



Anesthésie Réanimation des nouveau-nés avec Transposition des Gros Vaisseaux.



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Cardiopathies Congénitales

Anesthetic Considerations and Management of Transposition of the Great Arteries

Seminars in Cardiothoracic and
Vascular Anesthesia
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Preoperative Physiology, Imaging, and Management of Transposition of the Great Arteries

Seminars in Cardiothoracic and
Vascular Anesthesia
1–13
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Matthew D. Files, MD¹, and Bhawna Arya, MD¹

- 1. Files MD, Arya B. Preoperative Physiology, Imaging, and Management of Transposition of the Great Arteries. Semin Cardiothorac Vasc Anesth. 2015;19(3):210-222.
- 2. Frandsen EL, Files MD. Transposition of the Great Arteries. In: Pediatric Cardiac Anesthesia. 2020.
- 3. Latham GJ, Joffe DC. Anesthetic Considerations and Management of Transposition of the Great Arteries. Semin Cardiothorac Vasc Anesth. 2015;19(3):223-234.
- 4. Wernovsky G. Transposition of the Great Arteries and Common Variants. Pediatr Crit Care Med. 2016;17(8 Suppl 1):S337-343.
- 5. Karl TR. Guidelines for transposition surgery and why we need them. Eur J Cardiothorac Surg. 2017;51(1):6-10.
- 6. Vida VL, et al. Arterial switch operation for transposition of the great arteries: A single-centre 32-year experience. J Card Surg. 2019;34(9):841-848.

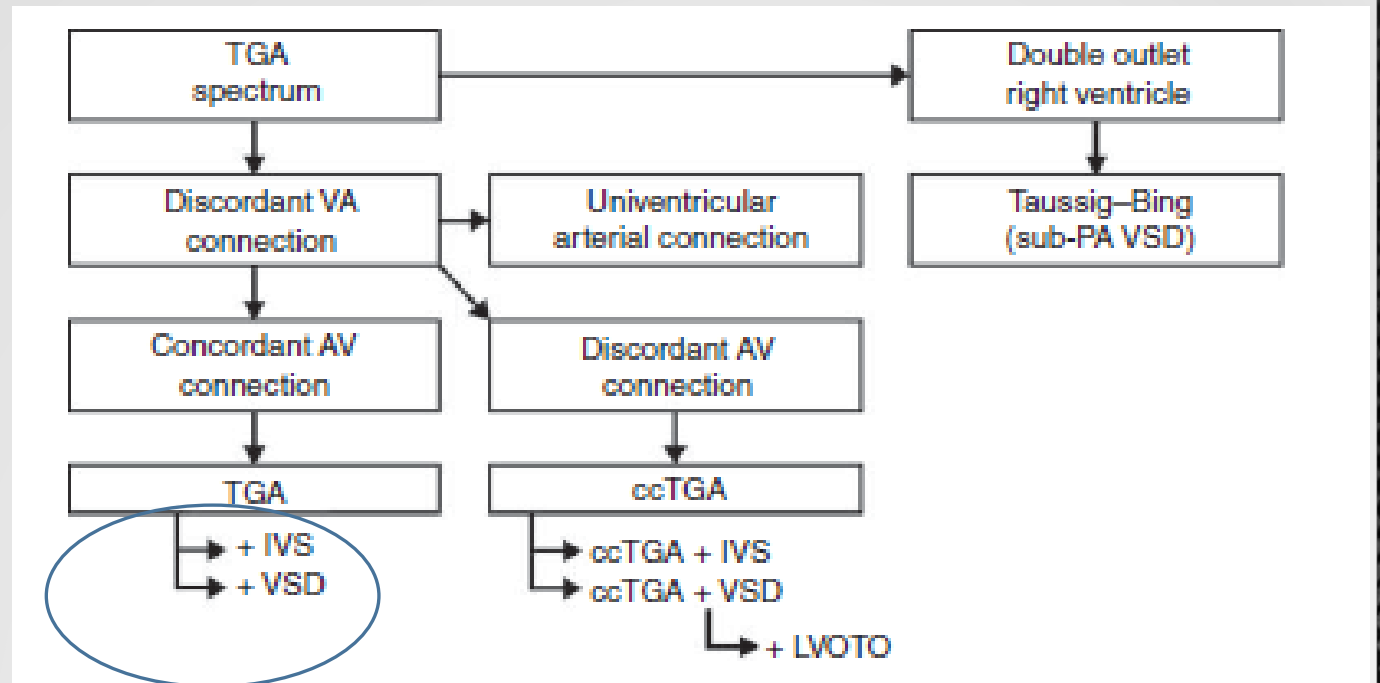
Références

Introduction

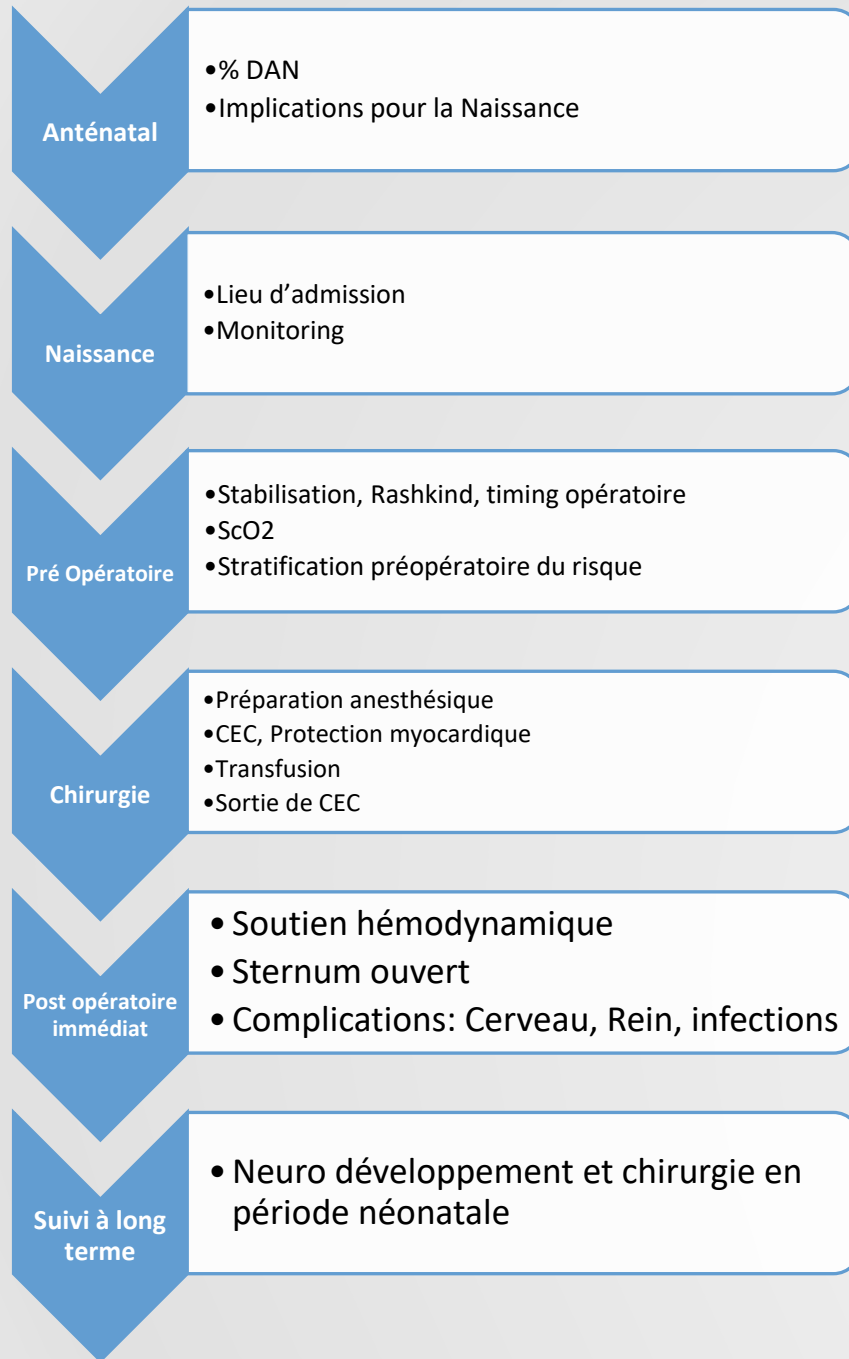
- TGA réfère à un grand nombre d'anomalies de connection ventriculo artérielle.
- Dans cette présentation, nous parlerons essentiellement de TGA (6% des cardiopathies)

En pratique:

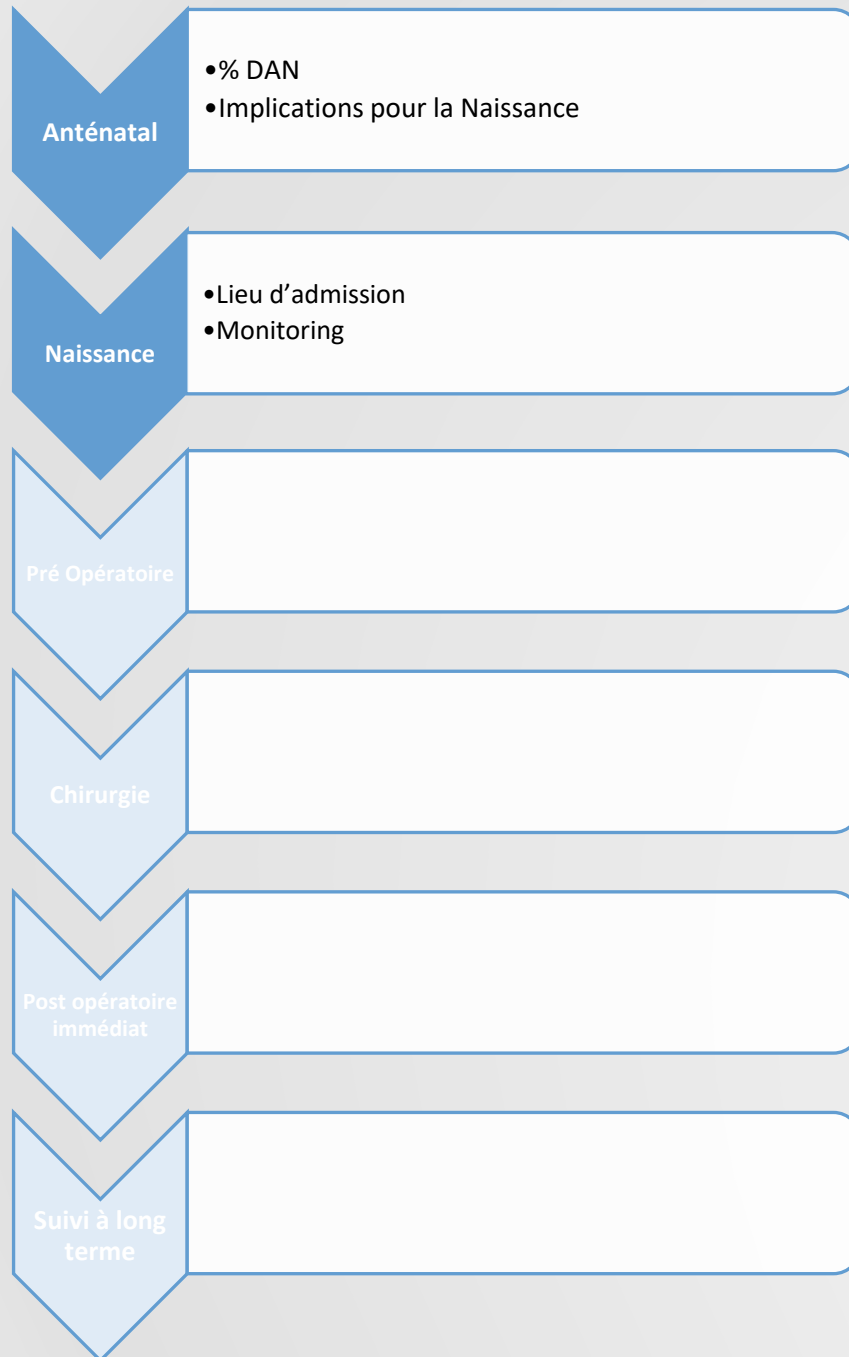
- Centre M3C de Nantes: 15 TGA/ an, période néonatale.
- Très peu d'expérience pour les TGA vieilles



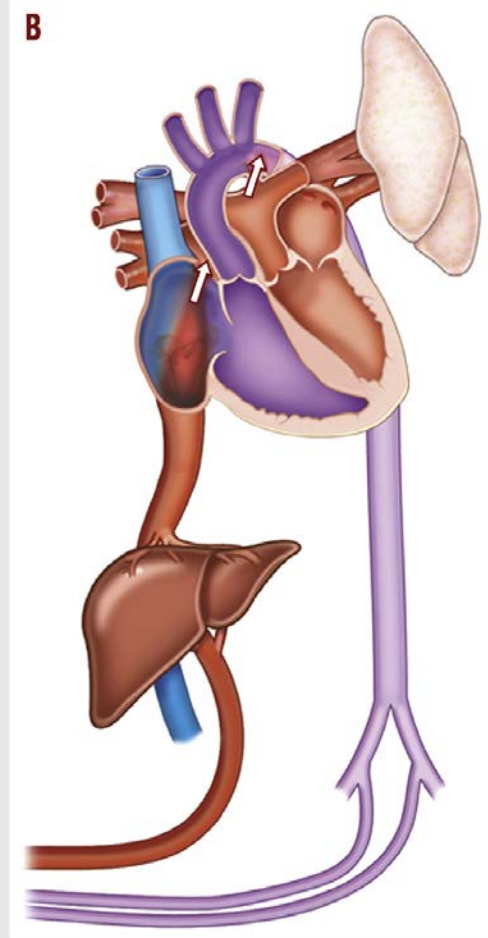
Plan



Introduction (3): Plan



Circulation Foetale



A: Cœur Normal

Sat V. Ombilicale: 85%

RcO₂ (via FOP puis DA): 65%

B: TGA

Sat V. Ombilicale: 85%

RcO₂ (via FOP puis DA): 45%

Higher SaO₂ in the descending aorta: somatic « hypertrophy » (pancreatic dysfunction, hyperinsulinism)

Circulation Foetale (2)



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

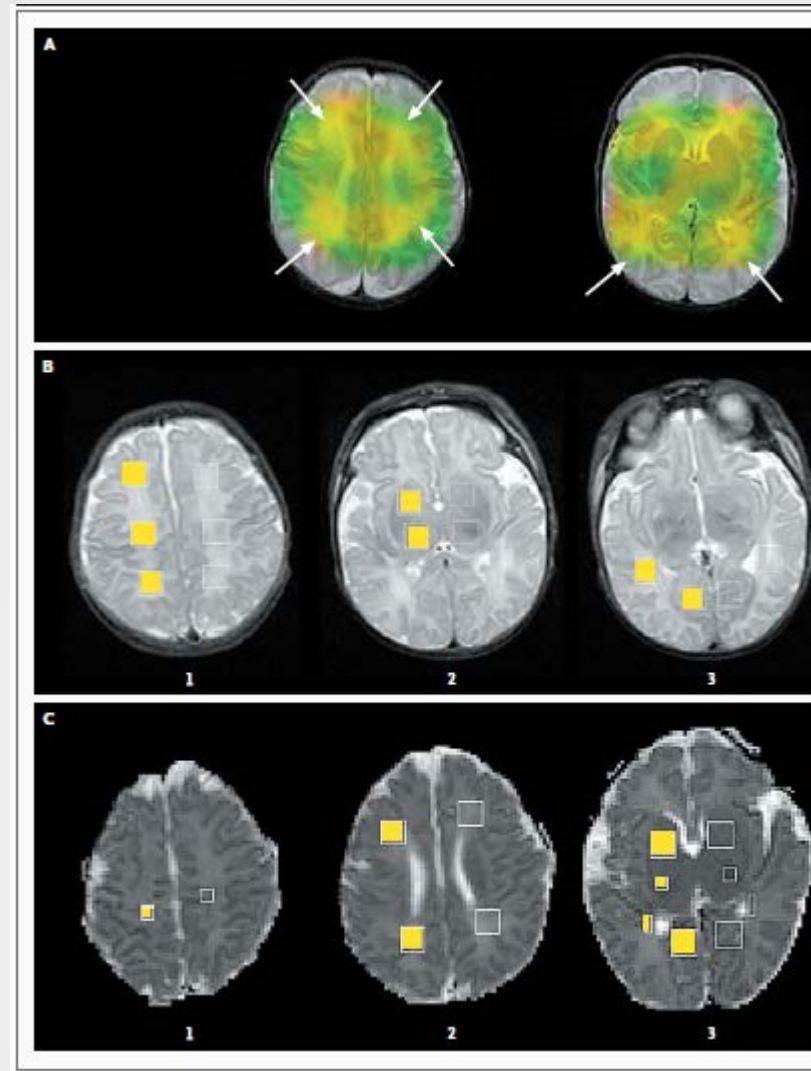
Abnormal Brain Development in Newborns with Congenital Heart Disease

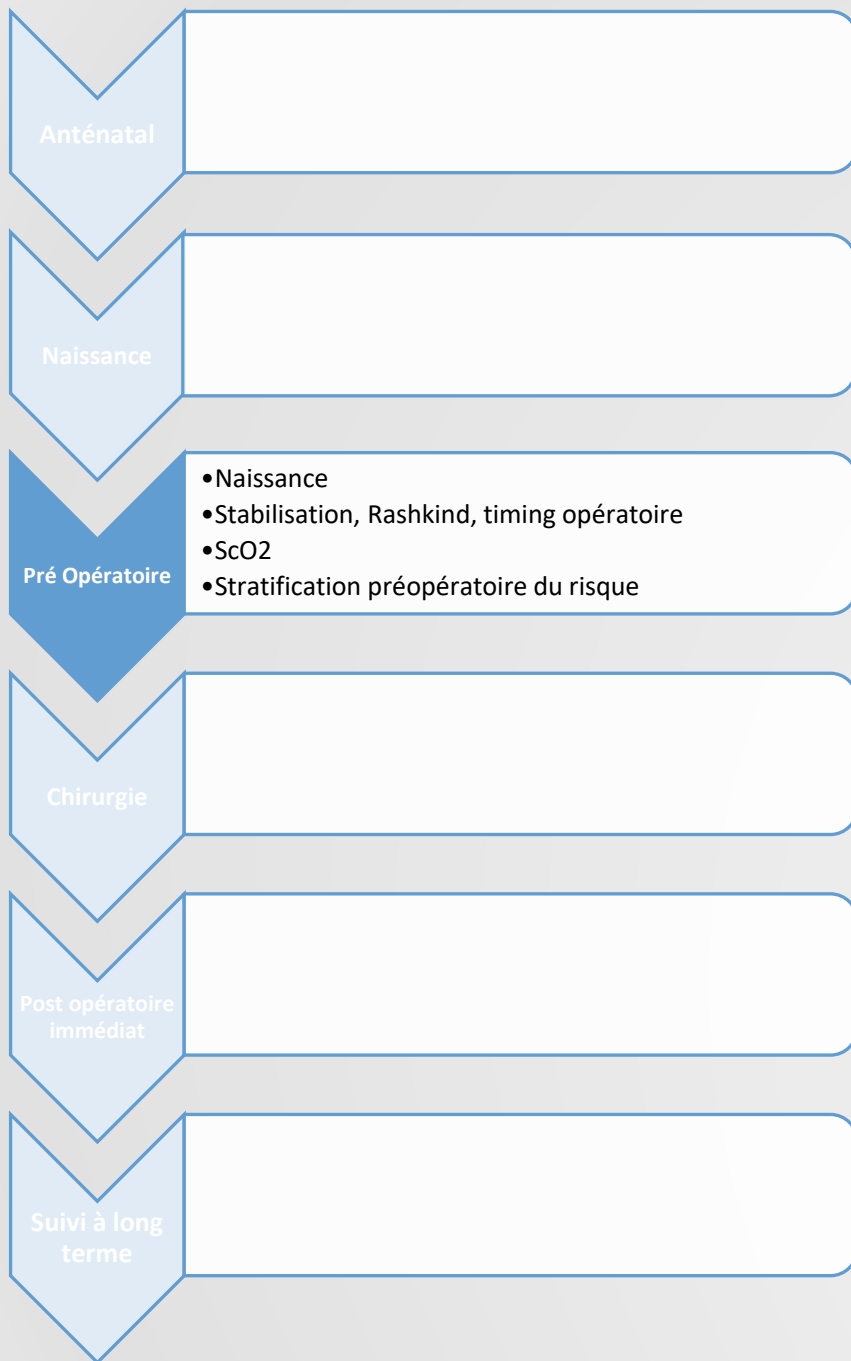
Steven P. Miller, M.D., C.M., Patrick S. McQuillen, M.D., Shannon Hamrick, M.D., Duan Xu, Ph.D., David V. Glidden, Ph.D., Natalie Charlton, B.S., Tom Karl, M.D., Anthony Azakie, M.D., Donna M. Ferriero, M.D., A. James Barkovich, M.D., and Daniel B. Vigneron, Ph.D.

