Actualités Transfusionnelles en Chirurgie Cardiaque Pédiatrique

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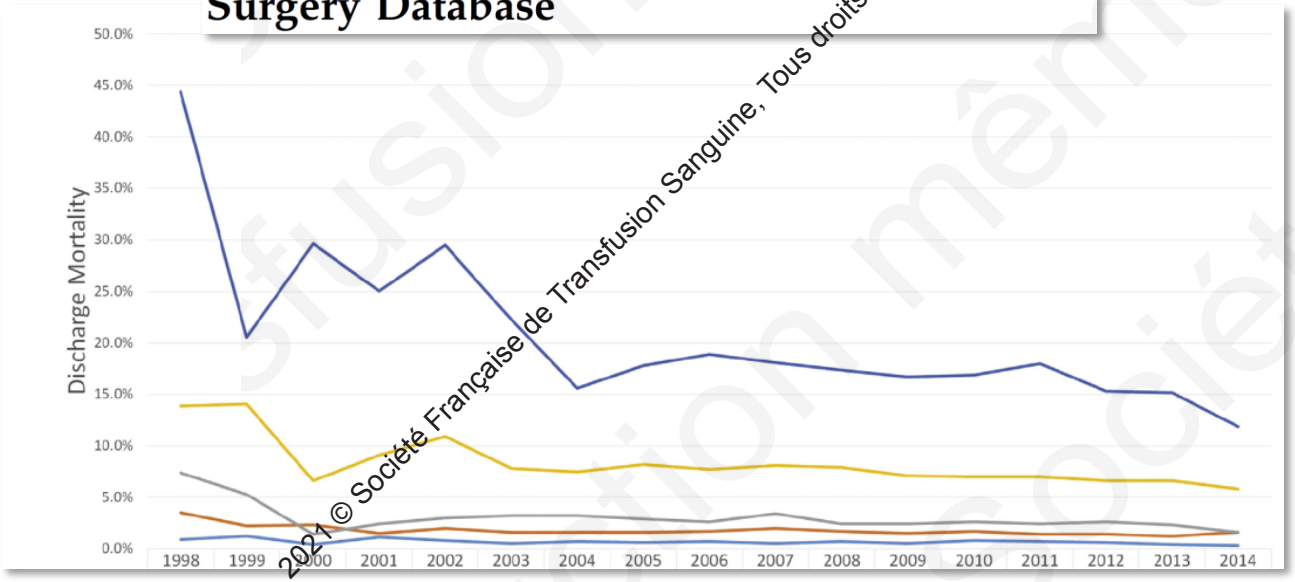
Etat des lieux

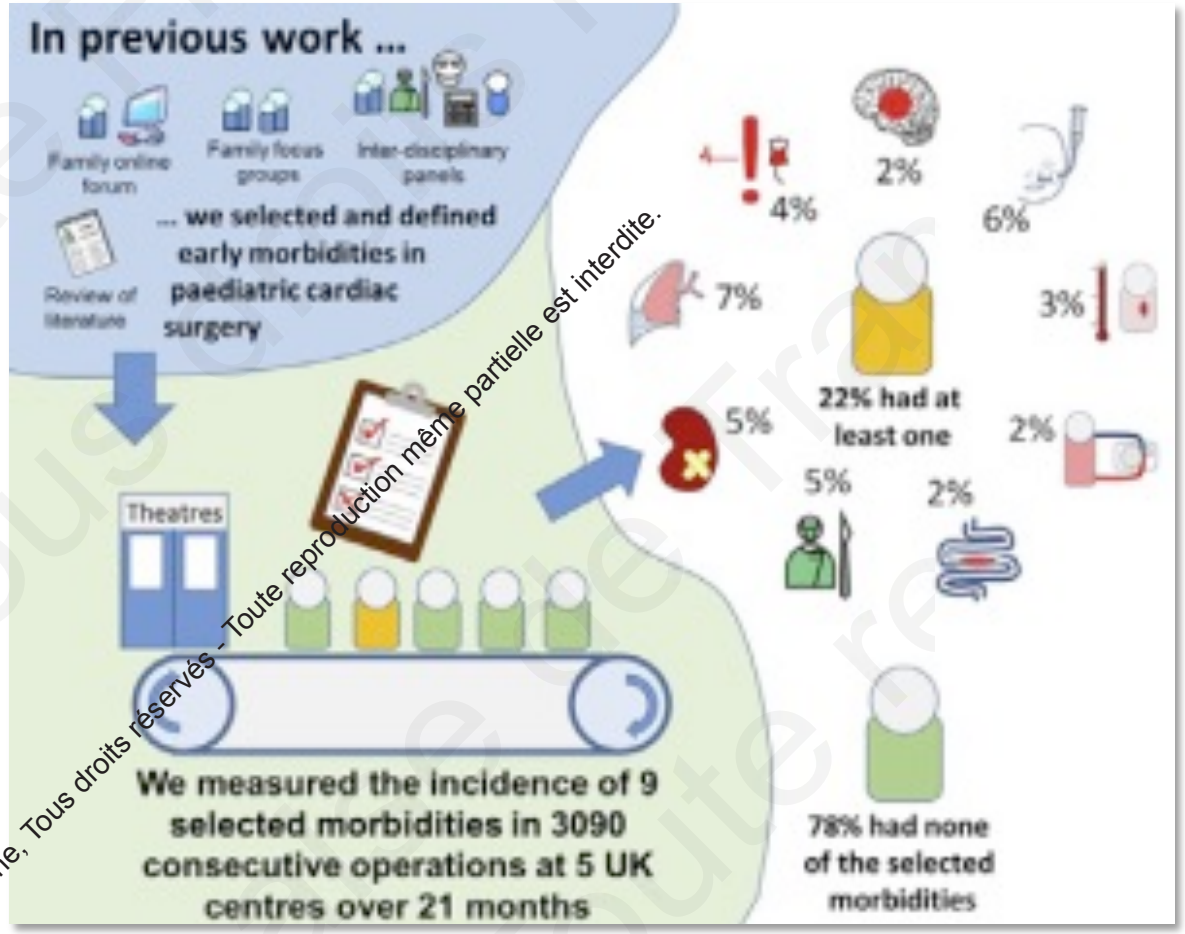
Mortality Trends in Pediatric and Congenital Heart Surgery: An Analysis of The Society of Thoracic Surgeons Congenital Heart Surgery Database



SCORE	Procedure exemple	Model based Mortality
STAT-1	ASD repair	0,3% (0,1 – 0,5%)
STAT-2	TOF repair (ventriculotomy transannular patch)	4,2% (2,4 – 6,4%)
STAT-3	Arterial Switch Operation	4,8% (3,9 – 5,7%)
STAT-4	Ross Kono procedure	9,4% (5,8 – 13,9%)
STAT-5	Norwood operation	23,6% (21,9 – 25,3%)

Incidence and risk factors for important early morbidities associated with pediatric cardiac surgery in a UK population

