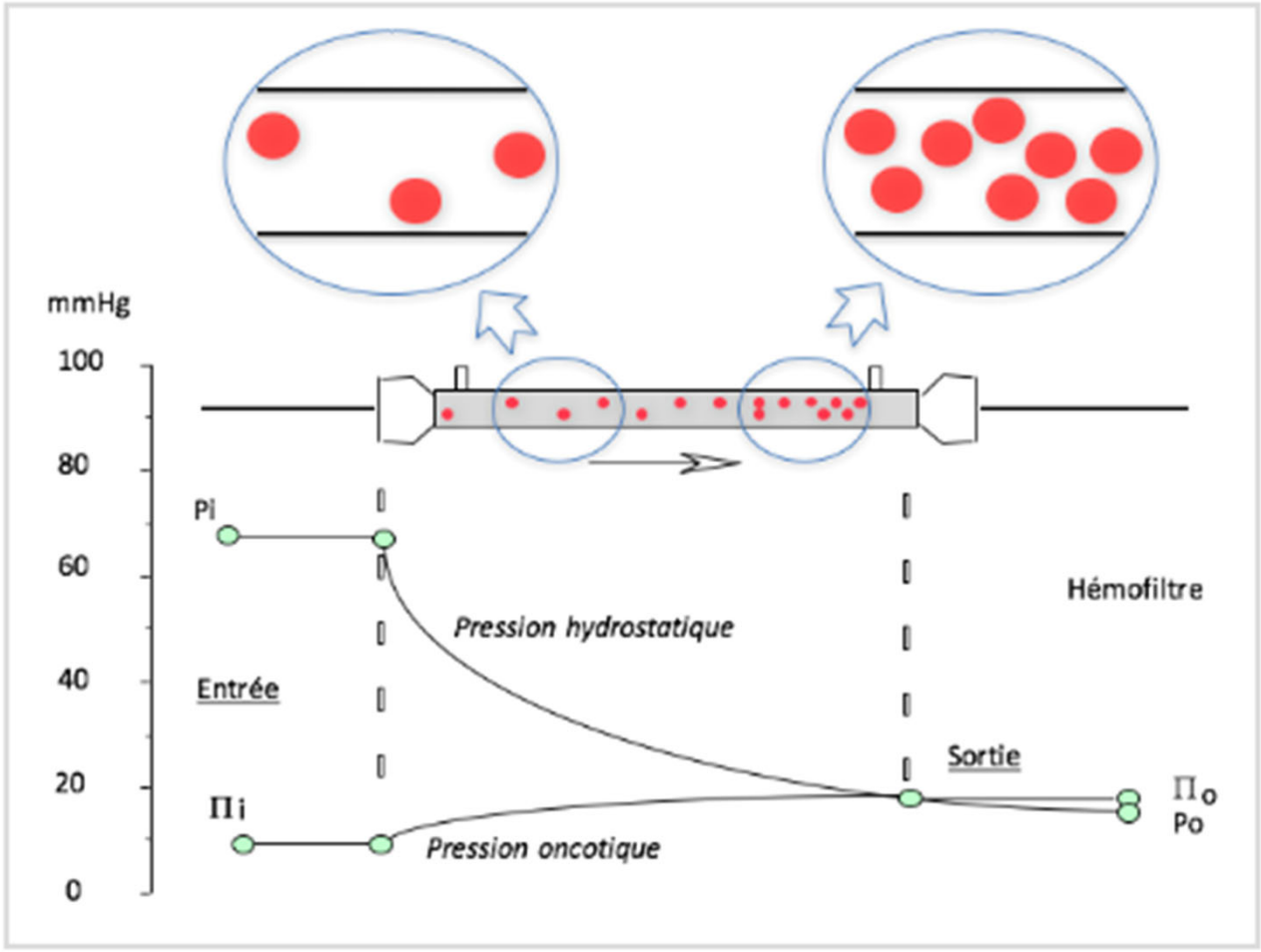
- S'intègre dans une pratique globale d'épargne sanguine
- Possible coagulopathie pour hauts volumes traités (pauvres en plaquettes et en facteurs de coag et possible quantité non négligeable d'héparine)
- Cancer/endocardites: non contre indiqué
- Utilisation pour tous les patients? **Quelle gestion des aspiration sur le champ?**

Hémofiltration

Principe

- Principe de convection, le plasma sanguin est filtré à travers une membrane semi-perméable grâce à une différence de pression transmembranaire.
- Les solutés de taille inférieure aux pores de la membrane (électrolytes, cytokines…) sont ainsi éliminés avec l'eau plasmatique, tandis que les cellules sanguines et les protéines de grande taille, sont retenues par la membrane.

Principe



D. Journois in vivo CRRT

Principe

- Élimination de l'eau, des électrolytes et des petites molécules fonction:

-1)Pression hydrostatique

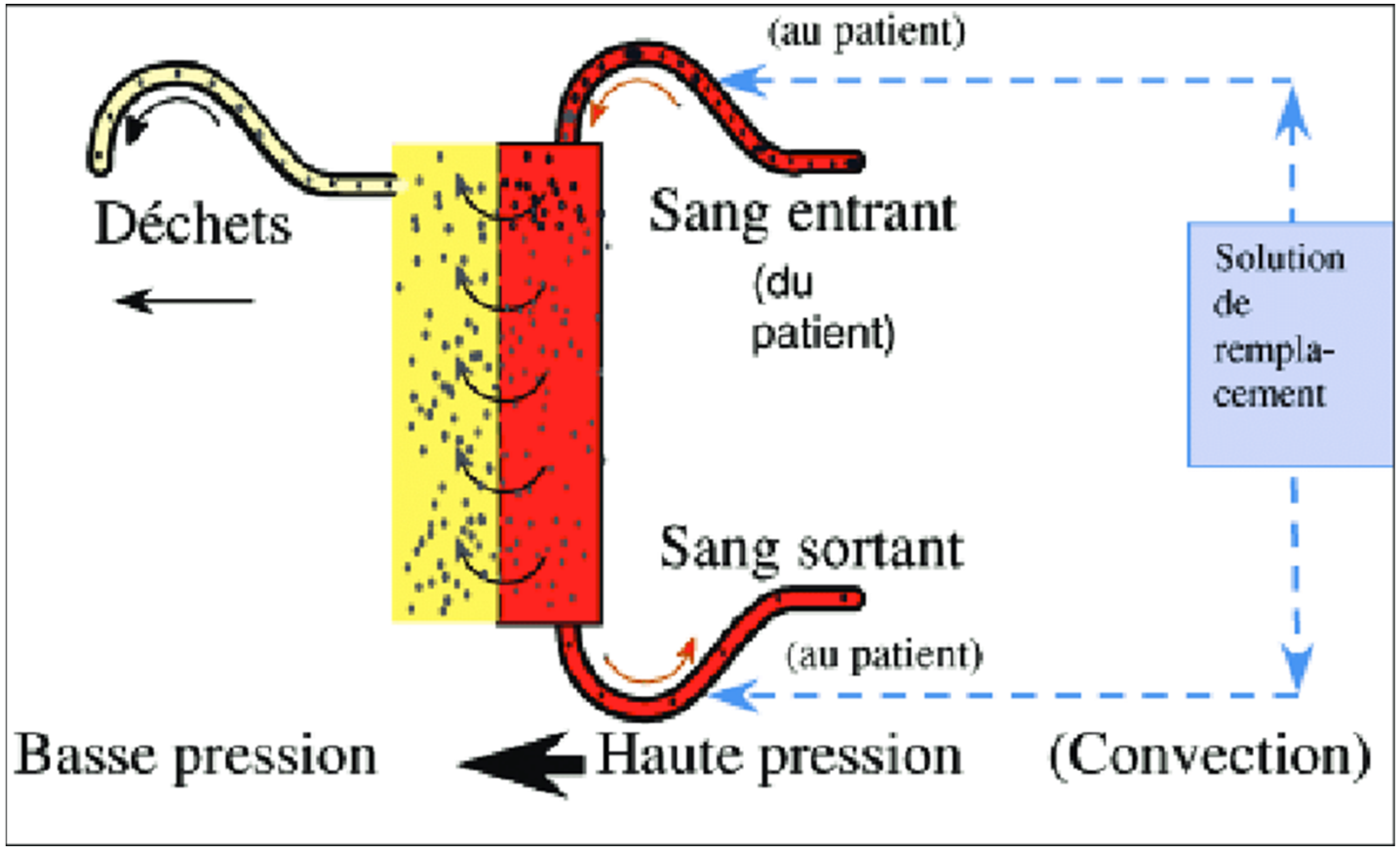
-2)taille des pores=point de coupure (poids moléculaire < 30-50 k Daltons)

-3)débit sanguin

- Quantité de volume ainsi éliminé est nommé: « UF » pour UltraFiltrat

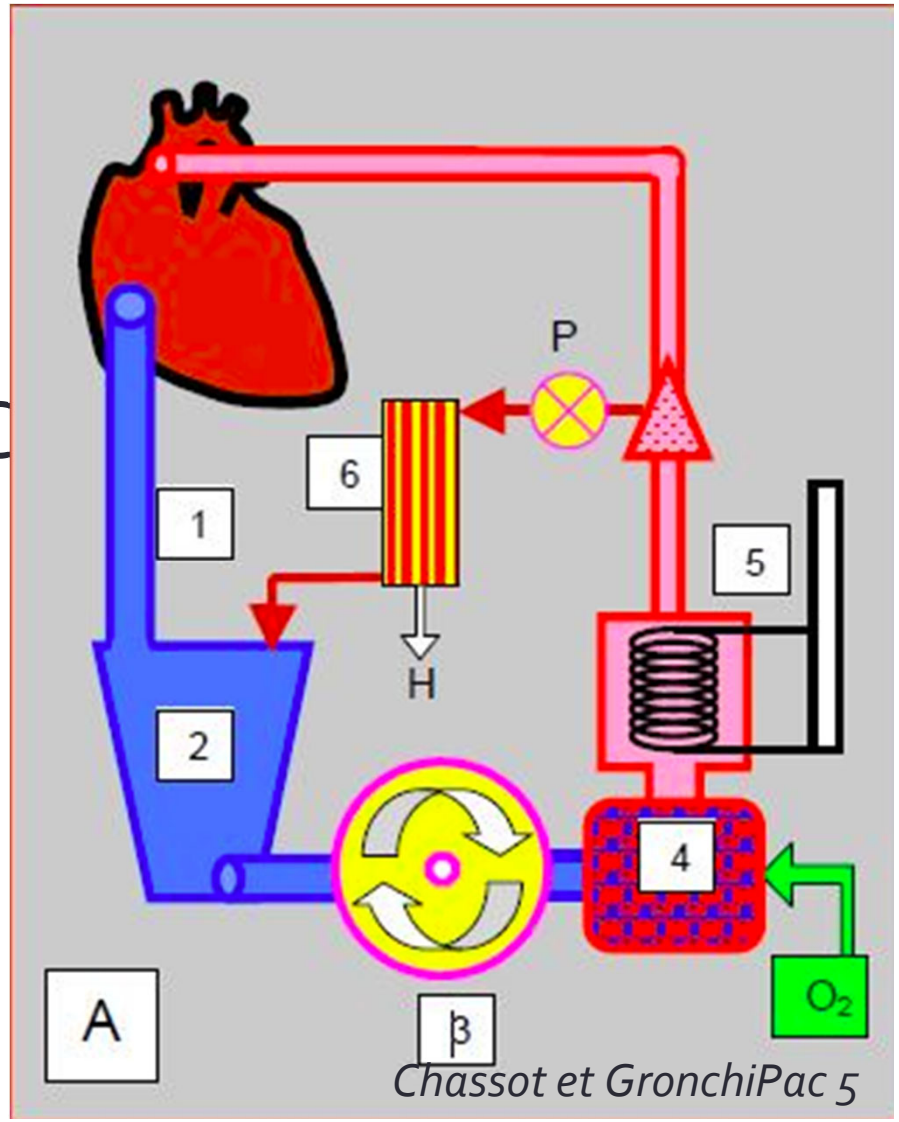
- Branchement du filtre sur pompe dédiée, intégré au circuit de CEC

Principe


(au patient)
Déchets
Sang entrant
(du
patient)
Solution
de
rempla-
cement
Sang sortant
(au patient)
Basse pression
Haute pression
(Convection)