→ Immaturité cérébrale préopératoire variable (ie brain volume, metabolic patterns, and WMI)

→ Vulnérabilité périopératoire

FDR neuro développemental à 2 et 4 ans



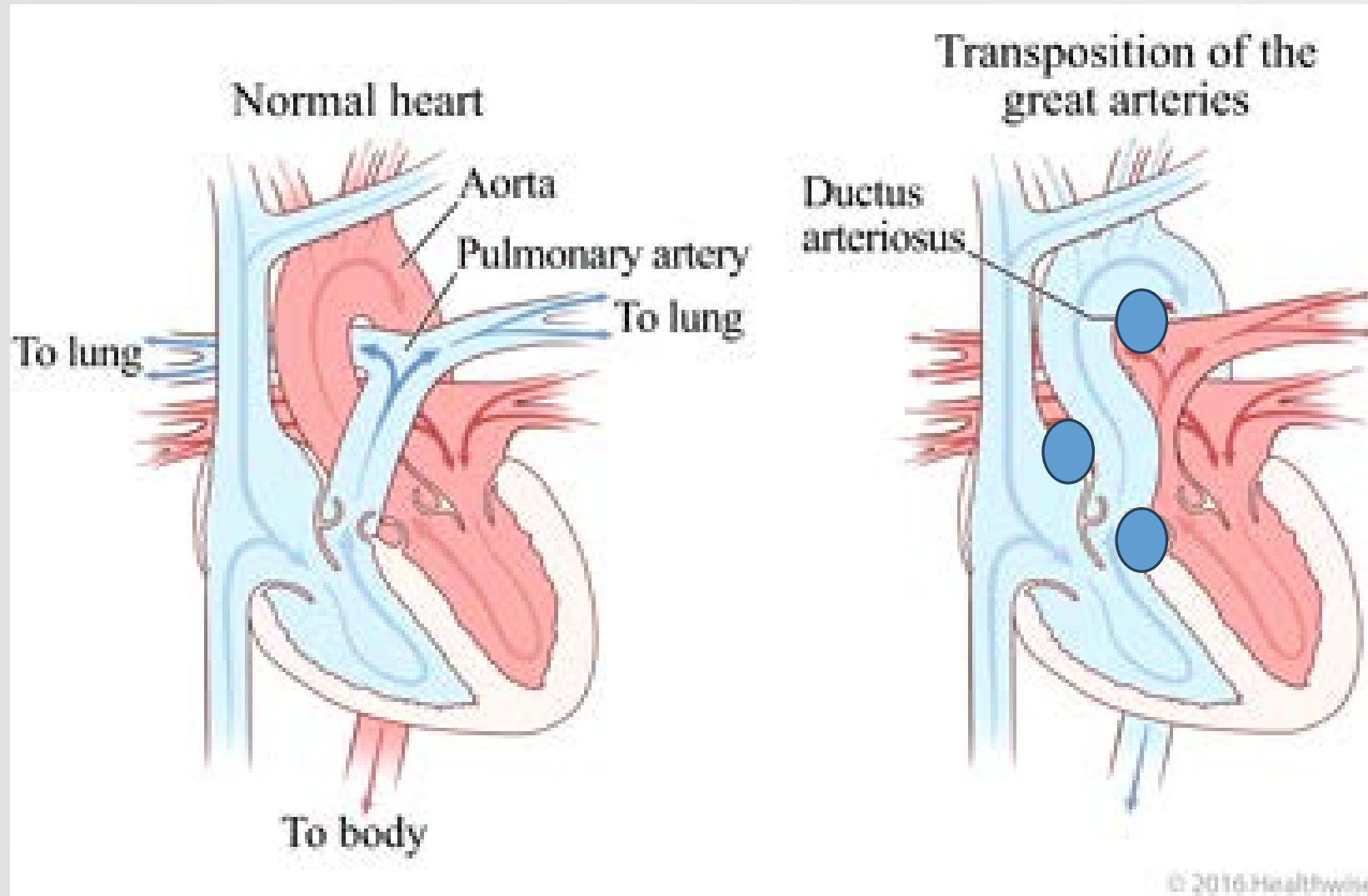


Version anesthésique!

Adaptation à la vie extra-utérine

- Naissance dans un centre chirurgical: Meilleure option si DAN
 - Soongswang J, Adata I, Newman C, Smallhorn JF, WilliamsWG, Freedom RM. Mortality in potential arterial switch candidates with transposition of the great arteries. J Am Coll Cardiol 1998;32:753—7. 4% **décès malgré PGE1 alone.**
 - BAS: **urgence extrême pour 10% des patients**
 - Bon pronostic ECMO préopératoire (Expérience locale: N=3 en 10 ans dont 2 UMACs)
- Naissance programmée? Déclenchement, césarienne programmée (?). Dépend des fonctionnements locaux, lien avec la maternité, la pédiatrie...etc

Adapatation à la vie extra-utérine



Tiré de: myheartalberta.ca.com

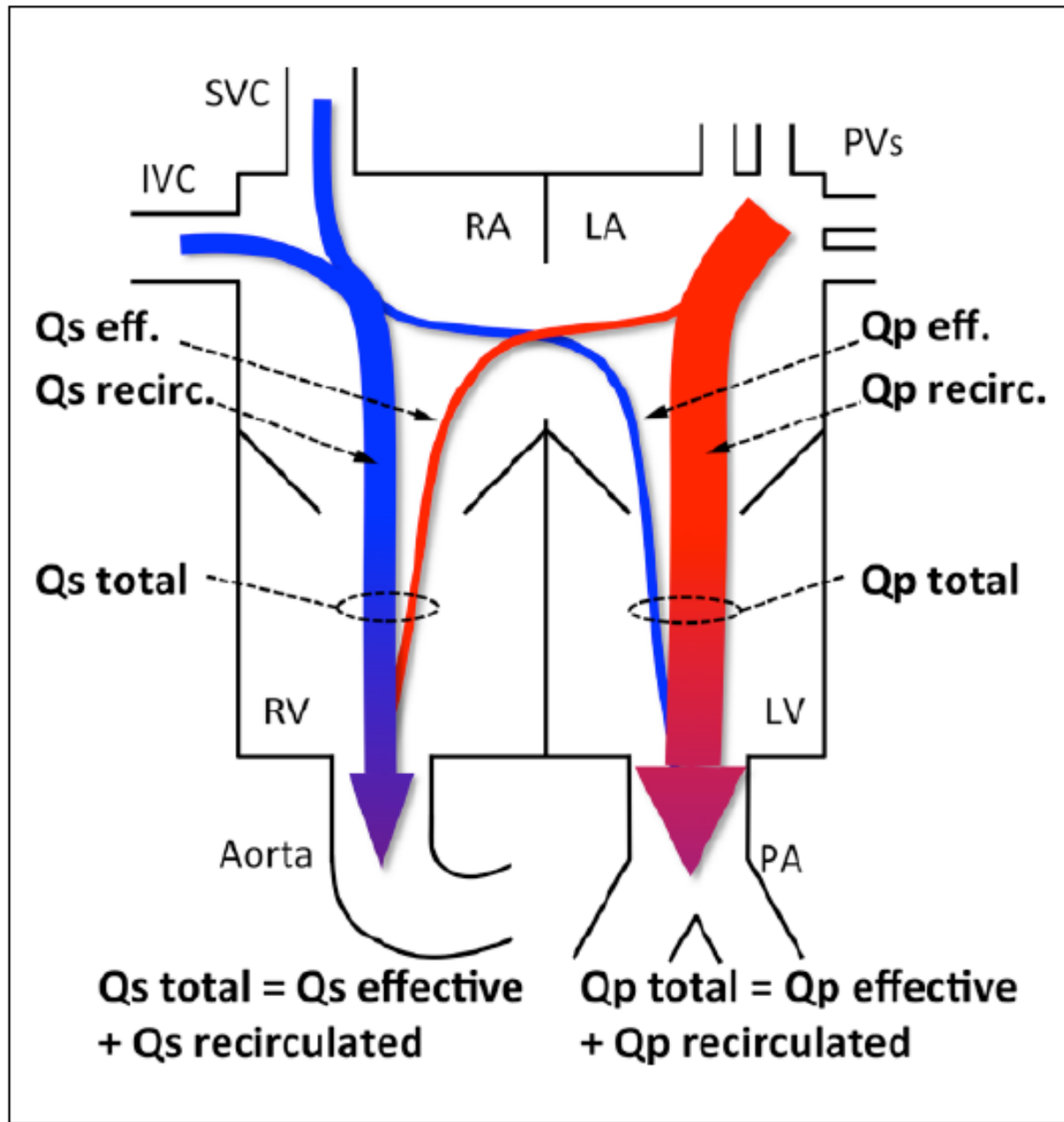
Adaptation à la vie extra-utérine

2 circulations en parallèle;

1 mélange (mixing) est nécessaire afin d'assurer:

- Un débit systémique EFFECTIF (transport d'oxygène)
- Un débit pulmonaire EFFECTIF (sang désaturé)

Le Mixing est INTRA et EXTRA cardiaque



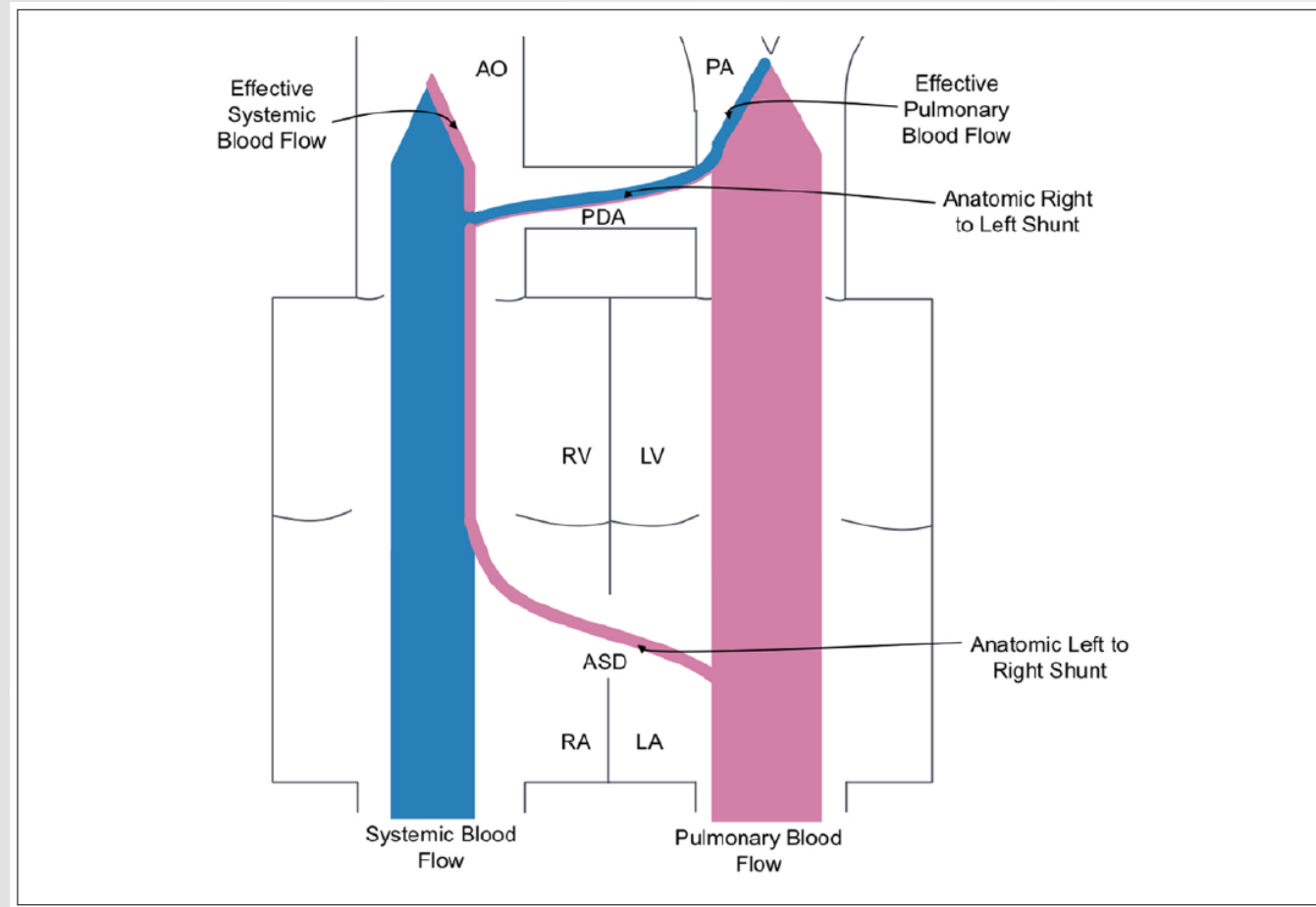
Adaptation à la vie extra-utérine:

N: $\downarrow$ RVP/ $\uparrow$ RVS: $\uparrow$ PTDVG/POG; fermeture du FOP; $\uparrow \uparrow$ du Qp

TGA: persistance PTDVD élevées: FOP maintenu ouvert; mixing

Taille du FOP/ PTDVG/ Respiration/ lésions associées: influencent la qualité du mixing

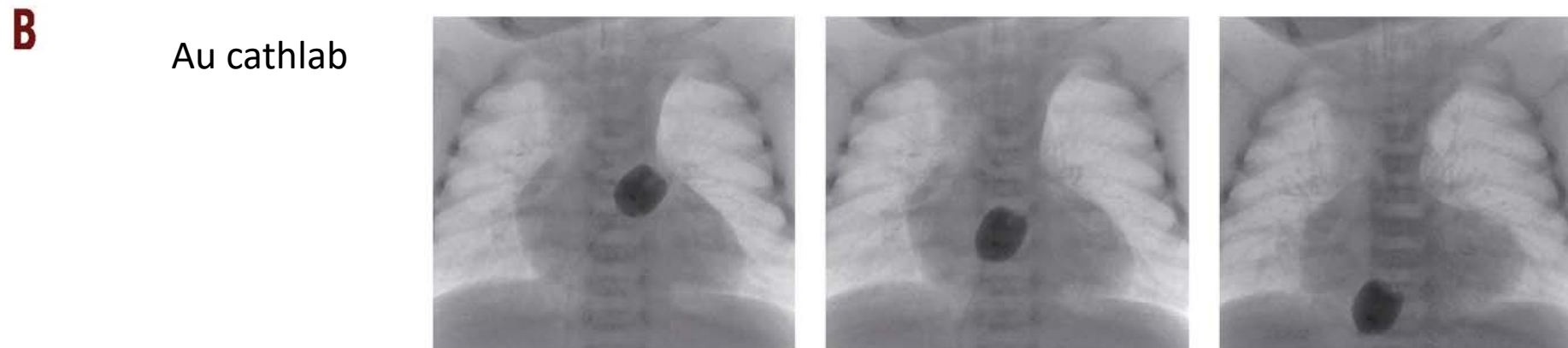
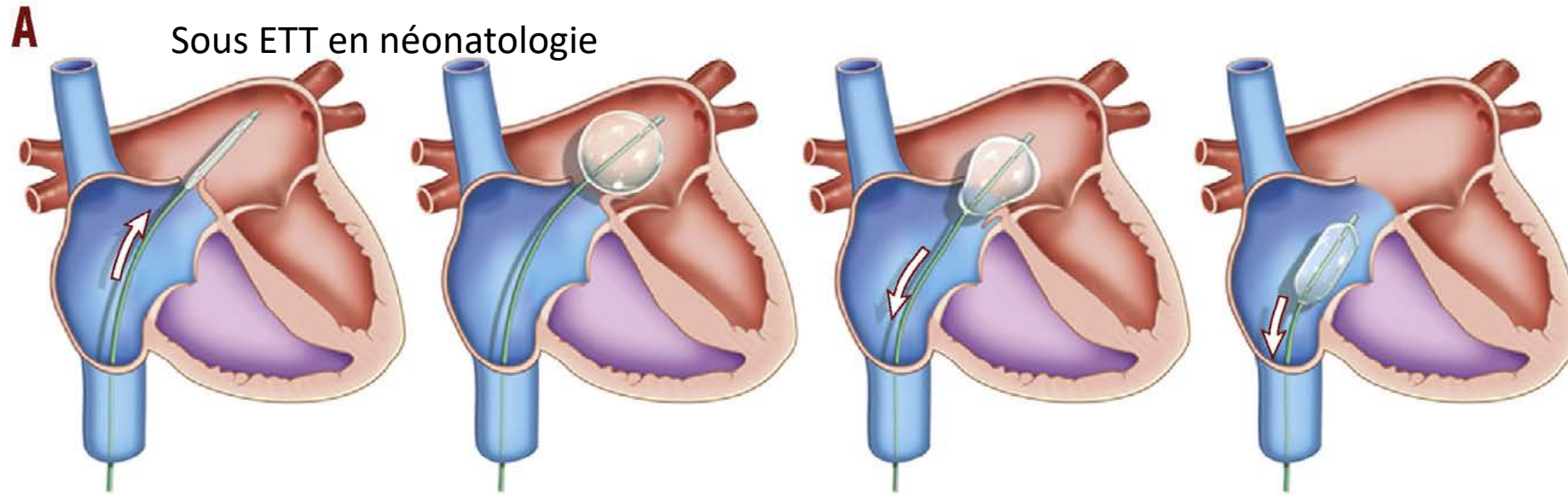
Anatomic shunt, total and effective pulmonary/ systemic blood flow



- ✓ $Q_p \gg Q_s$
- ✓ Désaturation:
- ✓ 1/ FOP
- ✓ 2/ DA?
- ✓ DA: assure le débit pulmonaire EFFECTIF; expose le VG aux résistances systémiques

BAS: Balloon Atrial Septostomy.

