Epargne transfusionnelle en anesthésie pédiatrique

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ADARPEF 24 mai 2024

Université Paris Cité

AR-Péd-Obst
Hôpital Robert-Debré AP-HP

- Aucun conflit d’intérêt

Gestion du capital sanguin en periopératoire

=

Patient Blood management

- Démarche organisationnelle
- Eviter le recours à la transfusion non nécessaire
- Eviter l'apparition ou l'aggravation d'une anémie
- Améliorer la prise en charge et la tolérance en cas d'anémie

Patient Blood management: pourquoi?

- Database pédiatrique US (ACS NSQIP) 2012-2014
- **51622 enfants** de 1 à 18 ans (avec hématocrite préop)
- Anémie préop 24%
- Hématocrite moyenne des anémiques 33%

Table 2. Multivariable Analysis of Factors Associated In-Hospital Mortality

Variables	B (SE)	Odds Ratio	95% CI	*P* Value
Anemia	0.77 (.20)	2.17	1.48–3.19	<.001
RBC transfusion	0.76 (.22)	2.13	1.39–3.26	<.001
Neurological disorders	0.75 (.20)	2.11	1.13–3.11	<.001
Emergency surgery	0.83 (.17)	2.29	1.56–3.35	<.001
Inotropic support	1.40 (.36)	4.06	2.00–8.21	<.001
Mechanical ventilation	1.59 (.24)	4.91	3.06–7.89	<.001
Neoplasm	1.61 (.20)	5.00	3.40–7.35	<.001
ASA physical status ≥ III	2.55 (.37)	12.84	6.20–26.62	<.001

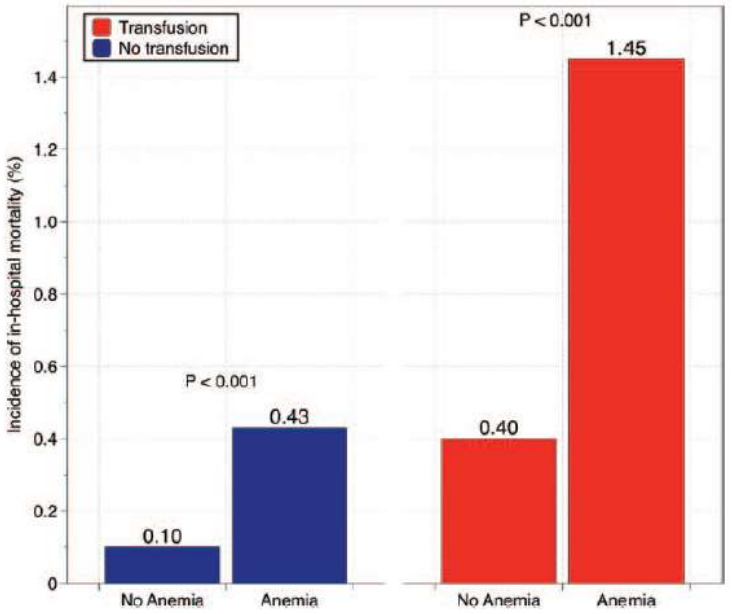


Figure 2. Incidence of in-hospital mortality in children with anemia for those with and without red blood cell transfusion. Unadjusted *P* value obtained from the χ^2 test.

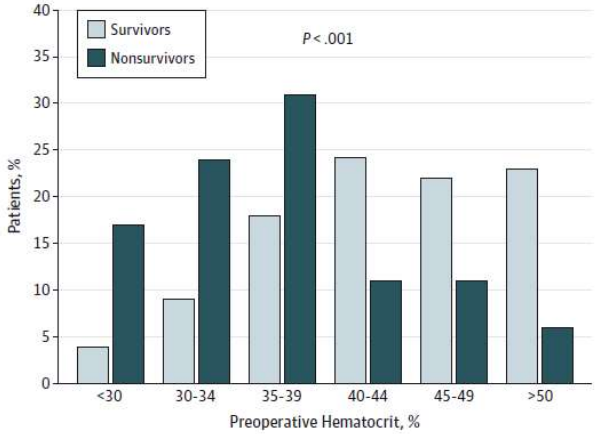
Faraoni and al , Anesthesia Analgesia 2016

Patient Blood management: pourquoi?

Table 3. Multivariable Analysis of Factors Associated With Postoperative In-Hospital Mortality (N = 2764)

Variable	Mortality, Odds Ratio (95% CI)	*P* Value
Hematocrit <40%	2.62 (1.51-4.57)	<.001
ASA classification 3, 4, or 5	9.72 (1.27-74.44)	.001
Body weight ≤2 kg	1.86 (1.08-3.22)	.02
Preoperative		
Mechanical ventilation	7.39 (3.50-15.62)	<.001
Inotropic support	3.04 (1.75-5.27)	<.001
Intraoperative RBC transfusion	1.09 (0.64-1.89)	.75

Figure. Distribution of Preoperative Hematocrit for Neonatal Population in Survivors and Nonsurvivors



Anémie= facteur indépendant de mortalité
Prévalence mortalité si anémie:
7,5% (95%CI, 1%-10%) vs 1,4%(95%CI, 0%-4%)

Goobie and al , Jama Paediatrics 2016

Patient Blood management: pourquoi?

- Registre US (ACS NSQIP)
- Arthrodèse rachidienne 2012-2016
- **9095** patients
- Anémie préop **14%**
- Transfusion **67%**

TABLE 2. Multivariable analysis of

Variables	B (SE)
Anemia	0.421 (0.072)
Cerebral palsy	0.484 (0.103)
Neuromuscular disease	0.425 (0.066)
Surgery duration > 350 minutes	0.788 (0.060)
Number of level fused > 7	1.140 (0.068)

Data obtained from multivariable (adjusted) logistic regression 95% confidence interval (CI), and Wald test p-value.

