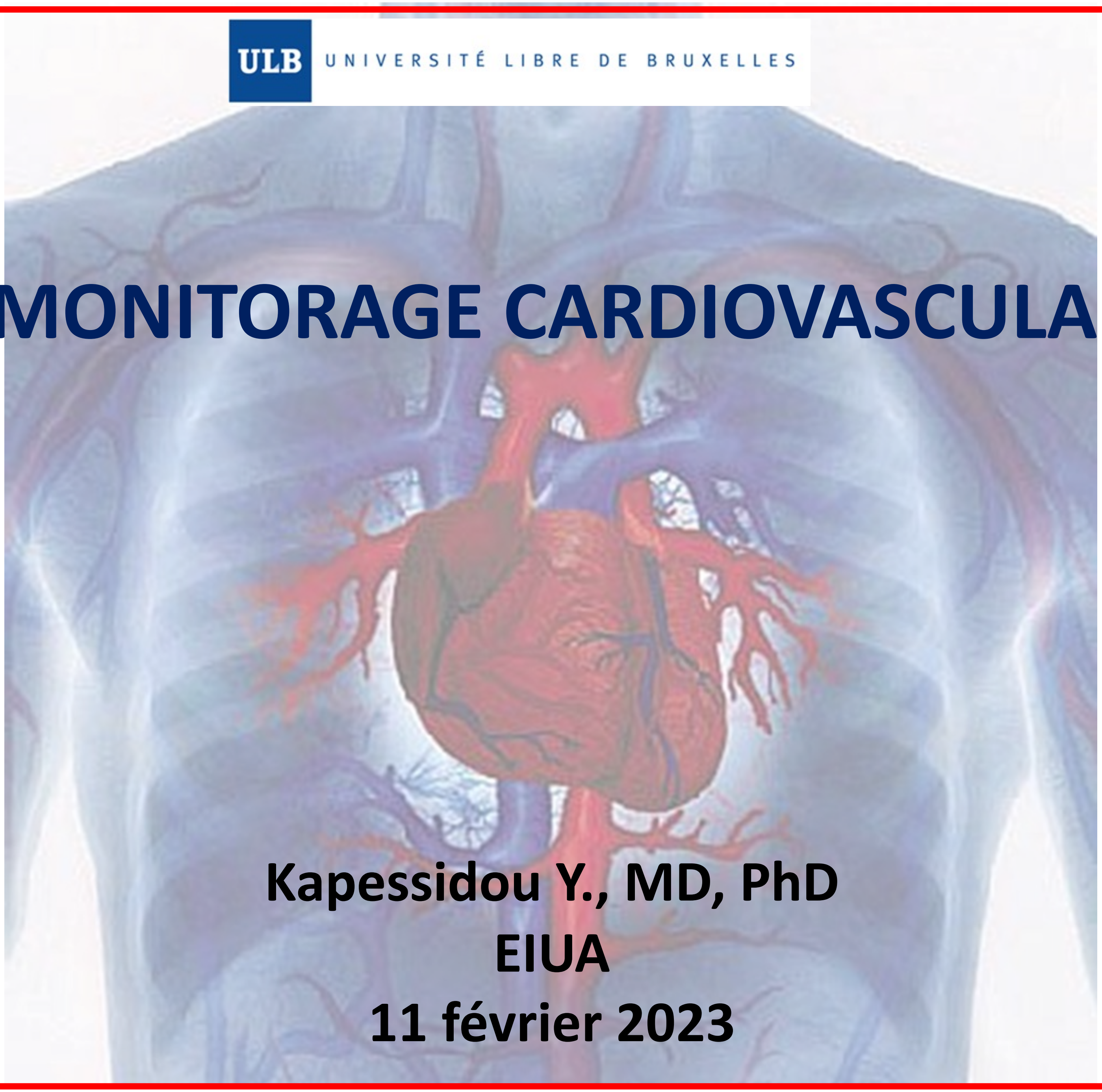
ULB UNIVERSITÉ LIBRE DE BRUXELLES

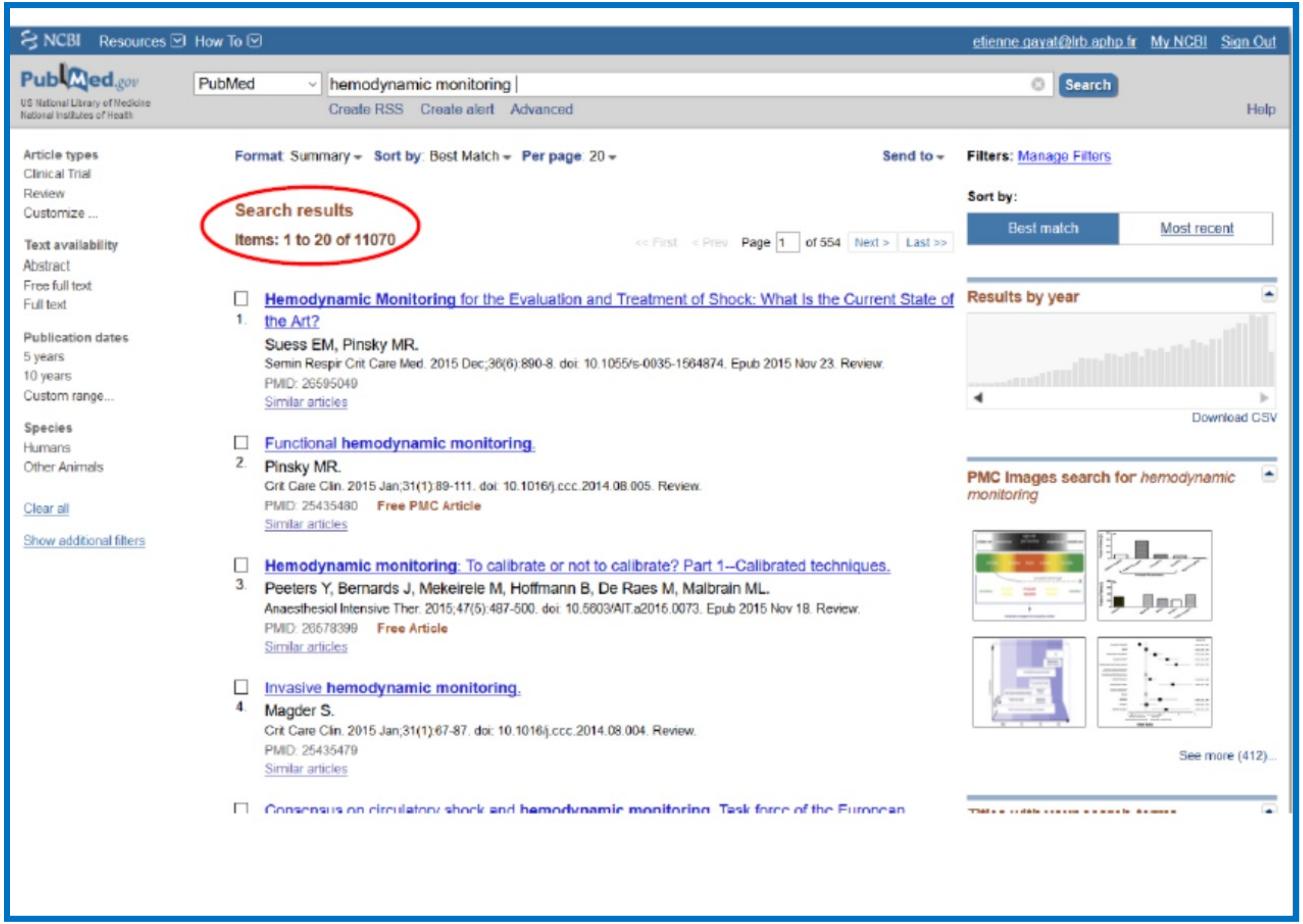


MONITORAGE CARDIOVASCULAIRE

Kapessidou Y., MD, PhD
EIUA
11 février 2023

CHU Saint-Pierre

MONITORAGE HEMODYNAMIQUE

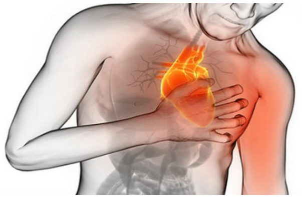


Plan

- Pourquoi monitorer

ImPrOve
Improving Patient Outcomes

- Quel patient



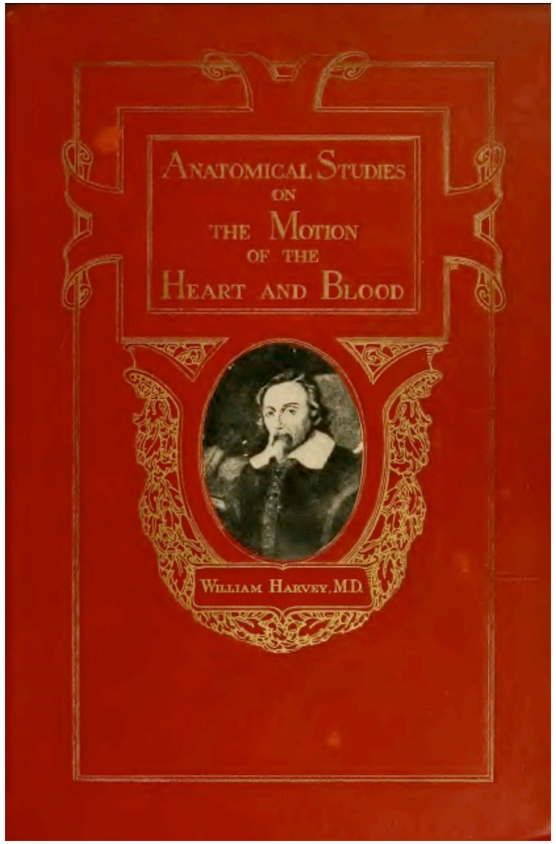
- Quels paramètres

- Quels outils

- Perspectives

Histoire

William Harvey
1628

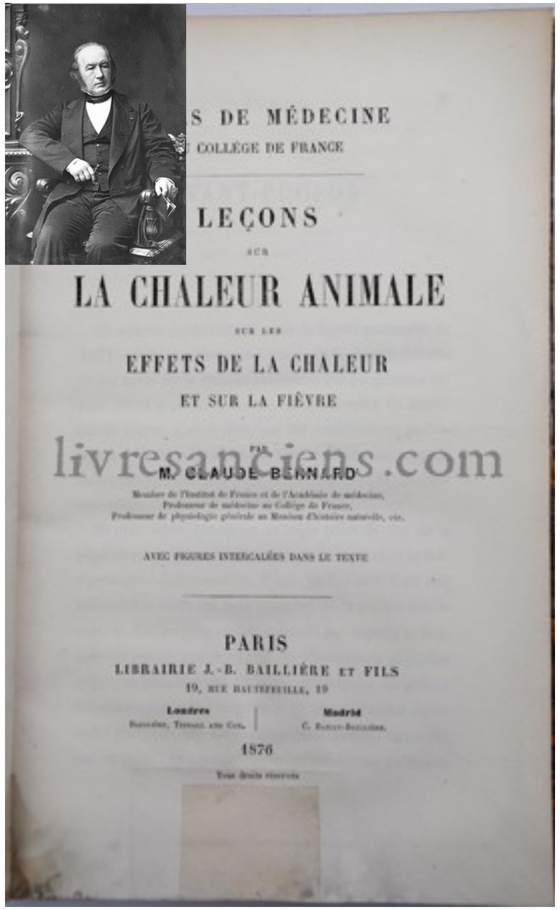


Flux sanguins et Pressions

Stephen Hales
1733

Mesure de la PA

Claude Bernard
1844



KT cardiaque

Monitorage hémodynamique: Pourquoi faire ?

