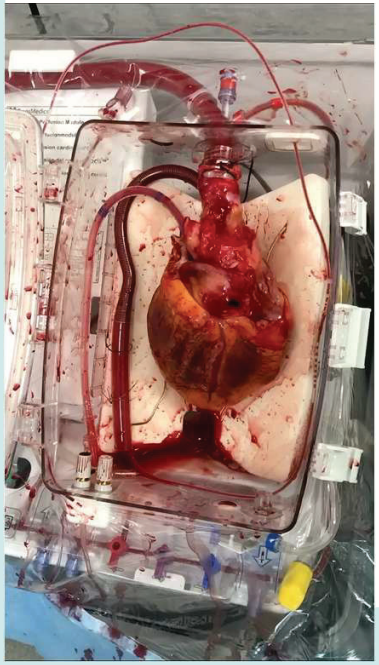
Syndrome hémorragique périopératoire



DU de Circulation ExtraCorporelle

Antoine BEURTON
Service d'anesthésie-réanimation cardiovasculaire
CHU Bordeaux

Hémorragie et mortalité

1 Ranucci, M et al. (2013). *The Annals of Thoracic Surgery* 96, 478–485 //

2000–2012
16154 patients inclus

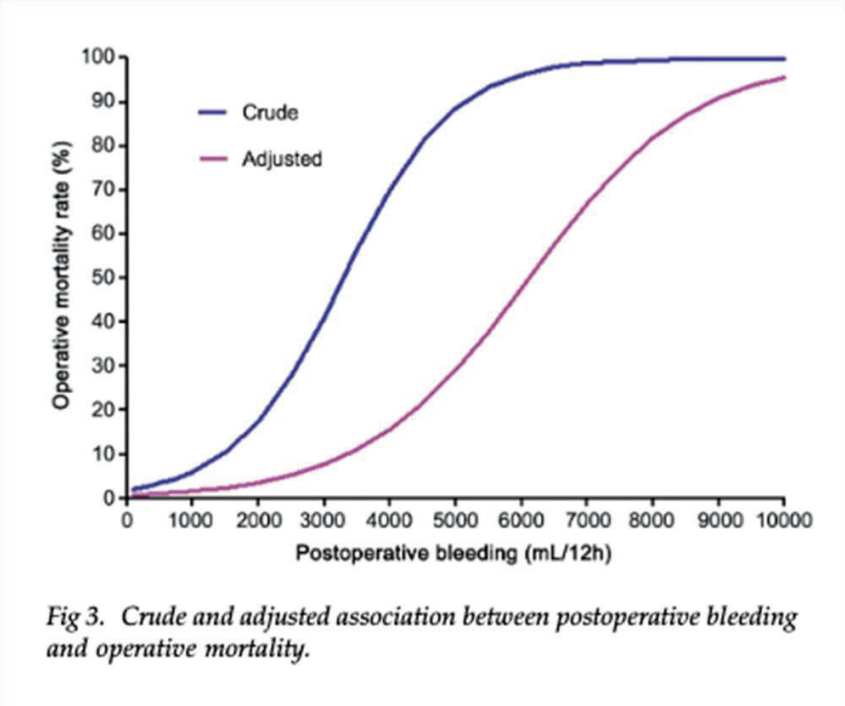
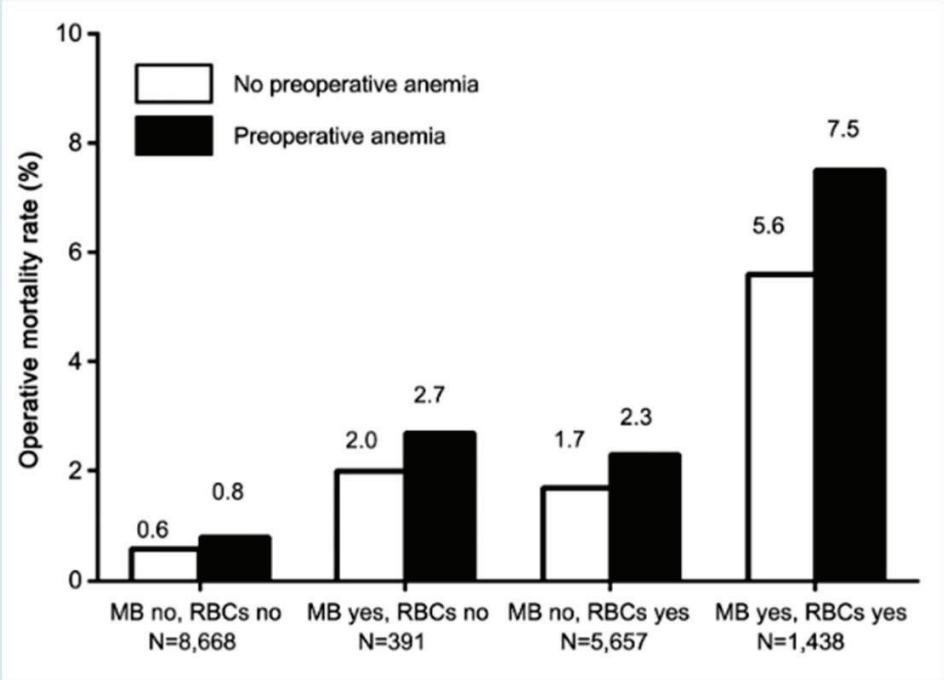


Fig 3. Crude and adjusted association between postoperative bleeding and operative mortality.

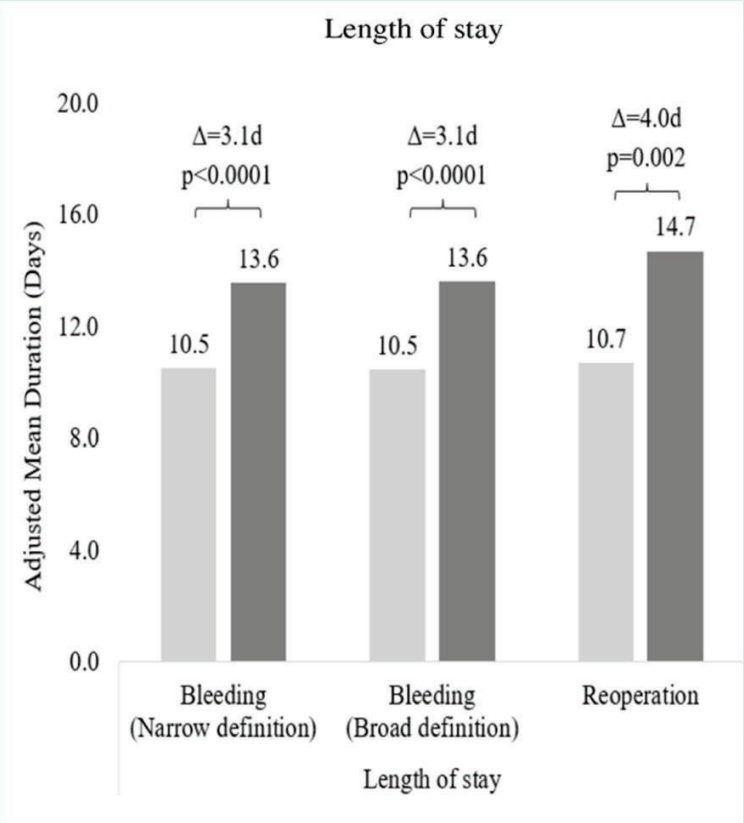


Major Bleeding (MB)

Hémorragie

Al-Attar, N et al. (2019). *J Cardiothorac Surg* 14**,** 64

7774 patients de chirurgie cardiaque (3963 PAC, 2363 valves, 160 aortes)



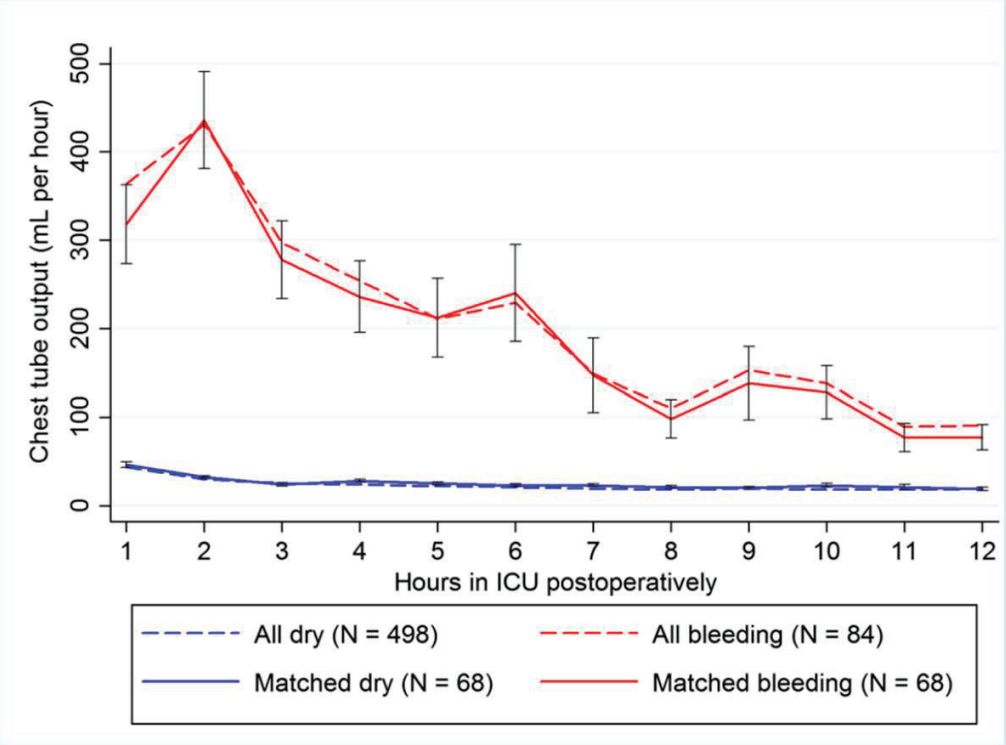
Est-ce grave de saigner sans instabilité

Magruder, JT et al. (2017). *Gen Thorac Cardiovasc Surg* 65, 102–109 //

2010 and 2014
Excusion des tamponades et instabilité HD
Cohorte matchée par propensity
Outcome : score composite morbi-mortalité

bleeding'' group :
300 mL in the first postoperative hour (i.e., in the ICU),
more than 200 mL in the second hour,
and more than 100 mL in the third hour

and a ''dry'' group, defined as patients who bled less than 50 mL/h for each of the first three postoperative hours.



Est-ce grave de saigner sans instabilité

Magruder, JT et al. (2017). *Gen Thorac Cardiovasc Surg* 65, 102–109 //

Critères	Dry	Bleeding	p-value
Nombre de patients (n)	68	68	-
CGR	2 (1–3)	3 (2–7)	**0,03**
PFC	0 (0–0)	2 (1–5)	**<0,001**
PLT	0 (0–0)	1 (0–2)	**<0,001**
Mortalité à 30 jours (%)	1,5 (1)	11,8 (8)	**0,02**
Ventilation prolongée >24 h (%)	7,4 (5)	33,8 (23)	**<0,001**
Médiastinite	1,5 (1)	0	**0,32**
Morbidité/mortalité combinée (hors réopération) (%)	13,2 (9)	36,8 (25)	**0,002**

Coût

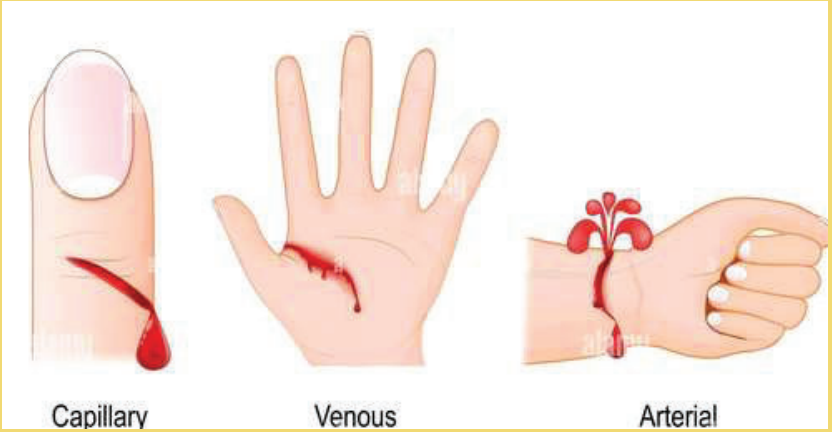
Christensen, MC et al. (2009). *The Journal of Thoracic and Cardiovascular Surgery* 138, 687–693 //

Unit cost by hospital resource

Cost component	Cost (€)	Source/reference
Surgery		
Surgery time (per minute)	13.33	OP Management, 2007 (€800 per hour)
Hemofiltration (run time per day)	943.00	Herzchirurgie, Bad Krozingen, 2007[20]
ECMO	5736.00	Herzchirurgie, Bad Krozingen, 2007[20]
IABP	1283.00	Herzchirurgie, Bad Krozingen, 2007[20]
Recovery		
Cost for reexploration	3305.00	Herzchirurgie, Bad Krozingen, 2007[20]
Transfusion of RBC (cost per unit)	75.00	Harig et al., 2007[21]
Transfusion of FFP (cost per unit)	67.00	Harig et al., 2007[21]
Transfusion of platelets (cost per unit)	467.00	Harig et al., 2007[21]
ICU cost per day (24 h)	1334.00	Graf et al., 2002[22]
Cost per ward day	62.00	Herzchirurgie, Bad Krozingen, 2007[20]
TISS-28 (cost per point/score)	36.00	Graf et al., 2002[22]

ECMO, Extracorporeal membrane oxygenation; *IABP*, intra-aortic balloon pump; *RBC*, red blood cells; *FFP*, fresh frozen platelets; *ICU*, intensive care unit; *TISS-28*, Therapeutic Intervention Scoring System; *AMI*, acute myocardial infarction.

Définir l'hémorragie



Cinétique du saignement

1 Saour, M et al. (2021). *The Annals of Thoracic Surgery* 111, 1308–1315 /

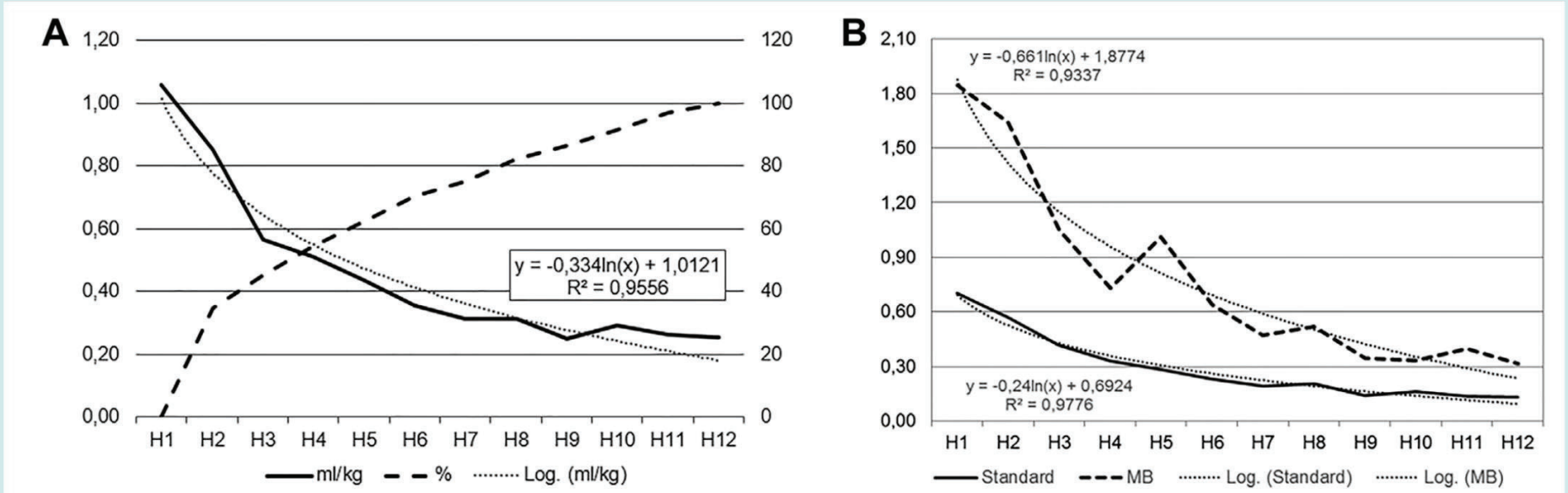


Figure 2. Chest tube bleeding kinetics. (A) Bleeding kinetics during the first 12th postoperative hour, expressed as mL/kg/h (left Y axis) and cumulative bleeding expressed as percentage of blood volume (right Y axis) at hour (H) 12. (B) Bleeding kinetics during the first 12th postoperative hour, expressed as mL/kg/h. Comparison between standard patients and patients with major bleeding (MB) ($P < .004$ at each time period).

Hémorragie massive

1 Saour, M et al. (2021). *The Annals of Thoracic Surgery* 111, 1308–1315 /

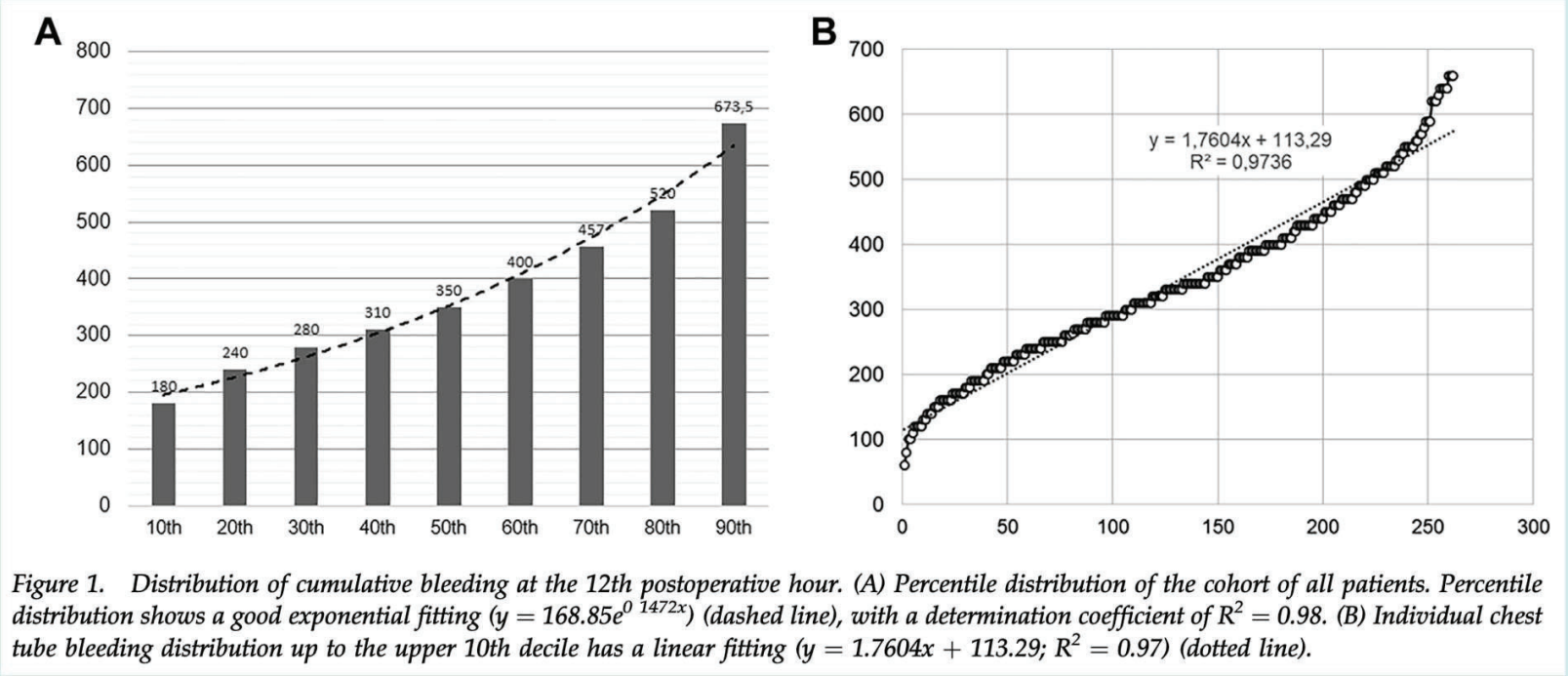


Figure 1. Distribution of cumulative bleeding at the 12th postoperative hour. (A) Percentile distribution of the cohort of all patients. Percentile distribution shows a good exponential fitting ($y = 168.85e^{0.1472x}$) (dashed line), with a determination coefficient of $R^2 = 0.98$. (B) Individual chest tube bleeding distribution up to the upper 10th decile has a linear fitting ($y = 1.7604x + 113.29$; $R^2 = 0.97$) (dotted line).

Hémorragie massive

1 Saour, M et al. (2021). *The Annals of Thoracic Surgery* 111, 1308–1315 /

Table 2. Predictive Value of Early Blood Loss for Major Bleeding[a]

Time	Threshold mL/kg	Se	Sp	PPV	NPV	ROC AUC	95% CI	*P*
H1	1.08	0.83	0.73	0.25	0.98	0.81 ± 0.05	0.72-0.91	<.001
H2	0.95	0.87	0.79	0.31	0.98	0.84 ± 0.04	0.76-0.93	<.001
H3	0.74	0.67	0.79	0.26	0.96	0.75 ± 0.06	0.64-0.86	<.001
H4	1.02	0.47	0.94	0.44	0.94	0.71 ± 0.06	0.60-0.83	<.001
H1-H2	2.73	0.73	0.89	0.42	0.97	0.87 ± 0.04	0.79-0.94	<.001
H1-H3	3.96	0.77	0.92	0.52	0.97	0.87 ± 0.04	0.79-0.95	<.001
H1-H4	4.6	0.77	0.92	0.53	0.97	0.90 ± 0.04	0.83-0.97	<.001

[a]Blood loss threshold at each postoperative hour (H), or cumulative blood loss at H2 (H1 to H2), H3 (H1 to H3), or H4 (H1 to H4); *P* value vs null hypothesis.

CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value; ROC AUC, area under the receiver operating characteristics curve; Se, sensitivity; Sp, specificity.

Surveillance renforcée si

> 1 ml/kg à H1

> 2.7 ml/kg cumulée à H2

> 4,5 ml/kg cumulée à H4

BARC

Mehran, R et al. (2011). *Circulation* 123, 2736–2747 //

Table 3. Bleeding Academic Research Consortium Definition for Bleeding

Type 4: CABG-related bleeding

- Perioperative intracranial bleeding within 48 h
- Reoperation after closure of sternotomy for the purpose of controlling bleeding
- Transfusion of ≥5 U whole blood or packed red blood cells within a 48-h period†
- Chest tube output ≥2L within a 24-h period

Type 5: fatal bleeding

- Type 5a
  - Probable fatal bleeding; no autopsy or imaging confirmation but clinically suspicious
- Type 5b
  - Definite fatal bleeding; overt bleeding or autopsy or imaging confirmation

Mean postoperative chest tube output during the first 24 hours after standard CABG is estimated to be **400 +/-200 mL** and up to 1200 mL in patients treated with dual antiplatelet therapy including clopidogrel.

Bleeding is similar with off-pump CABG and on-pump CABG. Five percent to 7% of patients lose 2 L of blood within the first 24 hours after surgery

UDPB classification

Mehran, R et al. (2011). *Circulation* 123, 2736–2747 //

TABLE 1. Bleeding categories according to the UDPB in adult cardiac surgery (if different categories indicate mixed definitions of bleeding, the worst definition applies)

Bleeding definition	Sternal closure delayed	Postoperative chest tube blood loss within 12 hours (mL)	PRBC (units)	FFP (units)	PLT (units)	Cryoprecipitate	PCCs	rFVIIa	Reexploration/ tamponade
Class 0 (insignificant)	No	<600	0*	0	0	No	No	No	No
Class 1 (mild)	No	601-800	1	0	0	No	No	No	No
Class 2 (moderate)	No	801-1000	2-4	2-4	Yes	Yes	Yes	No	No
Class 3 (severe)	Yes	1001-2000	5-10	5-10	N/A	N/A	N/A	No	Yes
Class 4 (massive)	N/A	>2000	>10	>10	N/A	N/A	N/A	Yes	N/A

UDPB, Universal definition for perioperative bleeding; *PRBC*, packed red blood cells; *FFP*, fresh frozen plasma; *PLT*, platelet concentrates; *PCCs*, prothrombin complex concentrates; *rFVIIa*, recombinant activated factor VII; *N/A*, not applicable. *Correction of preoperative anemia or hemodilution only; the number of PRBCs used should only be considered in the UDPB when accompanied by other signs of perioperative bleeding.

TABLE 2. Independent predictors of UDPB classification

UDPB class	n	EuroSCORE score (%)	Preoperative hematocrit (%)	CPB duration, minutes (SD)
Class 0 (insignificant)	588	4.7 (5.2)	40.0 (4.3)	78.2 (30.6)
Class 1 (mild)	170	5.5 (4.8)	38.2 (3.9)	77.2 (29.1)
Class 2 (moderate)	274	11.1 (12.3)	35.5 (5.1)	99.1 (47.8)
Class 3-4 (severe-massive)	112	13.0 (15.4)	35.5 (6.5)	138.5 (81.4)
P value		.001	.001	.001

UDPB, Universal definition for perioperative bleeding; *CPB*, cardiopulmonary bypass; *SD*, standard deviation.

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Mehran, R et al. (2011). *Circulation* 123, 2736–2747 //

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UDPB, Universal definition for perioperative bleeding; *CPB*, cardiopulmonary bypass; *SD*, standard deviation.

Development and validation of an intraoperative bleeding severity scale for use in clinical studies of hemostatic agents

1 Lewis, KM et al. (2017). *Surgery* 161, 771–781 //

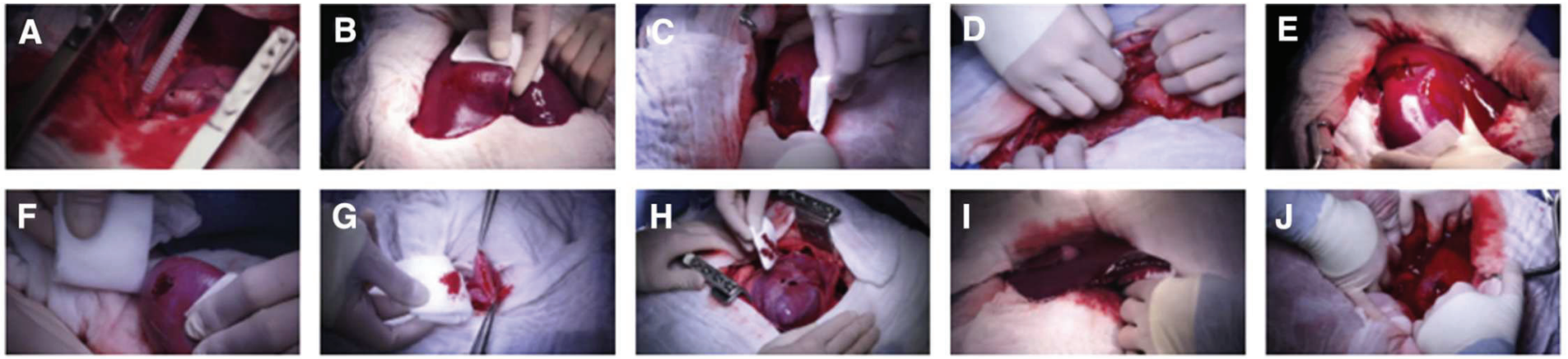


Fig 1. Bleeding severity models. Various depictions of clinically relevant bleeding performed in a porcine animal model; specifically, (*A*) aortotomy closure site, (*B*) untreated, superficial hepatic abrasion, (*C*) untreated, deep nephric abrasion, (*D*) untreated intramammary dissection with vascular rupture, (*E*) untreated hepatic laceration, (*F*) untreated, superficial nephric abrasion, (*G*) untreated partial cystotectomy, (*H*) superficial, cardiac laceration, (*I*) untreated partial hepatectomy, and (*J*) untreated, supra-renal abdominal aortotomy.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

En France

Table 1. Incidence of active bleeding by center (*N = 29*). Incidence of active bleeding (AB) during the 3-month period of the survey, according to the number (N) of cardiac surgery cases in each cardiac surgery center

Cardiac surgery center	Cardiac Cases (N)	AB Frequency (N)	AB Incidence (%)
1	337	18	5.34
2	268	1	0.37
3	254	19	7.48
4	118	3	2.54
5	70	2	2.86
6	74	5	6.76
7	98	3	3.06
8	108	1	0.93
9	332	4	1.20
10	141	4	2.84
11	92	15	16.30
12	151	3	1.99
13	168	5	2.98
14	125	3	2.40
15	150	5	3.33
16	124	2	1.61
17	238	4	1.68
18	214	2	0.93
19	159	2	1.26
20	106	4	3.77
21	96	1	1.04
22	90	1	1.11
23	226	1	0.44
24	168	1	0.60
25	94	0	0.00
26	259	4	1.54
27	198	5	2.53
28	243	5	2.06
29	203	6	2.96
Overall	4904	129	2.63

doi:10.1371/journal.pone.0162396.t001

Alors ?

1) Le seuil d'hémorragie à prendre en compte lors d'une chirurgie cardiaque est de **>1,5 mL/kg/h pendant 6 heures consécutives dans les 24 premières heures, ou toute réintervention dans les 12h pour hémostase**.

2) Volume de drainage > 675 mL dans les 12 heures (> 90° percentile)

3) Taux horaire > 2.7 ml/kg sur les 2 premières heures

1 Colson, PH et al. (2016). *PLOS ONE* 11**,** e0162396 //

Back to the base

VIIa

Vincent, J-L et al. (2007). *Annales Françaises d'Anesthésie et de Réanimation* 26, 145–156 //

Recommandations européennes pour l'utilisation du facteur VII activé recombinant comme thérapeutique adjuvante du saignement majeur ☆

Recommendations on the use of recombinant activated factor VII as an adjunctive treatment for massive bleeding. A European perspective

J.-L. Vincent[a], R. Rossaint[b], B. Riou[c,*], Y. Ozier[d,2], D. Zideman[e,3], D.-R. Spahn[f,1]

1) Température corporelle centrale > 34 °C

2) Hypocalcémie

3) pH ≥7,20

4) Plaquettes > 50 000 /mm3

5) TP > 40 %

6) Hématocrite > 24%

7) Fibrinogène 0,5-1g/L

Wallner, B et al. (2022). *Front. Physiol.* 13, 852182 //

1) Temperature

Whole blood samples from 18 healthy volunteers were analyzed at the target temperatures of 37, 32, 24, 18, and 13.7°C

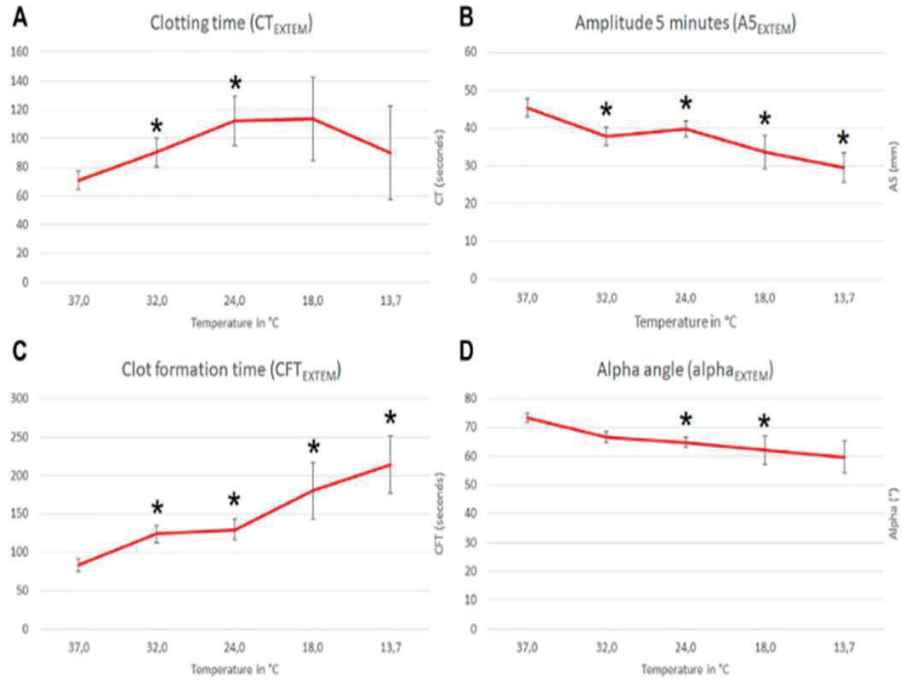


FIGURE 1 | Influence of temperature (x-axis, temperature in degrees Celsius) on ROTEM EXTEM standard parameters (y-axis, seconds in **(A)** and **(C)**; mm in **(B)** and degrees in **(D)**; mean values with respective 95% confidence interval (CI) are shown). * indicates significant differences to baseline at 37°C (*p*-values <0.05).

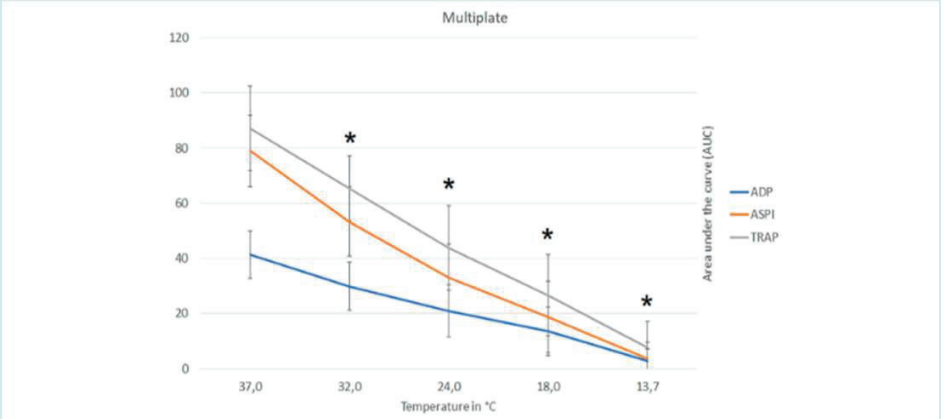
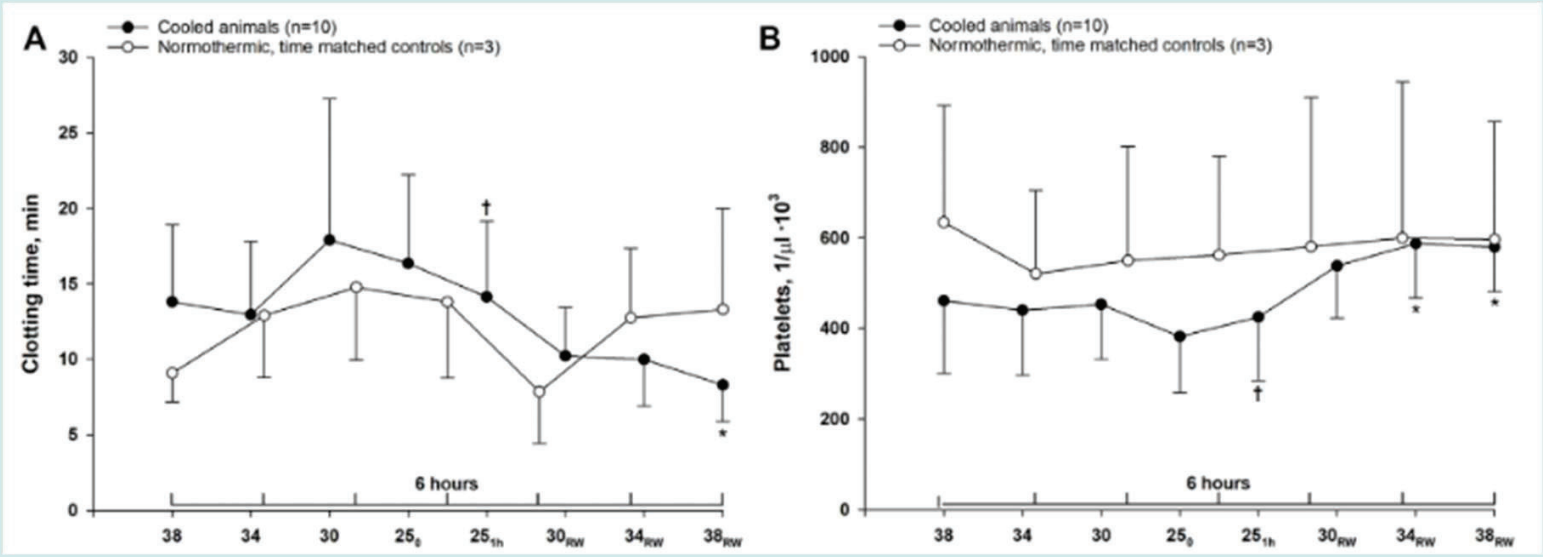


FIGURE 3 | Influence of temperature (x-axis, temperature in degrees Celsius) on platelet function (y-axis, AUC area under the curve) assays ADP, ASPI and Trap, respectively, as measured with multiple-electrode aggregometry (MULTIPLATE). Figure shows mean values with respective 95% confidence interval. AUC, area under the curve; ADP, adenosine diphosphate; ASPI, arachidonic acid; TRAP, thrombin receptor-activating peptide; * indicates significant differences to baseline at 37°C (*p*-values <0.05).