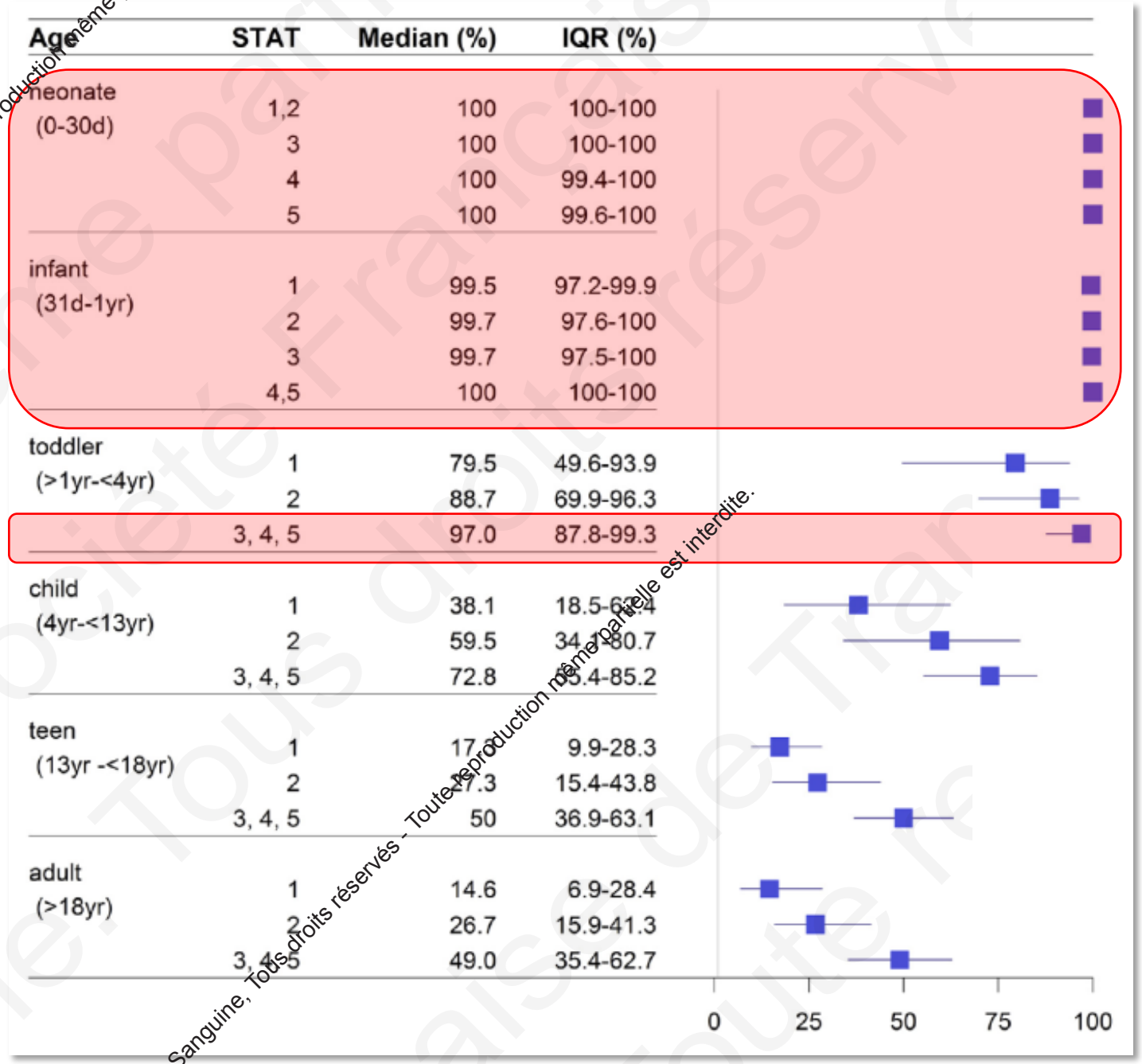
Brown KL and al. J Thorac Cardiovasc Surg. 2019



National Benchmarks for Proportions of Patients Receiving Blood Transfusions During Pediatric and Congenital Heart Surgery: An Analysis of the STS Congenital Heart Surgery Database

Ann Thorac Surg 2018;106:1197–203

- 22874 CEC pédiatriques.
- 81 centres de chirurgie cardiaque pédiatrique
- 2014 - 2015



Transfusion Strategies for Patients in Pediatric Intensive Care Units

Jacques Lacroix et al. N ENGL J MED 356;16 WWW.NEJM.ORG APRIL 19, 2007

CONCLUSIONS

In stable, critically ill children a hemoglobin threshold of 7 g per deciliter for red-cell transfusion can decrease transfusion requirements without increasing adverse outcomes. (Controlled-trials.com number, ISRCTN37246456.)

Anemia, Blood Loss, and Blood Transfusions in North American Children in the Intensive Care Unit

Scot T. Bateman[1], Jacques Lacroix[2], Katia Boven[3], Peter Forbes[4], Roger Barton[5], Neal J. Thomas[6], Brian Jacobs[7], Barry Markovitz[8], Brahm Goldstein[9], James H. Hanson[10], H. Agnes Li[3], and Adrienne G. Randolph[4], for the Pediatric Acute Lung Injury and Sepsis Investigators Network*

AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE VOL 178 2008

TABLE 4. REASON FOR FIRST TRANSFUSION BY ORDERING PHYSICIAN (n = 476)

	No. (%)	Mean No. of PICU Transfusion Events/Child (SD) [median]	Mean Pretransfusion Hemoglobin, g/dl (SD) [median]
Low hemoglobin	198 (42)	3.1 (3.5) [2.0]	8.2 (2.4) [7.9]
Unknown	80 (17)	1.8 (2.1) [1.0]	10.4 (3.0) [9.9]
Acute blood loss (gastrointestinal bleeding/surgical procedures*)	78 (16)	4.8 (6.2) [2.0]	10.5 (2.5) [10.6]
Cardiovascular insufficiency†	41 (9)	3.6 (3.3) [2.0]	10.4 (2.3) [10.0]
Specific technologies‡	35 (7)	10.9 (8.2) [10.0]	10.7 (3.1) [10.3]
Respiratory insufficiency§	34 (7)	2.9 (1.9) [2.0]	9.6 (2.2) [9.5]
Bone marrow suppression/coagulopathy	9 (2)	5.2 (5.4) [3.0]	8.8 (1.4) [9.4]

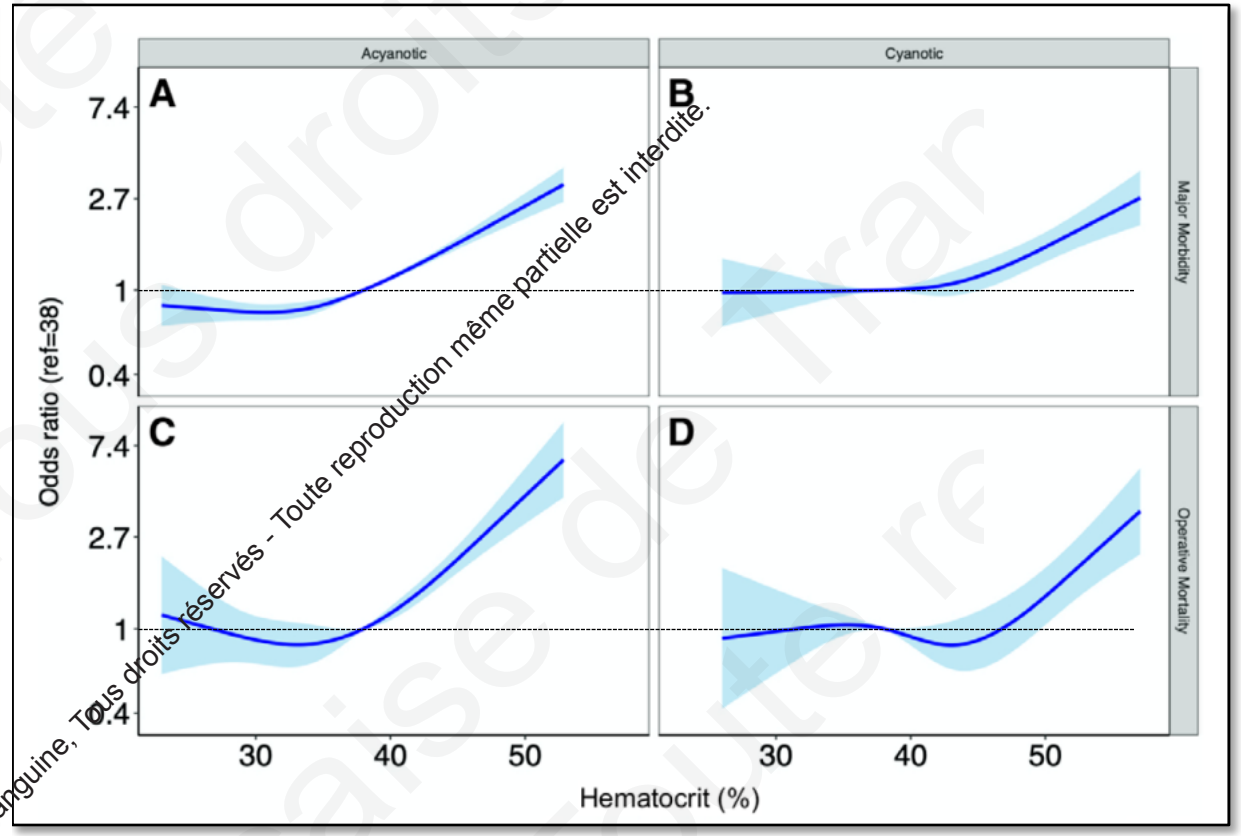
- Augmentation des durées de ventilation (2,1 jour; p<0,001)
- Augmentation de la mortalité (OR 11,6 ; IC 95% [1,43-90,9]