A) Hémofiltration conventionnelle

-Per CEC
-Perte d'eau et électrolytes
-hémoconcentration perCEC
-Perte de poids



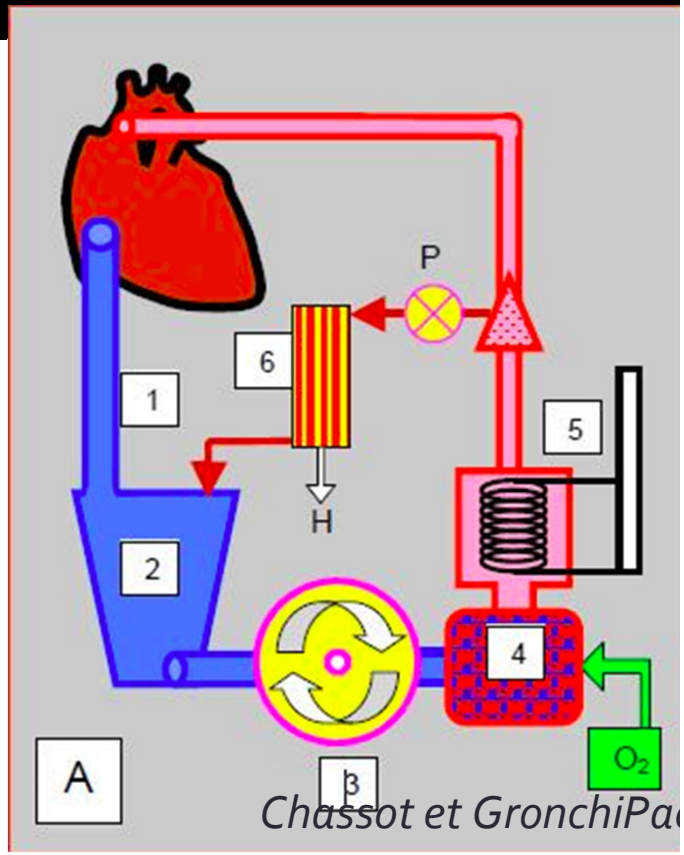
Chassot et GronchiPac 5

A')Hémofiltration « balance Zéro »

-Per CEC

-Perte d'eau et electrolytes

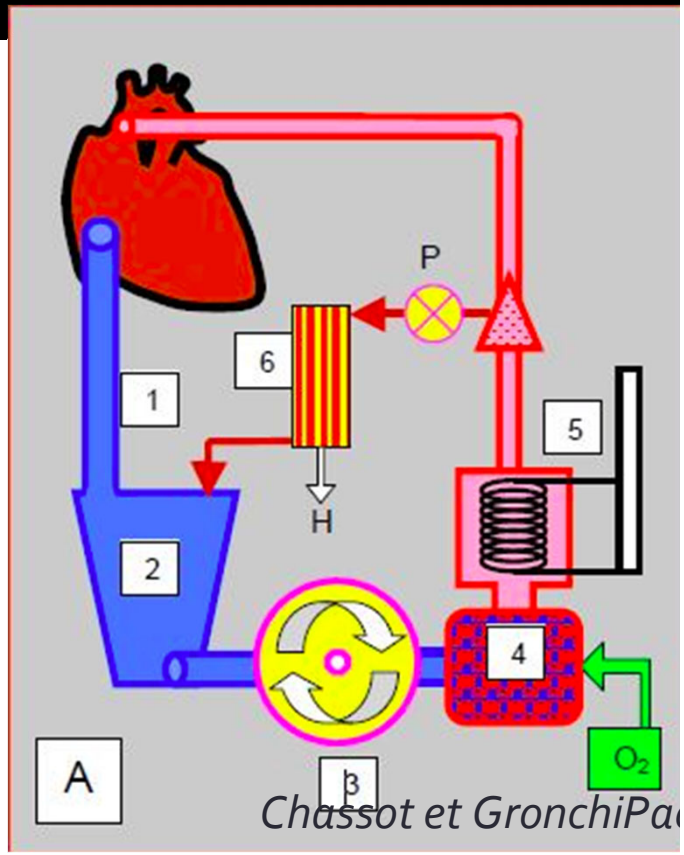
-Compensée par ajout d'un soluté cristalloïde (ou autre)



Chassot et GronchiPa

A')Hémofiltration « balance Zéro »

-Per CEC
-Perte d'eau et electrolytes
-Compensée par ajout d'un Soluté cristalloide
-épuration de hauts volumes
-Pas d' hémoconcentration
-Pas de perte de poids
-« Renouvellement » plasma « débarrassé » de petites molécules potentiellement délétère.

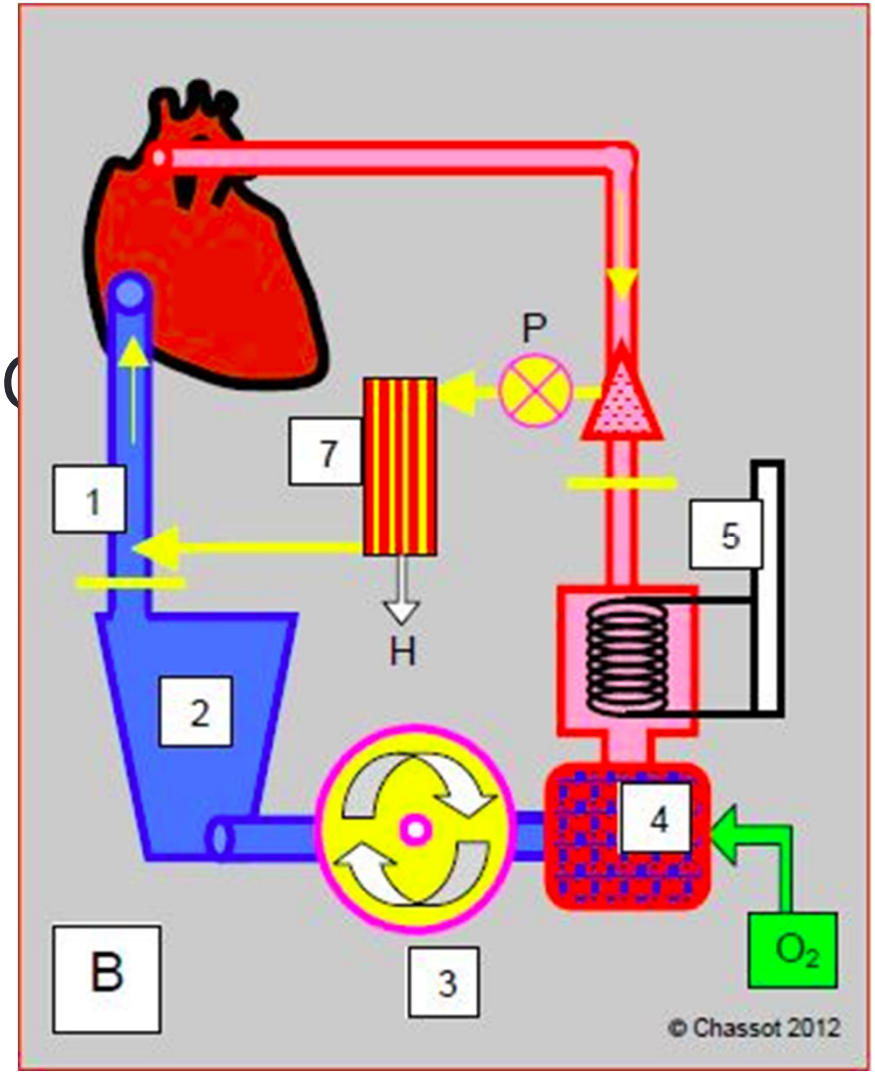


Chassot et GronchiPa

B) Hémofiltration modifiée (MUF)

-En fin de CEC
-Perte d'eau et electrolytes
-hémoconcentration post CEC
-débit sang 150mL/min

-stratégie diurétique



17. Groom RC, Akl BF, Albus RA, et al. Alternative method of ultrafiltration after cardiopulmonary bypass. *Ann Thorac Surg*. 1994;58:573–574.

Indications hémofiltration

- Evidentes: Surcharge volémique avec hémodilution et oedème interstitiel (souffrance multi organe), désordre électrolytique ou élimination d'un toxique hémofiltrable (taille et liaison protéiques)

- Supposée: Bénéfice à l'élimination de molécules pro inflammatoires (majeures parties des cytokines pro inf ont un poids moléculaire< point de coupure)

Littérature hémofiltration

A) Hémofiltration conventionnelle

2011 Update to The Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists Blood Conservation Clinical Practice Guidelines*

Conventional ultrafiltration is a method of ultrafiltration used during CPB. One meta-analysis [347], four randomized trials [348, 349, 350, 351], and two cohort studies [352, 353] report the use of conventional ultrafiltration in patients undergoing cardiac procedures using CPB. Subgroup analysis of five studies included in the meta-analysis by Boodhwani [347] demonstrated no advantage in terms of red cell usage or blood loss with conventional ultrafiltration alone [349, 350, 351, 352, 353].

- Pas d'avantage en terme de transfusion

A) Hémofiltration conventionnelle

Ann Card Anaesth. 2016 Jan-Mar;19(1):45-51. doi: 10.4103/0971-9784.173019.

Conventional hemofiltration during cardiopulmonary bypass increases the serum lactate level in adult cardiac surgery.

Soliman R[1], Fouad E, Belghith M, Abdelmageed T.

-Etude observationnelle, CEC prog, hypothermie modérée
-138 patient avec HF VS 145 sans (pts similaires)
-HF après départ en CEC pour obj Ht entre 25 et 30%
-instabilité hémodynamique et hyperlactatémie en per et au sevrage de la CEC….

Table 2: Intraoperative data of patients

Dopamine			
Number of patients	96	123	0.001
Dose (µg/kg/min)	5.23±1.63	7.95±197	0.001
Epinephrine			
Number of patients	42	40	0.001
Dose (µg/kg/min)	0.08±0.02	0.12±0.05	0.001
Norepinephrine			
Number of patients	16	33	0.001
Dose (µg/kg/min)	0.03±0.02	0.05±0.03	0.008
IABP (number of patients)	17	38	0.015
Packed red blood cells (units)	1.55±0.28	2.78±0.78	0.005
Urine (L)	1.49±0.28	3.62±0.46	0.001
Fluid removal (L)	2.56±0.22	-	0.001

Table 1: Preoperative data of patients

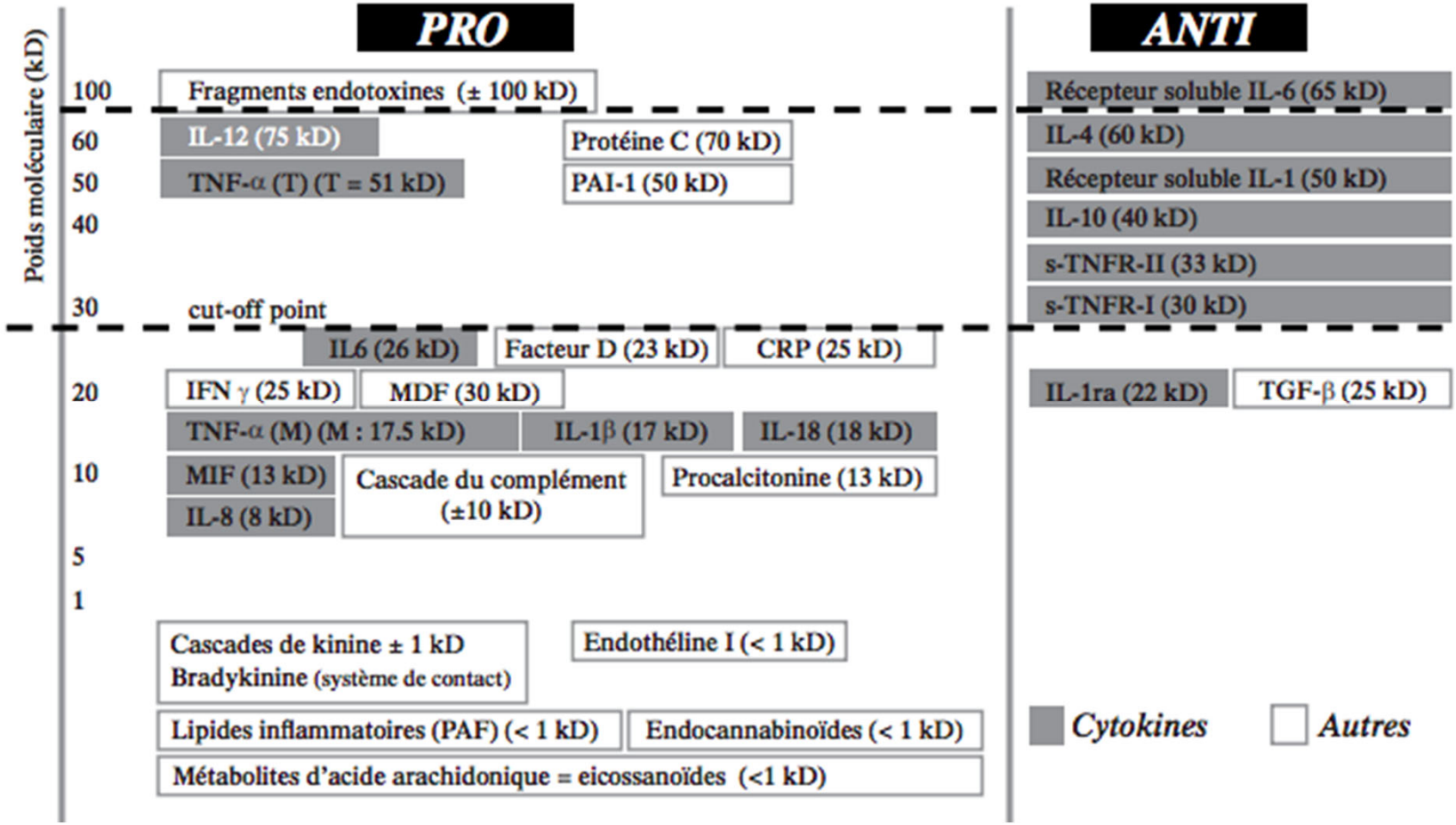
A') Hémofiltration « balance zero »

2011 Update to The Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists Blood Conservation Clinical Practice Guidelines[*]*

With ZBUF, the ultrafiltrate fluid is replaced with an equal volume of balanced electrolyte solution during CPB. Patients may benefit from ZBUF through the removal of mediators and products of systemic inflammatory response syndrome, rather than as a result of fluid removal [356]. Randomized controlled trials investigating ZBUF in adult cardiac procedures did not demonstrate a reduction in blood loss or transfusion with the application of ZBUF [357, 358].

