

la CEC mini-invasive (MiECC)

définition, principes et fonctionnement

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De quoi parle-t-on ?

MECC : Minimal Extra-Corporeal Circulation

MiECC : Minimal Invasive Extra-Corporeal Circulation

- Ce n'est pas une "petite CEC conventionnelle" C'est une CEC minimale

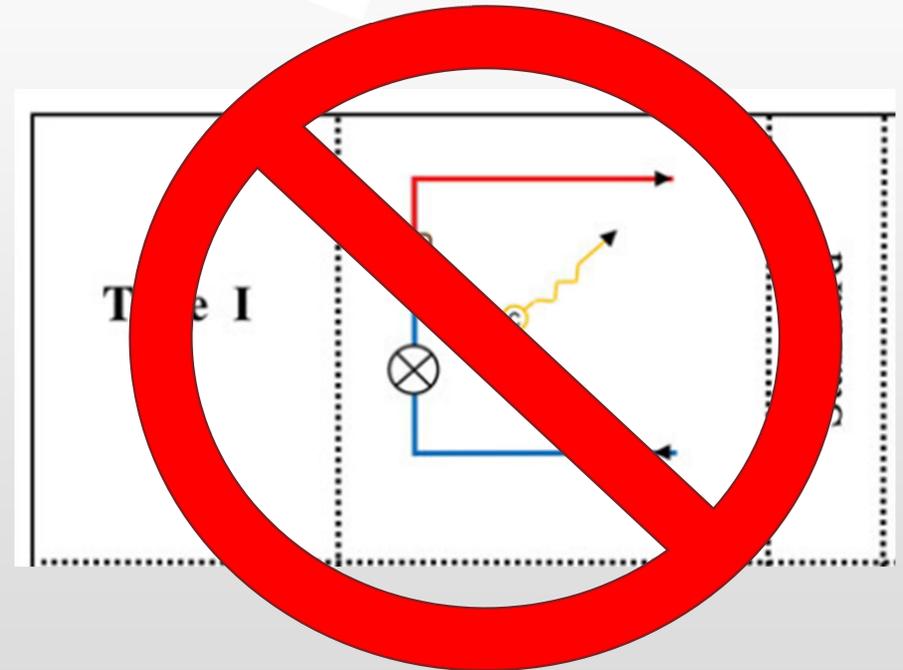
Grande hétérogénéité de circuits et de pratiques

2016 : Classification Société internationale des technologies extra-corporelles mini-invasives (MiECTiS) -> 4 Types

Type I : Standard



- Veine
 - Pompe centrifuge
 - Oxygénateur
 - Artère
 - Cardioplégie
- ECMO
+
Cardioplégie

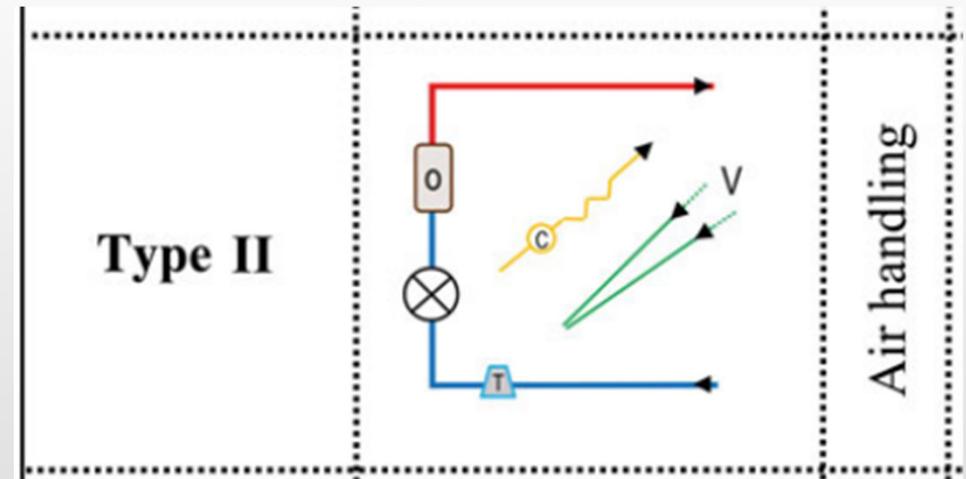


Problème de sécurité : pas de piège à air

MiECC type II



- Type I + gestion de l'air
- + Piège à bulle (veine) 
- + Aspiration racine aortique
- + Aspiration AP/veines pulmonaires