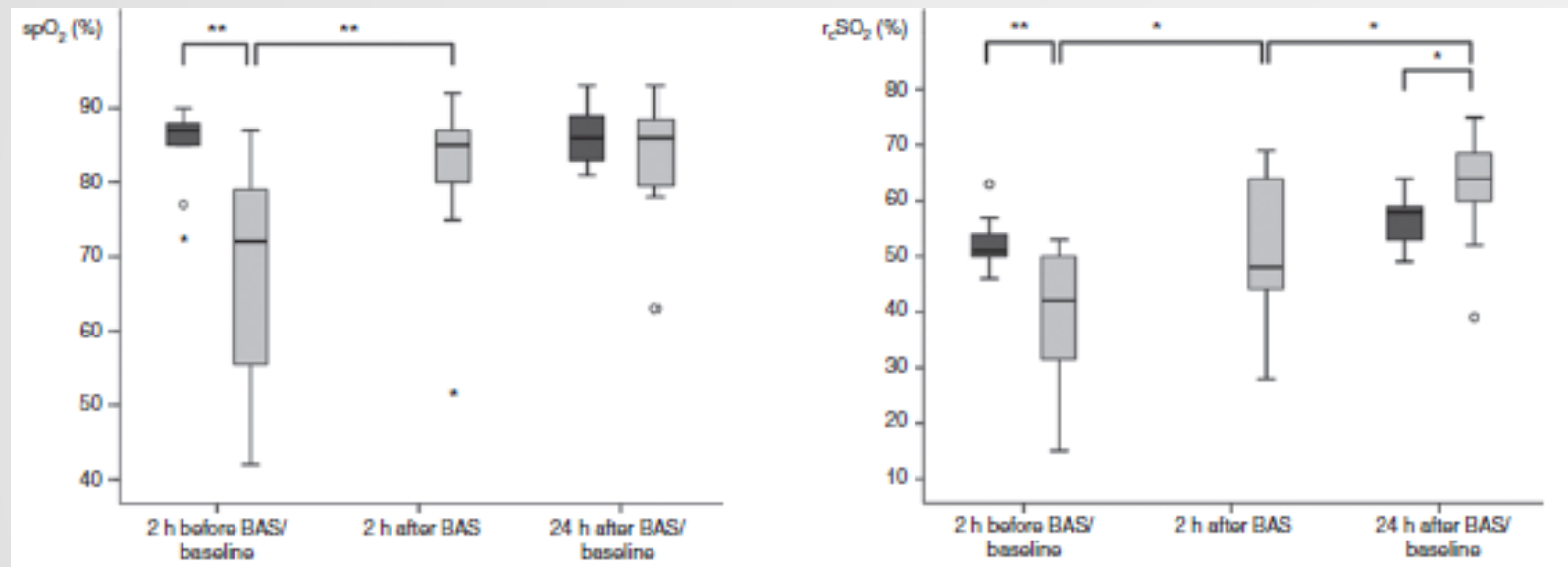
30% à 50% des patients. BAS en extrême urgence 10% des cas



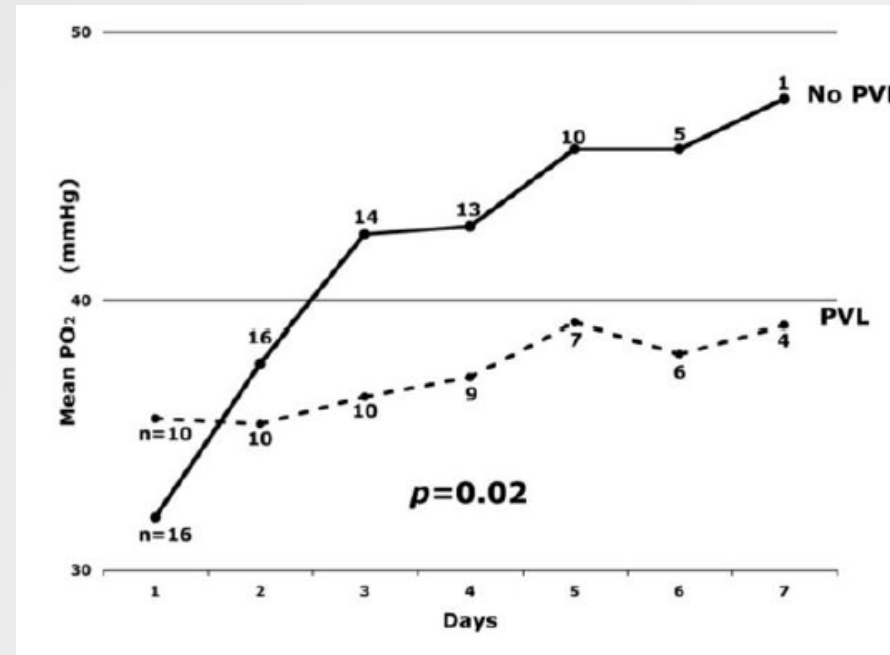
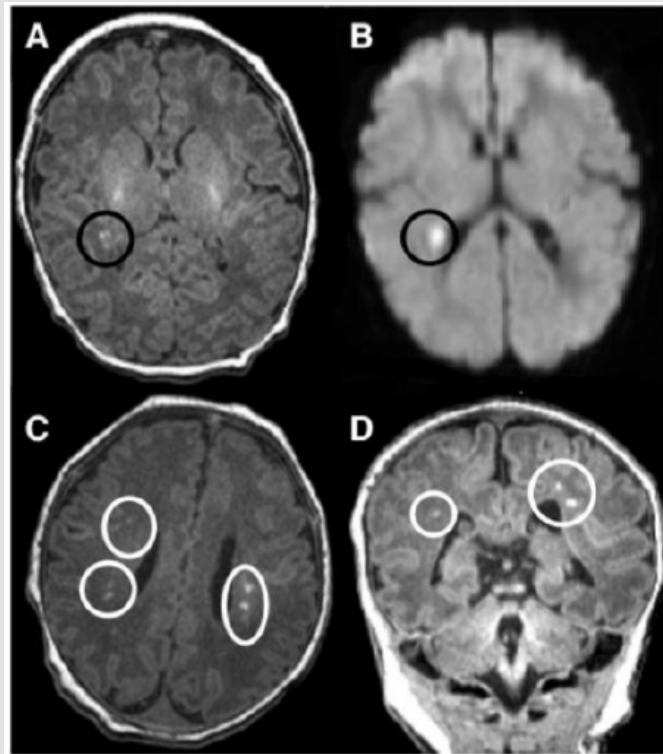
Indication BAS: FO restrictif ($V > 1\text{m/sec}$), acidose, clinical instability.

Effect of balloon atrial septostomy on cerebral oxygenation in neonates with transposition of the great arteries

Van Der Laan M, Pediatr Research 2013



Petit CJ et al. Preoperative Brain Injury in Transposition of the Great Arteries Is Associated With Oxygenation and Time to Surgery, Not Balloon Atrial Septostomy. Circulation 2009.



Lésions Préopératoires: 30%. Nouvelles lésions post opératoires: 30%



En pratique (CHU Nantes)

- Déclenchement pour naissance aux heures ouvrables
- Admission en secteur de réanimation néonatale ou pédiatrie ou USINN
- ETT immédiate
- BAS: indication **large**
- **1 VVP. Bilan préop. Cs Anesthésie** (peut être différée)
- Réalisée au lit sous ETT. Kétamine 1 mg/kg à renouveler. Indication de BAS au Cathlab: de plus en plus (problème matériel)
- Monitoring NIRS: non systématique (future cohorte).

Prostacyclines PGE1



Assure le mixing en Attendant BAS

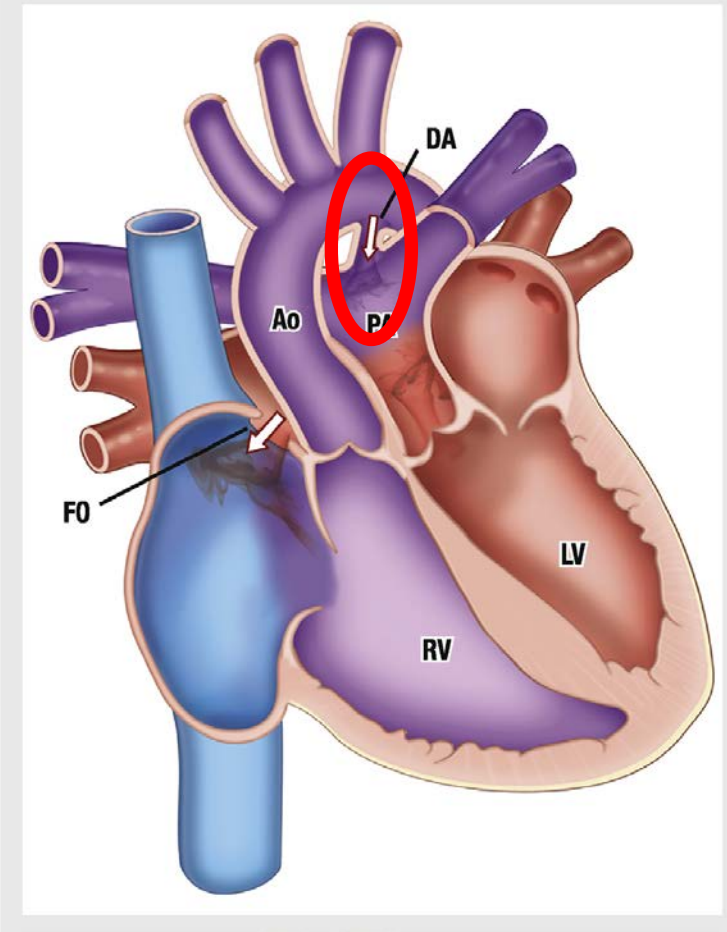
Posologie: 5ng/kg/min (réouverture CA).

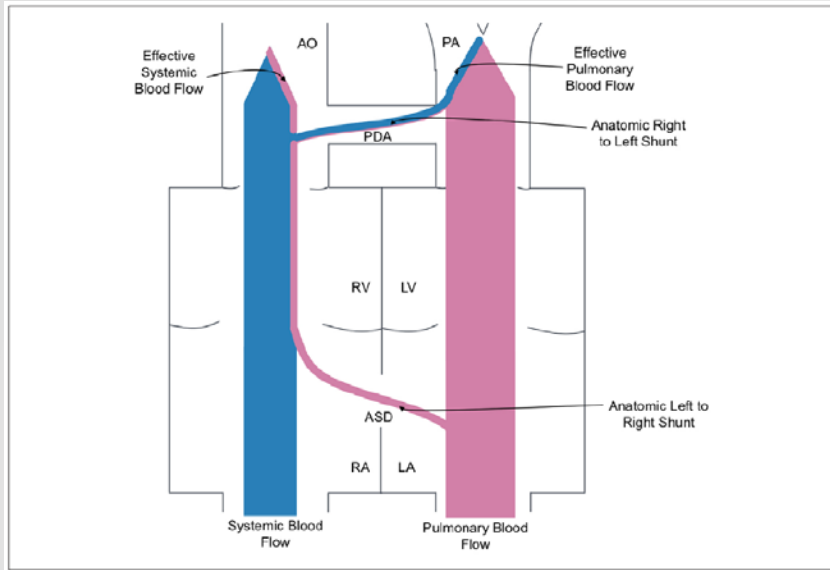
Sd inflammatoire (fièvre, irritabilité, leucocytose).

Signes neurologiques (Seizure like, cental apnea 12%). FDR: low birth weight.

Sevrage après BAS si possible. Reprise si besoin, jusqu'à la CEC, à doses minimales

Question des voies d'abord vasculaires





Objectifs

préopératoires

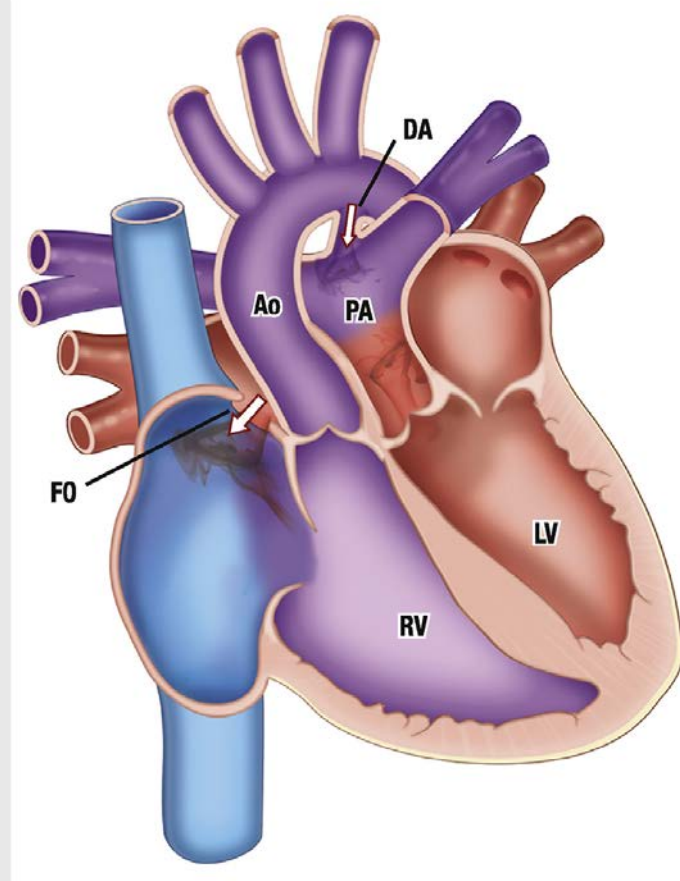
SpO₂ > 70% ET

perfusion tissulaire
adequat

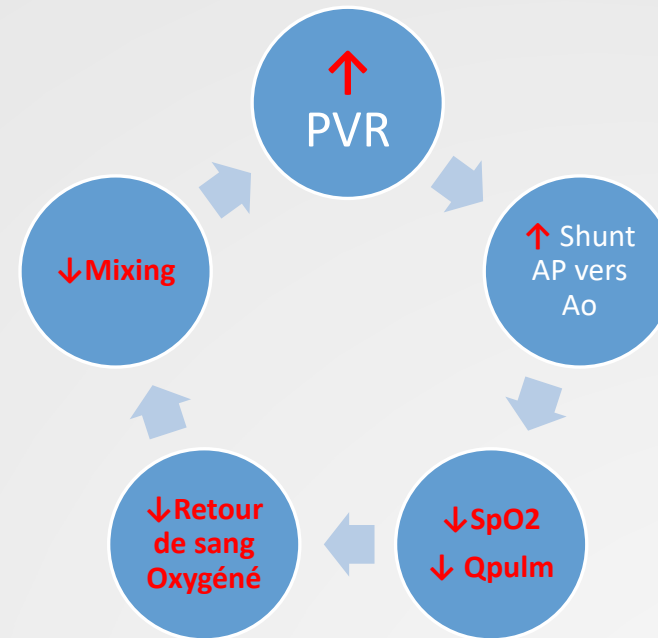
→ 1/ BAS et PGE1

→ 2/ si effective Qp
satisfaisant: O₂,
transfusion,
inotrope...interventi
on précoce?

PPHTN: Persistent Pulmonary Hypertension of the Newborn



- 6-12%. Roofthoof MT et al. Persistent pulmonary hypertension of the new-born with transposition of the great arteries. Ann Thorac Surg 2007.
- Sallaam S, et. Persistent pulmonary hypertension of the newborn with D-transposition of the great arteries: management and prognosis. Congenit Heart Dis 2016;11:239—44.
- Mortalité élevée.