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

CONCLUSIONS: High hematocrit on arrival to the intensive care unit (ICU) is associated with increased operative mortality and major complications in pediatric patients following cardiac surgery. (Anesth Analg 2021;133:1077–88)

Table 3. Association Between Hematocrit es Stratified by Acyanotic and Cyanotic Procedures

Outcomes	Variable	Levels	Adjusted Odds ratio (95% CI)	*P* value	Global *P* value
Operative mortality	Acyanotic	Per 5% increment, for HCT <38	0.88 (0.74-1.05)	.150	<.001
		Per 5% increment, for HCT ≥38	1.45 (1.28-1.65)	<.001	
	Cyanotic	Per 5% increment, for HCT <42	0.94 (0.78-1.13)	.481	.009
		Per 5% increment, for HCT ≥42	1.31 (1.10-1.55)	.003	
Major complication composite	Acyanotic	Per 5% increment, for HCT <38	0.97 (0.91-1.04)	.353	<.001
		Per 5% increment, for HCT ≥38	1.21 (1.14-1.29)	<.001	
	Cyanotic	Per 5% increment, for HCT <42	1.01 (0.92-1.11)	.842	<.001
		Per 5% increment, for HCT ≥42	1.22 (1.10-1.36)	<.001	

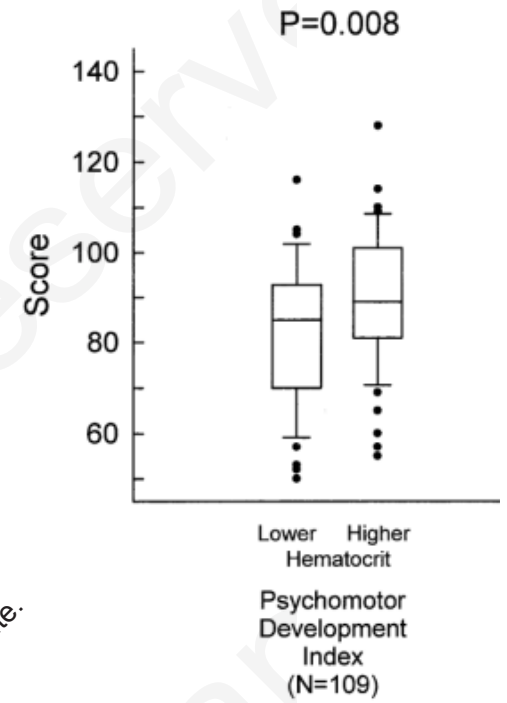


Pour la CEC, hématocrite ≥ 24%.

The influence of hemodilution on outcome after hypothermic cardiopulmonary bypass: Results of a randomized trial in infants

The Journal of Thoracic and Cardiovascular Surgery • December 2003

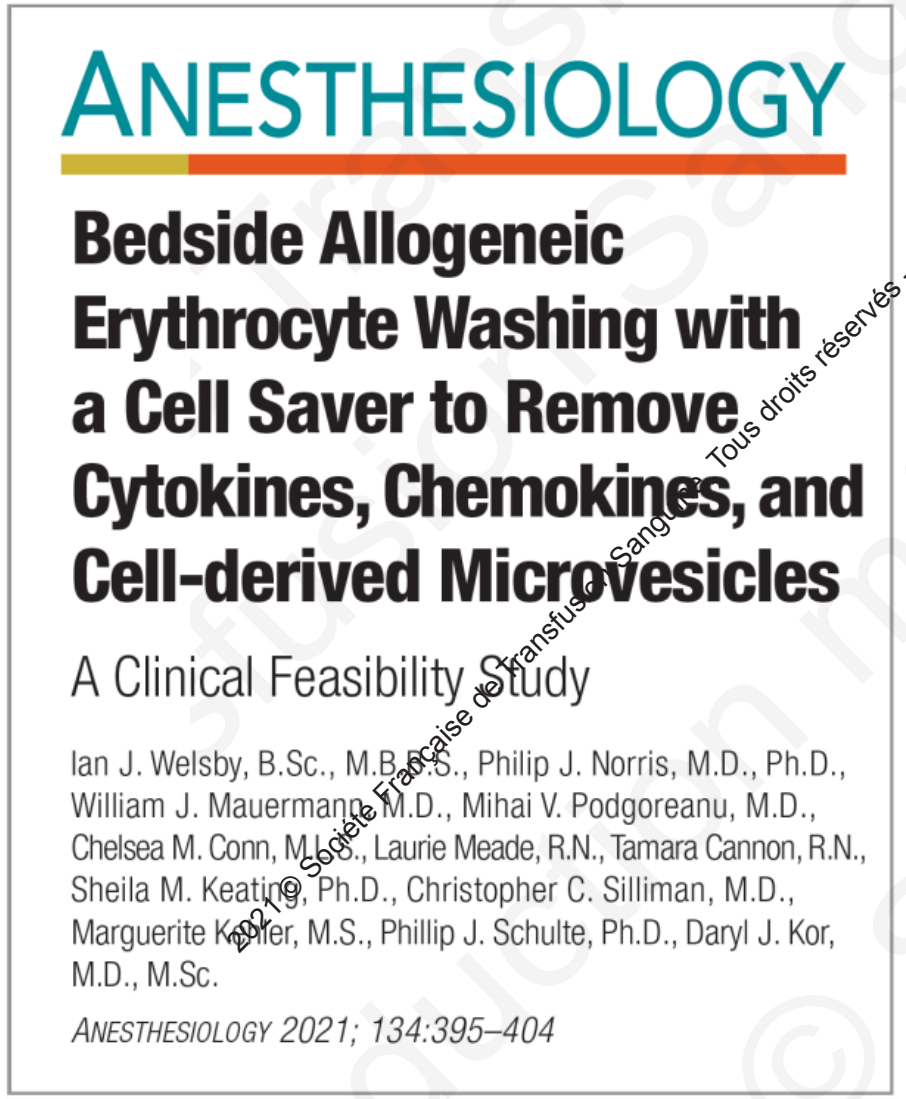
Conclusions: Hemodilution to a hematocrit level in wide use for cardiopulmonary bypass and thought to be safe is associated with adverse perioperative and developmental outcomes in infants.

