MICROCIRCULATION ET MARQUEURS :

ET CHEZ LE TRAUMATISE ?

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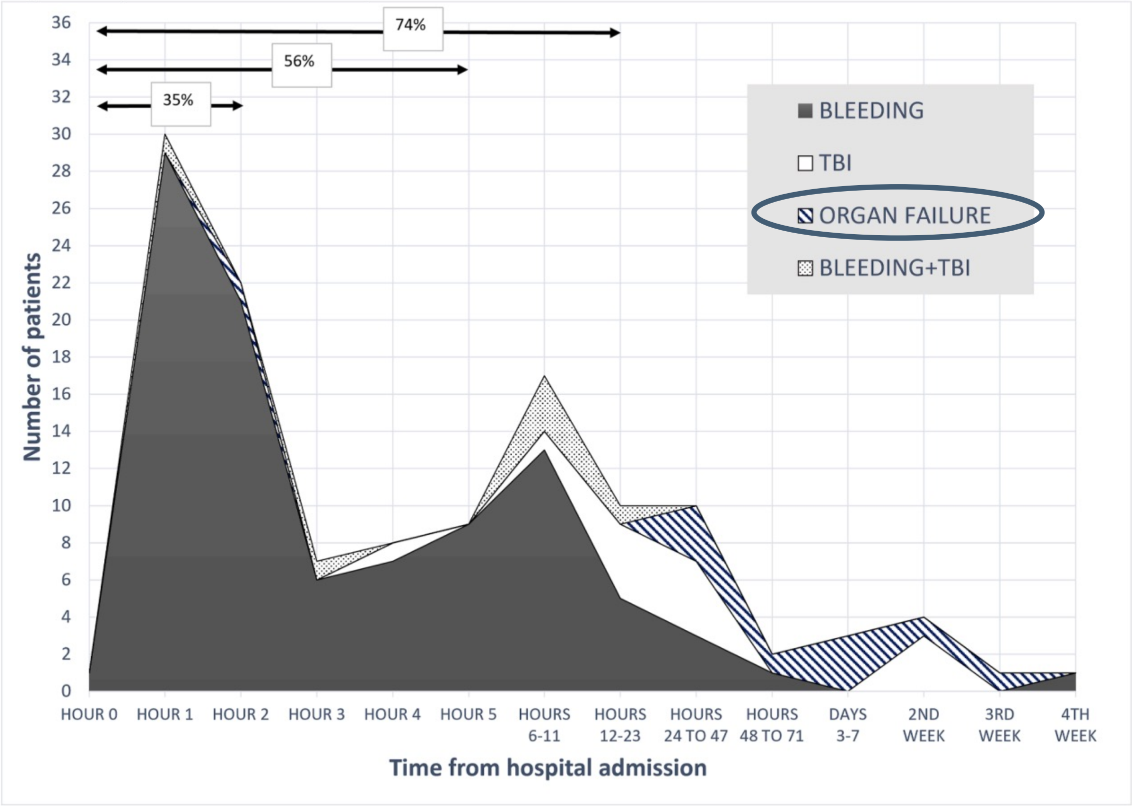
CHU de Nice

Figure: Temporal distribution of in-hospital trauma deaths in a multicenter cohort at risk for massive transfusion



I.M. Bernhardt et al. 2025

GUIDELINES **Open Access**

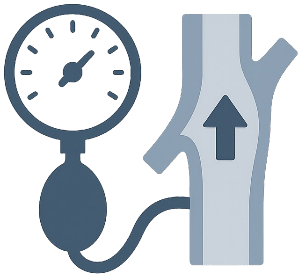
The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition

II. Diagnosis and monitoring of bleeding

Initial assessment

Recommendation 5 We recommend that the physician clinically assess the extent of traumatic haemorrhage using a combination of patient physiology, anatomical injury pattern, mechanism of injury and the patient response to initial resuscitation (Grade 1C).

We recommend that the shock index (SI) and/or pulse pressure (PP) be used to assess the degree of hypovolaemic shock and transfusion requirements (Grade 1C).



III. Tissue oxygenation, volume, fluids and temperature

Volume replacement and target blood pressure

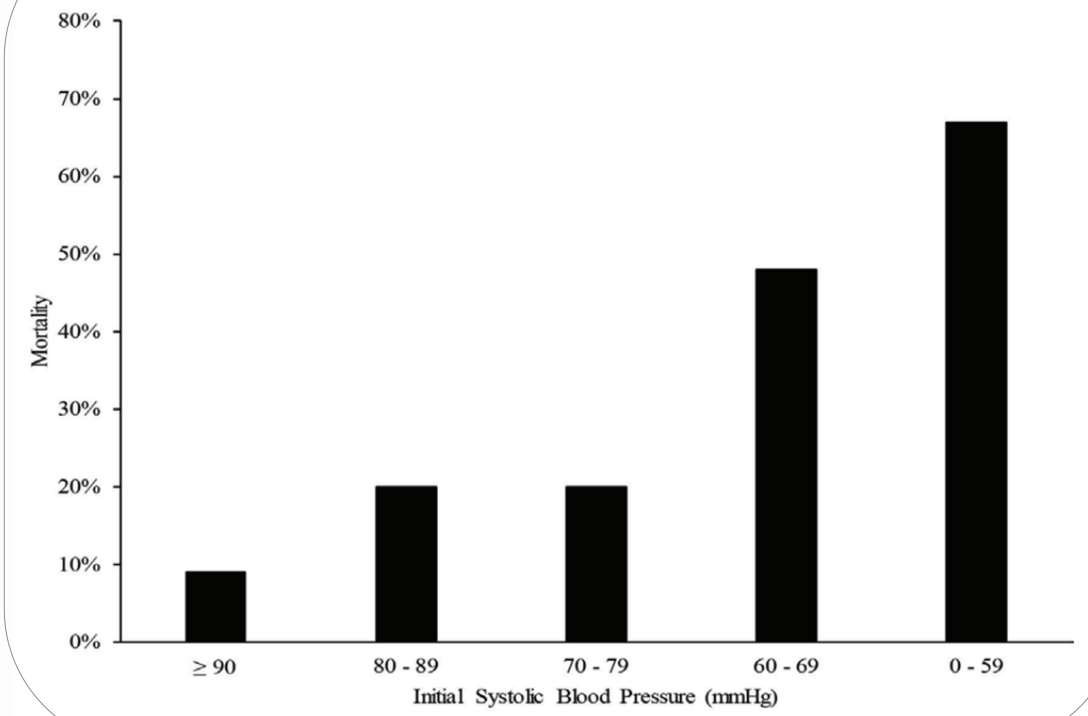
Recommendation 13 In the initial phase following trauma, we recommend the use of a restricted volume replacement strategy with a target systolic blood pressure of 80–90 mmHg (mean arterial pressure 50–60 mmHg) until major bleeding has been stopped without clinical evidence of brain injury (Grade 1B).

In patients with severe TBI (GCS ≤ 8), we recommend that a mean arterial pressure ≥ 80 mmHg be maintained (Grade 1C).

Vasopressors and inotropic agents

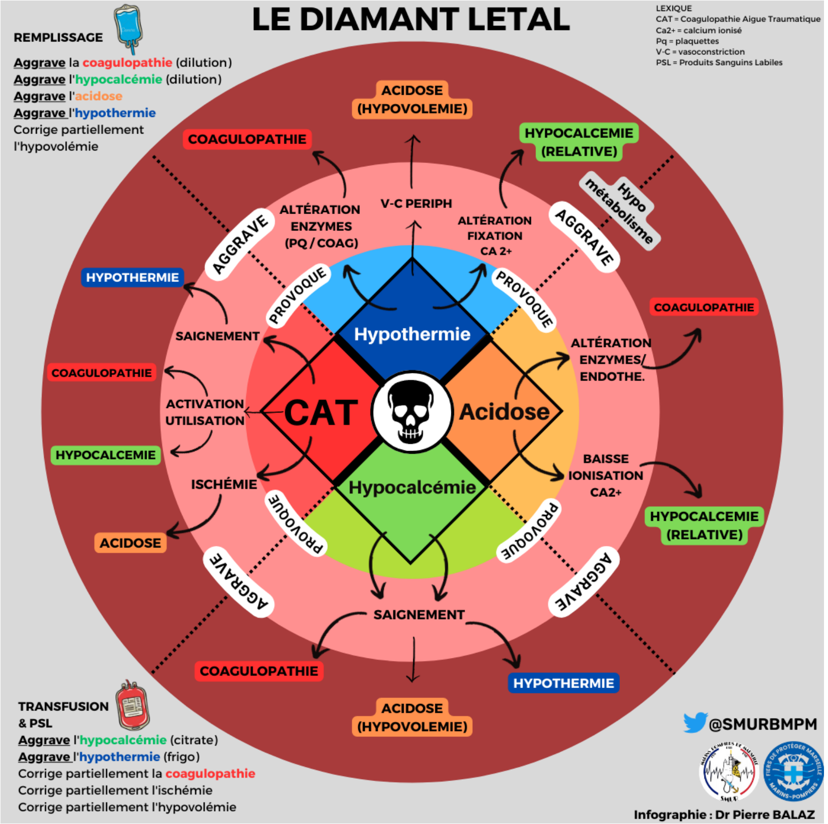
Recommendation 14 If a restricted volume replacement strategy does not achieve the target blood pressure, we recommend the administration of noradrenaline in addition to fluids to maintain target arterial pressure (Grade 1C).

We recommend infusion of dobutamine in the presence of myocardial dysfunction (Grade 1C).