1) Temperature

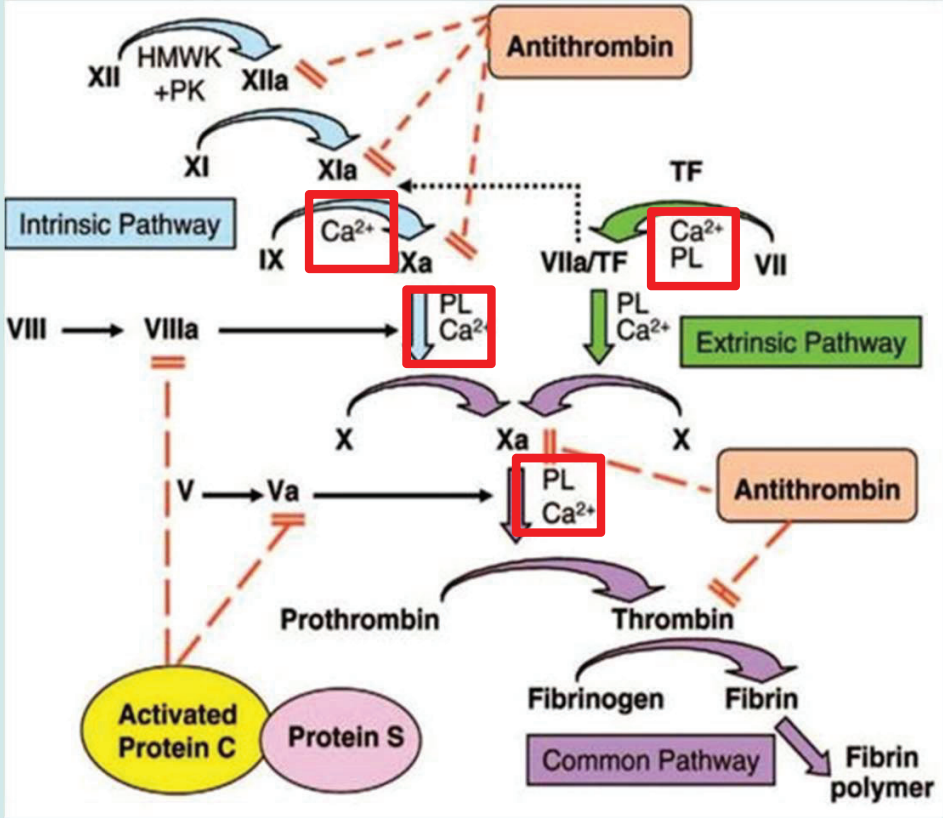
1 Schanche, T et al. (2022). *Front Physiol* 13**,** 901908 //

Etat hypercoagulabilité dans le groupe hypothermie -> normothermie par rapport aux animaux normotherme



2) Calcémie

Butterworth J, et al (1990) Probl Crit Care 1990:402–15



2) Calcémie

James, MFM & Roche, AM. (2004). *Journal of Cardiothoracic and Vascular Anesthesia* 18, 581–586 //

Une calcémie ionisée supérieure à 0,56 mmol/L permet une coagulation normale ; au-dessus de ce seuil, le calcium n'est généralement pas la cause d'anomalies de la coagulation

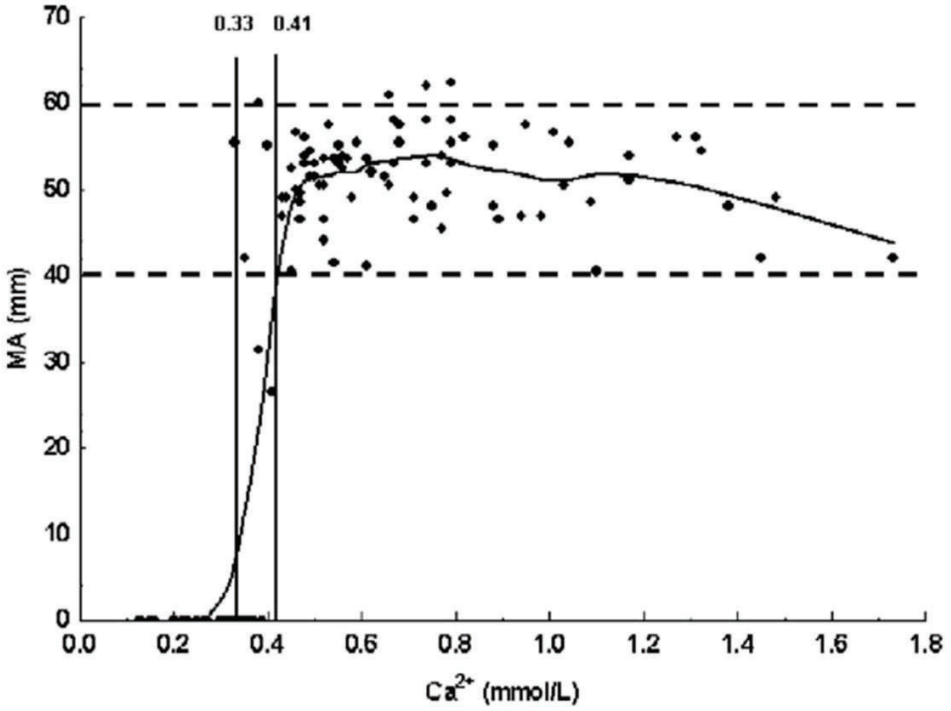


Fig 5. Scatterplot of maximum amplitude values against ionized calcium concentrations. Horizontal dashed lines indicate the range of normal values. No coagulation occurred in any sample with a Ca^{2+} <0.33 mmol/L; all but 2 samples with Ca^{2+} >0.33 mmol/L showed normal clot strength, and only 2 samples in which clotting occurred had an MA below the normal range. All samples with Ca^{2+} >0.41 mmol/L developed normal strength clot.

Cardiovasculaire : ionized Ca < 0.9 mmol/L peuvent avoir un effet significatif sur le myocarde et les résistances vasculaires et les arythmies

3) Acidose

Etulain, J et al. (2012). *Thromb Haemost* 107, 99–110 //
Lv, X et al. (2018). *The American Journal of Emergency Medicine* 36, 1332–1340 //

pH < 7,20

Coagulation :

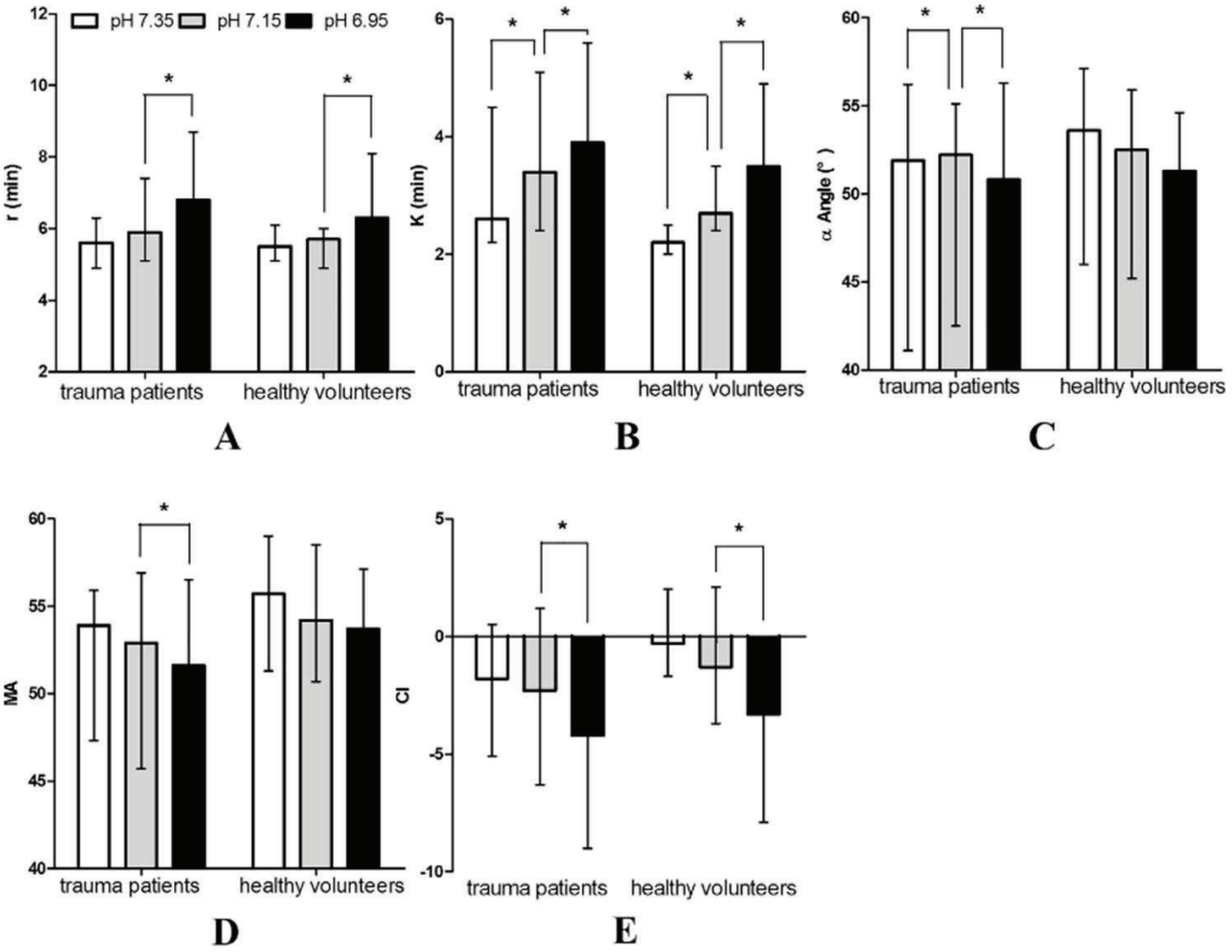
- Ralenti la génération de thrombine : baisse force et stabilité des caillots
- Prolonge la phase de propagation
- Accélère la dégradation du fibrinogène sans affecter sa synthèse
- Favorise l'hyperfibrinolyse,

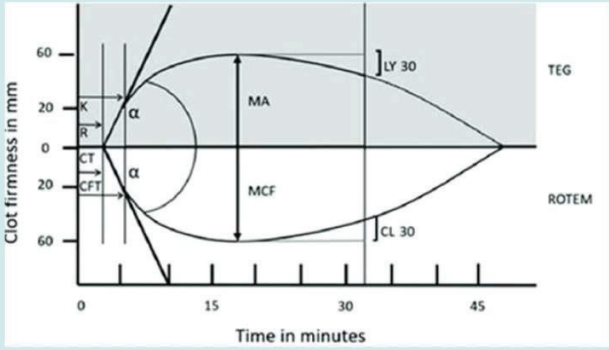
Plaquettes :

- Diminution de l'adhésion, de l'agrégation, de la libération d'ATP et de la rétraction du caillot (pH ≤ 7,0)

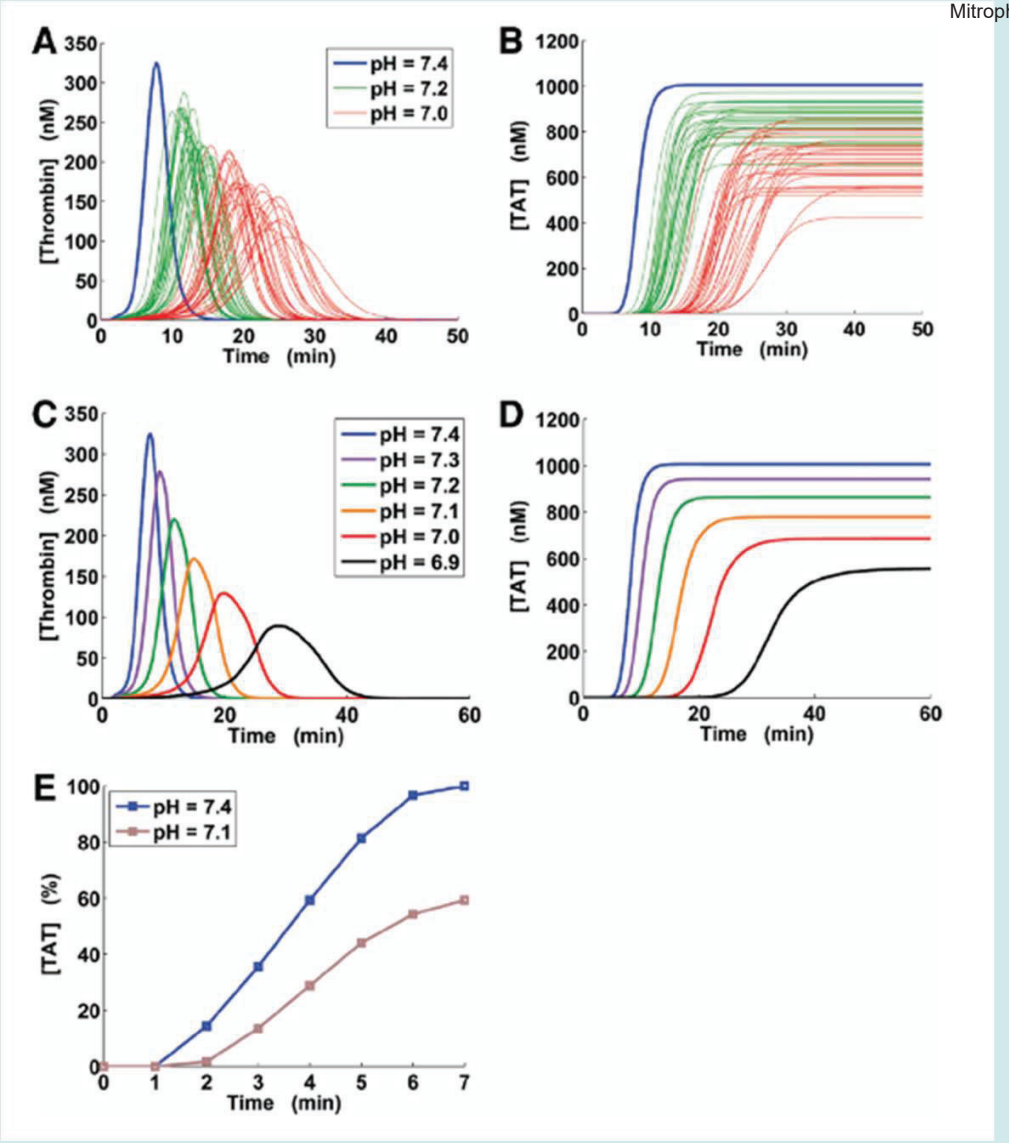
3) Acidose

Lv, X et al. (2018). *The American Journal of Emergency Medicine* 36, 1332–1340 //





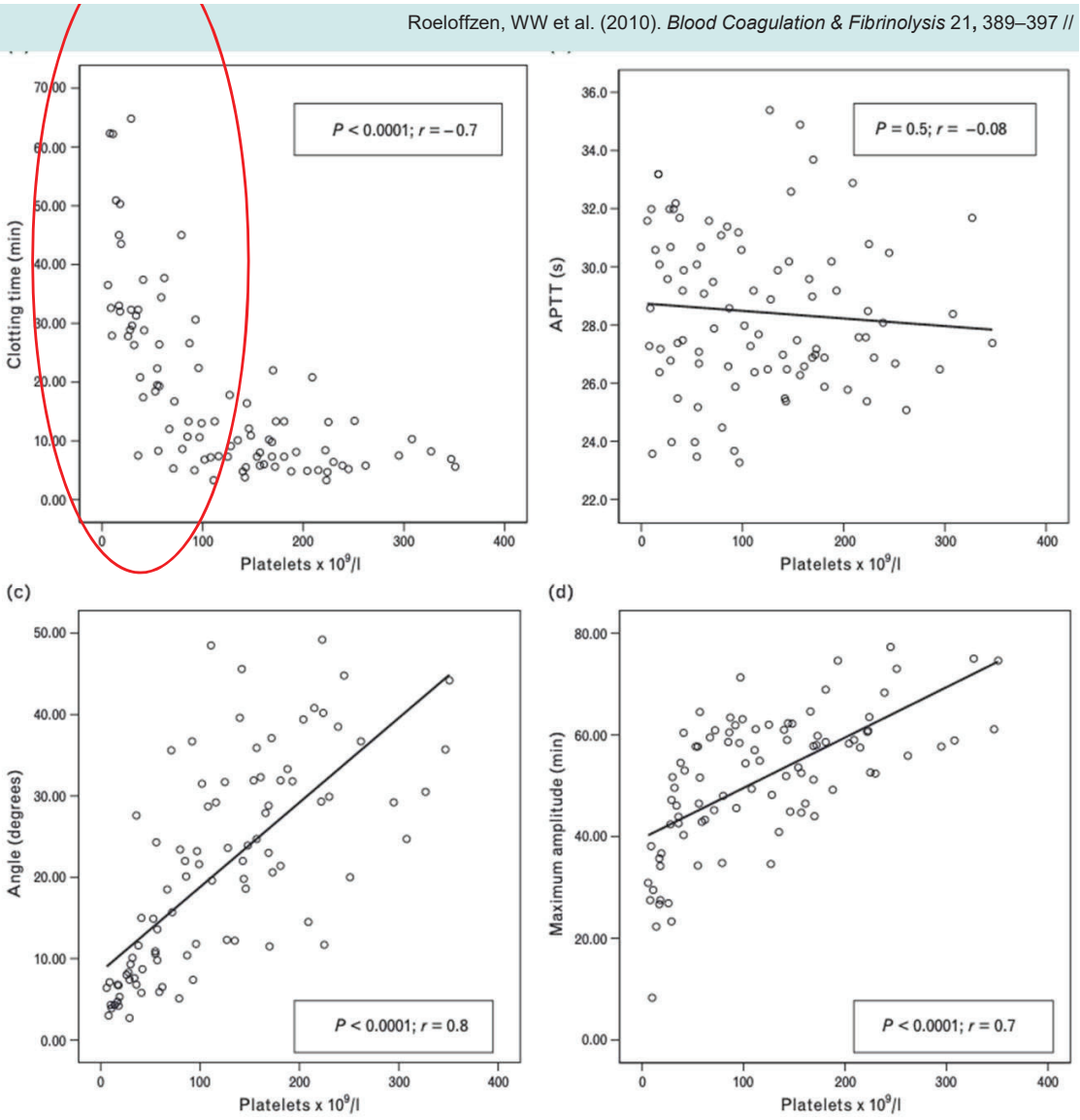
3) Acidose



Mitrophanov, AY et al. (2015). *Anesthesia & Analgesia* 121

4) Thrombopénie

Roeloffzen, WW et al. (2010). *Blood Coagulation & Fibrinolysis* 21, 389–397 //



Thrombopénie

Impact of Preoperative Thrombocytopenia on the Outcome after Coronary Artery Bypass Grafting

Nammas, W et al. (2019). *Platelets* 30, 480–486 //

	Platelets count 150-450 x 10^9/L (N=6590)	Platelets count 100-149 x 10^9/L (N=548)	Platelets count <100 x 10^9/L (N=51)	Mixed-effects multivariate analysis p-value
Hospital/30-day mortality	123 (1.9)	17 (3.1)	2 (3.9)	**0.009**
1-year mortality (%)	3.4	5.7	4.3	**0.021**
Intensive care unit stay (days)	2.8±3.6	3.5±9.0	4.2±4.3	**<0.0001**
Stroke	75 (1.1)	6 (1.1)	1 (2.0)	0.803
Prolonged inotropic support	1784 (27.1)	196 (35.8)	18 (35.3)	0.112
Intra-aortic balloon pump	291 (4.4)	23 (4.2)	4 (7.8)	0.772
Postoperative ECMO	42 (0.6)	3 (0.5)	0	0.745
Deep sternal wound infection	157 (2.4)	19 (3.5)	2 (3.9)	**0.046**
KDIGO acute kidney injury*	1442 (22.2)	144 (27.0)	20 (40.0)	**<0.0001**
De novo dialysis	112 (1.7)	16 (3.0)	2 (4.0)	**0.021**
Postoperative atrial fibrillation	1736 (26.3)	178 (32.5)	19 (37.3)	**0.034**
Chest drainage output at 12 h (ml)	456±300	517±379	535±356	**<0.0001**
Nadir hemoglobin (g/mL)	99±16	100±17	93±13	0.152
Nadir hematocrit (%)	30±4.8	30±5	28±4	0.312
Resternotomy for bleeding	168 (2.5)	17 (3.1)	4 (7.8)	0.060
Blood products				
Red blood cells (units)	1.1±2.4	1.2±2.2	2.7±4.4	**0.027**
Fresh frozen plasma	398 (6.0)	45 (8.2)	12 (23.5)	**0.001**
Platelets	478 (7.3)	69 (12.6)	20 (39.2)	**<0.0001**
Fibrinogen	228 (3.5)	24 (4.4)	5 (9.8)	**<0.0001**
Prothrombin	108 (1.6)	8 (1.5)	3 (5.9)	**0.036**
Cryoprecipitate	20 (0.3)	0	0	1.000
rfVIIa	10 (0.2)	1 (0.2)	0	0.983
E-CABG bleeding grade 2-3	412 (6.3)	50 (9.1)	12 (23.5)	**<0.0001**
UDPB bleeding grade 3-4	537 (8.2)	63 (11.7)	12 (23.5)	**0.001**

Thrombopénie

Roeloffzen, WW et al. (2010). *Blood Coagulation & Fibrinolysis* 21, 389–397 //

JAMA | Special Communication

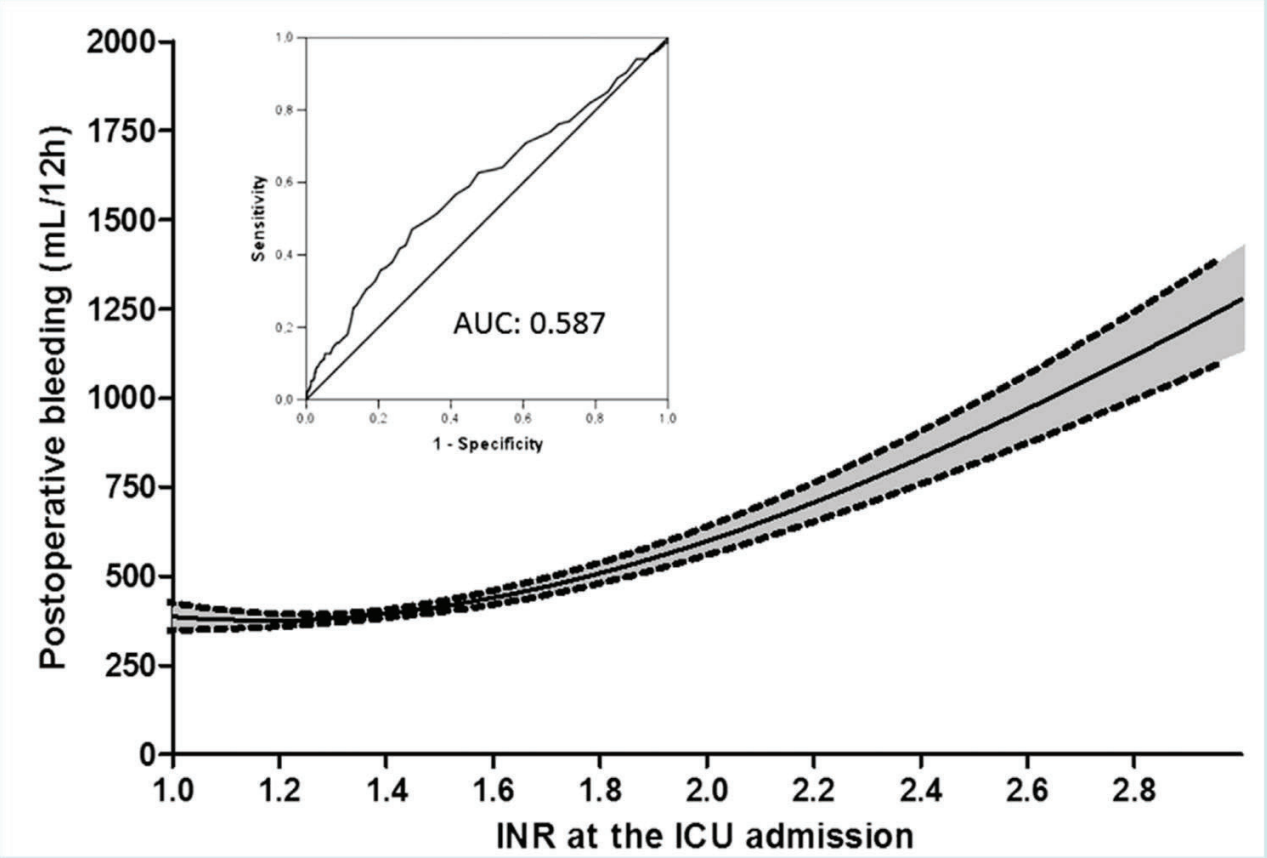
Platelet Transfusion
2025 AABB and ICTMG International Clinical Practice Guidelines

2.6: Nonthrombocytopenic patients undergoing cardiovascular surgery in the absence of major hemorrhage, including those receiving cardiopulmonary bypass	No platelet transfusion	Very low	The limited data available support no benefit with use of platelets

Le seuil transfusionnel de plaquettes recommandé en cas de thrombocytopénie préopératoire chez les patients subissant une chirurgie cardiaque est inférieur à 50 × 10^9/L

5) TP/INR

Ranucci, M et al. (2016). *The Annals of Thoracic Surgery* 102, 78–85 //



Anomalie de coagulation

1 Lim, K et al. (2022). *Transfusion* 62, 2223–2234 /

Intra /post-operative bleeding complication requiring transfusion

Others (9)

Abnormal INR/aPTT & Low PLT (8)

Abnormal INR/aPTT (7)

Abnormal aPTT (6) >70

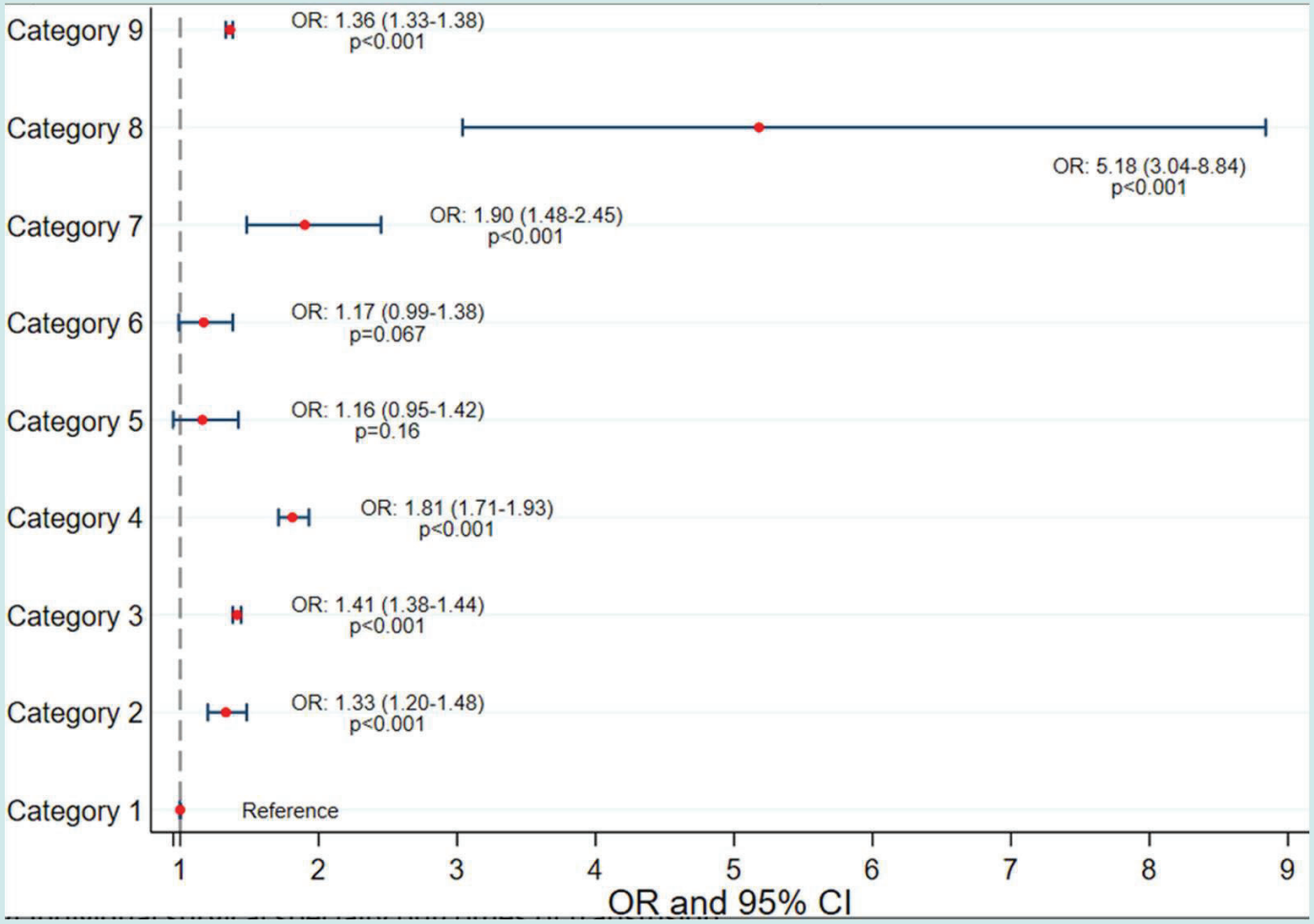
Equivocal aPTT (5) 60–70

Abnormal INR (4) > 1.5

Equivocal INR (3) (1.1–1.5)

Low PLT (2) (<100G/)

Normal (1)



6) Hématocrite

Weisel, JW & Litvinov, RI. (2019). *Journal of Thrombosis and Haemostasis* 17, 271–282 //

Effets	Mécanismes
Effets hémorhéologiques	Augmentation de la viscosité sanguine par augmentation de l'hématocrite, une agrégation accrue des GR et une diminution de leur déformabilité = augmentation de la résistance à l'écoulement Les GR rigides obstruent les petits vaisseaux. Les RBCs migrent vers le centre du flux sanguin et poussent les plaquettes vers l'endothélium (margination) de manière dépendante de l'hématocrite et du cisaillement.
Effets sur la réactivité plaquettaire	Augmentation de l'adhésion et de l'agrégation plaquettaire par libération d'ADP et de thromboxane A_2. Formation d'agrégats avec les plaquettes via des molécules adhésives
Structure et propriétés des caillots et thrombi	La déformabilité variable des RBCs affecte les mécanismes de formation des caillots. La rétention des RBCs médiée par le Facteur XIIIa augmente la taille du thrombus.
Effets sur la fibrinolyse et la thrombolyse	Les RBCs réduisent la perméabilité des caillots. Les RBCs inhibent l'activation du plasminogène induite par le tPA. Les RBCs diminuent le diamètre des fibres de fibrine et modifient la structure du réseau, réduisant ainsi la susceptibilité à la fibrinolyse.
Effets hémostatiques des transfusions de RBCs	Les transfusions de CGR arrêtent les saignements associés à l'anémie et la thrombocytopénie. Les transfusions de CGR améliorent la réactivité plaquettaire à la stimulation.