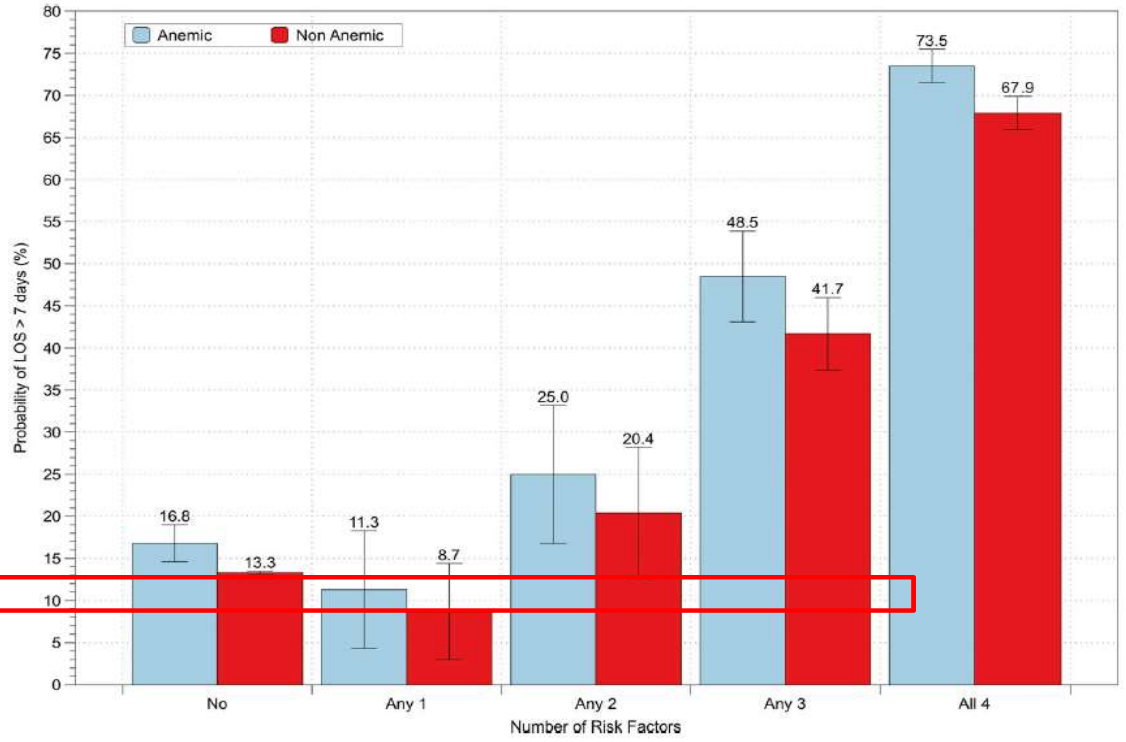


Fig. 2. Probability of length of hospital stay > 7 days between anemic and non-anemic patients after stratification for the number of multivariable risk factors identified (e.g., neuromuscular disease, cerebral palsy, surgery duration > 350 minutes, and > 7 levels fused). Data are presented with a probability (%) and 95% confidence interval. P-value for comparing anemic vs. non-anemic <0.001 for all comparisons. [Color figure can be viewed at wileyonlinelibrary.com]

Fontanals and al , Transfusion 2018

Patient Blood management

Optimisation de la masse sanguine	Minimisation des pertes sanguines	Amélioration de la tolérance à l'anémie

En pré, per et postopératoire

Shander and al, Anesthesiology 2012

Optimisation de la masse sanguine

Préopératoire

- **Dépister** une anémie préopératoire
  - A la naissance < 135 g/L
  - Naissance à 6 ans < 110 g/L
  - Entre 6 et 14 ans< 120 g/L

- 1ère étiologie: **Carence martiale**
- 60 à 75%

Table 2. Global and WHO regional mean blood haemoglobin concentration and prevalence of anaemia by population group for 2011

WHO region	Mean (95% CI) blood haemoglobin concentration (g/L)	Percentage (95% CI) of population with anaemia[a]	Number (95% CI) of people with anaemia (millions)[b]	Percentage (95% CI) of population with severe anaemia[c]	Number (95%CI) of people with severe anaemia (millions)[b]
Children aged 6–59 months					
African Region	104 (103 to 105)	62.3 (59.6 to 64.8)[c]	84.5 (81.0 to 87.9)[c]	3.6 (2.9 to 4.4)	4.9 (4.0 to 6.0)
Region of the Americas	119 (117 to 121)	22.3 (17.7 to 27.9)	17.1 (13.5 to 21.3)	0.2 (0.1 to 0.5)	0.18 (0.1 to 0.4)
South-East Asia Region	107 (104 to 112)	53.8 (39.9 to 63.9)	96.7 (71.7 to 115.0)	1.5 (0.4 to 3.7)	2.7 (0.8 to 6.6)
European Region	119 (115 to 122)	22.9 (14.9 to 32.8)	12.7 (8.2 to 18.1)	0.3 (0.1 to 0.8)	0.2 (0.0 to 0.5)
Eastern Mediterranean Region	109 (106 to 112)	48.6 (40.4 to 57.0)	35.8 (29.7 to 41.9)	2.0 (1.0 to 3.1)	1.5 (0.7 to 2.3)
Western Pacific Region	120 (114 to 125)	21.9 (12.0 to 36.9)	25.7 (14.2 to 43.4)	0.2 (0.0 to 0.6)	0.2 (0.0 to 0.7)
Global	111 (110 to 113)	42.6 (37.7 to 47.4)	273.2 (241.8 to 303.7)	1.5 (1.0 to 2.2)	9.6 (6.9 to 14.1)

Worldwide prevalence of anaemia 1993–2005

Optimisation de la masse sanguine: Fer

Préopératoire

- Etude rétrospective 2013-2017
- 382 arthrodèses vertébrales
- Supplémentation martiale PO préop
- Transfusion per op 45,5%

TABLE 2 Multivariable analysis for intraoperative transfusion

Variables	OR	95% CI	*P* value
Female (%)	1.813	0.956-3.439	.068
Nonidiopathic (%)	4.179	2.277-7.668	<.001
Cobb angle (deg.)	1.025	1.010-1.040	.001
Number of vertebrae fused (n)	1.169	1.042-1.312	.008
Preoperative hemoglobin (g/L)			
<120 g/L	-	-	-
≥120-<130 g/L	0.294	0.080-1.082	.066
≥130-<140 g/L	0.195	0.057-0.669	.009
≥140 g/L	0.157	0.046-0.540	.003

Switzer and al , Paediatric Anesthesia 2019

Optimisation de la masse sanguine: EPO

Préopératoire

- 117 patients
- EPO vs contrôle
- 600 ui/kg/sem pdt 3 semaines
- Hématocrite préop 43 vs 35
- Transfusion 54 vs 98%
- Vol transfu 82 vs 282 ml

TABLE 2. Outcomes of Included Studies

Article	Type of Study	N	Groups	N/ Group	Treatment Protocol	Initial Hct (%)*	Preop Hct (%)*	Surgical Time (min)	Estimated Blood Loss (mL)	Intraoperative ABT (% of pts)	Volume of ABT (mL)
Helfaer et al 1998[15]	Prospective trial	60	EPO	30	Preop EPO 300 U/kg 3 times/wk for 3 weeks	N/A‡	43.3	242	227	64	60
			Control	30	None		34.2	266	371	100	241
Fearon et al 2002[9]	Prospective trial	29	EPO	14	Preop EPO 600 U/kg once/wk for 3 weeks	37.2	40.3	162	161	57	–
			Control	15	None	36.4	36.4	152	205	93	–
Meara et al 2005[7]	Retrospective review	19	EPO	10	Preop EPO 600 U/kg once/wk	34.9	44.5	–	–	50	154
			Control	9	None	36.2	36.2	–	–	100	421
CostaVal et al 2013[14]	Prospective trial	9	EPO	9	Preop EPO 600 U/kg once/wk	–	–	–	–	22	–
Total	–	117	EPO	63	–	36.2	42.7	216	206.0	54.2	83.5
			Control	54	None	36.3	35.1	228	315.7	98.1	282.5
P value						0.7	0.000†	0.25	0.000†	0.000†	0.000†

ABT, allogenic blood transfusion; EPO, erythropoietin.
*Hct, hematocrit (%).
†*P* value $\leq$ 0.05.
‡No quantitative values provided in the original study, however authors stated no significant difference between both groups in the initial Hct.