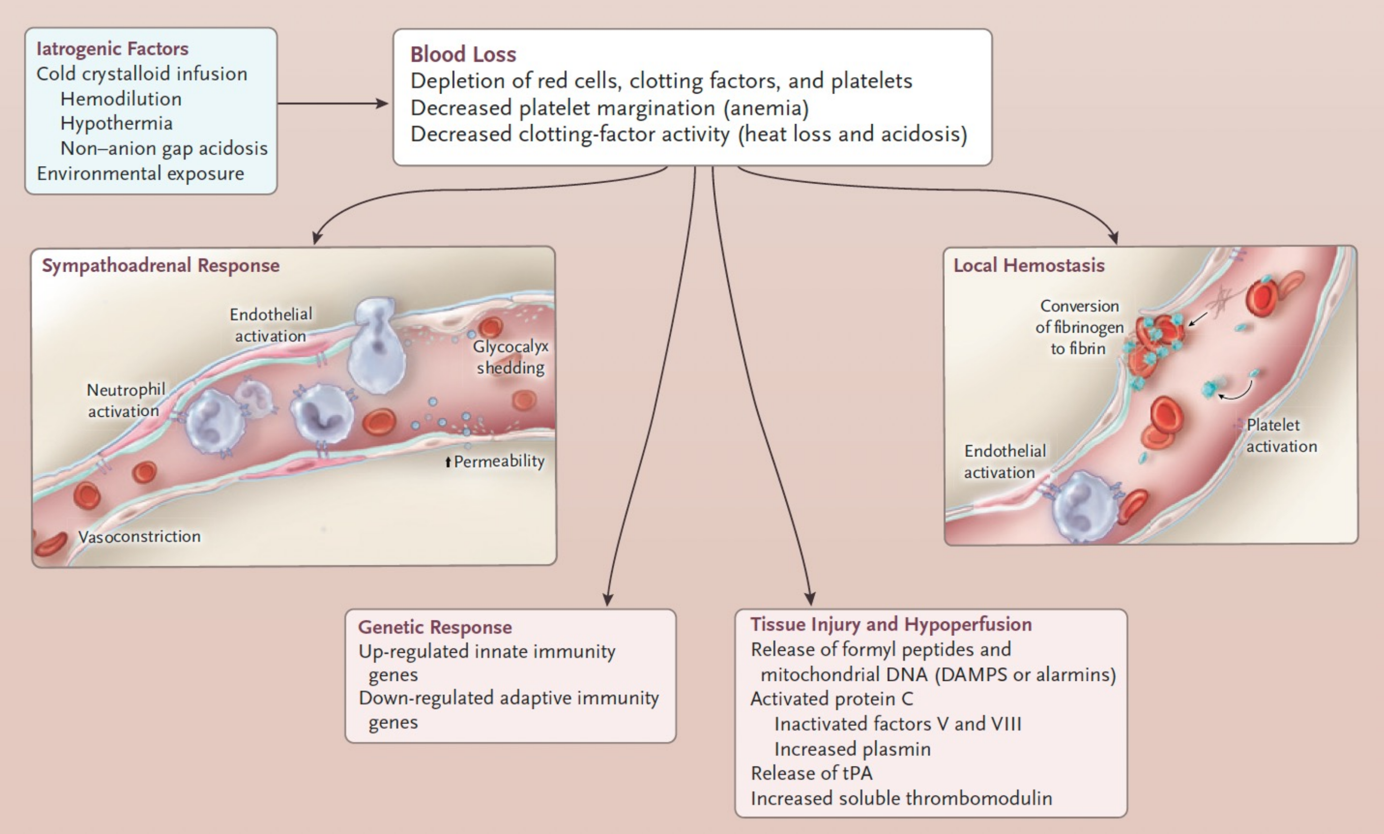
Davis JW, et al. Trauma Surg Acute Care Open 2021

LE RÔLE CENTRAL DE LA COAGULOPATHIE



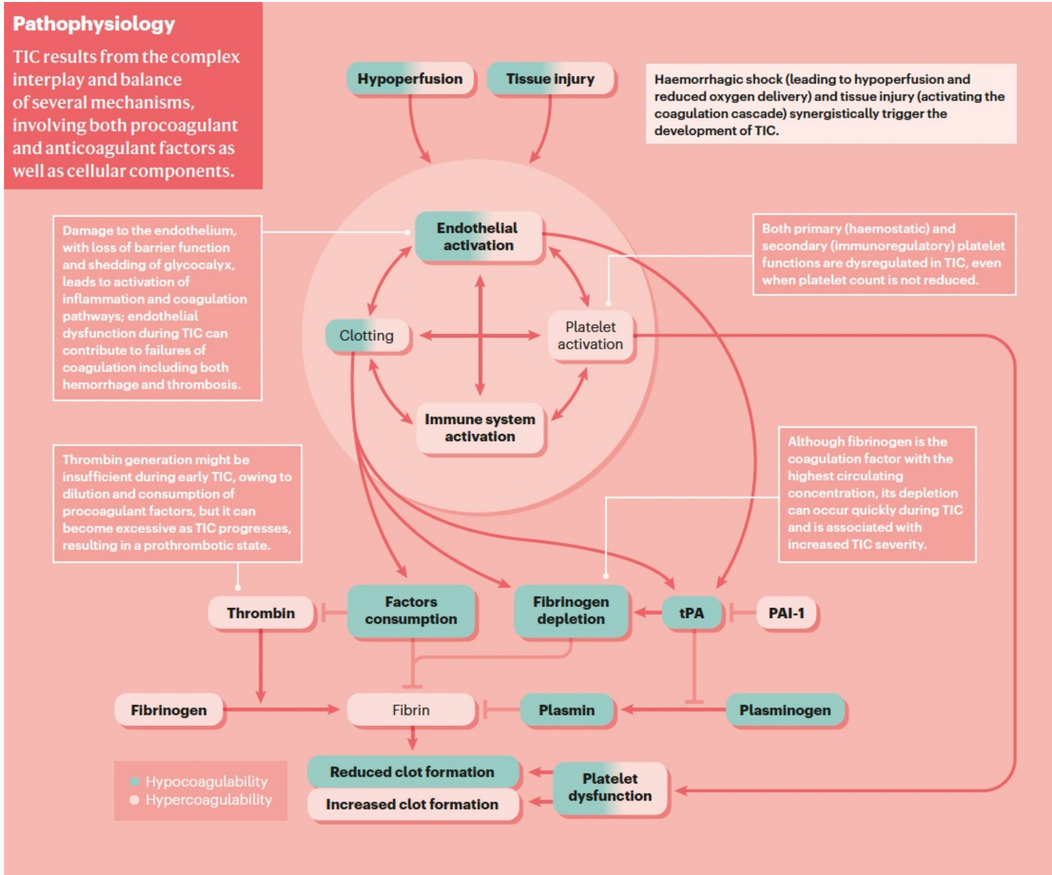
BMPM, Dr Pierre BALAZ

ET LE VAISSEAU ?