Quelle est ma mission ?

- anesthésier mon patient
- garantir une perfusion satisfaisante de tous ses organes et une délivrance d'O_2 adéquate (DO_2)

Optimisation péri-opératoire

- **Réduction de la morbi-mortalité post-opératoire**
- **Optimisation des objectifs hémodynamiques individualisés (GDT), basée sur le monitorage**
- Remplissage et traitement de l'instabilité de la pression artérielle (PA)
- Diagnostiquer et corriger le surdosage des drogues anesthésiques
- Optimiser l'analgésie péri-opératoire
- **Réhabilitation rapide post-opératoire (ERAS)**

L’ampleur du problème en chirurgie non-cardiaque

European Society of Cardiology
European Heart Journal (2014) **35**, 2383–2431
doi:10.1093/eurheartj/ehu282
ESC/ESA GUIDELINES
European Society of Anaesthesiology ESA

2014 ESC/ESA Guidelines on non-cardiac surgery: cardiovascular assessment and management

- 7-11% de complications générales
- 0,8-1,5% de mortalité
- 42% < complications cardiaques
- Europe: 167 000 complications cardiaques par an dont 19 000 mortelles

Cause ?

Hypoperfusion tissulaire et inadéquation entre transport et consommation d'O2

DO2

VO2

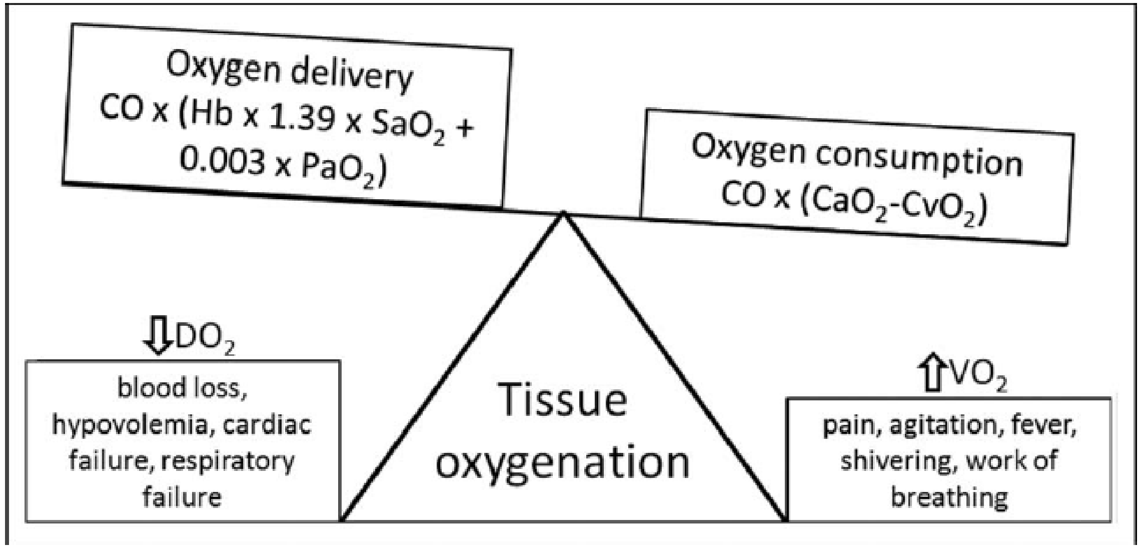


FIGURE 1. Factors affecting oxygen delivery and demand/consumption. CaO_2, arterial oxygen content; CO, cardiac output; CvO_2, venous oxygen content; DO_2, oxygen delivery; Hb, hemoglobin; PaO_2, arterial partial pressure of oxygen; SaO_2, arterial oxygen saturation; VO_2, oxygen consumption. For further explanation, see main text.

Molnar Z, et al.; Curr Opin Anaesthesiol. 2017 Apr;30(2):171-177

Objectifs du Monitorage hémodynamique

<u>En l'absence d'instabilité hémodynamique</u>:

- optimisation du transport artériel en oxygène (DO_2 = CaO_2 x **DC**)

<u>En présence d'une instabilité hémodynamique</u>:

- établir le mécanisme physiopathologique de l'insuffisance circulatoire
- choisir la stratégie thérapeutique la plus appropriée
- surveiller l'efficacité des actions thérapeutiques entreprises

Goal Directed Therapy

- ↓ **Mortalité** chez les patients à haut risque (> 20 % mortalité)
- ↓ **Morbidité** (infections, fuites anastomoses)
- ↓ Durée de séjour (1-2 j)
- Chirurgie digestive et à très haut risque
- Variations respiratoires de la précharge

Anesthesiology 2002; 97:820–6

Goal-directed Intraoperative Fluid Administration Reduces Length of Hospital Stay after Major Surgery

Tong J. Gan, M.B., B.S, F.R.C.A., Andrew Soppitt, B.Sc., M.B., B.S., F.R.C.A.,† Mohamed Maroof, M.D.,‡ Habib El-Moalem, Ph.D.,§ Kerri M. Robertson, M.D.,* Eugene Moretti, M.D.,† Peter Dwane, M.D.,‡ Peter S. A. Glass, M.B., F.F.A. (S.A.)‖*

Cecconi *et al. Critical Care* 2013, **17**:209
http://ccforum.com/content/17/2/209

CRITICAL CARE

REVIEW

Clinical review: Goal-directed therapy - what is the evidence in surgical patients? The effect on different risk groups

Maurizio Cecconi*, Carlos Corredor, Nishkantha Arulkumaran, Gihan Abuella, Jonathan Ball, R Michael Grounds, Mark Hamilton and Andrew Rhodes

Intraoperative intravascular volume optimisation and length of hospital stay after repair of proximal femoral fracture: randomised controlled trial

Susan Sinclair, Sally James, Mervyn Singer

BMJ VOLUME 315 11 OCTOBER 1997

BJA

British Journal of Anaesthesia, 128 (3): 416–433 (2022)

doi: 10.1016/j.bja.2021.10.046
Advance Access Publication Date: 13 December 2021
Review Article

CLINICAL PRACTICE

Goal-directed haemodynamic therapy during general anaesthesia for noncardiac surgery: a systematic review and meta-analysis

Pourquoi monitorer ?

Fluids are drugs: type, dose and toxicity

Karthik Raghunathan[a], Andrew D. Shaw[a,b], and Sean M. Bagshaw[c]

Curr Opin Crit Care 2013, 19:290–298

Perioperative fluids: a clear road ahead?

Zhi-Yong Peng and John A. Kellum

Curr Opin Crit Care 2013, 19:353–358

ERAS et GDT

Review Article

Goal-directed fluid therapy in the perioperative setting

Julia B. Kendrick, Alan David Kaye, Yiru Tong[1], Kumar Belani[2], Richard D. Urman[3], Christopher Hoffman[4], Henry Liu[4]

Abstract

Improvement in patient outcomes has become a significant consideration with our limited resources in the surgical setting. The implementation of enhanced recovery pathway protocols has resulted in significant benefits to both the patients and hospitals, such as shorter length of hospital stays, reduction in the rate of complications, and fewer hospital readmissions. An emerging component and a key element for the success of Enhanced Recovery After Surgery (ERAS) protocols has been the concept of goal-directed fluid therapy (GDT). GDT related to ERAS protocols attempts to minimize complications associated with fluid imbalance during surgery. We performed a literature search for articles that included the terms enhanced recovery and GDT. We

- **Réponse au remplissage < Indices dynamiques (VVE)**
- **Eviter l'overload !**

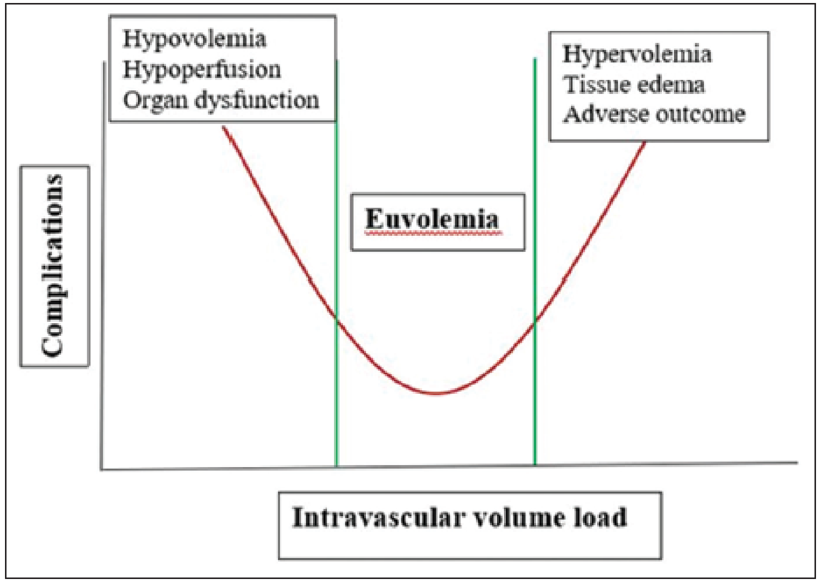


Figure 1: A depiction of how fluid overload can lead to interstitial edema and local inflammation, impairing the regeneration of collagen, and thus negatively affecting tissue healing and increasing the risk of wound dehiscence, wound infections, and anastomotic leakage

J Anaesthesiol Clin Pharmacol 2019;35:S29-34

GUIDELINES

ACC/AHA Clinical Practice Guideline

2014 ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

Developed in Collaboration With the American College of Surgeons, American Society of Anesthesiologists, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and Society of Vascular Medicine

Endorsed by the Society of Hospital Medicine

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This document was approved by the American College of Cardiology Board of Trustees and the American Heart Association Science Advisory and Coordinating Committee in July 2014.

The online-only Comprehensive Relationships Data Supplement is available with this article at http://circ.ahajournals.org/lookup/suppl/doi:10.1161/CIR.0000000000000106/-/DC1.

The online-only Data Supplement files are available with this article at http://circ.ahajournals.org/lookup/suppl/doi:10.1161/CIR.0000000000000106/-/DC2.

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This article has been copublished in *Journal of the American College of Cardiology*.

(*Circulation*. 2014;130:e278–e333.)

Circulation is available at http://circ.ahajournals.org DOI: 10.1161/CIR.0000000000000106

European Heart Journal (2014) 35, 2383–2431
doi:10.1093/eurheartj/ehu282

ESC/ESA GUIDELINES

European Society of Anaesthesiology ESA

2014 ESC/ESA Guidelines on non-cardiac surgery: cardiovascular assessment and management

The Joint Task Force on non-cardiac surgery: cardiovascular assessment and management of the European Society of Cardiology (ESC) and the European Society of Anaesthesiology (ESA)

Authors/Task Force Members: Steen Dalby Kristensen* (Chairperson) (Denmark), Juhani Knuuti* (Chairperson) (Finland), Antti Saraste (Finland), Stefan Anker (Germany), Hans Erik Bøtker (Denmark), Stefan De Hert (Belgium), Ian Ford (UK), Jose Ramón Gonzalez-Juanatey (Spain), Bulent Gorenek (Turkey), Guy Robert Heyndrickx (Belgium), Andreas Hoeft (Germany), Kurt Huber (Austria), Bernard Iung (France), Keld Per Kjeldsen (Denmark), Dan Longrois (France), Thomas F. Lüscher (Switzerland), Luc Pierard (Belgium), Stuart Pocock (UK), Susanna Price (UK), Marco Roffi (Switzerland), Per Anton Sirnes (Norway), Miguel Sousa-Uva (Portugal), Vasilis Voudris (Greece), Christian Funck-Brentano (France).