6) Hématocrite

Weisel, JW & Litvinov, RI. (2019). *Journal of Thrombosis and Haemostasis* 17, 271–282 //
Lassila, R & Weisel, JW. (2023). *Journal of Thrombosis and Haemostasis* 21, 3024–3032 //

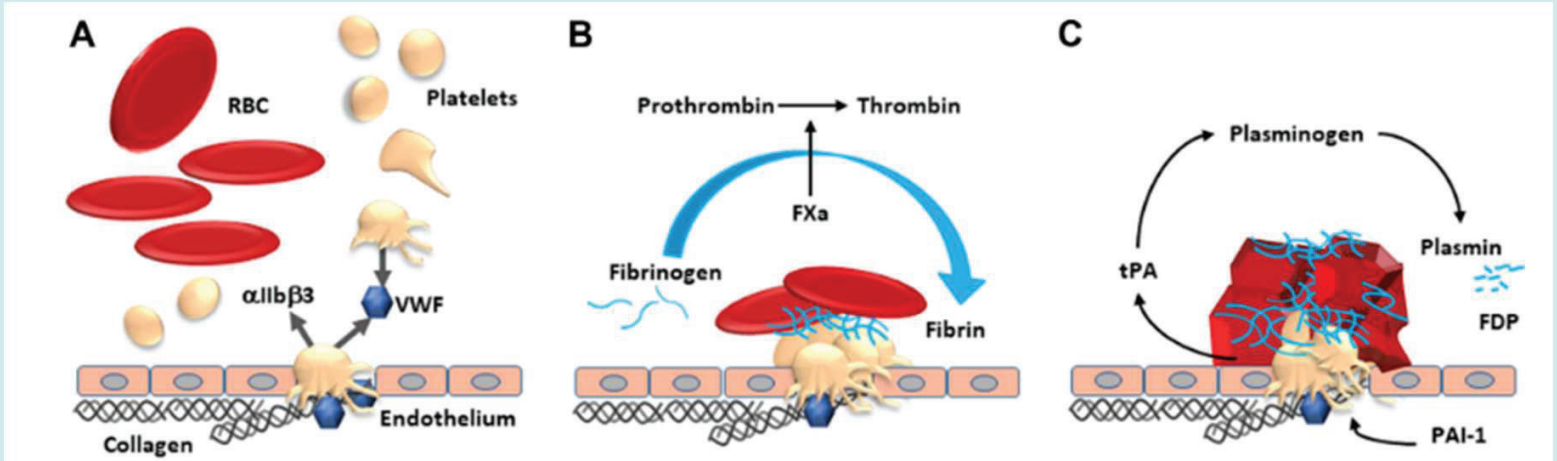
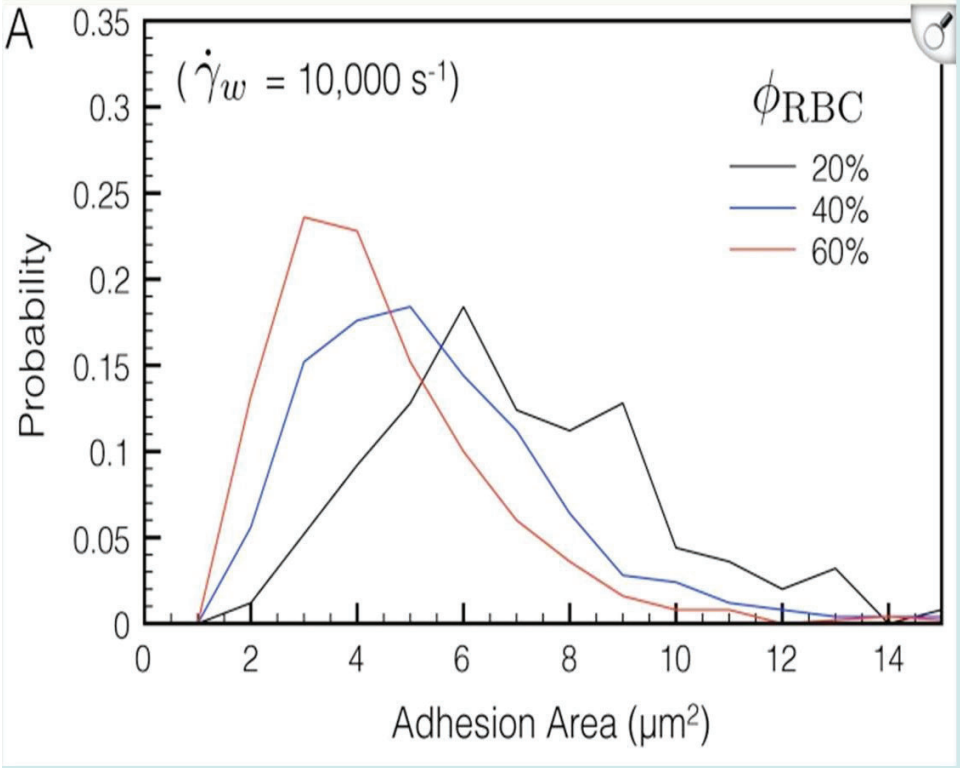


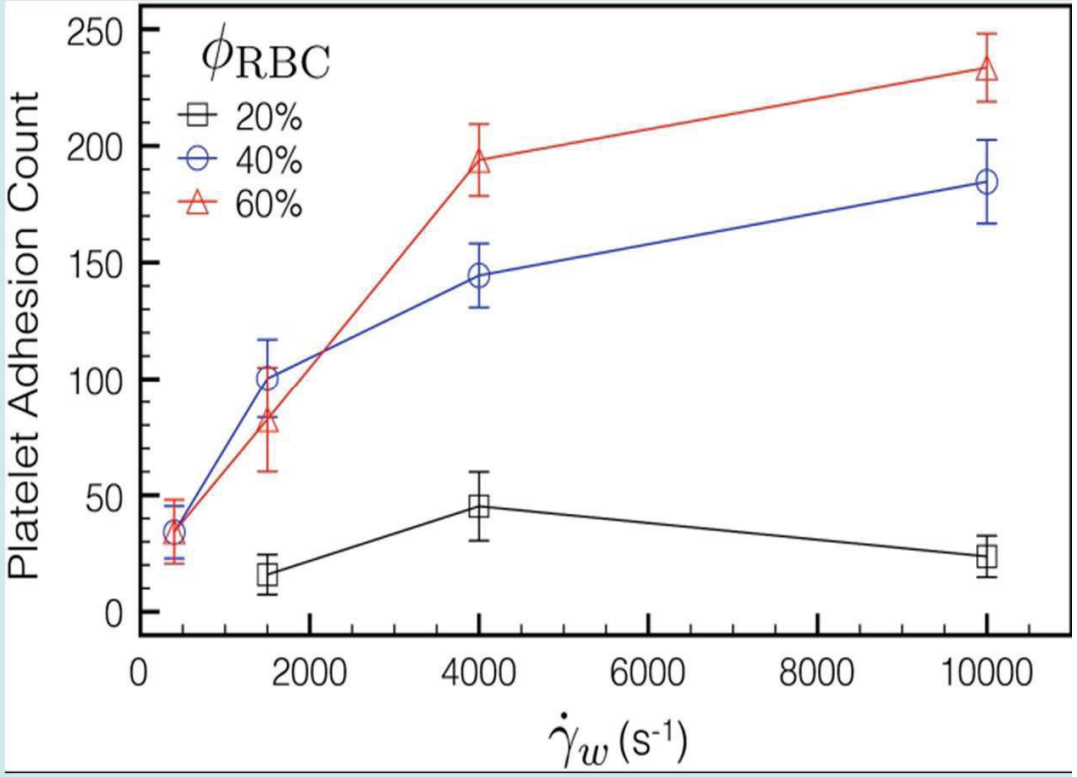
FIGURE 2 Three stages (A–C) in which red blood cells (RBCs) contribute to hemostasis. (A) Primary hemostasis and platelet activation. RBCs, by increasing local vessel wall shear forces, induce margination and activation of platelets at an injured vascular wall, unfold von Willebrand factor (VWF), and enhance platelet-vascular wall interactions. (B) Thrombin generation and fibrin formation. RBCs provide phosphatidylserine, which is a procoagulant surface to assemble coagulation factors and contribute to thrombin generation, platelet activation, and fibrin formation. (C) Fibrin stability, clot contraction, and formation of polyhedrocytes. RBCs have a procoagulant surface, enhancing thrombin generation, and bind to platelets via interactions between platelet integrin αIIbβ3 (or glycoprotein IIb/IIIa) and endothelial cell intercellular adhesion molecule 4 (ICAM-4) and to fibrin(ogen) via a β3 integrin, which aids in clot stabilization and prevents early fibrinolysis. During clot contraction, RBCs are compressed to tightly packed polyhedrocytes, forming an impermeable seal. (A) The activation and secretion of platelets, (B) clot structure from thrombin generation and fibrin polymerization, as well as activation of coagulation factor XIII, a fibrin stabilizing factor, all affect fibrinolysis together with clot contraction (C). Integrin αIIbβ3 is a receptor of VWF (high shear rates) and fibrinogen (low shear rates). FXa, activated coagulation factor X, FDP, fibrin degradation products. including D-dimer; PAI-1, plasminogen activator inhibitor; tPA, tissue plasminogen activator.

6) Hématocrite

Weisel, JW & Litvinov, RI. (2019). *Journal of Thrombosis and Haemostasis* 17, 271–282 //

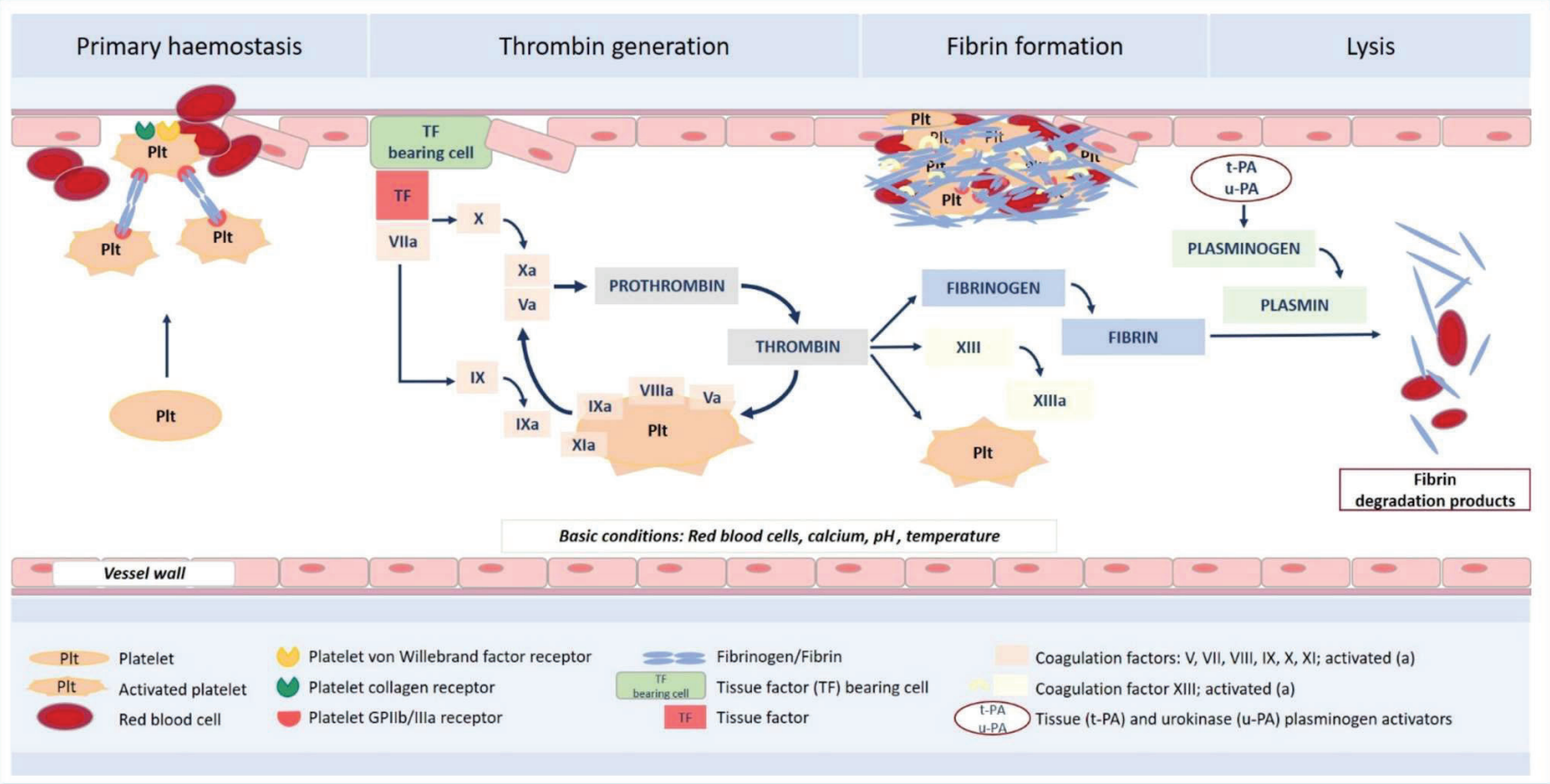
Etude sur volontaire sain





7) Fibrinogène

1 Ranucci, M et al. (2016). *The Annals of Thoracic Surgery* 102, 78–85 //

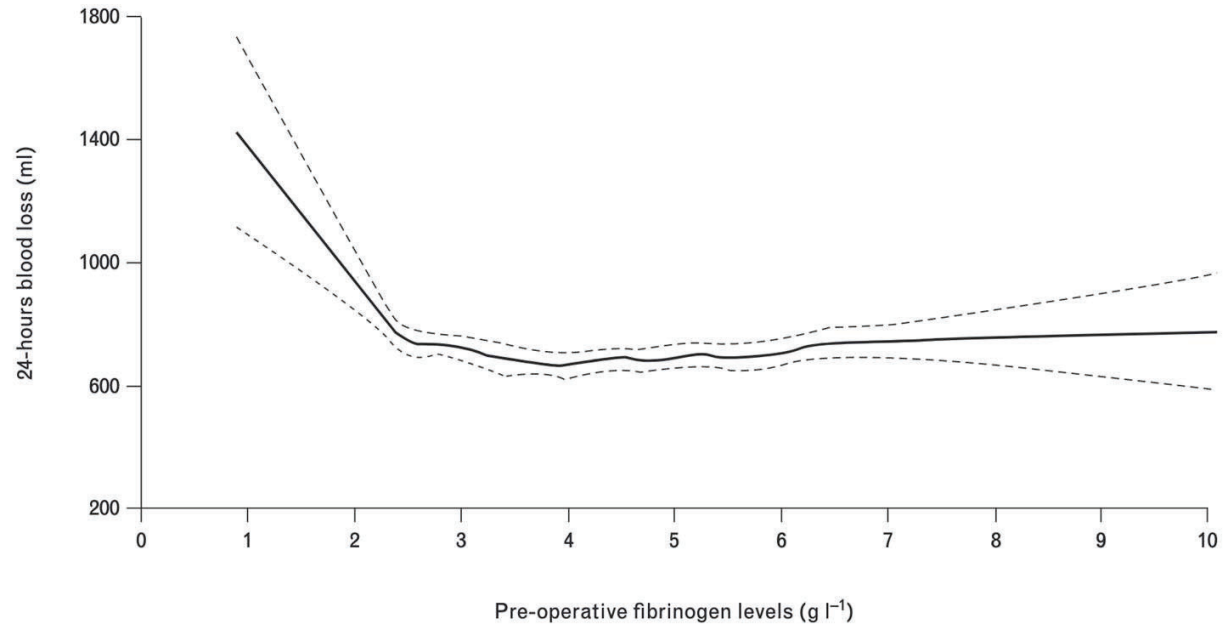


Fibrinogène

1 Mion, S et al. (2020). *European Journal of Anaesthesiology | EJA* 37**,** 889–897 /

Etude rétrospective, 3883 patients, exclusion en cas d'administration de fibrinogen

Fig. 2

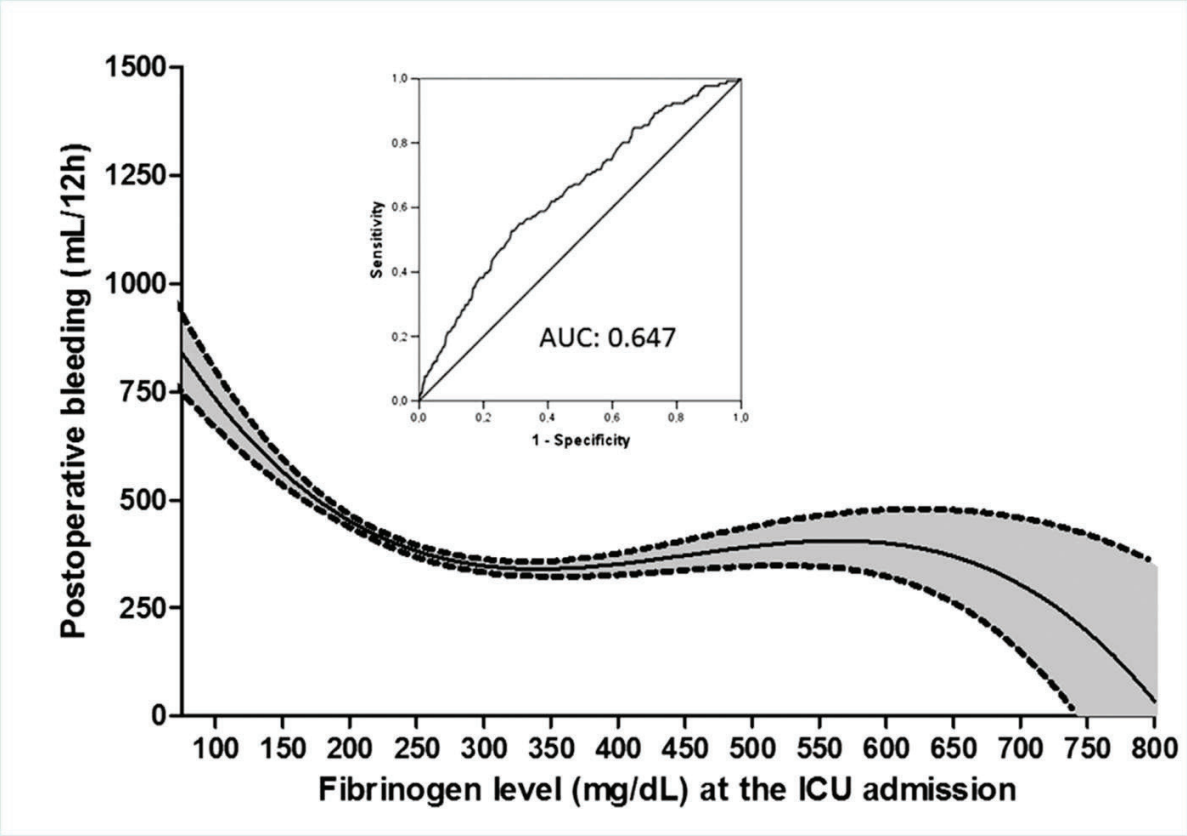


Relationship between preoperative fibrinogen levels and 24-h postoperative blood loss, with 95% upper and lower confidence bands (all patients).

Fibrinogène

1 Ranucci, M et al. (2016). *The Annals of Thoracic Surgery* 102, 78–85 //

Etude rétrospective, 2800 patients, 2012-2015, exclusion en cas d'administration de fibrinogen



Fibrinogène

1 Erdoes, G et al. (2018). *PLOS ONE* 13, e0201647 //

Augmentation progressive en postopératoire, environ 0,6g/L par heure

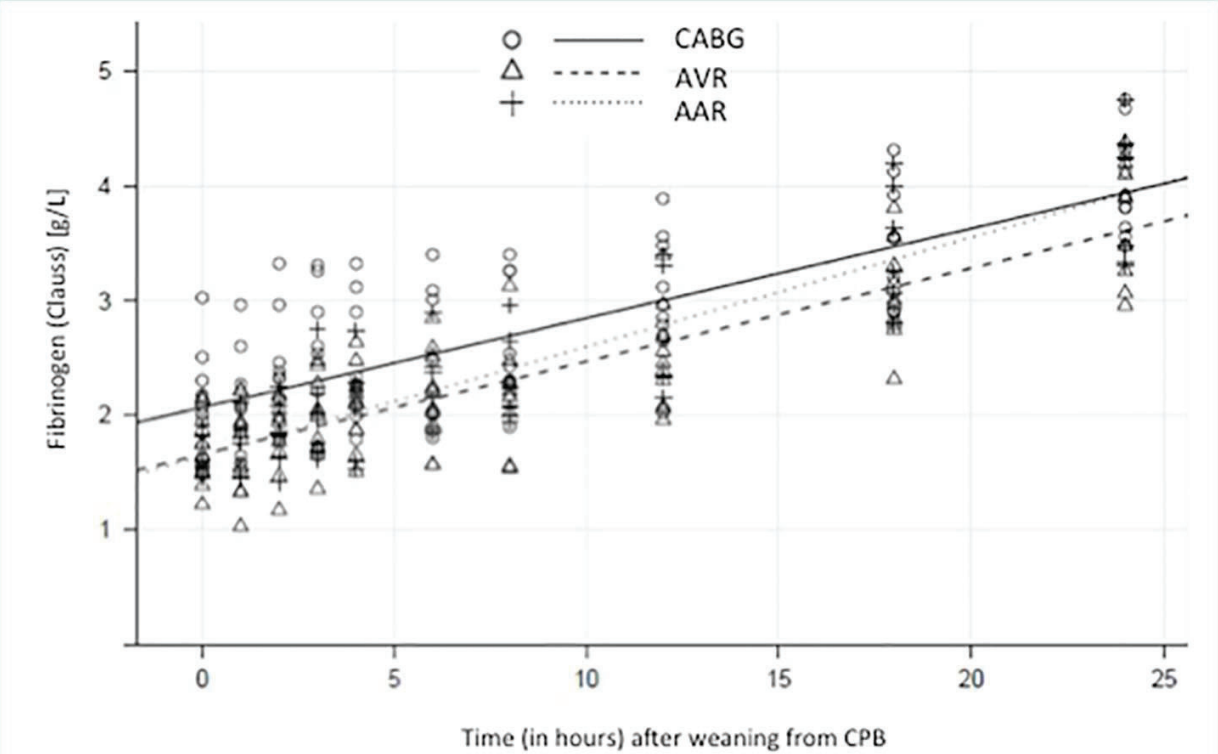


Fig 3. Clauss fibrinogen increase after weaning from CPB, according to surgery type. Clauss fibrinogen measurements over time, starting at the time point *Protomine*. The comprehensive plots show all patients, with the three types of surgery represented by different symbols. Predictions based on the fixed effects of the three respective linear mixed-effects models are superimposed.

Fibrinogène

1 Talvasto, A et al. (2025). *Can J Anesth/J Can Anesth* doi:10.1007/s12630-025-03046-7 //

In summary, prophylactic fibrinogen administration is not recommended for reducing postoperative bleeding and transfusion risks. However, in patients with a low fibrinogen level (<1.5 g/L) and signs of persistent microvascular bleeding, fibrinogen substitution should be considered to reduce the requirement for transfusions.

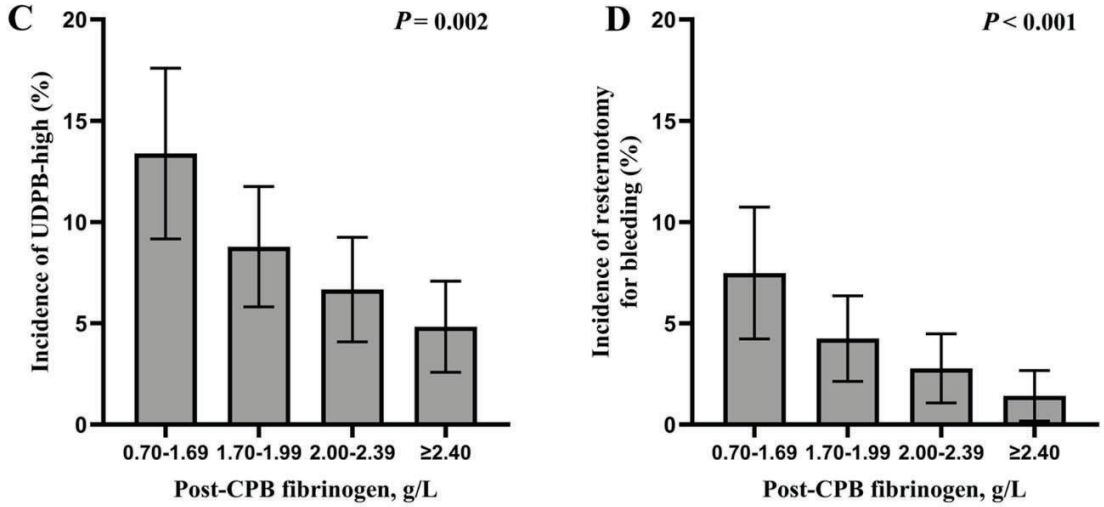


Fig. 3 Post-CPB plasma fibrinogen and UDPB-high ($n = 112$) *vs* UDPB-low ($n = 1,274$) (A), post-CPB plasma fibrinogen and resternotomy ($n = 50$) *vs* no resternotomy ($n = 1,336$) (B), post-CPB plasma fibrinogen in quartiles and incidence of UDPB-high (C), and post-CPB plasma fibrinogen in quartiles and incidence of resternotomy (D). "Post-CPB" refers to 30 min after the administration of protamine in the operating room.

$^{***}P < 0.001$ (UDPB-high *vs* UDPB-low or resternotomy *vs* no resternotomy)

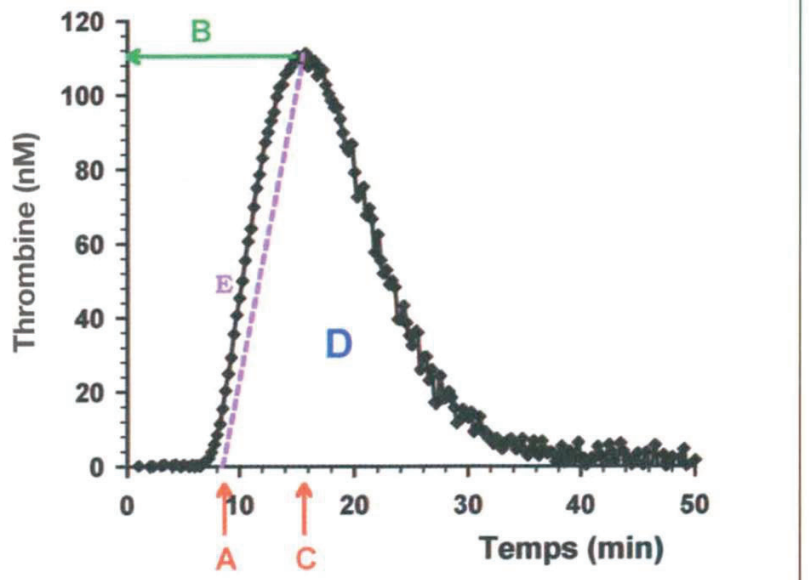
UDPB-high = Universal Definition of Perioperative Bleeding class 3 or 4; UDPB-low = Universal Definition of Perioperative Bleeding classes 0–2

Le temps

Manshanden, JSJ et al. (2015). *EBioMedicine* 2, 1217–1223
Fitzgerald, J et al. (2020). *Can J Anesth/J Can Anesth* 67, 746–753
Membré, A et al. (2007). *Revue Francophone des Laboratoires* 2007, 37–43 //

Endogenous thrombin potential (ETP) observée après la protamine est principalement liée à la consommation des facteurs de coagulation, à l'hémodilution et à l'effet anticoagulant intrinsèque de la protamine, notamment en cas de surdosage, qui inhibe l'activation du facteur V et aggrave la réduction de la génération de thrombine

Figure 1 / Paramètres du thrombinogramme.



(A) Phase d'initiation (min) ; **(B)** Concentration maximale en thrombine (nM) ; **(C)** Temps pour atteindre la concentration en thrombine maximale (min) ; **(D)** Potentiel endogène de thrombine (ETP) (nM.min) ; **(E)** Pente maximale de génération de IIa (nM/min).

Altération de la génération de thrombine

Bartoszko, J et al. (2022). *Can J Anesth/J Can Anesth* 69, 311–322

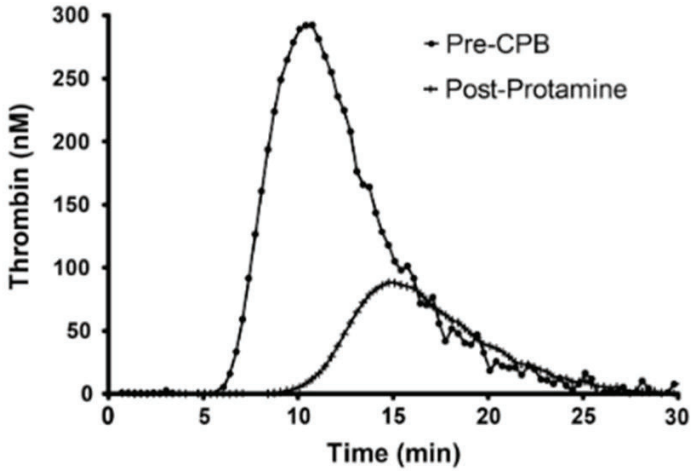


Fig. 2 Representative Thrombograms Illustrating Typical Changes Post-Protamine at the time of Conclusion of Cardiopulmonary Bypass (CPB) Compared with Baseline (Pre-CPB)

Table 2 Changes in hemostatic parameters after CPB compared with baseline

Hemostatic parameter	Pre-CPB value	Post-protamine reversal value	Percentage change from baseline	*P* value (signed-rank)
Thrombin generation				
Lag time (min), median [IQR]	5.6 [5.0–6.3]	9.9 [8.5–12.1]	+76% [48–117]	< 0.001*
Peak thrombin (nM), median [IQR]	312 [283–344]	81 [25–179]	− 73% [-49–-91]	< 0.001*
Endogenous thrombin potential ($nM \cdot min^{-1}$), median [IQR]	2567 [1,468–1,776]	703 [268–1,192]	− 56% [-30–-83]	< 0.001*
Time to peak (min), median [IQR]	8.1 [7.4–9.1]	14.7 [12.2–16.7]	+72% [43–104]	< 0.001*

CPB = cardiopulmonary bypass; IQR = interquartile range; nM = $nmol \cdot L^{-1}$

MDS

Fibrinogène

JAMA | Original Investigation

Effect of Fibrinogen Concentrate on Intraoperative Blood Loss Among Patients With Intraoperative Bleeding During High-Risk Cardiac Surgery

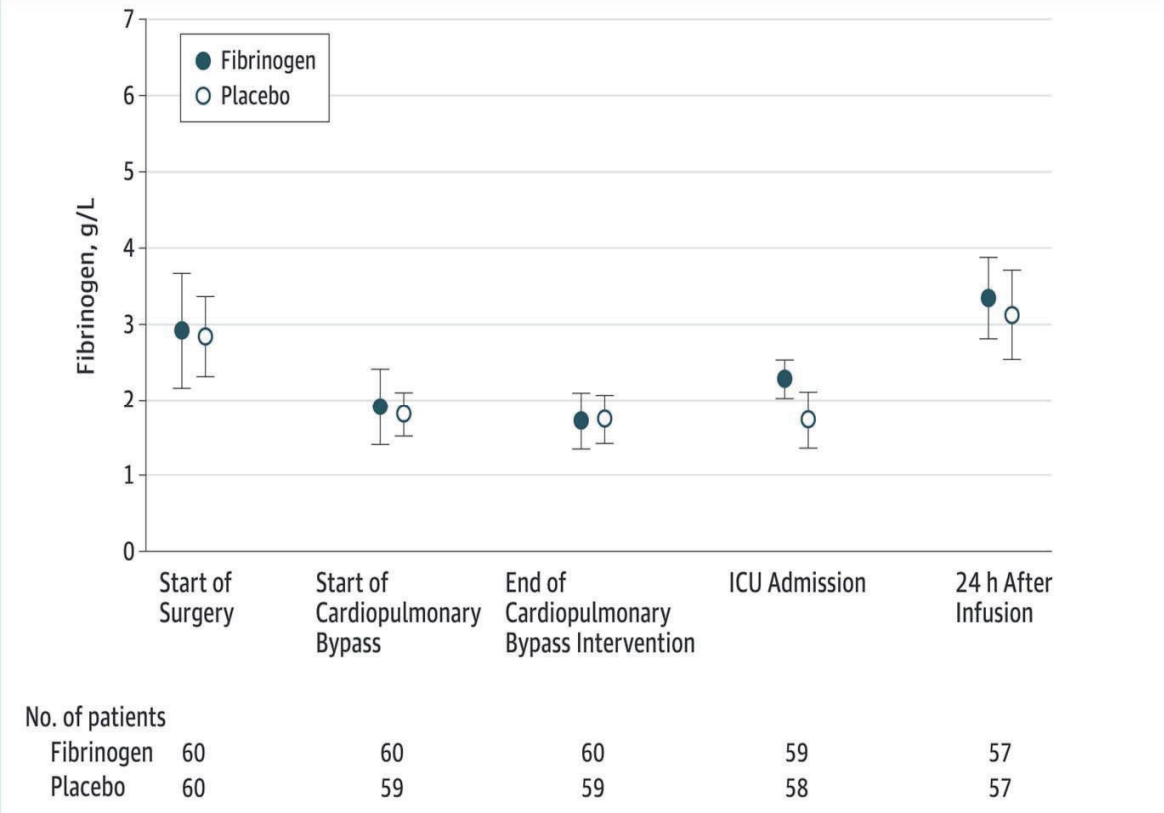
A Randomized Clinical Trial

Objectif

Évaluer si l'administration de concentré de fibrinogène de **2,5 g/L**, réduit les **pertes sanguines peropératoires** chez les patients en **chirurgie cardiaque à haut risque** présentant des saignements peropératoires.

RCT, Pays Bas, 2011-2015
Participants : 120 patients subissant une **chirurgie cardiaque élective à haut risque**

Saignement peropératoire défini par **60 à 250 mL de sang aspiré en 5 minutes**.



Fibrinogène

JAMA | Original Investigation

Effect of Fibrinogen Concentrate on Intraoperative Blood Loss Among Patients With Intraoperative Bleeding During High-Risk Cardiac Surgery

A Randomized Clinical Trial

Table 2. Primary, Secondary, and Exploratory Study Outcomes

	Median (IQR), mL			
	Fibrinogen (n = 58)	Control (n = 57)	Absolute Difference (95% CI)	*P* Value
Primary Outcome				
Blood loss between intervention and chest closure	50 (29-100)	70 (33-145)	20 (−13 to 35)[a]	.19
Secondary or Exploratory Outcome				
No. of patients	58	59		
Blood loss in the ICU/time interval starting from admission				
0-1 h	70 (35-130)	90 (46-149)		
>1-3 h	80 (50-156)	110 (40-220)		
>3-6 h	100 (54-169)	110 (60-208)		
>6-12 h	110 (80-160)	125 (83-224)		
>12-24 h	130 (80-180)	160 (90-270)		
Cumulative 24-h blood loss	570 (390-730)	690 (400-1090)	120 (−45 to 355)[a]	.047[b]

Fibrinogène

JAMA | Original Investigation

Effect of Fibrinogen Concentrate on Intraoperative Blood Loss Among Patients With Intraoperative Bleeding During High-Risk Cardiac Surgery

A Randomized Clinical Trial

Calculer la bonne dose :

(2.5 −[Plasma Fibrinogen Level at the End of Cardiopulmonary Bypass, g/L])
× 0.07
× (1−Hematocrit on Cardiopulmonary Bypass)
× Body Weight (kg)
= Whole Grams Fibrinogen Concentrate To Be Dosed

Exemple : 70kg, Hte 25%, Fibrinogen 1.2 g/L

(2,5 – 1,2) *0,07 * (1-0,25) * 70) = 4,7g

Fibrinogène

Randomized evaluation of fibrinogen *vs* placebo in complex cardiovascular surgery (REPLACE): a double-blind phase III study of haemostatic therapy

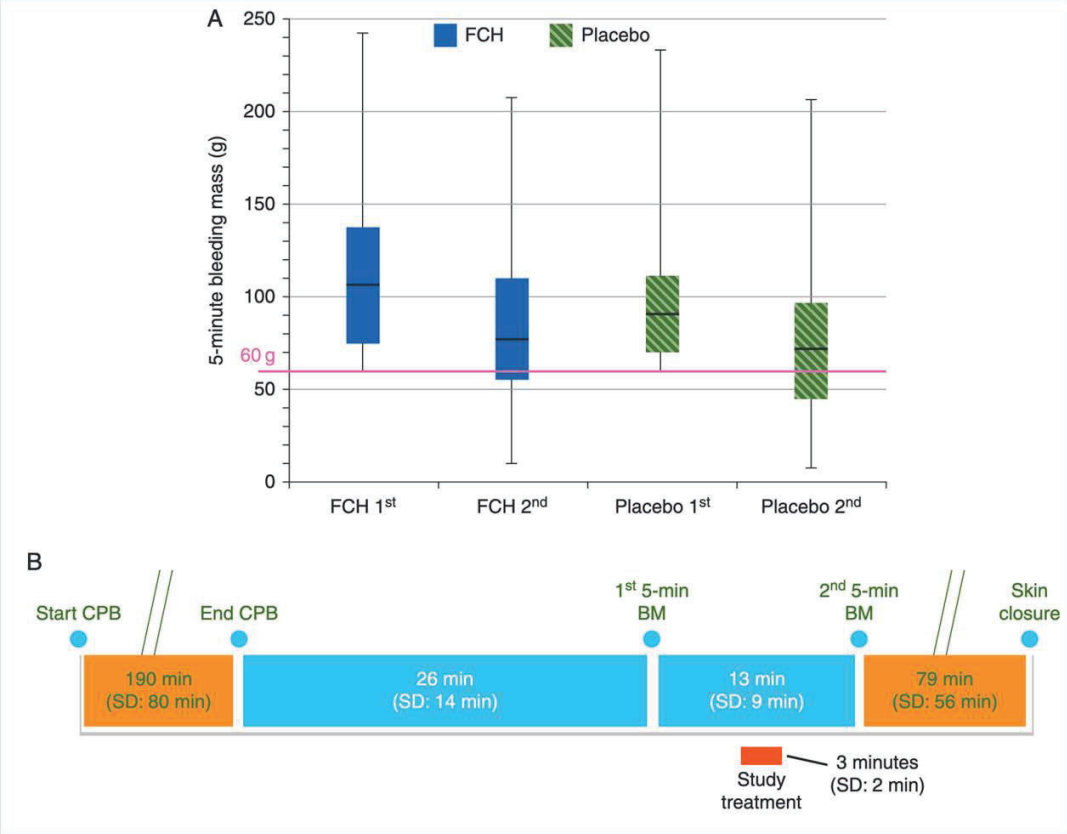
N. Rahe-Meyer[1,*], J. H. Levy[2], C. D. Mazer[3], A. Schramko[4], A. A. Klein[5], R. Brat[6], Y. Okita[7], Y. Ueda[8], D. S. Schmidt[9], R. Ranganath[10] and R. Gill[11]

1 Rahe-Meyer, N et al. (2016). *British Journal of Anaesthesia* 117, 41–51

RCT
Chirurgie programmée de l'aorte ascendante

Inclusion si saignement : 60 à 250 g en 5 minutes
après le sevrage de la CEC et l'hémostase chirurgicale..