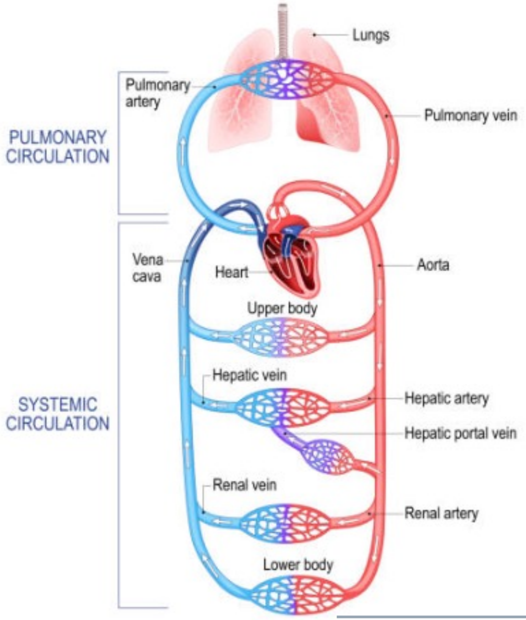
Dan L. Longo, NEJM 2018

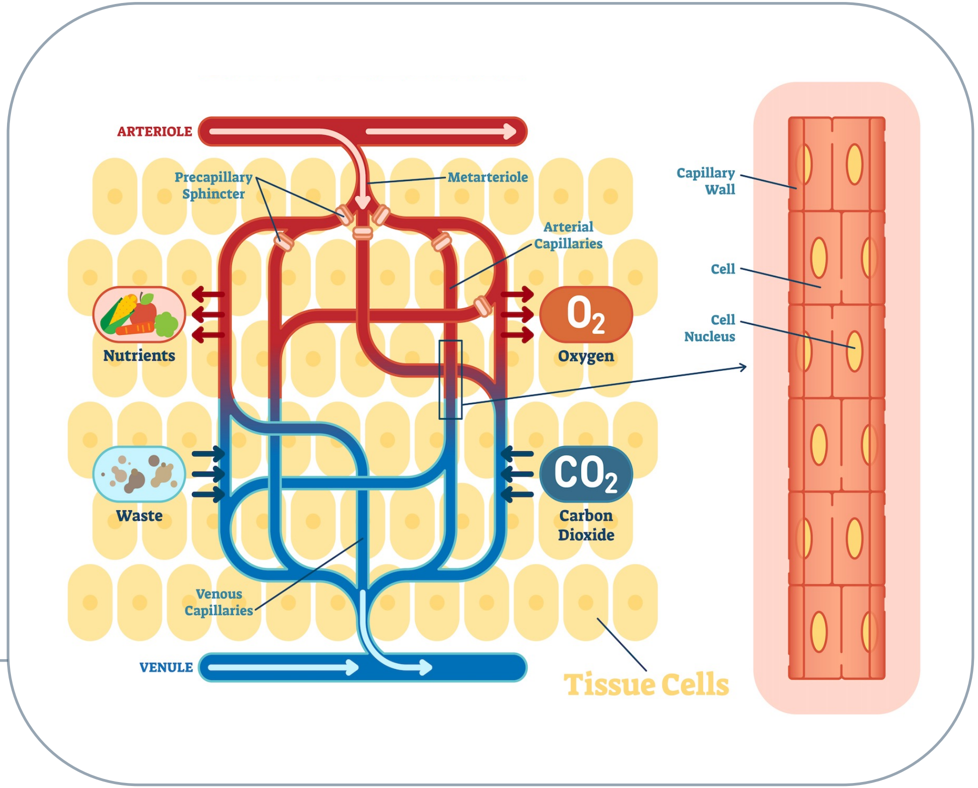
L'ATTEINTE MICROVASCULAIRE



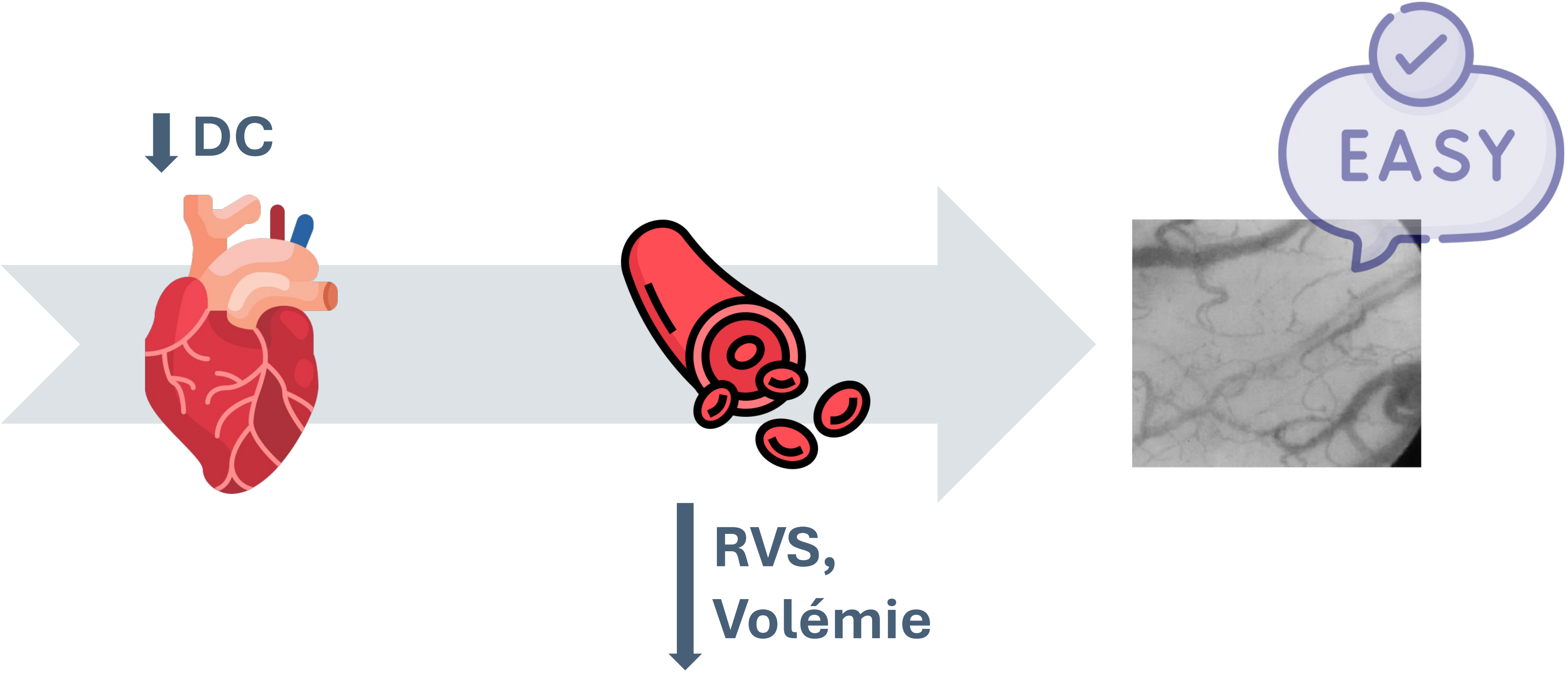
Moore et al. 2021

LE SYSTÈME MICROCIRCULATOIRE

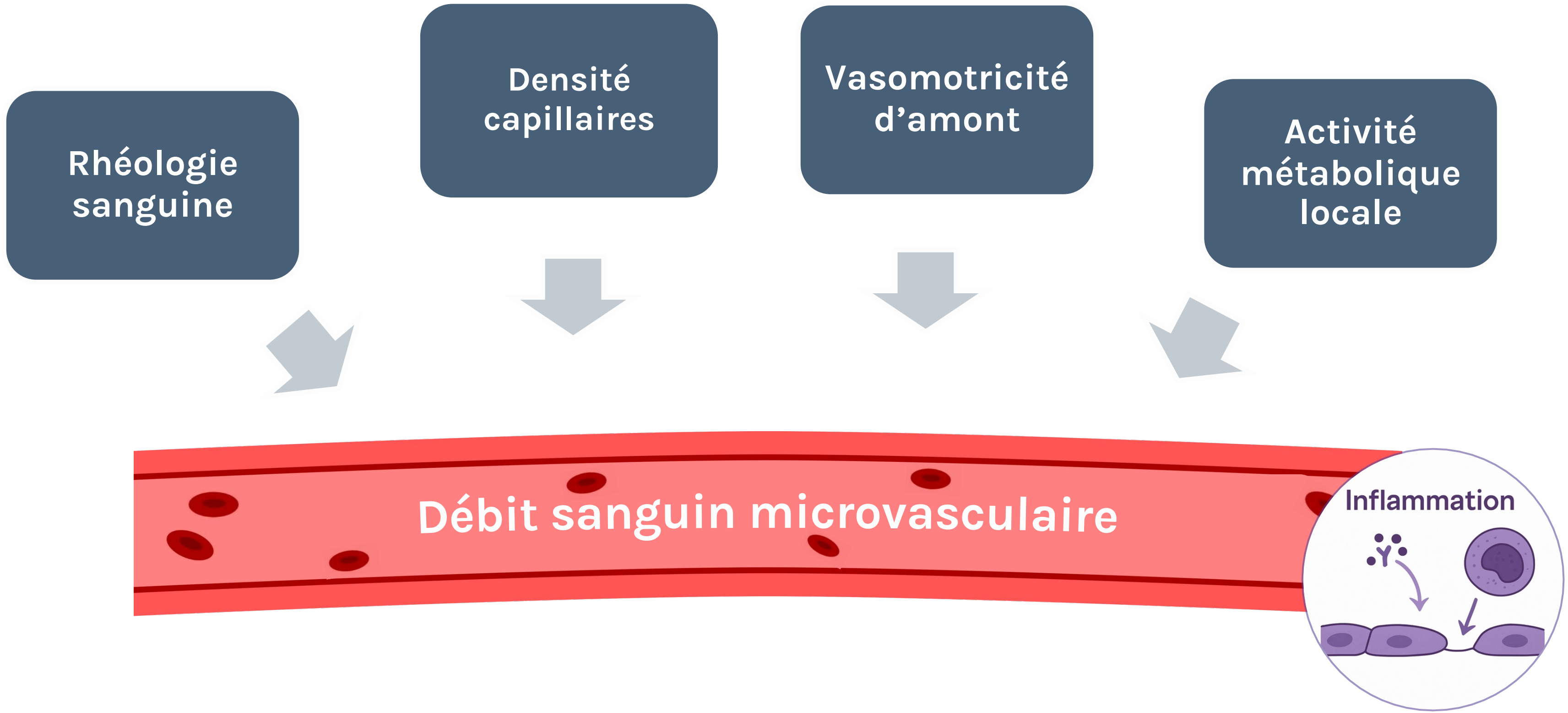


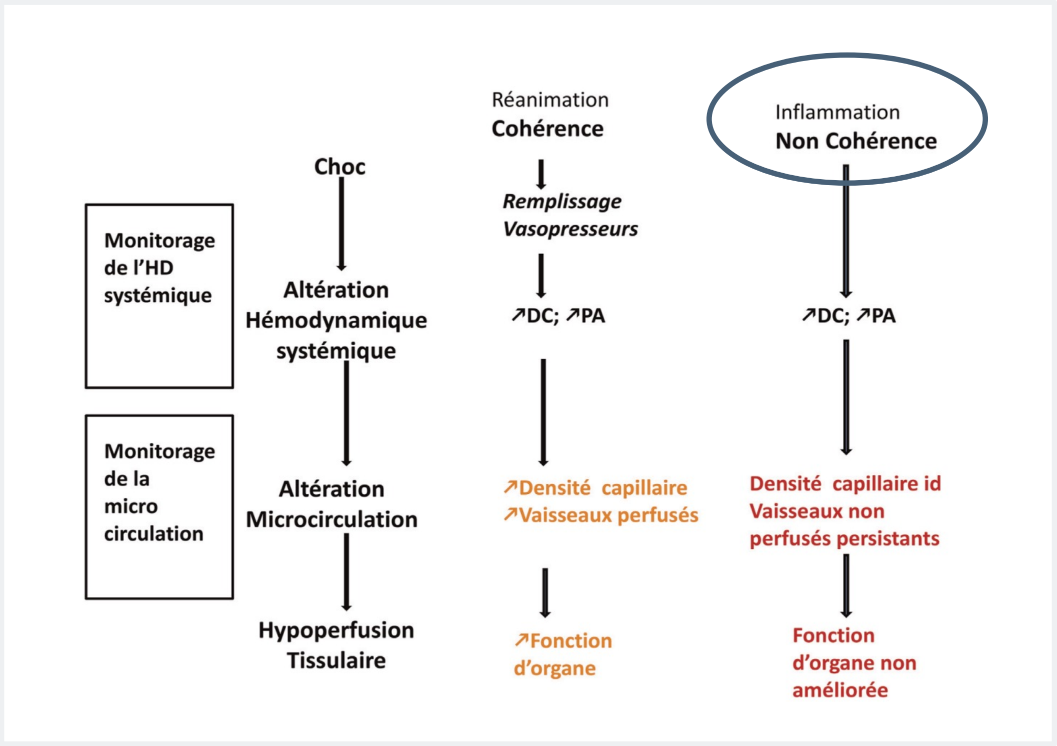


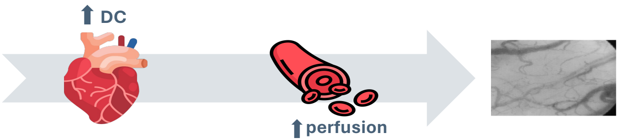
COHERENCE MACRO - MICRO



AUTO-REGULATION DU DEBIT MICROVASCULAIRE





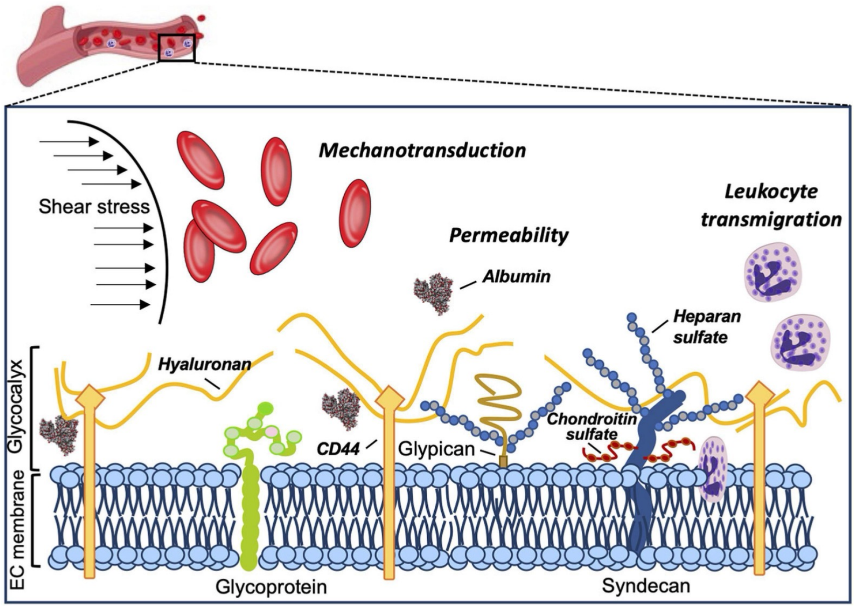


Marie-Reine Losser [1,2], Didier Payen de la Garanderie [3]