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Other ESC entities having participated in the development of this document:

ESC Associations: Acute Cardiovascular Care Association (ACCA); European Association for Cardiovascular Prevention & Rehabilitation (EACPR); European Association of Cardiovascular Imaging (EACVI); European Association of Percutaneous Cardiovascular Interventions (EAPCI); European Heart Rhythm Association (EHRA); Heart Failure Association (HFA).

ESC Councils: Council for Cardiology Practice (CCP); Council on Cardiovascular Primary Care (CCPC).

ESC Working Groups: Cardiovascular Pharmacology and Drug Therapy; Cardiovascular Surgery; Hypertension and the Heart; Nuclear Cardiology and Cardiac Computed Tomography; Thrombosis; Valvular Heart Disease.

Le patient à haut risque cardiaque

- Le patient porteur d'une maladie cardiaque susceptible
- d'entraîner des complications lors d'une **chirurgie non-cardiaque**

- Le risque de complications depend:

- - de l'état de base du patient
- - la présence de comorbidités
- - le degré d'urgence, type et durée de la procedure chirurgicale

Le patient à haut risque cardiaque

- Cardiopathie ischémique
- Cardiopathie valvulaire
- Insuffisance cardiaque
- Cardiomyopathie
- Arythmie, maladie pulmonaire vasculaire
- Cardiopathie congénitale adulte

Risque chirurgical
ESC/ESA 2014

Table 3 Surgical risk estimate according to type of surgery or intervention[a,b]

Low-risk: < 1%	Intermediate-risk: 1–5%	High-risk: > 5%
• Superficial surgery • Breast • Dental • Endocrine: thyroid • Eye • Reconstructive • Carotid asymptomatic (CEA or CAS) • Gynaecology: minor • Orthopaedic: minor (meniscectomy) • Urological: minor (transurethral resection of the prostate)	• Intraperitoneal: splenectomy, hiatal hernia repair, cholecystectomy • Carotid symptomatic (CEA or CAS) • Peripheral arterial angioplasty • Endovascular aneurysm repair • Head and neck surgery • Neurological or orthopaedic: major (hip and spine surgery) • Urological or gynaecological: major • Renal transplant • Intra-thoracic: non-major	• Aortic and major vascular surgery • Open lower limb revascularization or amputation or thromboembolectomy • Duodeno-pancreatic surgery • Liver resection, bile duct surgery • Oesophagectomy • Repair of perforated bowel • Adrenal resection • Total cystectomy • Pneumonectomy • Pulmonary or liver transplant

CAS = carotid artery stenting; CEA = carotid endarterectomy.

[a]Surgical risk estimate is a broad approximation of 30-day risk of cardiovascular death and myocardial infarction that takes into account only the specific surgical intervention, without considering the patient's comorbidities.

[b]Adapted from Glance et al.[11]

European Heart Journal
doi:10.1093/eurheartj/ehu282

European Heart Journal (2014) 35, 2383–2431
doi:10.1093/eurheartj/ehu282

ESC/ESA GUIDELINES

2014 ESC/ESA Guidelines on non-cardiac surgery: cardiovascular assessment and management

The Joint Task Force on non-cardiac surgery: cardiovascular assessment and management of the European Society of Cardiology (ESC) and the European Society of Anaesthesiology (ESA)

Recommendations on anaesthesia

Recommendations	Class[a]	Level[b]	Ref.[c]
Patients with high cardiac and surgical risk should be considered for goal-directed therapy.	IIa	B	261–264

European Heart Journal (2014) 35, 2383–2431
doi:10.1093/eurheartj/ehu282
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Monitorage et GDT

		Surgery-related risk		
		Low < 1 %	Moderate < 5 %	High > 5 %
Patient-related risk	Low	Stand	SV	SV/CO
	Moderate	Stand	SV	SV/CO
	High	Stand ?	SV/CO	SV + $ScvO_2$

Quels paramètres monitorer ?

« Traditionnels »: **FC (ECG), PA, PAM, PVC, diurèse…**

- pas de spécificité / sensibilité

SvO2: étudiée en chirurgie cardiaque

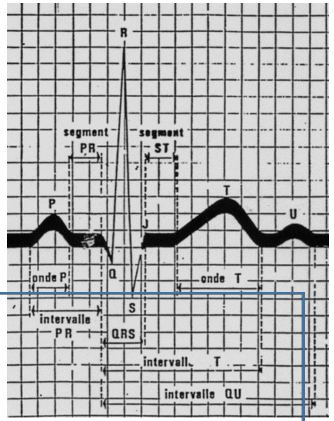
ScvO2: ↓morbidité et durée de séjour après chirurgie abdominale

Donati A, et al.; Chest 2007; 132: 1817–24

DC/IC

Indices dynamiques de Remplissage: SV + …

ECG



Troubles du rythme et de la conduction

- **DII**
- + ischémie paroi inférieure

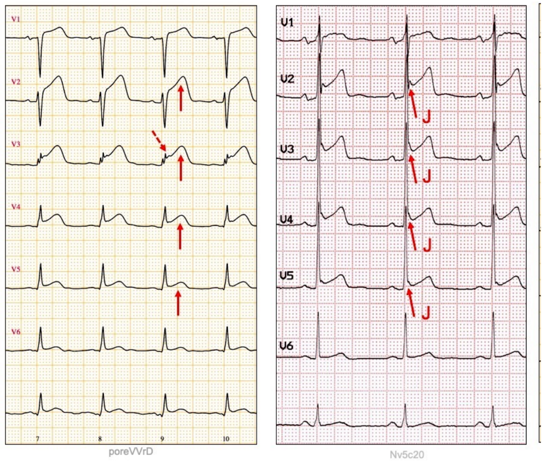
Insuffisance coronarienne aiguë

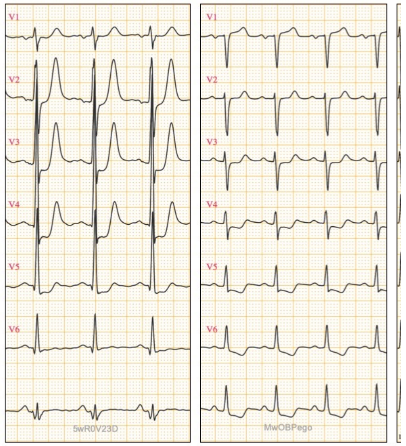
- **V5**
- ischémie paroi antérieur et latérale
- **Segment ST**: *t dépolarisation cellules myocardiques*

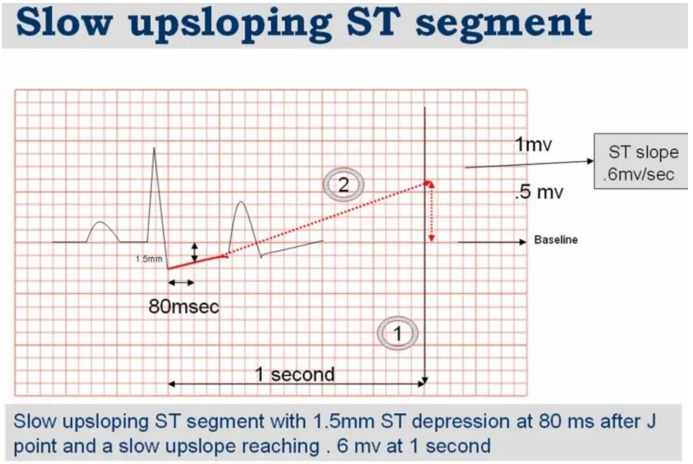
✓ sous/sus décalage, > ou < à 0,1 mV (~ 1 mm), pdt > 20 sec, 60-80 msec après J point

✓ si ST à pente ascendante: sous décalage > 2 mm, 80 msec après J

Segment ST







Erreurs d'interprétation:

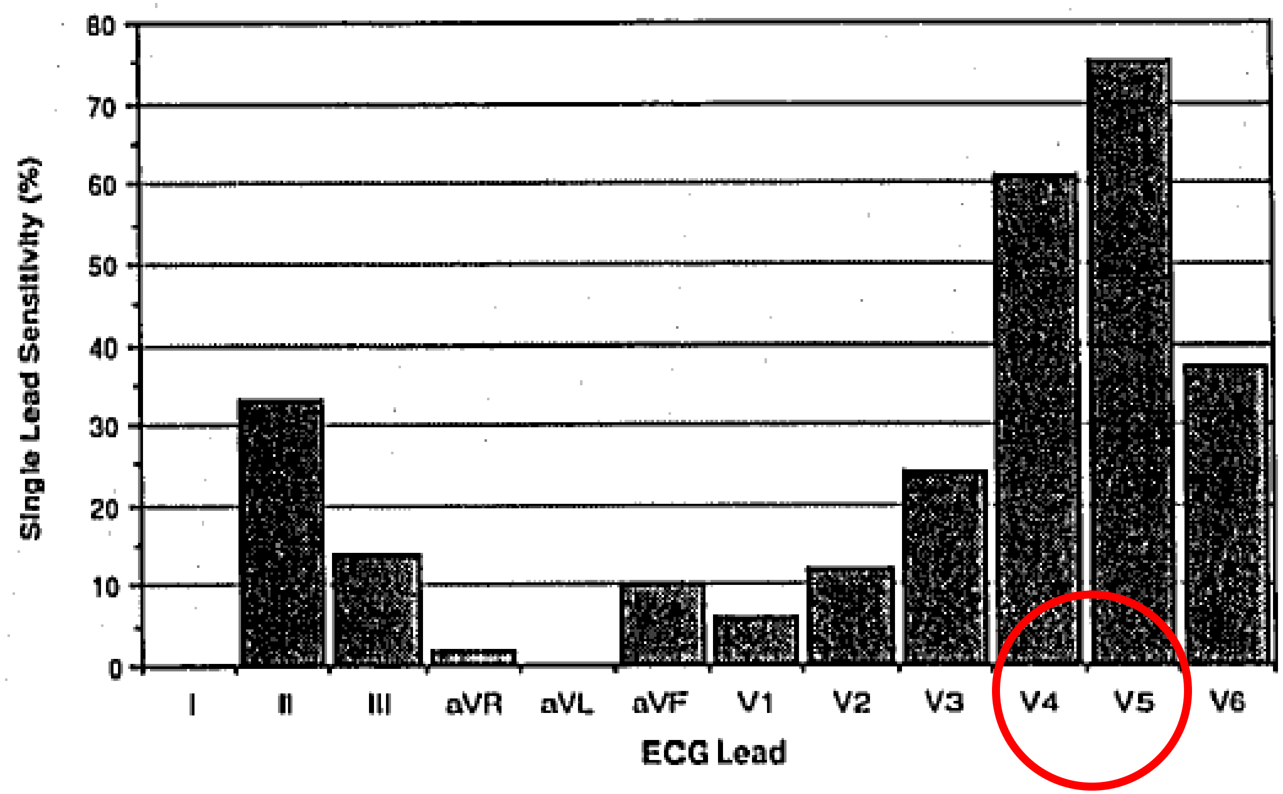
- **bloc de branche (gauche en particulier)**
- WPW
- tachycardie, PM
- hypokaliémie (calcémie, magnésémie)
- hypothermie, hypocapnie
- digitaliques
- HVG
- cycle respiratoire
- position des électrodes

Interférences:

- obésité
- hyperinflation pulmonaire
- épanchements péricardique, pleuraux
- tremblements, frissons
- électrocautère

Ischémie peropératoire

London MJ, et al. **Intraoperative myocardial ischemia: localizations by continuous 12-lead electrocardiography.** ***Anesthesiology*** 1988; 69: 232-241.