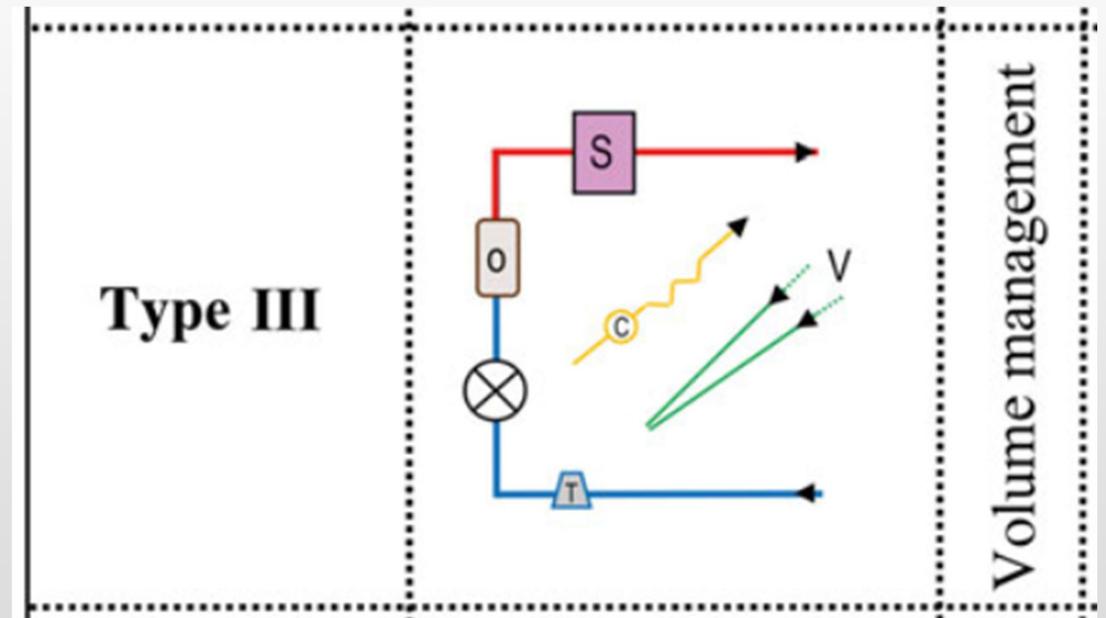


MiECC type III



- Type II + gestion du volume

+ réservoir souple



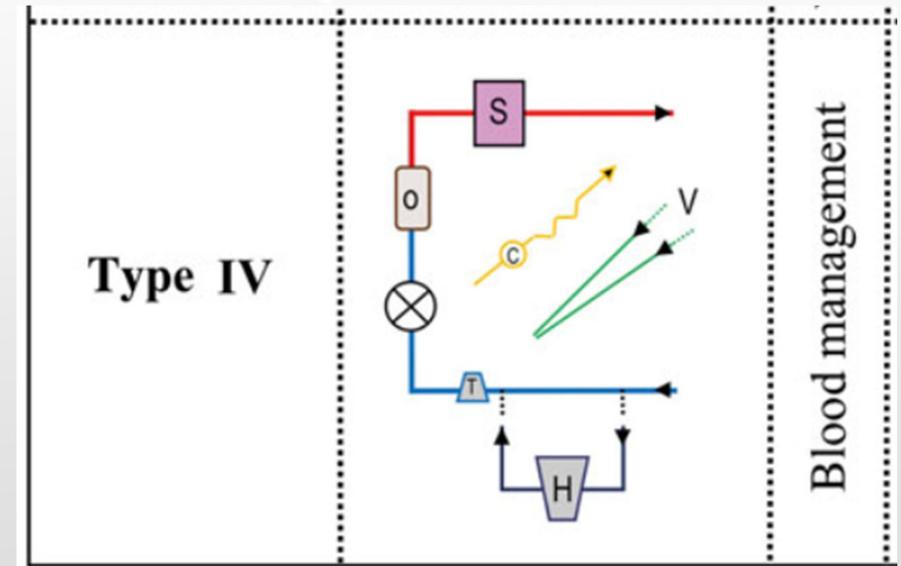
MiECC type IV



- Type III + gestion des complications

+ réservoir veineux rigide

-> conversion si problème

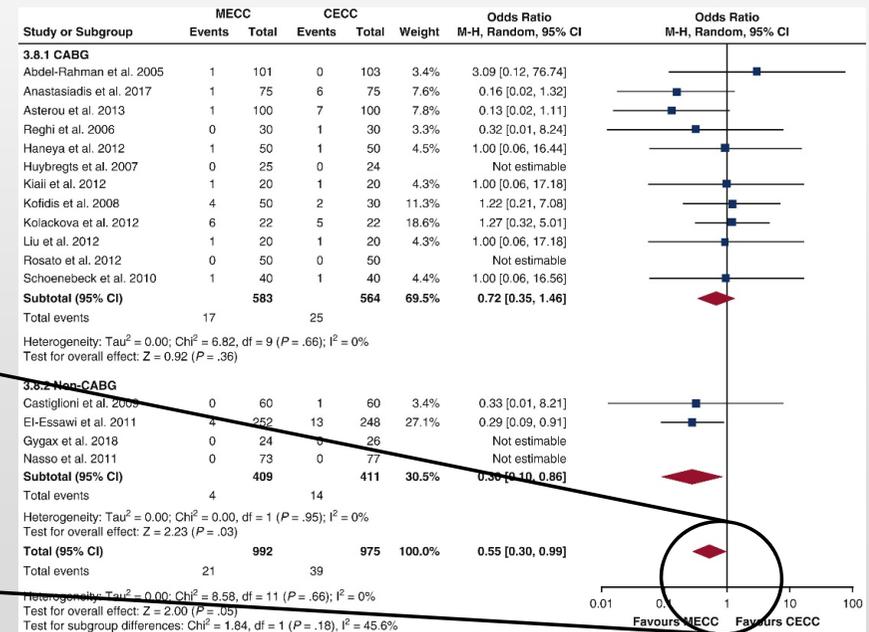
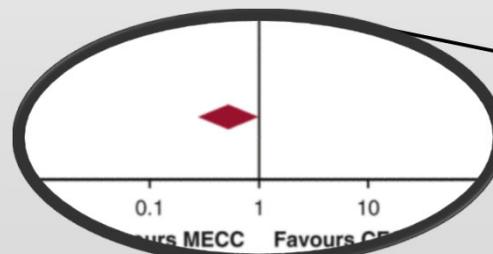


La MiECC dans la littérature

Méta analyse 42 études (2021)

4350 patients CECC vs MiECC

- Saignement post opératoire

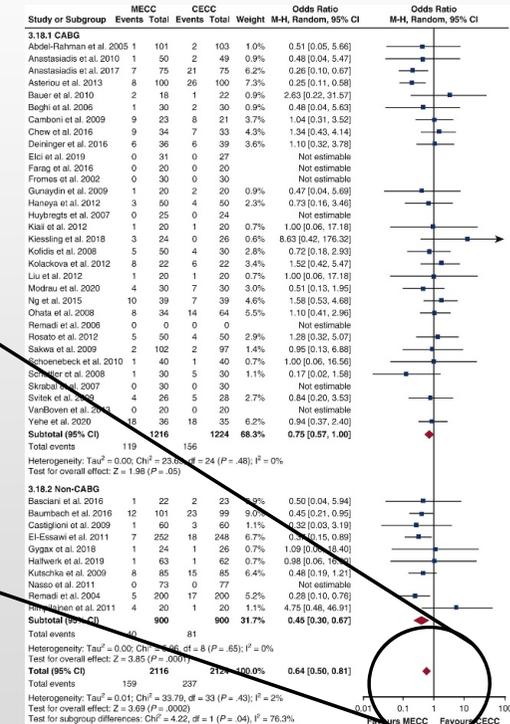
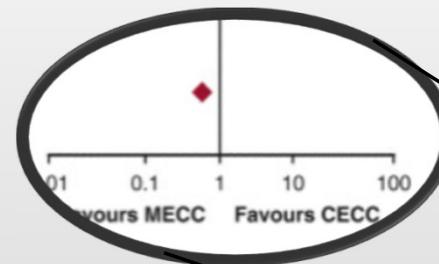


La MiECC dans la littérature

Méta analyse 42 études (2021)

4350 patients CECC vs MiECC

- FA post opératoire



La MiECC dans la littérature

Méta-analyse 24 études (2013)

2 770 patients MiECC vs CECC

- Diminution de la transfusion

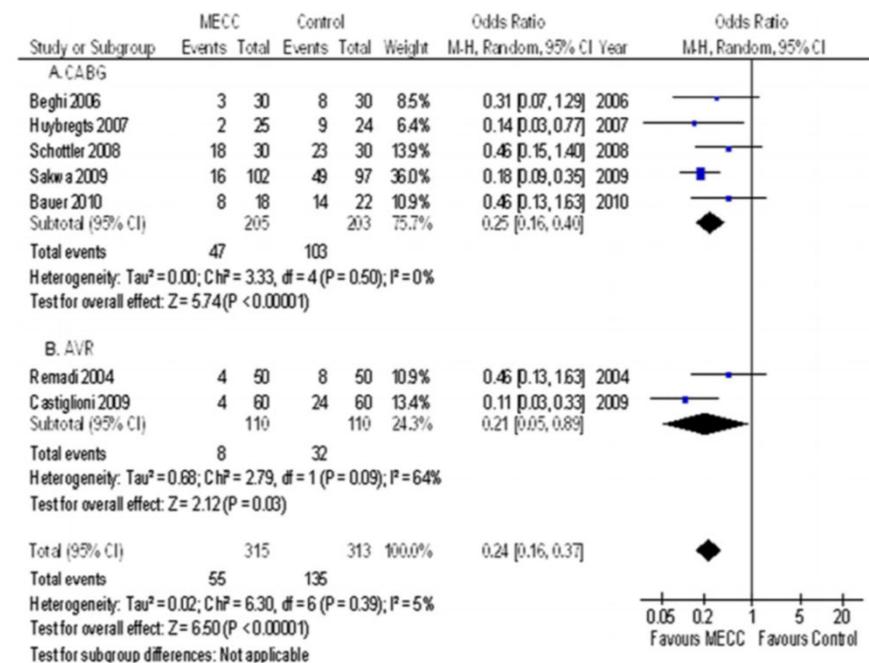


Fig. 4. Forest plot for risk of red blood cells transfusion comparing MECC vs. CECC (control) in (A) CABG procedures, (B) AVR procedures and total. AVR: Aortic Valve Replacement; CABG: Coronary Artery Bypass Grafting; CI: Confidence Interval; CECC: Conventional ExtraCorporeal Circulation; MECC: Minimal ExtraCorporeal Circulation.