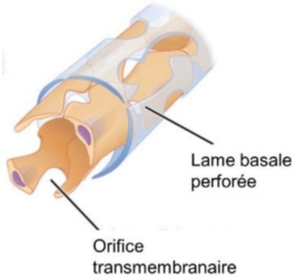
Anesth Reanim. 2019; 5: 193-199

Endothelium

Glycocalyx



Villalba et al. Frontiers 2021



Production substances vasoactives

Perméabilité vasculaire

Endothelium

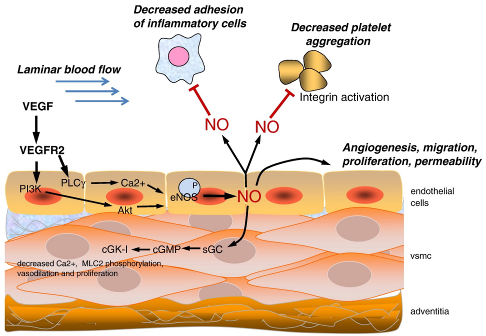
Glycocalyx

Propriétés pro ou anti-coagulantes

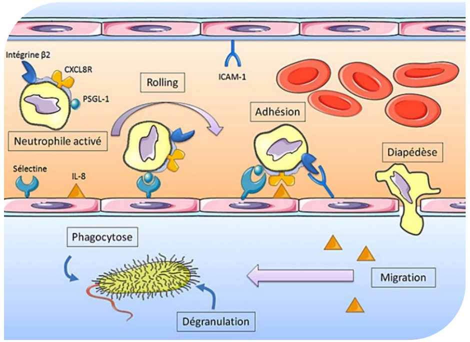
Adhésion leucocytaire

Diapédèse

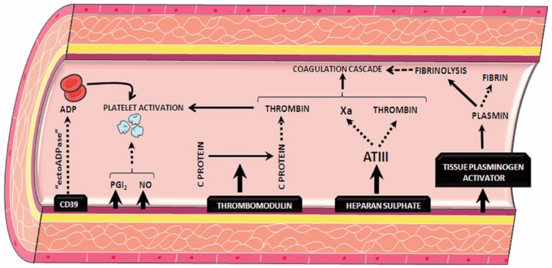
Propriétés pro ou anti-fibrinolytiques



M. Rogers N et al. 2014

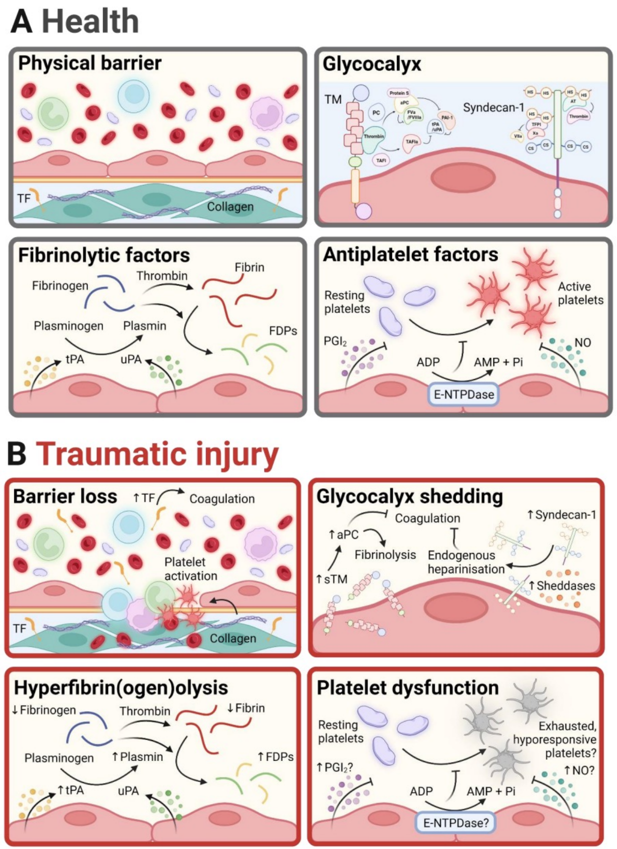


Libert N et al. 2010

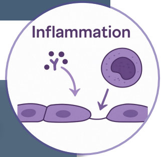


Badimon L et al. 2010

ENDOTHELIOPATHIE TRAUMATIQUE



Barrett et al. 2023



Perte fonction barrière = fuite capillaire

Atteinte glycocalyx

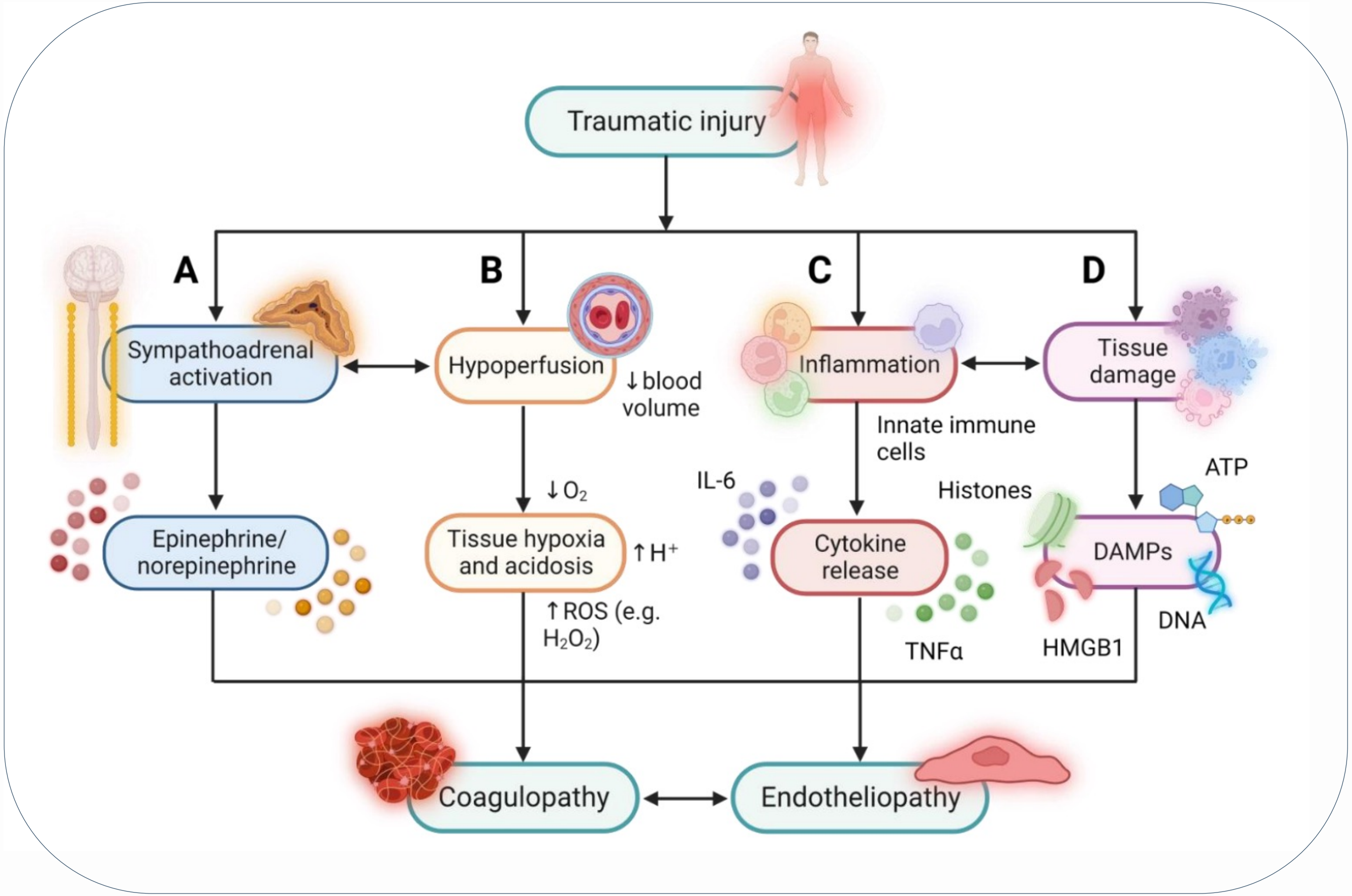
Activation plaquettaire

Etat pro coagulant, pro fibrinolytique = microthrombi

Extravasation leucocytes = inflammation

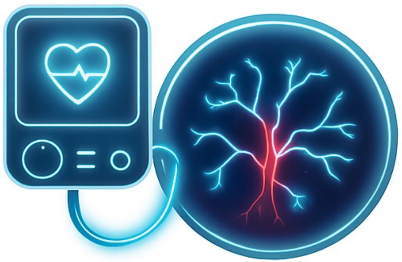
↓ Proportion de capillaires perfusés

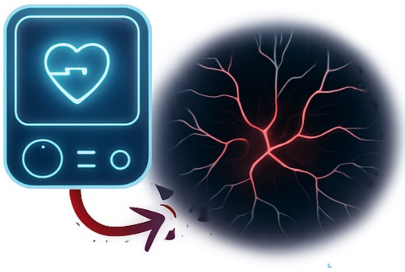
Altération oxygénation tissulaire



Barrett et al. 2023

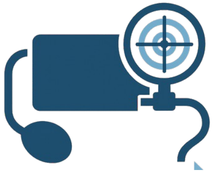
ALORS QUEL MONITORAGE ?

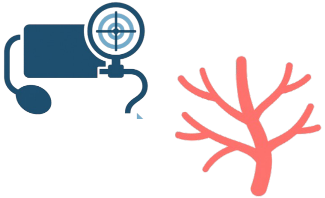




COHERENCE MACRO-MICRO

NON COHERENCE





MONITORER LA PAM… PAS UNE FIN EN SOI

Table 1. Hemodynamic variables in the first four days of ICU admission for the two groups of patients (SOFA[a] score at D4≤6.5 and SOFA score at D4>6.5).