- Pas d'avantage en terme de transfusion

A') Hémofiltration « balance zero »



Silvester W. Mediator removal with CRRT (continuous renal replacement therapy): complement and cytokines. Am J Kid- ney Dis 1997;30(Suppl 4):S38-43.

A') Hémofiltration « balance zero »

Perfusion. 2002 Mar;17(2):111-5.

Inflammatory mediator removal by zero-balance ultrafiltration during cardiopulmonary bypass.

Tallman RD[1], Dumond M, Brown D.

Author information

1 Circ

Table 2 Mean (std. dev.) values taken immediately before surgery (T1), immediately after surgery (T2), and 12 h post-surgery (T3)

	T1		*T2*		*T3*	
	Control	*ZBUF*	*Control*	*ZBUF*	*Control*	*ZBUF*
Hematocrit (%)	36.36 (3.92)	36.48 (3.86)	29.19 (4.86)	29.03 (2.81)	29.94 (3.49)	30.95 (4.01)
Hemoglobin (g/dl)	12.64 (1.43)	12.51 (1.26)	10.16 (1.90)	10.03 (1.05)	10.69 (1.90)	10.63 (1.37)
White Cell Count ($\times 10^3$/dl)	6.85 (1.88)	6.47 (1.29)	11.33 (2.46)	10.06 (2.46)	11.97 (3.36)	11.23 (1.83)
IL-1 (pg/ml)	0.62 (1.33)	0.24 (0.22)	0.61 (0.95)	0.63 (0.59)	0.79 (1.08)	0.51 (0.62)
IL-6 (pg/ml)	2.83 (1.93)	3.23 (2.66)	61.62 (32.51)	64.43 (68.88)	160.83 (103.62)	145.07 (74.00)
TNF- (pg/ml)	2.01 (2.42)	3.46 (3.50)	2.91 (2.49)	9.43*(8.68)	1.86 (2.13)	5.27 (4.92)
C3a (ng/ml)	1111.04 (1026.99)	1417.57 (802.31)	1686.91 (1448.48)	3282.09* (2407.75)	528.27 (400.78)	837.59 (585.19)
C5a (ng/ml)	278.30 (317.65)	158.37 (98.48)	1007.35 (338.83)	1299.17 (277.13)	110.24 (53.05)	175.75 (126.01)
Prothrombin time (s)	13.53 (0.77)	13.23 (0.61)	19.14 (3.17)	19.38 (4.87)	15.02 (1.37)	15.06 (1.05)
Partial thromboplastin time (s)	33.87 (12.45)	41.37 (23.96)	37.60 (10.03)	30.18 (7.90)	32.60 (3.83)	33.07 (4.92)
SVR	1095.80 (272.64)	1307.53 (421.56)	731.40 (301.70)	732.33 (238.65)	844.93 (193.37)	894.67 (377.75)
PVR	105.33 (42.10)	112.47 (69.76)	75.53 (29.19)	77.13 (46.09)	87.93 (34.19)	73.67 (41.34)
Cardiac output (l/min)	5.03 (1.29)	4.79 (1.37)	7.91 (2.22)	7.30 (1.53)	6.61 (1.62)	6.93 (1.84)
Cardiac index (l/min per m^2)	2.63 (0.59)	2.29 (0.51)	4.08 (1.06)	3.59 (0.65)	3.39 (0.66)	3.29 (0.64)

SVR=systemic vascular resistance. PVR=peripheral vascular resistance. *Indicates a significant difference from corresponding control values as determined by Kruskal–Wallis test of the ANCOVA residuals ($p<0.05$).

A') Hémo

Am J Respir Crit Care Med. 2015 Nov 15;192(1

**Early High-Volume Hemofil
HEROICS Study.**

Combes A[1], Bréchot N[1], Amour J[2], Cozic N
A[12], Trouillet JL[1], Mallet A[3], Chastre J[1], Lep

-HVHF (80 ml/kg/h maximum of 8 L/h) VS Standard
-224 patients choqués

Time since ICU admission, h	12.9 (11.7)	12.7 (11.8)
Patients on ECMO	47 (42%)	52 (46%)
Patients on IABP	19 (17%)	15 (13%)
Patients on IABP or ECMO	58 (52%)	60 (54%)
SAPS II	54.0 (12.3)	55.1 (12.3)
SOFA score	11.5 (2.8)	12.0 (2.9)
Glasgow coma score	13.5 (3.0)	13.2 (3.4)
Systolic blood pressure, mm Hg	113 (24)	109 (25)
Diastolic blood pressure, mm Hg	63 (14)	62 (14)
Mean blood pressure, mm Hg	79 (14)	77 (14)
Heart rate, beats/min	94 (18)	94 (16)
Epinephrine dose, μg/kg/min	0.23 (0.39)	0.27 (0.46)
Norepinephrine dose, μg/kg/min	0.23 (0.45)	0.32 (0.70)
Inotropic score‡	45.6 (53.9)	59.1 (80.7)
Creatinine, μmol/L	148 (81)	162 (77)
Blood urea nitrogen, mmol/L	11.1 (6.7)	12.0 (5.6)
Urine output, ml		
<500	36 (31)	46 (41)
500–999	35 (32)	26 (23)
>1,000	41 (37)	40 (36)
Lactate, mmol/L	5.0 (3.9)	4.8 (3.8)
Bicarbonate, mmol/L	19.5 (4.9)	19.1 (3.8)

A') H

Am J Respir Crit Care Med. 2

Early High-Volun HEROICS Study.

Combes A[1], Bréchot N[1], Ar A[12], Trouillet JL[1], Mallet A[3]

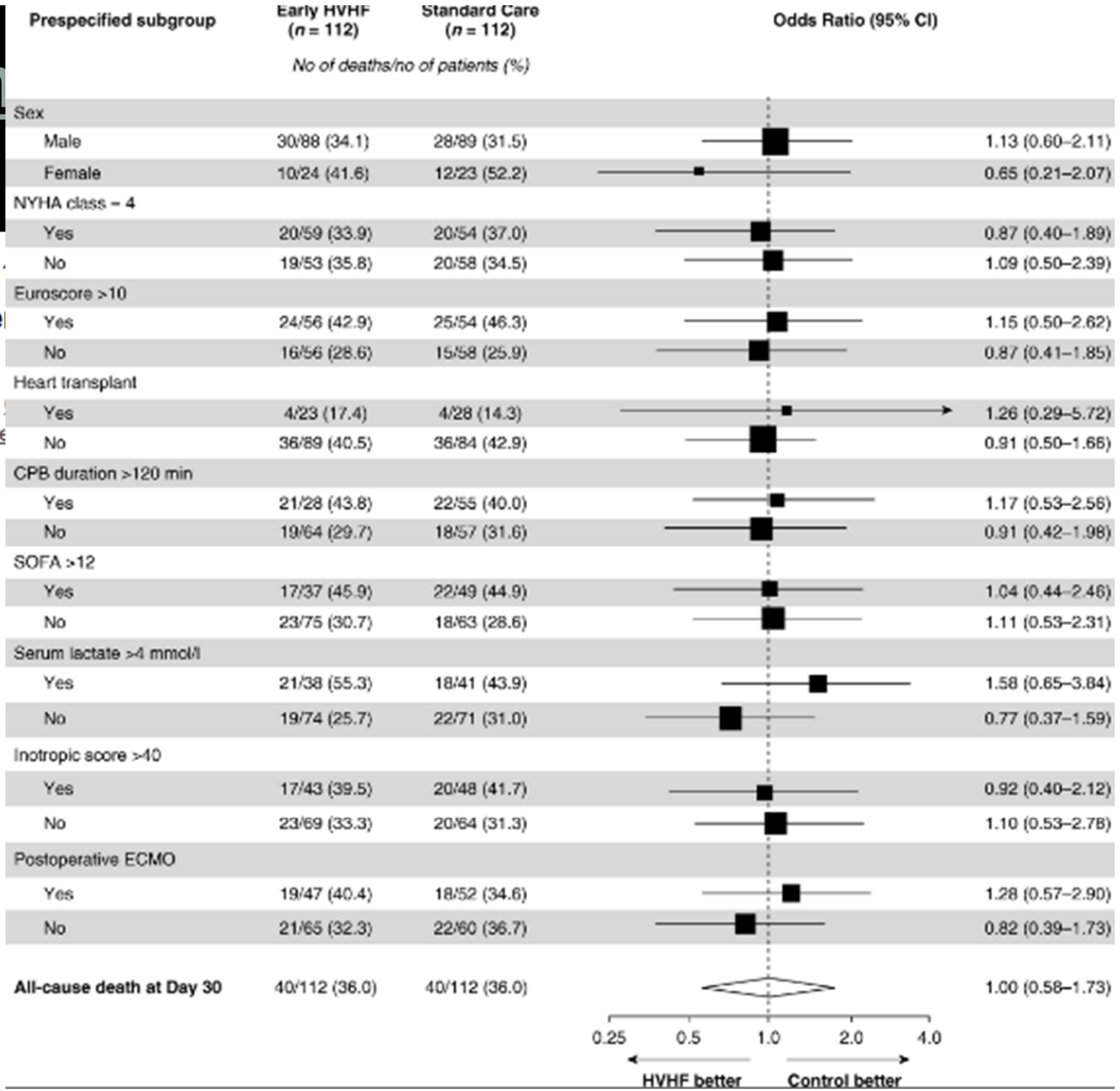
Variable	Early HVHF (*n* = *112*)	Standard Care (*n* = *112*)	Odds Ratio (95% CI)	*P* Value
Mortality				
Day 30	40 (36%)	40 (36%)	1.00 (0.58–1.73)	1.00
Day 60	48 (43%)	42 (38%)	1.25 (0.73–2.05)	0.82
Day 90	51 (46%)	43 (38%)	1.34 (0.79–2.28)	0.28
ICU	49 (44%)	44 (39%)	1.20 (0.71–2.05)	0.50
In-hospital	50 (45%)	44 (39%)	1.25 (0.73–2.12)	0.42
ICU length of stay, d				
For ICU survivors	13 [7–25]	13 [8–29]	—	0.78
For patients who died in the ICU	11 [2–21]	6 [2–14]	—	0.15
Hospital length of stay, d				
For survivors	37 [22–54]	29 [20–49]	—	0.31
For patients who died in-hospital	11 [2–22]	6 [2–14]	—	0.12
Day 1–60 ICU-free days	21 [0–48]	22 [0–48]	—	0.66
Day 1–60 hospital-free days	0 [0–24]	0 [0–31]	—	0.75
Days with catecholamines	5 [3–9]	5 [3–9]	—	0.50
Day 1–30 catecholamine-free	3 [0–10]	3 [0–8]	—	0.64

A') Hén

Am J Respir Crit Care Med. 2015 Nov

Early High-Volume He
HEROICS Study.

Combes A[1], Bréchot N[1], Amour J[2], A[12], Trouillet JL[1], Mallet A[3], Chastre



B) Hémofiltration modifiée (MUF)

2011 Update to The Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists Blood Conservation Clinical Practice Guidelines*,*

2017 EACTS/EACTA Guidelines on patient blood management for adult cardiac surgery FREE

Domenico Pagano ✉, Milan Milojevic, Michael I Meesters, Umberto Benedetto, Daniel Bolliger, Christian von Heymann, Anders Jeppsson, Andreas Koster, Ruben L Osnabrugge, Marco Ranucci ... Show more
Author Notes

European Journal of Cardio-Thoracic Surgery, Volume 53, Issue 1, January 2018, Pages

Eur J Cardiothorac Surg. 2006 Dec;30(6):892-7. Epub 2006 Oct 13.

Ultrafiltration reduces blood transfusions following cardiac surgery: A meta-analysis.