Aljaaly and al , Journal craniofacial surgery 2017

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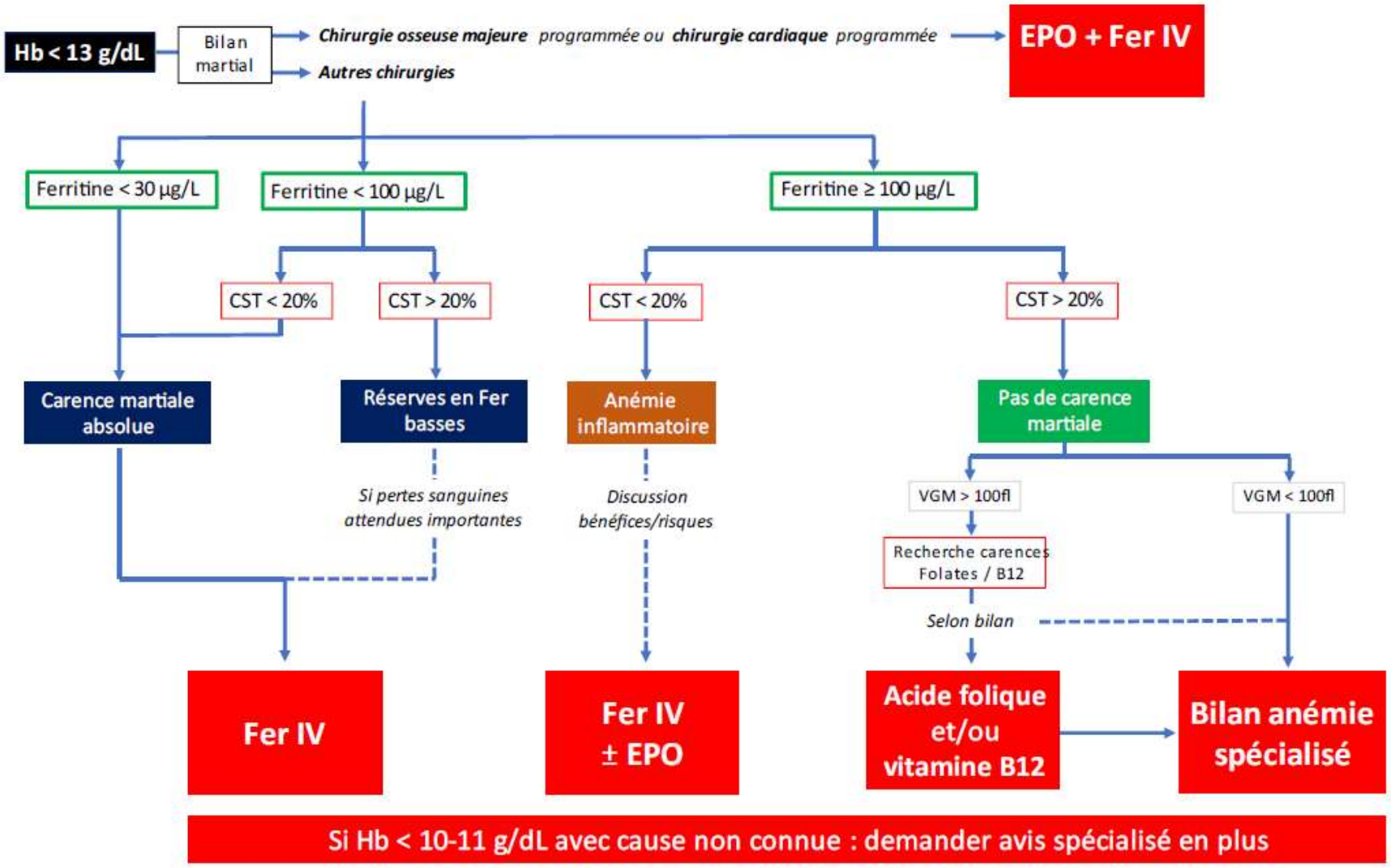
Gestion du capital sanguin en pré, per et postopératoire et en obstétrique



Optimisation de la masse sanguine: Fer

Préopératoire

FER

ORAL:

- 3-4 semaines avant chirurgie (durée totale 3 mois)
- Réponse réticulocytaire à J4, pic J7-J10
- Tolérance / observance
- 3-6 mg/kg/j en 3 prises avant les repas

IV

- si chirurgie non différable ou intolérance fer PO ou absence de réponse au fer PO
- HDJ ou HAD
- Carboxylmaltose (Ferinject®): max 15 mg/kg/sem (max 750mg jusqu'à 16ans) sur 15 min. Renouvelable 1 fois à 7J.

EPO

- 600 UI/kg/semaine voie S/C
- pendant 3 à 4 semaines
- Toujours associée à un traitement martial

Optimisation de la masse sanguine

Peropératoire

- **1520** enfants chirurgie cardiaque
- 2004-2008
- 72h post opératoire
- Mortalité **90 (5,9%)**

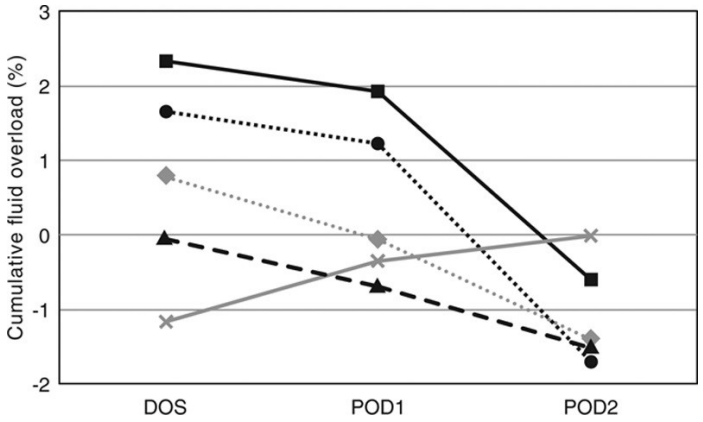
Predictors	Adjusted OR (95% CI)	p	No Complications n = 729 (47.9%)
Age (log)	0.520 (0.282–0.958)	0.036	16.94 (7.94 to 27.67)
Acute operation	4.682 (1.341–16.34)	0.016	−10.35 (−23.50 to 0.10)
Cardiopulmonary bypass time (min)	1.005 (1.001–1.012)	0.031	−1.30 (17.80 to 11.40)
Renal replacement therapy	2.937 (1.027–8.401)	0.045	−0.05 (15.30 to 15.13)
Low cardiac output syndrome	14.08 (2.951–67.199)	0.001	−1.03 (−2.35 to 0.01)
Cumulative fluid overload on the day of the surgery (%)	1.142 (1.008–1.303)	0.041	−0.13 (−1.78 to 1.14)
			0.01 (−1.53 to 1.51)
			3.12 (2.14 to 3.91)
			3.90 (2.76 to 5.45)
POD2 (mL/kg/hr)	(0.29 to 10.16)	**(2.64 to 5.81)**	**(0.91 to 5.50)**	**(1.66 to 5.45)**	**(3.66 to 6.41)**	4.04 (2.95 to 5.70)

OR = odds ratio.

Data are presented as adjusted OR (95% CI) of the predictors according to the risk of in-hospital mortality. Nonsignificant variables in the final model were maximum vasoactive-inotropic score, gender (male), and postoperative infection.