		SOFA≤6.5 at D4	SOFA>6.5 at D4	p value
		15 (53.6%)	13 (46.4%)	
MAP[b], mmHg				
	D1	86 [75–99]	85 [77–95]	0.964
	D2	82 [71–99]	89 [71–95]	0.648
	D3	89 [84–102]	88 [79–97]	0.413
	D4	91 [74–106]	88 [84–89]	0.932
HR[c], bpm				
	D1	63 [57–83]	83 [74–102]	0.142
	D2	77 [64–100]	84 [60–101]	0.717
	D3	71 [62–88]	78 [63–92]	0,964
	D4	75 [64–87]	74 [70–85]	0.843
Norepinephrine, mcg/kg/min				
	D1	0.00 [0.00–0.22]	0.23 [0.026–0.48]	***0.033***
	D2	0.00 [0.00–0.182]	0.22 [0.02–0.28]	0.085
	D3	0.00 [0.00–0.00]	0.09 [0.04–0.33]	***0.001***
	D4	0.00 [0.00–0.00]	0.1 [0.04–0.17]	***0.001***
Arterial pH, AU				
	D1	7.43 [7.4–7.58]	7.45 [7.38–7.49]	0.329
	D2	7.48 [7.44–7.49]	7.45 [7.42–7.49]	0.892
	D3	7.47 [7.43–7.52]	7.48 [7.43–7.53]	0.440
	D4	7.48 [7.44–7.49]	7.47 [7.45–7.51]	0.936
BE[d], mmol/L				
	D1	0.6 [(-)0.9,-2.3]	0.6 [(-)2.7–3.8]	0.880
	D2	4.5 [2.2–8.5]	4.4 [1.7–6.2]	0.751
	D3	5.5 [3.7–9.4]	6.4 [2.1–7.6]	0.892
	D4	5.2 [3.7–9.7]	7.7 [4.2–11.8]	0.538
Lactate, mmol/L				
	D1	1.3 [0.9–2.0]	1.7 [1.1–2.2]	0.235
	D2	1.0 [0.7–2.0]	1.1 [0.7–2.0]	0.217
	D3	0.9 [0.8–1.1]	0.9 [0.7–1.2]	0.413
	D4	0.7 [0.7–1.1]	0.9 [0.6–1.4]	0.590
ScvO2[e], %				
	D1	79.4 [75.6–81.7]	74.3 [59.2–84.4]	0.161
	D2	74.8 [67.1–80.8]	79.3 [70.7–85.2]	0.347
	D3	75 [67.5–78.6]	72 [71.6–90.6]	0.219
	D4	72.1 [68.6–74.4]	78.6 [73.3–81.0]	0.148
Hb[f], g/dl				
	D1	10.8 [9.0–12.4]	10.4 [10.2–11.2]	0.751
	D2	10.3 [9.2–11.5]	9.3 [8.4–9.9]	0.170
	D3	9.3 [8.9–11.4]	9.8 [9.5–10.9]	0.316
	D4	9.4 [8.2–11.3]	9.8 [9.3–10.8]	0.630
Hct[g], %				
	D1	30.2 [27.1–3.8]	30.7 [29.2–32.]	0.856
	D2	30.9 [26.0–34.3]	27.4 [24.4–29.7]	0.170
	D3	27.7 [27.0–34.8]	29.5 [28.6–31.4]	0.440
	D4	29.0 [25.8–33.9]	29.6 [27.8–31.9]	0.79
Patients transfused, n° (%)				

RESEARCH ARTICLE

Association between sublingual microcirculation, tissue perfusion and organ failure in major trauma: A subgroup analysis of a prospective observational study

Roberta Domizi, Elisa Damiani, Claudia Scorcella, Andrea Carsetti, Roberta Castagnani, Sara Vannicola, Sandra Bolognini, Vincenzo Gabbanelli, Simona Pantanetti, Abele Donati**

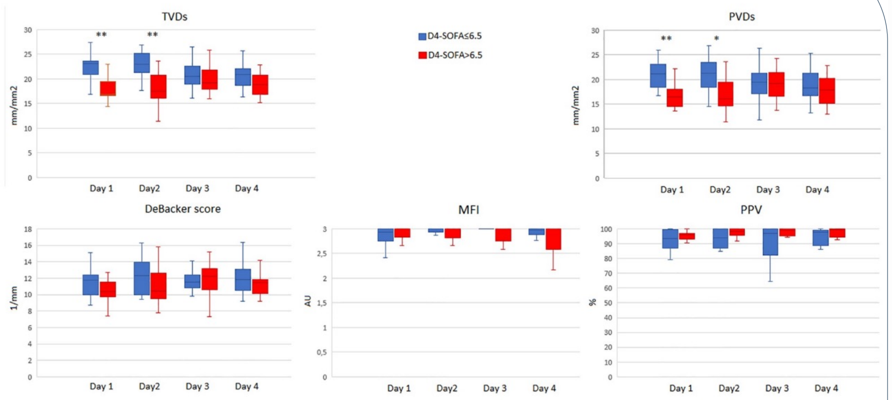
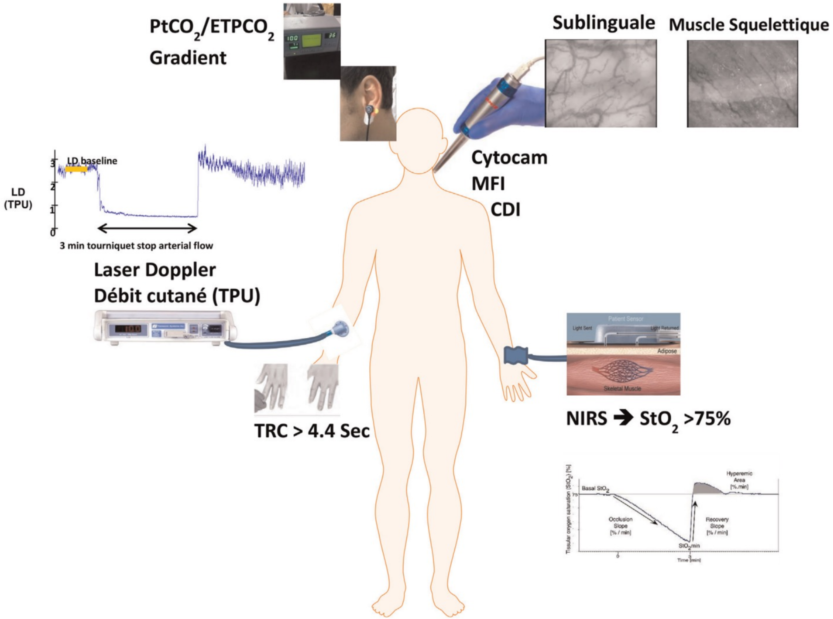


Fig 1. Changes in the sublingual microvascular parameters in the first 4 days of admission in ICU for the two groups of patients (SOFA score at D4≤6.5 and SOFA score at D4>6.5). * **p<0.05;** ** **p<0.01.** TVDs: total small vessel density; PVDs: perfused small vessel density; MFI: microvascular flow index; PPV: percentage of perfused vessels.

EVALUATION MICROCIRCULATOIRE



Marie-Reine Losser [1,2], Didier Payen de la Garanderie [3]

Anesth Reanim. 2019; 5: 193–199

Table 1 Techniques used to evaluate the microcirculation at the bedside

	Variable measured	Main limitations
Techniques measuring microvascular perfusion		
Laser Doppler	Flow (relative), hemoglobin content/ microvascular reactivity test	Global flow to relatively large sampling volume (mixture of arterioles, capillaries, and venules)
Nailfold videomicroscopy	Vascular density, heterogeneity, flow	Restricted to fingers/sensitivity to temperature and vasoconstriction
OPS and SDF	Vascular density, perfusion heterogeneity, flow	Mostly restricted to semiquantitative scoring/limited sites to investigate/ movement and pressure artifacts
Techniques measuring tissue oxygenation		
SvO_2	Adequacy of perfusion to flow	Global measurement
O_2 electrodes	Tissue PO_2	Global measurement in sampled volume (mixture of arterioles, capillaries, and venules)
NIRS	Tissue O_2 saturation	Global measurement in sampled volume (mixture of arterioles, capillaries, and venules)
Reflectance spectroscopy	O_2 saturation/microvascular reactivity test	Global measurement in sampled volume (mixture of arterioles, capillaries, and venules) unless SO_2 histograms are provided
Gastric tonometry	Tissue CO_2 (reflects inadequate perfusion and/or anaerobic metabolism)	Interference (feeding/reflux)/difficult discrimination between low flow and anaerobic metabolism
Sublingual capnometry	Tissue CO_2 (reflects inadequate perfusion and/or anaerobic metabolism)	Availability limited/difficult discrimination between low flow and anaerobic metabolism
Microdialysis and equilibrium dialysis	Lactate/pyruvate	Time lag/limited sites to investigate

OPS orthogonal polarization spectral imaging technique; *SDF* sidestream dark field imaging technique; *SvO_2* mixed-venous oxygen saturation; *NIRS* near-infrared spectroscopy; *EMPHO* Erlangen MicroPHOtometer

Intensive Care Med (2010) 36:1813–1825
DOI 10.1007/s00134-010-2005-3

REVIEW

Daniel De Backer
Gustavo Ospina-Tascon
Diamantino Salgado
Raphaël Favory
Jacques Creteur
Jean-Louis Vincent

Monitoring the microcirculation in the critically ill patient: current methods and future approaches

Intensive Care Med
https://doi.org/10.1007/s00134-018-5070-7

CONFERENCE REPORTS AND EXPERT PANEL

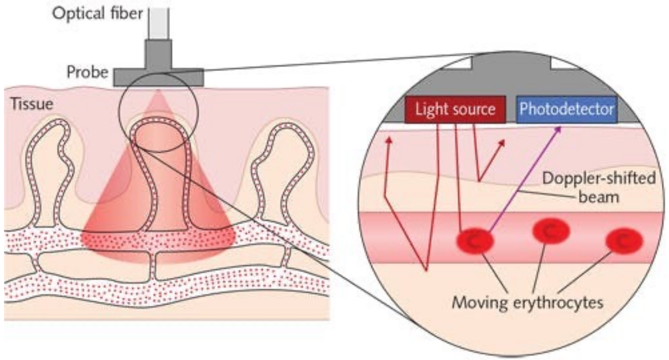
Second consensus on the assessment of sublingual microcirculation in critically ill patients: results from a task force of the European Society of Intensive Care Medicine