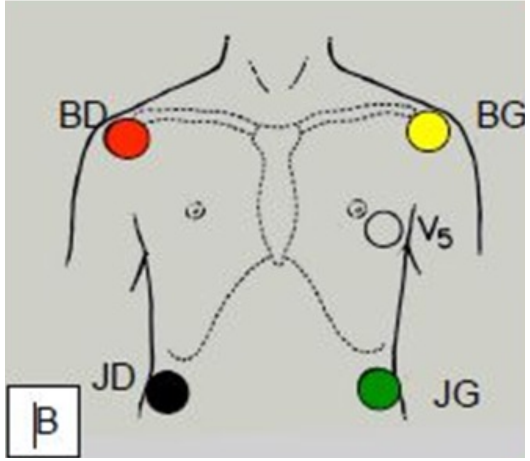


↑ sensibilité détection ST :

- **II + V5: 80%**
- **V4 + V5: 90%**
- **II, V4, V5: 96%**
- **II, V2, V3, V4, V5: 100%**

Positionnement des électrodes

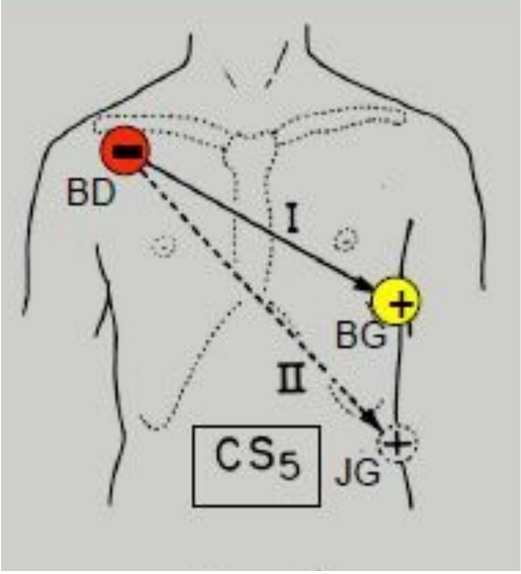
Scope 5 dérivations:



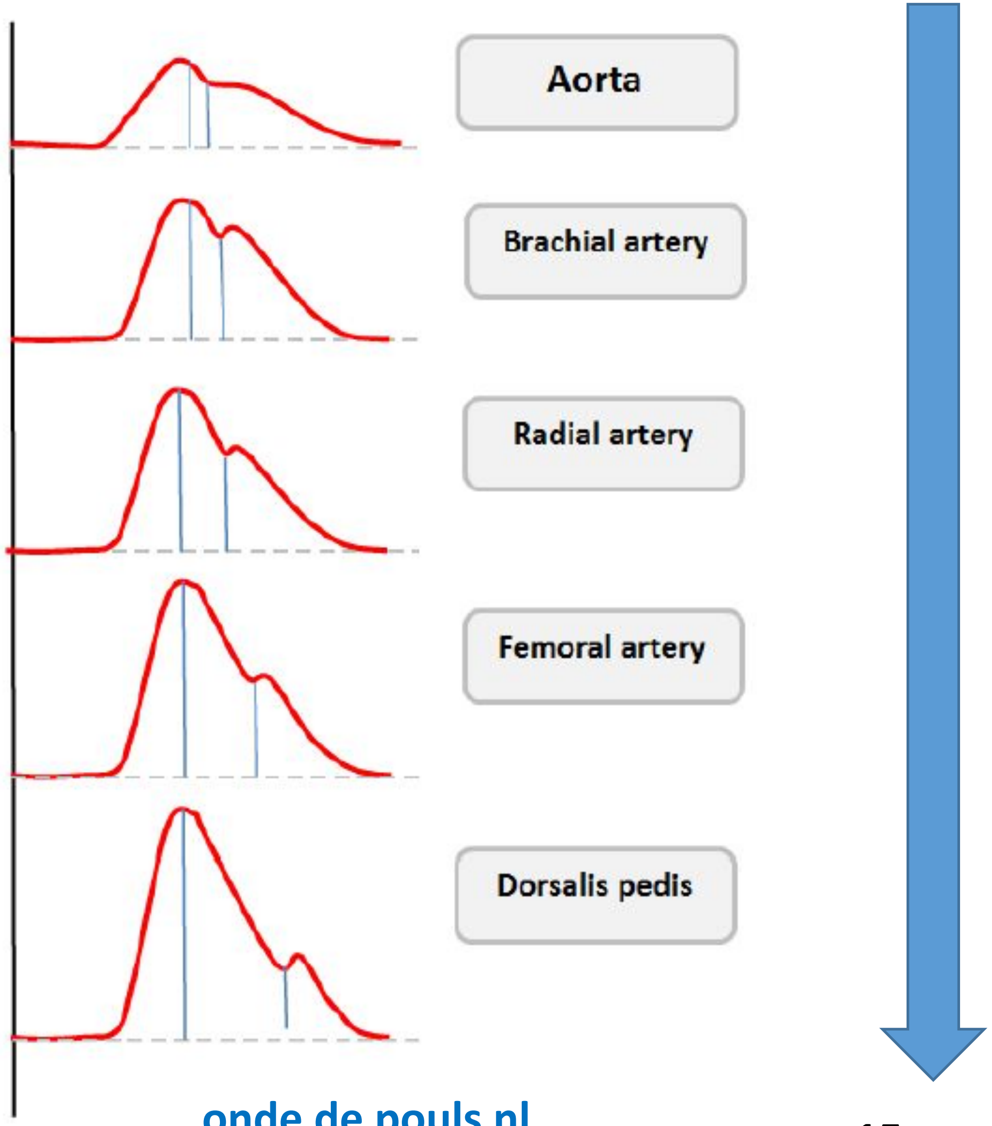
- ✓ **V5 et DII**
- ✓ haut risque cardiaque, chirurgie lourde (vasculaire, cardiaque..)

Scope 3 dérivations:

- ✓ **V5** modifiée (CS5)



Pression artérielle (PA)



onde de pouls nl

+ 15 mm Hg

Mesure invasive (continue):

Le pic systolique ↑

L'onde dicrote s'éloigne

PAD ↓

MAP ~ $MAP = \frac{2\,(DBP) + SBP}{3}$

PAi vs PNI: PAS + 5%, PAD – 8%, PAM ≤ 5%

Pression artérielle invasive (PAi)

Indications

- états de choc
- soins intensifs, vasopresseurs, inotropes, PA continue
- variations rapides prévisibles ou volontaires de la pression (shift volémique, chirurgie cardiaque, Rx interventionnelle…)
- prélèvements artériels fréquents
- mesure non-invasive difficile ou impossible
- analyse de l'aspect de la courbe

Contre-indications

- absence de flux collatéral *
- pathologie vasculaires périphériques
- désordre de coagulation
- infection topique, lésions cutanées, chirurgie vasculaire

* *Test d'Allen: recoloration nle 5-10 s*

Inconvénients:

thrombose, infection, embolisation, hématome, injection accidentelle, lésion…

Pression artérielle invasive: voies d'abord

Voies d'abord	Caractéristiques

Artère radiale 	• La plus souvent utilisée pour le cathétérisme, du fait de sa situation superficielle, donc accessible et compressible, et de l'existence d'un réseau collatéral important par l'artère ulnaire et l'arcade palmaire.
	• Voie radiale réservée dans les cas de traumatisme des deux MI, de prothèse ou pontage vasculaire ou de pathologie abdominale grave.
	• Lors des purges sous pression, les embolies systémiques rétrogrades sont moins fréquentes que dans d'autres artères.
	• Contre-indication à la voie radiale:
	  • absence de suppléance lors du test d'Allen
	  • syndrome de Buerger
	  • hyperlipidémies majeures.

Artère ulnaire	• Alternative possible à la radiale (technique de ponction identique) • La pratique du test d'Allen s'impose, car cette artère est souvent l'artère dominante de la main
Artère fémorale 	• Site important du cathétérisme artériel privilégié dans les conditions d'urgence, car: • le diamètre de l'artère en facilite la ponction malgré la situation plus profonde • plus fiable que l'artère radiale, notamment en situation de choc • plus simple et plus rapide si un abord veineux fémoral est également requis (polytraumatisée) • sa pression reflète mieux la pression aortique.
Artère humérale	Ponction à proscrire en raison de l'absence de réseau de suppléance et du risque de lésions nerveuses.

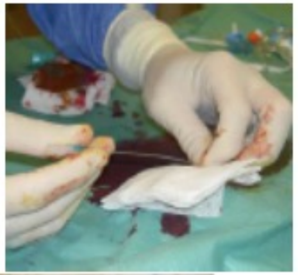
Pression artérielle invasive: fiche technique

4ème EIC

Mise en place

test d'Allen: vérifier la suppléance vasculaire (non complètement fiable !)
Pat inconsient: avec oxymétrie de pouls.

la mise en place du cathéter



Calibration - zéro - niveau

Essentials of Critical Care Nursing - A Holistic Approach - P. Morton, D. Fontaine (Lippincott, 2013)

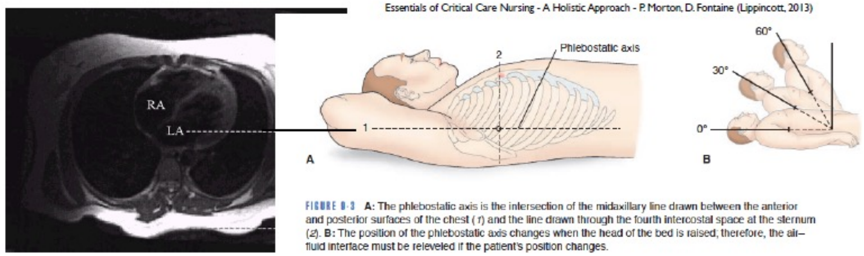
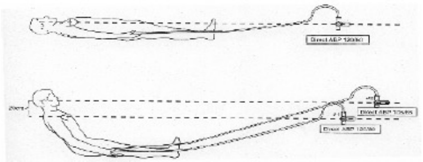
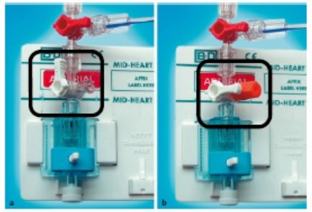


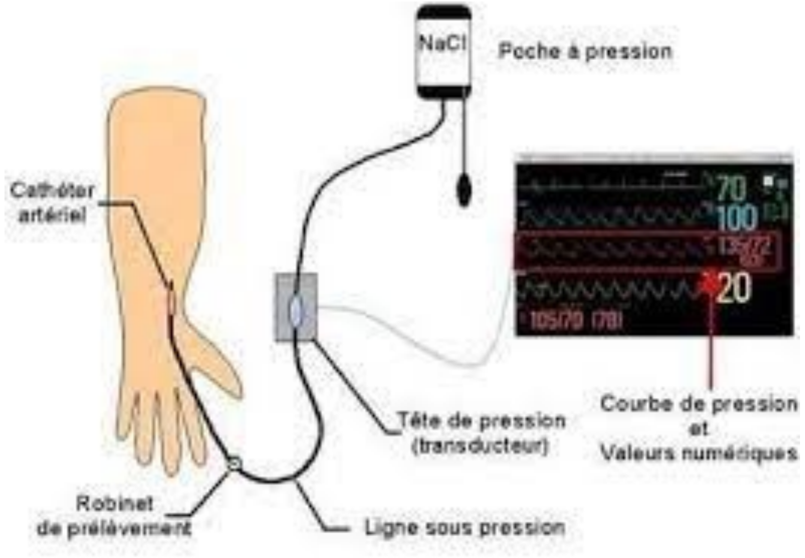
FIGURE 8-3 A: The phlebostatic axis is the intersection of the midaxillary line drawn between the anterior and posterior surfaces of the chest (1) and the line drawn through the fourth intercostal space at the sternum (2). B: The position of the phlebostatic axis changes when the head of the bed is raised; therefore, the air–fluid interface must be releveled if the patient's position changes.