La MiECC dans la littérature

- Diminution des inotropes

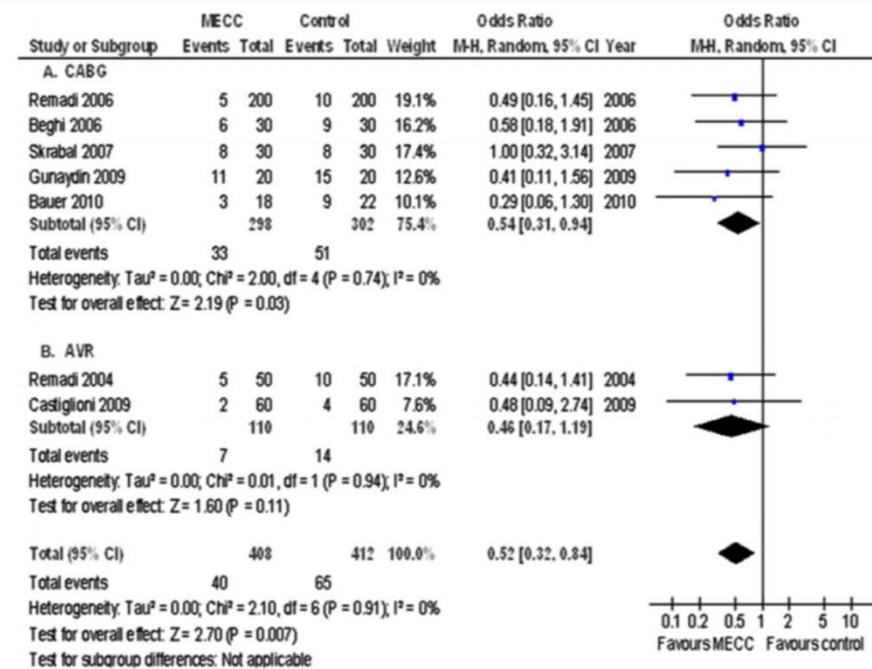


Fig. 6. Forest plot for need for inotropic support comparing MECC vs. CECC (control) in (A) CABG procedures, (B) AVR procedures and total. AVR: Aortic Valve Replacement; CABG: Coronary Artery Bypass Grafting; CI: Confidence Interval; CECC: Conventional ExtraCorporeal Circulation; MECC: Minimal ExtraCorporeal Circulation.

La MiECC dans la littérature

Pontages mortalité $p = 0,02$

- **MiECC 0,5 %**
- **CECC 1,7 %**

Anastasiadis et al.

Mortalité à 30 jours $p < 0,001$

- **MiECC 0,8 %**
- **CECC 2,7 %**

Merkle et al.

Mortalité 30 jours

- **MiECC 1,20 %**
- **Off pomp 1,94 %**
- **CECC 2,59 %**

Ried et al.



La MiECC dans la littérature



- Réduction de l'inflammation
Ranucci M et al, J Thorac Dis. 2019
- Diminution incidence FA post op.
Ranucci M, J Thorac Dis. 2019
- Réduction des besoins transfusionnels
Anastasiadis K et al, Interact Cardiovasc Thorac Surg. 2016
- Diminution de la durée de séjour
Anastasiadis K et al, Interact Cardiovasc Thorac Surg. 2016

- Moins d'hémodilution
Gunaydin S et al, Perfusion. 2009
- Moins de complications neurologiques
Zangrillo A et al, Thorac Cardiovasc Surg. 2010
- Diminution du pic de Troponine
Zangrillo A et al, Thorac Cardiovasc Surg. 2010
- ...

La MiECC dans la littérature



- Réduction de l'inflammation

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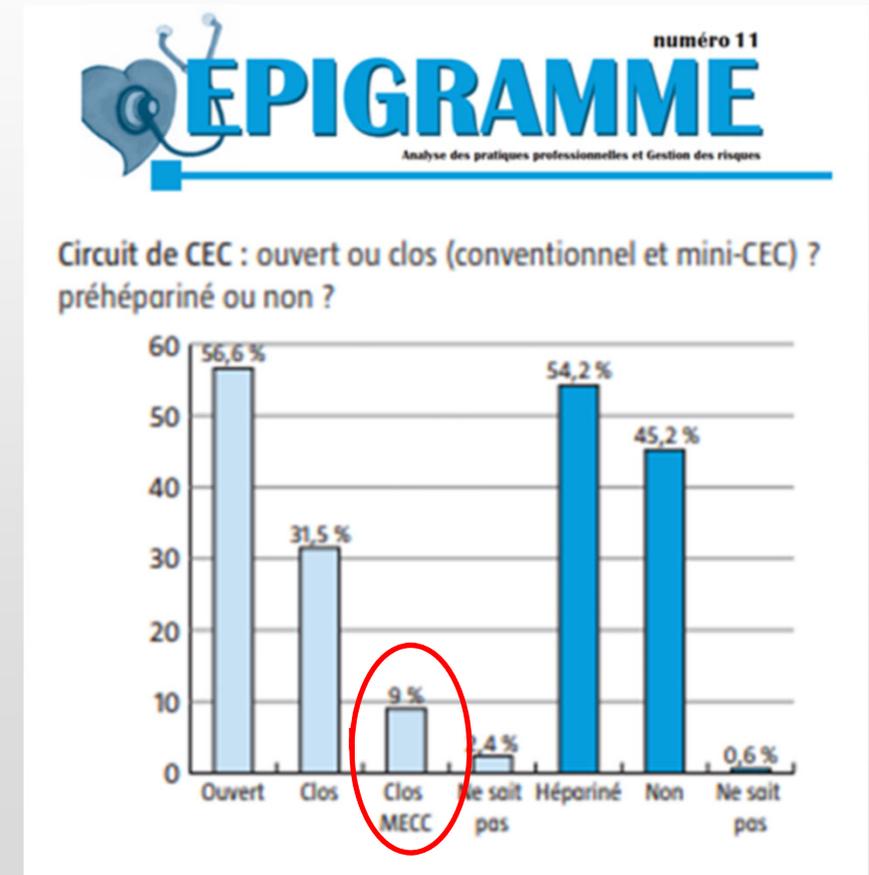
- ...

Pas d'étude en défaveur de la MiECC

Et dans les blocs ?

Enquête 2014 :

- 166 questionnaires analysés
- 9% des CEC sont des MiECC



Qui utilise la MiECC ?

Annuaire des pratiques 2016 :

- 50 centres de chirurgie cardiaque
- 15 centres utilisent la MiECC



En 2022



SOCIÉTÉ FRANÇAISE DE CHIRURGIE THORACIQUE ET CARDIO-VASCULAIRE
ANESTHÉSIE RÉANIMATION CŒUR-THORAX-VAISSEAUX

SOCIÉTÉ FRANÇAISE D'ASSISTANCE CIRCULATOIRE ET DE CIRCULATION EXTRA-CORPORELLE

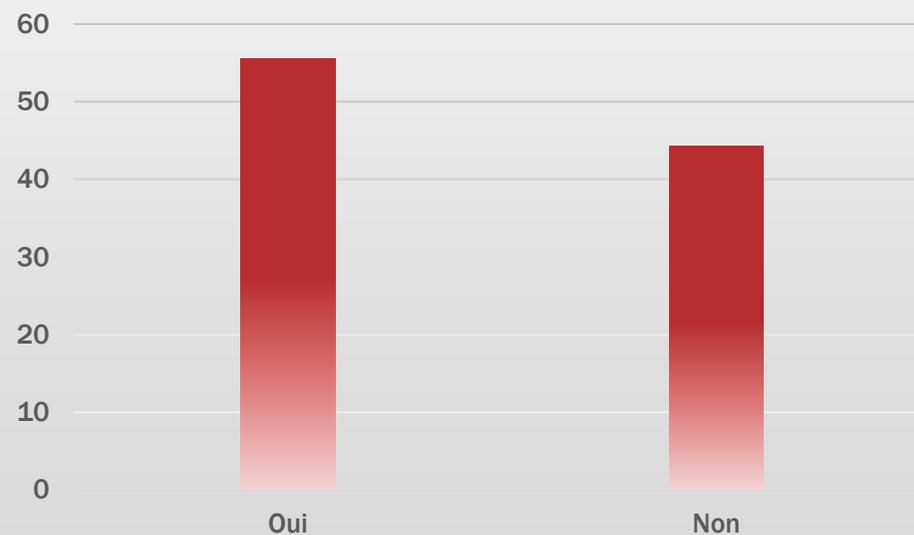
Groupes de Travail Circulation Extra Corporelle

CEC optimisée (79 centres)

Oui - 55,6%

Non - 44,3%

CENTRES UTILISANT DES CEC OPTIMISÉES



Pourquoi si peu de MiECC ?