Plasma fibrinogen* (g litre^{-1})		
n	73	68
Mean (SD)	3.03 (0.92)	3.06 (0.83)
FIBTEM MCF* (mm)		
n	70	66
Mean (SD)	16.3 (4.7)	16.5 (5.2)
Duration of CPB [*n* (%)]		
<120 min	13 (16.7)	10 (13.5)
120–180 min	30 (38.5)	25 (33.8)
>180 min	35 (44.9)	39 (52.7)
Duration of circulatory arrest [*n* (%)]		
0	53 (67.9)	41 (55.4)
>0 and <30 min	18 (23.1)	22 (29.7)
30–60 min	6 (7.7)	7 (9.5)
>60 min	1 (1.3)	4 (5.4)



Fibrinogène

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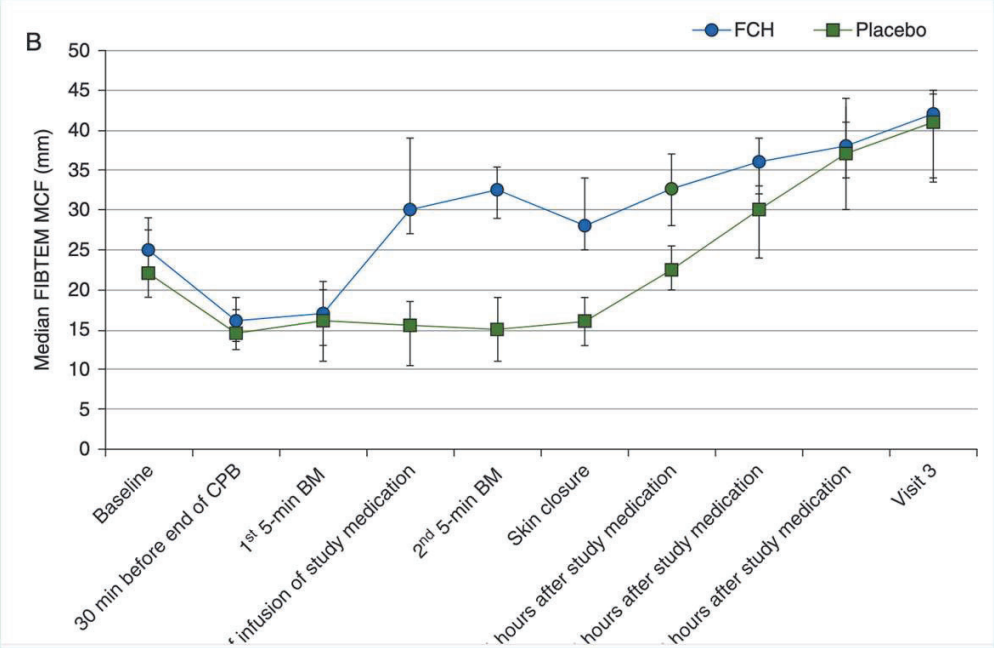
Rahe-Meyer, N et al. (2016). *British Journal of Anaesthesia*

519 patients

Saignement pré-traitement (médiane [IQR]) :
- **Groupe FCH** : **107 g** (76–138 g).
- **Groupe placebo** : **91 g** (71–112 g) *(p = 0,13)*.

Transfusions de produits sanguins allogéniques dans les 24 heures :
- **Groupe FCH** : **5,0 unités** (2,0–11,0).
- **Groupe placebo** : **3,0 unités** (0,0–7,0) *(p = 0,026)*.

Patients sans transfusion :
- **Groupe FCH** : **15,4 %**.
- **Groupe placebo** : **28,4 %** *(p = 0,047)*.



Fibrinogène

1 Li, J-Y et al. (2018). *Anesthesia & Analgesia* 127, 612–621 //

GUIDELINES

Management of severe peri-operative bleeding: Guidelines from the European Society of Anaesthesiology and Intensive Care

Second update 2022

We recommend treatment with fibrinogen concentrate or cryoprecipitate if bleeding is accompanied by hypofibrinogenaemia (viscoelastic signs of a functional fibrinogen deficit or a plasma Clauss fibrinogen level ≤1.5 g l^{-1}). 1B

Society of Cardiovascular Anesthesiologists Clinical Practice Improvement Advisory for Management of Perioperative Bleeding and Hemostasis in Cardiac Surgery Patients

In summary, prophylactic fibrinogen administration is not recommended for reducing postoperative bleeding and transfusion risks. However, in patients with a low fibrinogen level (less than 150 mg/dL) and persistent post-CPB bleeding, fibrinogen supplementation, provided as cryoprecipitate of fibrinogen concentrate, should be considered to reduce bleed- ing and blood transfusion.

PFC ou PPSB

PFC/PPSB

The PCC dose was 15 IU/kg or closest standardized dose; the plasma dose was a suggested volume of 10 to 15 mL/kg rounded to the nearest unit.

JAMA Surgery

RCT: Prothrombin Complex Concentrate vs Plasma for Coagulopathy and Bleeding After Cardiopulmonary Bypass

POPULATION

61 Men, 39 Women

Adults ≥18 y with post-cardiopulmonary bypass coagulopathy and bleeding following cardiac surgery

Mean age, 66.8 y

INTERVENTION

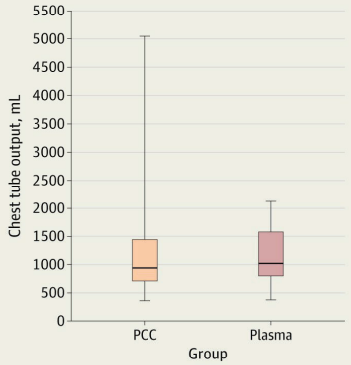
100 Participants randomized and analyzed

51 PCC
Administration of prothrombin complex concentrate (PCC) 15 IU/kg or closest standardized dose

49 Plasma
Administration of fresh frozen plasma 10-15 mL/kg rounded up to the nearest unit

FINDINGS

There was no significant difference in chest tube output between the 2 groups



Effect estimate (ratio of geometric means), PCC vs plasma: 0.98 (95% CI, 0.81-1.19); *P* = .84

SETTINGS / LOCATIONS

1 Medical Center in the United States

PRIMARY OUTCOME

Chest tube output, as measured in milliliters from the time of the initial postsurgical intensive care unit admission through midnight on postoperative day 1

Smith MM, Schroeder DR, Nelson JA, et al. Prothrombin complex concentrate vs plasma for post-cardiopulmonary bypass coagulopathy and bleeding: a randomized clinical trial. *JAMA Surg*. Published online June 29, 2022. doi:10.1001/jamasurg.2022.2235

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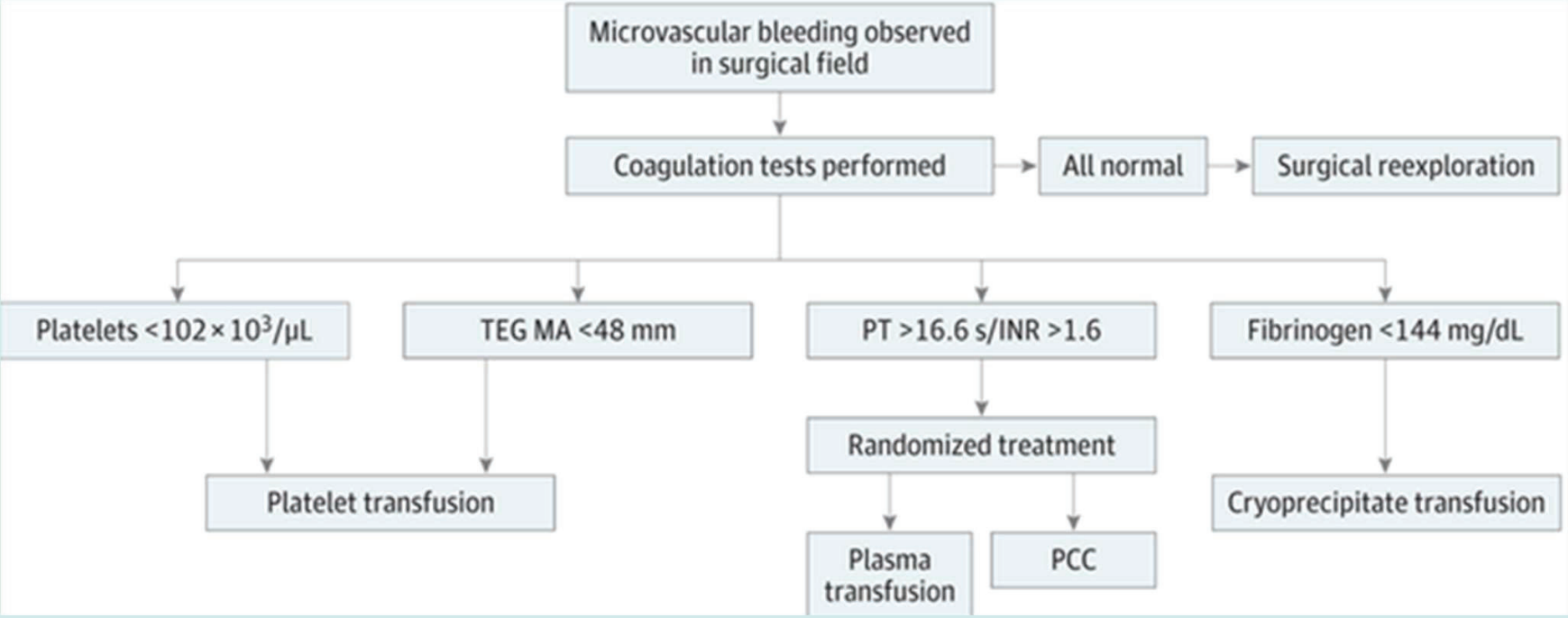
PFC/PPSB

Prothrombin Complex Concentrate vs Plasma for Post-Cardiopulmonary Bypass Coagulopathy and Bleeding
A Randomized Clinical Trial

1 Smith, MM et al. (2022). *JAMA Surg* 157, 757–764 //



PFC/PPSB

Prothrombin Complex Concentrate vs Plasma for Post-Cardiopulmonary Bypass Coagulopathy and Bleeding

A Randomized Clinical Trial

1 Smith, MM et al. (2022). *JAMA Surg* 157, 757–764 //

Table 2. Posttreatment Chest Tube Output and Transfusions[a]

Characteristic	Plasma, No. (%) (n = 48[b])	PCC, No. (%) (n = 51)	Effect estimate[c]	
			Estimate (95% CI)	*P* value
Chest tube output, median (IQR), mL	1022 (799-1575)	937 (708-1443)	0.98 (0.81-1.19)	.84
RBCs, units				
0	26 (52.0)	36 (70.6)	0.49 (0.22-1.11)	.09
1	11 (22.9)	8 (15.7)		
2	6 (12.5)	5 (9.8)		
≥3	5 (10.4)	2 (3.9)		
Platelets, units				
0	30 (62.5)	36 (70.6)	0.76 (0.33-1.73)	.51
1	13 (27.1)	9 (17.6)		
2	3 (6.3)	3 (5.9)		
≥3	2 (4.2)	3 (5.9)		
Cryoprecipitate, units				
0	40 (83.3)	40 (78.4)	1.39 (0.51-3.79)	.53
1	2 (4.2)	2 (3.9)		
2	5 (10.4)	8 (15.7)		
≥3	1 (2.1)	1 (2.0)		
Plasma, units				
0	43 (89.6)	48 (94.1)	0.52 (0.12-2.30)	.39
1	0	1 (2.0)		
2	4 (8.3)	2 (3.9)		
≥3	1 (2.1)	0		

Abbreviations: PCC, prothrombin complex concentrate; RBCs, red blood cells.

[a] Chest tube output was measured from initial postsurgery intensive care unit admission through midnight of the next day. Transfusions were recorded from completion of study drug administration through midnight of the next day.

[b] One patient in the plasma group was excluded from the efficacy analysis because of a protocol violation.

[c] For chest tube output, a log transformation was used, and the analysis was performed using linear regression. For blood product transfusions, the analysis was performed using proportional odds logistic regression. In all cases, the effect estimate is provided for PCC relative to plasma. For chest tube output, the effect estimate corresponds to the ratio of the geometric mean; for transfusions, the effect estimate corresponds to the odds ratio.

PFC/PPSB

Prothrombin Complex Concentrate vs Frozen Plasma for Coagulopathic Bleeding in Cardiac Surgery
The FARES-II Multicenter Randomized Clinical Trial

Keyvan Karkouti, MD[1,2,3]; Jeannie L. Callum, MD[4,5]; Justyna Bartoszko, MD[1,2,3] ; et al

1 Karkouti, K et al. (2025). *JAMA* 333, 1781–1792 //

Multicentrique 12 centres

Randomisation si saignement après la CEC : PPSB (1500 UI ≤60 kg ; 2000 UI >60 kg), soit du PFC (3 U ≤60 kg ; 4 U >60 kg). Un second bolus était autorisé dans les 24 heures si nécessaire, puis seul le PFC était permis.

Le critère principal était l'absence d'intervention hémostatique supplémentaire entre 60 minutes et 24 heures après l'administration.

PFC/PPSB

Prothrombin Complex Concentrate vs Frozen Plasma for Coagulopathic Bleeding in Cardiac Surgery
The FARES-II Multicenter Randomized Clinical Trial

Keyvan Karkouti, MD[1,2,3]; Jeannie L. Callum, MD[4,5]; Justyna Bartoszko, MD[1,2,3] ; et al

1 Karkouti, K et al. (2025). *JAMA* 333, 1781–1792 //

Outcomes	No. (%) of patients		% Difference (95% CI)	Relative risk or LS mean ratio (95% CI)	*P* value
	PCC (n = 213)	Frozen plasma (n = 207)			
Primary outcome					
Hemostatic response					
Effective	166 (77.9)	125 (60.4)	17.6 (8.7 to 26.4)	RR: 0.56 (0.41 to 0.75)	<.001
Ineffective[a]	47 (22.1)	82 (39.6)			
Components for response					
Surgical reopening for bleeding	11 (5.2)	15 (7.2)	2.1 (−2.5 to 6.7)	RR: 0.71 (0.34 to 1.5)	.38
Second dose of IMP	19 (8.9)	40 (19.3)	10.4 (3.8 to 17.0)	0.46 (0.28 to 0.77)	.003
Platelets	32 (15.0)	63 (30.4)	15.4 (7.5 to 23.3)	0.49 (0.34 to 0.72)	<.001
Fibrinogen concentrate	14 (6.6)	23 (11.1)	4.5 (−0.9 to 10.0)	0.59 (0.31 to 1.12)	.11
Cryoprecipitate	6 (2.8)	7 (3.4)	0.6 (−2.8 to 3.9)	0.83 (0.28 to 2.44)	.74
Non-IMP PCC	0	14 (6.8)	6.8 (3.3 to 10.2)	0.03 (0.002 to 0.56)	.02
Non-IMP frozen plasma	7 (3.3)	7 (3.4)	0.1 (−3.3 to 3.5)	0.97 (0.35 to 2.72)	.96
Recombinant activated factor VII	0	9 (4.3)	4.4 (1.6 to 7.1)	0.05 (0.003 to 0.87)	.04
Chest tube drainage, LS mean (95% CI), mL					
12 h	471 (415 to 527)	642 (585 to 699)	171 (91 to 250)	NA	<.001
24 h	691 (616 to 766)	923 (847 to 999)	232 (126 to 338)	NA	<.001

PFC/PPSB

Prothrombin Complex Concentrate vs Frozen Plasma for Coagulopathic Bleeding in Cardiac Surgery
The FARES-II Multicenter Randomized Clinical Trial

Keyvan Karkouti, MD[1,2,3]; Jeannie L. Callum, MD[4,5]; Justyna Bartoszko, MD[1,2,3] ; et al

1 Karkouti, K et al. (2025). *JAMA* 333, 1781–1792 //

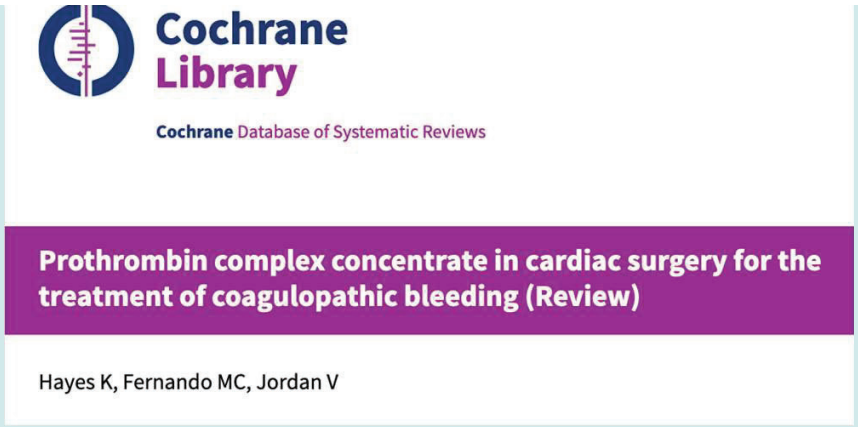
Table 1. Characteristics of the Study Population and Dosing Details

Characteristic	No. (%) of patients	
	Prothrombin complex concentrate (n = 213)	Frozen plasma (n = 207)
IMP administration details		
Doses		
1	213 (100)	207 (100)
2[g]	37 (17.4)	47 (22.7)
Amount of first dose		
Mean (SD)	23.9 (4.3) IU/kg	11.8 (2.8) mL/kg[g]
Median (IQR)	23.7 (21.1-27.0) IU/kg	11.8 (10.0-13.8) mL/kg[g]
Amount of second dose		
Mean (SD)	22.9 (6.3) IU/kg	10.3 (3.8) mL/kg[h]
Median (IQR)	23.1 (20.1-28.2) IU/kg	10.5 (7.3-13.3) mL/kg[g]
Time from end of CPB to start of first dose of IMP, median (IQR), min	41 (26-67)	45 (28-69)
Time to complete administration of IMP, median (IQR), min	7 (4-10)	26 (17-45)

(3 U ≤60 kg; 4 U >60 kg)

PFC/PPSB

18 études (4 993 participants) dont 2 RCT



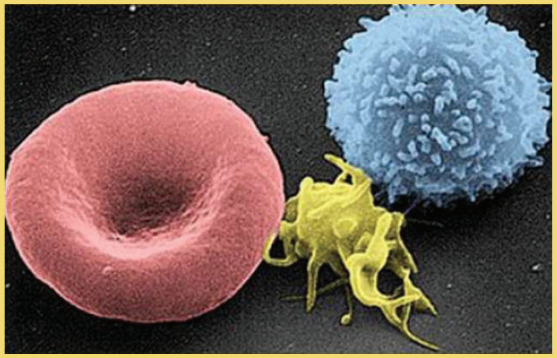
PPSB vs Traitement standard (incluant PFC)

Transfusions sanguines : Réduction du nombre d'unités transfusées (MD : **-0,89**, IC 95 % : -1,78 à 0,00 ; **évidence modérée**).

Événements thrombotiques : Pas de différence dans le nombre d'événements thrombotiques (OR : **0,68**, IC 95 % : 0,20 à 2,31 ; **évidence modérée**).

Saignements postopératoires : Pas de différence (MD : **-107,05 mL**, IC 95 % : -278,92 à 64,83 ; **faible qualité**).

Plaquettes



Transfusion plaquettaire

1 Hinton, JV et al. (2024). *Journal of Cardiothoracic and Vascular Anesthesia*

Sur 165 427 patients, 35 657 (22 %) ont reçu une transfusion de plaquettes

l'exposition préopératoire à des **médicaments antiplaquettaires** dans les 7 jours précédant la chirurgie a augmenté de manière marquée chez les patients ayant reçu une transfusion de plaquettes, passant de **46,5 % à 63,8 %** entre 2005 et 2021 ($p < 0,001$).

Table 1
Platelet Transfusion, Antiplatelet Exposure, and Secondary Outcomes in Cardiac Surgery Patients From 2005 Through 2021

			Antiplatelet Exposure, n (%)						
Year	Admissions	PLT Transfusions, n (%)	Any Antiplatelet	Aspirin (<7 d)	Clopidogrel (<7 d)	Ticagrelor (<7 d)	Tirofiban/ Eptifibatide (<7 d)	Abciximab (<7 d)	Other antiplatelets (<7 d)
2005	2,764	620 (22.4)	288 (10.4)	278 (10.1)	36 (1.3)	0 (0.0)	16 (0.6)	3 (0.1)	14 (0.5)
2006	3,508	679 (19.4)	390 (11.1)	369 (10.5)	75 (2.1)	0 (0.0)	13 (0.4)	4 (0.1)	18 (0.5)
2007	4,431	970 (21.9)	536 (12.1)	513 (11.6)	117 (2.6)	0 (0.0)	22 (0.5)	4 (0.1)	13 (0.3)
2008	6,133	1,311 (21.4)	763 (12.4)	724 (11.8)	181 (3.0)	0 (0.0)	51 (0.8)	9 (0.1)	35 (0.6)
2009	6,948	1491 (21.5)	895 (12.9)	854 (12.3)	274 (3.9)	0 (0.0)	44 (0.6)	8 (0.1)	41 (0.6)
2010	7,753	1,860 (24.0)	1082 (14.0)	1025 (13.2)	352 (4.5)	0 (0.0)	52 (0.7)	8 (0.1)	40 (0.5)
2011	8,594	2,206 (25.7)	1286 (15.0)	1247 (14.5)	413 (4.8)	0 (0.0)	35 (0.4)	17 (0.2)	56 (0.7)
2012	8,479	2,020 (23.8)	1195 (14.1)	1138 (13.4)	388 (4.6)	0 (0.0)	35 (0.4)	11 (0.1)	64 (0.8)
2013	9,931	2,258 (22.7)	1363 (13.7)	1303 (13.1)	348 (3.5)	0 (0.0)	28 (0.3)	15 (0.2)	123 (1.2)
2014	9,524	1,896 (19.9)	1153 (12.1)	1082 (11.4)	213 (2.2)	0 (0.0)	25 (0.3)	5 (0.1)	140 (1.5)
2015	11,959	2,171 (18.2)	1345 (11.2)	1267 (10.6)	282 (2.4)	0 (0.0)	22 (0.2)	4 (0.0)	147 (1.2)
2016	12,075	2,291 (19.0)	1450 (12.0)	1373 (11.4)	254 (2.1)	116 (1.0)	20 (0.2)	4 (0.0)	152 (1.3)
2017	13,043	2,665 (20.4)	1709 (13.1)	1599 (12.3)	268 (2.1)	173 (1.3)	16 (0.1)	6 (0.0)	151 (1.2)
2018	14,004	2,915 (20.8)	1818 (13.0)	1686 (12.0)	283 (2.0)	198 (1.4)	31 (0.2)	2 (0.0)	161 (1.1)
2019	15,200	3,244 (21.3)	1985 (13.1)	1830 (12.0)	303 (2.0)	230 (1.5)	24 (0.2)	6 (0.0)	158 (1.0)
2020	15,213	3,462 (22.8)	2229 (14.7)	2074 (13.6)	330 (2.2)	273 (1.8)	34 (0.2)	2 (0.0)	158 (1.0)
2021	15,868	3,598 (22.7)	2297 (14.5)	2146 (13.5)	328 (2.1)	245 (1.5)	21 (0.1)	8 (0.1)	132 (0.8)

Transfusion plaquettaire

Fletcher, CM et al. (2023). *Journal of Cardiothoracic and Vascular Anesthesia* 37, 528–538 //

Platelet Transfusion After Cardiac Surgery

Calvin M. Fletcher, MD*,[1], Jake V. Hinton, MD†,

Table 3
Binary Outcomes of Platelet Transfusion Using the Propensity-Matched Cohort

Binary Outcomes, n (%)	Platelet Transfusion n = 1,046	No Platelet Transfusion n = 1,046	Pooled Adjusted Odds Ratio (99% CI)	p Value
Hospital mortality	26 (2.5)	21 (2.0)	1.28 (0.49, 3.35)	0.4981
Suspected infection	182 (17.4)	242 (23.1)	0.70 (0.50, 0.97)	**0.0050**
Acute kidney injury	455 (43.5)	448 (42.8)	1.03 (0.79, 1.34)	0.7897

NOTE. All values presented as frequency (%) unless otherwise specified.

Table 4
Continuous Outcomes of Platelet Transfusion Using the Propensity-Matched Cohort

Continuous Outcomes	Platelet Transfusion n = 1,046	No Platelet Transfusion n = 1,046	Pooled Adjusted Mean Difference (99% CI)	p Value
Chest tube output, median (IQR), mL*				
2 h	120.0 (70.0-198.0)	100.0 (60.0-150.0)	30.95 (13.92-47.99)	< **0.0001**
4 h	210.0 (138.0-323.0)	170.0 (115.0-260.0)	53.71 (30.90-76.53)	< **0.0001**
6 h	286.0 (190.0-412.0)	230.0 (160.0-340.0)	66.42 (36.85-95.99)	< **0.0001**
8 h	350.0 (235.0-500.0)	280.0 (200.0-410.0)	71.37 (36.62-106.13)	< **0.0001**
Intensive care unit length of stay, median (IQR), d	2.25 (1.29-4.25)	2.13 (1.17-4.00)	0.83 (-0.15 to 1.82)	0.0291
Hospital length of stay, d	6.1 (5.0-9.3)	6.0 (4.9-8.8)	0.86 (-0.27 to 1.98)	0.0484

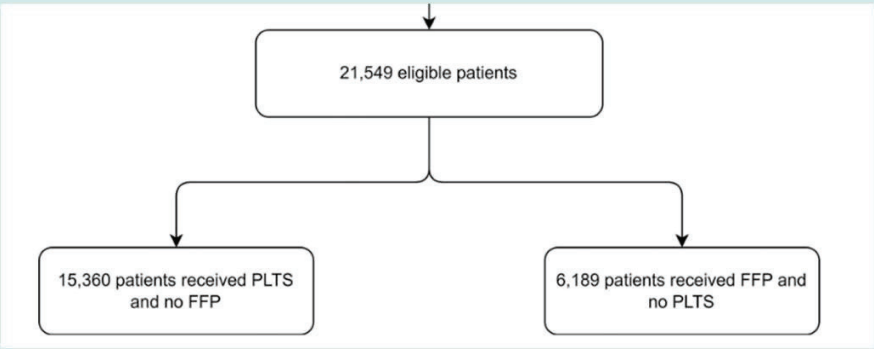
* Post-transfusion of platelets, cumulative volume.

Plaquettes

Platelet versus fresh frozen plasma transfusion for coagulopathy in cardiac surgery patients

1 Hinton, JV et al. (2024). *PLoS ONE* 19**,** e0296726 //

Entropy-weighted retrospective cohort study
Australian and New Zealand
All adults undergoing cardiac surgery between 2005–2021 across 58 sites were included



plaquettes

Platelet versus fresh frozen plasma transfusion for coagulopathy in cardiac surgery patients

1 Hinton, JV et al. (2024). *PLoS ONE* 19, e0296726 //

Table 2. Outcomes in the entropy-weighted cohort.

Outcomes	PLT (n = 15,360)	FFP (n = 6,189)	RR	CI (95%)	P-Value
Primary Outcomes					
Operative Mortality	455 (3.0)	300 (4.8)	1.63	(1.40,1.91)	<0.001
Bleeding Complications					
Return to Theatre	1826 (11.9)	755 (12.2)	0.98	(0.90,1.07)	0.675
Return to Theatre for Bleeding	848 (5.5)	293 (4.7)	0.85	(0.73,0.97)	0.020
Cardiac Complications					
Prolonged Inotrope Use (>4 hrs)	9742 (63.4)	3666 (59.2)	0.93	(0.90,0.95)	<0.001
Fluid Balance Complications					
AKI	996 (6.5)	484 (7.8)	1.13	(1.01,1.27)	0.033
New Postoperative RRT	552 (3.6)	286 (4.6)	1.20	(1.03,1.41)	0.020
Infection					
All Infection	1319 (8.6)	525 (8.5)	0.91	(0.82,1.00)	0.062
Pneumonia	1111 (7.2)	400 (6.5)	0.84	(0.74,0.94)	0.004
Septicaemia	278 (1.8)	124 (2.0)	1.02	(0.81,1.29)	0.866
Wound Infection	126 (0.8)	78 (1.3)	1.46	(1.08,1.97)	0.014
Hospital Resource Use					
Readmission to ICU	692 (4.5)	391 (6.3)	1.24	(1.09,1.42)	0.001
Other Outcomes					
Long Term (1yr) Mortality	695 (4.5)	492 (7.9)	1.50	(1.32,1.71)	<0.001
Continuous Outcomes			**AMD**	**CI (95%)**	**P-Value**
ICU Length of Stay, hrs (median [IQR])	53.00 [37.39, 96.63]	58.98 [27.43, 114.50]	2.98	(-1.51,7.48)	0.193
Ventilation Time, hrs (median [IQR])	12.97 [7.50, 20.86]	14.75 [9.00, 22.93]	1.18	(-1.82,4.18)	0.441
4hr Chest Drain Output, ml (median [IQR])	240 [150, 400]	270 [160, 420]	28.37	(19.35,37.38)	<0.001

plaquettes

1 Yanagawa, B et al. (2021). *The Annals of Thoracic Surgery* 111, 607–614 //

Platelet Transfusion in Cardiac Surgery: A Systematic Review and Meta-Analysis

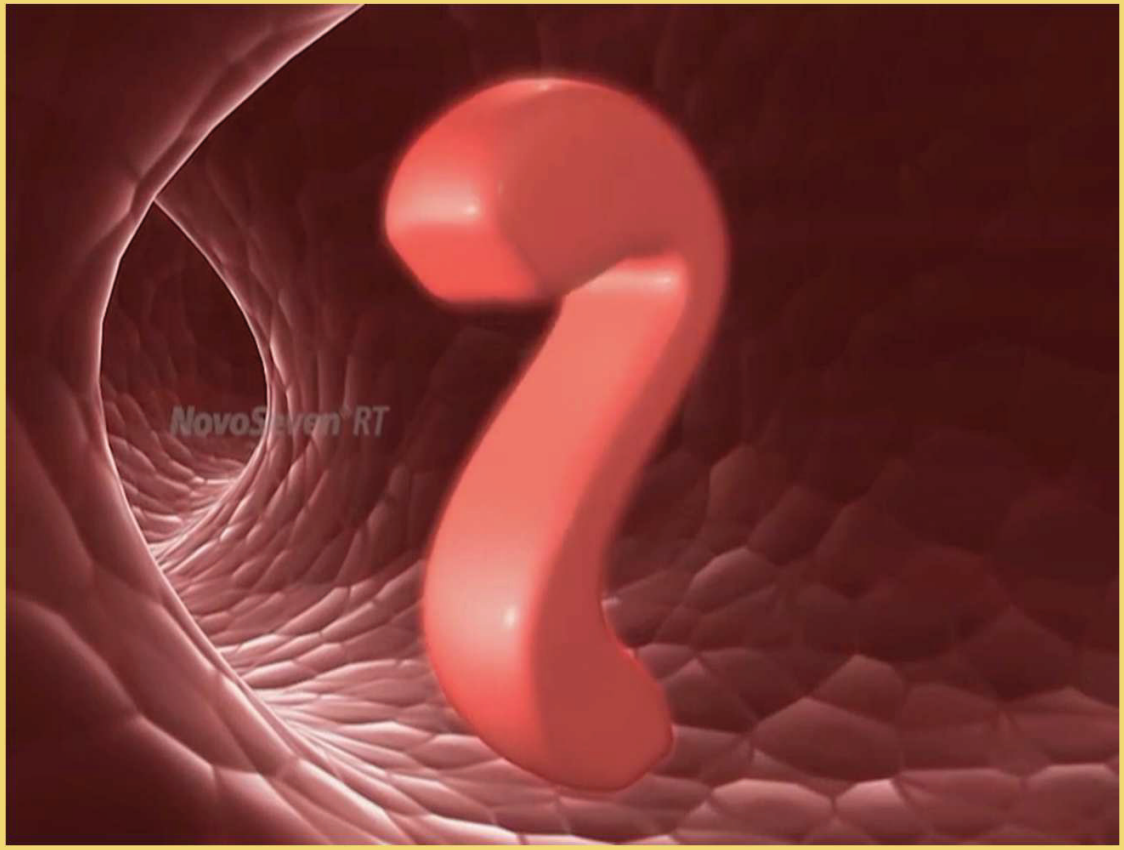
Bobby Yanagawa, MD, PhD, Roberto Ribeiro, MD, PhD(c), Jessica Lee, BSc(c), C. David Mazer, MD, Davy Cheng, MD, Janet Martin, PharmD, MSc, Subodh Verma, MD, PhD, and Jan O. Friedrich, MD, DPhil, on behalf of the Canadian Cardiovascular Surgery Meta-Analysis Working Group

101 511 patients
9 études observationnelles

Critère de jugement postopératoire	Risque relatif (RR)	Intervalle de confiance à 95 %	Valeur de p
Mortalité postopératoire	1,26	0,69 – 2,32	0,46
AVC (Accident Vasculaire Cérébral)	0,94	0,62 – 1,45	0,79
Infarctus du myocarde	1,29	0,95 – 1,77	0,11
Réopération pour saignement	1,20	0,46 – 3,18	0,71
Infection	1,02	0,86 – 1,20	0,85
Insuffisance rénale aiguë périopératoire nécessitant une dialyse	0,91	0,63 – 1,32	0,62

https://www.novomedlink.com/rare-bleeding-disorders/products/treatments/novosevenrt/about/pharmacology.html

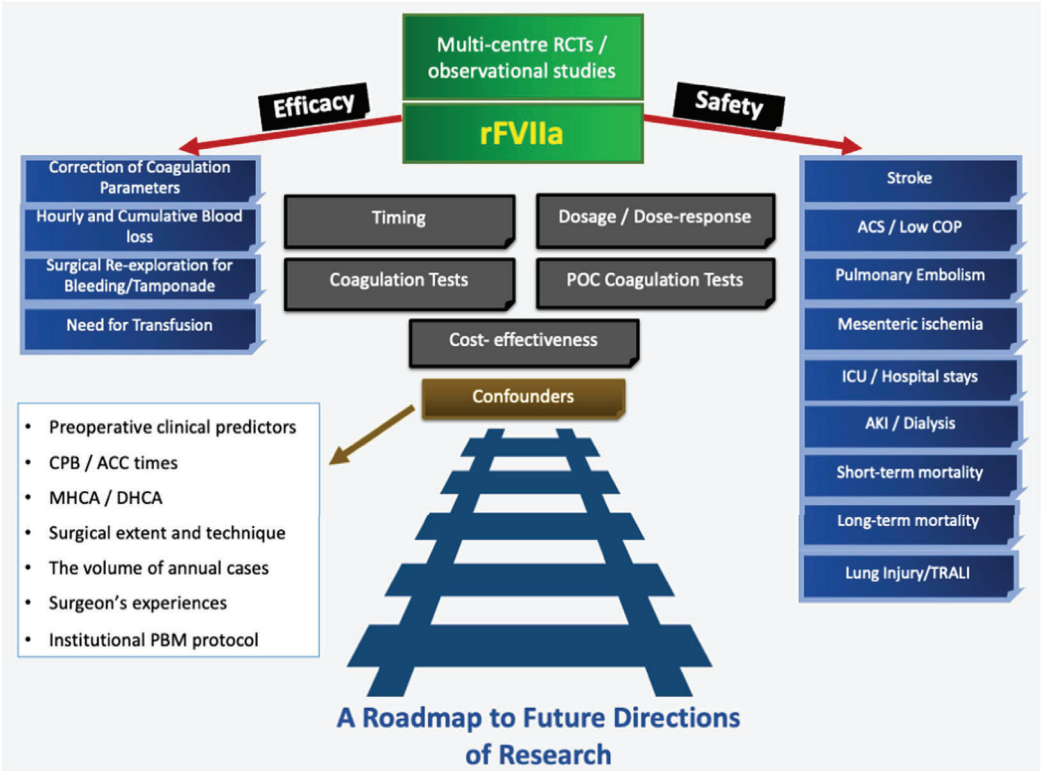
VIIa



VIIa

1 Navarro, R et al. (2024). *Journal of Cardiothoracic and Vascular Anesthesia* 38, 275–284 //

The prophylactic use of rFVIIa is not recommended to prevent bleeding complications.	III	B	[411, 413]
In patients with refractory, non-surgical bleeding, off-label use of rFVIIa may be considered to reduce bleeding complications.	IIb	B	[413]



Contexte clinique	Posologie standard
Hémophilie	**90 à 120 µg/kg** en bolus, **toutes les 2-3 heures** jusqu'à l'arrêt du saignement.
Saignements réfractaires (hors AMM)	**13 à 180 µg/kg**
Chirurgie cardiaque (études rétrospectives)	**10 à 100 µg/kg** (moyenne rapportée).