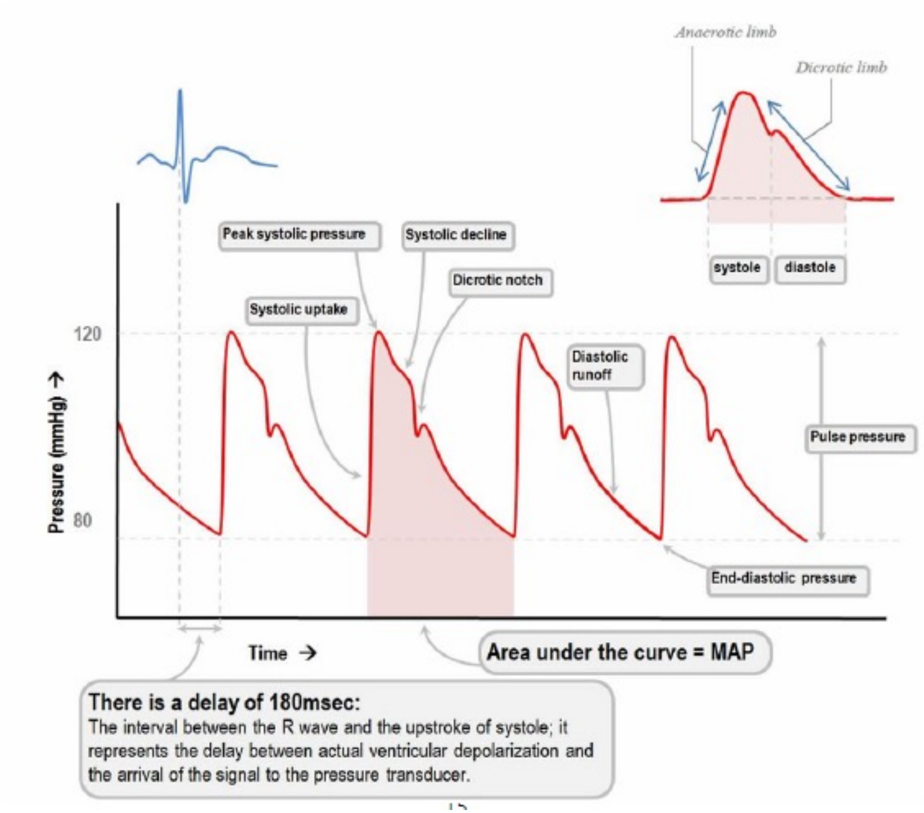


position de calibrage avec la pression atmosphérique

position de mesure



Mesure invasive PA et onde de pouls: lecture

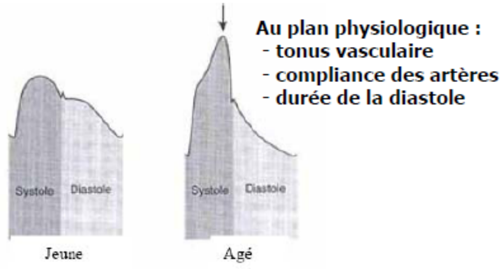


<u>Composantes du pouls artériel</u>

Pic de la pression systolique : à l'ouverture de la VAo, PS VG max

Onde dicrotique : fermeture VAo, fin de la systole/début de la diastole

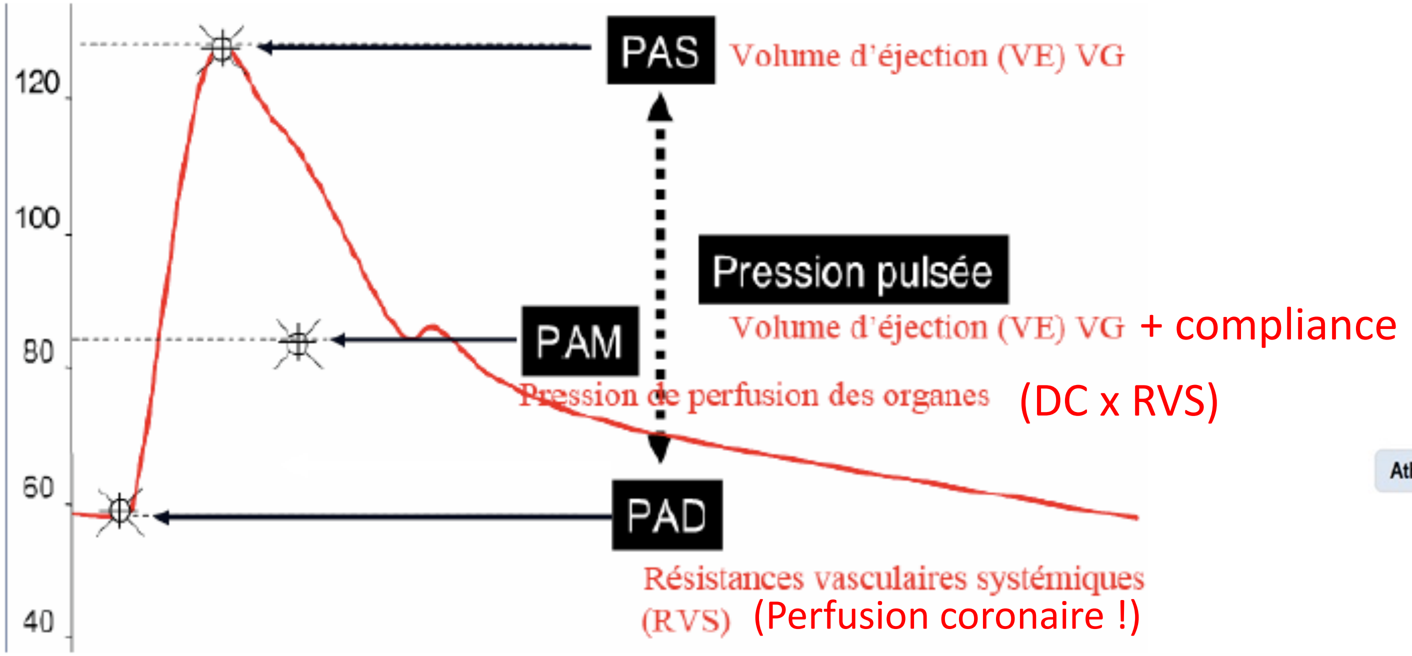
Pression diastolique : correspond à la quantité de vasoconstriction dans le système artériel

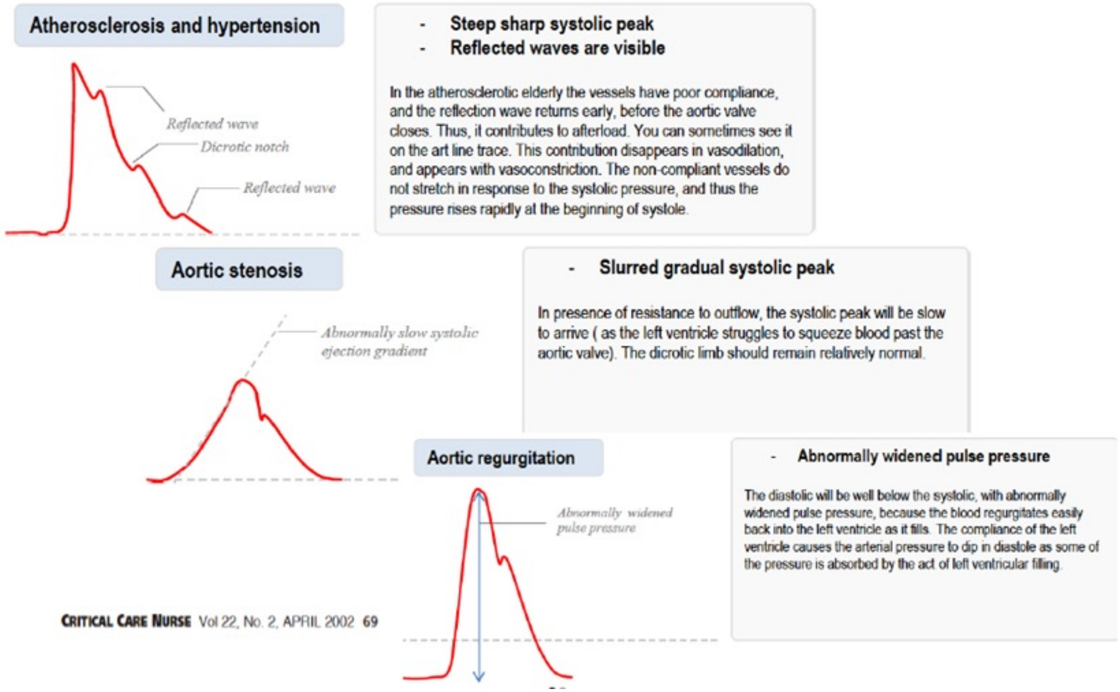


Impact de l'âge sur la morphologie de la courbe de pression

Courbe: représentation graphique physiologique, âge, terrain, site; PAM si état de choc

Mesure invasive PA et onde de pouls: interprétation





Hernandez G, Intensive Care Med. 2022 Oct;48

Saugel *et al. Critical Care* (2020) 24:172
https://doi.org/10.1186/s13054-020-02859-w

Critical Care

REVIEW Open Access

How to measure blood pressure using an arterial catheter: a systematic 5-step approach

Bernd Saugel[1,2*†], Karim Kouz[1†], Agnes S. Meidert[3], Leonie Schulte-Uentrop[1] and Stefano Romagnoli[4,5]