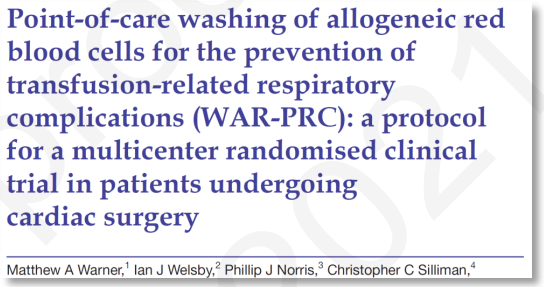


Randomized trial of hematocrit 25% versus 35% during hypothermic cardiopulmonary bypass in infant heart surgery

The Journal of Thoracic and Cardiovascular Surgery • February 2008

Conclusions: Hemodilution to hematocrit levels of 35% compared with those of 25% had no major benefits or risks overall among infants undergoing 2-ventricle repair. Developmental outcomes at age 1 year in both randomized groups were below those in the normative population.





- Etude 2ndaire prévue à priori d'une étude clinique évaluant l'impact clinique du lavage des concentrés globulaires avant transfusion en chirurgie cardiaque adulte (en cours d'analyse)

- Analyse du surnageant de 75 CGR <u>avant</u> et <u>après</u> lavage, administrés aux patient inclus dans le bras « lavage ».
  - ✓Microvésicules
  - ✓Ligand CD-40 soluble
  - ✓Neutral lipids
  - ✓Chemokine ligand 5
  - ✓Hémoglobine libre

Exploratory pathogenic BRMs	Primary process evaluated
Neutral lipids	Lung inflammation
sCD40L	Lung inflammation
CCL5/RANTES	Lung inflammation
RBC-derived microparticles	NO scavenging
Cell-free haemoglobin	NO scavenging

ANESTHESIOLOGY

Bedside Allogeneic Erythrocyte Washing with a Cell Saver to Remove Cytokines, Chemokines, and Cell-derived Microvesicles

A Clinical Feasibility Study

Ian J. Welsby, B.Sc., M.B.B.S., Philip J. Norris, M.D., Ph.D., William J. Mauermann, M.D., Mihai V. Podgoreanu, M.D., Chelsea M. Conn, M.D.S., Laurie Meade, R.N., Tamara Cannon, R.N., Sheila M. Keating, Ph.D., Christopher C. Silliman, M.D., Marguerite Kohler, M.S., Phillip J. Schulte, Ph.D., Daryl J. Kor, M.D., M.Sc.

ANESTHESIOLOGY 2021; 134:395–404

Point-of-care washing of allogeneic red blood cells for the prevention of transfusion-related respiratory complications (WAR-PRC): a protocol for a multicenter randomised clinical trial in patients undergoing cardiac surgery

Matthew A Warner,[1] Ian J Welsby,[2] Phillip J Norris,[3] Christopher C Silliman,[4]

- Cell saver CATS, Fresenius
- Predilution avec une solution héparinée
- Solution de lavage: serum physiologique
- Protocole de lavage automatique
- Volume de lavage = 4/1
- Délai transfusionnel imposé ≈ 25’

ANESTHESIOLOGY

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- Médiane de la durée de stockage des CGR = 15,5 jours.
- 65% des CGR transfusés ont des durées de stockage ≤ 20 jours.
- Pas de corrélation entre la durée de stockage avec les différents biomarqueur et/ou l'hémoglobine libre.
- Il existe par contre de différence significative fonction des solution de conservation (solution-1 vs solution-3 vs solution-5) en défaveur de la solution-3.

Table 1. Microvesicle Counts and Details of the Microvesicle Cellular Origin from the 74 Paired Erythrocyte Units Pre- and Postwashing in a Cell Saver

	Prewash Median (Interquartile Range)	Postwash Median (Interquartile Range)	*P* Value
Total count per microliter	6,900,000 (4,100,000–20,000,000)	830,000 (330,000–2,800,000)	< 0.0001
Cell markers			
P-selectin, activated endothelial cell or platelet-derived microvesicle	99 (0–350)	20 (0–56)	< 0.0001
Glycophorin A, erythrocyte-derived microvesicles	13,000 (5,400–32,000)	4,600 (2,400–15,000)	0.004
Semaphorin-7A, activated lymphocytes or erythrocyte-derived microvesicle	730 (300–1,800)	130 (43–310)	< 0.0001
Glycoprotein IIb, megakaryocyte/platelet-derived microvesicle	33,000 (21,000–48,000)	6,900 (3,200–17,000)	< 0.0001

Most are of indeterminate cellular origin. After Bonferroni correction, a significant P value is < 0.0055.

ANESTHESIOLOGY

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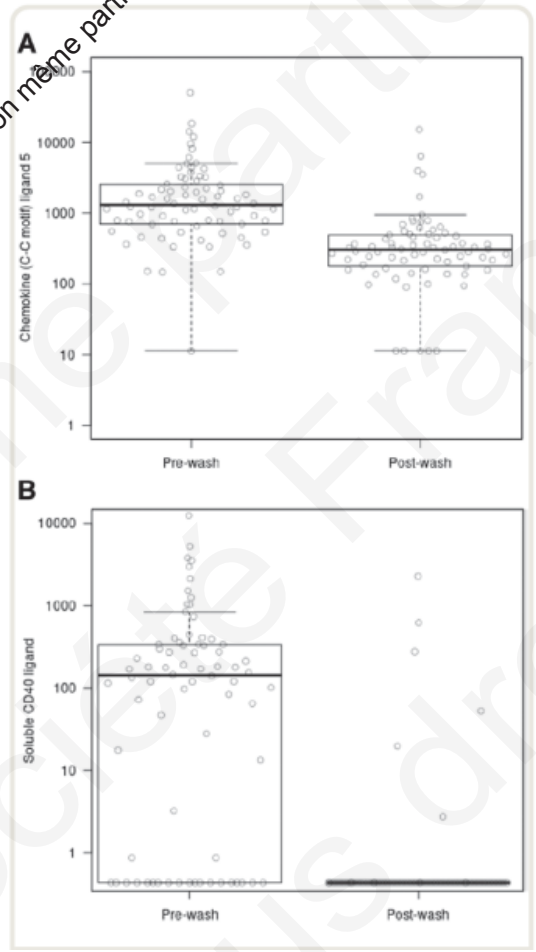
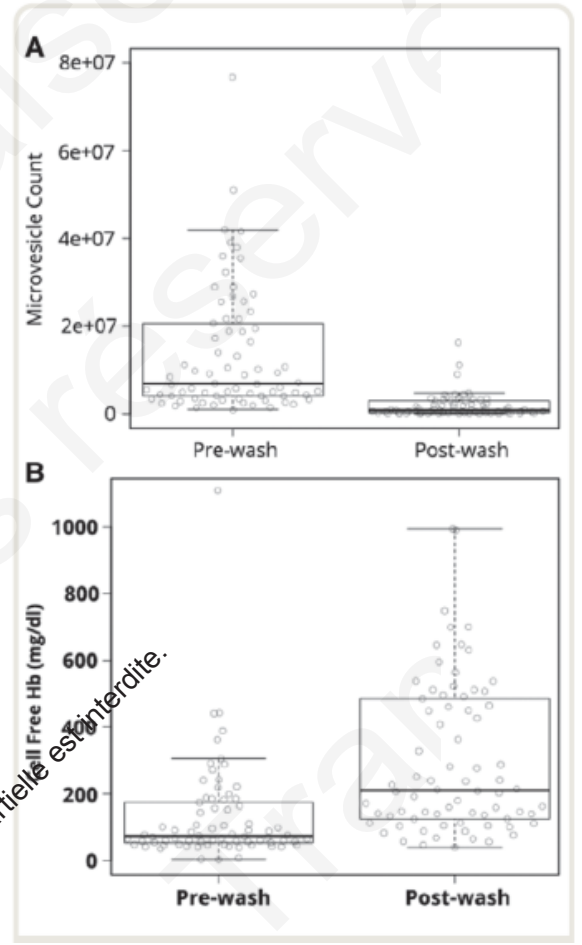
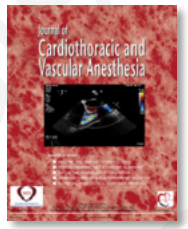