Table 5 Characteristics of microvascular variables

Variable	Abbreviation	Definition	Characteristics	Units	Strength/weakness
Proportion of perfused vessels	PPV	Grid-based score (3 horizontal and vertical equidistant lines). Percentage of perfused vessels per total number of vessel crossings	Binominal determinant of red blood cell velocity: flow or no-flow	%	Good reproducibility. Based upon tradition of preclinical research. Score is sensitive to isotropy (change in image size during optical magnification)
De Backer score	NA	Grid-based score (3 horizontal and vertical equidistant lines). Total number of vessel crossings per grid length	Proxy of total vessel density. Applicable to different vessel types (capillary density)	n/mm	Together with the percentage of perfused capillaries proxy of functional capillary density
Microvascular flow index	MFI	Grid-based score per quadrant. 0 = stop flow, 1 = intermittent flow, 2 = sluggish flow, 3 = normal flow	Semi-quantitative assessment of the average red blood cell velocity per quadrant	AU	Good reproducibility. Quick and possible by "eyeballing". Non-continuous separation between categories of flow. Potential loss of detail, overcome by similar score per vessel
Total vessel density	TVD	Software supported measurement of total vessel area per surface area	Determinant of capillary distance (diffusive capacity)	mm^2/mm^2	Absolute number, continuous data. Time consuming because of necessary manual correction of software-supported vessel tracing of vessels. Exact measurements of vessel diameter
Perfused vessel density	PVD	Percentage of perfused vessels × TVD	Determinant of capillary distance (diffusive capacity) and red blood cell velocity (convective capacity)	mm^2/mm^2	Equal to functional capillary density = gold standard in preclinical research. Time consuming
Space–time diagram	STD	Measurement of exact red blood cell velocity	Determinant of red blood cell velocity (convective capacity)	mm/s	Absolute number, continuous data. Time consuming, applicability limited to non-tortuous vessels of sufficient length
Heterogeneity index	HI	Coefficient of variation, expressed as (highest − lowest value)/mean	Determinant of heterogeneity of blood flow, characteristic of distributive abnormalities	AU	Provides additional information, missed by absolute numbers. Calculation may be based upon MFI or PPV

NA not applicable, *AU* arbitrary unit

LE LASER DOPPLER



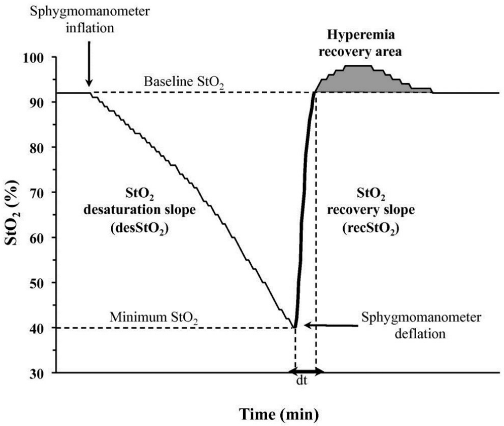
Fx laser qui rencontre les GR en mouvement

analyse changement fréquence

VELOCITE SANGUINE

Données expé
ne cible pas les vaisseaux atteints
pas de prise compte de l'hétérogénéité

NIRS



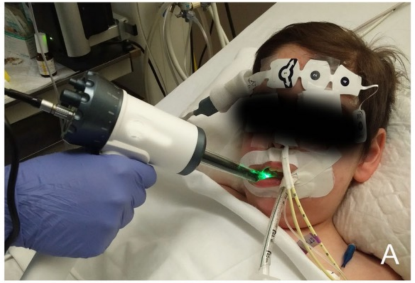
diffusion et l'absorption de lumière infra rouge
dans les tissus

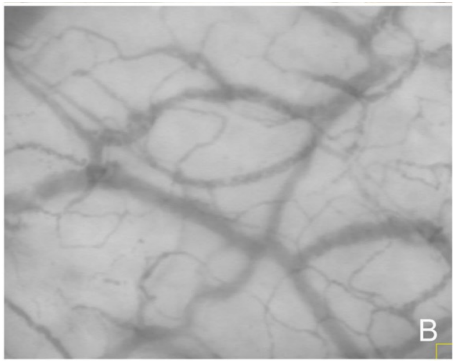
OXYGENATION TISSULAIRE

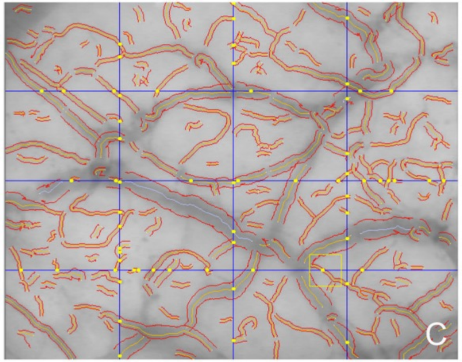
(StO2)

Valeurs de réf variables ++
Influence épaisseur tissu cut ou graisseux
Mesure localisée ++
Nécessite évaluation dynamique (test occlusion)

IMAGERIE SUBLINGUALE







González et al. BMC Pediatrics (2017) 17:75
DOI 10.1186/s12887-017-0837-5

BMC Pediatrics

RESEARCH ARTICLE Open Access

Evaluation of sublingual microcirculation in a paediatric intensive care unit: prospective observational study about its feasibility and utility

Rafael González[1,2,3], Jorge López[1,2,3], Javier Urbano[1,2,3], María José Solana[1,2,3], Sarah Nicole Fernández[1,2,3], María José Santiago[2,3] and Jesús López-Herce[1,2,3,4*]

Continuous Noninvasive Tissue Oximetry in the Early Evaluation of the Combat Casualty: A Prospective Study

Alec C. Beekley, MD, Matthew J. Martin, MD, Teresa Nelson, MS, Kurt W. Grathwohl, MD, Matthew Griffith, MD, Gregory Beilman, MD, and John B. Holcomb, MD

TABLE 3. Multivariate Logistic Regression Modeling to Predict Life-Saving Intervention (LSI), Blood Transfusion, and Massive Transfusion in the Whole Group

Parameters (Units)*	LSI, Odds Ratio (95% CI)†	Blood Transfusion, Odds Ratio (95% CI)†	Massive Transfusion, Odds Ratio (95% CI)†
SBP [−10 mm Hg)]	Not retained	1.40 (1.1–1.8)	Not retained
DBP (5 mm Hg)	1.17 (1.0–1.4)	Not retained	Not retained
INR (0.50)	15.11 (3.7–61.3)	5.91 (1.6–21.9)	10.24 (2.5–41.9)
Hgb (−1.0 g/dL)	Not retained	Not retained	1.7 (1.1–2.6)
HCT (−5.0%)	2.39 (1.5–3.8)	3.01 (1.8–4.9)	Not retained
BD (−2 mEq/L)	1.54 (1.1–2.2)	Not retained	Not retained
THI (−1)	Not retained	1.18 (1.0–1.4)	Not retained
Logistic regression equation	$\text{Log}\,[p/(1-p)] = 1.55 + 5.43 \times \text{INR} - 0.22 \times \text{BD} + 0.03 \times \text{DBP} - 0.17 \times \text{HCT}$	$\text{Log}\,[p/(1-p)] = 9.88 - 0.03 \times \text{SBP} + 3.55 \times \text{INR} - 0.16 \times \text{THI} - 0.22 \times \text{HCT}$	$\text{Log}\,[p/(1-p)] = 1.94 - 0.53 \times \text{Hgb} + 4.65 \times \text{INR}$
AUC (95% CI)	0.85 (0.79–0.91)	0.90 (0.84–0.96)	0.91 (0.79–1.0)

AUC, area under the receiver operating characteristic curve; SBP, systolic blood pressure; DBP, diastolic blood pressure; INR, international normalized ratio; Hgb, hemoglobin; HCT, hematocrit; BD, base deficit; THI, tissue hemoglobin index.

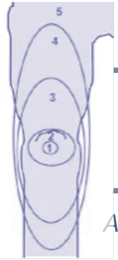
* Parameters entered into a model but not retained in any outcome equation include tissue oxygenation (StO_2), radial pulse character, heart rate, platelets, and pH.

† The odds ratio provided in the table is associated with the change in the units specified.

EN PRATIQUE...

T° cut

Δ T°



Marbrures

Ait-Oufella et al. Réanimation. 2012

Perfusion organes

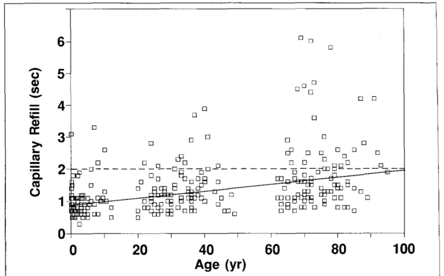
TRC

Lactate

Defining Normal Capillary Refill: Variation With Age, Sex, and Temperature

David L Schriger, MD
Larry Baraff, MD, FACEP
Los Angeles, California

Annals *of* Emergency Medicine
An International Journal



Solid line = regression equation, capillary refill (secs) = 0.013 age (yr) + 0.901.
Dashed line = previously advocated two-second upper limit of normal.

Adverse Lighting Condition Effects on the Assessment of Capillary Refill

LAWRENCE H. BROWN, EMT-P,* N. HERAMBA PRASAD, MD,* THEODORE W. WHITLEY, PHD†

SHORT REPORT

Are bedside features of shock reproducible between different observers?

H Otieno, E Were, I Ahmed, E Charo, A Brent, K Maitland

Arch Dis Child 2004;**89**:977–979. doi: 10.1136/adc.2003.043901

LES BIOMARQUEURS

LE BASE EXCESS

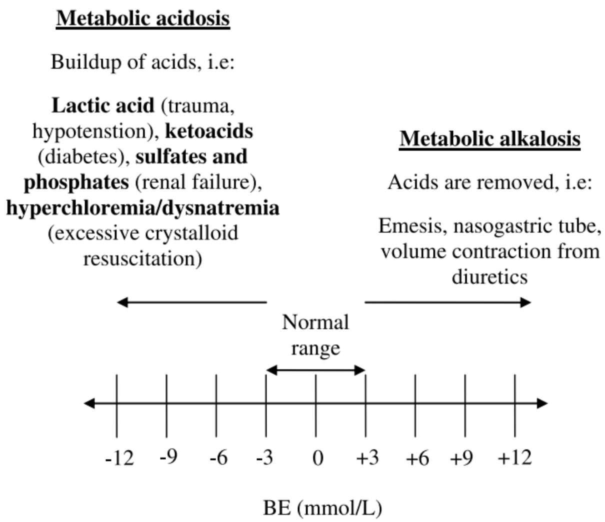


Figure 1. BE represented on a number line with common causes for metabolic acidosis and alkalosis.