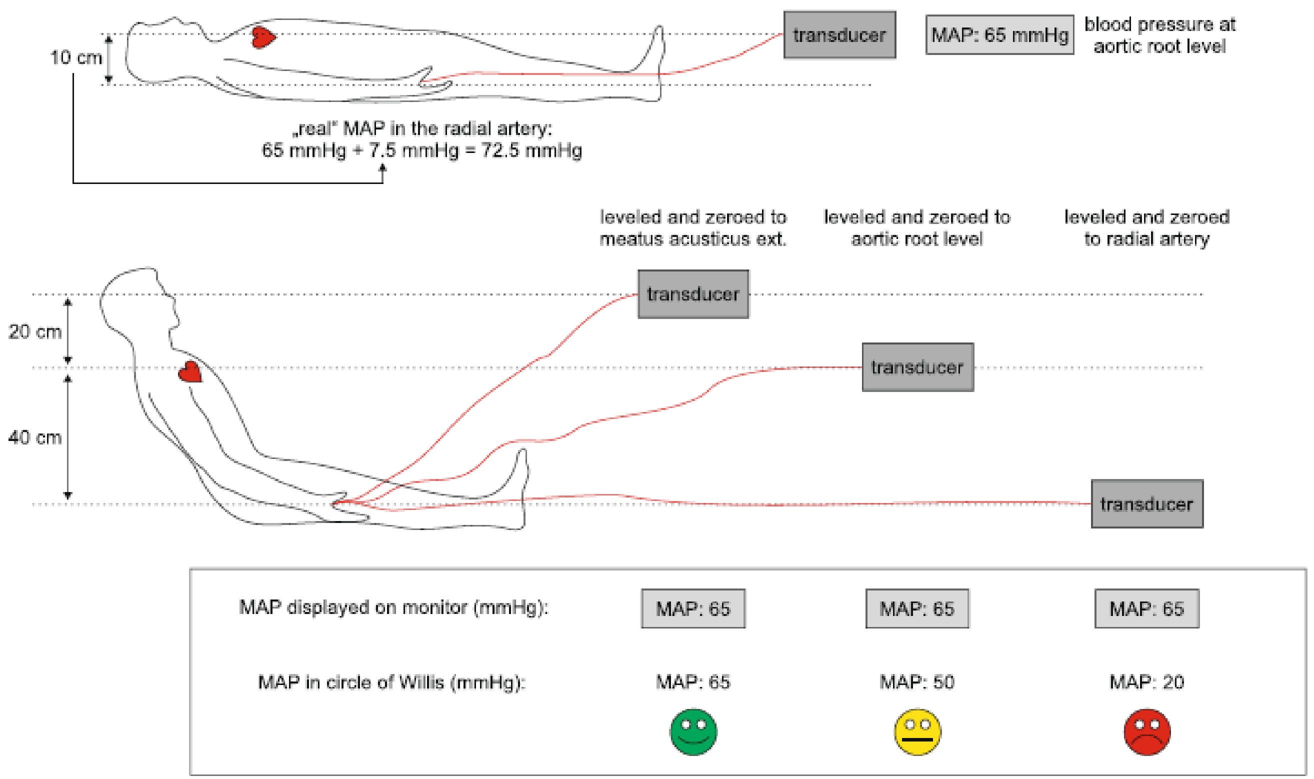
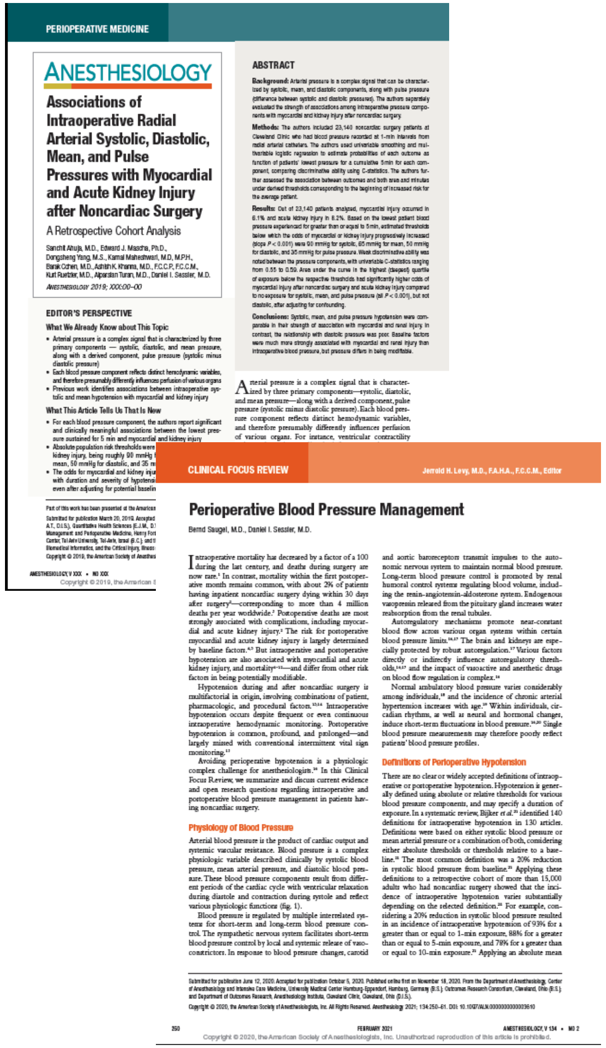


Fig. 1 Leveling and zeroing of the pressure transducer. A vertical difference of 10 cm between the pressure transducer and the artery of interest results in a pressure difference of 7.5 mmHg due to hydrostatic pressure. Especially in non-supine positions (e.g., beach chair), wrong leveling and zeroing can result in wrong therapeutic actions with the consequence of low perfusion pressure in the circle of Willis

TA et comorbidités

MAP < 65 mmHg, 20'
MAP < 50 mm Hg, 5'
MAP < 40 mm Hg
PP < 35 mm Hg



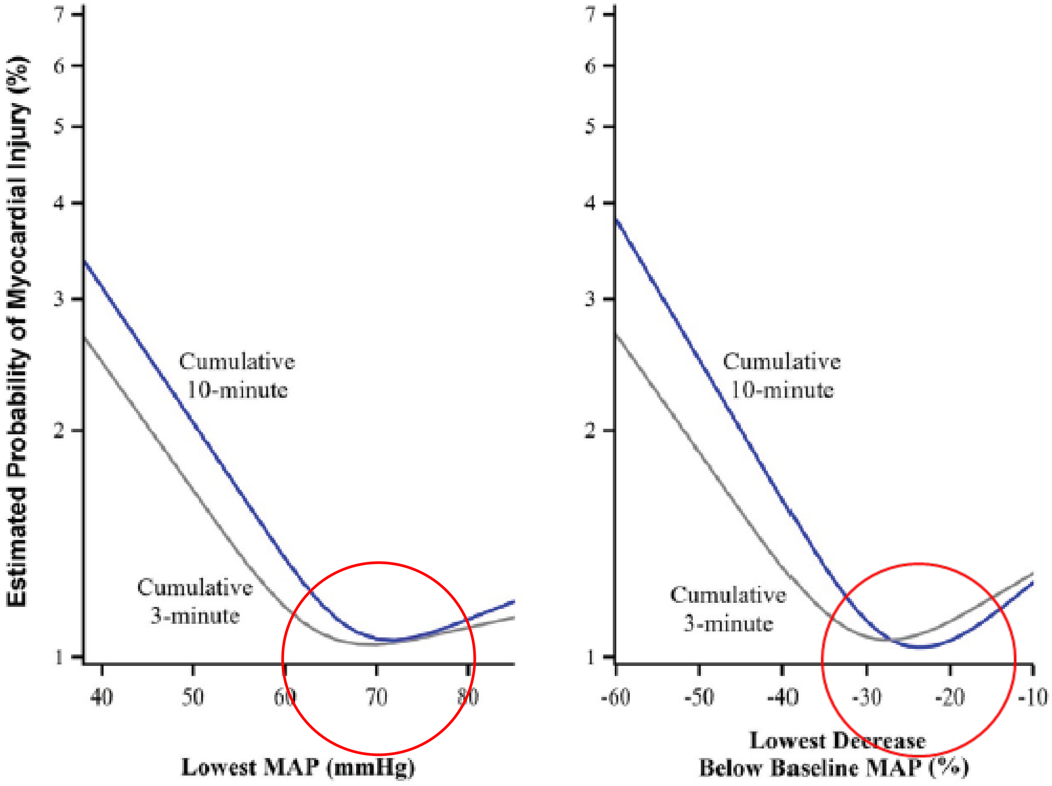


Fig. 2. Lowest mean arterial pressure (MAP) thresholds for myocardial injury after noncardiac surgery. The *left-hand graph* shows multivariable relationships between myocardial injury after noncardiac surgery and lowest absolute MAP thresholds that were sustained for a cumulative 3 and 10 min. The *right-hand graph* shows multivariable relationships between myocardial injury after noncardiac surgery and lowest relative MAP thresholds compared with preoperative clinic MAP that were sustained for a cumulative 3 and 10 min. Multivariable logistic regressions were smoothed by restricted cubic spline with 3 degrees and knots at 10th, 50th, and 90th percentiles of given exposure variable. With permission from Salmasi *et al.*[7]

Recommandations des sociétés savantes sur le monitorage hémodynamique en vigueur en 2022

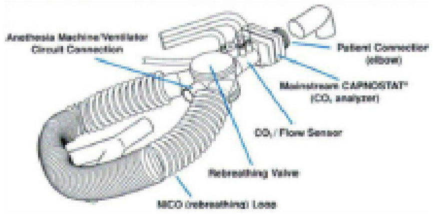
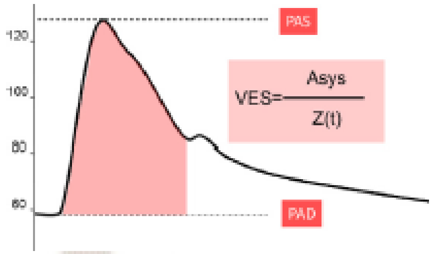
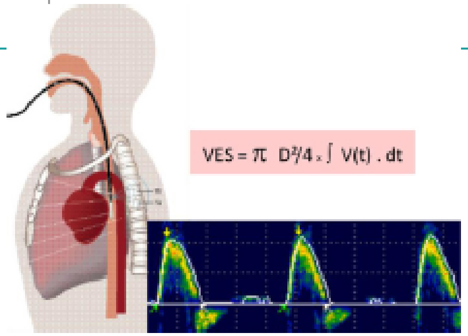
	SFAR (2013) [2]	ESC/ESA (2014) [3]	ACC/ASA (2014) [4]	CCS (2017) [5]
Monitorage du volume d'éjection systolique	Recommandation pour guider le remplissage vasculaire chez les patients à haut risque (grade I+) ; recommandation de réévaluer régulièrement le VES, en particulier en cas d'instabilité hémodynamique (grade I+) ; pas de précision sur la méthode de mesure à privilégier	Recommandation d'une prise en charge basée sur des objectifs personnalisés (*goal-directed therapy*) utilisant notamment une mesure du VES chez les patients à haut risque (grade IIa)	Non discuté	Non discuté
Utilisation du cathéter artériel pulmonaire	Non discuté	Non recommandé pour le monitorage en chirurgie non cardiaque	Recommandation de ne pas utiliser le CAP en routine ; technique à réserver aux cas d'instabilité hémodynamique complexe	Recommandation de ne pas utiliser de CAP pour l chirurgie non cardiaque
Monitorage de la pression artérielle	Non discuté	Éviter l'hypotension artérielle (pression artérielle moyenne < 60 mmHg) pendant des périodes prolongées (= périodes cumulatives prolongées > 30 minutes) (grade IIb) ; pas de précision sur la méthode de mesure de la pression artérielle	Non discuté	Non discuté

Gayat E, Anesth Reanim. 2022; 8: 152–157
Fellahi et al. Ann. Intensive Care (2021) 11:58

Débit cardiaque (DC)

- Le plus souvent, le seul aspect de la perfusion que nous monitorons est la **pression artérielle systémique** (MAP= (SBP+ (2xDBP))/3)
- La PA est étroitement régulée et varie indépendamment du DC, même sous anesthésie
- La connaissance du DC est très utile pour évaluer l'autre aspect de la perfusion: « transport »
- Le **débit** est plus sensible que la pression pour détecter une altération de fonction cardio-vasculaire!