Boodhwani M[1], Williams K, Babaev A, Gill G, Saleem N, Rubens FD.

- Méta analyse sur HF:
- Diminution transfusion en terme de CGR, PFC et plaquettes dans les études MUF
- Etudes « Anciennes » fin 90 début 2000,hypothermie, cardioplégie importante en Volume, méthodo imparfaite

Modified Ultrafilt

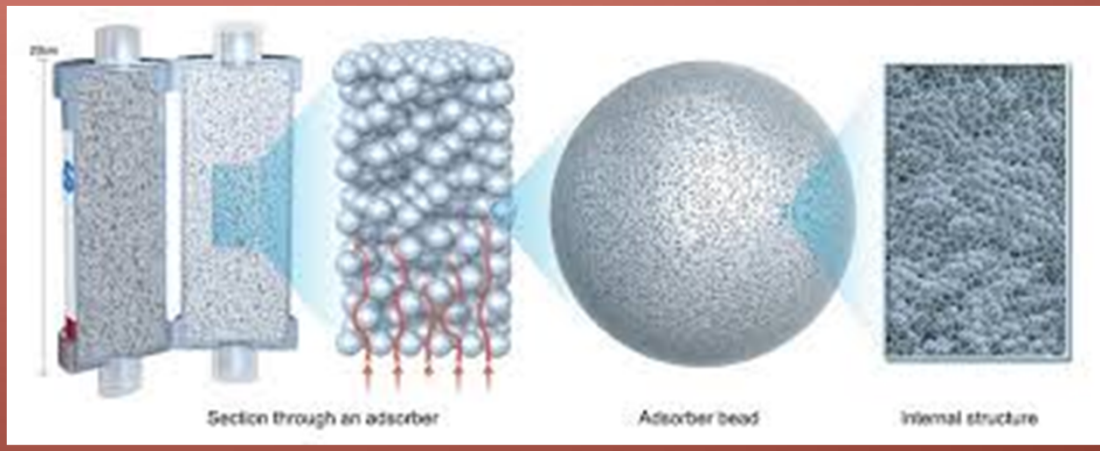
Indications hémofiltration per CEC

- Probablement pas d'intérêt en systématique
- en fonction du patient:

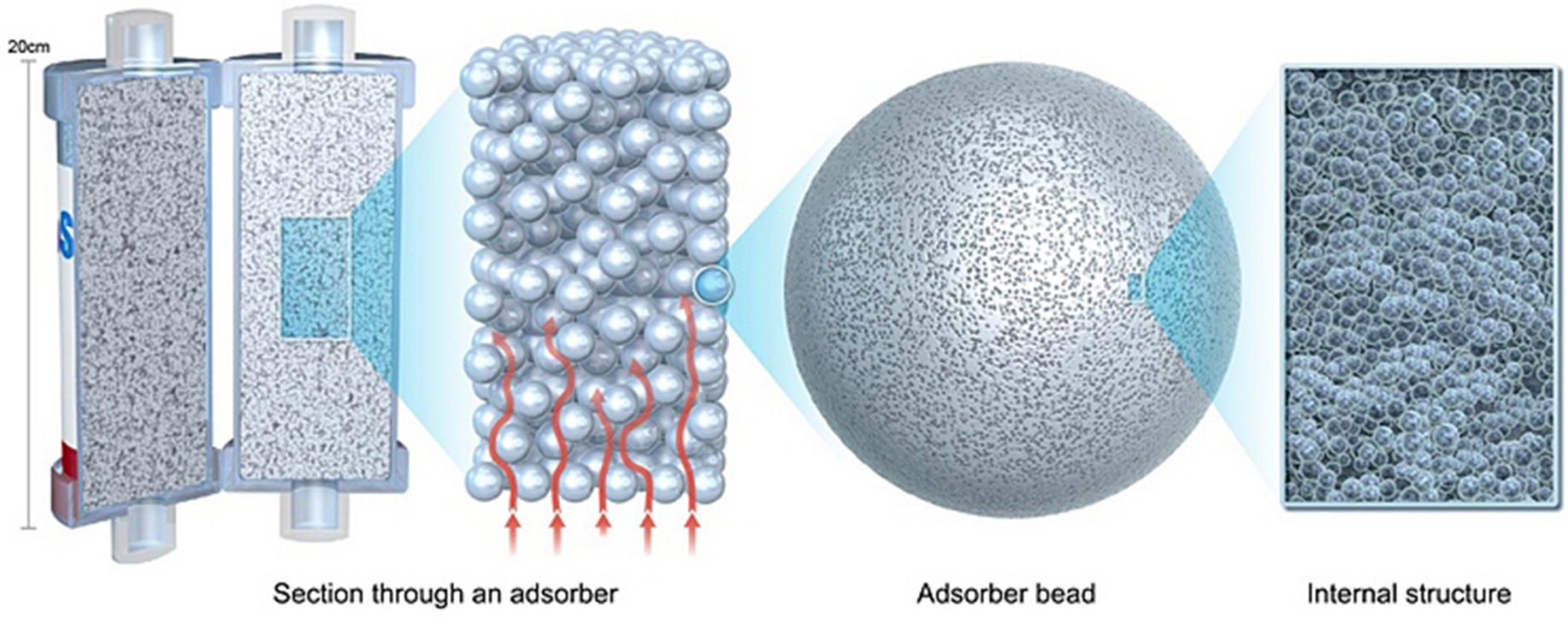
-Surcharge volémique avec hémodilution et œdème interstitiel (souffrance multi organe)
-Elimination d'un médicament épurable (ex: Dabigatran) ou d'un « déchet métabolique »
-Gestion du volume dans le reservoir de cardiotomie: un diurétique peut aussi faire l'affaire…

- Non prouvée: Bénéfice à l' élimination de molécules pro inflammatoires ….. Et anti inflammatoires

Hémoadsorption



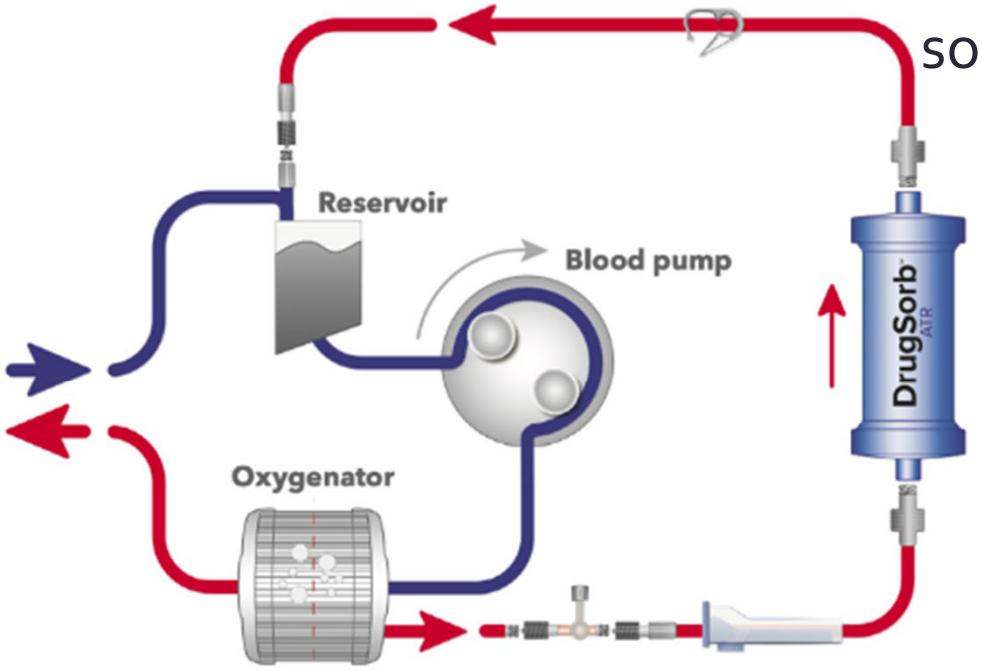
Hémoadsorption Cytosorb /Jafron



-Cartouche remplie de billes de polymère poreuses
-Adsorption de surface des molécules entre 5 et 60 kDA
-Sur un principe uniquement « physique »
-Adsorption concentration dépendante
-surface d'échange de 4 terrains de foot
-Saturation possible

Intégration circuit

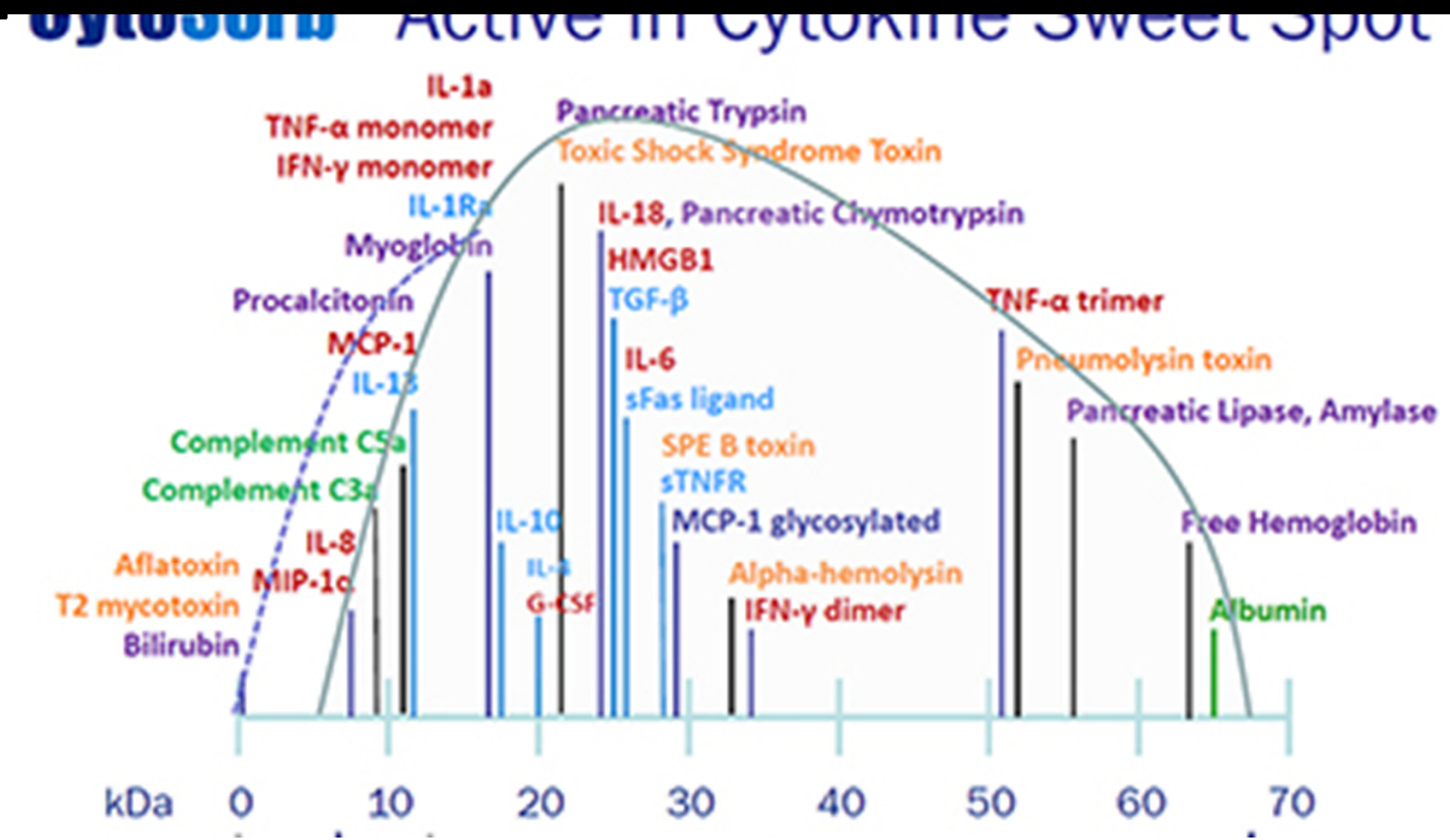
-Faible résistance d'écoulement
-Débit sanguin recommandé 150-500 ml/min
-Préchargé/primé avec une solution saline isotonique



C. Michael Gibson et al

Standard integration of DrugSorb-ATR within a CPB circuit: DrugSorb is integrated as a parallel shunt circuit to the main CPB circuit. Blood flow intake to the parallel circuit is after the pump in the main CPB circuit, and blood flow return from the parallel circuit is to the blood reservoir in the main CPB circuit.

Principe Hémoadsorption



Littérature

Cytokines

Crit Care. 2019 Apr 3;23(1):108. doi: 10.1186/s13054-019-2399-4.

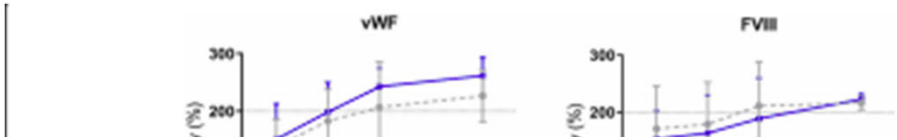
Cytokine clearance with CytoSorb® during cardiac surgery: a pilot randomized controlled trial.