VIIa

Navarro, R et al. (2024). *Journal of Cardiothoracic and Vascular Anesthesia* 38, 275–284 //

Study Characteristics

Study	Study Type	Confounding Factors Controlled	Comparator	Sample Size		rFVIIa Dose (μg/kg)	Indication for Using rFVIIa
				rFVIIa	Control		
Raivio et al. 2005[31]	Case Series	No	-	11	-	60.9	Uncontrolled refractory bleeding
Bishop et al. 2006[30]	Case Series	No	-	8	-	100	Uncontrolled refractory bleeding
Tritapepe et al. 2007[10]	Retrospective (propensity-matched)	Yes	Conventional hemostatic methods	23	23	70	Uncontrolled refractory bleeding
Goksedef et al. 2012[11]	Retrospective (propensity-matched)	Yes	Conventional hemostatic methods	29	29	23 ± 12	Uncontrolled refractory bleeding
Andersen et al. 2012[32]	Retrospective (propensity-matched)	Yes	Conventional hemostatic methods	44	44	32	Uncontrolled refractory bleeding
Yan et al. 2014[7,*]	Non-randomized clinical trial	N/A	Conventional hemostatic methods	25	46	25.8-53.3	Nonrandomized allocation to the experimental group
Zindovic et al. 2017[28]	Retrospective (propensity-matched)	Yes	Conventional hemostatic methods	120	120	NR	Uncontrolled refractory bleeding
Hang et al. 2021[29]	Retrospective	No	Conventional hemostatic methods	20	39	45.4	Uncontrolled refractory bleeding
Elnaggar et al. 2021[33]	Case Series	No	-	10	-	60	Uncontrolled refractory bleeding
Ise et al. 2022[18]	Retrospective (propensity-matched)	Yes	Conventional hemostatic methods	29	29	56 (32, 83)	Uncontrolled refractory bleeding

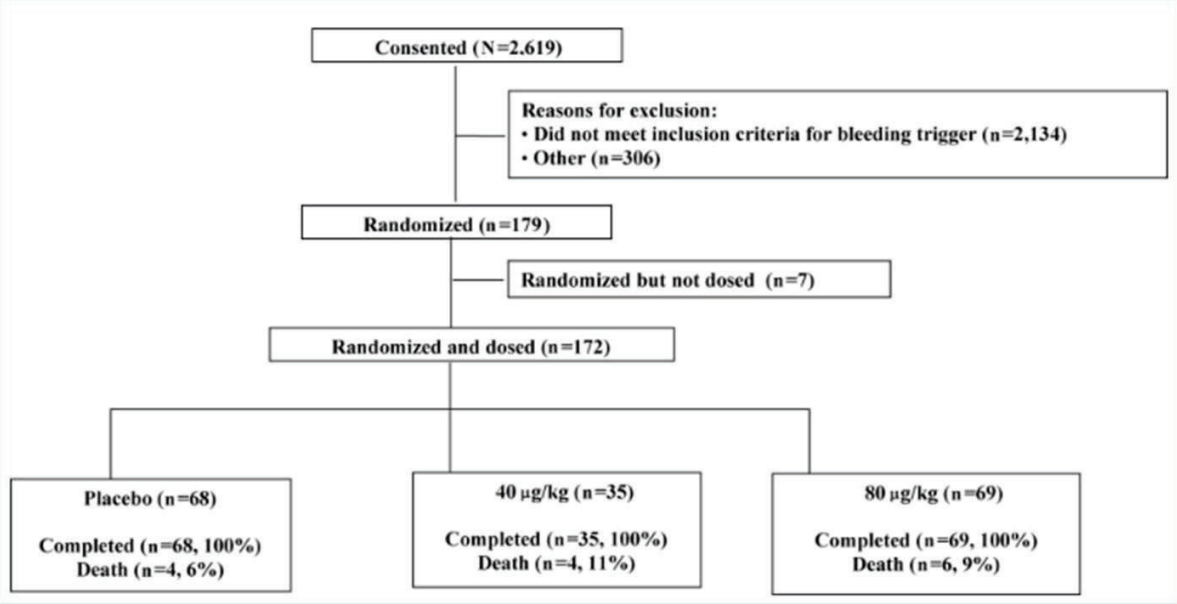
VIIa

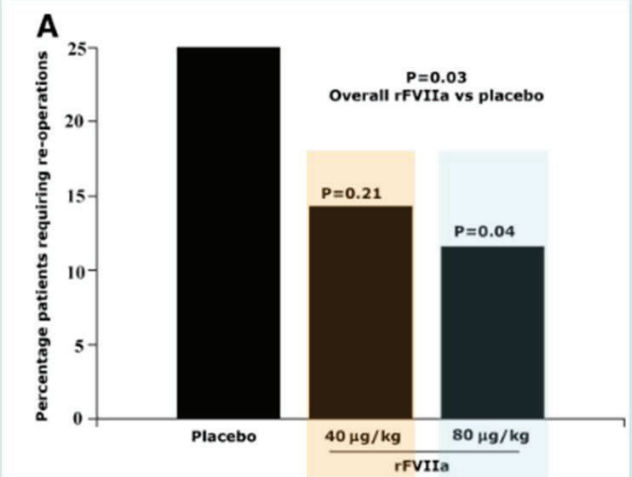
Warren, O et al. (2007). *The Annals of Thoracic Surgery* 83, 707–714 //

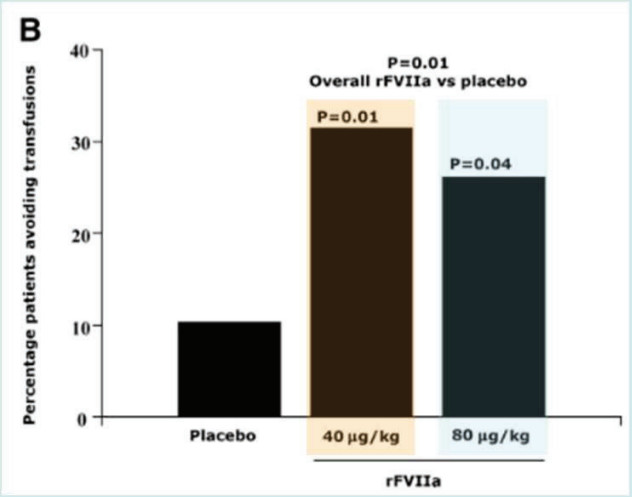
Safety and Efficacy of Recombinant Activated Factor VII

A Randomized Placebo-Controlled Trial in the Setting of Bleeding After Cardiac Surgery

Ravi Gill, BM, MD, FRCA; Mike Herbertson, MBBS, MRCP, FRCA;
Alain Vuylsteke, MD, DESAR, FRCA; Peter Skov Olsen, MD, DMSc;
Christian von Heymann, MD, DEAA; Monty Mythen, MD; Frank Sellke, MD;
Frank Booth, MsC, MD; Thomas Andersen Schmidt, MD, DMSc







VIIa

Vincent, J-L et al. (2007). *Annales Françaises d'Anesthésie et de Réanimation* 26, 145–156 //

Recommandations européennes pour l'utilisation du facteur VII activé recombinant comme thérapeutique adjuvante du saignement majeur ☆

Recommendations on the use of recombinant activated factor VII as an adjunctive treatment for massive bleeding. A European perspective

J.-L. Vincent[a], R. Rossaint[b], B. Riou[c,*], Y. Ozier[d,2], D. Zideman[e,3], D.-R. Spahn[f,1]

Température corporelle centrale > 34 °C

Correction hypocalcémie

pH ≥7,20

Plaquettes > 50 000 /mm3

TP > 40 %

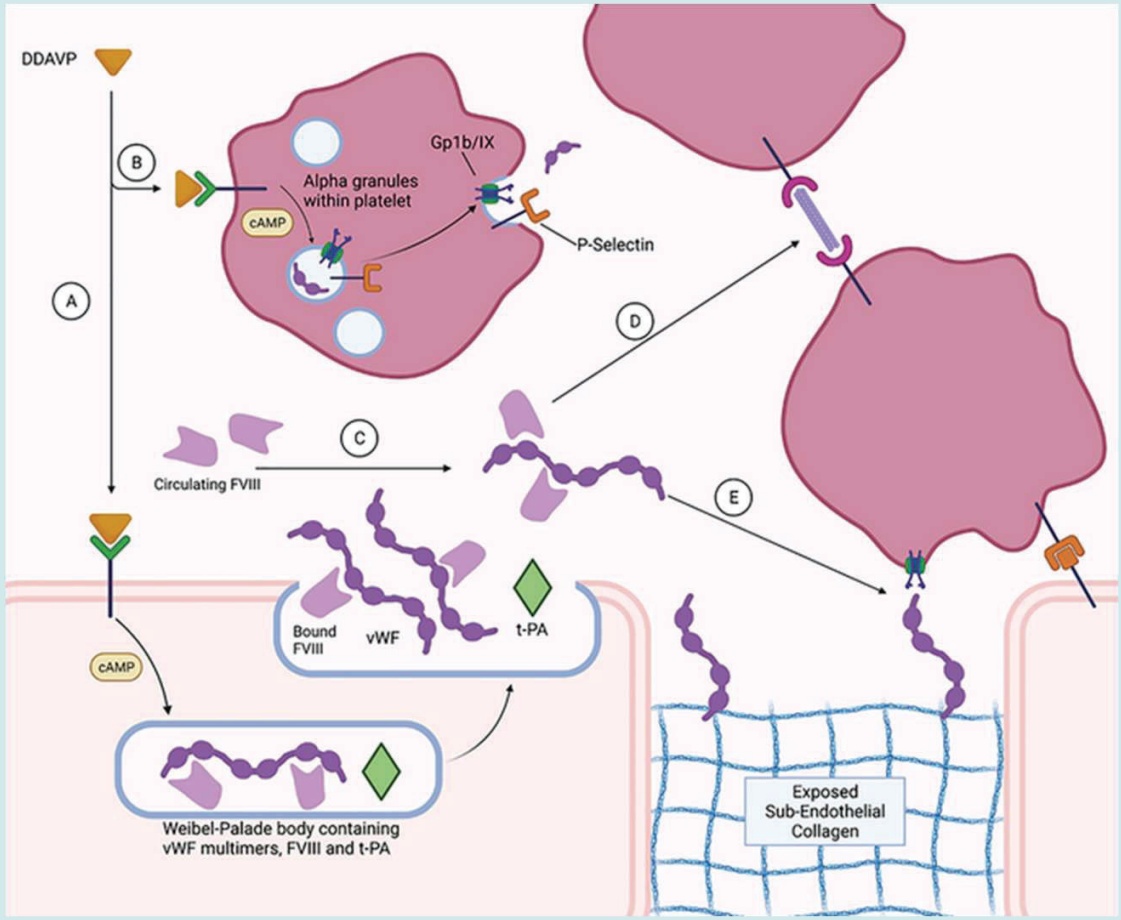
Hématocrite > 24%

Fibrinogène 0,5-1g/L

Desmopressine

Desmopressine

Mohinani, A et al. (2023). *European J of Haematology* 110, 470–479 //
Picchio, M et al. (2025). *Heart, Lung and Circulation* 34, 674–692 //



Étape	Description	Effet sur l'hémostase
(A)	La desmopressine se lie aux **récepteurs V2** des **cellules endothéliales**, stimulant la voie de l'**AMP cyclique (cAMP)**. ➔ libération de **vWF**, **facteur VIII**, et **t-PA**.	Le vWF domine l'effet du t-PA, favorisant la coagulation.
(B)	La desmopressine active aussi les **récepteurs V2 des plaquettes** ➔ **l**ibération de **vWF** et expression des récepteurs **Gp1b/IX** et **P-sélectine**.	Augmentation de l'adhésivité plaquettaire.
(C)	Le **vWF** se lie au **facteur VIII circulant** et à celui libéré par les cellules endothéliales, le protégeant d'une dégradation rapide.	Prolongation de la demi-vie du facteur VIII,
(D)	Le **facteur VIII**, stabilisé par le vWF, devient disponible pour la **cascade coagulante**, facilitant la formation du **caillot de fibrine**.	Accélération de la formation du caillot.
(E)	Le **vWF** se fixe au **collagène sous-endothélial exposé** (en cas de lésion vasculaire) et aux récepteurs plaquettaires **Gp1b/IX**. La **P-sélectine** interagit avec les leucocytes et les cellules endothéliales.	Promotion de l'**adhésion plaquettaire** et de la formation du thrombus.

Desmopressine

34 RCT entre 1986-2017 – 2523 patients

Picchio, M et al. (2025). *Heart, Lung and Circulation* 34, 674–692 //

Critère évalué	Nombre d'études	Nombre de patients (Desmopressine/Placebo)	Effet relatif (IC 95 %)	Certitude des preuves
Perte sanguine	25	773 / 784	MD -96.2 mL (-1.9 à -43.96)	**Faible**
Transfusion CGR	17	546 / 550	SMD -0.32 (-0.05 à -0.59)	**Faible**
Transfusion PFC	10	332 / 333	SMD -0.3 (-0.06 à -0.54)	**Très faible**
Transfusion de plaquettes	7	248 / 249	SMD -0.16 (-0.02 à -0.30)	**Très faible**
Incidence totale des transfusions	17	509/1943 (26.2 %) / 532/1908 (27.9 %)	RR 0.94 (0.84 à 1.06)	**Élevée**
Réexploration	16	23/655 (3.5 %) / 39/660 (5.9 %)	RR 1.90 (1.47 à 2.92)	**Très faible**
Evnts thrombo-emboliques	19	43/708 (6.1 %) / 26/676 (3.8 %)	RR 4.64 (2.61 à 11.66)	**Modérée**
Mortalité	14	11/380 (1.9 %) / 10/364 (1.8 %)	RR 2.94 (1.57 à 13.06)	**Faible**

Desmopressine

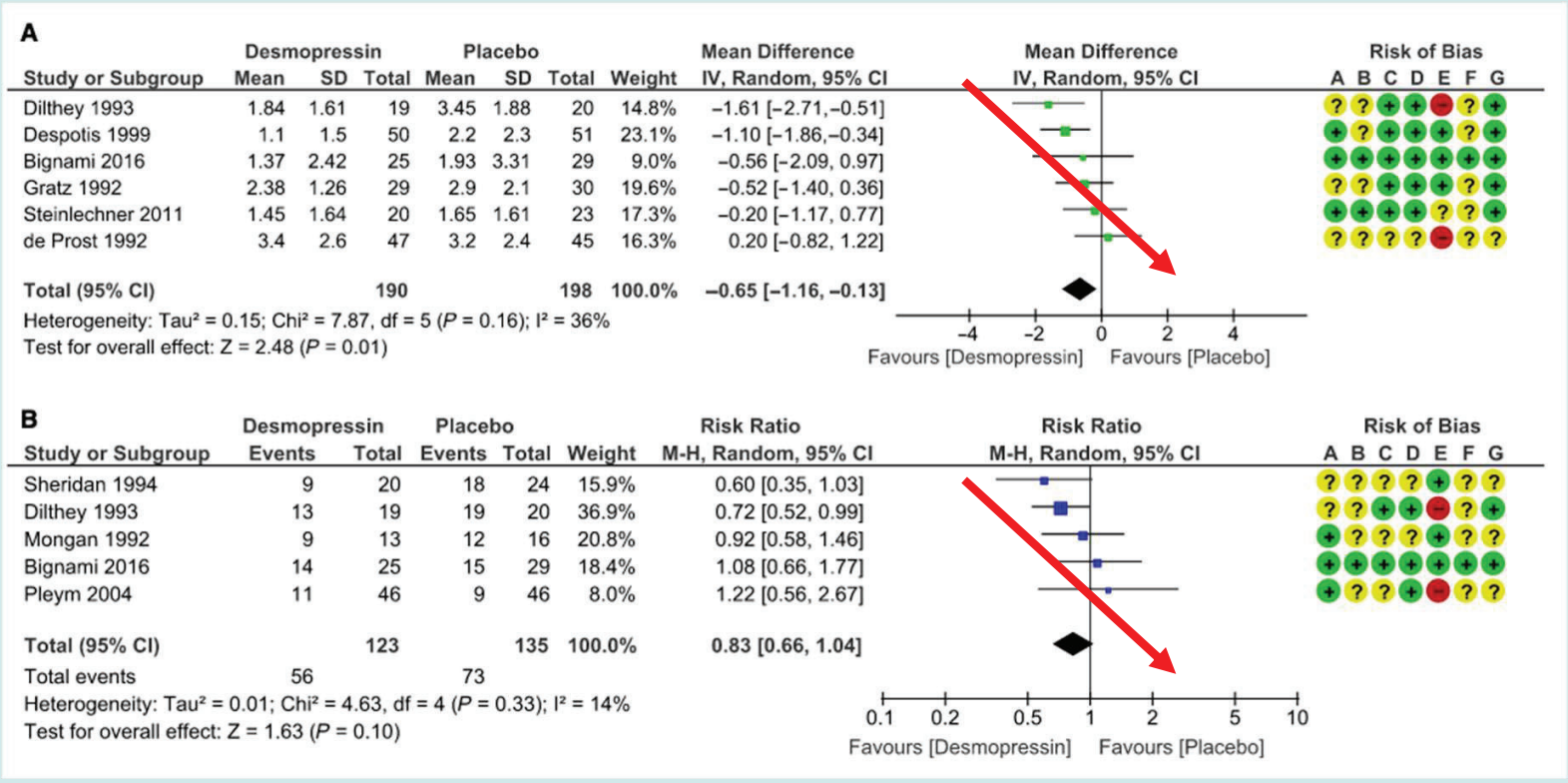
Desborough, MJR et al. (2017). *Journal of Thrombosis and Haemostasis* 15, 263–272 //

10 RCT - 596 patients
Chirurgie cardiaque + dysfonction plaquettaire (AAP, test de plaquettes etc ..)

Desmopressin for treatment of platelet dysfunction and reversal of antiplatelet agents: a systematic review and meta-analysis of randomized controlled trials

M. J. R. DESBOROUGH,*† K. A. OAKLAND,*‡ G. LANDONI,§¶ M. CRIVELLARI,§ C. DOREE,* L. J. ESTCOURT*† and S. J. STANWORTH*†

Total blood loss
MD -253.93 mL (-408.01 to -99.85 mL) ⊕⊕◯◯ Low



A

Study or Subgroup	Desmopressin Mean	SD	Total	Placebo Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Dilthey 1993	1.84	1.61	19	3.45	1.88	20	14.8%	−1.61 [−2.71,−0.51]
Despotis 1999	1.1	1.5	50	2.2	2.3	51	23.1%	−1.10 [−1.86,−0.34]
Bignami 2016	1.37	2.42	25	1.93	3.31	29	9.0%	−0.56 [−2.09, 0.97]
Gratz 1992	2.38	1.26	29	2.9	2.1	30	19.6%	−0.52 [−1.40, 0.36]
Steinlechner 2011	1.45	1.64	20	1.65	1.61	23	17.3%	−0.20 [−1.17, 0.77]
de Prost 1992	3.4	2.6	47	3.2	2.4	45	16.3%	0.20 [−0.82, 1.22]
Total (95% CI)			**190**			**198**	**100.0%**	**−0.65 [−1.16, −0.13]**

Heterogeneity: Tau² = 0.15; Chi² = 7.87, df = 5 (*P* = 0.16); I² = 36%
Test for overall effect: Z = 2.48 (*P* = 0.01)

Mean Difference IV, Random, 95% CI
−4 −2 0 2 4
Favours [Desmopressin] Favours [Placebo]

Risk of Bias A B C D E F G

B

Study or Subgroup	Desmopressin Events	Total	Placebo Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Sheridan 1994	9	20	18	24	15.9%	0.60 [0.35, 1.03]
Dilthey 1993	13	19	19	20	36.9%	0.72 [0.52, 0.99]
Mongan 1992	9	13	12	16	20.8%	0.92 [0.58, 1.46]
Bignami 2016	14	25	15	29	18.4%	1.08 [0.66, 1.77]
Pleym 2004	11	46	9	46	8.0%	1.22 [0.56, 2.67]
Total (95% CI)		**123**		**135**	**100.0%**	**0.83 [0.66, 1.04]**
Total events	56		73			

Heterogeneity: Tau² = 0.01; Chi² = 4.63, df = 4 (*P* = 0.33); I² = 14%
Test for overall effect: Z = 1.63 (*P* = 0.10)

Risk Ratio M-H, Random, 95% CI
0.1 0.2 0.5 1 2 5 10
Favours [Desmopressin] Favours [Placebo]

Risk of Bias A B C D E F G

Desmopressine

Desborough, MJR et al. (2017). *Journal of Thrombosis and Haemostasis* 15, 263–272
Carless, PA et al. (2004). *Cochrane Database Syst Rev* CD001884

La **desmopressine en prophylaxie systématique** n'a **pas sa place** en chirurgie cardiaque de routine pour la population générale.

➔ Réduction très modeste des perte sanguines
➔ Effet peu significatif cliniquement
➔ Possible réduction de la transfusion mais uniquement en combinant les indices

La desmopressine peut être **envisagée de manière sélective** dans des sous-groupes spécifiques :

- Patients avec **dysfonction plaquettaire documentée** (AAP actif).
- Patients avec des **temps prolongés de CEC (> 140 min :** −344.74 ml, 95% CI −478.50 to −210.97 ml**)**.
- Patients présentant des **preuves biologiques de dysfonction plaquettaire**.

Dose typique de **0,3 µg/kg en IV (ampoule de 4 µg)**
Attention : alerte sur le risque d'insuffisance rénale aigue (Kato, H et al. (2024). *Medicina* 60, 2064)

The prophylactic use of DDAVP is not recommended to reduce bleeding complications.	III	A	[402–404]
In bleeding patients with platelet dysfunction, the use of DDAVP should be considered to reduce bleeding complications.	IIa	C	[403]

Check-list d'hémostase

Cleaveland Checklist

Loor, G et al. (2013). *The Journal of Thoracic and Cardiovascular Surgery* 146, 1028–1032

Prior to Sternal Wires:

- ☑ Surgical Sites
  - ☐ Cannulation sites
  - ☐ Proximals/ distals
  - ☐ Aortotomies/ atriotomies/ ventriculotomies
- ☑ Mediastinum
  - ☐ Thymus
  - ☐ Pericardium
- ☑ Chest Wall
  - ☐ Mammary bed
- ☑ Sternum

Fig 5. Cleveland Clinic Reoperation for Bleeding Checklist.

Cleaveland Checklist

Van Boxtel, AGM et al. (2017). *Interactive CardioVascular and Thoracic Surgery* 25, 555–558 //

2013 – 2015 : 3210 procedures were performed (Group 1) : 112 re-explorations for bleeding (3.5%).
2015 – 2016 : 1607 patients (Group 2) : 29 re-explorations for bleeding (1.8%)

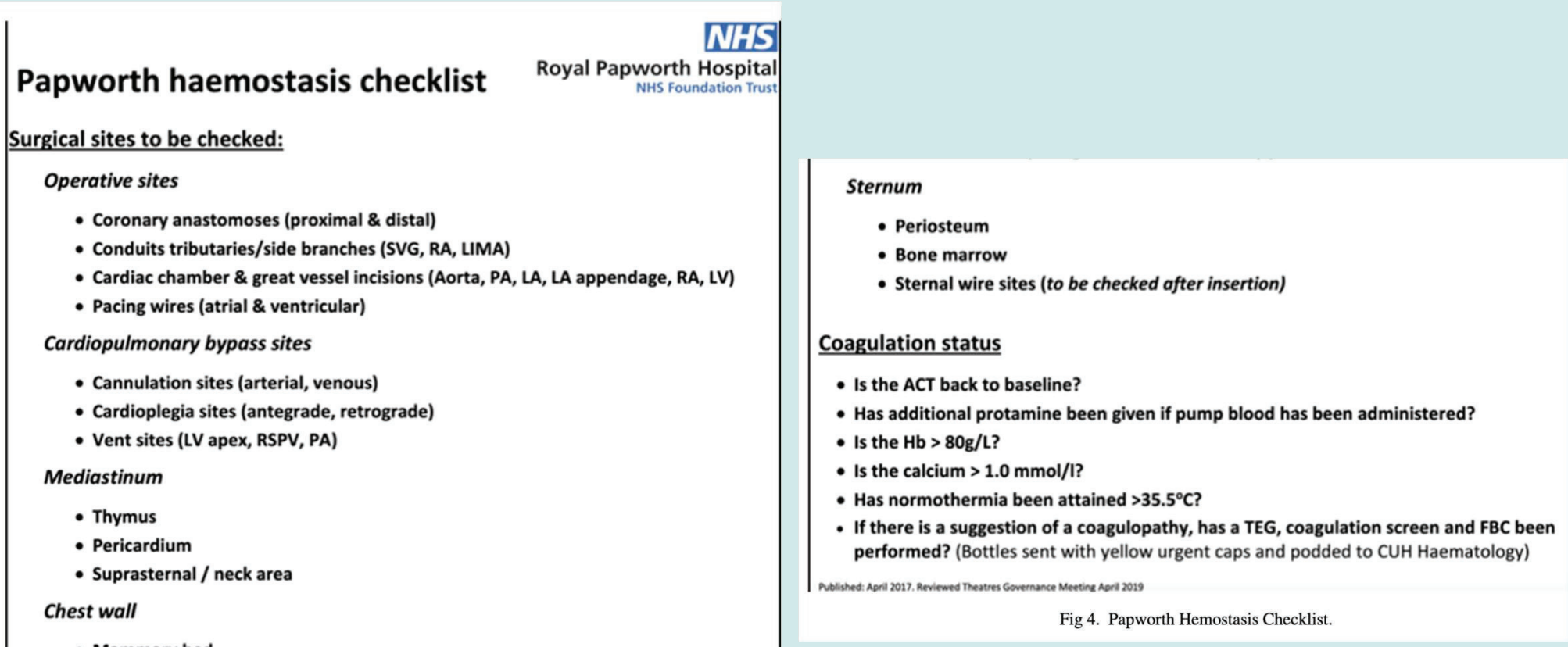
Table 1: Demographic data of the 2 patient groups

Variable	1 Jan 2013–1 May 2015 (*n* = 3210) Group 1	1 May 2015–1 July 2016 (*n* = 1607) Group 2	*P*-value
Age, years, mean	66.7 ± 10.1	67.4 ± 9.8	0.443
Male gender, *n* (%)	2272 (70.8)	1202 (74.8)	0.003
Diabetes, *n* (%)	666 (20.7)	330 (20.5)	0.88
COPD, *n* (%)	266 (8.3)	140 (8.7)	0.62
PVD, *n* (%)	309 (9.6)	191 (11.9)	0.02
Serum creatinine, mean mmol/l	91.4 ± 37.9	95.8 ± 55	0.034
LVEF<35%, *n* (%)	109 (3.4)	59 (3.7)	0.62
Logistic EuroSCORE	7.6 ± 10.9	7.8 ± 11.7	0.350

Data are presented as mean ± SD or *n* (%).
COPD: chronic obstructive pulmonary disease; LVEF: left ventricular ejection fraction; PVD: peripheral vascular disease.

Papworth checklist

Ali, JM et al. (2019). *Eur J Cardiothorac Surg* 55, 729–736



NHS
Royal Papworth Hospital
NHS Foundation Trust

Papworth haemostasis checklist

Surgical sites to be checked:

Operative sites

- Coronary anastomoses (proximal & distal)
- Conduits tributaries/side branches (SVG, RA, LIMA)
- Cardiac chamber & great vessel incisions (Aorta, PA, LA, LA appendage, RA, LV)
- Pacing wires (atrial & ventricular)

Cardiopulmonary bypass sites

- Cannulation sites (arterial, venous)
- Cardioplegia sites (antegrade, retrograde)
- Vent sites (LV apex, RSPV, PA)

Mediastinum

- Thymus
- Pericardium
- Suprasternal / neck area

Chest wall

- Mammary bed
- Chest drain and pacing wires chest wall entry points

Sternum

- Periosteum
- Bone marrow
- Sternal wire sites (*to be checked after insertion)*

Coagulation status

- Is the ACT back to baseline?
- Has additional protamine been given if pump blood has been administered?
- Is the Hb > 80g/L?
- Is the calcium > 1.0 mmol/l?
- Has normothermia been attained >35.5°C?
- If there is a suggestion of a coagulopathy, has a TEG, coagulation screen and FBC been performed? (Bottles sent with yellow urgent caps and podded to CUH Haematology)

Published: April 2017. Reviewed Theatres Governance Meeting April 2019

Fig 4. Papworth Hemostasis Checklist.

Papworth checklist

Ali, JM et al. (2019). *Eur J Cardiothorac Surg* 55, 729–736

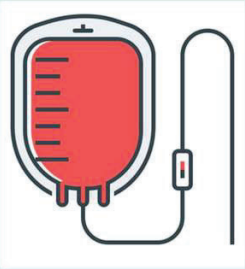
1 April 2016 to 30 June 2018

Table 1: Baseline characteristics of patients

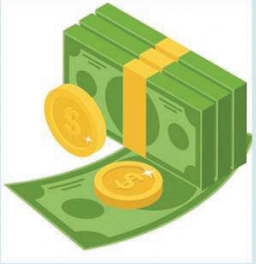
	Prechecklist implementation (n = 1944)	Post-checklist implementation (n = 1867)	P-value
Surgery (%)[b]			0.17
Aorta surgery	177 (9.1)	181 (9.7)	
CABG	777 (40.0)	747 (40.0)	
CABG + major cardiac	25 (1.3)	9 (0.5)	
CABG + valve	321 (16.5)	288 (15.4)	
Major cardiac	30 (1.6)	22 (1.2)	
Valve	614 (31.5)	620 (33.2)	
EuroSCORE, mean (SD)[c]	6.4 (3.5)	6.4 (3.6)	0.84
Logistic EuroSCORE, mean (SD)[c]	9.8 (12.6)	10.1 (13.0)	0.51

Papworth checklist

Ali, JM et al. (2019). *Eur J Cardiothorac Surg* 55, 729–736



	All patients		
	Pre (n = 1944)	Post (n = 1867)	P-value
Red blood cells[a]	1.73	1.42	<0.001
Fresh frozen plasma[a]	0.64	0.51	<0.001
Platelets[a]	0.49	0.41	<0.001
Cryoprecipitate[a]	0.17	0.14	0.03



	All patients		
	Pre (n = 1944)	Post (n = 1867)	Saving
All products	£364.24	£309.51	£102 165

Saving is calculated as difference × number of patients post-checklist implementation.

Papworth checklist

Ali, JM et al. (2019). *Eur J Cardiothorac Surg* 55, 729–736

Table 2: Postoperative outcomes

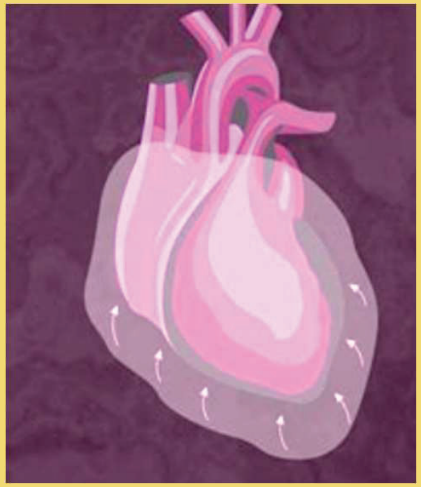
	Prechecklist (n = 1944)		Post-checklist (n = 1867)		P-value
	Median (range)	Mean (SD)	Median (range)	Mean (SD)	
Hours of ventilation[a]	9 (4–1156)	26.86 (71.52)	9 (4–973)	22.89 (65.89)	0.08
12-h blood loss (ml)[a]	300 (40–3666)	415.26 (344.54)	275 (28–3498)	342.47 (306.48)	**<0.001**
ICU length of stay (days)[a]	1.3 (0.5–51)	2.89 (4.60)	1.1 (0.5–49)	2.60 (4.13)	**0.04**
Hospital length of stay (days)[a]	7.9 (4–89)	10.12 (7.22)	7.4 (4–62)	9.16 (5.97)	**<0.001**
In-hospital mortality (%)[b]	46 (2.46)		47 (2.42)		0.93

1) reduction in the return-to-theatre rate (3.5% pre vs 2.1% post, P = 0.01).

2) proportion of patients bleeding >1 l in 12 h (6.1% pre vs 3.5% post, P < 0.001)

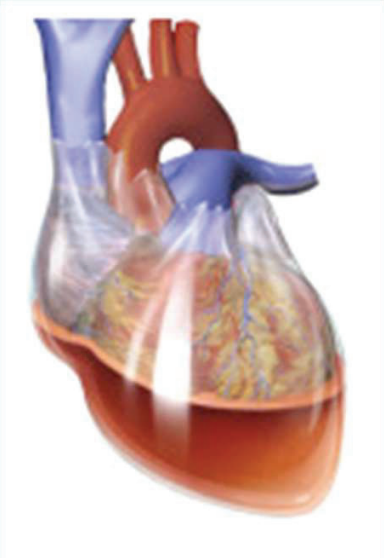
3) composite of patients bleeding >1 l and/or returning to theatre (7.9% pre vs 4.4% post, P < 0.001)

Gestion des aspirations



Péricarde

Manshanden, JSJ et al. (2015). *EBioMedicine* 2, 1217–1223



Mécanisme	Détails
Élévation du TF	Le TF est **fortement augmenté** dans le sang péricardique pendant la CEC, principalement issu des **monocytes activés** et des **complexes leucocytes-plaquettes**.
Activation de la voie extrinsèque	Le TF se lie au **facteur VII/VIIa**, formant le complexe **TF–FVIIa**, qui active efficacement le **facteur X** → génération massive de **thrombine** (marqueurs : F1+2, complexes thrombine-antithrombine).
Résistance à l'héparine	L'héparine systémique ne supprime que **partiellement** cette activation, car sa concentration dans le péricarde est souvent **insuffisante** pour inhiber complètement la voie extrinsèque.
Amplification par les microdébrits	Les microdébrits porteuses de TF **amplifient** la génération de thrombine via des mécanismes dépendants du facteur VII.