Acidose
Cyanose profonde

→ iNO, restriction du PDA si possible

Stratification du risque préopératoire

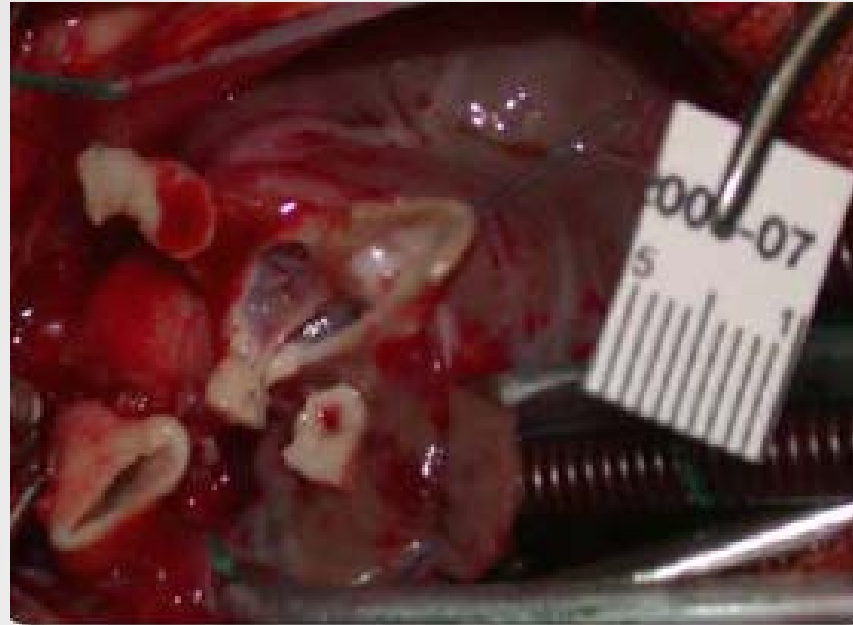
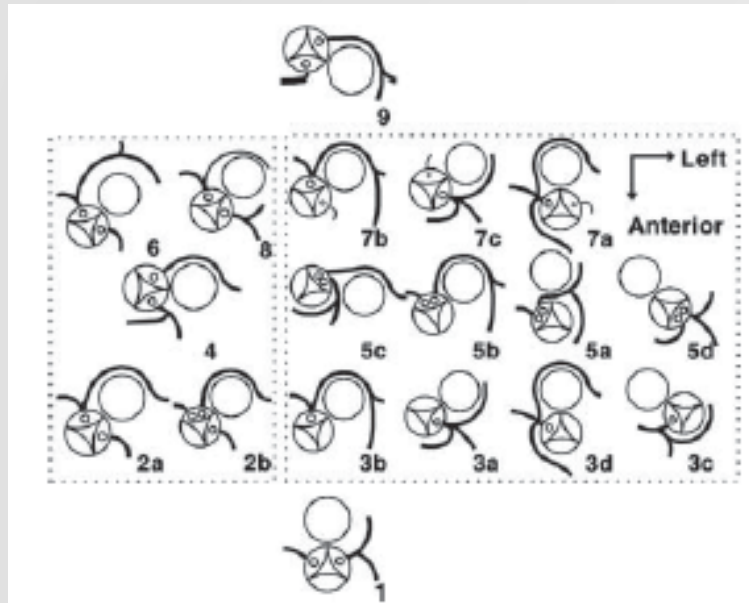
Variables associées à un risque de **complication péri opératoire**:

‘Low Birth Weight’, Prématurité, Restrictive PFO or ASD, PPHTN

Variables associées à un **risque chirurgical**:

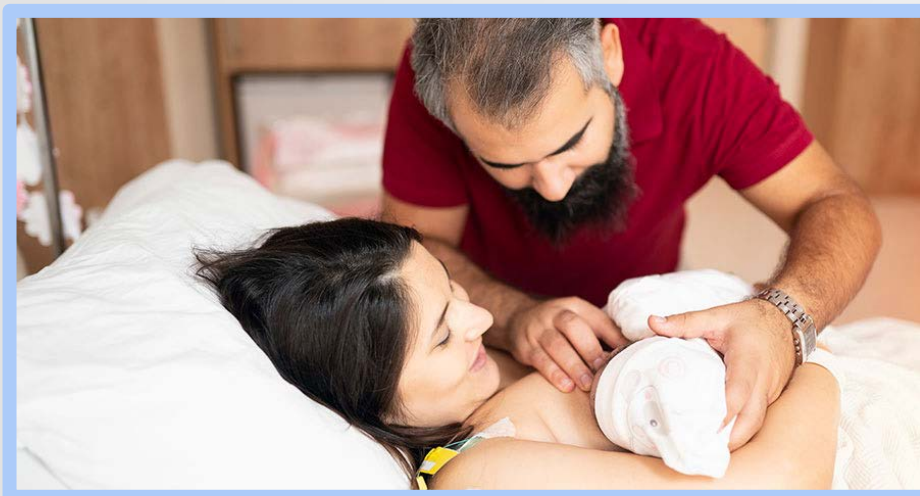
- **Prématurité et petit poids de naissance** (RCIU)
- **Anomalies coronariennes**
- **VSD associé**: 40%. Prolongation de l'acte, ouverture du cœur, troubles de conduction
- **LVOTO**: 5%, Coarctation, Interrupted aortic arch

Risque coronaire



Nutrition preopératoire

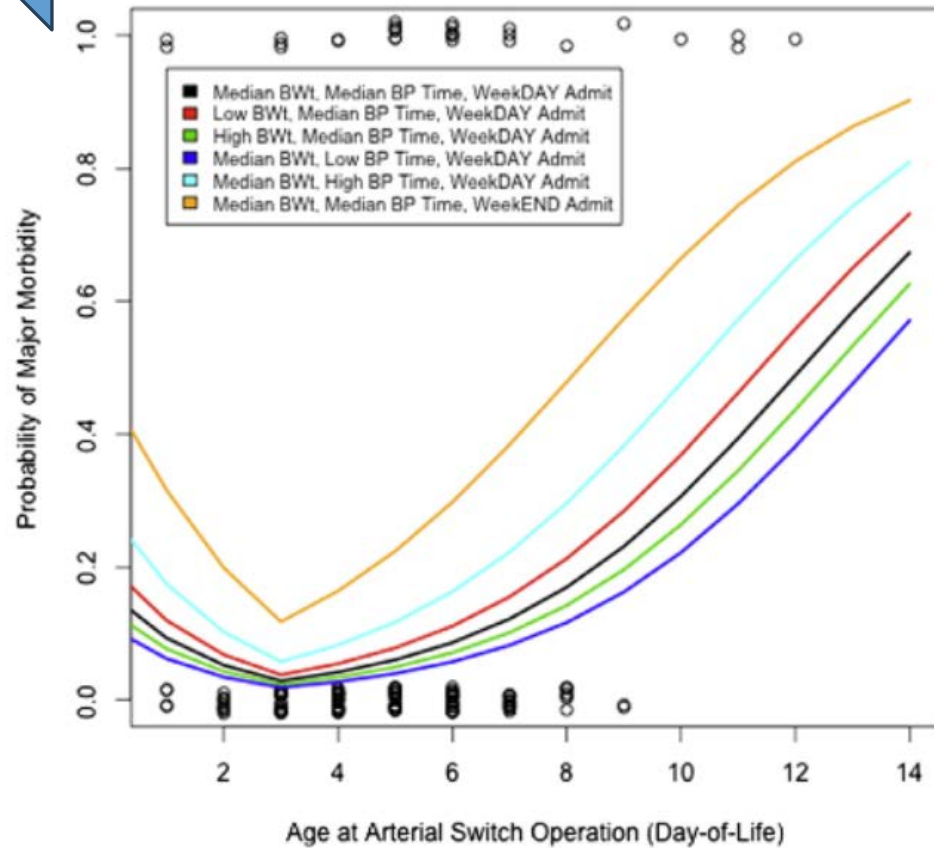
- NEC 3-4%
- FDR: HLHS, Truncus, Prématurité, instabilité HD et états de choc
- Spinner et al Necrotizing Enterocolitis and Associated Mortality in Neonates With Congenital Heart Disease: A Multi-Institutional Study. PCCM 2020.
- Mc Elhinney et al. Necrotizing enterocolitis in neonates with congenital heart disease: risk factors and outcomes. Pediatrics, 2000.
- Cognata a et al. **Human Milk Use in the Preoperative Period Is Associated with a Lower Risk for Necrotizing Enterocolitis in Neonates with Complex Congenital Heart Disease.** J Pediatr 2019.
- Becker K et al. Necrotizing enterocolitis in infants with ductal-dependent congenital heart disease. Am J Perinat.
 - 'The incidence of NEC is low and did not increase with enteral intake'



Timing opératoire

RVP élevées

LV afterload decrease, high
pulmonary flow, diastolic steal

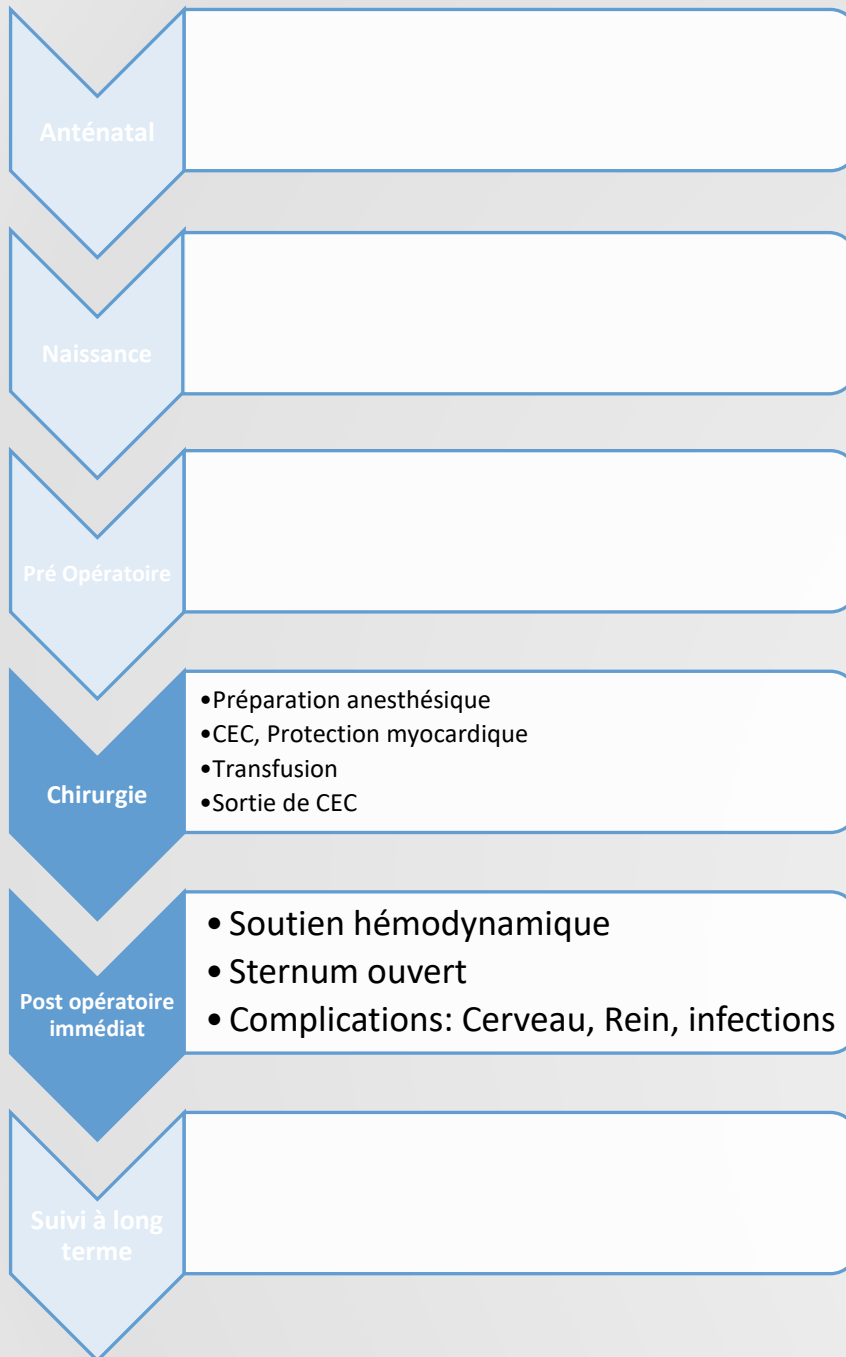


Earlier Arterial Switch Operation Improves Outcomes and Reduces Costs for Neonates With Transposition of the Great Arteries

Anderson, JACC 2014

Figure 1

Effects of Age at Arterial Switch Operation on Major Morbidity



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3rd Edition

ANESTHESIA FOR CONGENITAL HEART DISEASE



Editor-in-Chief
Dean B Andropoulos

Editors
Stephen Stayer
Emad B Mossad
Wanda C Miller-Hance

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KEY POINTS: ANESTHETIC GOALS

- Maintain the PDA with PGE_1 in the duct-dependent circulation.
- Avoid increases in PVR and reductions in SVR to ensure adequate pulmonary blood flow and avoidance of recirculation of pulmonary venous blood.
- After CPB, the LAP needs to be low while maintaining adequate cardiac output
- Pulmonary hypertension should be avoided.
- Intravascular volume administration should be very cautious, because even a small amount of volume can increase LAP dramatically.

Induction anesthésique

- Objectif à l'induction: **maintenir le meilleur mixing**

NIRS (basale souvent 50%)

Ne pas induire des modifications brutales de la pré- et postcharge

Ne pas provoquer de HTAP

En cas de désaturation: augmenter RVS, ne pas trianer à partir en CEC...un peu d'oxygène...

- jeune préopératoire minimal (hypoglycémies sous prostine/ TGA).

Schémas possibles:

Induction inhalatoire possible (diminue les RVP) douce et brève
(ne pas baisser trop les RVS pour assurer un mixing par le PDA) ou
IV lente

Relais: IV (midazolam, Dexmédétomidine, morphiniques, curares)

Anesthésie.

CHU Nantes
2017-2021 (5 ans)
593 CEC < 1 an
TGA: 82 (14%)

Dexmédétomidine: Bolus 1µg/kg 15' puis 1-1.4 µg/kg/h

Intraoperative variables	Missing	DEX group n=213	NO DEX group N =213	Std diff†
CPB duration (min)	0	145±72	139±63	0.12
Aortic Clamp duration (min)	0	81±42	79±40	0.06
Minimal core temperature (°C)	0	33.7±3.2	32.3±3.8	0.31
Midazolam (µg/kg/h)	103 (24.2%)	107±81	186±66	-2.58
Sufentanil (µg/kg/h)	105 (24.6%)	0.85±0.58	1.17±1.05	-1.58
VIS (at PICU admission)	85 (24.6%)	7.7±4.5	8.1±5.9	-0.19

Variable	Estimate	95% Confidence interval
Probability of POT in patients exposed to DEX	0.066	0.032 - 0.099
Probability of POT in patients not exposed to DEX	0.145	0.098 - 0.193
DRME	-0.088	-0.137 - -0.023

CEC.

EJCTS 2017

Recommendations for anaesthetic management

Recommendation	Class ^a	Level ^b	Ref ^c
The use of NIRS, added to the standard-of-care monitoring modalities, is recommended	I	C	
It is recommended that the haematocrit be maintained at a minimum level of 25% during CPB	I	C	
Fresh whole blood is not recommended over the use of packed RBCs (<5 days old) with FFP	III	C	
Heparin-coated circuits offer a beneficial effect in minimizing inflammatory response to CPB; their use is recommended	I	B	194, 195
Preoperative steroid use may be considered to ameliorate the inflammatory response to CPB	IIb	B	193, 197, 201, 202
A method of filtration, either ultrafiltration or modified ultrafiltration, is recommended	I	C	

CPB: cardiopulmonary bypass; FFP: fresh frozen plasma; NIRS: near-infrared spectroscopy; RBCs: red blood cells.

^aClass of recommendation.

^bLevel of evidence.

^cReferences.

Recommendations for management of cardiopulmonary bypass

Recommendation	Class ^a	Level ^b	Ref ^c
It is recommended that DHCA be avoided whenever possible	I	B	131, 132
Immediate postoperative haemodynamic target parameters recommended include a stable ECG, with no electrical instability (suggesting ischaemia); left atrial pressure 5–15 mmHg, with evidence of good tissue perfusion; and urine output >1 ml/kg/h. Active corrective measures are recommended if lactate levels and ongoing acidosis are noted in the operating room	I	C	133, 134
It is recommended that milrinone be started for any patient with signs or symptoms of low cardiac output and at least with a left atrial pressure >15 mmHg. If hypotension develops, blood pressure support with other inotropic/vasopressor agents (epinephrine or dopamine) may be necessary	I	C	
The use of prophylactic antifibrinolytic agents should be considered for ASOs, to minimize postoperative bleeding	IIa	B	137, 175

ASO: arterial switch operation; DHCA: deep hypothermic circulatory arrest; ECG: electrocardiogram.

^aClass of recommendation.

^bLevel of evidence.

^cReferences.

Priming CEC

UFAnesthésie-Réanimation - Hôpital HME CHU Nantes



Ordonnance de CEC (2-90 kg)

Date de l' intervention : 25-nov-20

IPP 012345678

NOM TANGER

Prénom Transpo

Date de naissance 20/11/2020

Age 5.0 jours

Poids (kg) 2.9kg

Taille (cm) 51cm

Hématocrite (%) 62%

Protidémie (g/l) 60g/l

facteur masse sanguine (ml/kg) 85ml/kg

Surface corporelle 0.2m²

MASSE SANGUINE 247ml

Canules métal coudées 2x3 mm

Circuit ØV 3/16-1/4

Oxygénateur Baby FX

Volume priming selon poids 270ml

Hématocrite désiré perCEC

32% (%)

Protidémie désirée perCEC

50 g/l

Albumine 20%(1) ou 4%(2) ou rien(0)

1 (0-1-2)

Alcalinisation ?

(Non=0, Oui=1)

1 (0-1)

Exacyl

(Non=0, Oui=1)

1 (0-1)

Mannitol ?

(Non=0, Oui=1)

1 (0-1)

Rétropriming

NON

Type de chirurgie

1120 = Arterial switch operation (ASO) and VSD repair

AVEC CEC

VOLUME DE PRIMING

270ml

CEFUROXIME

120mg pour 1° injection puis 60 mg/ 2h perop

EXACYL

0mg soit 0 ml d'une solution à 100mg/ml

HEPARINE

16mg

ou

1 600UI

PROTAMINE

26mg

ou

2 600UI

Composition du soluté d'amorçage			Débits de CEC		
CONCENTRE GLOBULAIRE		20ml	37°C (2.40 L/min/m2)	0.48	l/min
ALBUMINE	20 %	50ml	35°C (2.20 L/min/m2)	0.44	l/min
Bicarbonate Na 8.4 %		14ml (déduire 5 ml si Hémosol)	33°C (2.00 L/min/m2)	0.40	l/min
Mannitol 20 %		15ml	30°C (1.90 L/min/m2)	0.38	l/min
HEA 6%		0ml	27°C (1.75 L/min/m2)	0.35	l/min
RINGER LACTATE ou Hémosol		170ml (Hémosol # 5 ml de Bicar 8.4%)	25°C (1.60 L/min/m2)	0.32	l/min
HEPARINE		10mg soit 1000 UI	20°C (1.30 L/min/m2)	0.26	l/min
CEFUROXIME		60mg			
Ca Cl2 (si CG)		1ml			
Exacyl (si age < 1 an (0))		0mg			
Volume total du priming		271ml			

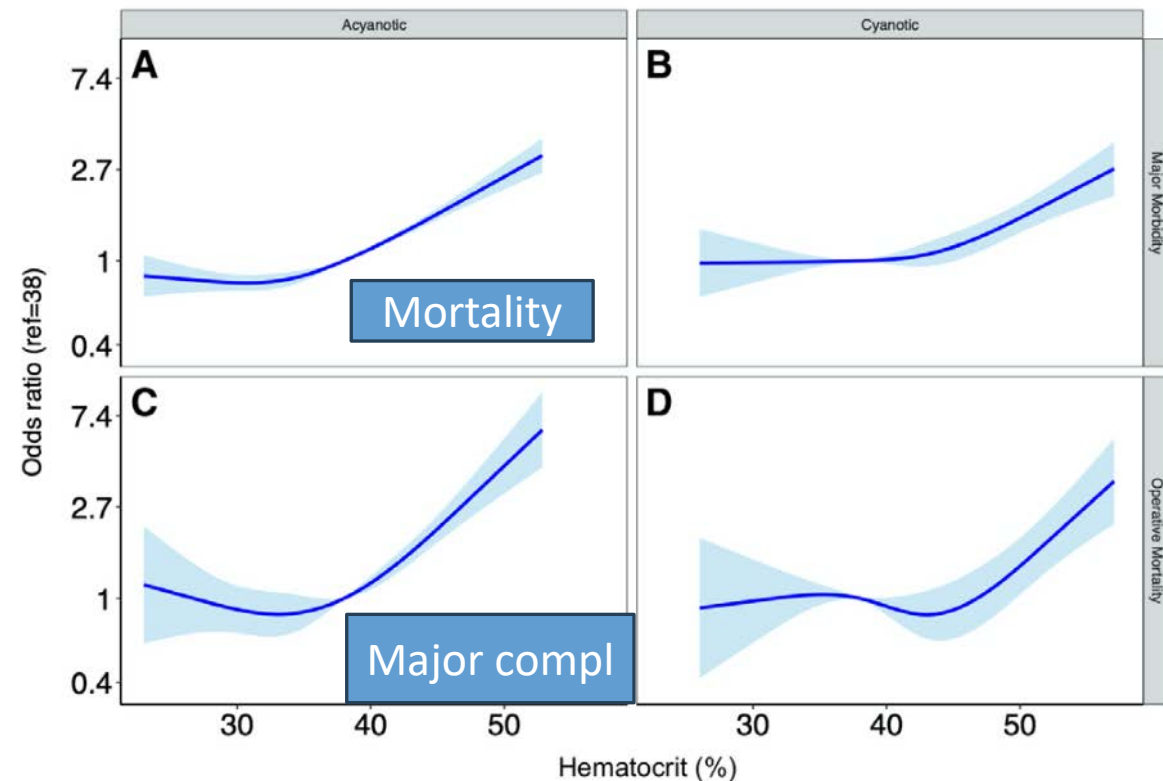
* Si le volume de ringer < 0 :