Méthodes mini-invasives de mesure du DC

Principes	Méthode de mesure	Explication	Avantages et limites
Ré-inhalation partielle du CO_2	<u>Modified Fick's equation</u> $CO = \Delta VCO_2 / S \times \Delta EtCO_2$  	Cette méthode applique le principe de Ficks, en utilisant la concentration expérimentale de dioxyde de carbone (CO_2). Le CO_2 veineux (VCO_2) peut être calculé à partir de la différence entre les gaz inspirés et expirés. Le système utilise une boucle supplémentaire du circuit ventilatoire pour créer une ré-inspiration partielle transitoire de CO_2, augmentant ainsi le CO_2 *end-tidal* ($EtCO_2$). Le débit cardiaque (DC) est estimé à partir du rapport entre la variation de la VCO_2 et de l'$EtCO_2$ pendant la période de ré-inhalation	Avantages : mesure continue du DC ; moins invasif que le cathéter artériel pulmonaire. Limites : besoin d'être intubé sous ventilation artificielle ; affecté par le niveau de shunt intra-pulmonaire
Analyse du contour de l'onde de pouls	 	L'analyse du contour de l'onde de pouls repose sur l'hypothèse que la forme d'onde de la pression artérielle est directement liée à la variation du volume systolique. Le volume systolique (SV) est proportionnel à l'aire sous la portion systolique (Asys) et inversement proportionnel à l'impédance (Z(t))	Avantages : mesure continue du DC ; moins invasif que le cathéter artériel pulmonaire. Limites : limitations en cas d'utilisation de vasopresseurs et chez les patients sévèrement instables ; invalide en cas de maladie artérielle sévère et en cas d'arythmie
Doppler transœsophagien	 	À l'aide d'une sonde insérée dans l'œsophage, la vitesse du sang est mesurée dans l'aorte descendante. L'intégrale vitesse-temps (ITV) est mesurée à l'aide d'un Doppler à onde continue. Le diamètre (D) de l'aorte descendante est estimé à partir des données anthropométriques des patients. Enfin, le volume d'attaque est extrapolé à partir du volume dans l'aorte descendante selon un rapport fixe du flux sanguin entre les axes supra-aortiques et l'aorte descendante	Avantages : pas de besoin de cathéter veineux central ou artériel ; mesure continue du DC ; toujours valide en cas d'arythmie. Limites : instabilité du signal ; courbe d'apprentissage ; estimation du VES basée sur différentes hypothèses (diamètre aortique constant, répartition cranio-caudale du débit constant notamment)

Méthodes invasives:
dilution d'un indicateur coloré (lithium)
thermodilution

Indices de Remplissage

« Vieux vs Nouveaux »

Indices Statiques: concept « ancien »

- **basé sur des mesures de Pressions**
- *invasifs et non-invasifs*

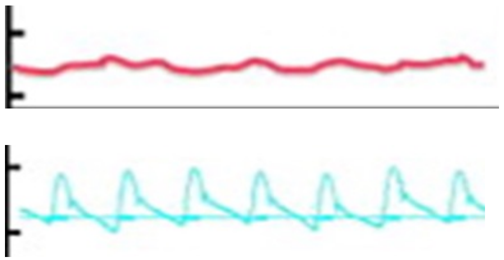
Indices Dynamiques: concept « jeune »

- **basé sur l'interaction Cœur – Poumon**
- analyse du contour de l'onde de pouls
- *invasifs et non-invasifs*

Indices de Remplissage Statiques

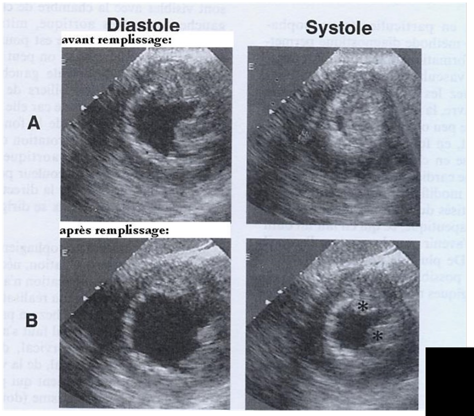
Invasifs:

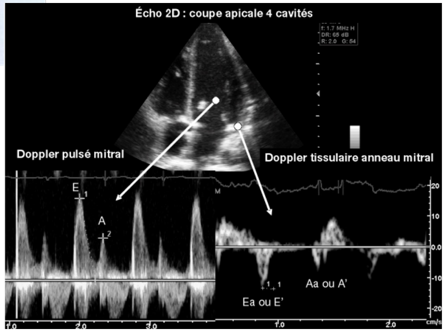
- Mesure Pressions de remplissage (PVC – PAC)
- Volume télédiastoliqe ventriculaire droit (PAC)
- Volume Sanguin intracardiaque (PiCCO)



Non Invasifs:

- Surface télédiastolique du VG (Echo)
- Flux Mitral (PWD) / Doppler tissulaire anneau Mitral





Indices de remplissage Dynamiques

1) Variations Respiratoires de la Veine Cave

- VCS accessible en ETO:
  - Index de collapsus: (VCSmax – VCSmin) / VCSmax
  - Index > 36 % = réponse au remplissage +
- VCI examiné en coupe sous-costale TTE:
  - Index > 18 % (limitation si P° intra-abdo ⍰)

Intensive Care Med 2004; 30

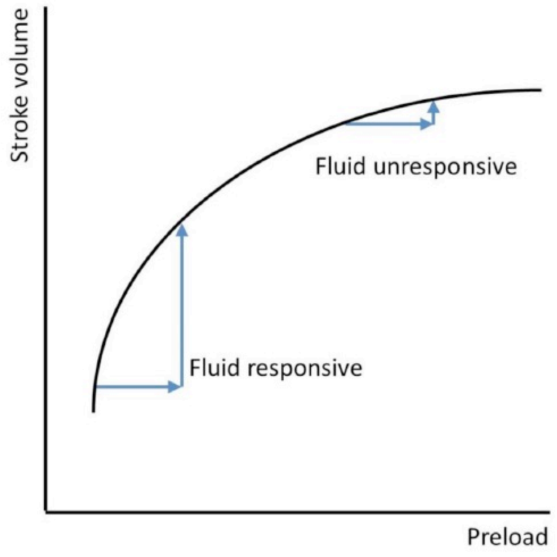
Limitations des techniques Echo: échogénicité / opérateur

Indices de remplissage Dynamiques

2) VVE: variations Respiratoires du VES

- Intégrale Temps-Vitesse doppler (échographie):
  - Longueur de la colonne de sang Traversant une A^2
  - VES = ITV x CSA
  - Ao CSA = constante -> Δ ITV = Δ VE (moins d'erreur)
  - **↑ 10-15% SV: répondeur**
  - Choc septique: ΔVpeak Ao 12 %: répondeurs au remplissage

  Feissel, Chest 2001; 119



Frank–Starling

Limitations des techniques Echo: échogénicité / opérateur

Indices de Remplissage Dynamiques

- **PiCCO (2002)**
  - DC calibré par Thermodilution Trans-pulmonaire
  - Analyse Contour de pouls: portion systolique -> VVE

  Limitations: Bulles, Plaques, Clots, Arythmies, IAO, IABP

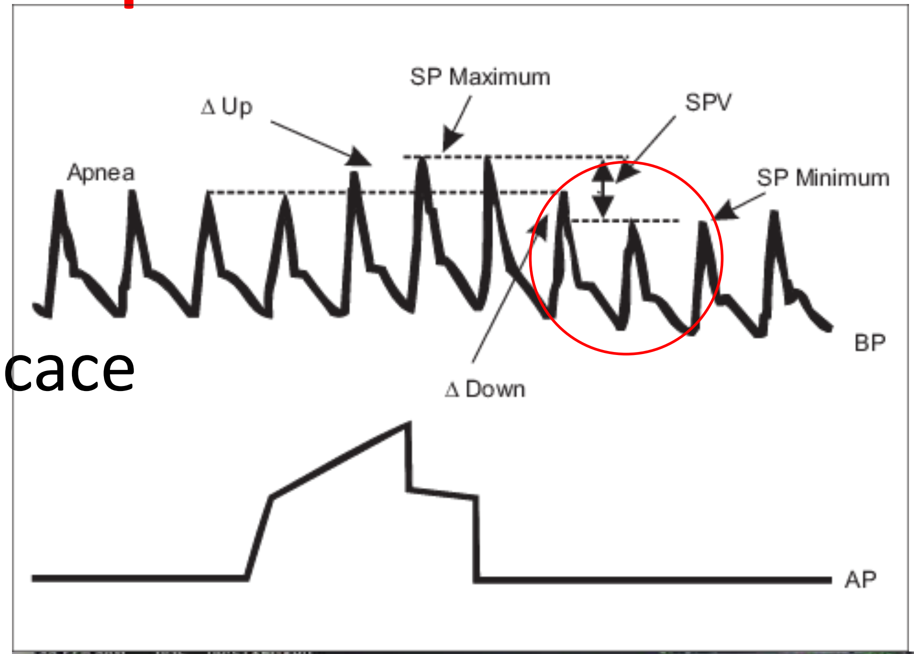
- **FloTrac / Vigileo (2005)**
  - Artère périphérique, analyse (2000 pts en 20sec)
  - VVE fiabilité similaire au PiCCO

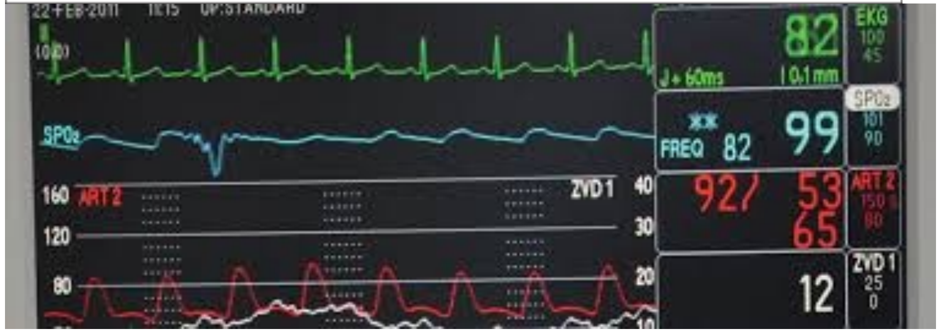
  Limitations: qualité signal d’artère, Arythmies, IABP, obésité

Indices de Remplissage Dynamiques

3) VPS: variations Respiratoires de la Pression Systolique

- Δ-Down: hypovolémie !
- PAS / PAS de référence (pause télé-expiratoire)
- Δ-Down > 5 mmHg = prédictif de remplissage efficace
- ↓ performant que ΔPP





Limitations:

- Ventilation Contrôlée
- VT > 8 ml/kg
- Rythme sinusal sans extrasystoles
- Défaillance droite

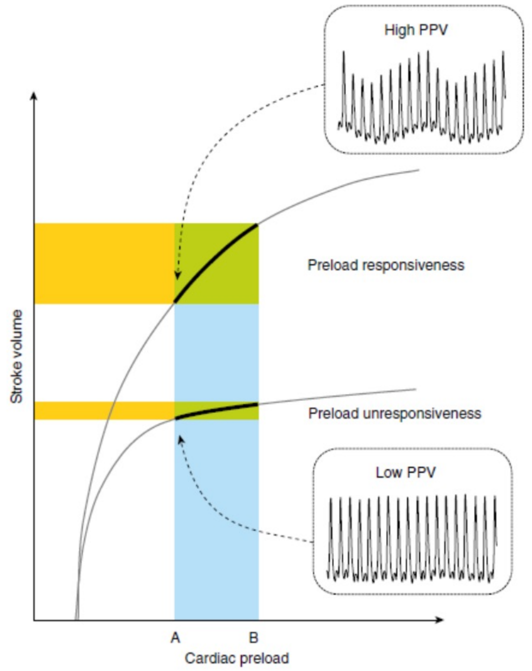
Frederic Michard, CHEST 2002; 121 / Benoit Tavernier, Anesthesiology 1998; 89)

Indices de Remplissage Dynamiques

4) VPP: Variations Respiratoires de la Pression Pulsée

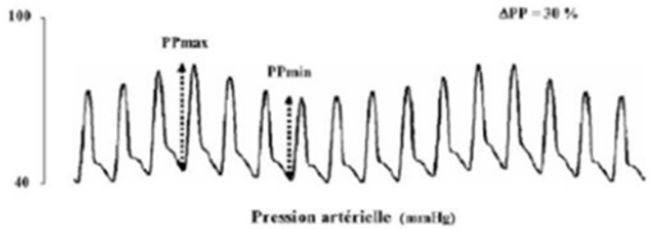
- **PP = PAS – PAD**
- **PP ~ VES**
- ΔPP %= (PPmax – PPmin) / (PPmax/2-Ppmin/2) x 100
- ↑ ΔPP= ↑ DC après remplissage
- VPP > 13 % = réponse au remplissage +