Poli EC[1], Alberio L[2,3], Bauer-Doerries A[4], Marcucci C[4,3], Roumy A[5], Kirsch M[5,3], De Stefano E[5], Liaudet L[1,3], Schneider AG[6,7].

15 patients cytosorb 15 controles, chirurgie réglée
Pas d'effet secondaire délétère
Pas de variation des taux de cytokines ni facteurs coag

Cardio-pulmonary bypass characteristics		
Median bypass duration—(IQR) min	138 (87–207)	145 (130–183)
Median cross-clamp duration (IQR) min	115 (68–159)	122 (97–146)
Centrifugal pump—no. (%)	5 (33.3)	4 (26.7)

CONCLUSIONS: CytoSorb® HA during CPB was not associated with a decrease in pro- or anti-inflammatory cytokines nor with an improvement in relevant clinical outcomes. The procedure was feasible and safe. Further studies should evaluate the efficacy of CytoSorb® HA in other clinical contexts.



Cytokines

The effect of perioperative hemadsorption in patients operated for acute infective endocarditis—A randomized controlled study

Silke Asch, Tobias Peter Kaufmann, Michaela Walter, Marcus Leistner, Bernd C. Danner, Thorsten Perl, Ingo Kutschka, Heidi Niehaus

First published: 21 June 2021 | https://doi.org/10.1111/aor.14019

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Patients with confirmed IE of any type (native or prosthetic valve) and localization (affected valve) undergoing cardiac surgery were included in this study and randomly assigned to either the HA group or the control group. Exclusion criteria were a lack of informed consent,

The primary endpoint of the study was the postoperative course of cytokine levels (IL-6, TNF-a, IL-1b) and infection parameters (CRP, PCT, leucocytes). Secondary endpoints were the development of the severity-of-the disease (estimated by the SOFA, SAPS II and APACHE II score), postoperative catecholamine and fluid requirement, the incidence of adverse events as well as in-hospital mortality.

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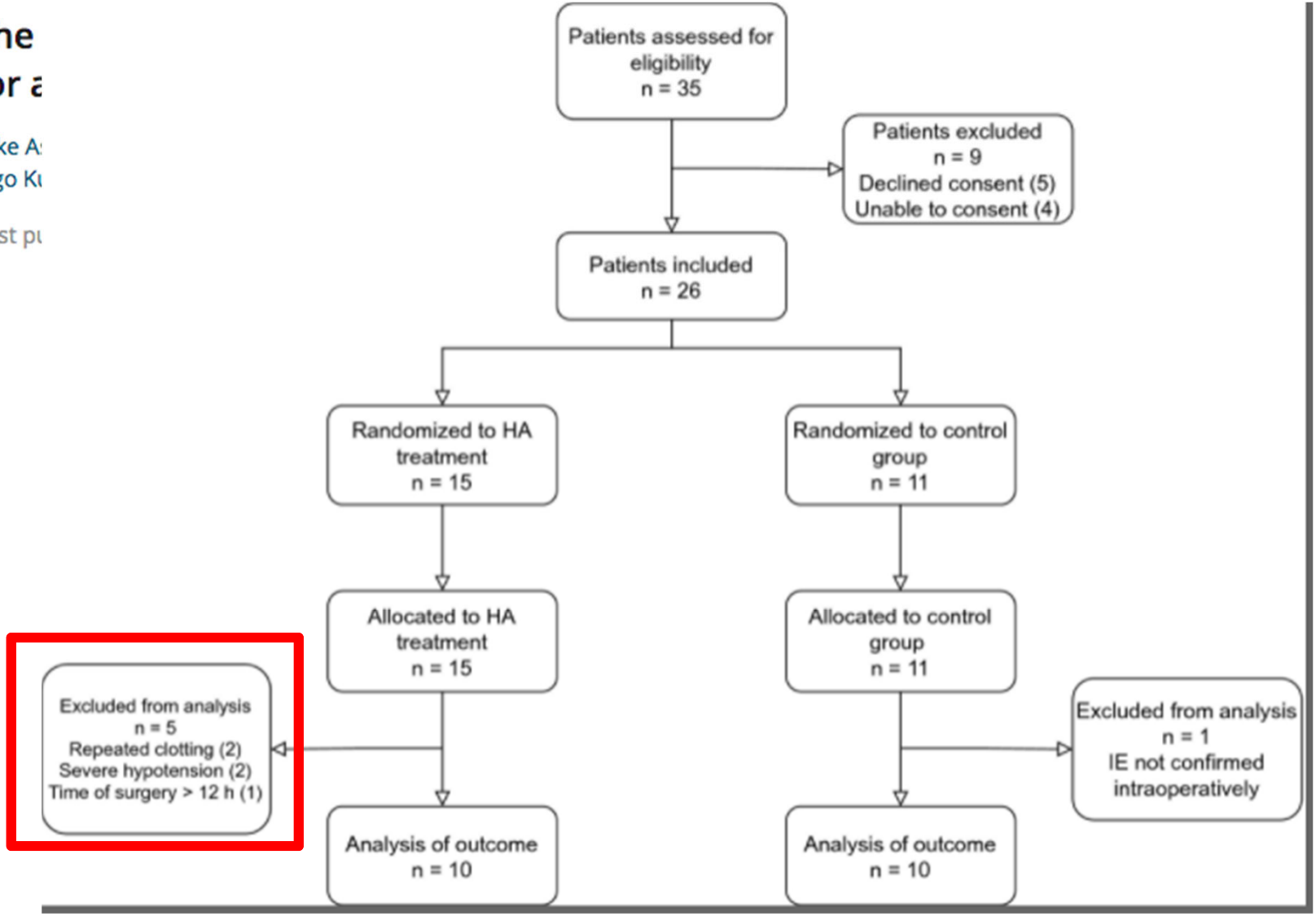

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	HA group	Control group	
	n = 10	n = 10	*P* value
Baseline parameters			
Age [years]	65 (53-70)	69 (56-81)	.315
Female gender [n]	3	1	.582
Body mass index [kg/m^2]	26.0 (21.5-30.6)	25.0 (20.7-31.8)	.853
LVEF [%]	50 (50-56)	60 (54-62)	.105
EuroSCORE II [%]	8.5 (2.7-16.4)	3.6 (2.6-11.8)	.393
Re-operation [n]	3	2	1.000
Emergency surgery [n]	2	1	1.000
Endocarditis-related parameters			
Single valve IE [n]	7	9	1.000
Multiple valves IE [n]	3	1	1.000
Septic embolism [n]	4	4	1.000
Cardiogenic shock [n]	1	0	1.000
Co-morbidities			
Arterial hypertension [n]	4	7	.370
Insulin-dependent diabetes [n]	1	3	.582
Peripheral artery disease [n]	2	0	.474
Renal replacement therapy [n]	1	1	1.000
COPD [n]	2	0	.474
Cardiac surgery			
AV surgery [n]	5	2	.350
MV surgery [n]	2	4	.628
AV and MV surgery [n]	2	3	1.000
MV and TV surgery [n]	1	1	1.000
Cross clamp time (minutes)	90 (65-150)	118 (60-148)	.888
CPB time (minutes)	126 (94-276)	180 (93-219)	.963

Cytokines

The effect of perioperative hemadsorption in patients operated for acute infective endocarditis—A randomized controlled study

Silke Asch, Tobias Peter Kaufmann, Michaela Walter, Marcus Leistner, Bernd C. Danner, Thorsten Perl, Ingo Kutschka, Heidi Niehaus

First published: 21 June 2021 | https://doi.org/10.1111/aor.14019

(n = 7). All patients survived to discharge. No significant differences concerning median cytokine levels (IL-6 and TNF-α) were observed between both groups. CRP and PCT baseline levels were significantly higher in the HA group (59.5 vs. 26.3 mg/dL, *P* = .029 and 0.17 vs. 0.05 μg/L, *P* = .015) equalizing after surgery. Patients in the HA group required significantly higher doses of vasopressors (0.093 vs. 0.025 μg/kg/min norepinephrine, *P* = .029) at 12 hours postoperatively as well as significantly more overall volume replacement (7217 vs. 4185 mL at 12 hours, *P* = .015; 12 021 vs. 4850 mL at 48 hours, *P* = .015). HA therapy did neither result in a reduction of inflammatory parameters nor result in an improvement of hemodynamic parameters in patients operated for IE. For a more targeted use of HA therapy, appropriate selection criteria are required.

Cytokines

Lancet Respir Med. 2021 Jul; 9(7): 755–762.
Published online 2021 May 14. doi: 10.1016/S2213-2600(21)00177-6
PMCID: PMC8121541
PMID: 34000236

Cytokine adsorption in patients with severe COVID-19 pneumonia requiring extracorporeal membrane oxygenation (CYCOV): a single centre, open-label, randomised, controlled trial

Alexander Supady, MD,[a,d,f,*] Enya Weber, PhD,[a,c] Marina Rieder, MD,[a,d] Achim Lother, MD,[a,d] Tim Niklaus, BA,[a,d]

The CYCOV trial was a single-centre, randomised, controlled, parallel group, open-label, superiority trial. All adult patients (≥18 years of age) admitted to the participating intensive care units (ICUs) of the Freiburg University Medical Center with reverse transcriptase (rt) PCR-confirmed SARS-CoV-2 infection who were selected to receive venovenous ECMO were eligible. Exclusion criteria were a known patient

In the intervention group, a CytoSorb adsorber was incorporated into the ECMO system and replaced every 24 h for a total treatment duration of 72 h. Routinely, the adsorber was installed in the ECMO as part of the system setup before connecting it to the patient circuit, but at the latest within 4 h after initiation of the

The primary endpoint was serum IL-6 after 72 h of ECMO with or without cytokine adsorption. Secondary endpoints were ICU survival and 30-day survival, days on ECMO, days on mechanical ventilation, serum lactate, Willebrand factor, D-dimers, vasopressor dosage, amount of fluid substitution, fluid balance after 72 h, and Sequential Organ Failure Assessment score after 24, 48, and 72 h.21

Cytokines

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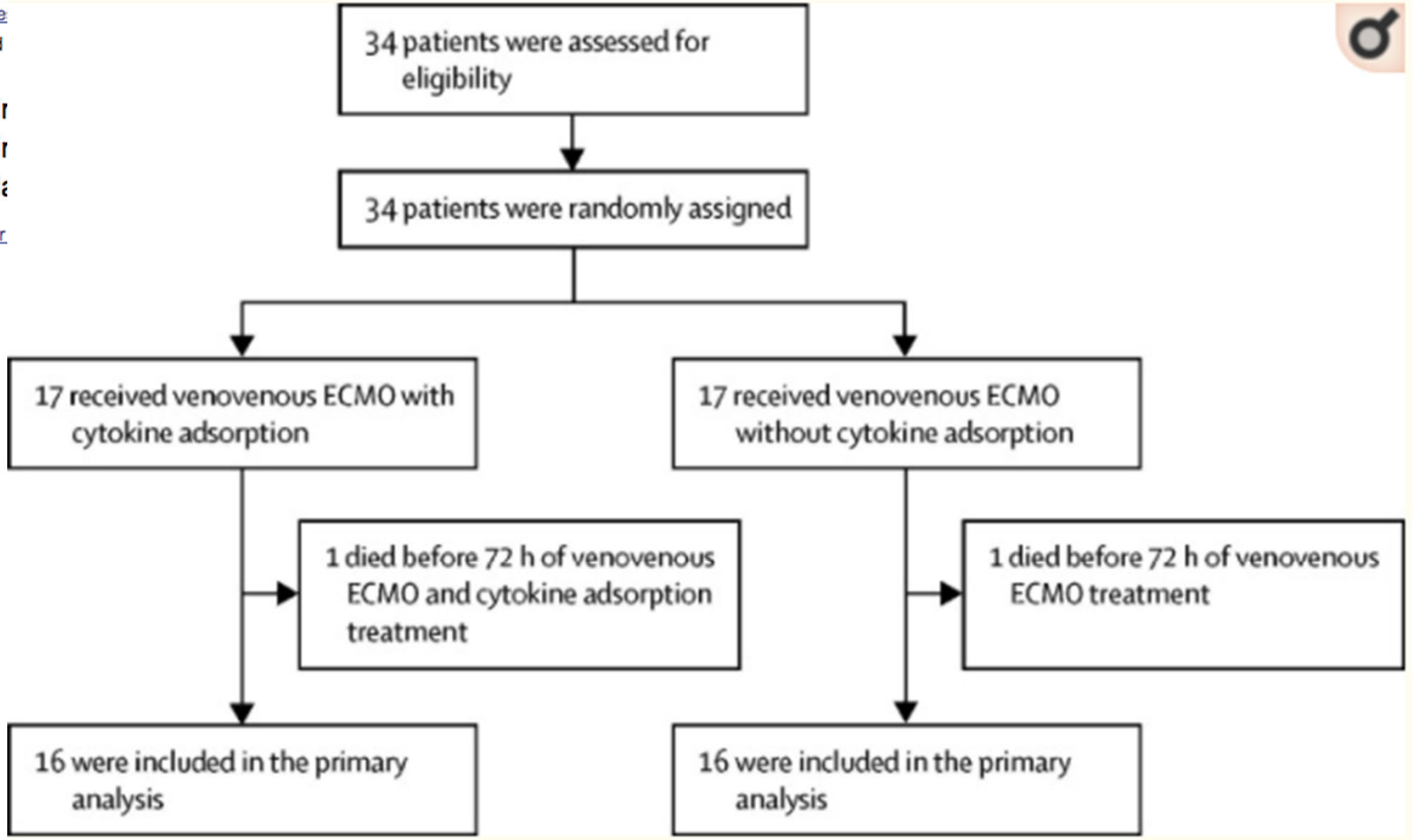