La sécurité

- Gestion de l'air
- Gestion des accidents de canulation
- Complexité du montage

Facteurs humains

- Changement d'habitude
- Formation
- Courbe d'apprentissage

La sécurité

La sécurité

Analyse d'études impliquant des problèmes de sécurité pendant une MiECC. (2021)

Problème type I et II

✓ L'AIR

Problème type III

✓ gestion des saignements

✓ gestion dissection site canulation Ao

Problème type IV

✓ Conversion sans conséquence clinique

Table 4. Qualitative analysis of studies implicating safety issues during surgery on MiECC.

Author	Year	Type of study	Procedures/patients	MiECC type	Safety issue/outcome
Nollert et al. ⁹	2005	RCT	CABG 15 MiECC/15 cCPB	I	Air entrainment in two patients (one from the RA and one from inadvertent opening of the RV). Resolved without any clinical consequences. Premature discontinuation of the study due to safety concerns.
Kiss et al. ¹⁷	2005	Expert opinion	CABG Not reported	I	Skepticism on air handling with type I MiECC and capability of delivering high circulatory flow (>7 L/min) for obese patients.
Ti et al. ¹⁸	2008	Retrospective, matched cohorts	CABG, AVR, MVR 60 MiECC/60 cCPB	III	Low indexed flows with MiECC (<1.7 L/min/m ²). No difference in clinical outcome.
Fernandes et al. ¹⁹	2009	Retrospective cohort study	MIMVS 34 MiECC	II	Air entrainment in two patients with undiagnosed ASDs removed successfully with venous air removing device. No clinical consequences.
Roosenhoff et al. ²⁰	2010	RCT	CABG 12 MiECC type II/ 11 MiECC type I	I and II	Integration of a venous bubble trap significantly reduced gaseous microemboli. Study discontinued.
Stehouwer et al. ²¹	2011	RCT	CABG 10 MiECC (Ox+AFJ)/ 10 MiECC (Ox)	II	Incident of massive air entrainment through the venous line in one patient evacuated through the venous bubble trap. No clinical complications.
Modrau et al. ²²	2020	RCT	CABG 30 MiECC/30 cCPB	III	Incidence of air entrainment into the venous line in three patients evacuated with venous air removing device. No clinical consequence.
Modular MiECC El-Essawi et al. ²³	2011	RCT	CABG + AVR 252 MiECC/248 cCPB	IV	Conversion to open in one patient due to tear in RA. No clinical consequences.
Ganushchak et al. ²⁴	2012	Cohort study	CABG 15 MiECC/12 cCPB	I and II with hard-shell standing-by	Sub-atmospheric fluctuations of venous line pressure are related to gaseous microemboli.
Anastasiadis et al. ¹²	2015	Cohort study	All types (emergency and re-operations included) 50 patients	IV	Conversion to open in 2/50 patients (1 due to air entrainment and one due to uncontrolled bleeding). No clinical consequences.
El-Essawi et al. ⁸	2017	Prospective cohort study	All types (emergency and re-operations included—circulatory arrest excluded) 100 patients	IV	Conversion to open in one patient due to tear in RA. No clinical consequences.
Antonitsis et al. ²⁵	2018	Cohort study	All types (emergency and re-operations included) 200 patients	IV	Conversion to open in 6/194 patients—excluding aortic dissection (4 due to air entrainment, one due to uncontrolled bleeding and one due to inadequate venous return). No clinical consequences.
Liebold and Albrecht ²⁶	2019	Cohort study	Non-CABG (excluding mitral surgery) 48 patients	IV	Conversion to open in 4/48 patients. No clinical consequences.
El-Essawi et al. ¹⁷	2020	Retrospective matched cohort study (octogenarians)	AVR 81 MiECC/142 TAVR	IV	No need for conversion to an open circuit reported.

AF: arterial filter; AVR: aortic valve replacement; CABG: coronary artery bypass grafting; cCPB: conventional cardiopulmonary bypass; MiECC: minimal invasive extracorporeal circulation; MIMVS: minimal invasive mitral valve surgery; MVR: mitral valve replacement; Ox: oxygenator; RA: right atrium; RV: right ventricle; TAVR: transcatheter aortic valve replacement.

La sécurité

Revue de la littérature (2019)

- Mortalité
- AVC
- Tropo
- Hospitalisation
- Inflammation

Type II et III

MiECC modulaire (IV)
dans chirurgie complexe

Table 1 Studies focusing on non-coronary MiECC

Author, (reference)	Patients, (surgery), study type	MiECC type	Main outcome
Remadi 2004 (18)	100 (AVR) RCT	Type II	MiECC: reduced CRP, troponin I and neurologic events; no differences in blood loss and transfusion
Bical 2006 (19)	40 (AVR) RCT	Type II	MiECC: reduced TNF- α and neutrophil elastase, no differences in clinical parameters
Castiglioni 2007 (20)	40 (AVR) RCT	Type II	MiECC: reduced blood loss, transfusion; higher hematocrit, longer hospital stays
Castiglioni 2009 (21)	120 (AVR) RCT	Type II	MiECC: reduced blood loss, transfusion, myocardial damage; no differences in mortality, stroke, hospital stay
Colli 2009 (22)	128 (AVR) RCT	Type III	No differences in blood loss, transfusion, mortality, renal injury, atrial fibrillation, stroke, ICU and hospital stay
Yilmaz 2009 (23)	50 (mini-AVR) observational	Type II	Feasibility of MiECC in minimal access AVR; no conversion to full sternotomy, low transfusion rate
Ariyaratnam 2018 (24)	187 (AVR, MVR) retrospective, matched pairs	Type III	MiECC: longer bypass- and cross-clamp times; higher rate of atrial fibrillation; reduced transfusion rate; higher 5-year survival
Momin 2013 (25)	49 (major aortic surgery) observational	Type III	MiECC: feasible in complex aortic surgery; no differences to CPB in perioperative mortality, blood consumption, renal or neurological complications
Anastasiadis 2011 (26)	3 (LVAD implant) observational	Type II	Feasibility of MiECC in LVAD implantation
Gygax 2018 (27)	50 (AVR) RCT	Type II	No difference in inflammation, complement or coagulation activation; similar clinical outcome
Basciani 2016 (28)	48 (AVR) RCT	Type II	MiECC: increased incidence of gaseous microemboli in transcranial Doppler
EI-Essawi 2010 (29)	291 (AVR + CABG) RCT	Type IV	MiECC: lower blood transfusion; reduced rate of atrial fibrillation; no difference in mortality, stroke, myocardial infarction, ICU and hospital stay
EI-Essawi 2018 (30)	104 (AVR) matched pairs	Type IV	MiECC: lower 90-day mortality in octogenarians
Anastasiadis 2015 (31)	50 (AVR, MVR) cohort study	Type IV	Feasibility of modular MiECC in complex cardiac surgery; low overall mortality