Choisissez Alb 20% (1) au lieu de Alb 4 % (2)

ORIGINAL CLINICAL RESEARCH REPORT

Postoperative Hematocrit and Adverse Outcomes in Pediatric Cardiac Surgery Patients: A Cross-Sectional Study From the Society of Thoracic Surgeons and Congenital Cardiac Anesthesia Society Database Collaboration

Justin B. Long, MD,* Branden M. Engorn, MD,† Kevin D. Hill, MD,‡ Liqi Feng, MS,§
Karen Chiswell, PhD,§ Marshall L. Jacobs, MD,|| Jeffrey P. Jacobs, MD,¶ and Dheeraj Goswami, MD#



Temps et Durées CEC

Début	Fin	Durée	Début	Fin	Durée	Début	Fin	Durée
CEC			Clampage Ao.			Assistance		
10:11	12:55	02:44:02	10:15	12:05	01:49:48	12:05	12:55	00:49:52

Matériel

Circuit	Circuit CEC < 10 Kg
Oxygénateur	TERUMO BabyFX RE
Hémofiltre	MAQUET Hémofiltre BC 20
Cardioplégie	SORIN Circuit Cardioplégie Pédi.
Circuit VAVD	EUROSET: VAVD Circuit Standard F

Console CEC	Sorin S5 N°8
GT 3T :	Sorin 3T N°7

Hémodilution - Médicaments/Cpg

Priming

Nom	Quantité	Unité
Albumine 20%	50.0	ml
Bicar 8,4%	14.0	ml
CaCl2 (si CG)	1.0	ml
Céfuroxime	140.0	mg
Concentré Globulaire	110.0	ml
Héparine	10.0	mg
Mannitol 20%	35.0	ml
Ringer-Lactate	70.0	ml
Totaux:	281.6	

Entrées/Médicaments/Cpg

Nom	Quantité	Unité
Concentré Globulaire	202.0	ml
CP1B	10.7	ml
Héparine	0.1	ml
Néosynéphrine Totale	9.0	ml
PFC	175.0	ml
Ringer-Lactate	120.0	ml
Totaux:	516.8	

Sorties

Nom	Quantité	Unité
Hémofiltration	-500.0	ml
Récupération CEC	-250.0	ml
Totaux:	-750.0	

Bilan des Volumes

Bilan des volumes (ml) :	48.4
--------------------------	------

Notes

pressions Dtes 48-6-28 Pour PA 89-53-68 mmHg

Stratégie de remplissage restrictive périopératoire

Fluid Overload Is Associated With Higher Mortality and Morbidity in Pediatric Patients Undergoing Cardiac Surgery*

Daniel J. Lex, MD¹; Roland Tóth, MD¹; Nikoletta R. Czobor, MD¹;
Stephen I. Alexander, MBBS, MPH, FRACP²; Tamás Breuer, MD, PhD³; Erzsébet Sági, MD³;
András Szatmári, MD, PhD⁴; Edgár Székely, MD³; János Gál, MD, PhD⁵; Andrea Székely, MD, PhD^{3,5}

PCCM 2016

TABLE 2. Daily Fluid Data and Urine Output According to Adverse Outcomes

	Nonsurvivors	Low Cardiac Output Syndrome	Renal Replacement Therapy	Kidney Disease Improving Global Outcomes Stage II + III	Prolonged Mechanical Ventilation	No Complications
Variables	<i>n</i> = 90 (5.9%)	<i>n</i> = 370 (24.3%)	<i>n</i> = 102 (6.7%)	<i>n</i> = 143 (9.4%)	<i>n</i> = 427 (28%)	<i>n</i> = 729 (47.9%)
Fluid balance, intraoperative (mL/kg)	22.58 (4.30 to 39.25)	21.7 (9.75 to 40.75)	32.20 (10.50 to 49.20)	25.00 (10.50 to 39.60)	21.4 (8.9 to 39.5)	16.94 (7.94 to 27.67)
Fluid balance, DOS (mL/kg)	16.90 (-12.50 to 48.00)	16 (-12.95 to 43.2)	12.35 (-17.50 to 39.33)	21.91 (-8.72 to 48.54)	0.5 (-23.88 to 28.88)	-10.35 (-23.50 to 0.10)
Fluid balance, POD1 (mL/kg)	7.60 (-18.85 to 65.30)	-3.1 (-24.4 to 16.3)	5.20 (-16.10 to 35.50)	0.23 (-15.31 to 31.66)	-5.55 (-25.3 to 12.73)	-1.30 (-17.80 to 11.40)
Fluid balance, POD2 (mL/kg)	-9.00 (-26.68 to 17.13)	-13.4 (-44.7 to 6.15)	-14.80 (-48.30 to 4.80)	-20.32 (-52.65 to 2.34)	-19.75 (-39.6 to 0.78)	-0.05 (-15.30 to 15.13)
cFO, DOS (%)	2.24 (-1.31 to 5.02)	1.6 (-1.29 to 4.32)	1.22 (-1.78 to 4.28)	2.18 (-0.87 to 4.85)	0.24 (-1.38 to 2.89)	-1.03 (-2.35 to 0.01)
cFO, POD1 (%)	0.76 (-1.88 to 6.53)	-0.31 (-2.43 to 1.63)	0.52 (-1.61 to 3.55)	0.02 (-1.52 to 3.15)	0.56 (-1.53 to 2.27)	-0.13 (-1.78 to 1.14)
cFO, POD2 (%)	-0.56 (-5.57 to 2.13)	-1.34 (-4.47 to 0.61)	-1.48 (-4.83 to 0.48)	-2.02 (-5.25 to 0.23)	0.12 (-1.96 to 1.07)	0.01 (-1.53 to 1.51)
Urine output, DOS (mL/kg/hr)	3.03 (1.46 to 3.77)	2.57 (1.49 to 3.62)	1.7 (0.79 to 3.12)	1.9 (1.06 to 2.77)	3 (1.94 to 4)	3.12 (2.14 to 3.91)
Urine output, POD1 (mL/kg/hr)	3.74 (0.22 to 7.06)	3.94 (2.51 to 5.29)	1.95 (0.73 to 4.00)	2.45 (0.95 to 4.05)	4.57 (3.17 to 5.87)	3.90 (2.76 to 5.45)
Urine output, POD2 (mL/kg/hr)	6.5 (0.29 to 10.16)	4.45 (2.64 to 5.81)	2.66 (0.91 to 5.50)	3.37 (1.66 to 5.45)	5.17 (3.66 to 6.41)	4.04 (2.95 to 5.70)

DOS = day of surgery, POD = postoperative day, cFO = cumulative fluid overload.

Data are presented as median and interquartile range. All comparisons were made with patients without any complications by using Mann-Whitney *U* test.

Significant values are represented in bold at *p* < 0.05.

Stratégie de remplissage restrictive périopératoire

Fluid Overload Is Associated With Higher Mortality and Morbidity in Pediatric Patients Undergoing Cardiac Surgery*

Daniel J. Lex, MD¹; Roland Tóth, MD¹; Nikoletta R. Czobor, MD¹;
Stephen I. Alexander, MBBS, MPH, FRACP²; Tamás Breuer, MD, PhD³; Erzsébet Sápi, MD³;
András Szatmári, MD, PhD⁴; Edgár Székely, MD³; János Gál, MD, PhD⁵; Andrea Székely, MD, PhD^{3,5}

PCCM 2016

EN pratique:

- Contrôle du BES intraopératoire
- Objectifs de CEC: SvO₂? NIRS? PAM?
- Stratégie de remplissage post opératoire:
 - Monitoring Lactates, SVO₂, ETT+++
 - Petites doses de vasopresseurs si besoin
 - HSHC
 - Furosémide 2mg/kg/jour continu
 - < 5% d'EER sur 10 ans



Effect of Intraoperative Dexamethasone on Major Complications and Mortality Among Infants Undergoing Cardiac Surgery: The DECISION Randomized Clinical Trial

Vladimir Lomivorotov^{1 2}, Igor Kornilov¹, Vladimir Boboshko¹, Vladimir Shmyrev¹, Ilya Bondarenko¹, Ilya Soynov¹, Alexey Voytov¹, Stanislav Polyanskiy¹, Oleg Strunin¹, Alexander Bogachev-Prokophiev¹, Giovanni Landoni^{3 4}, Caetano Nigro Neto⁵, Gretel Oliveira Nicolau⁵, Leonardo Saurith Izquierdo⁵, Vinícius Nogueira Nascimento⁵, Zhang Wen⁶, Hu Renjie⁶, Zhang Haibo⁶, Vladlen Bazylev⁷, Mikhail Evdokimov⁷, Shahriyar Sulejmanov⁷, Aleksei Chernomirnyy⁷, Dmitry Bogdanov¹

Affiliations + expand

PMID: 32573670 PMCID: PMC7211111

Abstract

Importance: Corticosteroids are used to suppress the inflammatory response and to reduce

Conclusions and relevance: Among infants younger than 12 months undergoing cardiac surgery with cardiopulmonary bypass, intraoperative administration of dexamethasone, compared with placebo, did not significantly reduce major complications and mortality at 30 days. However, the study may have been underpowered to detect a clinically important difference.

Trial registration: ClinicalTrials.gov Identifier: [NCT02615262](https://clinicaltrials.gov/ct2/show/study/NCT02615262).

Objective: To determine whether intraoperative administration of dexamethasone is more effective than placebo for reducing major complications and mortality during pediatric cardiac surgery.

Design, setting, and participants: The Intraoperative Dexamethasone in Pediatric Cardiac Surgery was an investigator-initiated, double-blind, multicenter randomized trial that involved 4 centers in China, Brazil, and Russia. A total of 394 infants younger than 12 months, undergoing cardiac surgery with cardiopulmonary bypass were enrolled from December 2015 to October 2018, with follow-up completed in November 2018.

ORIGINAL ARTICLE

Methylprednisolone for Heart Surgery in Infants — A Randomized, Controlled Trial

K.D. Hill, P.J. Kannankeril, J.P. Jacobs, H.S. Baldwin, M.L. Jacobs, S.M. O'Brien, D.P. Bichel, E.M. Graham, B. Blasiole, A. Resheidat, A.S. Husain, S.R. Kumar, J.L. Kirchner, D.S. Gallup, J.W. Turek, M. Bleiweis, B. Mettler, A. Benscoter, E. Wald, T. Karamlou, A.H. Van Bergen, D. Overman, P. Eghtesady, R. Butts, J.S. Kim, J.P. Scott, B.R. Anderson, M.F. Swartz, P.I. McConnell, D.F. Vener, and J.S. Li, for the STRESS Network Investigators*

Méthylprednisolone 30mg/kg

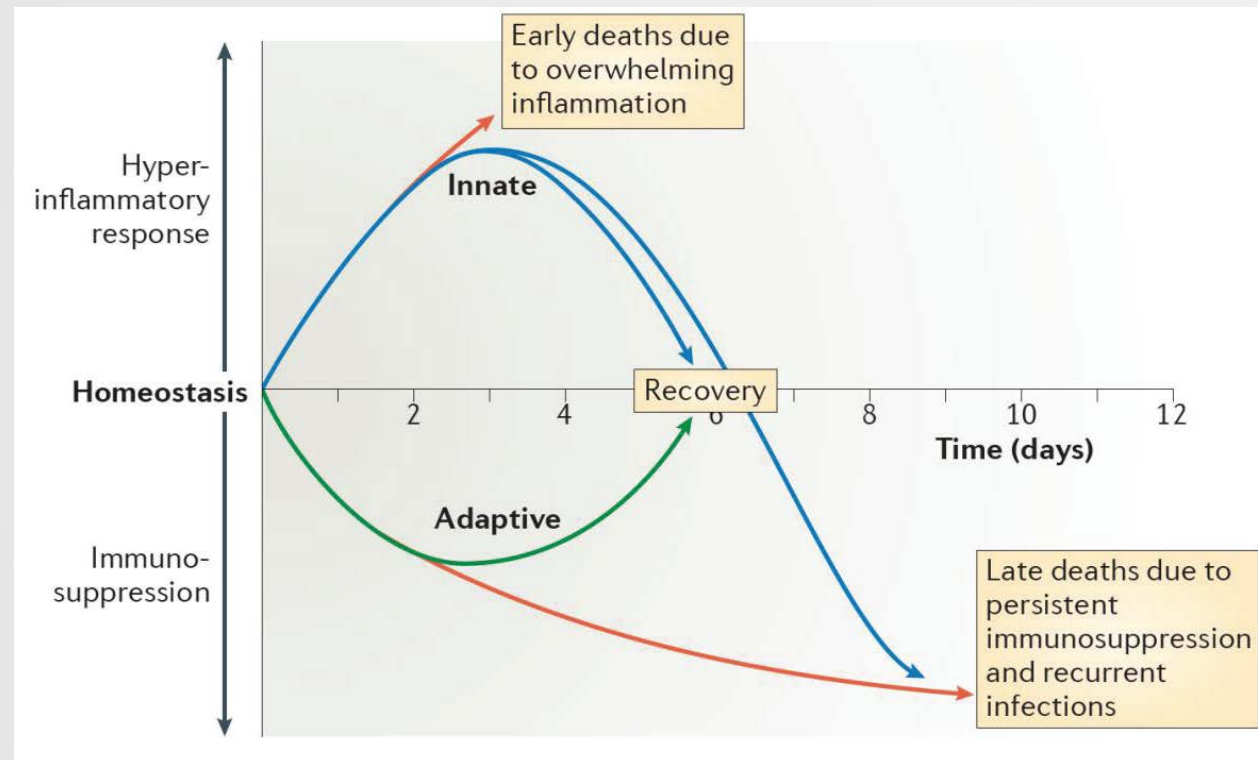
Table 2. Components of the Primary End Point with Global Rank.

End-Point Event	Rank According to Level of Prioritization	Methylprednisolone (N = 599)	Placebo (N = 601)
		<i>no. of infants (%)</i>	
Operative death	97	12 (2.0)	17 (2.8)
Heart transplantation during hospitalization	96	3 (0.5)	7 (1.2)
Kidney failure with permanent dialysis, neurologic deficit persistent at discharge, or respiratory failure warranting tracheostomy	95	4 (0.7)	8 (1.3)
Postoperative mechanical circulatory support or unplanned cardiac reoperation, exclusive of reoperation for bleeding	94	44 (7.3)	36 (6.0)
Reoperation for bleeding, unplanned delayed sternal closure, or unplanned interventional cardiac catheterization after surgery	93	12 (2.0)	30 (5.0)
Postoperative cardiac arrest, multisystem organ failure, kidney failure with temporary dialysis, or mechanical ventilator support for more than 7 days	92	24 (4.0)	22 (3.7)
Postoperative length of hospital stay			
>90 days	91	4 (0.7)	2 (0.3)
81 to 90 days	81 to 90	0	1 (0.2)
71 to 80 days	71 to 80	0	0
61 to 70 days	61 to 70	2 (0.3)	5 (0.8)
51 to 60 days	51 to 60	5 (0.8)	3 (0.5)
41 to 50 days	41 to 50	6 (1.0)	7 (1.2)
31 to 40 days	31 to 40	14 (2.3)	18 (3.0)
21 to 30 days	21 to 30	44 (7.3)	46 (7.7)
11 to 20 days	11 to 20	115 (19.2)	112 (18.6)
0 to 10 days	0 to 10	310 (51.8)	287 (47.8)

Monocytic Human Leukocyte Antigen DR Expression in Young Infants Undergoing Cardiopulmonary Bypass

Alexis Chenouard, MD, PhD, Marie Rimbart, PharmD, PhD, Nicolas Joram, MD, Cécile Braudeau, PhD, Antoine Roquilly, MD, PhD, Pierre Bourgoin, MD, and Karim Asehnoune, MD, PhD, for the ImmunoPed Group^{a,e,f}

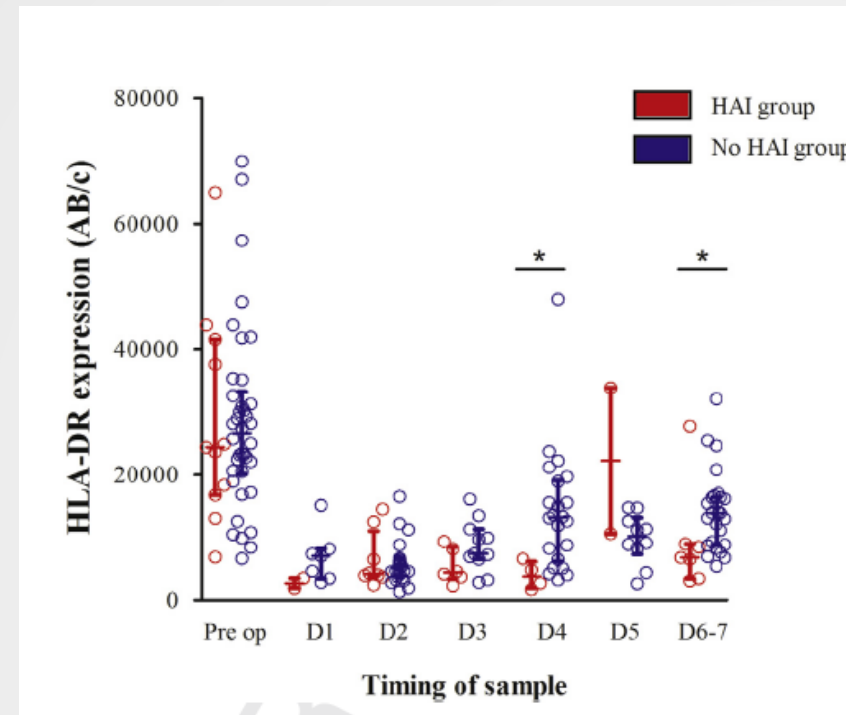
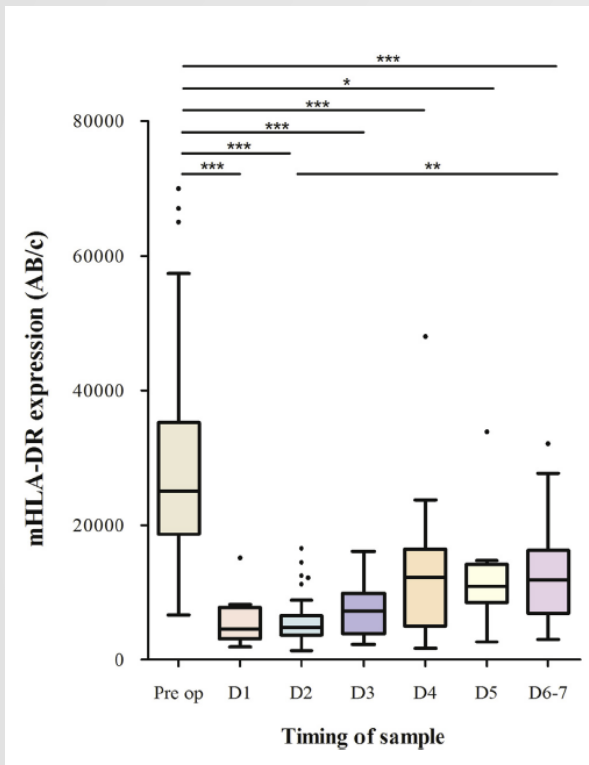
CHU Nantes, Service de Réanimation Pédiatrique, Nantes, France; CHU Nantes, Laboratoire d'Immunologie, CIMNA, Nantes, France; Centre de Recherche en Transplantation et Immunologie, UMR 1064, INSERM, Université de Nantes, Nantes, France; and CHU Nantes, Pôle anesthésie réanimations, Service d'anesthésie réanimation chirurgicale, Hôtel Dieu, Nantes, France



Monocytic Human Leukocyte Antigen DR Expression in Young Infants Undergoing Cardiopulmonary Bypass

Alexis Chenouard, MD, PhD, Marie Rimbert, PharmD, PhD, Nicolas Joram, MD, Cécile Braudeau, PhD, Antoine Roquilly, MD, PhD, Pierre Bourgoignie, MD, and Karim Asehnoune, MD, PhD, for the ImmunoPed Group^{a,e,f}

CHU Nantes, Service de Réanimation Pédiatrique, Nantes, France; CHU Nantes, Laboratoire d'Immunologie, CIMNA, Nantes, France; Centre de Recherche en Transplantation et Immunologie, UMR 1064, INSERM, Université de Nantes, Nantes, France; and CHU Nantes, Pôle anesthésie réanimations, Service d'anesthésie réanimation chirurgicale, Hôtel Dieu, Nantes, France



Post Operative Hydrocortisone?