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

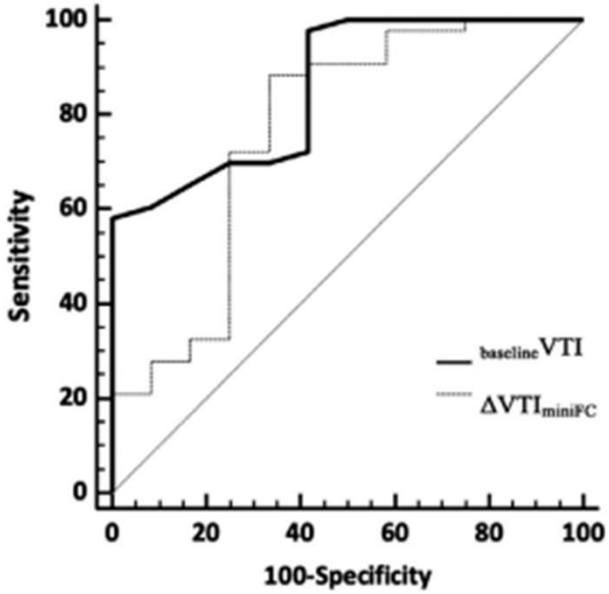
Data are presented as median and interquartile range. All comparisons were made with patients without any complications by using Mann-Whitney *U* test. Significant values are represented in bold at $p < 0.05$.



Lex D.J, Critical care soc 2016

Optimisation de la masse sanguine

Peropératoire



Parameters	ROC AUC (95% CI)	P-value
baseline HR	0.53 (0.39-0.66)	.78
baseline SBP	0.65 (0.50-0.77)	.14
baseline MBP	0.63 (0.48-0.75)	.26
baseline DBP	0.62 (0.48-0.75)	.27
baseline VTI	0.86 (0.74-0.94)	<.0001
ΔHR miniFC	0.65 (0.51-0.77)	.09
ΔSBP miniFC	0.57 (0.43-0.70)	.46
ΔMBP miniFC	0.51 (0.37-0.64)	.96
ΔDBP miniFC	0.51 (0.37-0.65)	.90
ΔVTI miniFC	0.77 (0.63-0.87)	.004

- 55 Enfants (6mois/11 ans)
- Chirurgie cardiaque
- ITV par ETT
- Répondeurs si augmentation de 10%

La variation d ITV sur mini épreuve de remplissage (3mL/Kg) prédit la réponse à un remplissage de 15mL/Kg

Violette Zorio, Paediatric Anesthesia 2020

Minimisation des pertes sanguines: Acide tranexamique

Peropératoire

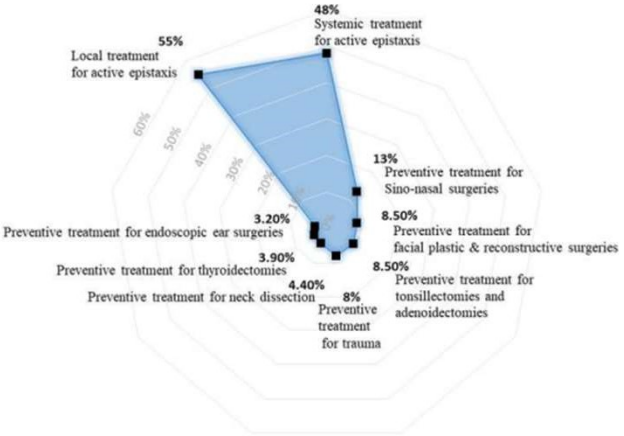


Fig. 1. Tranexamic acid administration practice among all survey study group.

Tranexamic acid administration practice in otolaryngology head & neck surgery; international survey☆

Ron Eliashar[a,1], Seth M. Cohen[b,1], Nir Hirshoren[a,*]

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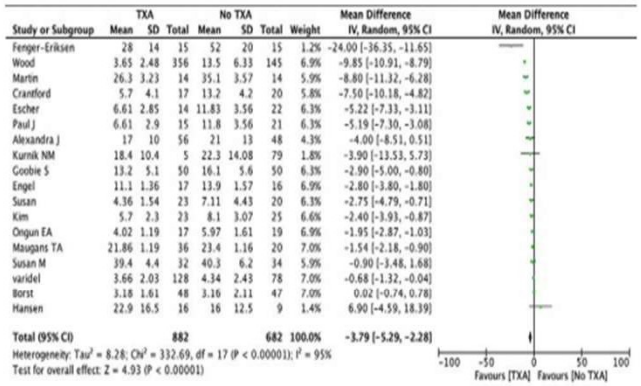
[b] Department of Head and Neck Surgery & Communication Sciences, Duke University, NC, United States



Study or Subgroup	TXA Mean	TXA SD	TXA Total	No TXA Mean	No TXA SD	No TXA Total	Weight	Mean Difference IV, Random, 95% CI
Fenger-Eriksen	28	14	15	52	20	15	1.2%	-24.00 [-36.35, -11.65]
Wood	3.65	2.48	356	13.5	6.33	145	6.9%	-9.85 [-10.91, -8.79]
Martin	26.3	3.23	14	35.1	3.57	14	5.9%	-8.80 [-11.32, -6.28]
Crantford	5.7	4.1	17	13.2	4.2	20	5.8%	-7.50 [-10.18, -4.82]
Escher	6.61	2.85	14	11.83	3.56	22	6.3%	-5.22 [-7.33, -3.11]
Paul J	6.61	2.9	15	11.8	3.56	21	6.3%	-5.19 [-7.30, -3.08]
Alexandra J	17	10	56	21	13	48	4.3%	-4.00 [-8.51, 0.51]
Kurnik NM	18.4	10.4	5	22.3	14.08	79	1.8%	-3.90 [-13.53, 5.73]
Goobie S	13.2	5.1	50	16.1	5.6	50	6.3%	-2.90 [-5.00, -0.80]
Engel	11.1	1.36	17	13.9	1.57	16	6.9%	-2.80 [-3.80, -1.80]
Susan	4.36	1.54	23	7.11	4.43	20	6.3%	-2.75 [-4.79, -0.71]
Kim	5.7	2.3	23	8.1	3.07	25	6.6%	-2.40 [-3.93, -0.87]
Ongun EA	4.02	1.19	17	5.97	1.61	19	6.9%	-1.95 [-2.87, -1.03]
Maugans TA	21.86	1.19	36	23.4	1.16	20	7.0%	-1.54 [-2.18, -0.90]
Susan M	39.4	4.4	32	40.3	6.2	34	5.9%	-0.90 [-3.48, 1.68]
varidel	3.66	2.03	128	4.34	2.43	78	7.0%	-0.68 [-1.32, -0.04]
Borst	3.18	1.61	48	3.16	2.11	47	7.0%	0.02 [-0.74, 0.78]
Hansen	22.9	16.5	16	16	12.5	9	1.4%	6.90 [-4.59, 18.39]
Total (95% CI)			**882**			**682**	**100.0%**	**-3.79 [-5.29, -2.28]**

Heterogeneity: $Tau^2 = 8.28$; $Chi^2 = 332.69$, df = 17 ($P < 0.00001$); $I^2 = 95\%$
Test for overall effect: $Z = 4.93$ ($P < 0.00001$)

Mean Difference IV, Random, 95% CI

-100 -50 0 50 100
Favours [TXA] Favours [No TXA]

Fig. 2. The effect of tranexamic acid on the reduction of blood loss in craniosynostosis surgery (total of 1,564 operations).