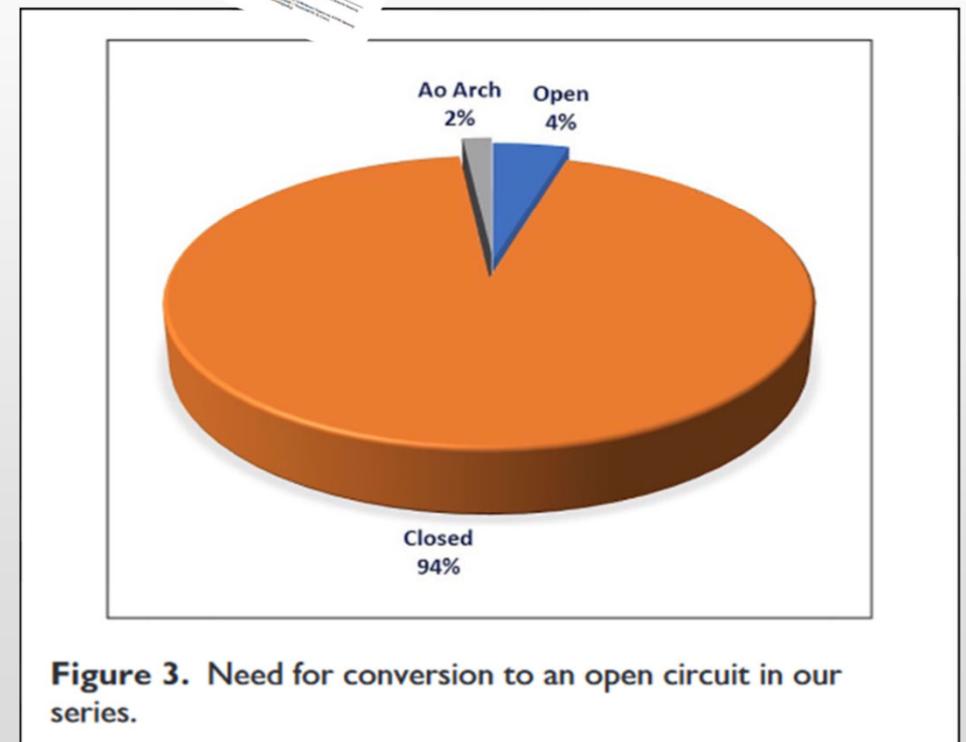
MiECC, minimally invasive extracorporeal circulation; AVR, aortic valve replacement; MVR, mitral valve replacement; CABG, coronary artery bypass grafting; LVAD, left ventricular assist device; RCT, randomized controlled trial; ICU, intensive care unit.

La sécurité

Étude rétrospective (2021) 403 patients

MiECC :

- Taux de conversion 4,5 %
- Motif conversion : air ligne veineuse
 - ✓ 28% réinterventions
 - ✓ 40 % mitrale ou cœur droit



Les facteurs humains



"ça fait 20 ans qu'on fait comme ça ..."

Beaucoup de monde

Technique exigeante

- **Point de vue du chirurgien**
 - **Point de vue de l'anesthésiste**
 - **Point de vue du perfusionniste**

Point de vue du chirurgien

Role of surgeon

The surgeon, as previously described, represents the major stakeholder of the surgical team in cardiac OR. When it comes to MICS on MiECC both techniques demand delicate surgical maneuvers. In this setting, it is of utmost importance for the surgeon not only to comprehend perfusion technology, but to deeply understand MiECC unique characteristics and its differences from cCPB, in order to **adapt surgical technique** to the special requirements of MiECC perfusion (23). **Special care must be taken to secure “air tightness”** during cannulation at all sites. The surgeon should primarily appreciate that when operating on MiECC shed blood does not recirculate into the closed system and it is literally “wasted” from patient’s intravascular compartment. **Continuous communication** with the perfusionist and the anesthesiologist is critical for

Review Article on Minimally Invasive Cardiac Surgery

From less invasive to minimal invasive extracorporeal circulation

Kyriakos Anastasiadis[^], Polychronis Antonitsis[^], Apostolos Deliopoulos, Helena Argiriadou

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Contributions: (I) Conception and design: K Anastasiadis; (II) Administrative support: P Antonitsis, H Argiriadou; (III) Provision of study materials or patients: H Argiriadou, A Deliopoulos; (IV) Collection and assembly of data: K Anastasiadis, P Antonitsis; (V) Data analysis and interpretation: KAnastasiadis, H Argiriadou, P Antonitsis; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Email: antonits@auth.gr.

- **Adapter** la technique chirurgicale aux exigences de la MiECC
- **Précautions particulières** pour la gestion de l'air
- **Communication continue** avec le perfusionniste et l'anesthésiste
- Evaluation prés-opératoire des patients

Point de vue de l'anesthésiste

Role of anesthesiologist

The anesthesiologist plays a significant role, as integration of the anesthetic strategy into a multidisciplinary perioperative MICS on MiECC strategy secures a unanimous and discrete plan for managing the patient. For this reason, it is considered mandatory to **acquire advanced knowledge on MiECC** perfusion technology (24). The closed MiECC circuit mandates judicious use of fluids, so as to eliminate hemodilution. A thorough monitoring strategy for securing body's homeostasis and preventing derangements is important for a smooth perioperative course. MICS on MiECC creates conditions for fast-track (25) or ultra-fast-track extubation management due to minimal perioperative surgical trauma (26,27). Thus, an anesthetic strategy based on short-acting intravenous drugs, like propofol and remifentanyl is recommended. A contemporary Point-of-Care (POC) heparin/protamine coagulation management in the OR includes thromboelastometry. platelets function

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Email: antonits@auth.gr.

- **Connaissances avancées obligatoires sur la MiECC**
- **Changement d'habitude :**
 - ACT plus court
 - Titration individualisée héparine/protamine

Point de vue du perfusionniste

The classification of MiECC circuits provides a clear definition of the different systems, and also give a clear distinction between conventional ECC und MiECC. MiECC presents a physiologically based perfusion strategy, not just another CPB circuit or a particular product. For this reason, a multidisciplinary approach is **mandatory**. **Close collaboration** between surgeons, anaesthesiologists and perfusionists is of **paramount importance** for the safe and efficient application of MiECC concepts (6).

Perspective

From minimal invasive extracorporeal circulation type I to type III: the perfusionist's view

Hansjoerg Jenni¹, Paul Philipp Heinisch¹, Balthasar Eberle², Fabian Gisler¹, Alexander Kadner¹, Thierry Carrel¹

- Approche multidisciplinaire obligatoire
- Formation spécifique
- Collaboration **étroite** d'une **importance primordiale**