Randomized Controlled Trial > [Pediatr Crit Care Med.](#) 2015 Sep;16(7):629-36.

doi: 10.1097/PCC.0000000000000426.

Postoperative Hydrocortisone Infusion Reduces the Prevalence of Low Cardiac Output Syndrome After Neonatal Cardiopulmonary Bypass

Stephen M Robert ¹, Santiago Borasino, Robert J Dabal, David C Cleveland, Kristal M Hock, Jeffrey A Alten

Affiliations + expand

PMID: 25901540 DOI: [10.1097/PCC.0000000000000426](#)

Conclusions: Prophylactic, postoperative hydrocortisone reduces low cardiac output syndrome, improves fluid balance and urine output, and attenuates inflammation after neonatal cardiopulmonary bypass surgery. Further studies are necessary to show if these benefits lead to improvements in more important clinical outcomes.

Design: Double-blind, randomized control trial.

Setting: Pediatric cardiac ICU and operating room in tertiary care center.

Patients: Forty neonates undergoing cardiac surgery with cardiopulmonary bypass were randomized (19 hydrocortisone and 21 placebo). Demographics and known risk factors were similar between groups.

Interventions: After cardiopulmonary bypass separation, bolus hydrocortisone (50 mg/m²) or placebo was administered, followed by continuous hydrocortisone infusion (50 mg/m²/d) or placebo tapered over 5 days. Adrenocorticotrophic hormone stimulation testing (1 µg) was performed before and after cardiopulmonary bypass, prior to steroid administration. Blood was collected for cytokine analysis before and after cardiopulmonary bypass.

Sortie de CEC

- Risque de défaillance VG (rare si intervention précoce)
 - Respect d'un délai d'assistance (peut inclure la fin de la chirurgie)
 - Intérêt de mesure de POG en sortie de CEC. « Exposition progressive » aux RVS
 - Stratégie prophylactique par milrinone
- Risque d'HTAP
 - NO en salle, non systématique
- Risque hémorragique
 - TEG délocalisé ?
 - « Leçons » des études TEG: Fibrinogène/ Plaquettes
- Hématocrite cible 35-40%
- Homéostasie ionique (Ca++, K+)

Efficacy and Safety of Milrinone in Preventing Low Cardiac Output Syndrome in Infants and Children After Corrective Surgery for Congenital Heart Disease

Timothy M. Hoffman, Gil Wernovsky, Andrew M. Atz, Thomas J. Kulik, David P. Nelson, Anthony C. Chang, James M. Bailey, Akbar Akbary, John F. Kocsis, Raymond Kaczmarek, Thomas L. Spray and David L. Wessel

Circulation. 2003;107:996-1002; originally published online February 10, 2003;

doi: 10.1161/01.CIR.0000051365.81920.28

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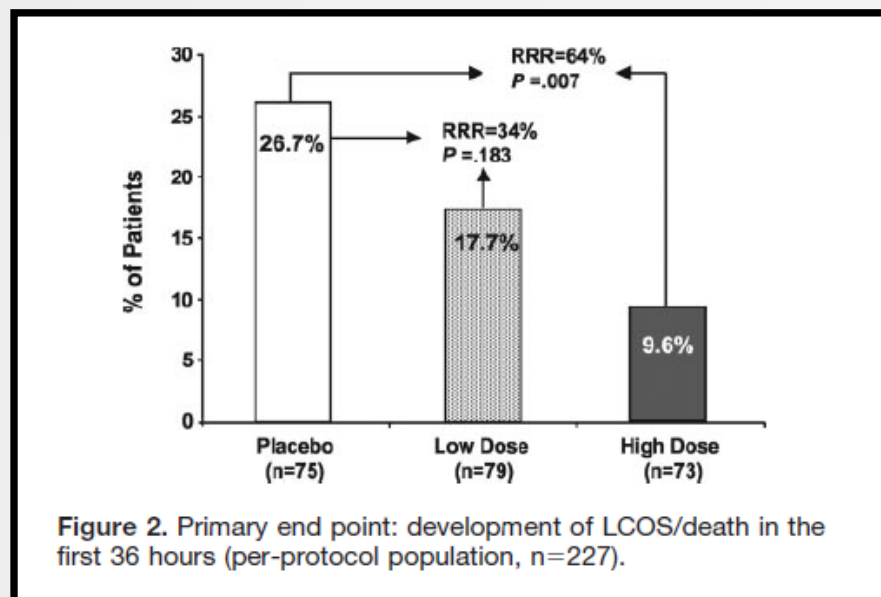
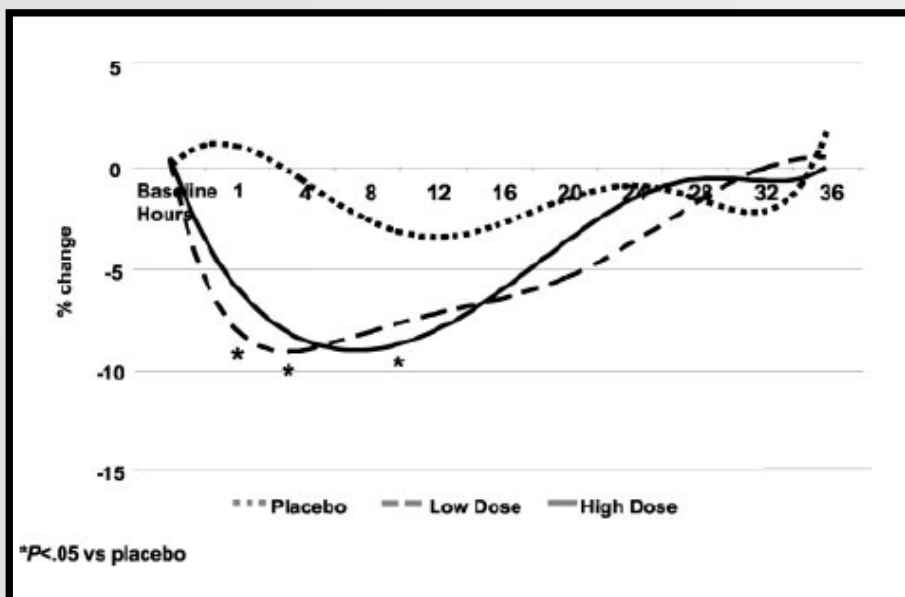
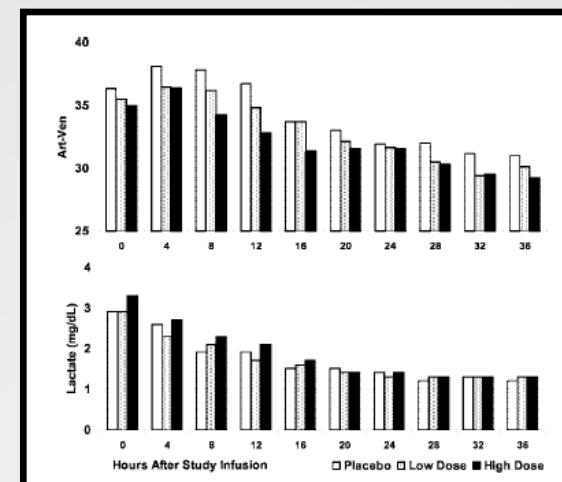
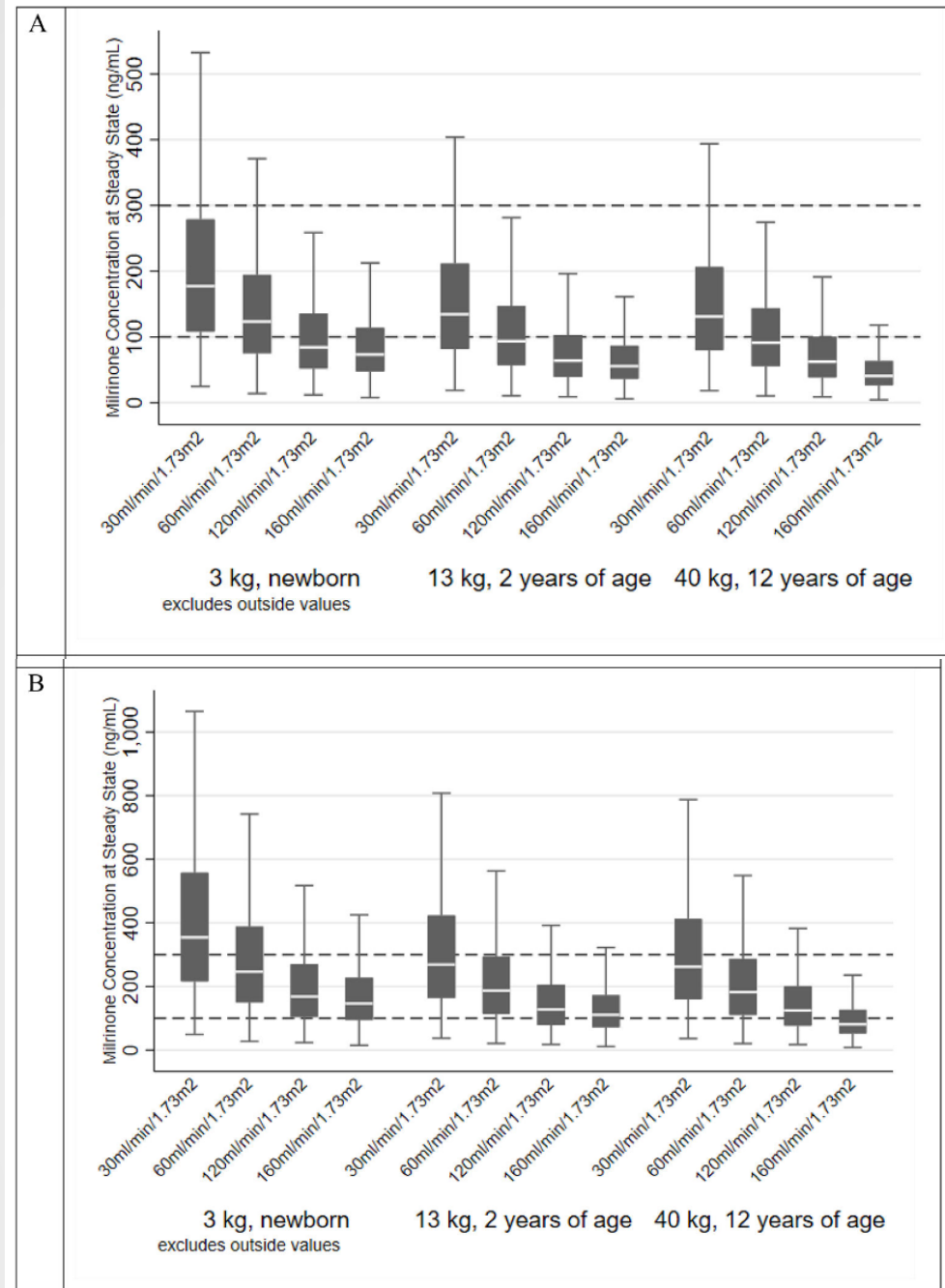


Figure 2. Primary end point: development of LCOS/death in the first 36 hours (per-protocol population, n=227).

0.25 µg/kg/h

■ 0.50 µg/kg/h

Population Pharmacokinetics of
Milrinone in Infants, Children,
and Adolescents
Christoph P. Hornik, 2019





The Perspective of the Intensivist on Inotropes and Postoperative Care Following Pediatric Heart Surgery: An International Survey and Systematic Review of the Literature

World Journal for Pediatric and Congenital Heart Surgery
2018, Vol. 9(1) 10-21
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DOI: 10.1177/2150135117731725
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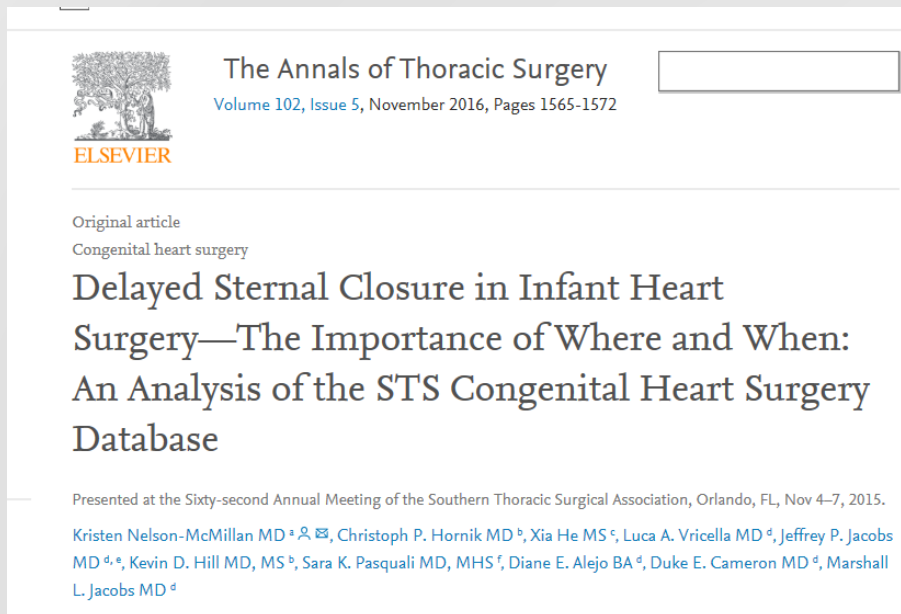
SAGE



Peter P. Roeleveld, MD¹ , and J. C. A. de Klerk, MD²

Notre pratique:

- Milrinone systématique (pour post op TGA!)
- Infusion 0.5 mcg/kg/min pendant 1 heure, fin de CEC
- Adrénaline diluée 1 cc/h = 0.05 mcg/kg/min. En moyenne: 0.02 mcg/kg/min
- En réanimation:
 - Sevrage de milrinone peut être débuté à h12
 - Attention aux surdosages en cas d'IR
 - Attention au sevrage si HTAP
 - Possible adjonction de mini doses de NAD (0.02 à 0.2 mcg/kg/min) en cas de profil normo/hyperkinétique avec diastoliques basses ET oligurie.
 - HSHC rapidement

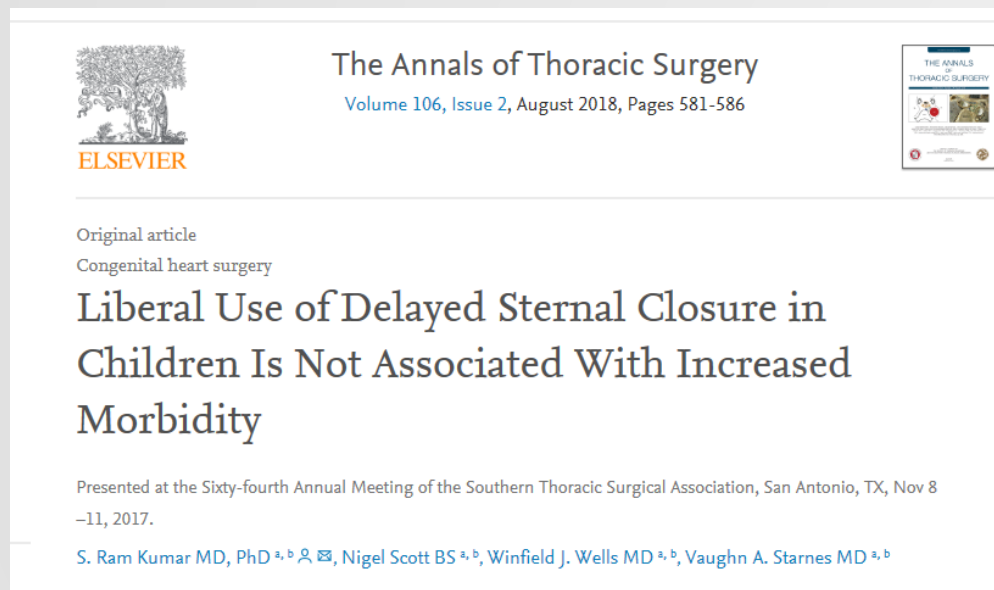


Notre attitude:

TGA simple: ~20% DST

TGA/ VSD/other defect:~30-50% DST

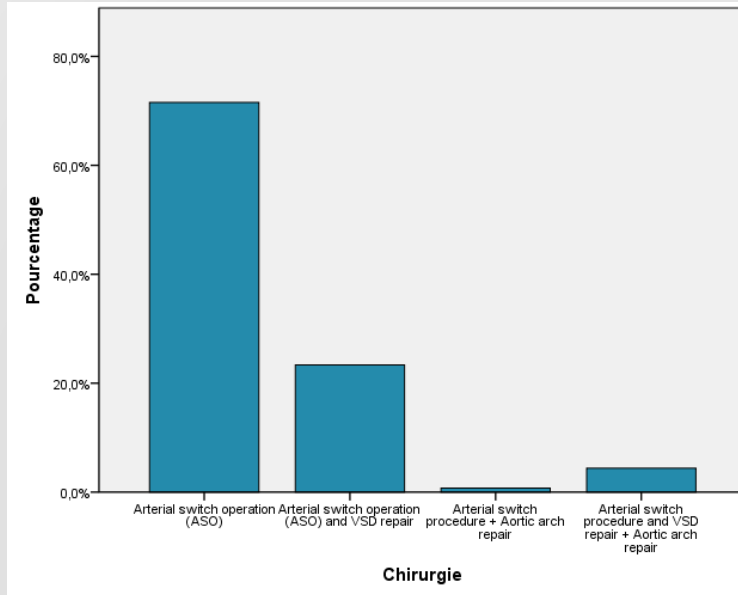
- Planned: Defects associés, risque coronarien.
- Sortie de CEC: Fonction VD, HTAP, Saignement, durée de CEC, épreuve de fermeture, niveau d'amines, compliance pulmonaire: Evaluation risque/ bénéfice AR/ chirurgical
- Intérêt de la POG pour guider?