- Diminution significative de nombreux médiateurs mesurés dont la chemokine ligand-5 (/10 000) et pour le ligand soluble CD-40 (/1000)
- En prennant compte les modification de l'hématocrite et le V3 du produit obtenu après lavage, l'hémolyse post lavage est evalué entre 0,1-0,2% (< 0,8%)

The Use of Umbilical Cord Blood for Autologous Transfusion in Neonatal Open Heart Surgery

Adam Fernandez, CCP, PhD, Kyrylo Chasovskyi, CPC, PhD, MD[1]



Journal of Cardiothoracic and Vascular Anesthesia 00 (2019) 1–6

- Sang disponible dans le placenta et le cordon ombilical.
- Produit riche en hémoglobine foetale
- Volume collecté variable et peu predictible ≈ 50-140 ml
- Stockage à la banque du sang:
  - Sang total
  - Concentré erythrocytaire
  - Plasma
- Conservation possible de 7 a 28 jours avec le conditionnement approprié.

Reports on UCB Collection and Transfusion in Neonatal Cardiac Surgery

Authors	n	Mode of Delivery	Cord Clamping Time	Collection Method	Amount of UCB (mL)	Storage Timing	UCB Transfused	Additional HBT (n, %)	Bacterial Contamination
Domanović et al.[20]	n = 1	V	NM	In utero	87	6 h	Post-CPB	0	NM
Fedevych et al.[21]	n = 14	V + CS	NM	In utero	92 ± 15.9	7 (4-9) h†	CPB + post-CPB	2 (14%)	Negative
Chasovskyi et al.[22]	n = 21	V + CS	<10 sec	In utero	85 ± 24 (50-140)*	11 ± 2 h	CPB + post-CPB	1 (5%)	Negative
Chasovskyi et al.[23]	n = 99	V + CS	NM	In utero	81 ± 22.6	3 ± 2 h	CPB + post-CPB	16 (16.2%)	Negative
Choi et al.[26]	n = 8	NM	<10 sec	NM	72 (43-105)†	21 d	CPB	1 (12.5%)	Negative
Sarin et al.[27]	n = 10	V+CS	NM	In utero + Ex utero	70 ± 15	20.2 ± 1.3 d	Post-CPB	10 (100%)	Negative

Abbreviations: CPB, cardiopulmonary bypass; CS, cesarean section; NM, not mentioned; UCB, umbilical cord blood; V, vaginal delivery.
* Data are presented as mean ± standard deviation (min-max).
† Data are presented as median (25%-75%).

ANESTHESIOLOGY

Fresh Frozen Plasma *versus* Crystalloid Priming of Cardiopulmonary Bypass Circuit in Pediatric Surgery

A Randomized Clinical Trial

Audrey Diet, M.D., Maria Rosal Martins, M.D., Stephane Eeckhoudt, Ph.D., Amine Matta, M.D., David Kahn, M.D., Céline Khalifa, M.D., Jean Rubay, M.D., Ph.D., Alain Poncelet, M.D., Ph.D., Astrid Haenecour, M.D., Emilien Derycke, M.D., Dominique Thiry, C.C.P., André Gregoire, C.C.P., Mona Momeni, M.D., Ph.D.

Anesthesiology 2020; 132:95–106

Table 6. Data of the Patients Analyzed on a Per-Protocol Basis

Variable	FFP (N = 28)	Crystalloid (N = 28)	*P* Value	Difference (95% CI)
N total allogeneic blood products (erythrocytes, FFP, platelets; priming not included)*	0 (0, 1)	0 (0, 2)	0.313	0 (0 to 0)
Patients transfused with any product (priming not included), no. (%)*	7 (25.0)	10 (35.7)	0.383	1.7‡ (0.5 to 5.3)
Chest drain blood loss 6 h postoperative, ml · kg^{-1}*	6.9 (5.1, 9.4)	5.7 (3.7, 8.4)	0.225	1.2 (−0.7 to 3.0)
Total volume erythrocytes transfused (ml · kg^{-1} (priming not included)†	8.8 (0, 17.2)	10.9 (0, 17.8)	0.641	0 (−6.8 to 4.4)
Total volume FFP transfused (ml · kg^{-1}) (priming not included)†	0 (0, 0)	0 (0, 3.2)	0.173	0 (0 to 0)
Total volume platelets transfused, ml · kg^{-1}†	0 (0, 0)	0 (0, 0)	0.231	0 (0 to 0)
N total allogeneic blood products including priming (erythrocytes, FFP, platelets)	2 (2, 2)	1 (1, 3)	0.001	
Total volume FFP transfused (priming included), ml · kg^{-1}	15.0 (15.0, 15.0)	0 (0, 3.2)	< 0.001	
Total N packed erythrocytes (priming not included)	0 (0, 1)	0 (0, 1)	0.709	
Total N FFP (priming not included)	0 (0, 0)	0 (0, 0)	0.263	
Total N platelet concentrates	0 (0, 0)	0 (0, 0)	0.124	
Patients receiving fibrinogen, no. (%)	0	1 (3.5)	0.999	

The continuous variables are expressed as medians (25th percentile, 75th percentile).
*Primary endpoint. †Secondary endpoint. ‡Odds ratio.
FFP, fresh frozen plasma.

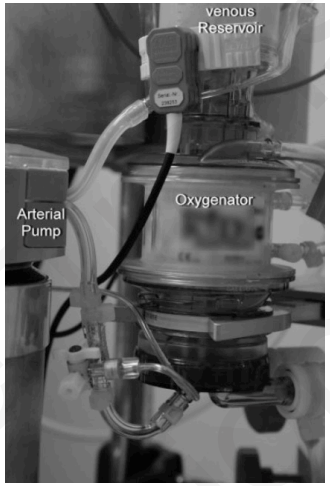
EDITOR'S PERSPECTIVE

What We Already Know about This Topic

- Fresh frozen plasma is often used to prime the cardiopulmonary bypass circuit for pediatric cardiac surgical patients to help offset dilutional coagulopathy that might result in increased perioperative bleeding and allogeneic blood transfusion
- Prior randomized trials of crystalloid *versus* fresh frozen plasma prime have reported conflicting results, but the vast majority of these studies were not blinded

What This Article Tells Us That Is New

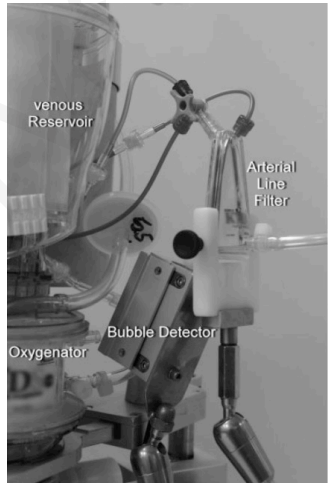
- In this double-blind randomized controlled trial of patients undergoing pediatric cardiac surgery with cardiopulomonary bypass, postoperative bleeding and the need for allogeneic blood products does not differ significantly between patients for whom the cardiopulmonary bypass circuit was primed with crystalloid *versus* fresh frozen plasma