Chirurgiens / anesthésistes / perfusionnistes

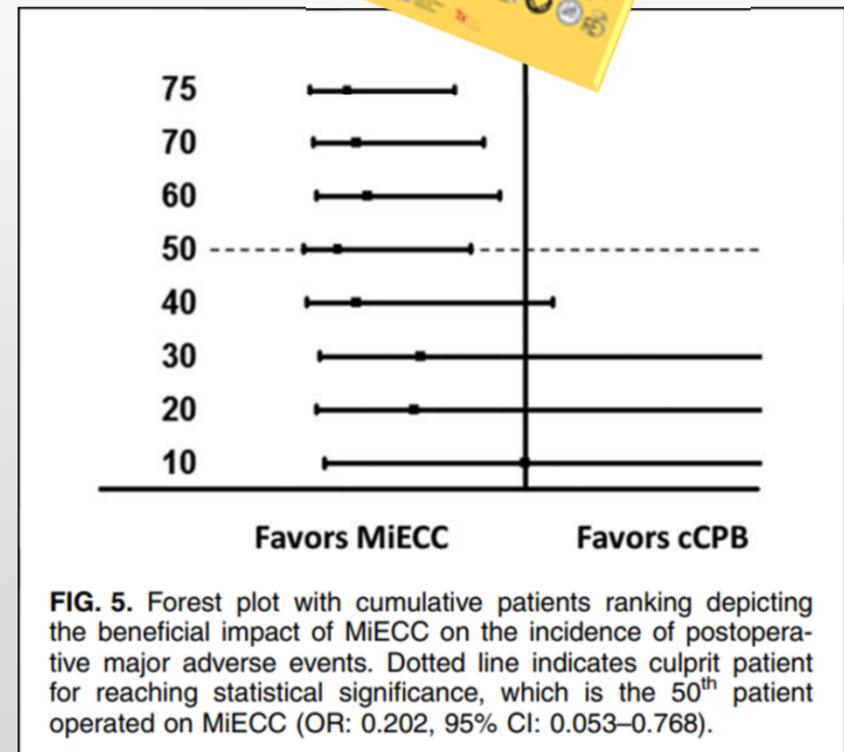
Courbe d'apprentissage



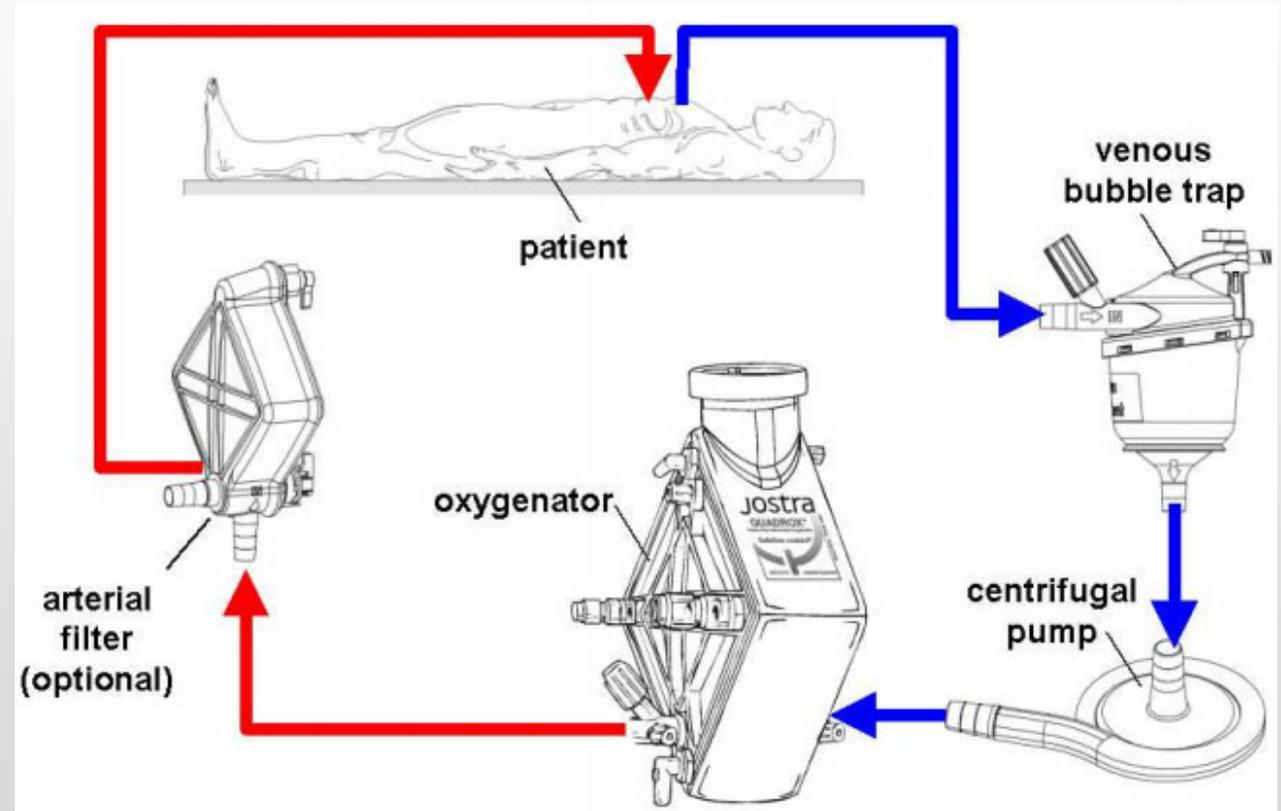
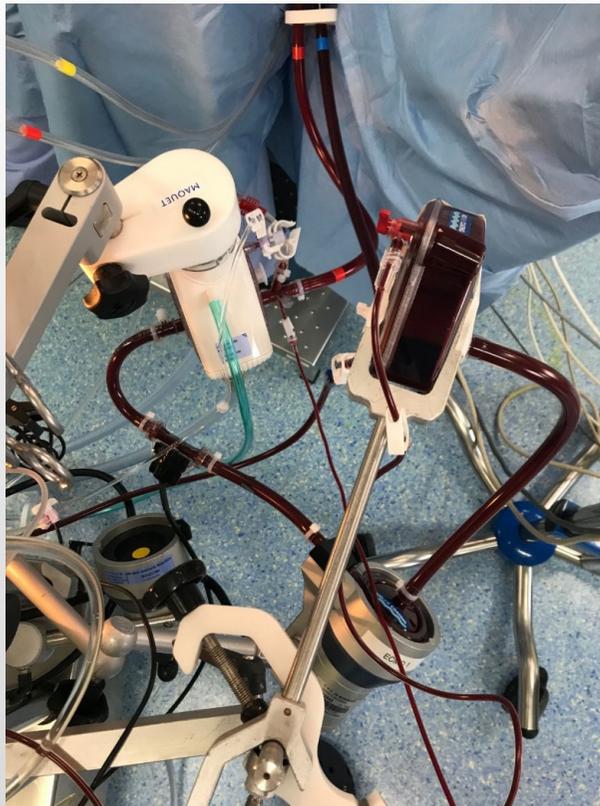
Pontages coronariens (2017) :

Critères de jugement :

- Besoins transfusionnels
- Taux d'hémoglobine
 - Même équipe
 - 50 patients consécutifs



Gestion de la MiECC



Gestion de la MiECC

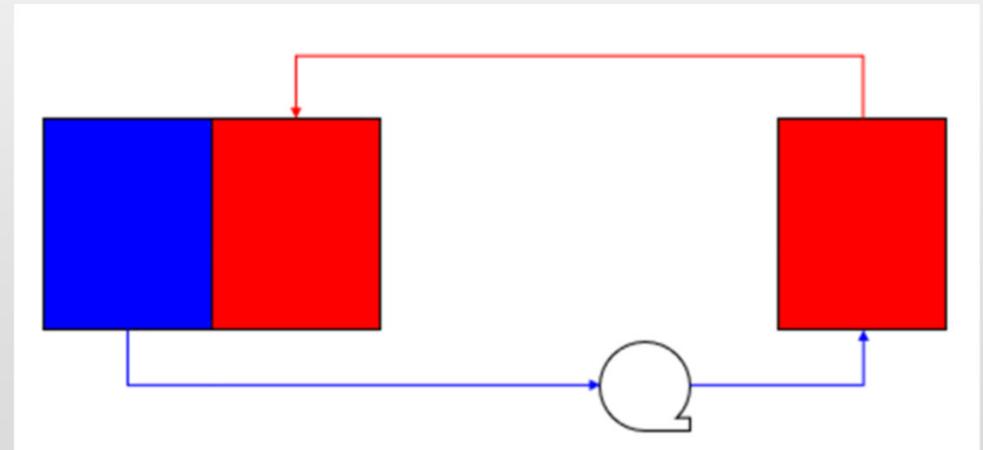
Adéquation entre le sang drainé et le volume réinjecté