Effect of Tranexamic Acid on the Reduction of Blood Loss in Craniosynostosis Surgery: A Systematic Review and Meta-analysis

Abdulaziz Alabdulkarim, MD, PRS Global Open • 2023

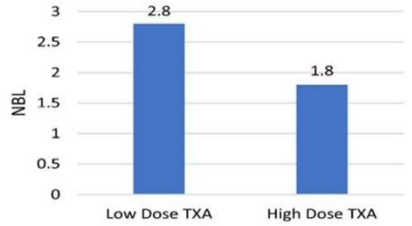


Fig. 1.
Effect of TXA Dosing on Normalized Blood Loss ((EBL/Levels Fused)/Kg)

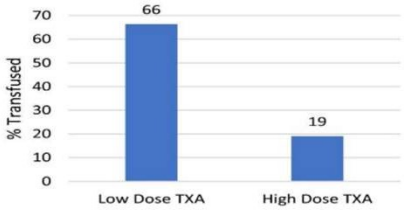


Fig. 3.
Effect of TXA Dosing on % of Patients Requiring PRBC Transfusion

High versus low dose tranexamic acid as part of a patient blood management strategy for reducing blood loss in patients undergoing surgery for adolescent idiopathic scoliosis

Sundeep Tumber, D.O.[1] Spine Deformity 2022

Minimisation des pertes sanguines: Acide tranexamique

Peropératoire

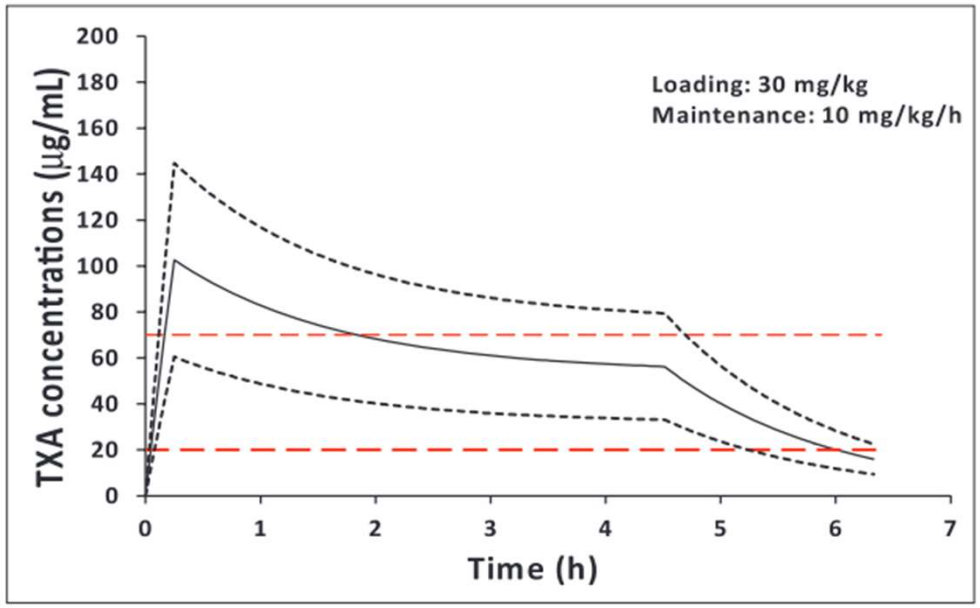


FIGURE 1. TXA plasma concentration time curve simulations for TXA 30 mg/kg loading dose and 10 mg/kg/h maintenance infusion rate. A 95% confidence interval is shown around the mean; the dashed lines indicate the 95% confidence interval around the mean which is represented by the solid line (for an interpatient variability of 25% coefficient of variation). TXA plasma concentration therapeutic target for 20 and 70 µg/ml shown in dashed lines.

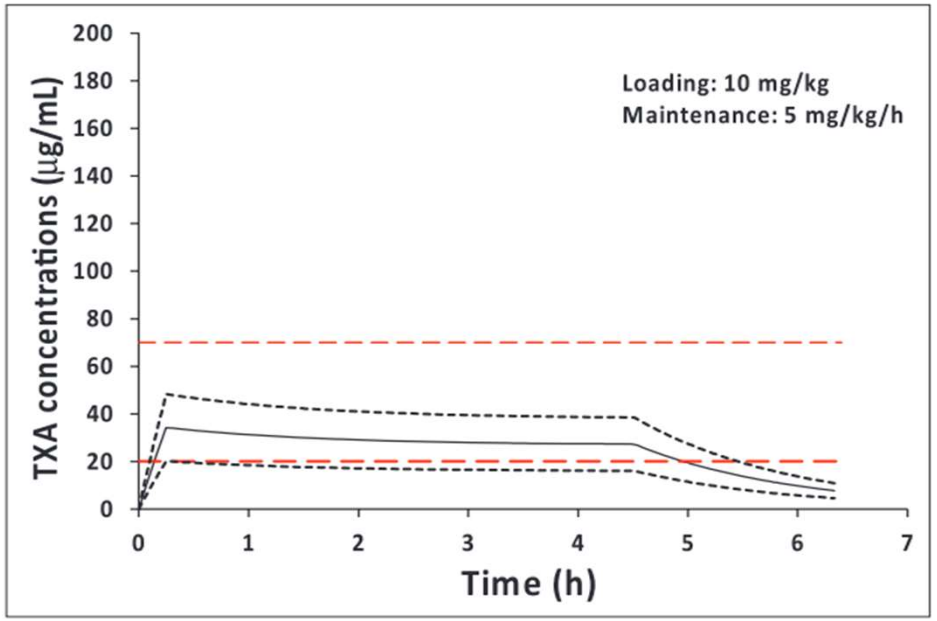


FIGURE 2. TXA plasma concentration time curve simulations for TXA 10 mg/kg loading dose and 5-mg/h/kg maintenance infusion rate. A 95% confidence interval shown around the mean; the dashed lines indicate the 95% confidence interval around the means which is represented by the solid line (for an interpatient variability of 25% coefficient of variation). TXA plasma concentration therapeutic target for 20 and 70 µg/ml shown in dotted lines.