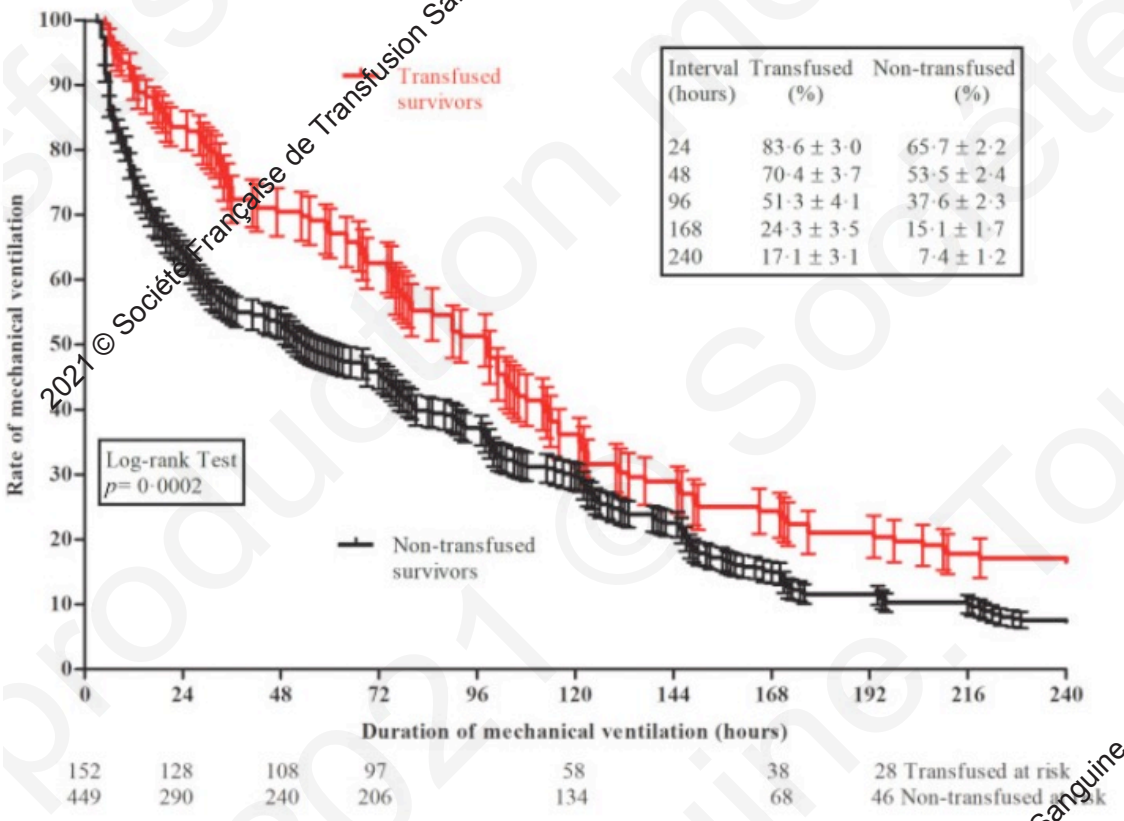


Cardiopulmonary Bypass Strategy to Facilitate Transfusion-Free Congenital Heart Surgery in Neonates and Infants

Thorac Cardiovasc Surg 2020;68:2–14.

Asanguineous Cardiopulmonary Bypass in Infants: Impact on Postoperative Mortality and Morbidity





Interval (hours)	Transfused (%)	Non-transfused (%)
24	83·6 ± 3·0	65·7 ± 2·2
48	70·4 ± 3·7	53·5 ± 2·4
96	51·3 ± 4·1	37·6 ± 2·3
168	24·3 ± 3·5	15·1 ± 1·7
240	17·1 ± 3·1	7·4 ± 1·2

Blood Transfusions Might Be Bad For You; That Is Unless You Are Bleeding

EDITORIAL

James A. DiNardo, MD

- Les objectifs d'hémoglobine peuvent variés au cours d'un séjour hospitalier chez un même individu.
  - Phase préopératoire
  - CEC
  - Réanimation hématologique en sortie de CEC
  - Réanimation post-opératoire
  - Réhabilitation postopératoire

- Il existe une association démontrée entre les pertes sanguines et la morbi-mortalité peri-opératoire.

Comment définir une hémorragie postopératoire significative?

First Author	Year	Type	Age	n	Definition	Incidence (%)
Pekelharing[14]	2014	Prospective	< 18	107	≥ 5 mL/kg/hr in first 4 hours	21.4
Moganasundram[9]	2018	Prospective	< 5 years	50	> 10 mL/kg in first 4 hours	38
Faraoni[35]	2015	Retrospective	≤ 16 years	150	> 10% EBV in first 6 hours	23
Savon[20]	2014	Retrospective	≤ 16 years	182		28.9
Timpa[18]	2016	Prospective	< 18 years	161	>10 mL/kg in the first CICU hour	26
Niebler[10]	2012	Prospective	< 18 years	60	> 6 mL/kg/hr for ≥ 2 consecutive hours in 6 hours	31.7
Niles[12]	2008	Retrospective	< 18 years	328	> 4 mL/kg/hr for ≥ 2 consecutive hours in 7 hours	NA
Tobias[22]	2004	Retrospective	< 18 years	17	≥ 12 mL/kg for the first 3 postoperative hours	NA
Razon[16]	2005	Prospective	≤ 19 years	5	> 8 mL/kg for any 1 hour > 4 mL/kg/hr for ≥ 3 consecutive hours	NA
Agarwal[5]	2015	Retrospective	< 18 years	253	> 10 mL/kg in 1st hour *OR* > 5 mL/kg for 3 consecutive hours in 12 hours	42
Guay[36]	1996	Review	NA	NA	> 10% EBV in any 1 hour *OR* > 5% EBV for 3 consecutive hours in 24 hours	NA
Oliver[37]	2005	Textbook	< 18 years			
Singh[17]	2012	Retrospective	< 15 years	20		
Tirosh-Wagner[19]	2011	Prospective	≤ 10 years	15	> 20% EBV in 24 hours	NA
Hoda[7]	2016	Retrospective	< 18 years	82	> 4 mL/kg/hr average for 24 hours	0
Pychynska-Pokorska[15]	2004	Prospective	< 5 years	8	Children ≤ 5kg: ≥ 10 mL/kg/hr Children ≥ 5kg: ≥ 2 mL/kg/hr	NA
Williams[11]	1999	Prospective	< 18 years	494	≥ 20% EBV in hours 0-2 *OR* ≥ 20% EBV in hours 2-6 *OR* ≥ 30% EBV in hours 7-12	19
Brenner[6]	2015	Retrospective		91		28.5
Guzzetta[3]	2015	Retrospective	≤ 30 days	167	Top 25th percentile for CTO in 24 hours	25
Wolf[4]	2014	Retrospective	< 1 year	1071	Top 25th percentile for CTO in 12 hours	25
Kylasam[8]	2009	Retrospective	≤ 90 mo	25	Required re-exploration for bleeding	2.5

Validation of a definition of excessive postoperative bleeding in infants undergoing cardiac surgery with cardiopulmonary bypass

Rachel S. Bercovitz, MD, MSc, Allison C. Shewmake, MD, Debra K. Newman, PhD, Robert A. Niebler, MD, John P. Scott, Eckehard Stuth, MD, Pippa M. Simpson, PhD, Ke Yan, PhD, Ronald K. Woods, MD, PhD

The Journal of Thoracic and Cardiovascular Surgery

Results: Excessive bleeding was defined as ≥ 7 mL/kg/hr for ≥ 2 consecutive hours in the first 12 postoperative hours and/or ≥ 84 mL/kg total for the first 24 postoperative hours and/or surgical re-exploration for bleeding or cardiac tamponade physiology in the first 24 postoperative hours. Excessive bleeding was associated with longer length of hospital stay, increased 30-day readmission rate, and increased transfusions in the postoperative period.