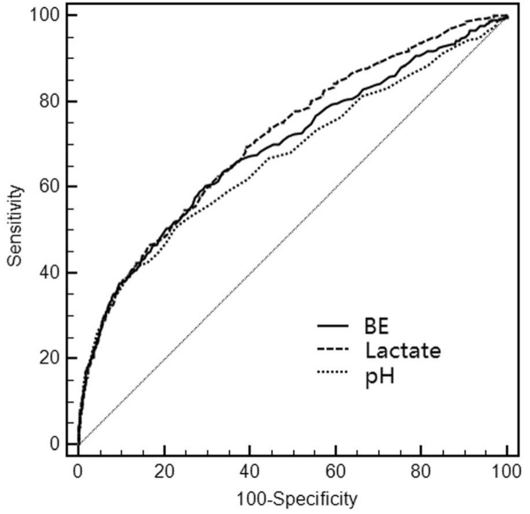


Fig. 3 ROC curves of BE, lactate and pH for 72 h in-hospital mortality of multiple trauma

Table 2 Logistic regression analyses

Variables	Univariate			Multivariate		
	OR	95%CI	P	OR	95%CI	P
BE	0.866	0.849–0.884	< 0.001	0.872	0.854–0.890	< 0.001
Lactate	1.353	1.299–1.410	< 0.001	1.353	1.296–1.413	< 0.001
pH	0.005	0.002–0.011	< 0.001	0.007	0.003–0.016	< 0.001

Variables in multivariate logistic models were adjusted for gender, age and ISS category.

Juern et al. 2012

Qi et al. 2021

LE LACTATE

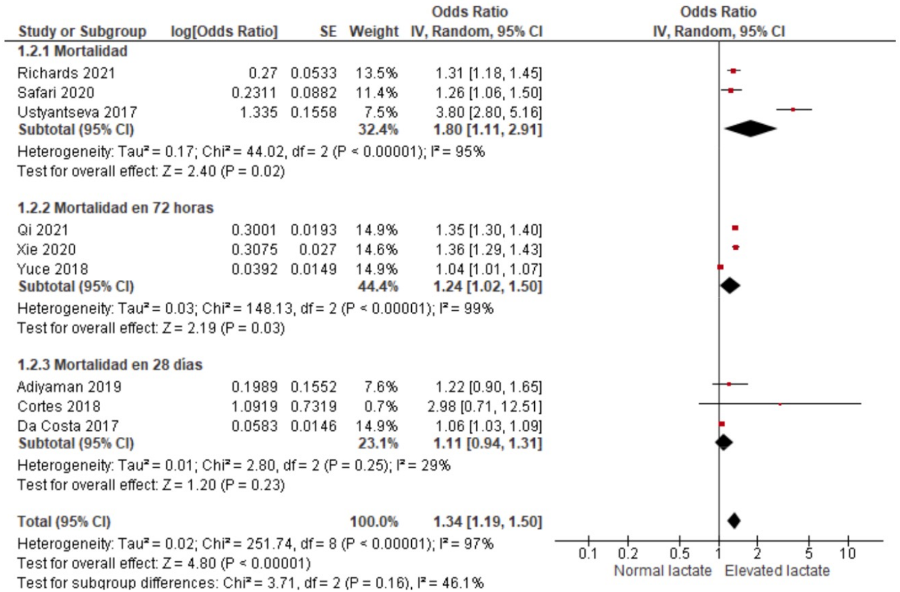
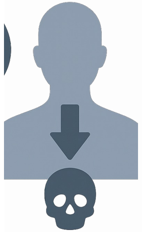
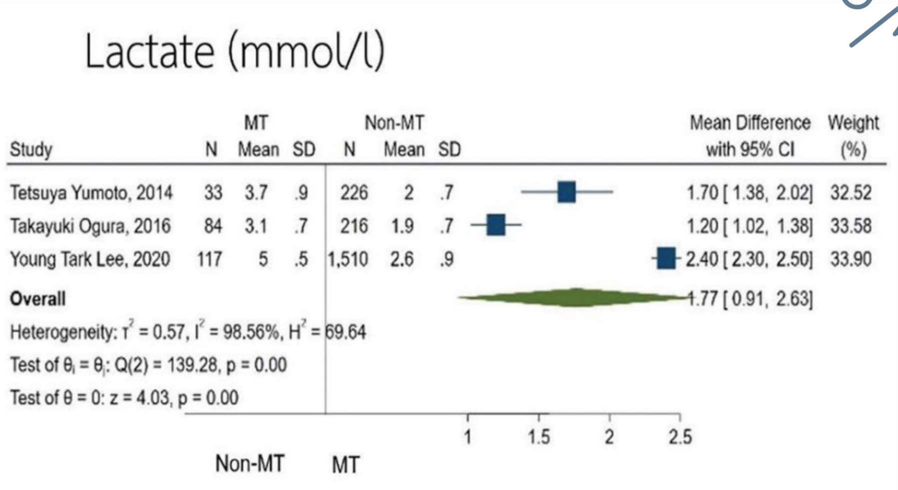


Figure 2: Forest plot of random effects of elevated lactate on mortality, 72-hour mortality, and 28-day mortality.

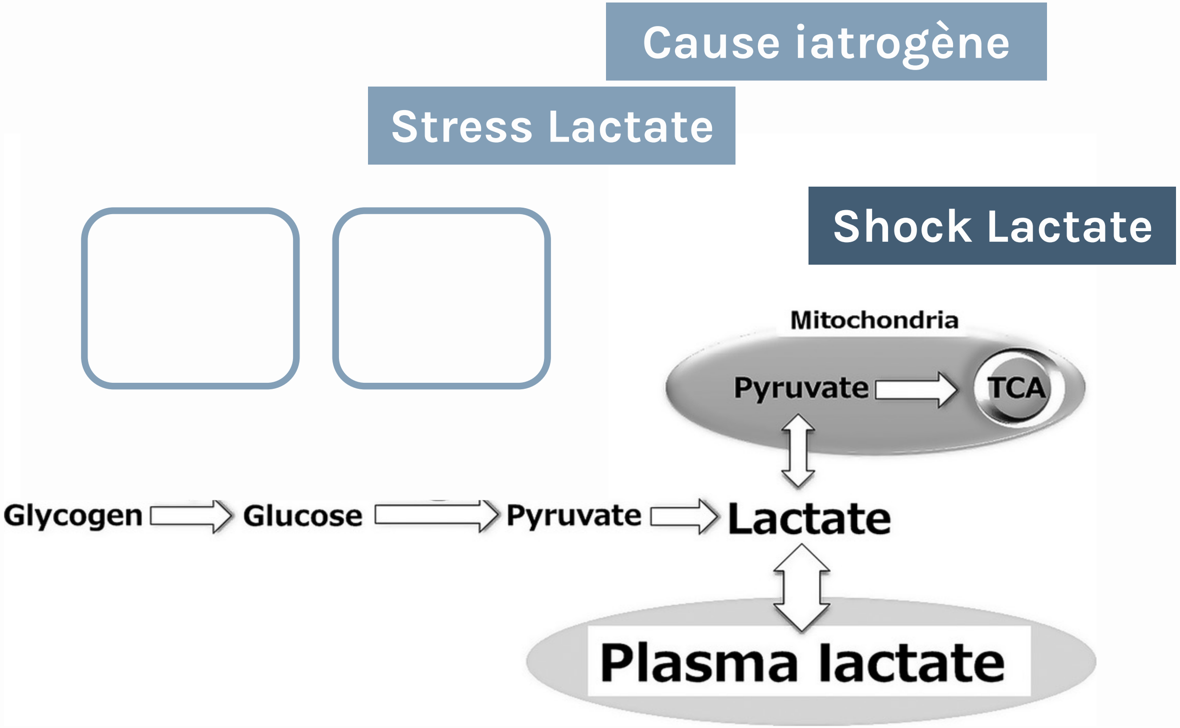


Carrasco et al. 2023

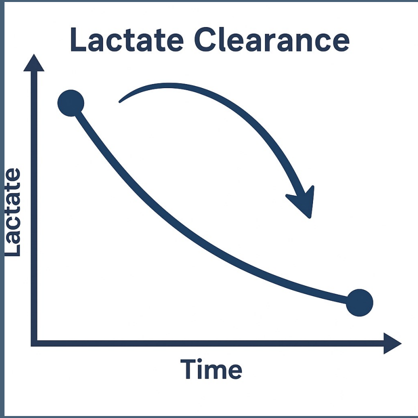
LE LACTATE



Ueamsaranworakul T et al. 2024

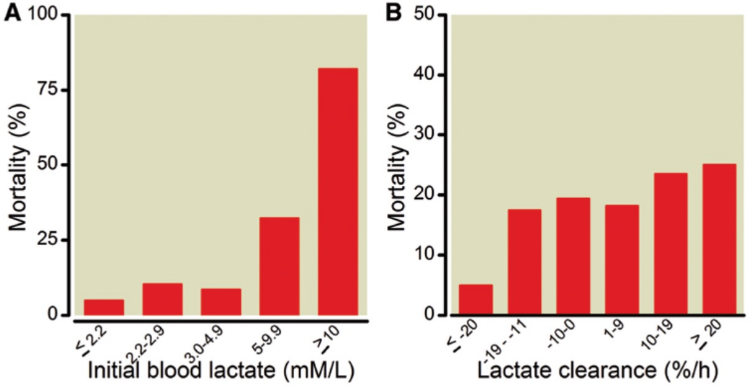


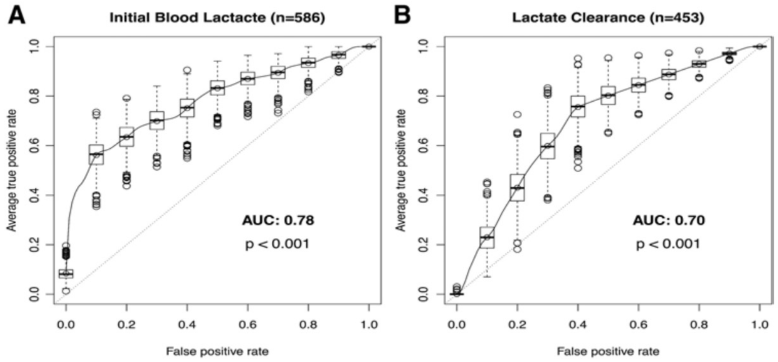
D'après Kushimoto et al, Acute Med Surg 2016