Goobie SM, Current opinion 2019

Minimisation des pertes sanguines: Acide tranexamique

Peropératoire

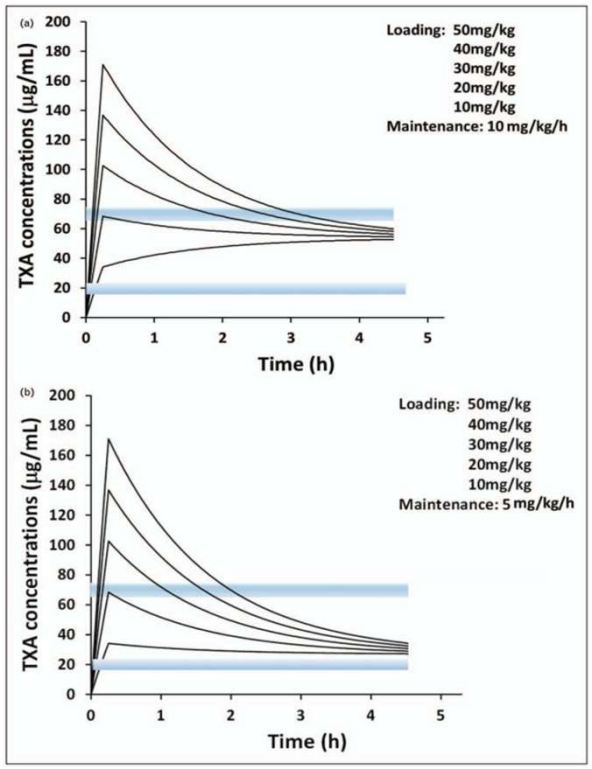


FIGURE 3. Simulated concentrations versus time profiles for different loading dose and two different maintenance infusion rate of 10 mg/kg/h (a) and 5 mg/kg/h (b). Shaded lines represent 20 and 70 µg/ml reference target TXA plasma concentration.

Pédiatrie: trauma et chirurgie

- Bolus 10 à 30 mg/Kg (maximum 2g)
- Entretien 5 à 10 mg/Kg/h

Goobie SM, Current opinion 2019

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RECOMMANDATION

Gestion du capital sanguin en pré, per et postopératoire et en obstétrique

10 à 20 mg/kg IV (souvent 1 g) sur 10 min environ à l'incision (ou avant lâcher garrot)

Jusqu'à 100 mg/kg (maximum !) en chirurgie cardiaque (par exemple bolus de 50 mg/kg sur 1 h à l'incision)

± Entretien
jusqu'à la fin de la chirurgie, ou pendant 8 à 18 h

- Bolus itératifs : ex : 10-15 mg/kg (souvent 1 g) toutes les 4 h (espacer si insuffisance rénale, par exemple toutes les 6-8 h).
- Ou IVSE : 1-5 mg/kg/h pendant la chirurgie.
- Ou IVSE : 1 g sur 8 h.

± Administration topique
par le chirurgien

- Par exemple : 3 g dans 120 mL : 1,5 g pendant puis 1,5 g à la fin.
- Ou par exemple : 1 g dans le cotyle, 1 g dans le fût fémoral avant implant, 1 g espace sous-cut lors fermeture.

Minimisation des pertes sanguines: Récupération sanguine

Peropératoire

Optimizing Blood Loss and Management in Craniosynostosis Surgery: A Systematic Review of Outcomes Over the Last 40 Years

Demetrius M. Coombs, MD[1], Rebecca Knackstedt, MD, PhD[1], and Niyant Patel, MD[2]

Reducing Blood Loss in Synostosis Surgery: The Liverpool Experience

Christian Duncan, MPhil, FRCSI(Plast),* David Richardson, FRCS,* Paul May, FRCS,* Janavikulam Thiruchelvam, FRCS(OMFS),* David Chin Shong, FRCS(OMFS),* Frank Potter, FRCA,* Joan Grogan, RSCN,* Mark Caswell, FRCPath†

Cell Saver: is it beneficial in scoliosis surgery?

Jennifer M. Weiss · David Skaggs · John Tanner · Vernon Tolo

Efficacité discutée

Indications ++

Minimisation des pertes sanguines: Récupération sanguine

Peropératoire

Predictive factors of intraoperative cell salvage during pediatric scoliosis surgery. Cell saver during scoliosis surgery in children

Daphné Michelet [a,c,d], Florence Julien-Marsollier [a,c,d], Julie Hilly [a,c,d], Thierno Diallo [a,c,d], Christophe Vidal [b,c,d], Souhayl Dahmani [a,c,d,*]

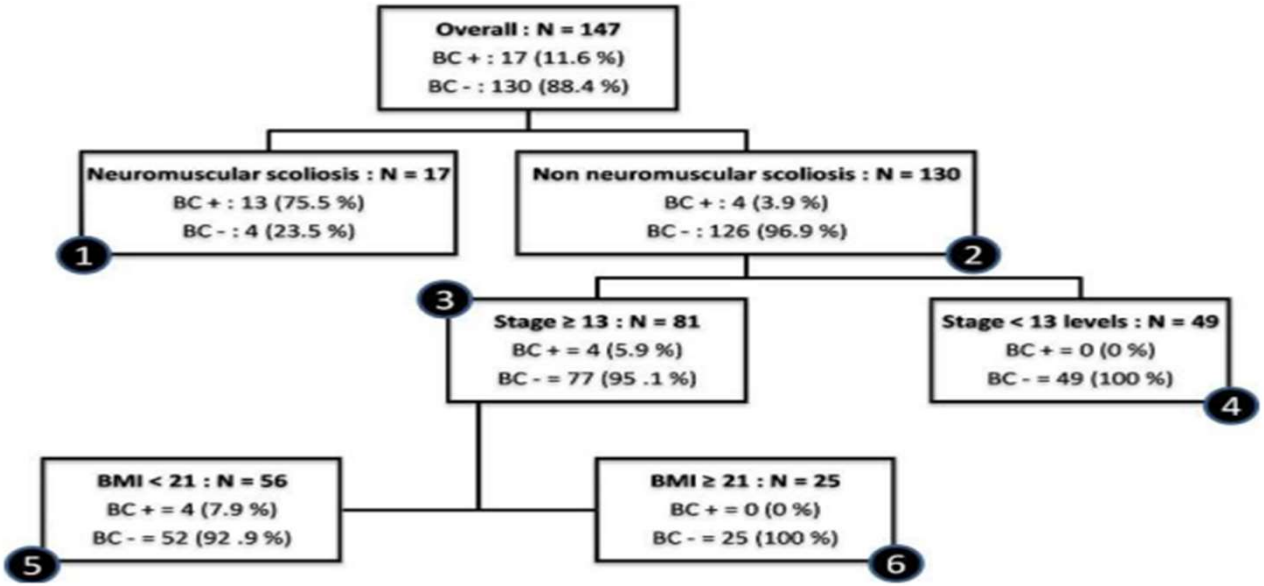


Fig. 1. Diagram of the classification and tree analysis. Each node contains the total number of patients, the studied factor and the proportion of patients with an efficacy (BC+) or inefficacy (BC−) of intraoperative blood salvage.