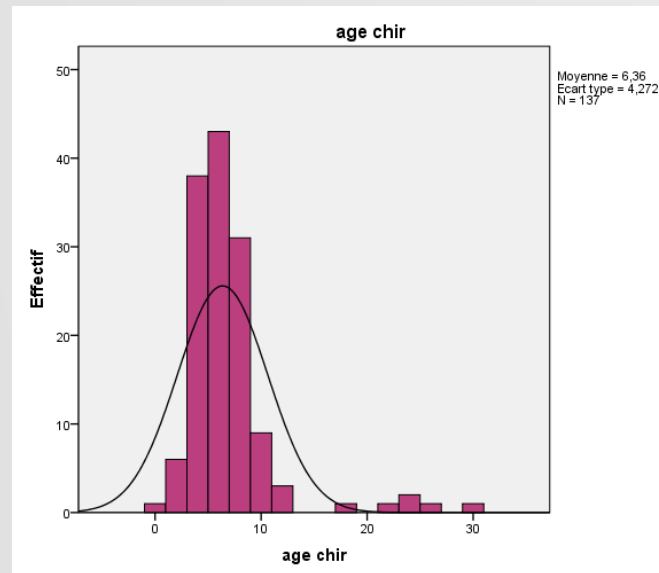
Données locales



European Congenital Heart
Surgeons Association



2010-2020: N=137 TGA <28j



Mortalité globale à J30: 2.2%. ECMO: N=4
(50% died) **Mortalité à 1 an: 4.4%**

Taux de complication (Exhaustivité >2014):
soit N=100. 1 décès.

Permanent PM: N=3

Bleeding req. Reintervention: N=3

Diaphragmatic paralysis: N=9

EER: N=2

Cardiac reintervention: N=4

Cathlab: N=3

Noncardiac reintervention: N=2

Chylothorax: N=5

ANE: n=6

Original Article

Perioperative Outcomes in Congenital Heart Disease: A Review of Clinical Factors Associated With Prolonged Ventilation and Length of Stay in Four Common CHD Operations

A. Rebecca L. Hamilton, MD, MSc^{*,†,1}, Koichi Yuki, MD, MBA[†],
Francis Fynn-Thompson, MD[‡], James A. DiNardo, MD[§],
Kirsten C. Odegard, MD, MBA[§]

^{*}*Division of Cardiac Anesthesia, Department of Anesthesia and Pain Medicine, Hospital for Sick Children;
Department of Anesthesiology, University of Toronto, Toronto, Ontario, Canada*

[†]*Department of Cell and Molecular Biology, Karolinska Institute, Stockholm, Sweden*

[‡]*Department of Cardiac Surgery, Boston Children's Hospital; Department of Surgery, Harvard Medical
School, Boston, MA*

[§]*Division of Cardiac Anesthesia, Department of Anesthesiology, Critical Care and Pain Medicine, Boston
Children's Hospital; Department of Anaesthesia, Harvard Medical School, Boston, MA*

TGA-IVS and TGA-VSD

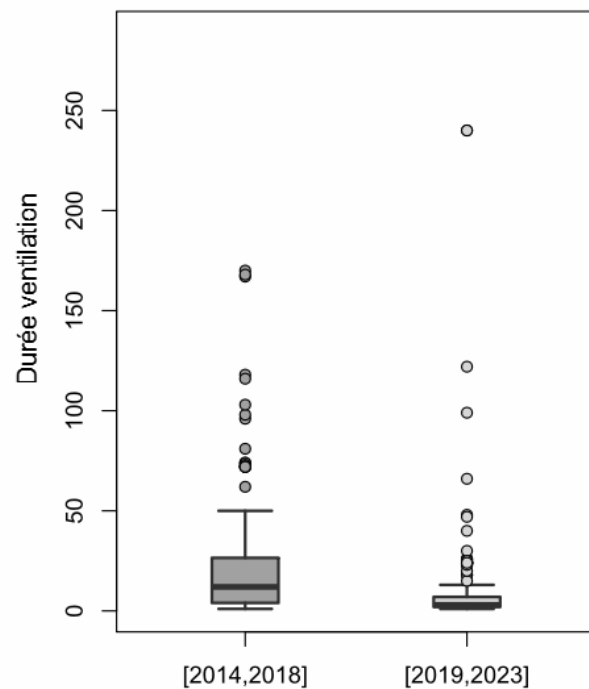


Centre	N	Surv.	Age (days)	Weight (Kg)	CPB (min)-ACC (min)	MV (hours)	LOS: ICU days	LOS: Hospital
Boston 2015-2020	143	97.9%	4.3[1.2-73]	3.2[1.4(?)-8.2]	201-134	89 [14-380]	5.9[0.7-166]	15.2[1.38-167]
Boston 2015-2020 Reference group			4.9	3.3	191-130	83	4.97	13.3
Nantes 2014-2018	74	94.6%	6 [4-8]	3.3 [3-3.8]	180-95 158 [136-208]	80 61[43-93]	9.1 6[5-10]	17.9 14[11-19]
Nantes 2019-2023	71	94.3%	7[5-13.7]	3.4[3.2-3.9]	194-112 189 [147-211]	71 48[23-96]	8.8 6.5[5-9.7]	17.8 13 (9-19)



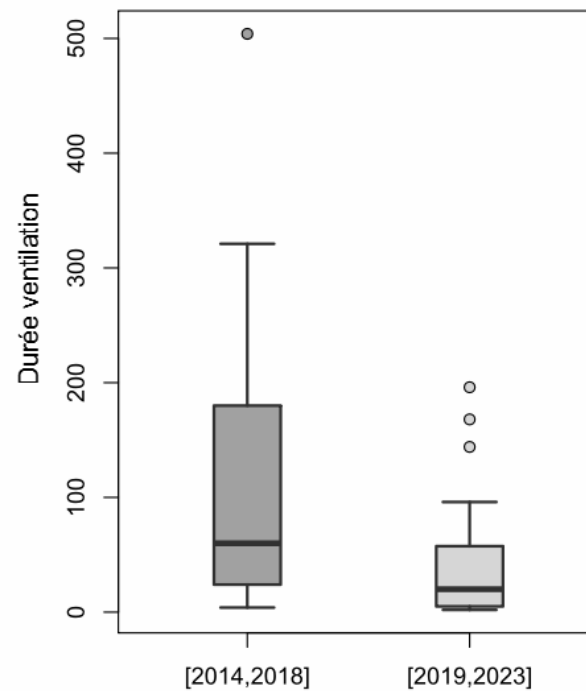
Durées de ventilation invasive

VSD



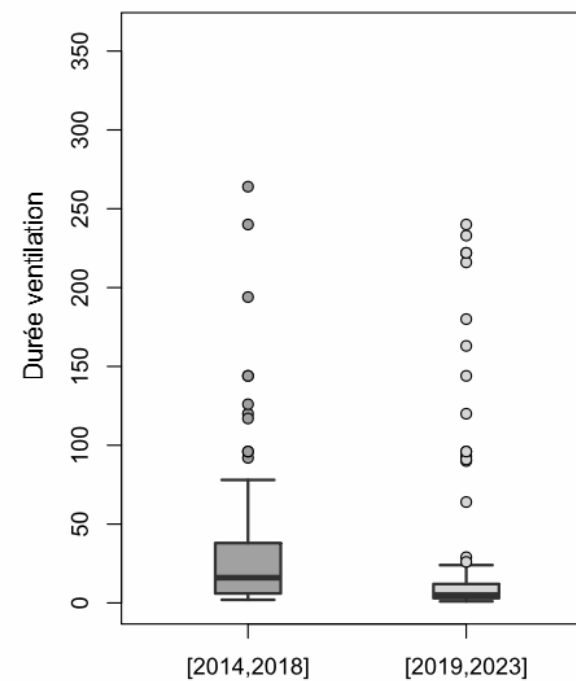
$P < 0.05$

CAVC



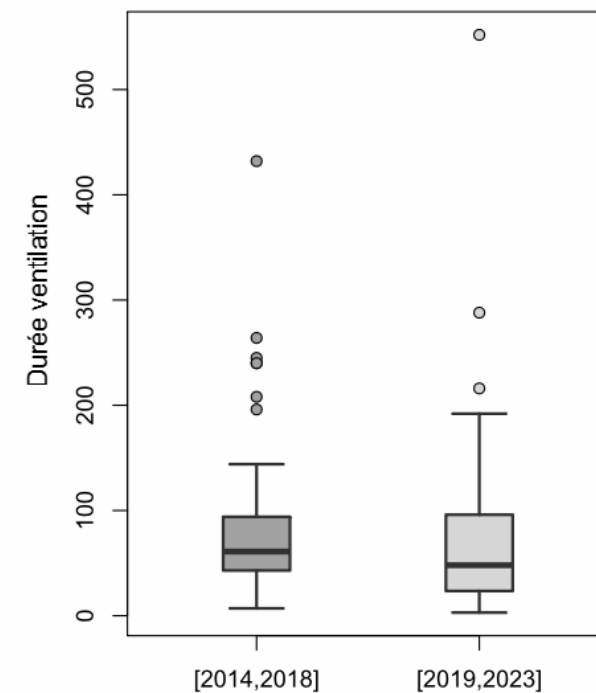
$P < 0.05$

TOF



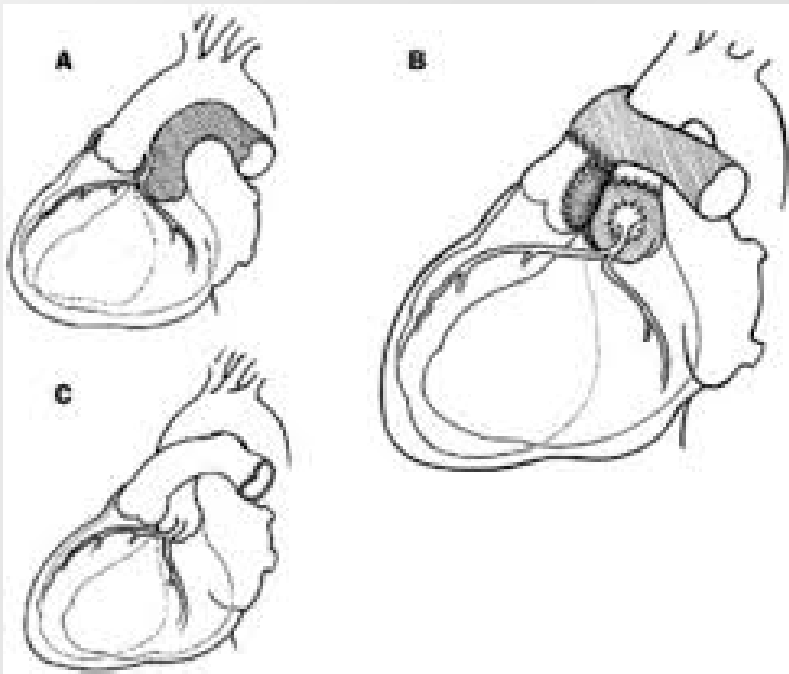
$P < 0.05$

TGA



$P = 0.119$

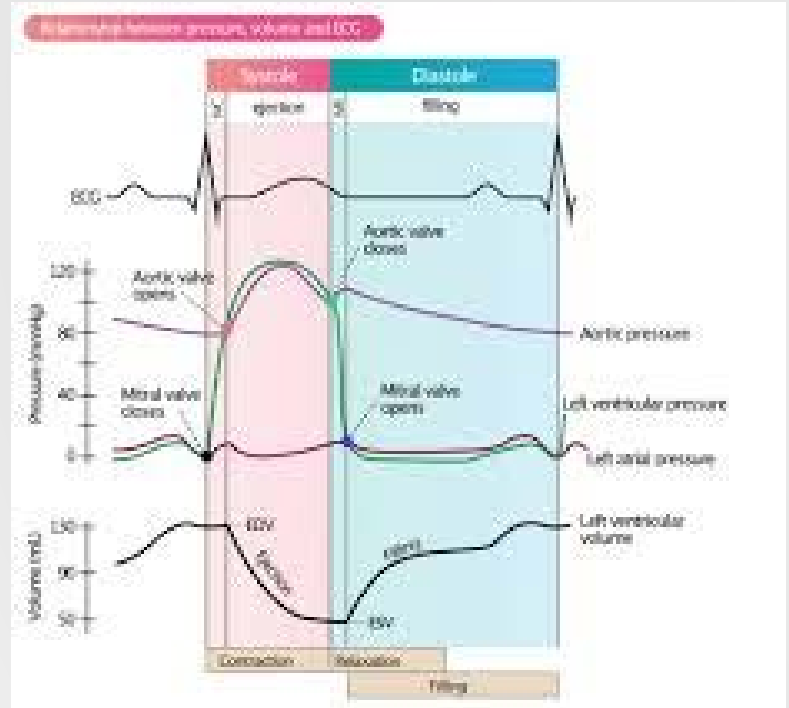
Intraoperative variables	Missing	DEX group n=213	NO DEX group N =213	Std diff†
CPB duration (min)	0	145±72	139±63	0.12
Aortic Clamp duration (min)	0	81±42	79±40	0.06
Minimal core temperature (°C)	0	33.7±3.2	32.3±3.8	0.31
Midazolam (µg/kg/h)	103 (24.2%)	107±81	186±66	-2.58
Sufentanil (µg/kg/h)	105 (24.6%)	0.85±0.58	1.17±1.05	-1.58
VIS (at PICU admission)	85 (24.6%)	7.7±4.5	8.1±5.9	-0.19
Outcomes	Missing	DEX group	NO DEX group	P-value
Serum lactate, max., day 0 (mmol/L)	16 (3.7%)	2.26±1.83	2.31±1.71	0.75
MV duration (hours)	0	20 [4-92]	26 [11-88]	0.07
PICU stay (days)	0	5 [4-8]	6 [4-9]	0.28
Hospital stay (days)	0	8 [6-13]	9 [7-16]	0.10
1 year Mortality	0	13 (6.1%)	11 (5.2%)	0.33
Post operative mechanical support	0	16 (7.5%)	12 (5.6%)	0.56
Sternum left open	0	44 (20.6%)	46 (21.6%)	0.93
Acute Kidney Injury (KDIGO)†	8 (1.9%)			
KDIGO Stage 0		93 (28.9%)	99 (30.7%)	0.82
KDIGO Stage 1		37 (11.4%)	34 (10.6%)	
KDIGO Stage 2		26 (8.1%)	20 (6.2%)	
KDIGO Stage 3		3 (1%)	10 (3.1%)	
Renal Replacement Therapy	0	5 (2.3%)	6 (2.8%)	0.97
Acute Neurologic Event*	0	12 (5.6%)	8 (3.8%)	0.49
POT	0	14 (6.6%)	31 (14.6%)	<0.01
Deep infection, mediastinitis	0	11 (5.2%)	13 (6.1%)	0.46



Réimplantation Coronaire

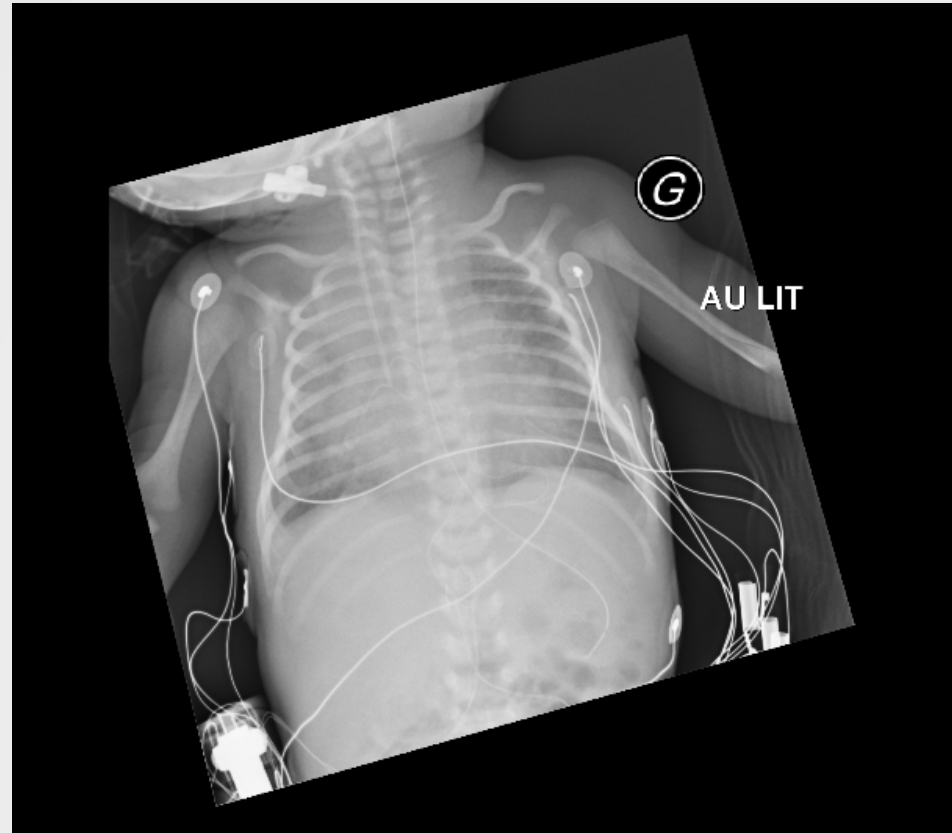
Thrombose, pressions
diastoliques, anomalies
coronariennes

Vigilance en post
opératoire

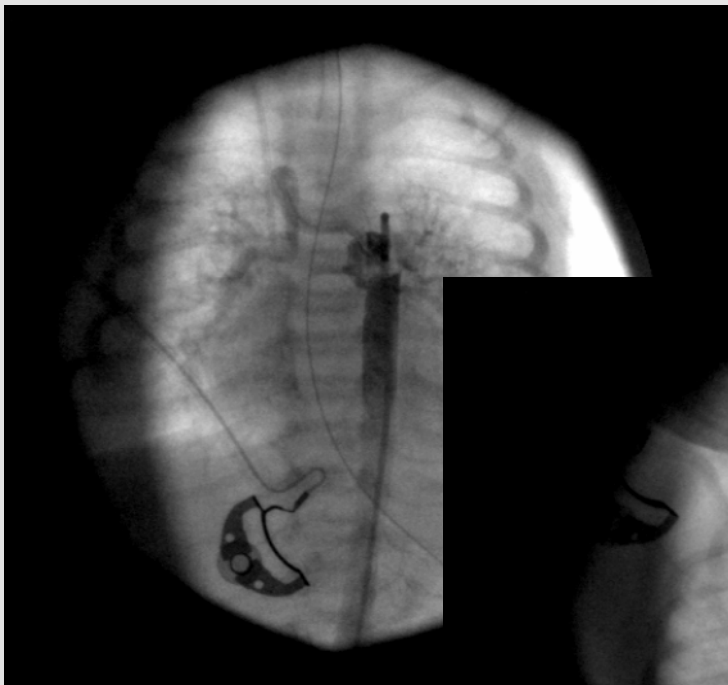


PTDVG/
Fonction/
troubles du
rythme

Post operative unusual PAH



... to the Cath Lab



Cas particulier:TGA-
IVS opérée
tardivement

Primary ASO?