→ Maintien d'une précharge normale à élevée avant la CEC

↓ retour veineux = ↓ débit de pompe

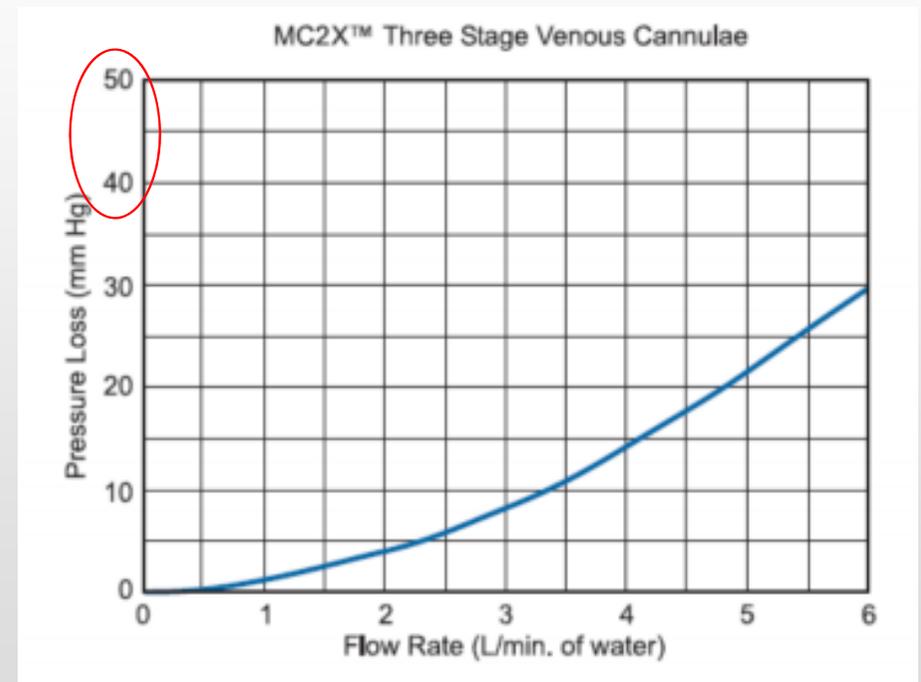
↑ retour veineux = ↑ débit pompe

ou « vase d'expansion »



Drainage veineux actif

- Par pompe centrifuge
 - Shunt 3/8 – 3/8
 - Canule veineuse plus petite



En pratique...

- Conduite facilitée

oui mais :

L'absence de réservoir de compliance entre le malade et la CEC rend la prise en charge plus délicate

Surtout si :

- Retour gauche important
- Bolus itératifs de vasopresseurs
- Gène du drainage veineux
(luxation, position des canules)

MiECC le circuit mais pas que...

Société internationale des technologies extra-corporelles mini-invasives (MiECTiS)

- "La MiECC fait référence à une **stratégie combinée** d'approche **chirurgicale**, gestion **anesthésique**, de **perfusion** et ne doit pas être limitée au seul circuit de CEC."

Recommandations



MiECC le circuit mais pas que...

*Société internationale des technologies extra-corporelles mini-invasives
(MiECTiS)*

Recommandations

- Biocompatibilité
- Température de perfusion
- Gestion anticoagulation
- Gestion de l'anesthésie
- Gestion chirurgicale

Bio compatibilité

Revêtement BIOLINE® (Maquet) : Albumine + Héparine

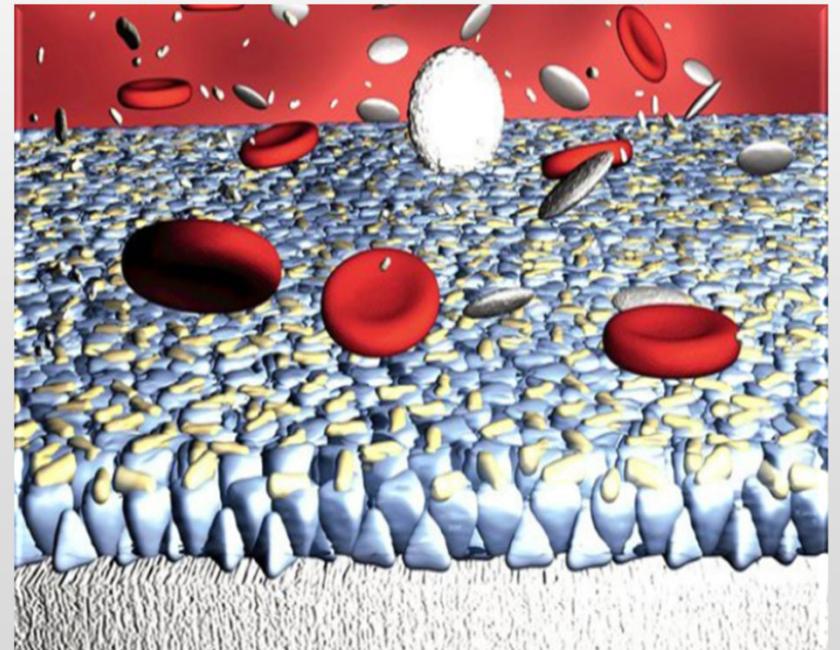
Limite l'activation de la coagulation

Diminue l'intensité de la réaction inflammatoire

Réduit l'adhésion plaquettaire

Limite la création de thrombus

Diminue les complications neurologiques



Température de perfusion



Mild hypothermia versus normothermia in patients undergoing cardiac surgery

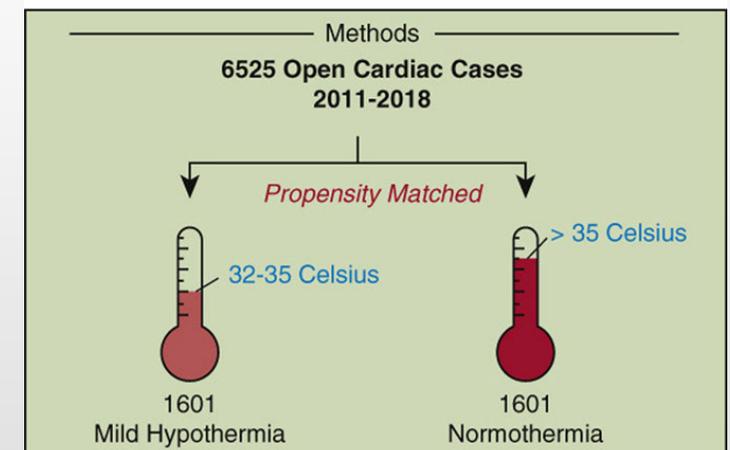
Normothermie :

- Moins d'insuffisance rénale aiguë ($p = 0,03$)
- Moins heures d'unité de soins intensifs ($p = 0,04$)

Aucune différence sur :

- l'AVC postopératoire ($p = 1,0$)
- La mortalité à 30 j ($p = 0,8$)
- La mortalité à long terme ($p = 1,0$)

Mild Hypothermia versus Normothermia in Patients Undergoing Cardiac Surgery



Results

Mortality	Complications
30-Day 2.6% vs 2.4% ($P = .8$)	Acute Renal Failure 3.7% vs 2.4% ($P = .03$)
Long-Term 18.1% vs 18.1% ($P = 1.0$)	ICU Stay Hours 46.5 vs 45.1 ($P = .04$)

Patients receiving mild hypothermia, while having **increased** postoperative complications, had **similar** long term mortality

Température de perfusion



Essai clinique prospectif randomisé, contrôlé en double insu (2020) n= 86

Hypothermie :

- Augmente temps d'intervention

- Augmente le saignement

péri opératoire

- Augmente la transfusion

Table 2 Operative and immediate postoperative data of patients of both groups

	NT group	HT group	P value
Operative data			
Aortic cross-clamping time (min)	51.5±17.9	48.3±14.2	0.353
Cardiopulmonary bypass time (min)	80.4±20.3	72.4±17	0.080
Total operative time (min)	178±35.1	200±29	0.0022
Number of distal anastomoses	2.9±0.8	2.7±0.9	0.319
ACT (s)			
Preoperative	106.02±14.539	103.79±11.595	0.433
Before sternal closure	133.65±10.312	149.49±7.814	0.001
P value	0.001	0.001	
Bleeding data			
Total bleeding (ml/24 h)	396.7±202	643.7±262	0.001
Transfusion requirement			
PRBC (U)	0.19±0.5	1.09±1.27	0.002
FFP (U)	0.47±1.01	1.93±1.67	0.003
PLTC (U)	1.37±2.37	4.07±5.01	0.002
Total (U)	2.02±2.73	7.09±6.08	0.001
Reopening for bleeding	2 (9.3)	5 (14)	0.236

Data are presented as mean±SD and n (%). ACT, activated clotting time; FFP, fresh frozen plasma; HT, hypothermic; NT, normothermic; PLTC; PRBC, packed red blood cells. P value more than 0.05 indicates nonsignificant difference. P value less than 0.05 indicated significant difference.