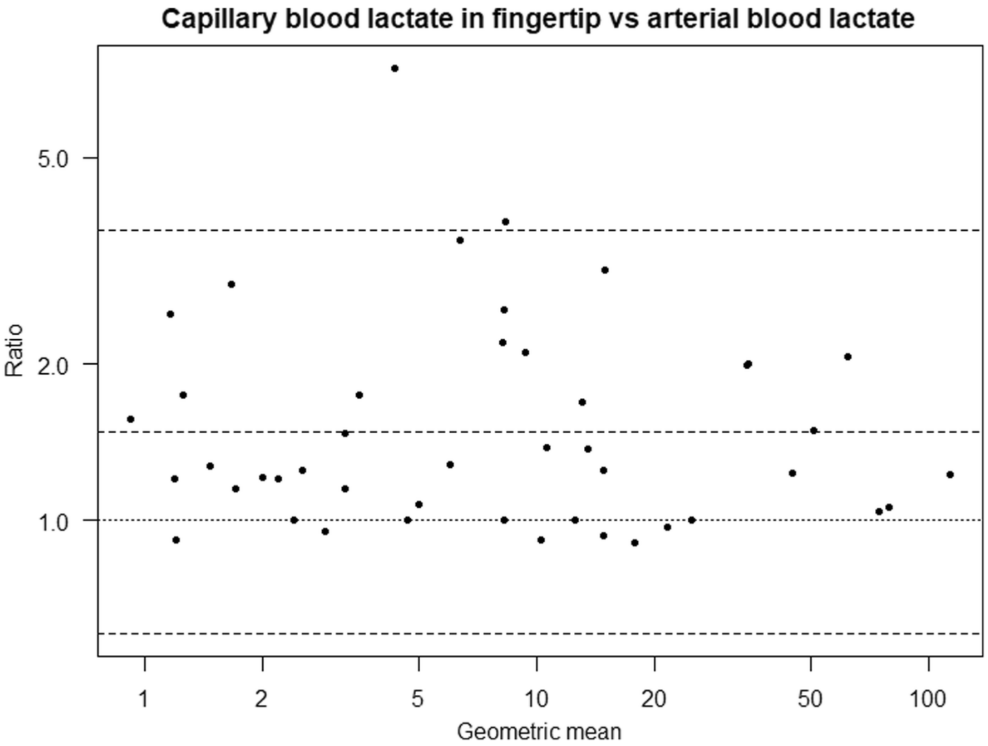


Prognostic Significance of Blood Lactate and Lactate Clearance in Trauma Patients

Marie-Alix Régnier, M.D.,* Mathieu Raux, M.D., Ph.D.,† Yannick Le Manach, M.D.,‡
Yves Asencio, M.D. M.Sc,* Johann Gaillard, M.D.,* Catherine Devilliers, Pharm. D.,§
Olivier Langeron, M.D., Ph.D.,‖ Bruno Riou, M.D., Ph.D.#







Raa, A et al. 2020

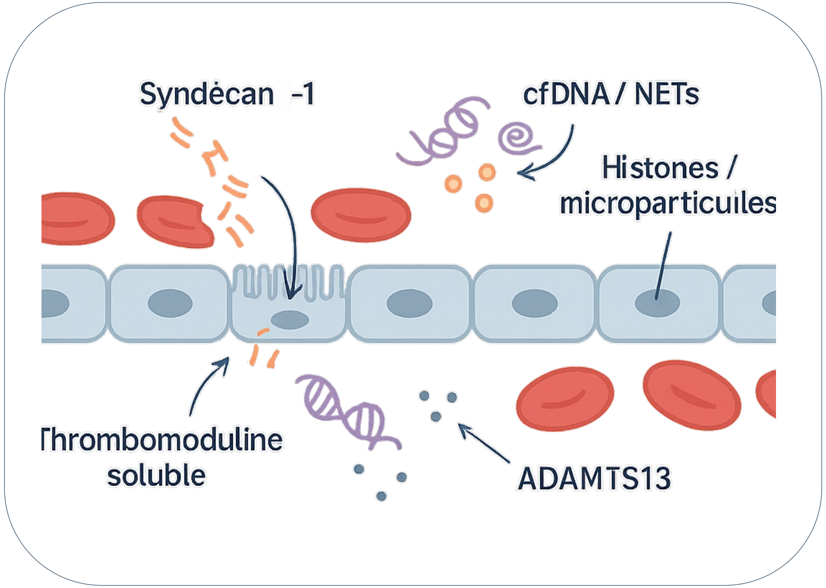
LES BIOMARQUEURS EMERGENTS

A High Admission Syndecan-1 Level, A Marker of Endothelial Glycocalyx Degradation, Is Associated With Inflammation, Protein C Depletion, Fibrinolysis, and Increased Mortality in Trauma Patients

Pär I. Johansson, MD, DMSc, MPA,* Jakob Stensballe, MD, PhD,† Lars S. Rasmussen, MD, PhD, DMSc,† and Sisse R. Ostrowski, MD, PhD, DMSc*

NEUTROPHIL-DERIVED CIRCULATING FREE DNA (CF-DNA/NETS): A POTENTIAL PROGNOSTIC MARKER FOR POSTTRAUMATIC DEVELOPMENT OF INFLAMMATORY SECOND HIT AND SEPSIS

Stefan Margraf,* Tim Lögters,† Jenny Reipen,† Jens Altrichter,† Martin Scholz,† and Joachim Windolf†



Temporal phenotyping of circulating microparticles after trauma: a prospective cohort study

Matthias Fröhlich[1,2*†], Nadine Schäfer[1†], Michael Caspers[1,2], Julia K. Böhm[1], Ewa K. Stürmer[3], Bertil Bouillon[2] and Marc Maegele[2]

Article

Shock-Driven Endotheliopathy in Trauma Patients Is Associated with Leucocyte Derived Extracellular Vesicles

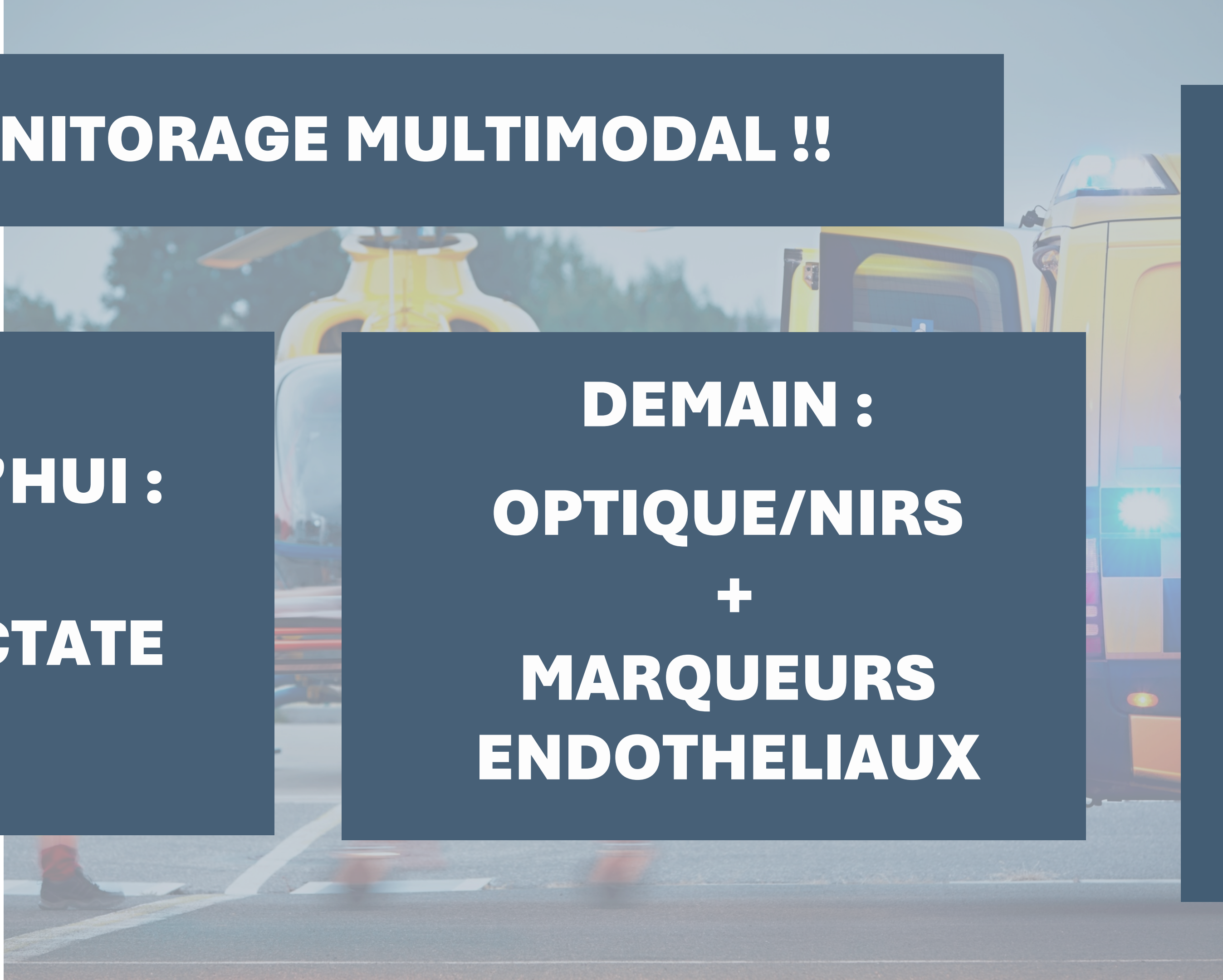
Romein W. G. Dujardin [1,2,*,†], Jeske E. C. Kisters [1,3,†], Mathijs R. Wirtz [1], Najat Hajji [4,5], Anita M. Tuip-de Boer [1], Jakob Stensballe [6], Pär I. Johansson [6], Karim Brohi [7], Ross A. Davenport [7], Christine Gaarder [8], Simon Stanworth [9,10], Marc Maegele [11], Rienk Nieuwland [4,5], Edwin van der Pol [4,5] and Nicole P. Juffermans [1,2]

Endotheliopathy of trauma is an on-scene phenomenon, and is associated with multiple organ dysfunction syndrome

Naumann, David N; Hazeldine, Jon; Davies, David J; Bishop, Jon; Midwinter, Mark J; Belli, Antonio; Harrison, Paul; Lord, Janet M

Angiopoietin-2, Marker and Mediator of Endothelial Activation With Prognostic Significance Early After Trauma?

Michael T. Ganter, MD,* Mitchell J. Cohen, MD,† Karim Brohi, FRCS, FRCA,‡ Brian B. Chesebro, MD,* Kristan L. Staudenmayer, MD,† Pamela Rahn, BS,† Sarah C. Christiaans, BS,* Natasha D. Bir, MD,† and Jean-François Pittet, MD*†



MONITORAGE MULTIMODAL !!

AUJOURD'HUI :

PAM + LACTATE

DEMAIN :

OPTIQUE/NIRS

+

MARQUEURS ENDOTHELIAUX