	Cytokine adsorption group (n=17)	Control group (n=17)
Age, years	62·0 (54·0–71·5)	59·0 (43·5–66·5)
Sex		
Female	5 (29%)	4 (24%)
Male	12 (71%)	13 (76%)
Body-mass index, kg/m²	29·41 (24·69–33·20)	29·68 (26·41–36·48)
Laboratory values		
Interleukin-6, pg/mL	357·0 (177·4–1186·0)	289·0 (84·7–787·0)
C-reactive protein, mg/L	254·9 (148·0–374·4)	169·3 (128·6–342·2)
Procalcitonin, ng/mL	0·73 (0·50–1·84)	1·34 (0·37–5·98)
Ferritin, ng/mL	2172·0 (883·5–3706·0)*	1489·0 (938·5–2543·0)
Leukocytes, $\times10^3$/μL	10·03 (8·22–19·92)	14·43 (8·40–16·48)
Neutrophils, $\times10^3$/μL	9·12 (6·59–14·84)*	11·86 (7·18–13·92)
Lymphocytes, $\times10^3$/μL	0·67 (0·44–1·15)*	0·59 (0·39–0·88)
Monocytes, $\times10^3$/μL	0·51 (0·20–0·98)*	0·46 (0·22–0·90)
Willebrand factor antigen, %	603·5 (458·5–642·5)†	399·0 (362·0–542·5)*
D-dimers, mg/L FEU	9·1 (4·5–21·0)*	4·7 (3·4–13·5)
Scores		
SOFA	9·0 (8·0–10·0)	9·0 (7·0–10·5)
RESP	1·0 (0·5–2·0)	1·0 (0–3·5)
PRESERVE	4·0 (3·0–5·0)	4·0 (2·0–6·0)
Comorbidities		
Hypertension	9 (53%)	7 (41%)
Diabetes	5 (29%)	3 (18%)
Coronary heart disease	3 (18%)	1 (6%)
Chronic lung disease	1 (6%)	3 (18%)
Liver cirrhosis	0	0
Haematological malignancy	1 (6%)	1 (6%)
Solid malignant tumour	0	0
Immunosuppressive therapy	1 (6%)	0
Active smoker	2 (12%)	1 (6%)
Any comorbidity	12 (71%)	10 (59%)
Pre-ECMO treatment		
Time from hospital admission to ECMO, days	6·0 (4·0–13·5)	8·0 (4·5–14·0)
Time from intensive care unit admission to ECMO, days	5·0 (2·5–11·5)	6·0 (4·0–14·0)
Duration of mechanical ventilation (including non-invasive and invasive	6·0 (3·5–12·0)	5·0 (2·0–14·0)

	Cytokine adsorption group (n=17)	Control group (n=17)
(Continued from previous page)		
Ventilation parameters		
FiO_2, %	100·0 (95·0–100·0)	100·0 (85·0–100·0)
Positive end-expiratory pressure, mbar	15·0 (14·0–17·0)	15·0 (12·5–18·0)
Peak pressure, mbar	34·0 (29·5–36·0)	32·0 (31·0–35·0)
Dynamic driving pressure, mbar	18·0 (15·0–20·0)	20·0 (14·0–20·0)
Tidal volume, mL	460·0 (354·0–576·5)	417·0 (334·3–479·5)*
Tidal volume, mL/kg	5·30 (3·90–6·25)	3·85 (2·95–4·83)*
Breathing rate, 1/min	25·0 (21·5–31·0)	25·0 (21·0–29·0)
Last blood-gas values pre-ECMO		
pH	7·34 (7·17–7·39)	7·28 (7·16–7·41)
PaO_2, mm Hg	57·3 (48·5–70·7)	75·1 (52·1–88·4)
$PaCO_2$, mm Hg	65·5 (42·5–80·1)	61·9 (55·1–73·8)
PaO_2/FiO_2, mm Hg	62·7 (48·5–72·7)	84·2 (59·9–95·6)
Plasma bicarbonate, mmol/L	25·3 (20·9–29·5)¶	24·6 (20·6–31·8)*
Arterial lactate, mmol/L	1·8 (1·2–2·3)	1·4 (0·9–1·8)
Pre-ECMO treatment		
Time from hospital admission to ECMO, days	6·0 (4·0–13·5)	8·0 (4·5–14·0)
Time from intensive care unit admission to ECMO, days	5·0 (2·5–11·5)	6·0 (4·0–14·0)
Duration of mechanical ventilation (including non-invasive and invasive ventilation) before ECMO, days	6·0 (3·5–12·0)	5·0 (2·0–14·0)
Duration of invasive ventilation before ECMO, days	5·0 (0·5–11·0)	4·0 (1·0–8·5)
Prone positioning	11 (65%)‡	12 (71%)
Renal replacement therapy	1 (6%)	0
Hydroxychloroquine	4 (24%)	5 (29%)
Lopinavir-ritonavir	3 (18%)	1 (6%)
Tocilizumab	2 (12%)	0
Remdesivir	5 (29%)	1 (6%)
Methylprednisolone	9 (53%)	10 (60%)§
Norepinephrine support, μg/kg per min	0·15 (0·04–0·22)	0·03 (0·00–0·36)

Cytokines

Lancet Respir Med. 2021 Jul; 9(7): 755–762. PMCID: PMC8121541

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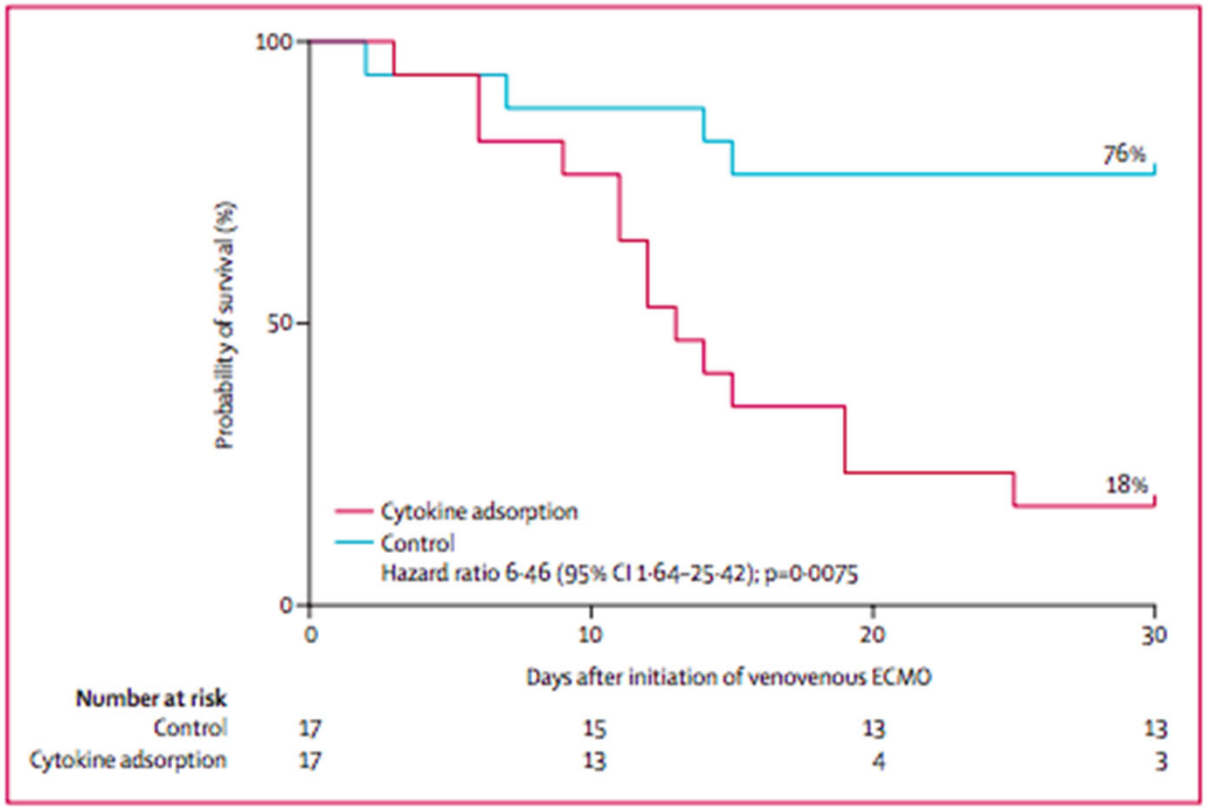
	Cytokine adsorption group (n=17)	Control group (n=17)	p value
Primary endpoint			
Serum interleukin-6 after 72 h	98·6 (71·0 to 192·8)*	112·0 (48·7 to 198·5)*	0·54†
Other endpoints			
30-day survival	3 (18%)	13 (76%)	0·0016‡
Discharged from intensive care unit until day 30	0	3 (18%)	0·23‡
Serum lactate after 72 h, mmol/L	1·35 (1·05–1·58)*	1·25 (0·93–1·85)*	0·80§
Willebrand factor antigen after 72 h, %	426·0 (396·0–501·0)¶	311·5 (287·8 to 405·8)*	0·021§
D-dimers after 72 h, mg/L FEU	8·77 (3·90 to 35·19)*	15·23 (5·79 to 34·23)*	0·48§
SOFA score after 24 h	7·0 (6·0 to 9·5)	8·0 (6·0 to 10·0)	0·59§
SOFA score after 48 h	8·0 (6·5 to 9·5)	8·0 (6·0 to 10·5)	0·95§
SOFA score after 72 h	7·5 (6·0 to 10·8)*	8·5 (6·0 to 10·0)*	0·81§
Norepinephrine support at 72 h, µg/kg per min‖	0·07 (0·03 to 0·13)*	0·00 (0·00 to 0·10)*	0·04§
Cumulative fluid balance for 72 h after initiation of ECMO, mL	2665·0 (663·5 to 5152·0)	2145·0 (−92·5 to 3002·0)	0·29§
Fluid substitution during the first 72 h after implementation of venovenous ECMO, mL	11 773 (8959 to 13 468)	8344 (7304 to 10 866)	0·0068§

Cytokines

Lancet Respir Med. 2021 Jul; 9(7): 755–762.
Published online 2021 May 14. doi: 10.1016/S2213-2600(21)00177-6
PMCID: PMC8121541
PMID: 34000236

Cytokine adsorption in patients with severe COVID-19 pneumonia requiring extracorporeal membrane oxygenation (CYCOV): a single centre, open-label, randomised, controlled trial

Alexander Supady, MD,[a,d,f,*]



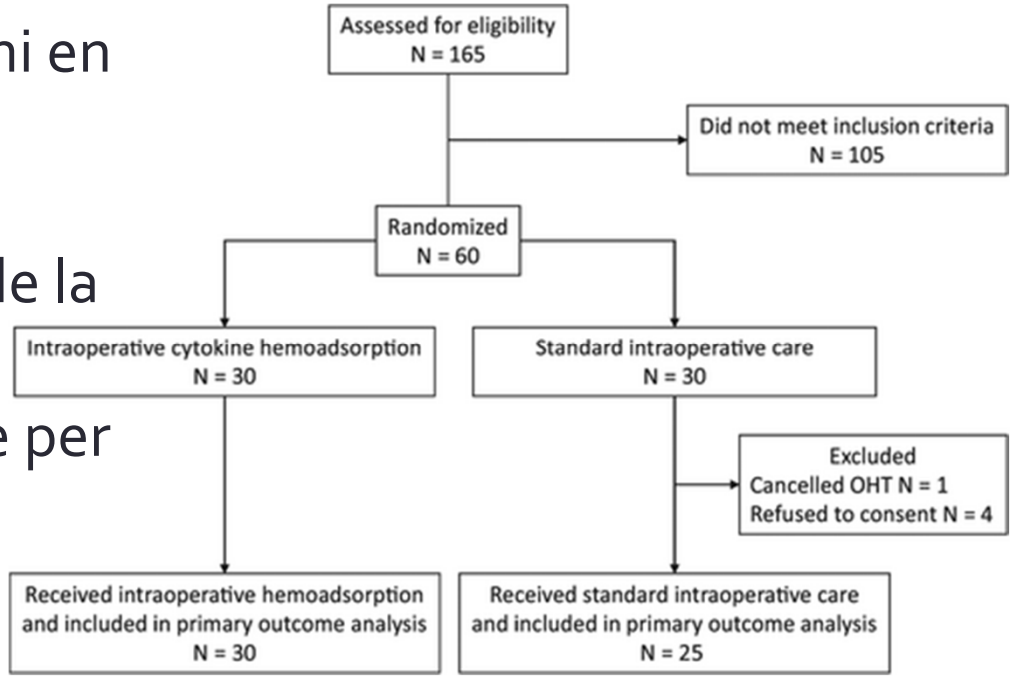
[redacted]

ESC Heart Fail. 2023 Dec 19. doi: 10.1002/ehf2.14632. Online ahead of print.