Péricarde

Tabuchi, N et al. (1993). *The Journal of Thoracic and Cardiovascular Surgery* 106, 828–833 //

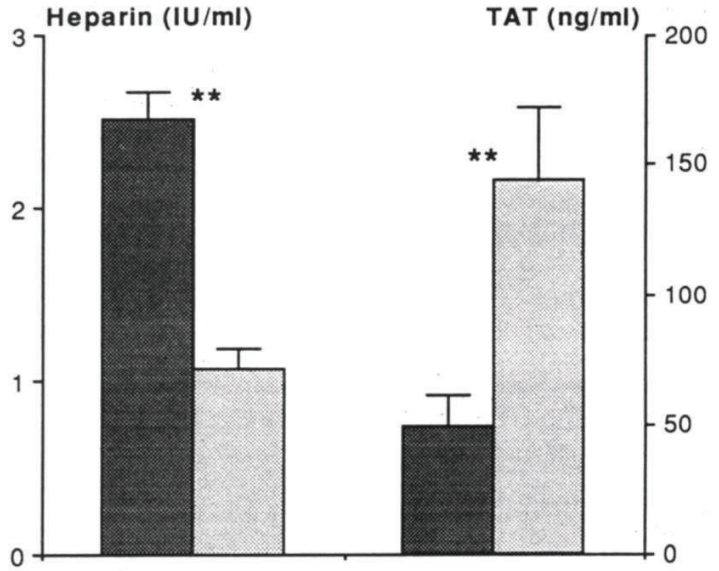


Fig. 1. Plasma heparin and TAT concentrations in systemic blood *(dark column)* compared with blood from the pericardial cavity *(light column)* before admixture. The samples were collected at the end of suturing of the distal coronary anastomosis. *Double asterisk* represents a significant difference between the two samples ($p < 0.01$).

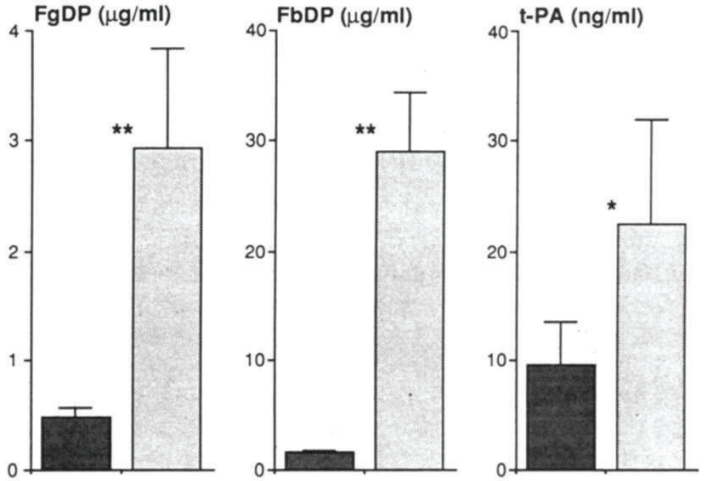
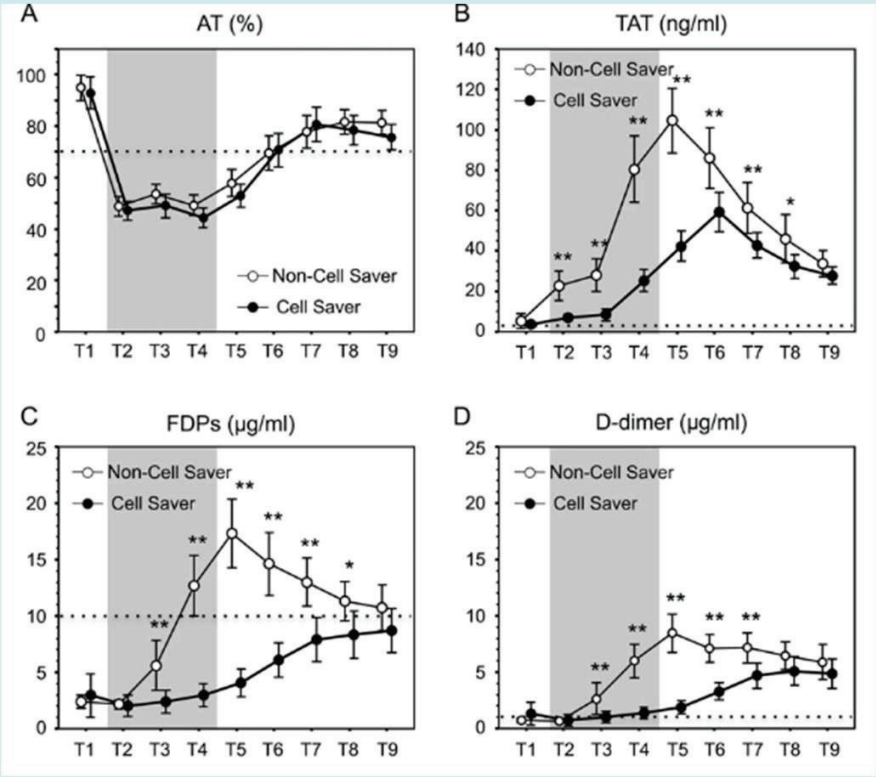


Fig. 2. Activation products in systemic blood *(dark column)* compared with blood from the pericardial cavity *(light column)* before admixture. The plasma concentrations of FgDP, FbDP, and t-PA antigen were measured at the end of suturing the distal coronary anastomosis. *Asterisk* and *double asterisk* represent a significant difference between two samples ($p < 0.05$ and $p < 0.01$, respectively).

Aspiration chirurgicale

1 Morisaki, A et al. (2013). *Interactive CardioVascular and Thoracic Surgery* 17, 507–514 //

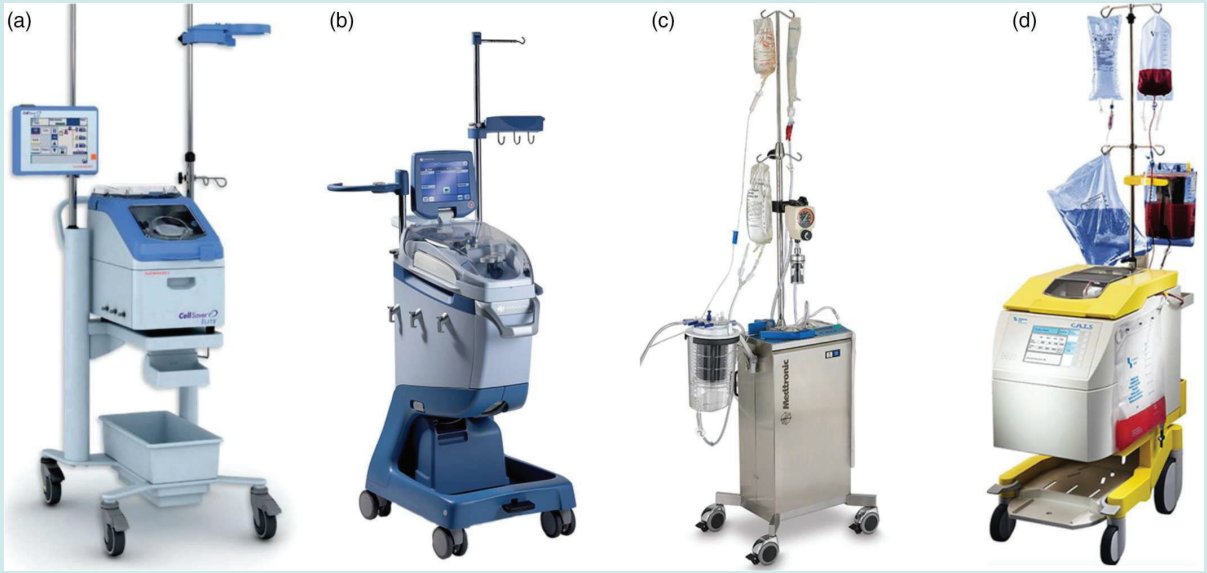
In 40 AVR operations between April 2009 and April 2011, the retransfusion method of pericardial blood during cardiopulmonary bypass (CPB) was allocated to the use of cardiotomy suction (non-Cell-Saver group, n = 20) or CATS (Cell-Saver group, n = 20)



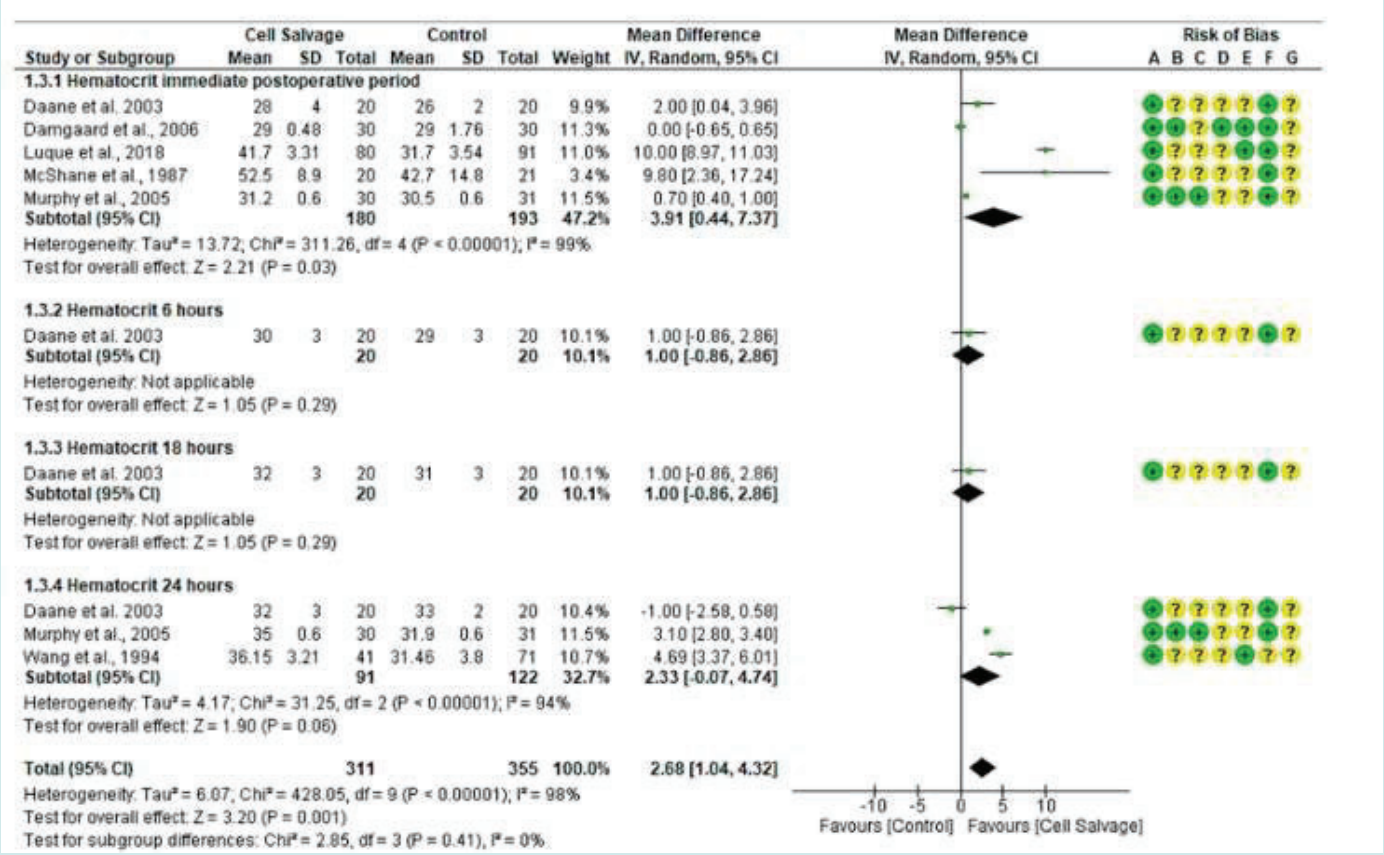
L'aspiration directe du sang péricardique dans la circulation extracorporelle lors d'une chirurgie cardiaque expose à un risque élevé d'activation de la coagulation, de la fibrinolyse et de l'inflammation, particulièrement en cas de troubles de l'hémostase ou de fibrinolyse accrue

Cell-saver

2 grandes technololgies



Attention aux grands volumes



Attention aux grands volumes

1 Luque-Oliveros, M et al. (2017). *Curr Vasc Pharmacol* 15, 576–581 //

Le volume retransfusé par le cell saver a un effet dose-dépendant sur l'hémorragie après chirurgie cardiaque.
Un volume élevé de sang autologue retransfusé (>1800 mL) est associé à une augmentation du risque d'hémorragie postopératoire immédiate

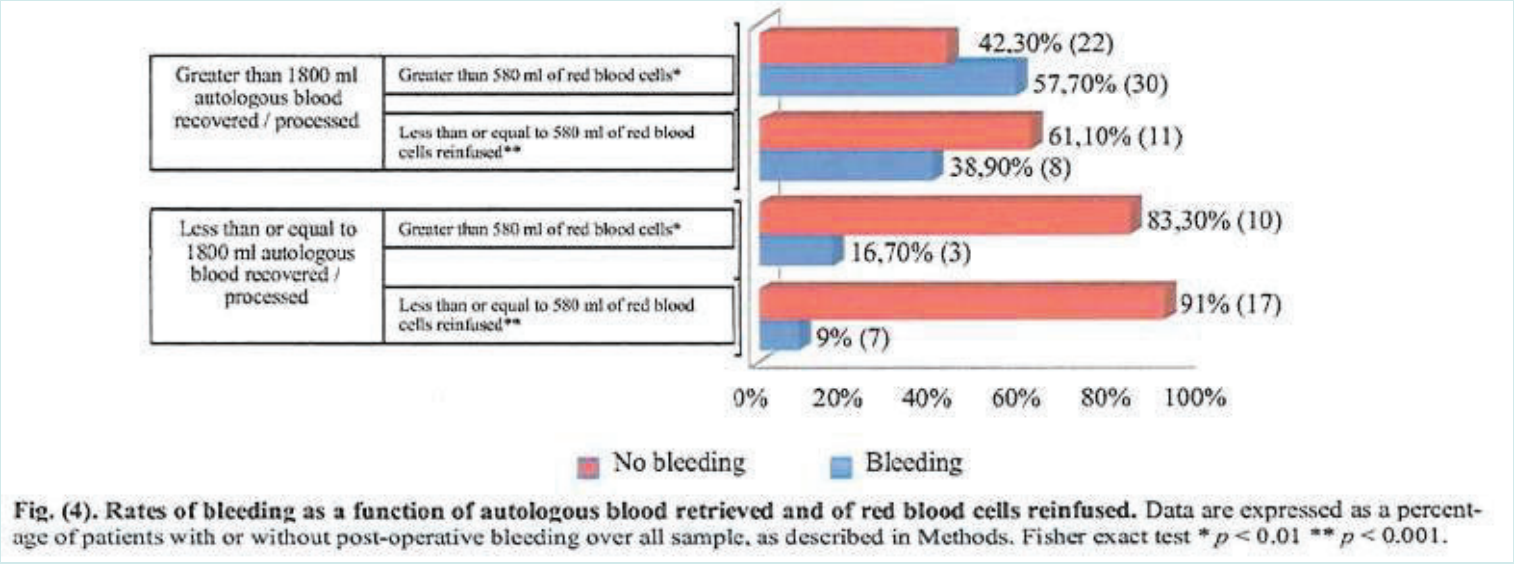
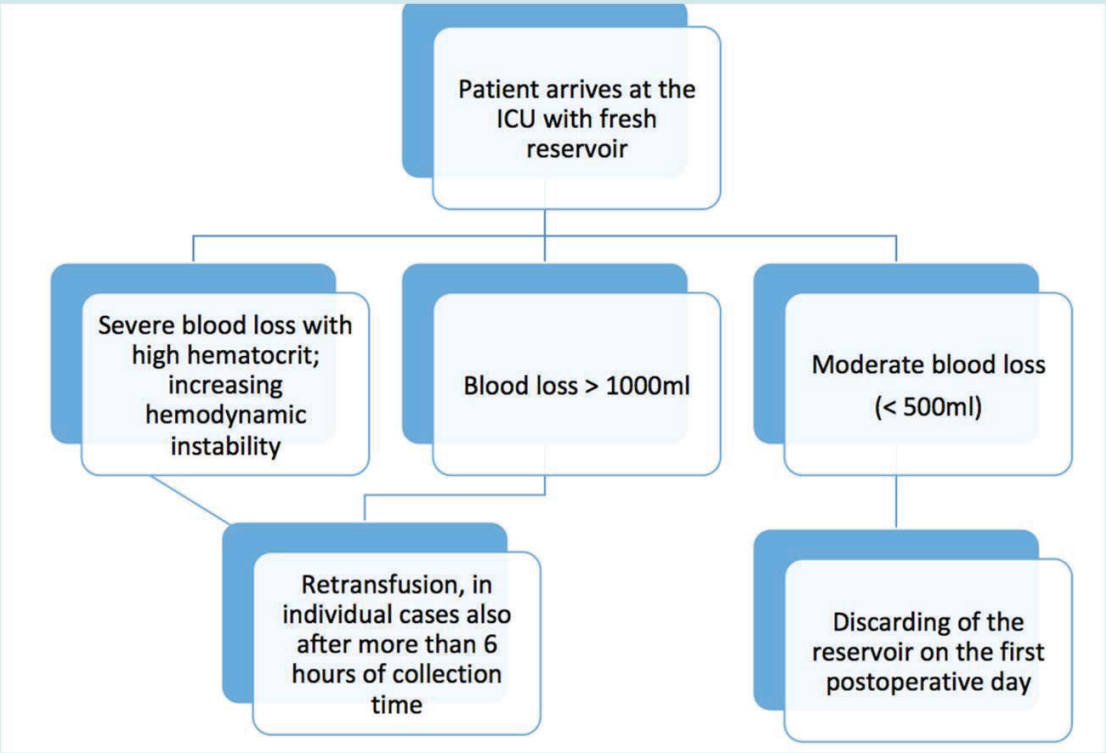


Fig. (4). Rates of bleeding as a function of autologous blood retrieved and of red blood cells reinfused. Data are expressed as a percentage of patients with or without post-operative bleeding over all sample, as described in Methods. Fisher exact test * $p < 0.01$ ** $p < 0.001$.

Cellsaver en réanimation

Luque-Oliveros, M et al. (2017). *Curr Vasc Pharmacol* 15, 576–581 //

Figure 1. Cell saver reservoir at the bedside of an intensive care patient.

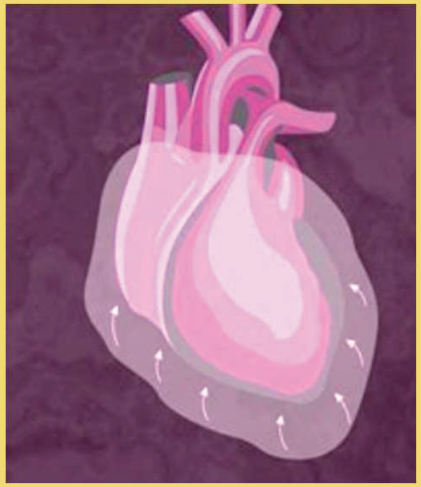


Cellsaver en réanimation

Luque-Oliveros, M et al. (2017). *Curr Vasc Pharmacol* 15, 576–581 //

Direct reinfusion of shed mediastinal blood from postoperative chest tube drainage is not recommended as a means of blood conservation and may cause harm.	Class III: Harm, Level B–NR

Lavage péricardique



Lavage péricardique continu

Manshanden, JSJ et al. (2015). *EBioMedicine* 2, 1217–1223
Yavari, M & Becker, RC. (2009). *J Thromb Thrombolysis* 27, 95–104 //

Irrigation : Nacl 0,9% - 38°c
500 ml/h pendant 2 heures - puis adapté à la perte sanguine (min 100ml/h) – durée 10h

Sécurité : stop si plus de 200mL de différence (1 patient)

Pas de différence sur les épanchements pleuraux et péricardiques en fin d'hospitalisation

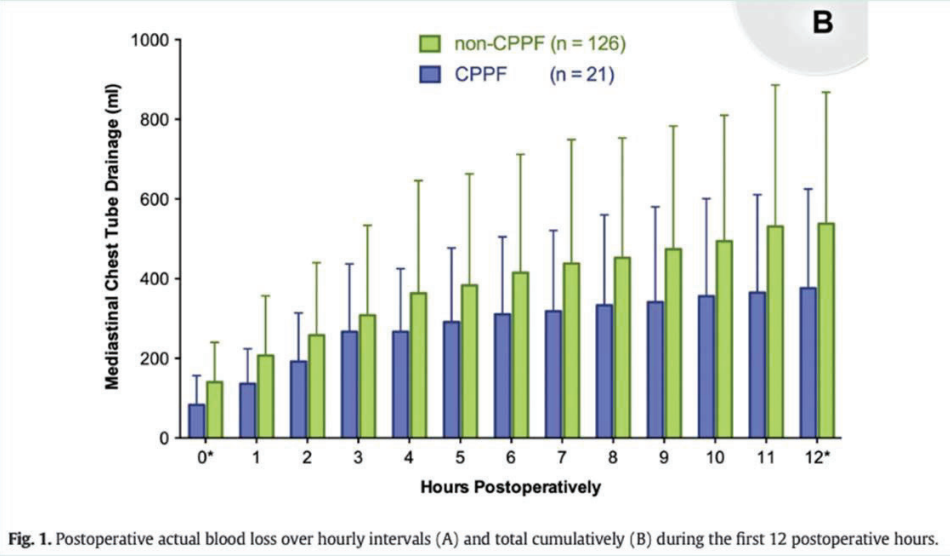


Fig. 1. Postoperative actual blood loss over hourly intervals (A) and total cumulatively (B) during the first 12 postoperative hours.

Table 4
Postoperative safety aspects of the CPPF and non-CPPF groups.

	CPPF n = 21 (%)	Non-CPPF n = 126 (%)	P value
In-hospital adverse events:			
Cardiac tamponade	0 (0.0)	4 (3.2)	0.411
Reexploration for bleeding	0 (0.0)	9 (7.1)	0.002*
Subxyphoidal drainage	0 (0.0)	3 (2.4)	0.478
Mortality	0 (0.0)	2 (1.6)	0.564
In-hospital data:[a]			
Time until extubation (hours ± SD)	7.6 ± 6.1	6.8 ± 5.2	0.535
Time until chest tube removal (hours ± SD)	21 ± 8	22 ± 14	0.762
ICU stay (days ± SD)	1.4 ± 0.9	1.7 ± 3.8	0.746
Total hospitalization (days ± SD)	7.7 ± 2.4	9.0 ± 8.6	0.472
Fluid accumulation at discharge:			
Pleural effusion (trace to mild)	10 (47.6)	77 (61.1)	0.272
In a surgically opened pleural cavity	5 (23.8)	23 (18.3)	0.563
Pericardial effusion (trace to mild)	7 (33.3)	38 (30.2)	0.486
Circular (≥50%/≥6 mm)	1 (4.8)	10 (7.9)	0.606
Adverse events after discharge:			
Late cardiac tamponade	1 (4.8)	3 (2.4)	0.477
For which subxyphoidal drainage	1 (4.8)	2 (1.6)	0.344
For which re-sternotomy	0 (0.0)	1 (0.8)	0.685
Reoperation	1 (4.8)	4 (3.2)	0.718
3-year mortality	0 (0.0)	6 (4.8)	0.014*

Lavage péricardique continu

Jain, SN et al. (2025). *J Cardiothorac Surg* 20, 195

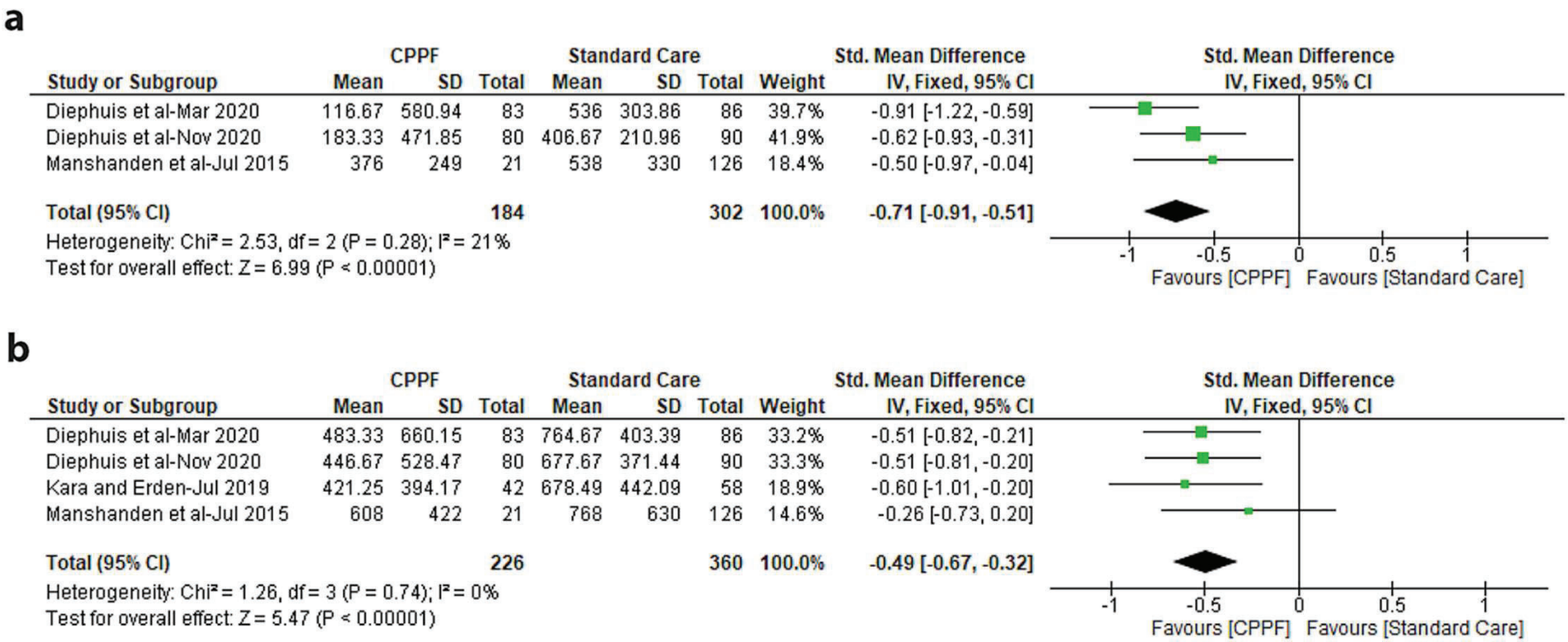


Fig. 2 **a**: Postoperative blood loss at 12 h **b**: Total mean actual postoperative blood loss

Lavage péricardique continu

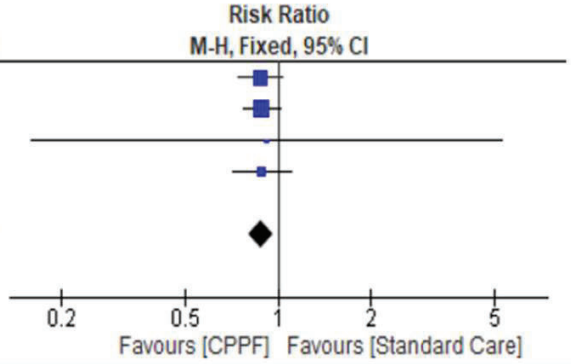
Jain, SN et al. (2025). *J Cardiothorac Surg* 20, 195

Réintervention : NS
Mortalité : NS (2 vs 11 patients)
Médiastinite : NS. (12 vs 14 patients)

Fluid accumulation

Study or Subgroup	CPPF Events	CPPF Total	Standard Care Events	Standard Care Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Diephuis et al-Mar 2020	60	83	71	86	38.7%	0.88 [0.74, 1.03]
Diephuis et al-Nov 2020	63	80	80	90	41.7%	0.89 [0.77, 1.01]
Kara and Erden-Jul 2019	2	42	3	58	1.4%	0.92 [0.16, 5.27]
Manshanden et al-Jul 2015	17	21	115	126	18.2%	0.89 [0.72, 1.10]
Total (95% CI)		**226**		**360**	**100.0%**	**0.88 [0.80, 0.97]**
Total events	142		269			

Heterogeneity: Chi² = 0.02, df = 3 (P = 1.00); I² = 0%
Test for overall effect: Z = 2.53 (P = 0.01)



Lavage à l'exacyl

Ker, K et al. (2013). *Cochrane Database of Systematic Reviews*
Szymańska, E et al. (2025). *Cardiothorac Surg* 33, 30
Bonis, MD et al. (2000). *The Journal of Thoracic and Cardiovascular Surgery* 119, 575–580

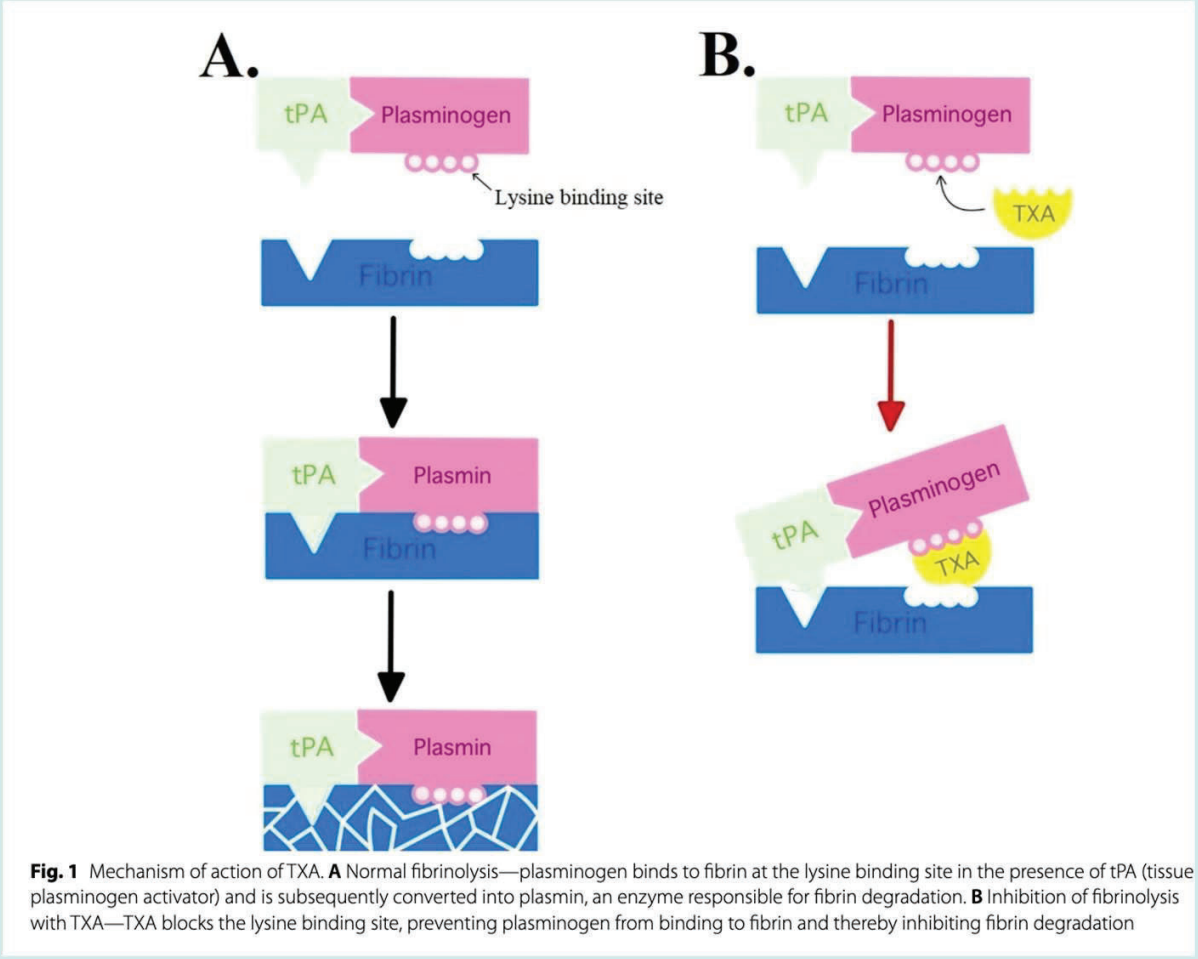


Fig. 1 Mechanism of action of TXA. **A** Normal fibrinolysis—plasminogen binds to fibrin at the lysine binding site in the presence of tPA (tissue plasminogen activator) and is subsequently converted into plasmin, an enzyme responsible for fibrin degradation. **B** Inhibition of fibrinolysis with TXA—TXA blocks the lysine binding site, preventing plasminogen from binding to fibrin and thereby inhibiting fibrin degradation

Lavage à l'exacyl

Ker, K et al. (2013). *Cochrane Database of Systematic Reviews*
Bonis, MD et al. (2000). *The Journal of Thoracic and Cardiovascular Surgery* 119, 575–580

RCT 1998
Double aveugle

Nacl 0,9% 100mL + 1g EXAYL vs placebo avant fermeture

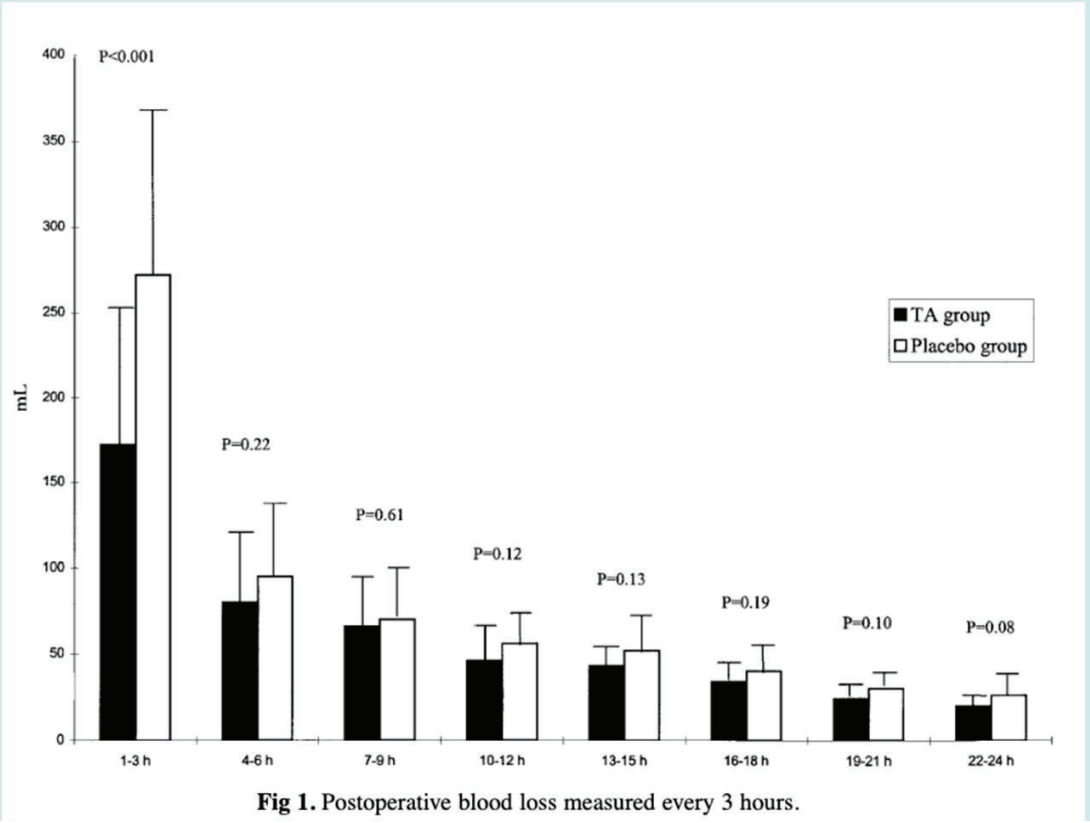


Fig 1. Postoperative blood loss measured every 3 hours.