Minimisation des pertes sanguines: autres mesures

Peropératoire

HAS
HAUTE AUTORITÉ DE SANTÉ

RECOMMANDER
LES BONNES PRATIQUES

RECOMMANDATION Gestion du capital sanguin en pré, per et postopératoire et en obstétrique

- Normothermie
- Monitorage hémoglobine
- Mesures chirurgicales
  - Garrot
  - Hémostase chirurgicale
  - Techniques chirurgicales mini invasives
  - Limitation utilisation/ durée drainage

Amélioration de la tolérance à l'anémie

Postopératoire

Surveillance du saignement et diagnostic de l'anémie postopératoire

- Limiter drainage et leur durée
- Limiter les prélèvements sanguins systématiques
  - Tests rapides de dosage de l'hémoglobine capillaire
- Hémogramme et bilan martial 4 semaines après la chirurgie

Amélioration de la tolérance à l'anémie

Postopératoire

Supplémentation en fer

- Per os Ferrostrane, tardyferon, timoférol
- Par voie intraveineuse
  - Veinofer
    - 3 à 5 mg/Kg
    - par 48h
  - Fer inject
    - 15 mg/Kg
    - max 750mg jusqu'a 16 ans
    - hebdomadaire

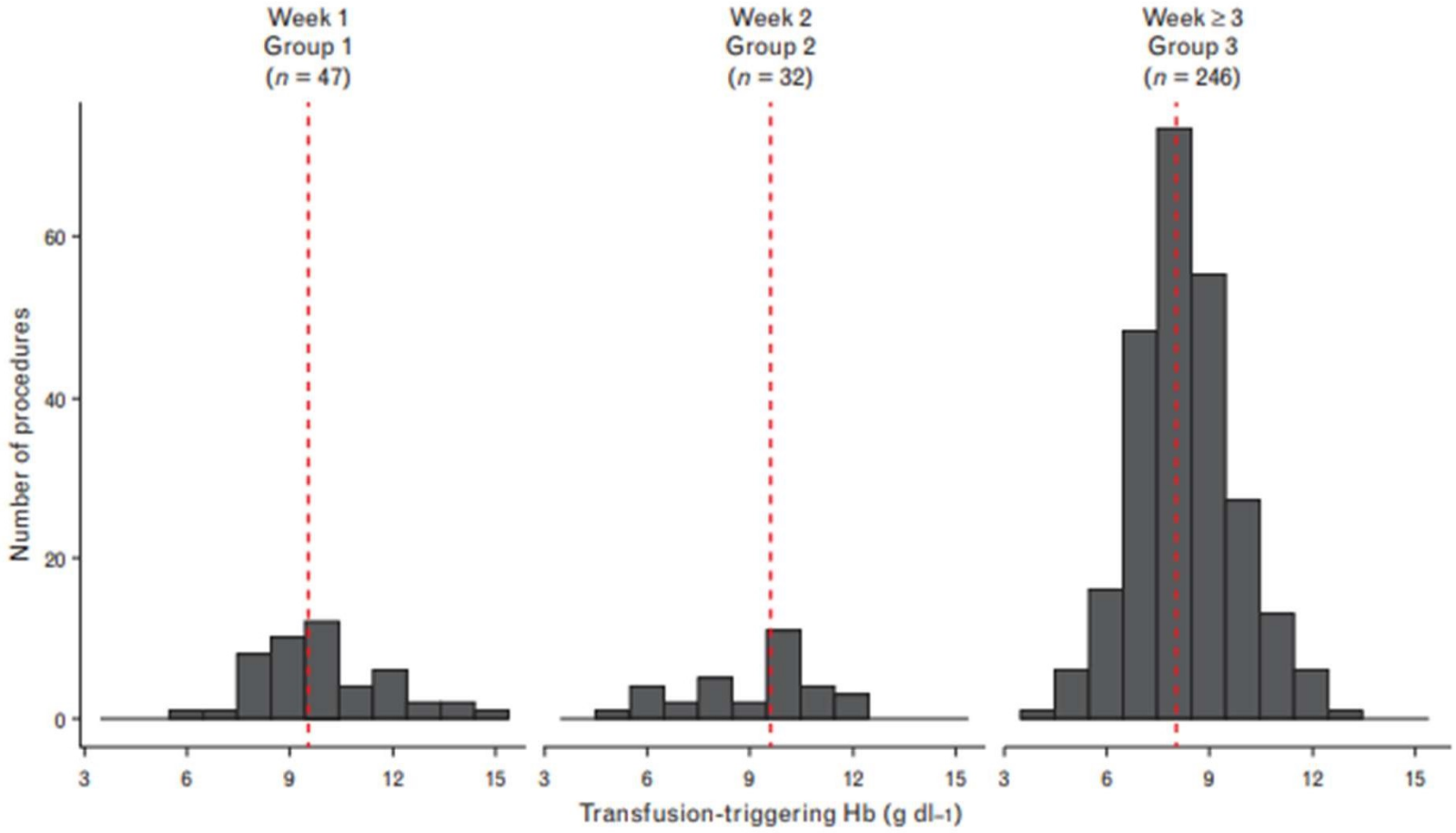
Amélioration de la tolérance à l'anémie

Postopératoire

Respect seuil Transfusionnel

	J0 – J2	J3-J7	> J8
VACI **VNI, LNHD Fi02 ≥ 30%**	12 g/dL	11 g/dL veineux/capillaire ?	10 g/dL
VS ou VNI/LNHD FiO2 <30%	12 g/dL	10 g/dL	8 g/dL
Asymptomatique en VS et réticulocytes <100G/L	NA pour le prématuré 10 g/dL pour le Nné à terme	NA pour le prématuré 8 g/dL pour le NN à terme	7 g/dL

Fig. 2 Histogram of the transfusion-triggering haemoglobin (Hb) thresholds in gram per decilitre (g dl^{-1}) classified by week of life



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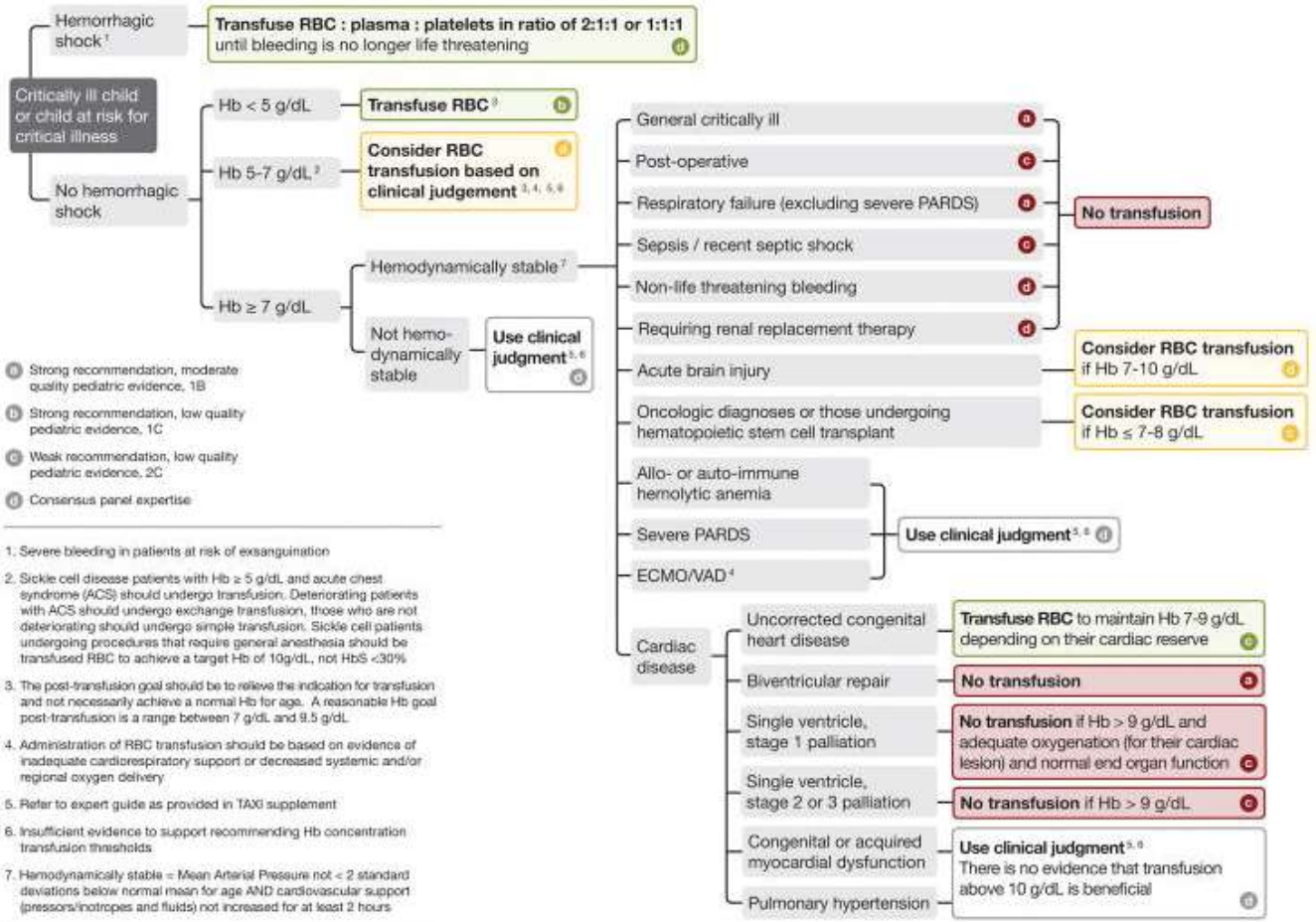
Fuchs, EJA 2022