Use of intraoperative haemoadsorption in patients undergoing heart transplantation: a proof-of-concept randomized trial

Endre Nemeth [1 2], Adam Soltesz [1 2], Eniko Kovacs [1 2], Zsofia Szakal-Toth [1], Eszter Tamaska [1 2], Hajna Katona [1 2], Kristof Racz [1 2], Gergely Csikos [1 2], Viktor Berzsenyi [1 2], Szabolcs Fabry [1 2], Zsuzsanna Ulakcsai [1 2], Csilla Tamas [1], Beata Nagy [3], Marina Varga [4], Bela Merkely [1]

-Greffe « simple » (ni en choc ni en aigue ni redux)
-Cyrosorb VS standard, uniquement durant le temps de la CEC au bloc
-majoration anibioprophylaxie per op



[redacted]

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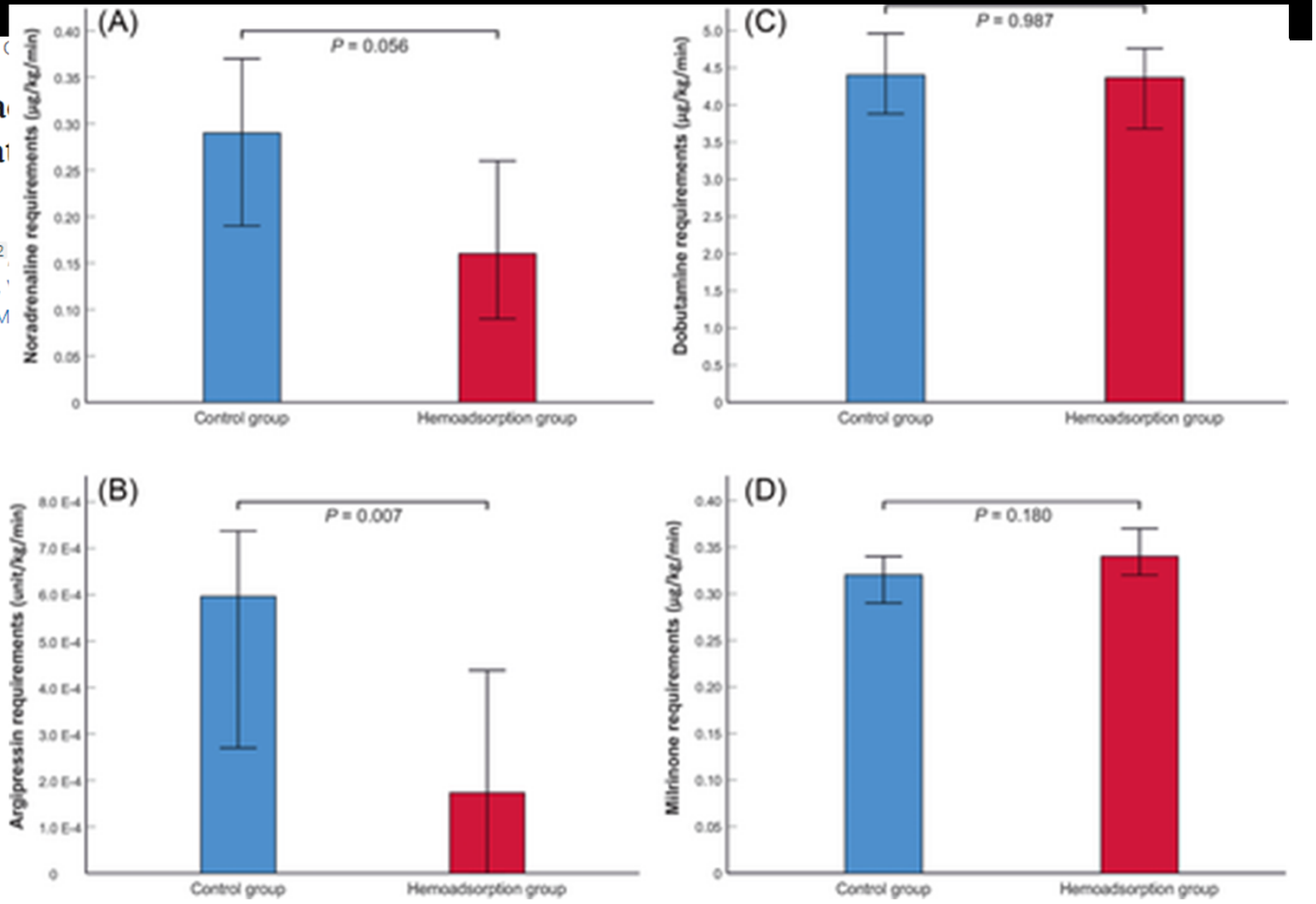
- Critère de jugement principal: vasoactive-inotropic score (VIS)
- Patients in the haemoadsorption group had significantly lower VIS than patients in the control group during the first post-operative 24 h (median VIS: 27.2 [14.6–47.7] vs. 41.9 [22.4–63.2], $P = 0.046$, respectively)

[redacted]

› ESC Heart Fail. 2023 Dec 19. doi: 10.1002/ehf2.14632. C

Use of intraoperative haemoa
undergoing heart transplanta
concept randomized trial

Endre Nemeth [1 2], Adam Soltesz [1 2], Eniko Kovacs [1 2],
Hajna Katona [1 2], Kristof Racz [1 2], Gergely Csikos [1 2],
Zsuzsanna Ulakcsai [1 2], Csilla Tamas [1], Beata Nagy [3], M



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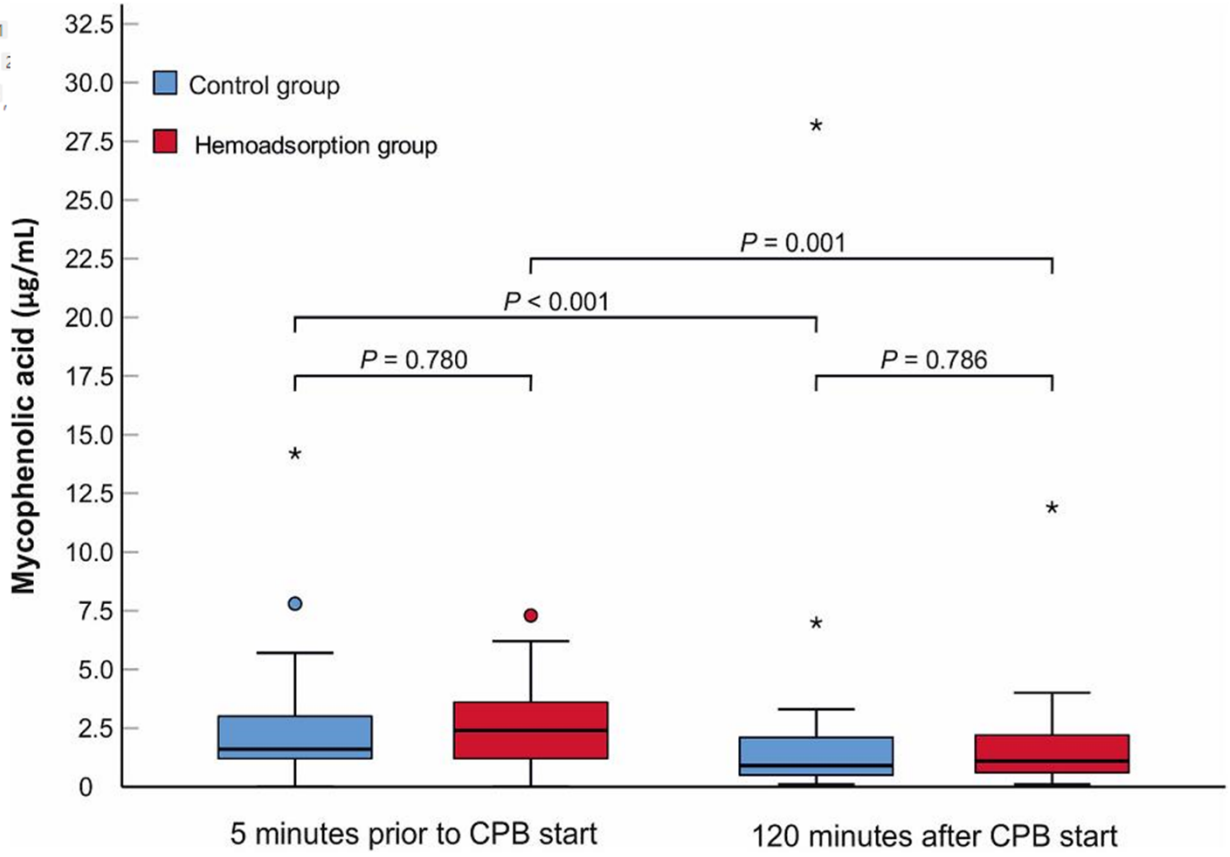

[redacted]

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able 3 Comparative analysis of secondary outcome parameters

arameters	Control group (N = 25)	Haemoadsorption group (N = 30)	P-valu
ost-cardiotomy ECMO, *n*	3 (12.0%)	0 (0%)	0.088
ost-operative bleeding, mL	570 [385–1305]	565 [350–1130]	0.543
eoperation for bleeding, *n*	2 (8.0%)	0 (0%)	0.202
RC/post-CPB 24 h, unit	4.0 [0–5.5]	2.0 [0–4.0]	0.243
FP/post-CPB 24 h, unit	2.0 [0–3.0]	2.0 [0–3.0]	0.571
LT/post-CPB 24 h, unit	12.0 [0–16.0]	12.0 [8.0–16.0]	0.597
ost-operative MV, h	65 [23–287]	25 [19–68.8]	0.025
cute kidney injury stage 1, *n*[a]	15 (60.0%)	9 (30.0%)	0.025
cute kidney injury stage 2, *n*[a]	0 (0%)	1 (3.3%)	1.00
cute kidney injury stage 3, *n*[a]	4 (16.0%)	1 (3.3%)	0.104
cute kidney injury$_{total}$, *n*	19 (76.0%)	11 (36.7%)	0.004
ost-operative RRT, *n*	4 (16.0%)	0 (0%)	0.037
er cent change in bilirubin, %	72.1 [11.2–191.4]	2.5 [−24.6–71.1]	0.009
arly sepsis, *n*[b]	1 (4.0%)	0 (0%)	0.455
ength of ICU stay, day	12 [8.5–18.0]	8.5 [8.0–10.3]	0.022
ength of hospital stay, day	28 [24–38.5]	25 [22–34.3]	0.232
)-day mortality, *n*	2 (8.0%)	0 (0%)	0.202
MB cellular rejection			
Post-transplant day 7, *n*	0 (0%)	0 (0%)	
Post-transplant day 14, *n*	5 (20.0%)	5 (16.7%)	1.00
Post-transplant day 21, *n*	5 (20.0%)	5 (16.7%)	1.00
Post-transplant day 28, *n*	6 (24.0%)	10 (33.3%)	0.448
MB antibody-mediated rejection			
Post-transplant day 7, *n*	1 (4.0%)	0 (0%)	0.455
Post-transplant day 14, *n*	1 (4.0%)	2 (6.7%)	1.00
Post-transplant day 21, *n*	1 (4.0%)	3 (10.0%)	0.617
Post-transplant day 28, *n*	2 (8.0%)	1 (3.3%)	0.585

ata are presented as number of patients (frequency) and median [interquartile range]. N = 55. Of 36 registered cellular rejections, 35
7.2%) were confirmed as grade 1R and 1 (2.8%) was confirmed as grade 2R (ISHLT 2005). The registered antibody mediated rejection
ere confirmed as pAMR 1I (ISHLT 2013).

CMO, extracorporeal membrane oxygenation; EMB, endomyocardial biopsy; FFP, fresh frozen plasma; ICU, intensive care unit; MV, me
anical ventilation; pAMR, pathologic antibody-mediated rejection; PLT, platelet transfusion; PRC, packed red cell; RRT, renal replace
ent therapy.