Lavage à l'exacyl

Ker, K et al. (2013). *Cochrane Database of Systematic Reviews*
Bonis, MD et al. (2000). *The Journal of Thoracic and Cardiovascular Surgery* 119, 575–580

Cochrane Library
Cochrane Database of Systematic Reviews

Topical application of tranexamic acid for the reduction of bleeding (Review)

Ker K, Beecher D, Roberts I

Un peu ancienne

Study or subgroup	Topical TXA N	Control N	log [Ratio] (SE)	Ratio IV,Fixed,95% CI	Weight	Ratio IV,Fixed,95% CI
1 Cardiac surgery						
Baric 2007	97	96	-0.231 (0.089)		1.3 %	0.79 [0.67, 0.95]
Fawzy 2009	19	19	-0.351 (0.188)		0.3 %	0.70 [0.49, 1.02]
Kurt 2011	20	20	-0.435 (0.117)		0.7 %	0.65 [0.51, 0.81]
Nouraei 2013	40	40	-0.356 (0.119)		0.7 %	0.70 [0.55, 0.88]
De Bonis 2000	20	20	-0.248 (0.092)		1.2 %	0.78 [0.65, 0.93]
Abul-Azm 2006	50	50	-0.503 (0.023)		18.9 %	0.60 [0.58, 0.63]
Yasim 2005	10	10	-0.02 (0.193)		0.3 %	0.98 [0.67, 1.43]
Subtotal (95% CI)	**256**	**255**			**23.3 %**	**0.63 [0.61, 0.66]**
Heterogeneity: Chi^2 = 21.76, df = 6 (P = 0.001); I^2 =72%						
Test for overall effect: Z = 22.29 (P < 0.00001)						

There is reliable evidence that topical application of tranexamic acid reduces bleeding and blood transfusion in surgical patients

Lavage à l'exacyl

Ker, K et al. (2013). *Cochrane Database of Systematic Reviews*
Szymańska, E et al. (2025). *Cardiothorac Surg* 33, 30
Bonis, MD et al. (2000). *The Journal of Thoracic and Cardiovascular Surgery* 119, 575–580

Table 3 Topical vs. IV TXA—study comparison

Study, year	Study type	Number of participants	Outcomes	Results
Habbab, 2019 (DEPOSITION pilot study) [42]	RCT	97	Mediastinal drainage	NS difference between IV and topical group
Lamy, 2024 (DEPOSITION) [41]	RCT	3242	Seizures (primary) Red blood cell transfusion (secondary)	NS difference between IV and topical group S difference, 8.3% more transfusions in topical group
Awad, 2025 [40]	Systematic review and meta-analysis	3581 (in total, differed depending on outcome)	Seizures Post operative blood loss Post operative FFP transfusion	S difference, less in topical NS difference NS difference

Abbreviations: *NS* not significant, *S* significant

Table 4 TXA dosage (IV + topical group)

Study, year	IV dose	Number of patients	Topical dose	Result (blood loss)
Spegar, 2011 [43]	1 g BSI + 400 mg/h infusion + 0.5 g CPP	100	2.5 g in 250 ml saline	NS
Mahaffey, 2013 [44]	2–10 g bolus ± continuous infusion	160	2 g in 120 ml saline	S
Kimenai, 2016 [45]	2 g BSI + 2 g after CBP	739 (245 patients in control group)	2 g in 200 ml saline	NS
Taksaudom, 2016 [46]	1 mg/kg/h after CBP (for 6 h after surgery)	82	1 g in 100 ml saline	NS

Abbreviations: *BSI* before skin incision, *CPP* crystalloid pump prime, *CBP* cardiopulmonary bypass, *FFP* fresh frozen plasma, *NS* not significant, *S* significant

Lavage à l'exacyl

Ker, K et al. (2013). *Cochrane Database of Systematic Reviews*
Szymańska, E et al. (2025). *Cardiothorac Surg* 33, 30
Bonis, MD et al. (2000). *The Journal of Thoracic and Cardiovascular Surgery* 119, 575–580

Routine use of topical sealants in cardiac surgery is not recommended to reduce blood loss and the need for transfusions.	III	B	[223–225]
Topical sealants may be considered in clinical situations where conventional approaches to surgical and medical improvement of haemostasis are insufficient and where bleeding problems are more local than generalized.	IIb	C	[225]

Drains

Gestion des drains

Technique	Description	Mécanisme proposé
Stripping	Compression d'un segment de tube avec les doigts ou un rouleau, en se déplaçant de proximal à distal tout en maintenant la pression. Une main tient le tube proximalement, l'autre distalement, et applique une pression ferme et constante.	Crée une pression négative, aspirant liquides et caillots hors du thorax.
Milking	Compression du tube par torsion ou pression (parfois main sur main) pour déplacer le fluide à l'intérieur.	Génère une pression positive pendant la compression, puis négative à la relâche.
Fanfolding	Repliement de sections du tube les unes sur les autres, suivi d'une pression.	Même mécanisme que le milking.
Tapping	Tapotement rythmé et doux du drain thoracique avec une pince pour faciliter l'écoulement du sang.	Favorise le drainage par vibration.

Gestion des drains

Guidelines for Perioperative Care in Cardiac Surgery
Enhanced Recovery After Surgery Society Recommendations

Daniel T. Engelman, MD[1]; Walid Ben Ali, MD[2]; Judson B. Williams, MD, MHS[3] ; et al

In meta-analyses of randomized clinical trials, chest-tube stripping has been shown to be ineffective and potentially harmful.

Another technique used to maintain patency is to break the sterile field to access the inside of chest tubes and use a smaller tube to suction the clot out. This technique may be dangerous, because it can increase infection risk and potentially damage internal structures.

III (No Benefit)		
	A	Stripping or breaking the sterile field of chest tubes to remove clots.

Gestion des drains

Ahmad, B et al. (2023). *Port J Card Thorac Vasc Surg* 30, 43–53 //

Cochrane Library

Cochrane Database of Systematic Reviews

Mediastinal chest drain clearance for cardiac surgery (Review)

Wallen MA, Morrison AL, Gillies D, O'Riordan E, Bridge C, Stoddart F

Objectives

To compare different methods of chest drain clearance (i.e. varying levels of suction or suction in combination with milking, stripping, fanfolding and tapping of chest drains) in preventing cardiac tamponade in patients following cardiac surgery.

Main results

Three studies with a total of 471 participants were included. There was no data which could be included in a meta-analysis. This was due to inadequate data provision by two of the studies. Where adequate data were provided there were no common interventions or outcomes to pool. On the basis of single studies there was no evidence of a difference between groups on incidence of chest tube blockage, heart rate, cardiac tamponade or incidence of surgical re-entry.

Gestion des drains

Ahmad, B et al. (2023). *Port J Card Thorac Vasc Surg* 30, 43–53 //

THE IMPACT OF ACTIVE CHEST TUBE CLEARANCE TECHNOLOGY ON SURGICAL OUTCOMES AFTER CARDIAC SURGERY: AN UPDATED SYSTEMATIC REVIEW AND META-ANALYSIS

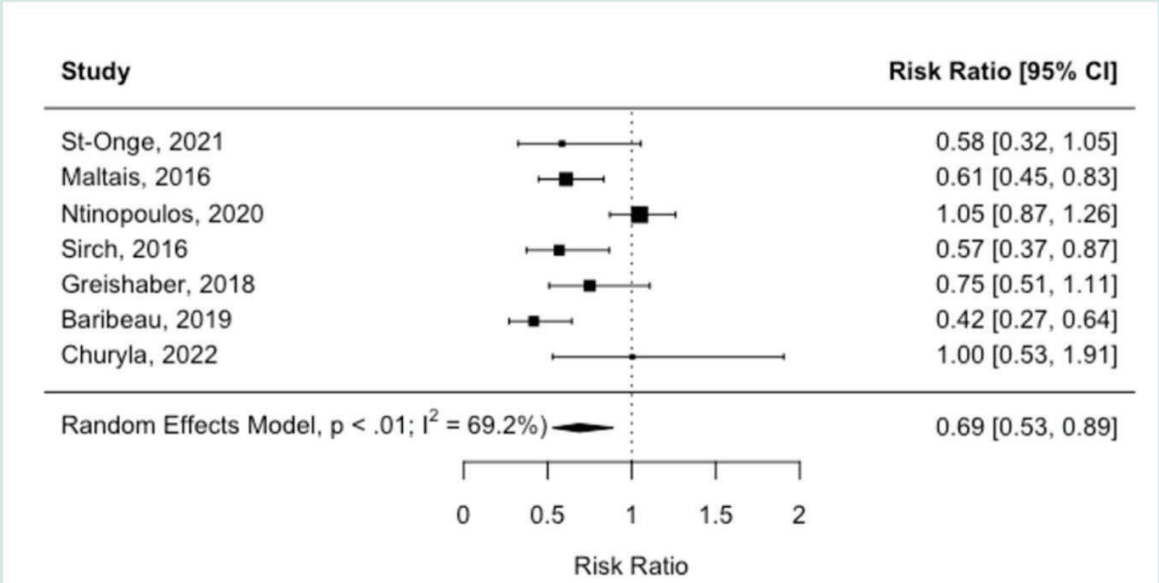


Figure 1 A *Pooled analysis of rates of retained blood syndromes in active chest tube clearance vs. conventional management.*

Gestion des drains

Ahmad, B et al. (2023). *Port J Card Thorac Vasc Surg* 30, 43–53 //

THE IMPACT OF ACTIVE CHEST TUBE CLEARANCE TECHNOLOGY ON SURGICAL OUTCOMES AFTER CARDIAC SURGERY: AN UPDATED SYSTEMATIC REVIEW AND META-ANALYSIS

Table 1a **Results of Studies examining Retained blood syndromes**

Author, Year of Publication	Number of Arms	Number of Patients in Conventional Chest Tube Protocol Arm (control)	Number of Patients in Active Chest Tube protocol (intervention)	Number of patients with RBS in Conventional Chest Tube Protocol	Number of Patients with RBS in Active Chest Tube Protocol	Conventional RBS Percentage	Active RBS Percentage	P Value	Notes
St- Onge, 2021	2	263	257	28	16	10.60%	6.20%	p=0.07	
Maltais, 2016	2	77	175	NR	NR	51%	31%	p=0.0044	
Ntinopoulos, 2020	2	471	471	148	155	31%	33%	p=0.68	
Sirch, 2016	2	256	256	51	29	19.90%	11.30%	p=0.0087	
Greishaber, 2018	2	222	222	48	36	22%	16%	p=0.015	
Baribeau, 2019	2	260	260	60	25	23%	9.60%	p<0.001	The number needed to treat for this RBS reduction was 7.4 [95% CI 5–14.6, p = 0.001}
Churyla, 2022	2	1113	254	NR	NR	4.30%	5.30%	p=0.527	

RBS = Retained blood syndrome

Gestion des drains

Ahmad, B et al. (2023). *Port J Card Thorac Vasc Surg* 30, 43–53 //

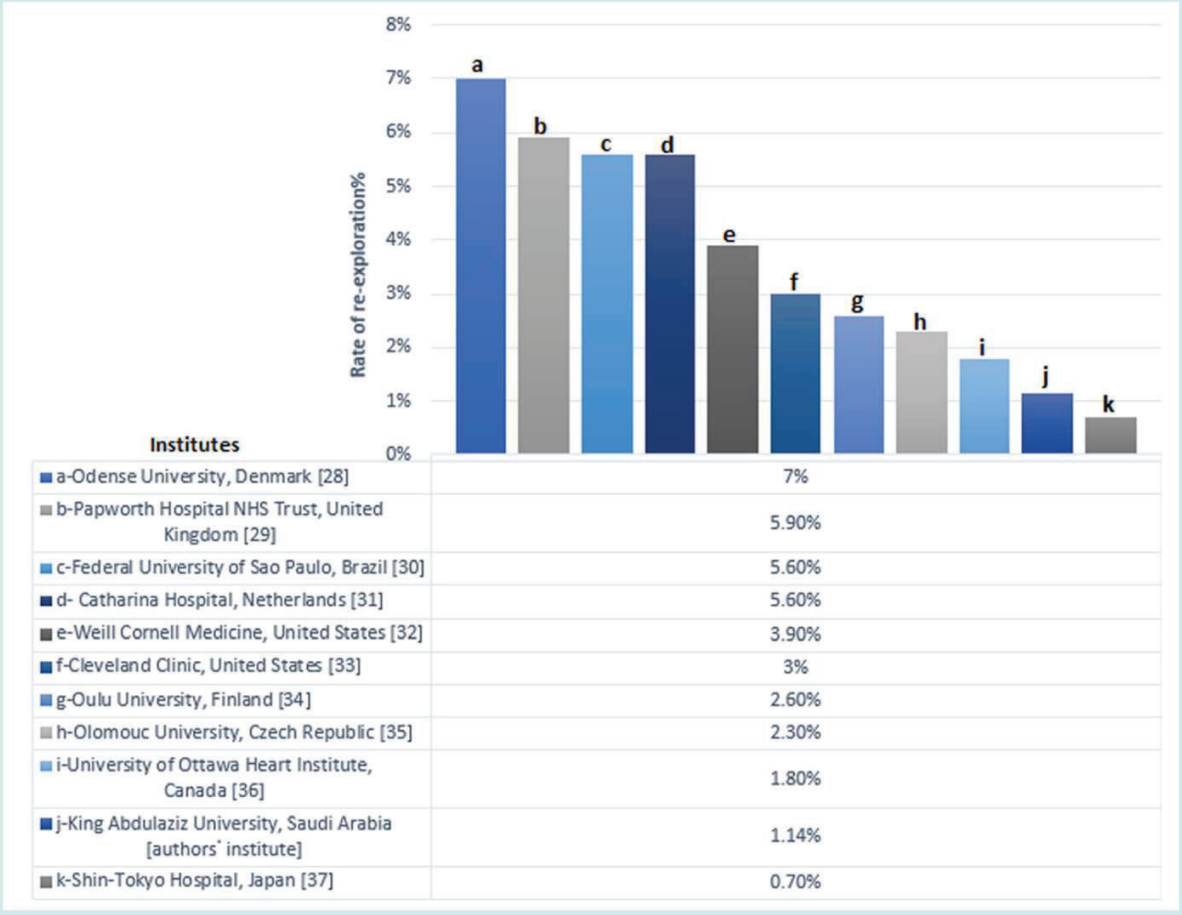
Table 1b **Results of studies examining re-exploration for bleeding**

Author, Year of Publication	Number of Arms	Number of Patients in Conventional Chest Tube Protocol Arm (control)	Number of Patients in Active Chest Tube Protocol (intervention)	Number of patients needing Re-exploration for Bleeding in Conventional Arm	Number of patients needing Re-exploration for bleeding in Active arm	Conventional Re-exploration percentage	Active Re-exploration Percentage	P Value
St- Onge, 2021	2	263	257	15	4	5.70%	1.60%	p=0.01
Maltais, 2016	2	77	175	33	27	43%	15%	p<0.001
Ntinopoulos, 2020	2	471	471	19	12	4.00%	3%	p=0.25
St-Onge, 2017	2	107	107	1	3	1%	3%	p=0.62
Sirch, 2016	2	256	256	12	9	4.70%	3.50%	p=0.65
Greishaber, 2018	2	222	222	22	9	9.10%	4.10%	p=0.015
Malegrud, 2020	2	50	50	1	4	2%	8%	p=0.36
Baribeau, 2019	2	260	260	6	2	2.30%	0.70%	p=0.28
Churyla, 2022	2	1113	254	27	5	2.40%	2.00%	p=0.664

Reprise hémostatique

Reprise hémostatique

Elassal, AA et al. (2021). *J Cardiothorac Surg* 16, 166 //



Institutes	
a-Odense University, Denmark [28]	7%
b-Papworth Hospital NHS Trust, United Kingdom [29]	5.90%
c-Federal University of Sao Paulo, Brazil [30]	5.60%
d- Catharina Hospital, Netherlands [31]	5.60%
e-Weill Cornell Medicine, United States [32]	3.90%
f-Cleveland Clinic, United States [33]	3%
g-Oulu University, Finland [34]	2.60%
h-Olomouc University, Czech Republic [35]	2.30%
i-University of Ottawa Heart Institute, Canada [36]	1.80%
j-King Abdulaziz University, Saudi Arabia [authors' institute]	1.14%
k-Shin-Tokyo Hospital, Japan [37]	0.70%

Source du saignement

Elassal, AA et al. (2021). *J Cardiothorac Surg* 16, 166 //

Etude de 1992-1993
2221 patients
85 avec reprise sternale

1. Drainage of:
   More than 500 mL during the first hour.
   More than 400 mL during each of the first 2 hours.
   More than 300 mL during each of the first 3 hours.
   More than 1,000 mL in total during the first 4 hours.
   More than 1,200 mL in total during the first 5 hours.
2. Excessive bleeding that restarts (indicating a possible surgical cause).
3. Sudden massive bleeding.

Table 4. Findings at Resternotomy

Source of Bleeding	No. of Patients[a]
Internal mammary artery side branch	8
Vein graft side branch	5
Graft/coronary artery anastomosis	9
Venous cannulation site	4
Aortotomy	10
Ventriculotomy/atriotomy	4
Great vessel anastomoses	2
Arterial bleeding from mediastinum	11
Thymus	1
Right innominate vein	1
Pacing wire site (1 patient after removal day 5)	2
No surgical cause discovered, "general ooze"	23
No information	5

[a] Three patients had more than one site of blood loss and another 3 patients with a surgical cause were described as having a concurrent "general ooze."

Source du saignement

Elassal, AA et al. (2021). *J Cardiothorac Surg* 16, 166 //

Etude de 1992-1993
2221 patients
85 avec reprise sternale

Table 4: Pooled proportions of sources of bleeding found in patients who underwent re-exploration for bleeding after cardiac surgery [8,10,11].

Source of bleeding	Pooled proportions	Analysis model	*P*-value
Internal mammary artery branches	22.7% (11.2%, 40.7%)	RE	<0.0001
Vein graft branches	7.9% (6.0%, 10.2%)	RE	0.457
Anastomoses	16.9% (13.9%, 20.3%)	RE	0.24
Other sites	30.0% (19.7%, 42.7%)	RE	<0.0001
Diffuse bleeding	20.6% (13.6%, 29.9%)	RE	0.003

RE: random effect.

Source du saignement

Elassal, AA et al. (2021). *J Cardiothorac Surg* 16, 166 //

51,497 patients, of whom 2,455 underwent reoperation for bleeding or tamponade
The pooled incidence of re-exploration was 4.6% (95% CI 3.9%-5.2%; I2 92%; 17 studies; 51,497 patients)

Sites of Surgical Bleeding in the Included Studies

Author	Year	Surgical Site Bleeding (%)	Cardiac Bleeding Sites (%)	Mediastinal/ Sternal Bleeding Sites (%)	Body of the Graft (%)	Sternum (%)	Vascular Sutures (%)	Internal Mammary Artery Graft Harvest Site (%)	Anastomoses (%)	Cannulation Sites (%)	Pericardial Vessels (%)	Myocardium (%)	Drain Insertion Site (%)	Pacemaker Insertion Site (%)
Sethi[24]	1990	38.9	-	-	-	-	-	-	-	-	-	-	-	-
Unsworth-White[11]	1995	70.6	51.8	4.7	15.3	-	27.1	-	10.6	4.7	-	-	-	2.4
Sellman[23]	1997	85.7	-	-	35.2	9.5	-	12.4	16.9	-	-	-	-	-
Hall[22]	2001	67.1	40.2	3.7	25.6	23.2	9.8	23.2	9.8	3.7	1.2	2.4	0.0	0.0
Karthik[21]	2004	82.0	49.4	2.2	-	25.8	-	-	-	2.2	-	-	-	-
Chu[25]	2004	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Choong[20]	2007	78.0	56.5	7.3	30.4	11.5	18.8	-	18.8	7.3	-	-	-	-
Gwozdziewicz[19]	2008	54.1	35.7	0.0	13.3	-	22.4	-	14.3	0.0	-	-	-	-
Okonta[18]	2011	61.1	23.7	3.5	17.0	14.0	0.9	-	1.8	3.5	-	2.6	-	-
Vivacqua[17]	2011	79.6	-	-	-	27.0	-	14.0	10.2	-	-	-	-	-
Biancari[5]	2012	73.5	60.2	0.9	23.9	19.5	8.8	20.4	8.8	0.9	8.0	3.5	1.8	1.8
Čanádyová[15]	2012	55.3	-	-	-	-	-	-	-	-	-	-	-	-
Kristensen[16]	2012	56.4	-	-	-	-	-	-	-	-	-	-	-	-
Ozolina[14]	2012	81.8	-	-	-	-	-	-	-	-	-	-	-	-
Ghavidel[26]	2015	76.2	-	-	-	-	-	-	-	-	-	-	-	-
Fröjd[10]	2016	67.2	-	-	-	-	-	-	-	-	-	-	-	-
Kim[12]	2016	67.3	30.7	10.9	-	-	19.8	-	-	10.9	-	-	-	-
Lopes[13]	2016	83.3	61.1	50.0	11.1	22.2	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0
Pooled rates	-	65.7	40.9	27.0	20.2	17.0	12.5	13.0	9.9	4.0	3.6	2.8	1.1	1.3

Source du saignement

Shou, BL et al. (2023). *The Annals of Thoracic Surgery* 115,

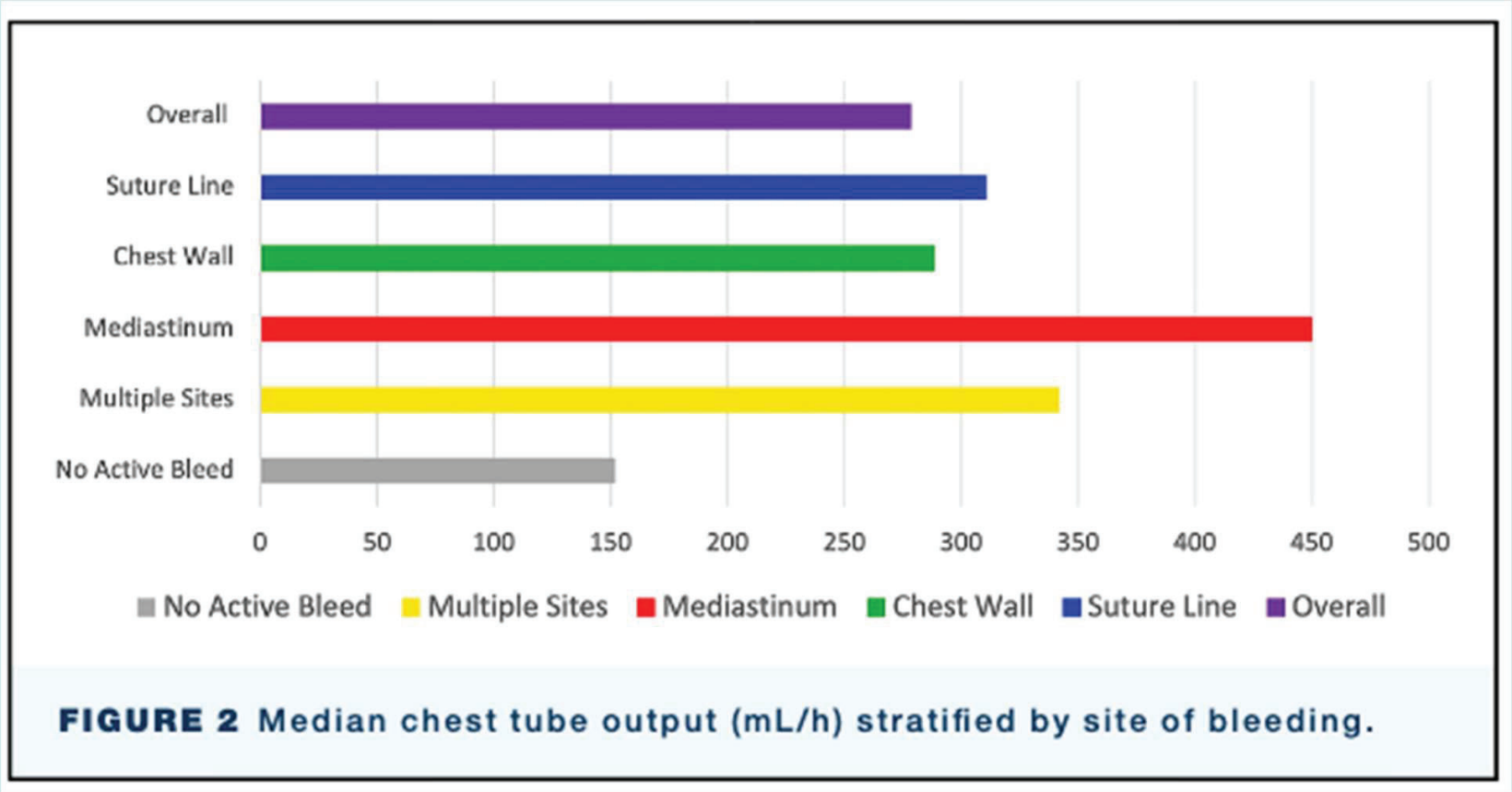


FIGURE 2 Median chest tube output (mL/h) stratified by site of bleeding.

Reprise hémostatique

1 Jr Soletti, G et al. (2024). *International Journal of Surgery* 110, 5795–5801 //

Re-exploration for bleeding and long-term survival after adult cardiac surgery: a meta-analysis of reconstructed time-to-event data

Giovanni Jr Soletti, MD[a], Gianmarco Cancelli, MD[a], Michele Dell'Aquila, BS[a], Tulio Caldonazo, MD[a,b], Lamia Harik, MD[a], Camilla Rossi, MD[a], Panagiotis Tasoudis, MD[c], Jordan Leith, BS[a], Kevin R. An, MD[a], Arnaldo Dimagli, MD[a], Michelle Demetres, MLIS[d], Mario Gaudino, MD, PhD[a,*]

Etudes entre 2021 et 2023 ; USA, Pologne, Suède, Danemark, Pays Bas
135 456 patients

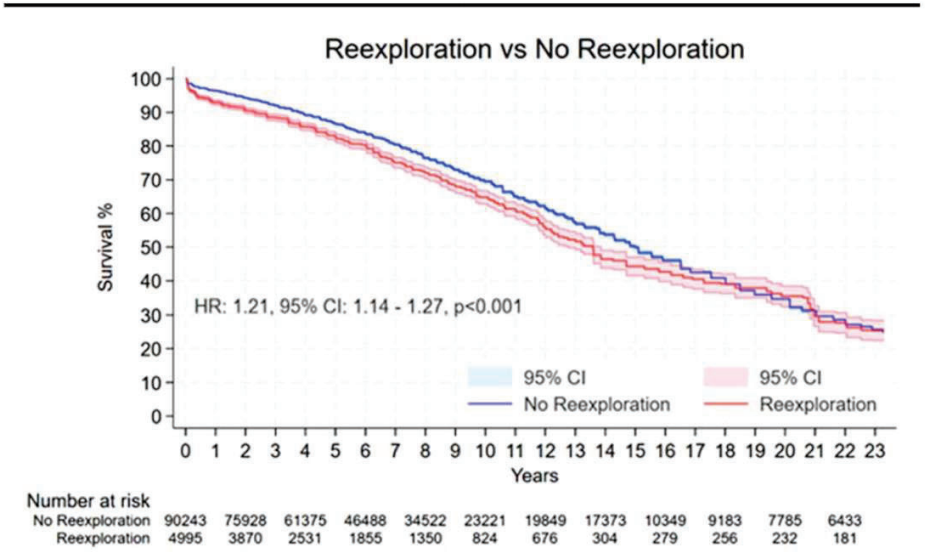


Figure 1. Pooled Kaplan–Meier curve showing the cumulative risk of all-cause mortality following re-exploration for bleeding versus no re-exploration. HR, hazard ratio.

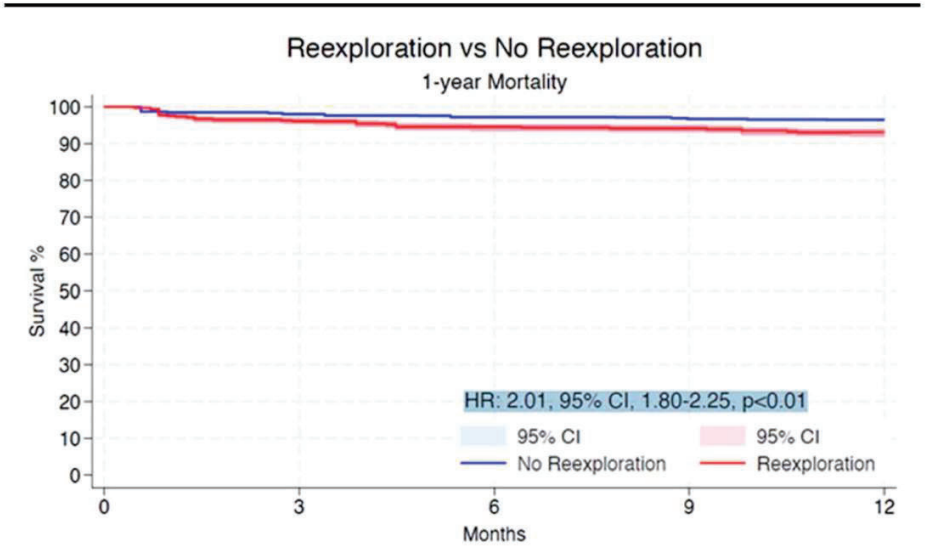


Figure 3. Pooled Kaplan–Meier curve showing the cumulative risk of all-cause mortality following re-exploration for bleeding versus no re-exploration at 1-year follow-up. HR, hazard ratio.

Reprise hémostatique

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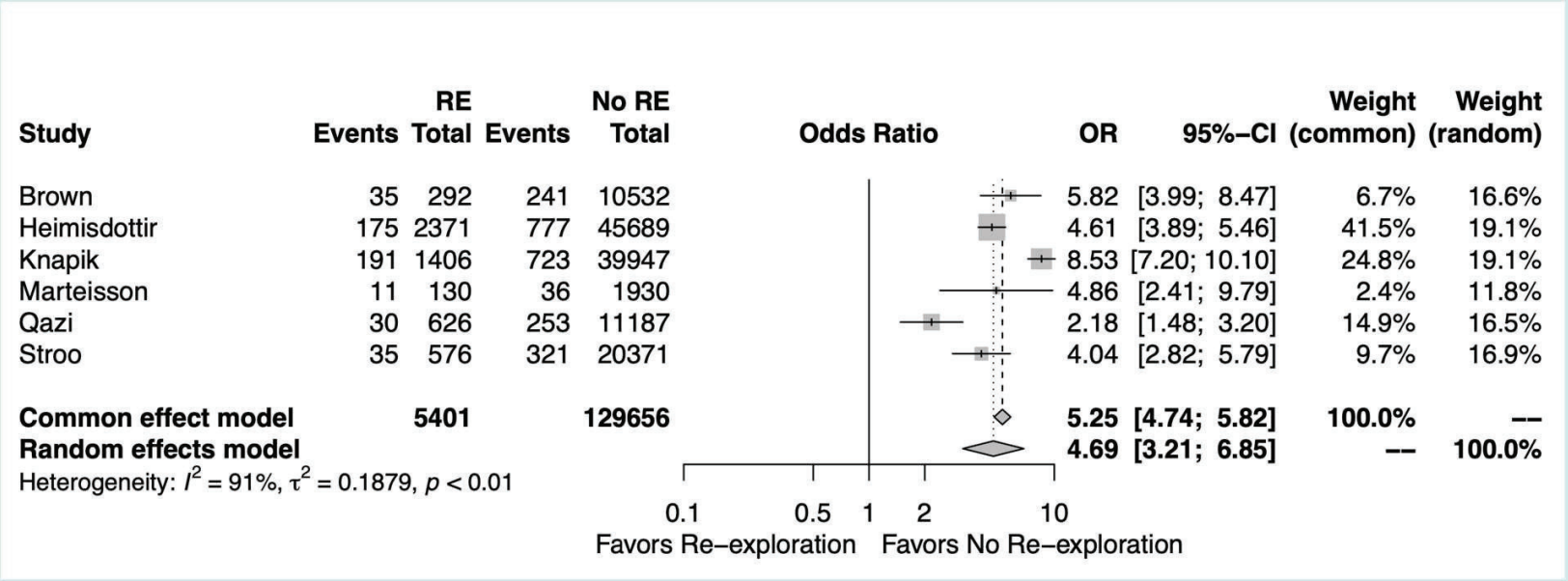
Etudes entre 2021 et 2023 ; USA, Pologne, Suède, Danemark, Pays Bas
135 456 patients

Supplementary Figure 3. Forest plot for operative mortality.



Reprise hémostatique

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Etudes entre 2021 et 2023 ; USA, Pologne, Suède, Danemark, Pays Bas
135 456 patients

Critère	OR ou Différence Moyenne (MD)	IC 95 %	P-value
Mortalité globale opératoire	OR : 5,25	4,74 – 5,82	**< 0,0001**
AVC	OR : 2,05	1,72 – 2,43	**< 0,0001**
Complications rénales	OR : 4,13	3,43 – 4,39	**< 0,0001**
Complications respiratoires	OR : 3,91	2,96 – 5,17	**< 0,0001**
Infarctus du myocarde (MI)	OR : 1,85	1,30 – 2,65	**0,0007**
Durée d'hospitalisation	MD : **+2,69 jours**	1,68 – 3,69	**< 0,0001**

Postoperative bleeding requiring re-exploration is associated with lower long-term survival and increased risk of short-term adverse events including operative mortality, stroke, renal and respiratory complications, and longer hospital length of stay. To improve both short-term and long-term outcomes, strategies to prevent the need for re-exploration are necessary

Reprise hémostatique

Shou, BL et al. (2023). *The Annals of Thoracic Surgery* 115,

2010-2020
10 070 eligible patients, 251 (2.5%) required reexploration for postoperative bleeding.