RBC = Red Blood Cell, Hb = hemoglobin, PARDS = Pediatric Acute Respiratory Distress Syndrome, ECMO = Extracorporeal Membrane Oxygenation, VAD = Ventricular Assist Device

Consensus Recommendations for Red Blood Cell Transfusion Practice in Critically Ill Children from the Pediatric Critical Care Transfusion and Anemia Expertise Initiative

Stacey L Valentine, 2018 pediatric critical care

Patient Blood management préopératoire

Optimisation de la masse sanguine

Minimisation des pertes sanguines

Amélioration de la tolérance à l'anémie

Dépister anémie

Supplémentation
Fer
Acide folique
EPO

Patient Blood management peropératoire

Optimisation de la masse sanguine

Monitorage débit cardiaque

Mini épreuve de remplissage

Minimisation des pertes sanguines

Acide tranéxamique Bolus puis entretien

Récupération sanguine peropératoire

Amélioration de la tolérance à l'anémie

Monitorage pertes sanguines et Hb

Normothermie

Hémostase chirurgicale

Patient Blood management postopératoire

Optimisation de la masse sanguine

Minimisation des pertes sanguines

Acide tranexamique

Amélioration de la tolérance à l'anémie

Supplémentation Fer

Seuil restrictif

Surveillance du saignement et diagnostic de l'anémie postopératoire

2022

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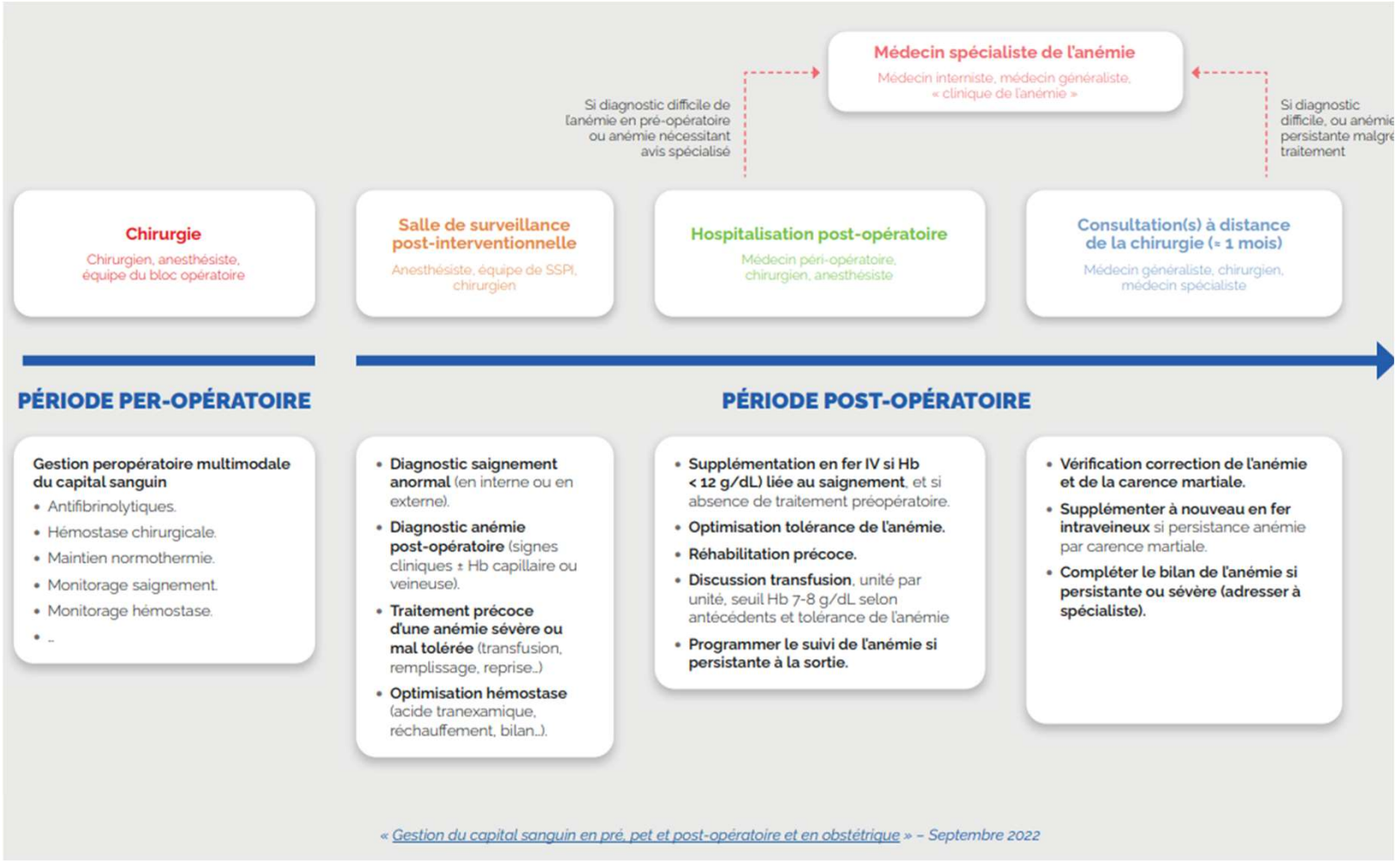
Gestion du capital sanguin en pré, per et postopératoire et en obstétrique



« Gestion du capital sanguin en pré, pet et post-opératoire et en obstétrique » – Septembre 2022

Epargne transfusionnelle en anesthésie pédiatrique

Dr Florence Julien-Marsollier

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