Acute kidney injury was classified according to Kidney Disease Improving Global Outcomes creatinine-based definition criteria over th
irst 5 post-operative days.

Adsorption médicament

Ann Thorac Surg. 2019 Jul;108(1):45-51. doi: 10.1016/j.athoracsur.2018.12.032. Epub 2019 Jan 23.

Cytosorb Adsorption During Emergency Cardiac Operations in Patients at High Risk of Bleeding.

Hassan K[1], Kannmacher J[2], Wohlmuth P[3], Budde U[4], Schmoeckel M[5], Geidel S[5].

55 patients avec CEC urgente traités par Ticagrelor ou Rivaroxaban
39 patients prospectifs traités par cytosorb VS 16 contrôles rétrospectifs

	CA Group		WA Group		
Variables	Ticagrelor (n = 32)	Rivaroxaban (n = 7)	Ticagrelor (n = 11)	Rivaroxaban (n = 5)	*p* Value
Desmopressin treated	21 (65.6)	4 (57.1)	11 (100)	5 (100)	0.4780
Rethoracotomy rate	0 (0)	0 (0)	4 (36.4)	2 (40)	0.0003
Drainage volume in 24 hours	350 (300–450)	390 (310–430)	890 (630–1,025)	600 (590–1,000)	0.0037
Intensive care, days	2 (1–3)	2 (2–3)	3 (2–4)	6 (5–6)	0.0141
Total length of stay, days	11 (9–12)	11 (10–13)	14 (10–16)	18 (18–20)	0.0244

Saignement, transfusion et reprises plus importantes dans groupe controle

Adsorption médicament

> Am Heart J. 2021 Nov 1;245:19-28. doi: 10.1016/j.ahj.2021.10.188. Online ahead of print.

Rationale and design of the safe and timely antithrombotic removal – ticagrelor (STAR-T) trial: A prospective, multi-center, double-blind, randomized controlled trial evaluating reductions in postoperative bleeding with intraoperative removal of ticagrelor by the drugsorb™-ATR device in patients undergoing cardiothoracic surgery within 48 hours from last ticagrelor dose

C Michael Gibson [1], Michael J Mack [2], Victoria T Lee [3], David J Schneider [4], Frank W Sellke [5], E Magnus Ohman [6], Vinod H Thourani [7], Gheorghe Doros [8], Hans Kroger [3], Donald E Cutlip [9], Efthymios N Deliargyris [3]

Adsorption antibiotiques

Ann Intensive Care. 2022; 12: 44.
Published online 2022 May 23. doi: 10.1186/s13613-022-01017-5
PMCID: PMC9124739
PMID: 35599248

Does the cytokine adsorber CytoSorb® reduce vancomycin exposure in critically ill patients with sepsis or septic shock? a prospective observational study

Christina Scharf,[1] Ferdinand Weinelt,[2,3] Ines Schroeder,[1] Michael Paal,[4] Michael Weigand,[4] Michael Zoller,[1] Michael Irlbeck,[1] Charlotte Kloft,[2] Josef Briegel,[1] and Uwe Liebchen[1,2]

Conclusion

Go to:

The use of CytoSorb® leads to a clinically significant adsorption of vancomycin (max. 572 mg) in critically ill patients with sepsis or septic shock. We recommend the administration of an additional dose of 500 mg vancomycin over 2 h to avoid subtherapeutic vancomycin exposure.

Conclusion hémoadsorption

- Technique récente
- Littérature encore faible pour bénéfice lié à l'imunomodulation, en chirurgie cardiaque et chez patients « médicaux », études randomisées discordantes
- Potentiellement intéressant sur adsorption ticagrelor et rivaroxaban (apixaban?)
- Adsorption de médicaments utiles?

Ventilation per CEC

Cours à venir

Insufflation de CO_2

Rationnel

-Remplacer l'air ambiant dans la cavité thoracique par du CO_2, +lourd + soluble dans le sang et + rapidement absorbé par les tissus.

-Vise à minimiser la présence de bulles d'air dans le sang susceptibles de provoquer des complications de type embolie gazeuse

Rationnel

J Thorac Cardiovasc Surg. 2006 Nov;132(5):1119-25.

Short-term changes in cerebral activity in on-pump and off-pump cardiac surgery defined by functional magnetic resonance imaging and their relationship to microembolization.

Abu-Omar Y[1], Cader S, Guerrieri Wolf L, Pigott D, Matthews PM, Taggart DP.

- 25 patient avec PAC CEC et 25 cœurs battant
- Association entre quantité d'emboles gazeux (doppler TC) et activation préfrontale à l'IRM fonctionnel à 1 mois

Rationnel

Circulation. 2004 Mar 9;109(9):1127-32. Epub 2004 Feb 23.

Effect of CO2 insufflation on the number and randomized clinical trial.

Svenarud P[1], Persson M, van der Linden J.

10 patients CO_2 VS 10 contrôles, detection micrembols par ETOau déclampage (lues en aveugle)

TABLE 2. No. of Microemboli According to Transesophageal Echocardiographic Evaluation of the Left Atrium and Ventricle and the Proximal Part of the Ascending Aorta

	No. of Microemboli		
Study Period/Area of Interest	Group Control (n=10)	Group CO_2 (n=10)	*P*
From release of cross-clamp until 20 minutes after end of CPB			
LA	340 (300/393)	69 (39/129)	<0.001
LV	254 (173/334)	68 (59/112)	<0.001
Ao	184 (155/244)	56 (19/78)	<0.001
LA+LV+Ao	723 (634/895)	161 (149/310)	<0.001
First 15 minutes after release of cross-clamp			
LA	224 (108/336)	36 (16/69)	<0.01
LV	131 (77/170)	43 (24/61)	<0.001
Ao	81 (71/111)	25 (11/33)	<0.001
LA+LV+Ao	414 (316/597)	101 (67/143)	<0.001
Last 10 minutes of CPB			
LA	72 (27/193)	17 (9/41)	<0.01
LV	50 (36/82)	21 (9/30)	<0.001
Ao	47 (30/87)	16 (5/26)	<0.01
LA+LV+Ao	179 (92/327)	66 (22/88)	<0.001
First 20 minutes after end of CPB			
LA	94 (40/141)	8 (4/32)	<0.01
LV	73 (14/175)	12 (2/33)	0.01
Ao	56 (16/105)	13 (1/19)	<0.01
LA+LV+Ao	221 (67/418)	32 (8/77)	<0.01

Values are given as median (25th/75th percentile). LA indicates left atrium; LV, left ventricle; and Ao, aorta.

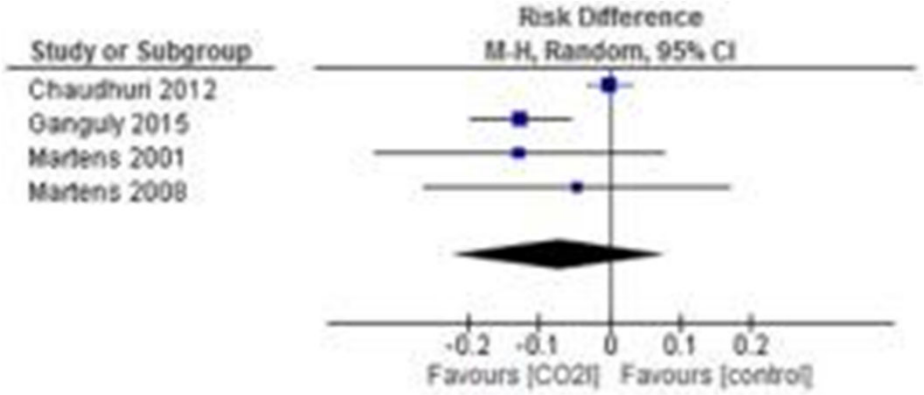
Littérature

Semin Thorac Cardiovasc Surg. 2017 Autumn;29(3):301-310. doi: 10.1053/j.semtcvs.2017.05.002. Epub 2017 May 23.

Carbon Dioxide Insufflation During Cardiac Surgery: A Meta-analysis of Randomized Controlled Trials.

Benedetto U[1], Caputo M[2], Guida G[2], Bucciarelli-Ducci C[2], Thai J[2], Bryan A[2], Angelini GD[2].

- 8 études à la méthodologie différentes+++
- Pas de différence sur le déclin cognitif



Direct visualization of carbon dioxide field flooding: Optical and concentration level comparison of diffusor effectiveness

Stijn Vandenberghe, PhD, David Iseli, BSc, and Stefanos Demertzis, MD

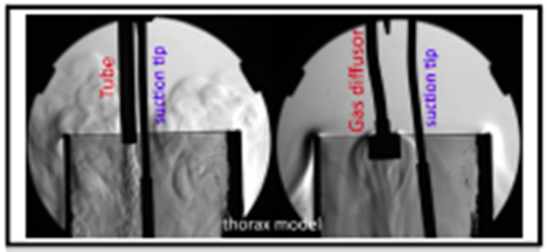
ABSTRACT

Objective: Carbon dioxide field flooding during open-heart surgery is intended to avoid blood-air contact, bubble formation, and embolism, and therefore potential neurologic and other ischemic complications. The inert gas is invisible, and thus its use and effectiveness are heavily debated. We intended to provide better insight in the behavior of the gas via direct concentration measurements and visualization of the gas cloud.

Methods: A transparent rectangular model of the open thorax was created, foreseen with carbon dioxide concentration sensors in 2 locations (atrial and aortic incisions), and placed in an optical test bench that amplifies the diffraction gradients. Six different commonly used carbon dioxide diffusors (3 commercial, 3 improvised) were tested with different flow rates of gas delivery (1, 4, 7, 10 standard liter per minute [SLPM]) and combined with the application of suction.

Results: The imaging reveals that commercially available diffusors generally create less turbulent flow than improvised diffusors, which is supported by the concentration measurements where improvised diffusors cannot generate a 100% carbon dioxide atmosphere at the aorta incision location. The atrial incision is easier to protect: 0% air with all commercial devices for all flow rates greater than 1 SLPM. A flow rate of 1 SLPM does not create an inert atmosphere with any device.

Conclusions: The optically observed carbon dioxide atmosphere is unstable and influenced by many factors. The device used for diffusion and the flow rate are important determinants of the maximum gas concentration that can be achieved, as is the location where this is measured. (J Thorac Cardiovasc Surg 2020;159:958-68)



CO_2 flow at 10 SLPM from an improvised delivery tube (L) versus a commercial diffusor (R).

Central Message

CO_2 field flooding is not well understood. We provided insight in diffusor effectiveness via visualization and concentration measurements and demonstrated an unstable CO_2 atmosphere.

Perspective

Many misunderstandings exist about CO_2 field flooding, mainly because the gas cannot be observed. This engineering study literally reveals the gas behavior, and the observations are corroborated by instantaneous concentration measurements. The reported findings should be mostly of interest to cardiac surgeons, who can easily improve cerebral protection of their next patient.

See Commentaries on pages 969 and 970.

Littérature

Randomized Controlled Trial > J Cardiovasc Surg (Torino). 2022 Jun;63(3):369-375.
doi: 10.23736/S0021-9509.22.12004-5. Epub 2022 Mar 28.

Warm humidified CO2 insufflation improves pericardial integrity for cardiac surgery: a randomized control study

Reny Segal [1 2], Paul M Mezzavia [1], Roni B Krieser [1], Shienny Sampurno [3], Michael Taylor [3], Robert Ramsay [2 3], Michael Kluger [1], Keat Lee [1 2], Francis L Loh [1], James Tatoulis [1 2], Michael O'Keefe [1 2], Yinwei Chen [1], Teresa Sindoni [1], Irene Ng [4 2]

Conclusions: Humidified warm CO<inf>2</inf> insufflation significantly reduced pericardial epithelial damage when compared to dry cold CO<inf>2</inf> insufflation in open-chamber cardiac surgery. Further studies are warranted to investigate its potential clinical benefits.

Littérature

BMJ Open. 2023; 13(5): e074221.
Published online 2023 May 17. doi: 10.1136/bmjopen-2023-074221
PMCID: PMC10193051
PMID: 37197819
Protocol

Efficacy and safety of carbon dioxide insufflation for brain protection for patients undergoing planned left-sided open heart valve surgery: protocol for a multicentre, placebo-controlled, blinded, randomised controlled trial (the CO2 Study)

Rachel Todd,[✉1] Chris A Rogers,[2] Maria Pufulete,[2] Lucy Culliford,[2] Pieter Pretorius,[3] Natalie Voets,[3] Enoch Akowuah,[4] Rana Sayeed,[5] Michelle Lazaroo,[2] Surinder Kaur,[1] Gianni D Angelini,[6,7] and Ben Gibbison[6,7]

Conclusion insufflation CO_2

-couramment utilisée pour réduire le risque d'embolie gazeuse

-preuves de son efficacité en termes de protection neurologique restent limitées.

-necessite une adaptation du balayage (pendant et apres)
-perturbe l'utilisation du CO_2 gap per CEC

Merci !