Demographics n=124	Patients without Bleeding (n=93)	Patients with bleeding (n=31)	Risk Ratio	*P*
Weight (kg)	4.2 (2.4 – 8.7)	3.1 (2.2 – 7.5)		< 0.0001
Age (days)	49 (0 – 180)	8 (0 – 146)		0.0002
STAT Score				
1	13 (14.0)	2 (6.4)		0.0117
2	20 (21.5)	2 (6.4)		
3	15 (16.1)	5 (16.1)		
4	31 (33.3)	8 (25.8)		
5	11 (11.8)	13 (41.9)		
Minimum Temperature (°C)	28.0 (17.0 – 37.0)	18 (16.7 – 32)		0.0024
DHCA (yes)	28 (30.1)	19 (61.3)	2 (1.3 – 3.1)	0.0027
Intraoperative FVIIa	5 (5.4)	6 (19.4)	3.6 (1.1 – 11)	0.0278
Prime				
Whole blood	61 (65.6)	11 (35.5)		0.0067
RBCs + plasma	31 (33.3)	19 (61.3)		
Other	1 (1.1)	1 (3.2)		
Delayed chest closure	37 (39.8)	26 (83.9)	2.1 (1.5 – 2.9)	< 0.0001
Single ventricle physiology	34 (36.6)	20 (64.5)	1.8 (1.2 – 2.6)	0.0113
Cyanotic heart disease (pre)	61 (65.6)	27 (87.1)	1.3 (1.1 – 1.7)	0.0234

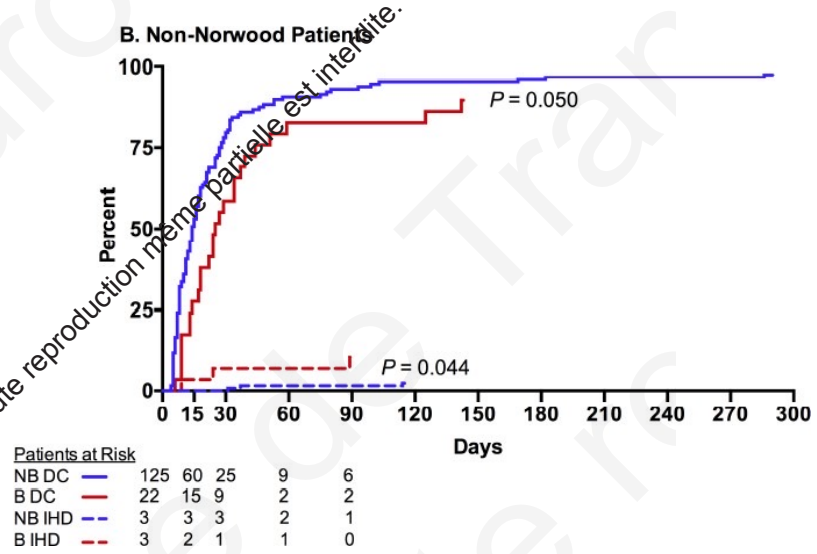
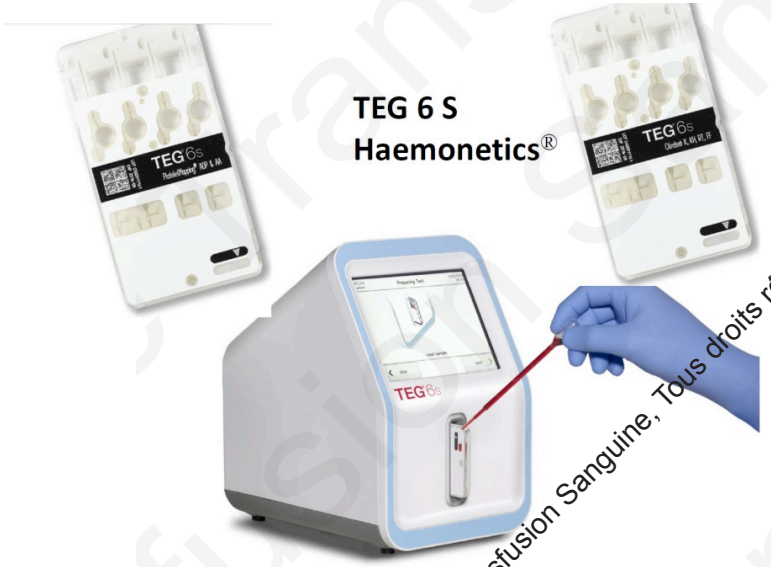
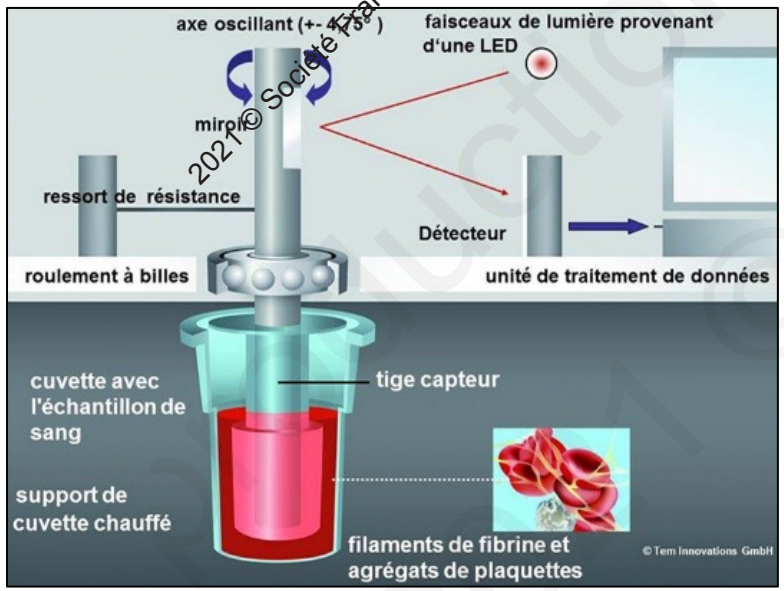
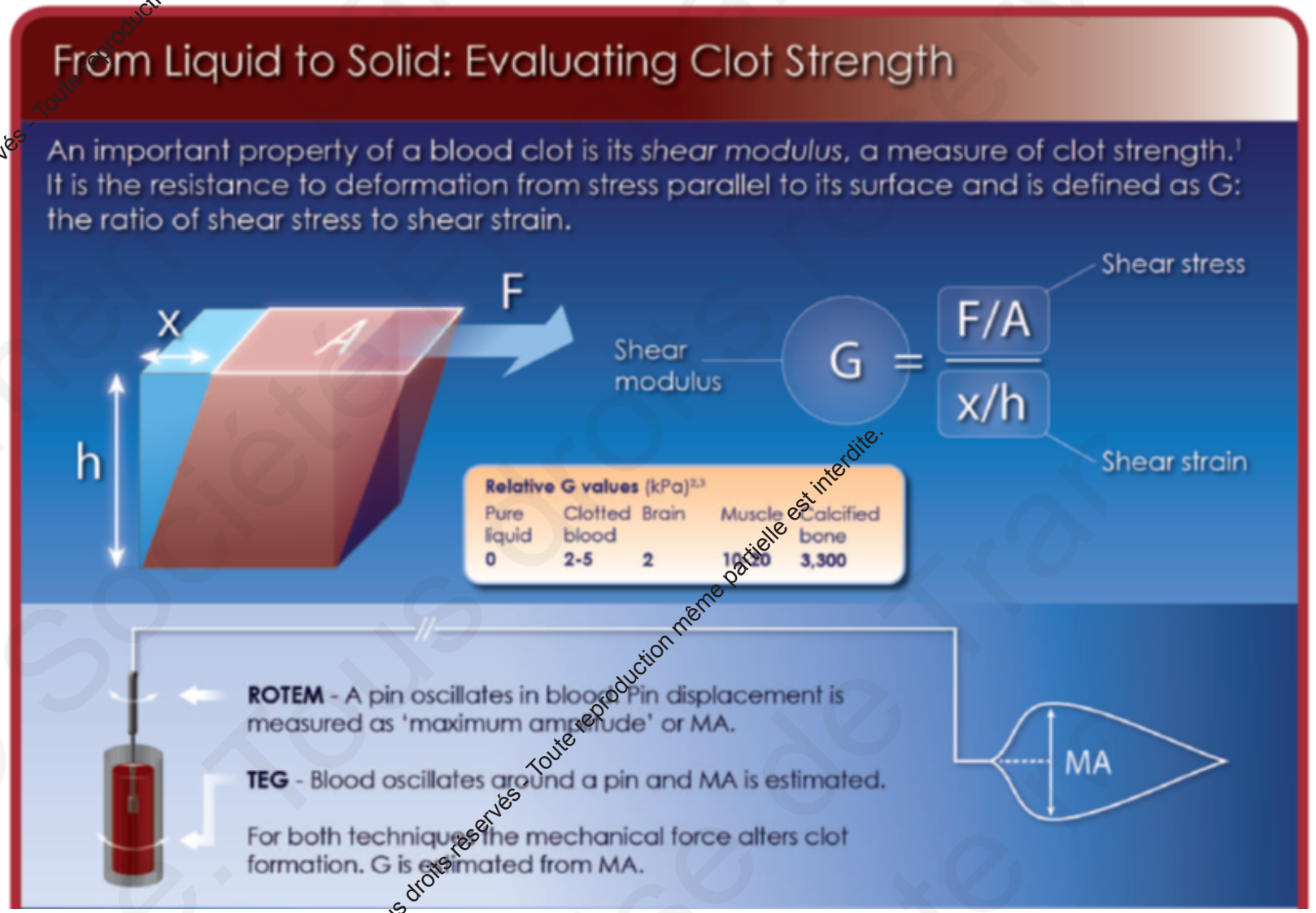