Gestion de l'anticoagulation

ACT plus court (*classe de recommandation IIB, niveau de preuve B*)

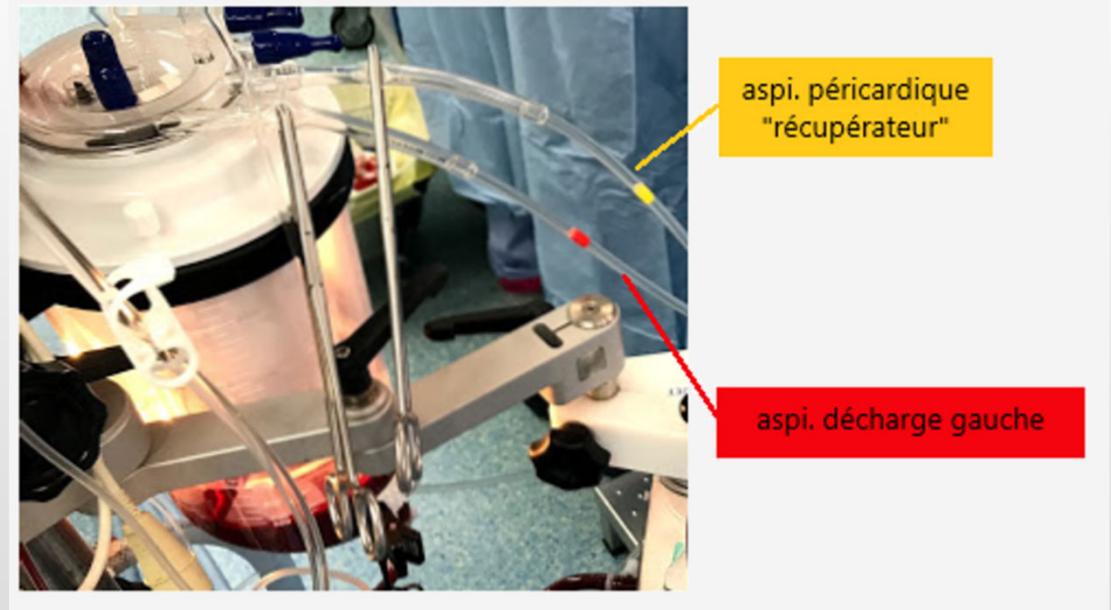
- 300 à 350" chirurgie coronaire
- 400 à 450" chirurgie valvulaire
- Dose protamine calculée (héparine résiduelle – HMS®)

Gestion de l'anesthésie

- Opiïdes à courte durée d'action + Propofol
- +/- anesthésiques volatiles
- BIS
 - ETO
 - Gestion optimale de la volémie (Trendelenburg ou anti-Trendelenburg)
 - Attention aux bolus de vasopresseurs

Gestion chirurgicale

- Gestion des aspirations
- Normothermie
- Vigilance sur l'hémostase



Inflammation et coagulation



Revue de la littérature (2019)

Journal of Thoracic Disease M. Ranucci

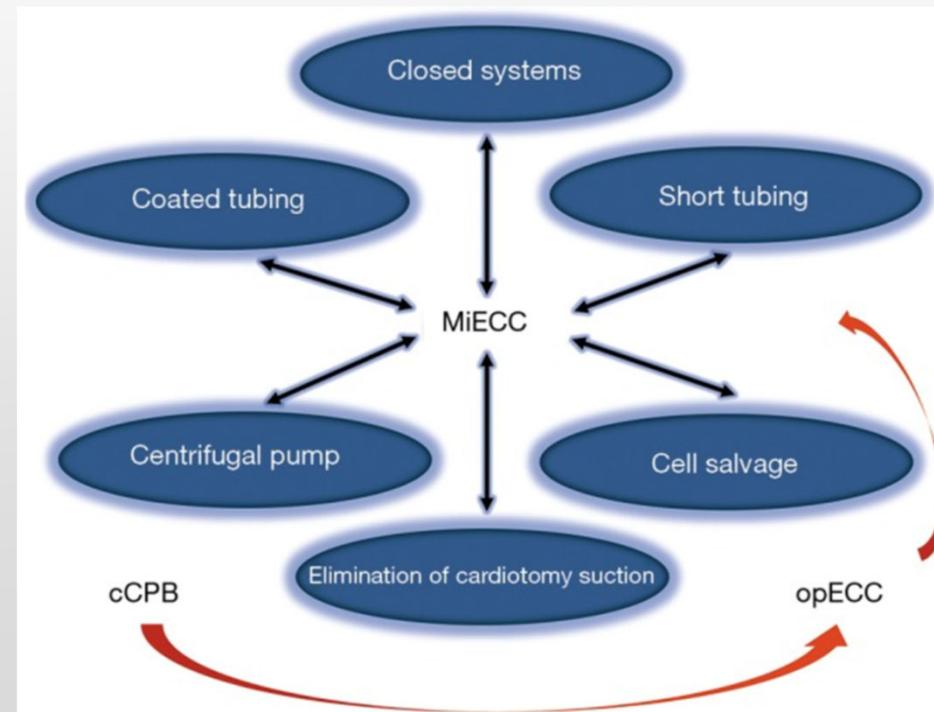
- Gestion stricte des aspirations
 - ACT entre 280 et 300s
 - Contact air / sang limité
 - Hémodilution limitée
- } ✓ Réduction de l'activation de la coagulation
✓ Réduction de la réponse inflammatoire

IL 6 : pontages sous MiECC = pontages sans CEC

En bref...

La MiECC intègre toutes les avancées de la CEC dans un seul circuit :

- Système clos
- Tubing réduit
- Gestion des aspirations
- Pompe centrifuge
- Traitement de surface



La MiECC et la RACC

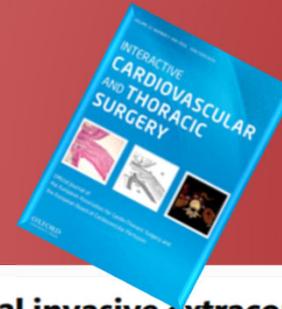


R4.4 – Il est recommandé de privilégier une technique de « CEC optimisée » afin de réduire la survenue de complications postopératoires et la mortalité hospitalière.

GRADE 1+ (accord FORT)



Conclusion



- Système exigeant
- Véritable stratégie globale
- Vrai travail d'équipe obligatoire :
 - ✓ Chirurgie méticuleuse
 - ✓ Un perfusionniste habile
 - ✓ Gestion anesthésique optimale

Use of minimal invasive extracorporeal circulation in cardiac surgery: principles, definitions and potential benefits. A position paper from the Minimal invasive Extra-Corporeal Technologies international Society (MiECTiS)

Nevertheless, it should be emphasized that MiECC is a demanding system that should be implemented in cardiac surgery as a strategy and not as a simple circuit. Real teamwork from all disciplines of the surgical team, meticulous surgery, a skilful perfusionist and optimal anaesthetic management are mandatory for a more physiological perfusion that could lead to improved clinical outcomes. MiECTiS supports initiatives that promote research and clinical application of MiECC systems as a strategy through multidisciplinary training programmes (dry labs/hands-on simulators, wet labs, peer-to-peer workshops). Integration of specific training programmes under the accreditation of MiECTiS will stimulate and improve the collaboration between clinicians while the industry will get important information to further improve the systems. MiECTiS is planning to endorse a comprehensive and structured programme that contributes to the advancement of patient care.

In conclusion, the authors consider MiECC as a physiologically based