**LV
reconditionning?
(PAB)**

Primary Arterial Switch Operation for Late Presentation of Transposition of the Great Arteries With Intact Ventricular Septum



Mauro Lo Rito, MD,^{*1} Irene Raso, MD,^{†,‡,1} Antonio Saracino, MD,[‡] Domenica Paola Basile, MD,[‡] Alessandro Varrica, MD PhD,^{*} Matteo Realì, MD,^{*} Mario Carminati, MD,[‡] Alessandro Frigiola, MD,^{*} and Alessandro Giamberti, MD^{*}

Semin Cardiovasc Surg 2022

Table 1. Baseline Characteristics of the 45 Patients Undergoing Late Arterial Switch Operation With a Comparison Between Groups

Preoperative Characteristics	Favorable – TGA (n = 29 pts)	Unfavorable -TGA (n = 16 pts)	Total (n = 45 pts)	P-values
Age at ASO (days)	37 (28-50)	32.5 (25-72)	35 (27-52)	0.721
Weight (kg)	3.50 (3.2-4.1)	3.60 (3.4-4.3)	3.60 (3.2-4.1)	0.339
Height (cm)	52 (51-55)	53 (50-56)	52 (51-55)	0.923
Gender (male/female)	19/10	12/4	31/14	0.738
BSA (kg/m ²)	0.23 (0.22-0.25)	0.23 (0.22-0.26)	0.23 (0.22-0.25)	0.569
Sat O2 at admission (%)	72% (17)	68% (11)	70% (11)	0.558
PDA > 2.5 mm 😊	10 (37.0%)	1 (6.3%)	11 (25.6%)	0.03
Coronary Arteries (Yacoub classification)				
A (%)	18 (62.1%)	11 (68.8%)	29 (64.4%)	0.63
B (%)	3 (10.3%)	0 (0%)	3 (6.7%)	
C (%)	1 (3.4%)	0 (0%)	1 (2.2%)	
D (%)	6 (20.7%)	3 (18.8%)	9 (20%)	
E (%)	1 (3.4%)	2 (12.5%)	3 (6.7%)	
High risk coronary artery (%)	4 (13.8%)	2 (12.5%)	6 (13.3%)	1.00
Echocardiographic evaluation of LV preparedness				<0.001
LV geometry 😊				
Favorable	7 (26.9%)	—	7 (16.7%)	
Acceptable	15 (57.7%)	—	15 (35.7%)	
Unfavorable	4 (15.4%)	16 (100%)	20 (47.6%)	
LV mass				<0.001
≤ 35 g/m ²	7 (26.9%)	16 (100%)	23 (54.8%)	
> 35 g/m ² 😊	19 (73.1%)	—	19 (45.2%)	
Banana-shape of the septum 😊	12 (46.2%)	16 (100%)	28 (66.7%)	<0.001

Categorical variables are expressed as numbers and percentages (P-values assessed with Chi-squared or Fisher exact test as appropriate). Continuous variables are expressed as median and IQR (P-values assessed with Wilcoxon rank-sum test).

Primary Arterial Switch Operation for Late Presentation of Transposition of the Great Arteries With Intact Ventricular Septum



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Table 2. Operative and Postoperative Results of Late ASO

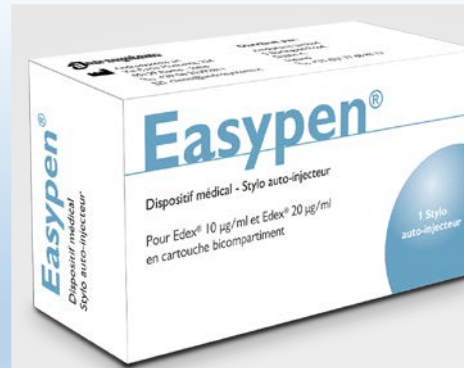
Variables	Favorable – TGA (n = 29 pts)	Unfavorable -TGA (n = 16 pts)	Total (n = 45 pts)	P-values
Cardiopulmonary bypass (min)	146 (133-160)	153 (132-173)	150 (133-165)	0.51
Aortic crossclamp (min)	73 (68-80)	72 (64-83)	73 (66-82)	0.70
Chest open (n/%)	15 (51.7%)	10 (62.5%)	25 (55.6%)	0.54
Chest open duration (days)	2 (2-3)	4 (3-6)	3 (2-4)	0.06
Mechanical ventilation (hours)	100 (67-140)	129 (83-164)	115 (72-144)	0.47
ICU stay (days)	7 (6-11)	7 (6-11)	7 (6-11)	0.38
Hospital stay (days)	23 (21-30)	23 (18-32)	23 (20-31)	0.97
Complications (n/%)				
Neurological damage	5 (17.2%)	3 (18.8%)	8 (17.8%)	1.00
Ischemia	1 (3.4%)	0 (0%)	1 (2.2%)	1.00
Sepsis	2 (6.9%)	1 (6.3%)	3 (6.7%)	1.00
Arrhythmia	2 (6.9%)	1 (6.3%)	3 (6.7%)	1.00
Delayed wound infection	0 (0%)	2 (12.5%)	2 (4.4%)	0.12
Mediastinitis	1 (3.4%)	2 (12.5%)	3 (6.7%)	0.29
Chylothorax	3 (10.3%)	1 (6.3%)	4 (8.9%)	1.00
ECMO (n/%)	2 (6.9%)	3 (18.8%)	5 (11.1%)	0.33
ECMO duration (days)	6 (4-9)	5 (5-7)	5 (5-7)	0.82
In-hospital mortality 	1 (3.4%)	0 (0%)	1 (2.2%)	1.00

ASO: arterial switch operation. ECMO: extracorporeal membrane oxygenation. ICU: intensive care unit.

Categorical variables are expressed as numbers and percentages. Continuous variables are expressed as median and IQR.



- Naissance à terme, césarienne pour ARCF en clinique
- Maman G3P3
- MAVEU: ACR 3 min puis ROSC.

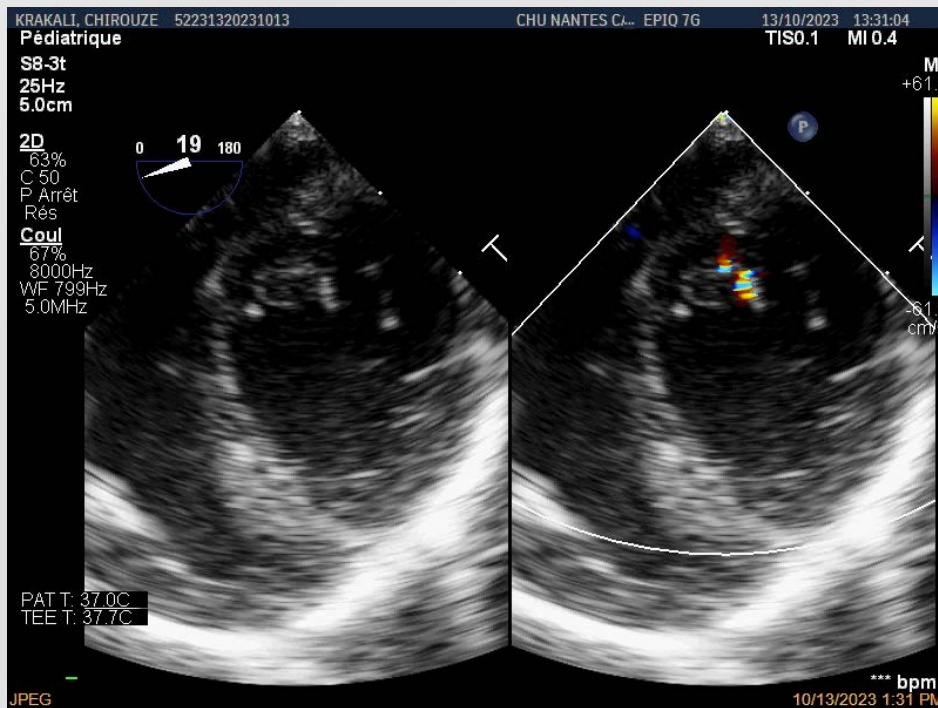


- A J3 transfert au CHU d'Abidjan pour une désaturation sévère.
- Hypotonie, teint cireux, « acide ».
- Diagnostique de TGA-IVS.
- Indication à BAS possible en présence de l'équipe
- Evolution favorable après BAS

- Admission Nantes à J26 de vie
- En état critique suite à la fermeture du CA
- ETT: Bonne FE bi V, FEVG 70%, masse VG 6.17g soit 28 g/m², courbure septale 2-3, pas d'aspect en banane. Mallignement commissural.
- ASO à J29

- Retour en clinique
- A j4: acidose, désaturation sévère
- FOP large
- Sous prostine





13h31 POG 24 mmHg

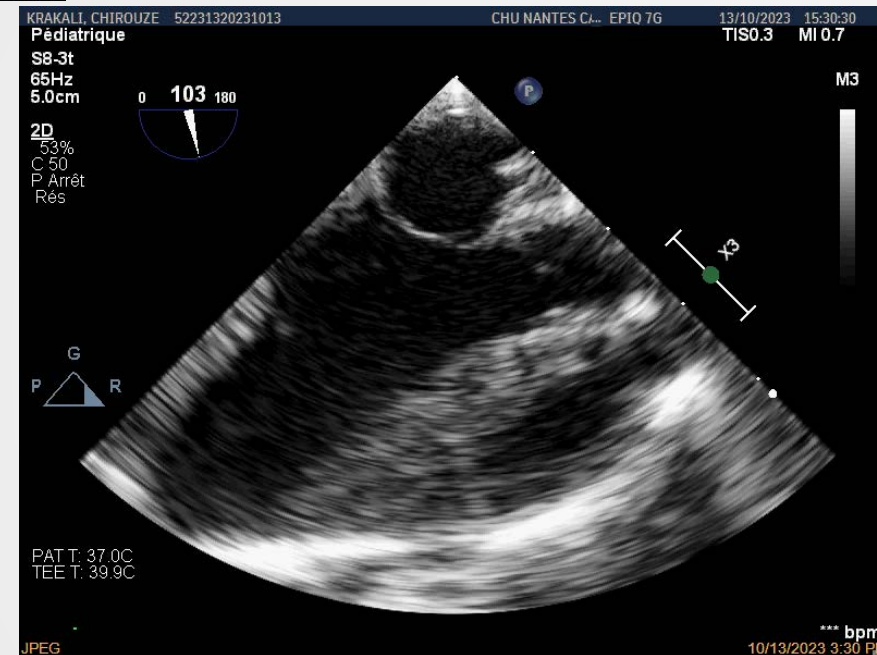
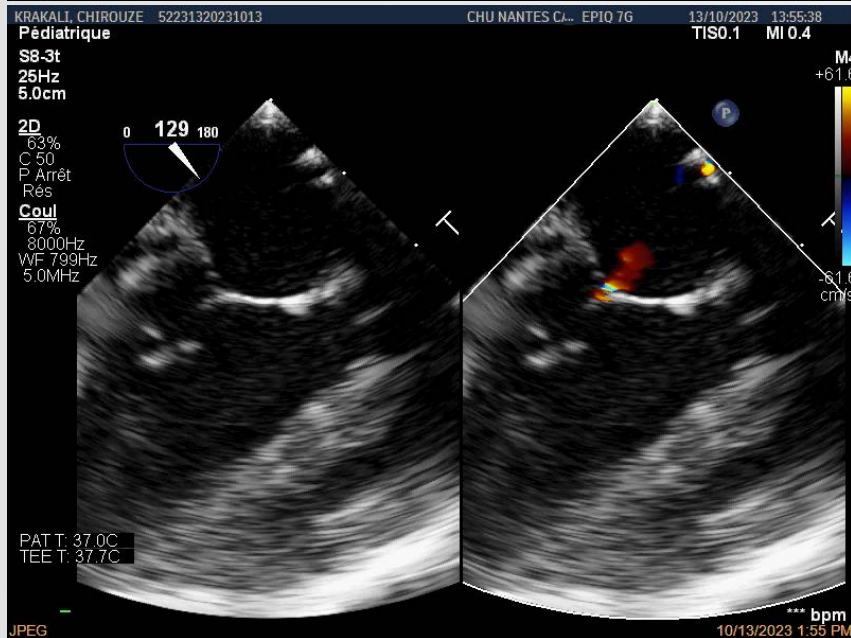
Milrinone 0.6 $\mu\text{g}/\text{kg}/\text{min}$

Adré 0.025 $\mu\text{g}/\text{kg}/\text{min}$

→ Décision de CEC d'assistance
prolongée

13h55 POG 19 mmHg

15h36 POG 12 mmHg Sortie thorax
ouvert



Suites opératoires.....

Fermeture sternale différée à J3

Sevrage d'adrénaline à J2, dose max 0.05 $\mu\text{g/kg/min}$

Introduction d'HSHC et de NAD à J0, 0.03 $\mu\text{g/kg/min}$

Sevrage de corotrope à J6, dose max 0.5 $\mu\text{g/kg/min}$

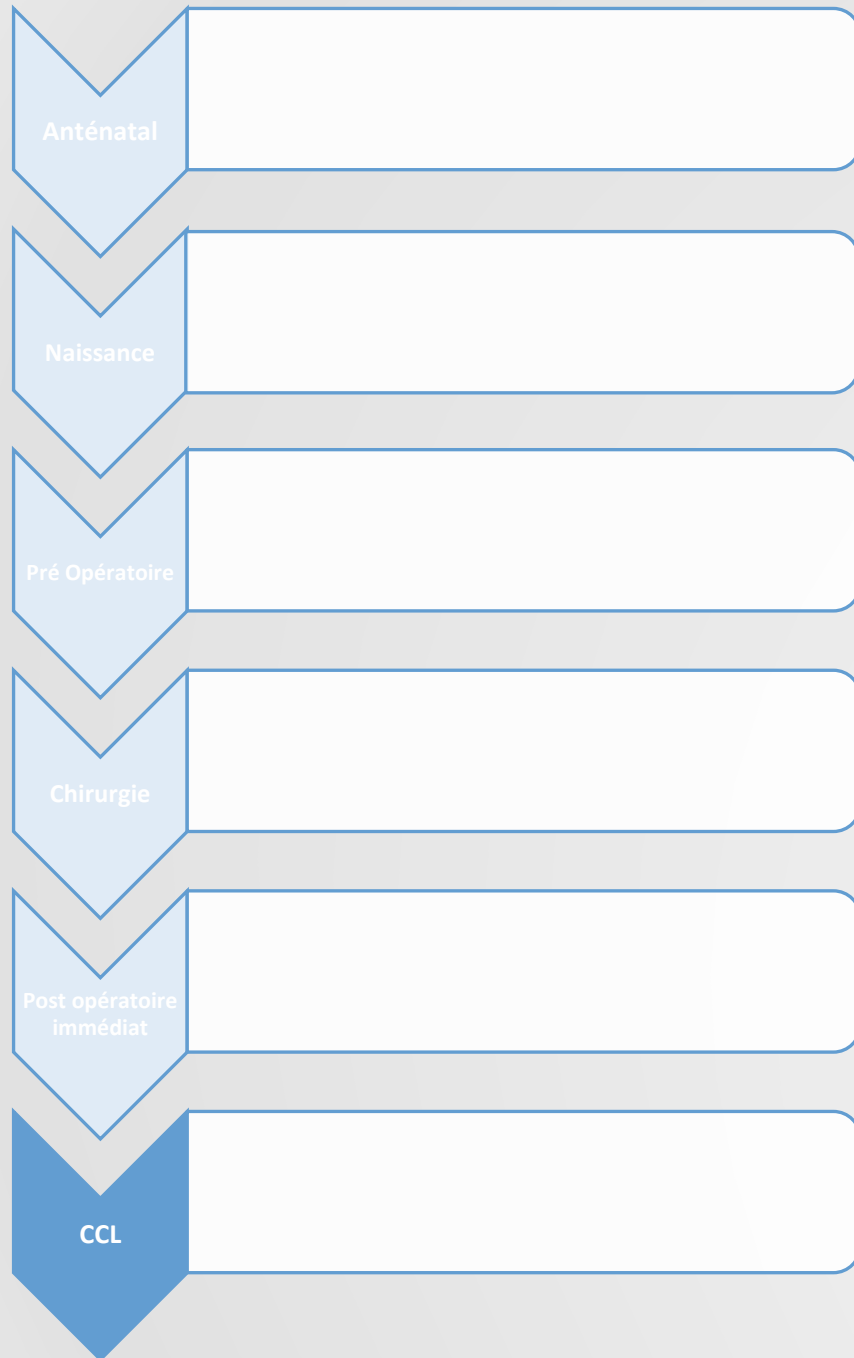
Extubation à J5. HTAP dans un contexte de collatérales suspectées, d'évolution favorable.

IRA aigüe post opératoire, non dialysée.
Hémolyse peropératoire. Reprise de diurèse à H8

Pas d'évènement neurologique (aEEGc, ETF, examen clinique). Sortie à domicile à J20.



Conclusion Anesthésie Réa



1. Prise en charge en milieu adapté. BAS indication large.
2. Pas de grande particularité anesthésique. Protocole d'équipe.
3. CEC: participe à la stratégie volumique restrictive.
4. CEC d'assistance. Guidée par la POG. ECMO après 2h d'assistance. Stratégie de prévention du LCOS
5. Stratégie postopératoire visant à optimiser la perfusion rénale.

- **Merci de votre attention. Questions, bibliographie**
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