Figure 2. Time to discharge or in-hospital death in patients with (red) and without (blue line) excessive bleeding undergoing either a Norwood procedure (A) or another surgery (B). Patients were divided based Supplement Materials 3 for the 95[th] % CI on days 15, 30, 60, and 90. *NB*, no bleeding; *B*, bleeding; *DC*, discharged; *IHD*, in-hospital death.







La prédiction du saignement est-elle possible?

- Profiter de la CEC pour optimiser les conditions de charge.
- L'obtention de l'hémostase est un sujet cruciale:
  - ➢ Hémostase chirurgicale: prolène – colle biologique – pansement hémostatique.
  - ➢ Hémostase biologique: Fondamentale pour créer les conditions du succès –
    - PH / T° / Hb / Ca^{2+}
    - Etude de l'hémostase au laboratoire – Point Of Care – PVI /CUP/ Cplx Prothrombinique/Fibrinogène/$fVII_a$

Excessive Postoperative Bleeding and Outcomes in Neonates Undergoing Cardiopulmonary Bypass

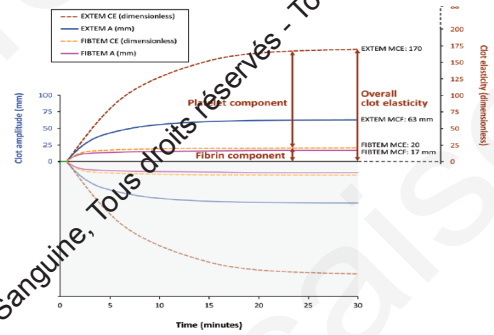
Anesth Analg 2014 Nina A. Guzzetta,

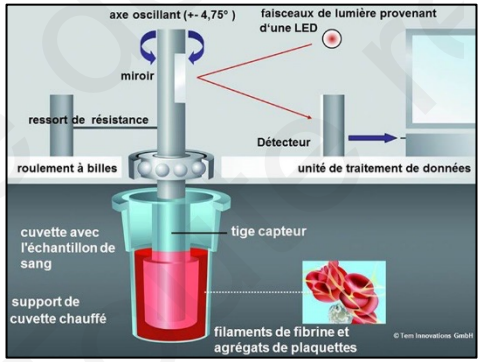
Table 6. Outcome Data Based on Bleeding Quartile and Adjusted Relative Risk

	CTO ≤75% (*n* = 124)	CTO >75% (*n* = 42)			
	Total (%)	Total (%)	RR[a]	95% CI	*P*
Renal dysfunction[b]	21 (17)	11 (26)	1.18	0.54–2.18	0.64
Dialysis	1 (1)	6 (14)	12.0	1.50–54.69	0.02
Thrombosis	9 (7)	4 (10)	0.82	0.17–2.87	0.78
ECMO	3 (2)	11 (26)	9.95	3.07–28.47	0.0008
In-hospital mortality	6 (5)	8 (19)	3.01	0.99–7.70	0.052

Thromboelastometry-guided intraoperative haemostatic management reduces bleeding and red cell transfusion after paediatric cardiac surgery

British Journal of Anaesthesia. 1 janv 2015;114(1):91-102.





Recommendations on Red Blood Cell Transfusion in Infants and Children with Acquired and Congenital Heart Disease from the Pediatric Critical Care Transfusion and Anemia Expertise Initiative

Pediatr Crit Care Med. 2018 September ; 19(9): S137–S148.

Biventricular repairs: 6.12 **In infants and children with CHD undergoing biventricular repair who are hemodynamically stable and have adequate oxygenation and normal end organ function, we recommend not administering a RBC transfusion if the Hb concentration is ≥ 7.0 g/dL.** *Strong recommendation, Moderate quality pediatric evidence (1B); 100% Agreement, (n=29), Median 8.5, IQR 7–9*

Stage 1 palliations: 6.10 **In infants undergoing stage 1 palliation procedures (Norwood, Damus-Kaye-Stansel, Blallock-Taussig or central shunt, or pulmonary artery band) for single ventricle physiology, who have stable hemodynamics, adequate oxygenation (for their cardiac lesion) and normal end organ function we recommend avoiding reflexive ("solely Hb-based") RBC transfusions if the Hb concentration is >9.0 g/dL.** *Weak recommendation, Low quality pediatric evidence (2C); 96% Agreement, (n=29), Median 8, IQR 7–9*

Conclusion

R6.5 **In infants and children undergoing cardiac surgery further studies are needed to investigate the complex relationship between anemia, RBC transfusion, oxygen delivery and utilization and outcomes; with focus on which patient subgroups may benefit from, or be harmed by RBC transfusion.** *Consensus panel expertise; 100% Agreement, (n=35), Median 9, IQR 8–9*

R6.8 **In children with acquired heart disease or CHD, further studies are warranted to determine if RBC storage time impacts clinical outcomes.** *Weak recommendation, Low quality pediatric evidence (2C); 90% Agreement, (n=35), Median 8, IQR 8–9*

R6.4 **In infants and children undergoing cardiac surgery with CPB, further research is needed to determine the benefits and risks associated with the administration of RBC to the CPB-prime, on-bypass and after separation of CPB.** *Consensus panel expertise; 97% Agreement, (n=35), Median 8, IQR 8–9*

R6.1 **We recommend further studies to determine the risks and benefits of RBC transfusion in critically ill children with documented right or left ventricular myocardial dysfunction (acquired or congenital).** *Consensus panel expertise; 97% Agreement, (n=35), Median 9, IQR 8–9* ……