TABLE 3 Comparison of Morbidity and Mortality at Varying Time to Reoperation

Time to Reoperation, h	N (%)	Morbidity, n (%)	Mortality, n (%)
Total	251 (100)	65 (25.9)	44 (17.5)
0-4	65 (25.9)	8 (12.3)	2 (3.1)
5-8	51 (20.3)	10 (19.6)	5 (9.8)
9-12	28 (11.2)	4 (14.3)	3 (10.7)
13-18	26 (10.4)	6 (23.1)	7 (26.9)
19-24	22 (8.8)	8 (36.4)	9 (40.9)
25-48	16 (6.4)	6 (37.5)	7 (43.8)
>48	43 (17.1)	23 (53.5)	11 (25.6)
P value		<.001	<.001

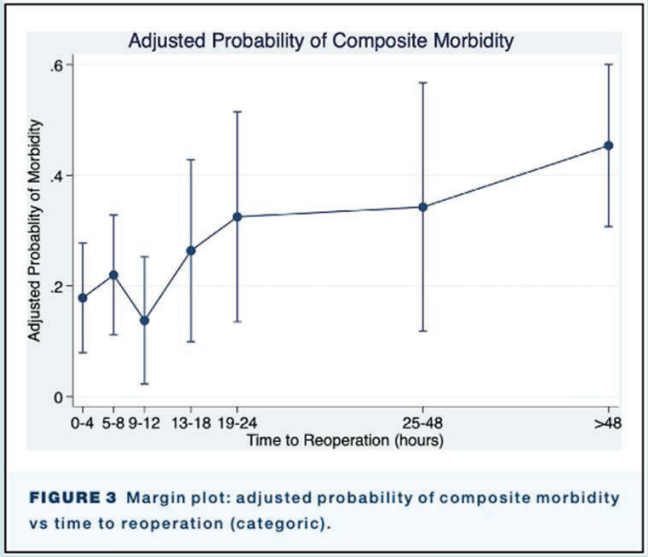


FIGURE 3 Margin plot: adjusted probability of composite morbidity vs time to reoperation (categoric).

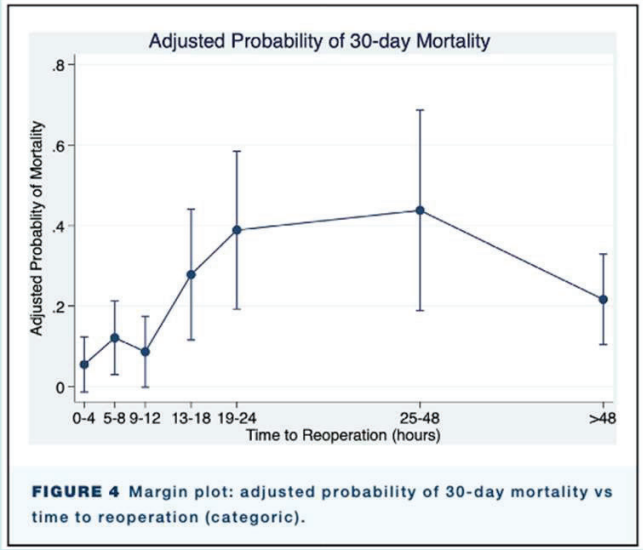


FIGURE 4 Margin plot: adjusted probability of 30-day mortality vs time to reoperation (categoric).

Reprise précoce vs. tardif

1 Patel, K et al. (2020). *Journal of Cardiac Surgery* 35, 3062–3069 //

A total of 5990 OPCABG et patients, 132 (2.2%) were re-explored

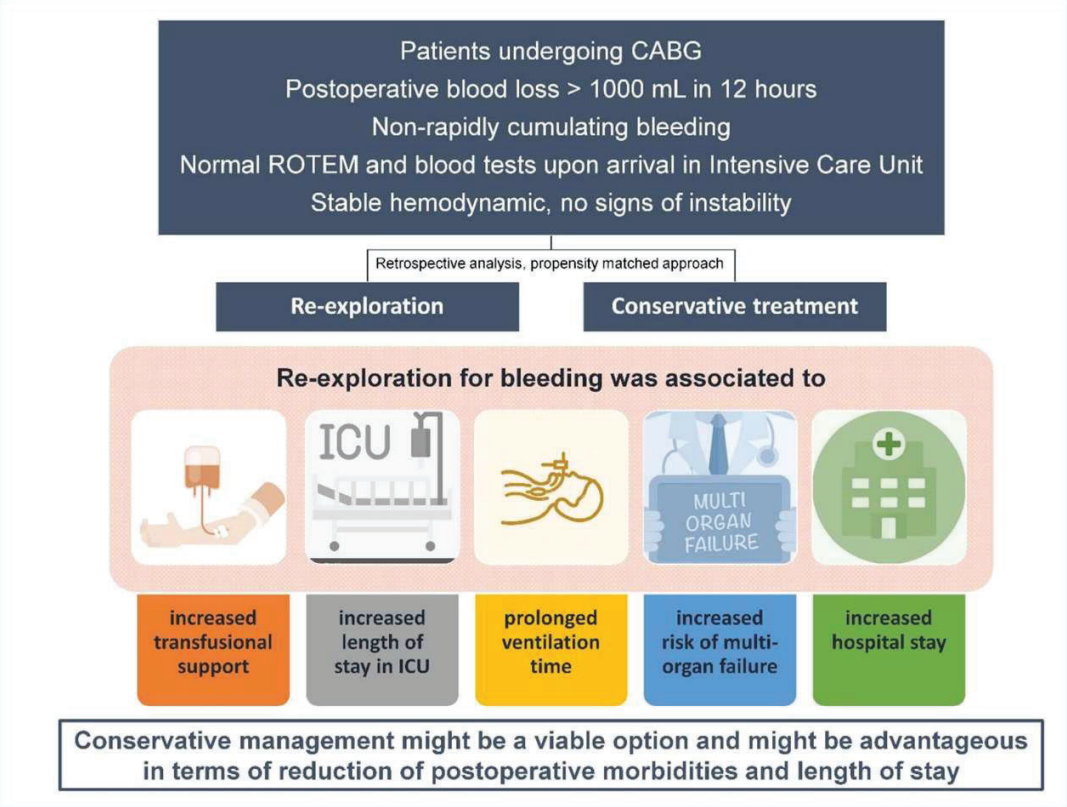
TABLE 5 Comparison of the early (<14 h) and late (>14 h) re-exploration group of the study population

	Early (<14 h, n = 96)	Group 2 (>14 h, n = 36)	*P* value
Age, y	59.24 ± 9.51	61.45 ± 11.19	.259
LVEF, %, mean ± SD	43.88 ± 8.22	42.43 ± 10.29	.426
Hemoglobin, g/dL, mean ± SD	12.19 ± 1.95	11.93 ± 2.28	.514
Serum creatinine, g/dL, mean ± SD	1.08 ± 0.35	0.98 ± 0.43	.143
Platelet count, mean ± SD	233 746.8 ± 85 471.6	255 966.6 ± 139 851.7	.262
Total drain output, mL, mean ± SD	995.54 ± 380.20	1458.16 ± 543.20	**<.0001**
Time to re-exploration after surgery, h, mean ± SD	5.56 ± 3.67	20.91 ± 8.47	**<.0001**
Time of ventilation, h, mean ± SD	13.05 ± 6.39	41.10 ± 81.08	**<.0001**
Unit transfused, mean ± SD	11.14 ± 11.89	23.73 ± 10.09	**<.0001**
Length of ICU stay, d, mean ± SD	5.03 ± 3.74	8.53 ± 6.03	**.021**
Mortality, n (%)	7 (7.29%)	11 (30.55%)	**.000**

Reprise hémostatique < 12h

Spadaccio, C et al. (2023). *JCM* 12, 3327 //

Patient stable, traitement conservateur vs. Reprise précoce



Une **consommation significativement plus élevée de produits sanguins** (notamment CGR)

Un **risque presque 6 fois plus élevé de complications respiratoires**

Une **durée prolongée en unité de soins intensifs** (+1,66 jours) et une **hospitalisation globale plus longue** (+2,16 jours).

Un **risque accru de défaillance multiviscérale** (multiplié par 4,59).

Une **tendance à une mortalité périopératoire plus élevée** (multipliée par 3,12).

Morbidité

Spadaccio, C et al. (2023). *JCM* 12, 3327 //

566 patients avec reprise stertnal / Etude avec propensity score

Table 4. Morbidity and Mortality Associated With Blood Use With and Without Reoperation for Bleeding

	No Blood Used					Blood Given				
	No Reop. for Bleeding (Total n = 10,056)		Reop. for Bleeding (Total n = 61)			No Reop. for Bleeding (Total n = 8,269)		Reop. for Bleeding (Total n = 505)		
Variable	n[a]	No. (%)	n[a]	No. (%)	*p*	n[a]	No. (%)	n[a]	No. (%)	*p*
Operative mortality	10,056	10 (0.099)	61	4 (6.6)	<0.0001	8,269	173 (2.1)	505	44 (8.7)	<0.0001
Major morbidity	10,056	559 (5.6)	61	22 (36)	<0.0001	8,269	1,666 (20)	505	245 (49)	<0.0001
Perioperative myocardial infarction	10,056	16 (0.16)	61	1 (1.6)	0.005	8,269	43 (0.52)	505	3 (0.59)	0.8
Stroke	10,056	81 (0.81)	61	0 (0)	0.5	8,269	160 (1.9)	505	11 (2.2)	0.7
Renal failure	10,056	165 (1.6)	61	5 (8.2)	<0.0001	8,269	723 (8.7)	505	74 (15)	<0.0001
Renal failure requiring hemodialysis	10,056	8 (0.08)	61	1 (1.6)	<0.0001	8,269	198 (2.4)	505	37 (7.3)	<0.0001
Prolonged ventilation (>24 hours)	7,785	215 (2.8)	56	5 (8.9)	0.005	6,033	970 (16)	408	191 (47)	<0.0001
Deep sternal wound infection	10,056	83 (0.83)	61	0 (0)	0.5	8,269	111 (1.3)	505	9 (1.8)	0.4
Reoperation for valve dysfunction	10,056	30 (0.30)	61	0 (0)	0.7	8,269	16 (0.19)	505	7 (1.4)	<0.0001
Reoperation for exclusion of valve dysfunction/graft Occlusion	10,056	24 (0.24)	61	5(8.2)	<0.0001	8,269	75 (0.91)	505	52 (10)	<0.0001
Other noncardiac reoperation	7,785	35 (0.45)	56	15 (27)	<0.0001	6,033	155 (2.6)	408	50 (12)	<0.0001
Stay <6 days	10,056	4,705 (47)	61	18 (30)	0.007	8,269	1,471 (18)	505	42 (8.3)	<0.0001
Stay >14 days	10,056	194 (1.9)	61	3 (4.9)	0.09	8,269	1,129 (14)	505	142 (28)	<0.0001

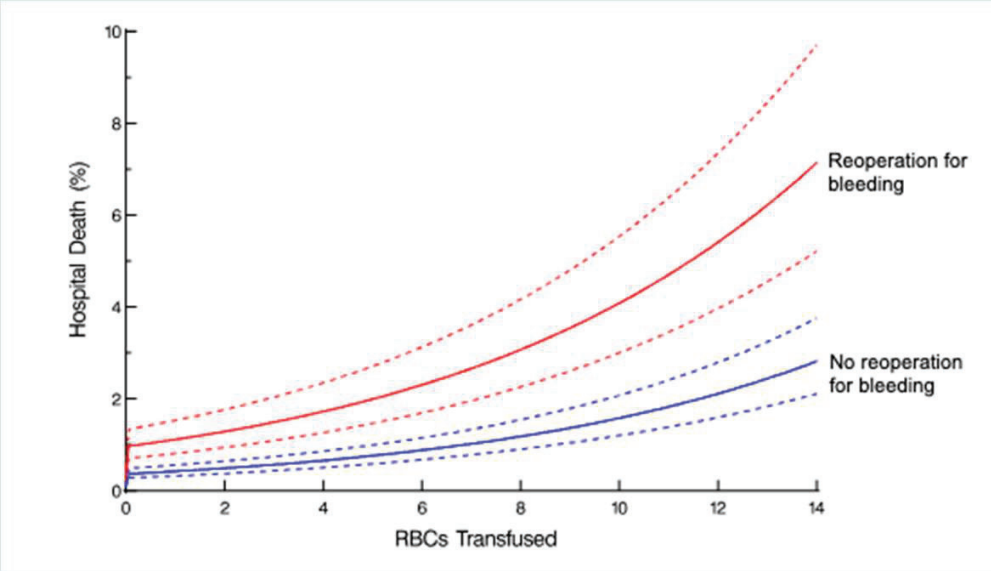
[a] Data available.

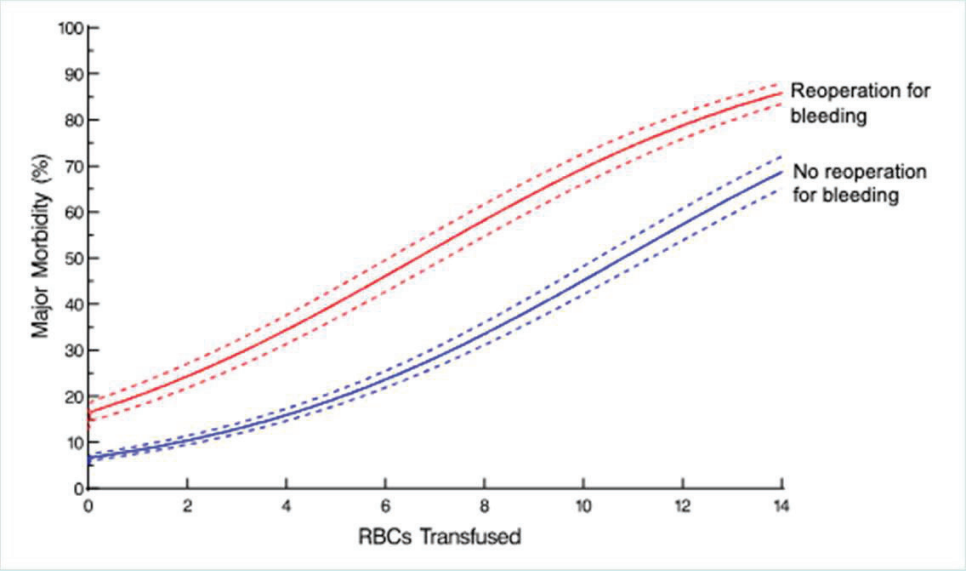
Reop = reoperation.

Morbidité

Spadaccio, C et al. (2023). *JCM* 12, 3327 //

566 patients avec reprise stertnal / Etude avec propensity score





Reprise sternales : conclusion

La **re-exploration précoce** est indiquée en cas de :

- ✓ **Saignement postopératoire actif ou persistant**.
- ✓ **Tamponnade cardiaque**.
- ✓ **Complications mécaniques suspectées non contrôlables** par un traitement conservateur ou médical

Bénéfices de la re-exploration précoce en cas d'instabilité

-> Réduction de la morbidité et de la mortalité si réalisée **dans les 4 à 14 heures** suivant la chirurgie initiale

-> Diminution des complications :

- Insuffisance rénale.
- AVC.
- Complications respiratoires et durée de ventilation mécanique prolongée.
- Séjour hospitalier prolongé

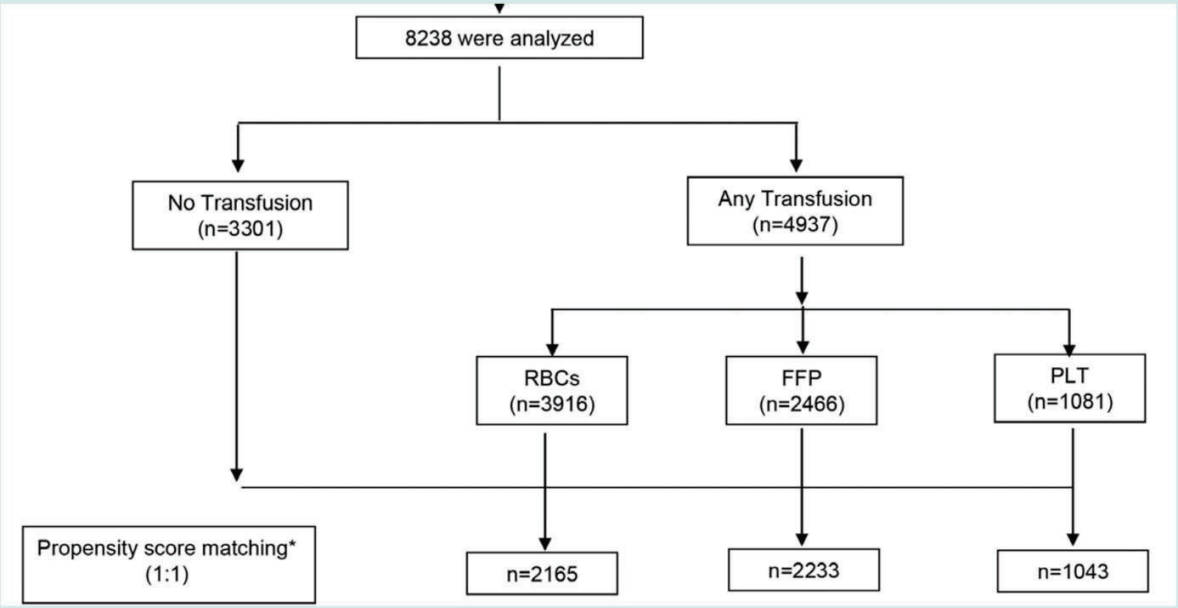
Patients hémodynamiquement stables avec saignement non critique : Une **prise en charge conservatrice** peut être envisagée.

Pour conclure

Et le ratio ?

1 (2022). *Anesthesia & Analgesia* 135, e31–e31 //

I est important de noter que la transfusion de tout produit sanguin (CGR, PFC, plaquettes) augmente le risque de mortalité et d'infection de façon dose-dépendante, ce qui impose une utilisation raisonnée et guidée par la clinique et les tests viscoélastiques.



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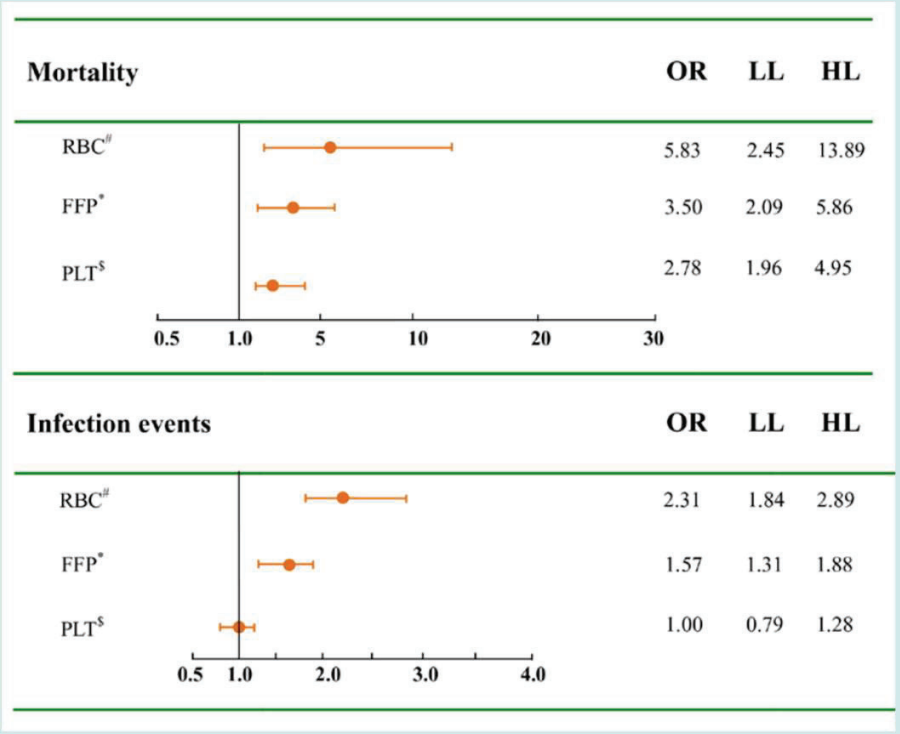

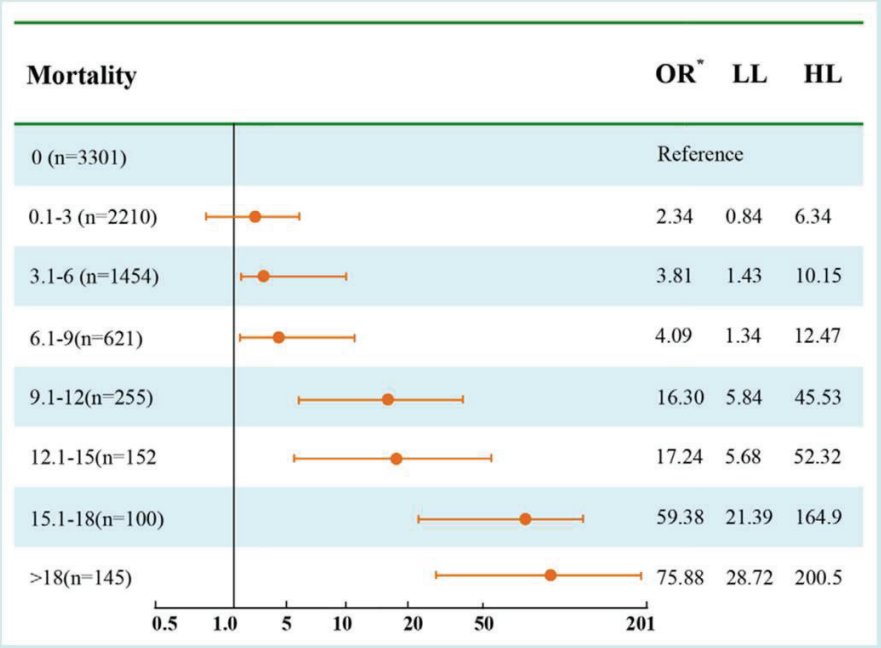

Et le ratio ?

Optimal Plasma Transfusion in Patients Undergoing Cardiac Operations With Massive Transfusion

Michael A. Mazzeffi, MD, MPH, Evan Chriss, MD, Kathryn Davis, BA, Min Zhan, PhD, Anthony Harris, MD, MPH, Peter Rock, MD, MBA, James S. Gammie, MD, and Kenichi Tanaka, MD

1 Mazzeffi, MA et al. (2017). *The Annals of Thoracic Surg*

A single-center retrospective cohort study was performed over an 8.5-year period.
Massive transfusion was defined as at least 8 RBC units administered during the operation.

Patients were classified as having received a high FFP/RBC ratio (greater than 1:1), a moderate ratio (between 1:1 and 1:2), or a low ratio (<1:2)

Table 2. Transfusion Details by FFP/RBC Transfusion Ratio Group

Variable[a]	High n = 103	Moderate n = 261	Low n = 88	*p* Value[b]
Intraoperative RBC transfusion (units, range)	10 (8–13)	10 (8–13)	9 (8–12)	0.50
Intraoperative FFP transfusion (units, range)	14 (12–17)	8 (6–11)	4 (2–4)	<0.0001
Intraoperative platelet transfusion (units, range)	4 (3–5)	3 (2–4)	2 (1–3)	<0.0001
Intraoperative cryoprecipitate transfusion (pools, range)	2 (0–3)	1 (0–2)	0 (0–0)	<0.0001
Intraoperative FFP/RBC ratio (range)	1.3 (1.2–1.5)	0.8 (0.6–0.9)	0.3 (0.2–0.4)	<0.0001
rFVIIa administration	43 (30.5%)	35 (15.6%)	1 (1.2%)	<0.0001
Postoperative RBC transfusion (units, range)	3 (1–9)	6 (2–16)	9 (2–20)	0.006
Postoperative FFP transfusion (units, range)	2 (0–5)	2 (0–9)	5 (2–12)	0.002
Postoperative platelet transfusion (units, range)	1 (0–4)	1 (0–4)	2 (0–6)	0.07
Postoperative cryoprecipitate transfusion (pools, range)	0 (0–0)	0 (0–0)	0 (0–0)	0.67

[a] Transfusion volumes are presented as medians with interquartile range; rFVIIa use is n (%). [b] *p* values represent the results of the Kruskal-Wallis test or the χ^2 test.

FFP = fresh frozen plasma; RBC = red blood cell; rFVIIa = recombinant activated factor VII.

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Patients with a high transfusion ratio had improved 30-day survival when compared with those with a low ratio (hazard ratio [HR] for death, 0.339; p = 0.002).

High transfusion ratios were also associated with fewer reoperations for bleeding, less renal failure, more prolonged ventilation, and more atrial fibrillation compared with low ratios.

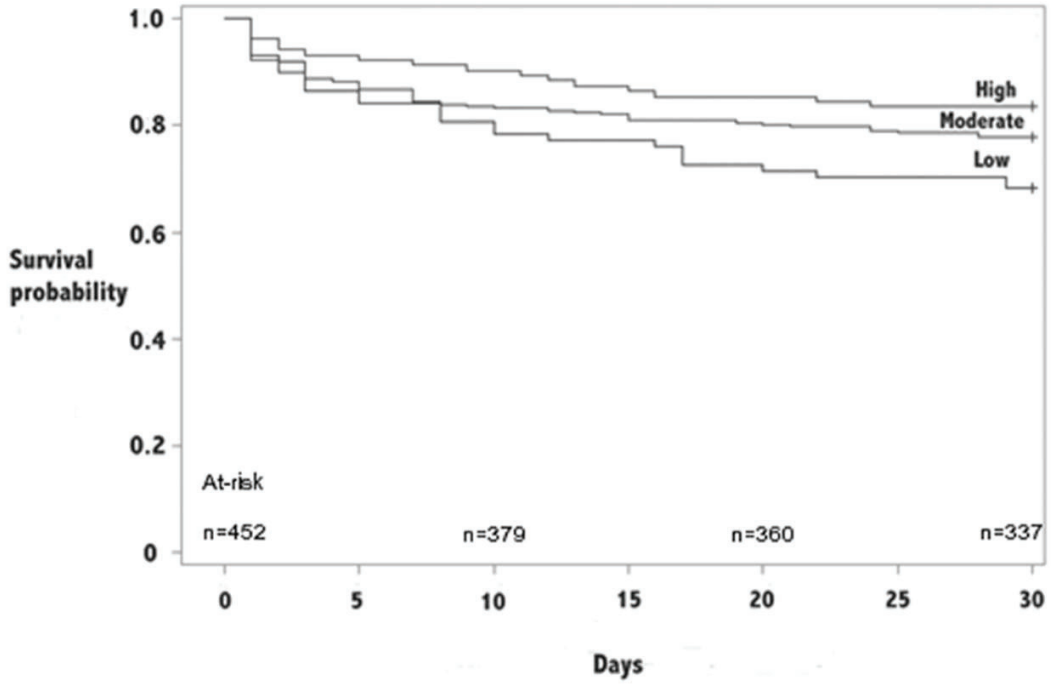

Fig 1. Thirty-day survival after stratification by fresh frozen plasma/red blood cell (FFP/RBC) transfusion ratio group.

1 Mazzeffi, MA et al. (2017). *The Annals of Thoracic Surgery* 104, 153–160 //

SCA Summary Statement on Blood Conservation and Transfusion in Cardiac Surgery

This is an abbreviated summary of established guidelines, consensus statements, and expert recommendations for blood management during cardiac surgical procedures based on existing literature to date. We also highly recommend the use of **anti-fibrinolytics, mini-circuits, retrograde autologous priming, or ultrafiltration** and the use of **red cell salvage using centrifugation**.

PRBC

- **Is indicated** if known Hb less than or equal to 7.5g/dL.
- **Is not indicated** if known Hb greater than 10g/dL.
- Acute normovolemic hemodilution **may reduce** the number of PRBCs transfused.

FFP

- **Is indicated** if excessive bleeding with coagulation factor deficiency and/or if ROTEM/TEG show signs of factor deficiency.
- **May be considered** if part of massive transfusion algorithm.

- **Is not indicated** for urgent warfarin reversal when PCC[$] available or no active bleeding.
- **Is not indicated** for volume replacement.

Cryoprecipitate

- **Is indicated** if there is excessive bleeding with fibrinogen less than 150mg/dL and/or if ROTEM/TEG show signs of a functional fibrinogen deficit.
- **Is indicated** if there is active bleeding and a known Factor XIII or von Willebrand factor deficiency.

- **Is not indicated** if fibrinogen level is greater than 200mg/dL

Platelets

- **Are indicated** if there is bleeding and platelet count is less than 50,000/μL.
- **May be indicated** if there is excessive bleeding with a platelet count less than 100,000/μL and/or if there is known exposure to platelet inhibitors.

- If patients are on P2Y12 inhibitors, the drug should be discontinued prior to the surgery if possible. Point-of-care platelet function tests prior to the surgical procedure **may be considered** for optimization of timing of surgery.
- The use of DDAVP **may be considered** in patients with platelet dysfunction and excessive post-bypass bleeding.

- **Are not indicated** prophylactically without bleeding and the platelet count is less than 50,000/μL.
- **Are not indicated**, prophylactically, in patients with HIT unless life-threatening bleeding occurs.

[$] May be considered off-label in some countries.

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Preoperative Optimization

- Cardiac surgical patients should be assessed for preoperative anemia in a timely manner in order to allow for adequate treatment.
- Iron studies should be performed in all anemic patients.
- Iron deficient patients should receive iron replacement, preferably intravenously.
- Patients anemic due to renal insufficiency or anemia of chronic disease should receive EPO and intravenous iron preoperatively, with evidence of positive response prior to elective surgery.
- Consider surgical delay of elective cases to allow for preoperative anemia treatment.

Point of Care Testing

- We recommend the application of transfusion algorithms incorporating predefined intervention triggers based on point-of-care coagulation monitoring assays to guide hemostatic intervention.
- Implementation of transfusion and coagulation management algorithms (based on ROTEM/TEG) can reduce transfusion-associated adverse events.
- Goal-directed therapy with coagulation factor concentrates (fibrinogen and/or PCC)[$] may reduce transfusion associated adverse events.

Heparin Resistance

- Antithrombin concentrates[$] are **indicated** in patients with antithrombin deficiency (activity <80%).

Factor Concentrates

- Evidence supports the superiority of PCCs to reverse warfarin over FFP.
- There is not enough evidence to make a recommendation for the routine use of PCC[$] in the setting of cardiac surgical bleeding.

- Treatment with fibrinogen concentrate*[$] **may be considered** for significant post-bypass bleeding, with suspected or established fibrinogen deficiency (functional deficit by ROTEM/TEG or fibrinogen less than 150-200mg/dL), although dosing and trigger/target values have not been determined.
- There is not enough evidence to support prophylactic or preoperative use of fibrinogen concentrate.*[$]

- The use of low dose Factor VIIa[$] (20-40mcg/kg) **may be considered** for intractable surgical bleeding, which has failed conventional therapy, although thrombotic risk must be carefully considered.

* At facilities where approved for routine use
[$] May be considered off-label in some countries.

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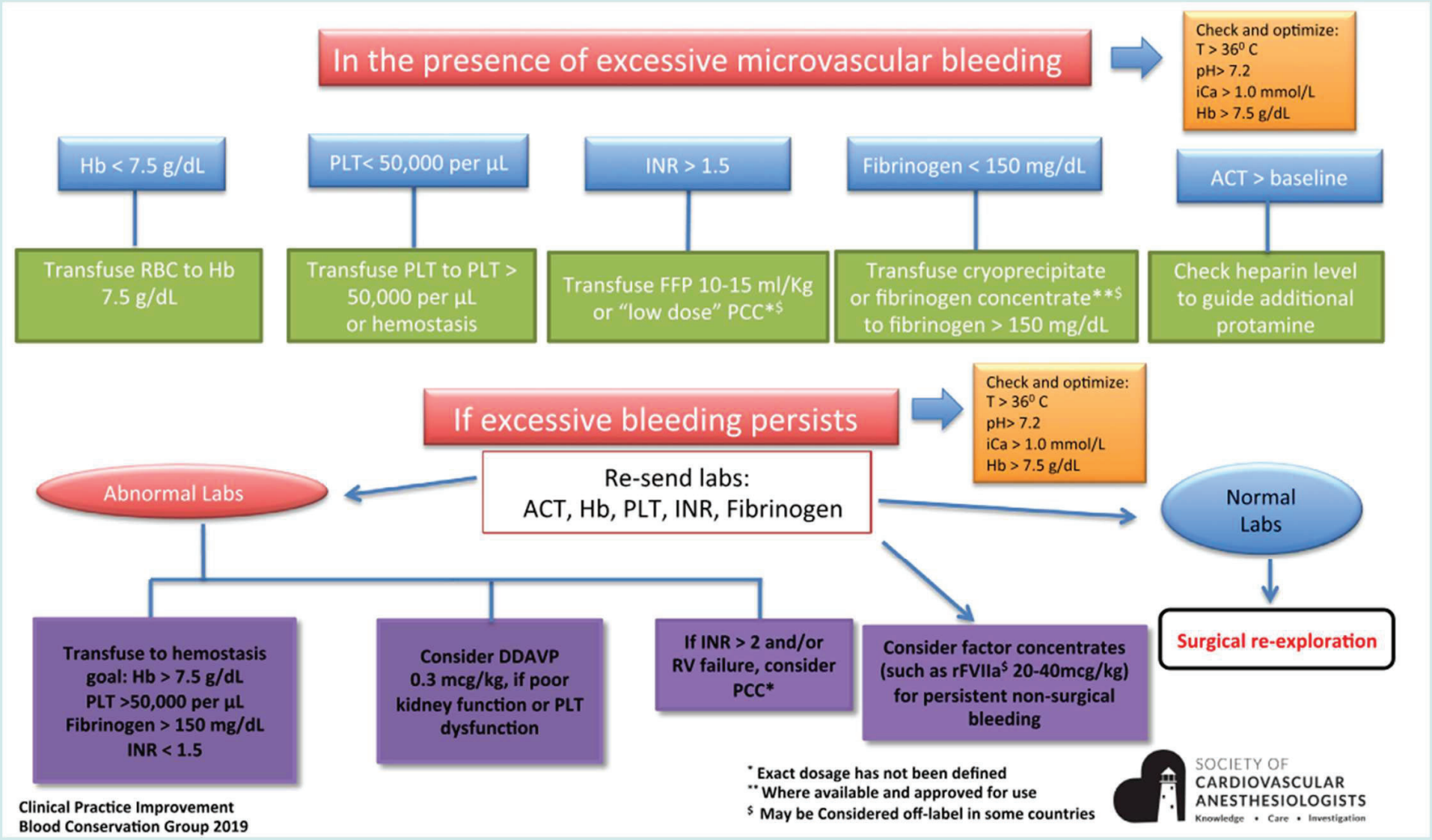
In the presence of excessive microvascular bleeding
Check and optimize:
T > 36⁰ C
pH> 7.2
iCa > 1.0 mmol/L
Hb > 7.5 g/dL
Hb < 7.5 g/dL
PLT< 50,000 per µL
INR > 1.5
Fibrinogen < 150 mg/dL
ACT > baseline
Transfuse RBC to Hb 7.5 g/dL
Transfuse PLT to PLT > 50,000 per µL or hemostasis
Transfuse FFP 10-15 ml/Kg or "low dose" PCC*$
Transfuse cryoprecipitate or fibrinogen concentrate**$ to fibrinogen > 150 mg/dL
Check heparin level to guide additional protamine
If excessive bleeding persists
Check and optimize:
T > 36⁰ C
pH> 7.2
iCa > 1.0 mmol/L
Hb > 7.5 g/dL
Re-send labs:
ACT, Hb, PLT, INR, Fibrinogen
Abnormal Labs
Normal Labs
Surgical re-exploration
Transfuse to hemostasis goal: Hb > 7.5 g/dL PLT >50,000 per µL Fibrinogen > 150 mg/dL INR < 1.5
Consider DDAVP 0.3 mcg/kg, if poor kidney function or PLT dysfunction
If INR > 2 and/or RV failure, consider PCC*
Consider factor concentrates (such as rFVIIa$ 20-40mcg/kg) for persistent non-surgical bleeding
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* Exact dosage has not been defined
** Where available and approved for use
$ May be Considered off-label in some countries
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