  (VPP 94% VPN 96%)



- Validé au cours du choc septique et en chir. cardiaque

  Michard, Am J Crit Care Med 2000;162 / Kramer, Chest 2004; 126



Limitations: idem que VPS, ARDS

Jean-Louis Teboul, Am J Respir Crit Care Med Vol 199

Indices de Remplissage Dynamiques

5) PVI: Variations Respiratoires de l'index de pléthysmographie
(Masimo Corp., Irvine, CA, USA)

$$PVI = \frac{PI_{max} - PI_{min}}{PI_{max}} \times 100$$

- Algorithme de mesure continue de ΔPOP
- Ratio entre la partie pulsatile et non-pulsatile du flux
- déterminé par le DC et l'activité sympathique
- ↑ range, tendance
- PPI: 4.3 (2.9–6.2)

6) ΔPOP: Variations de la courbe de pléthysmographie

$$\Delta POP = \frac{POP_{max} - POP_{min}}{POP_{mean}}$$

- corrélés avec VPP
- QOP

Limitations:
Vasoconstriction
T°

M. Cannesson, Br J Anaesth 2008; 101

Technique/équipement	Indice statique	Indice dynamique
Cathéter artériel pulmonaire	RAP, PAOP, RVEDV	-
Cathéter artériel	-	SPV, ΔDown, ΔPP
Cathéter artériel + ECG	-	ΔPEP
Echocardiographie-Doppler	STDVG	ΔVpeak, ΔDivc
PiCCO	GEDV, ITBV	SVV, PPV
LiDCO	-	SVV, PPV, SPV
Doppler esophagien	FTc	ΔABF
Oxymètre de pouls + ECG	-	ΔPEP

Existe-t'il un Monitorage IDEAL?

- DC – SvO2– VES
- Mini-invasif, continu, automatique, facile à utiliser, temps de réponse rapide
- Précis et reproductible, mesure fiable des variations, non opérateur dépendant
- Permettant une adaptation thérapeutique
- Bénéfique en terme de morbi-mortalité (stratégie préétablie)
- Techniques nombreuses, non exclusives, complémentaires

« Un outil de monitorage est cliniquement indiqué quand il a la capacité de détecter des anomalies ou des changements dans l’état physiologique du patient et quand il peut aider à guider la thérapeutique »

DJ Pierson, Principles and Practice of Intensive Care Monitoring

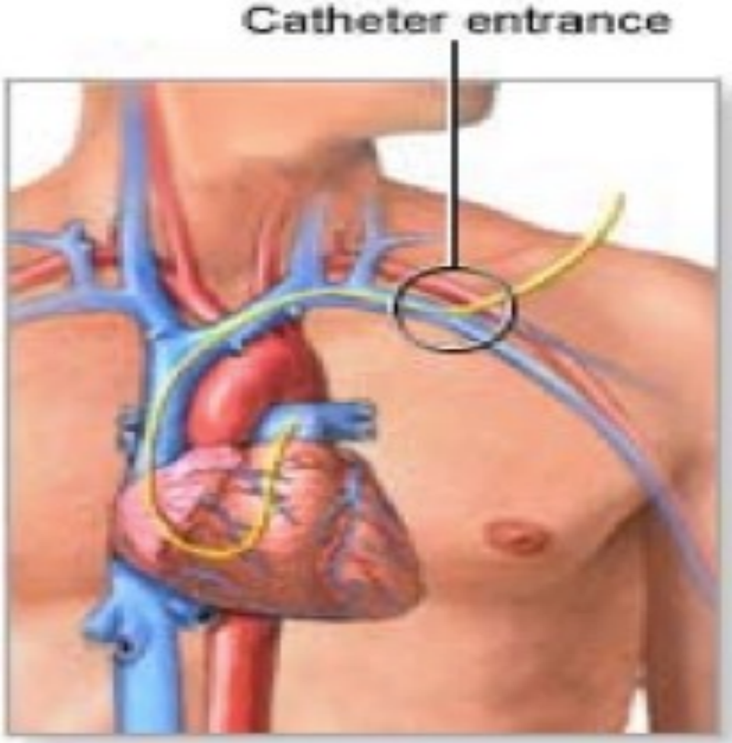
« La probabilité de survenue des anomalies ou changements recherchés doit être suffisante pour justifier l’inconfort, le travail et le surcoût engendrés par l’outil de monitorage. »

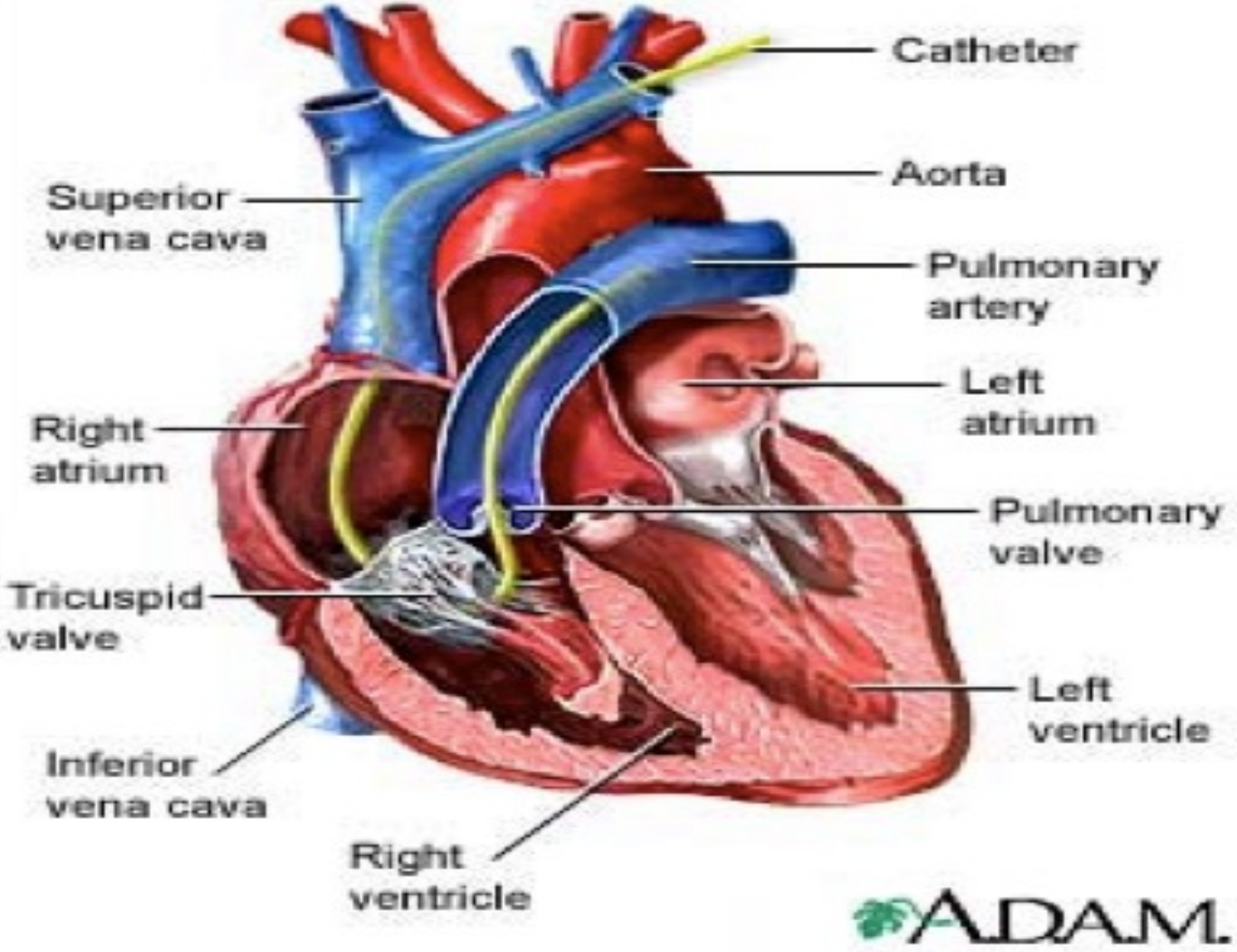
DJ Pierson, Principles and Practice of Intensive Care Monitoring

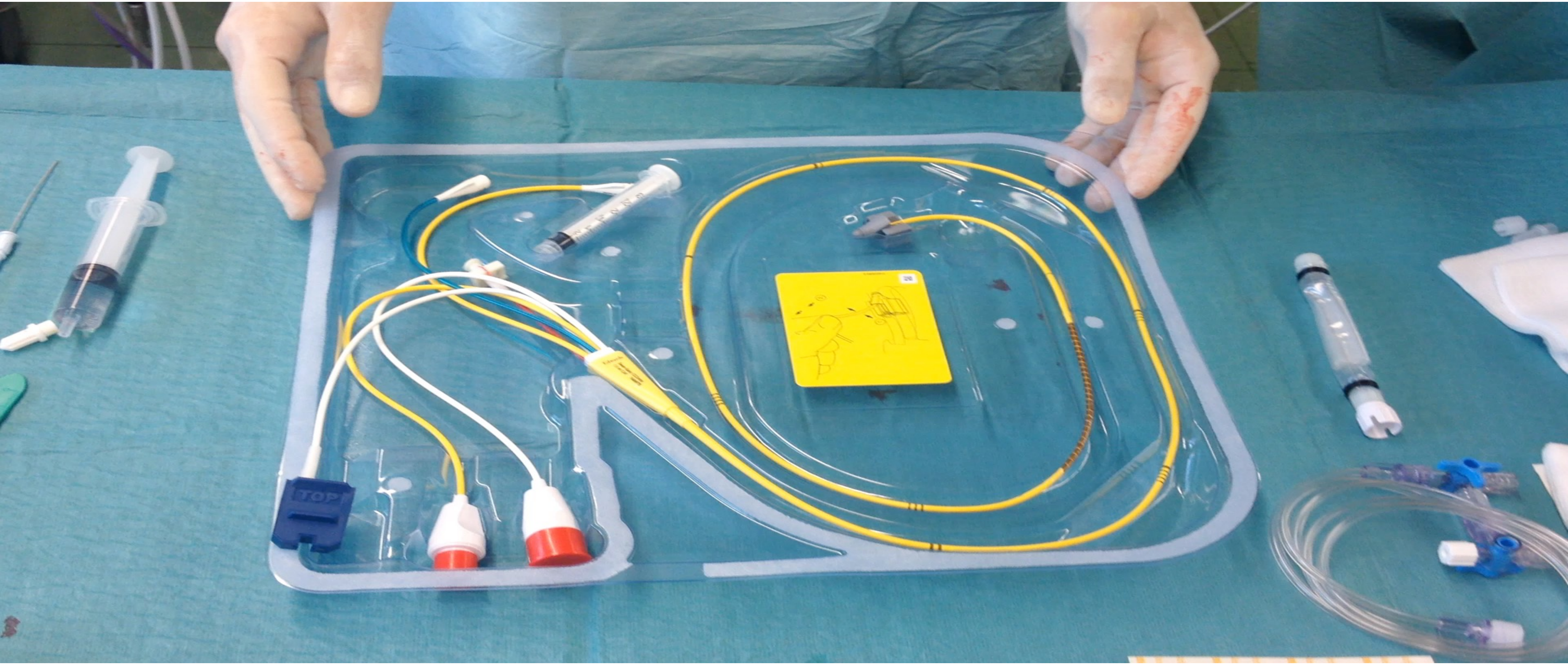
Différentes techniques: invasives, mini-invasives, non-invasives

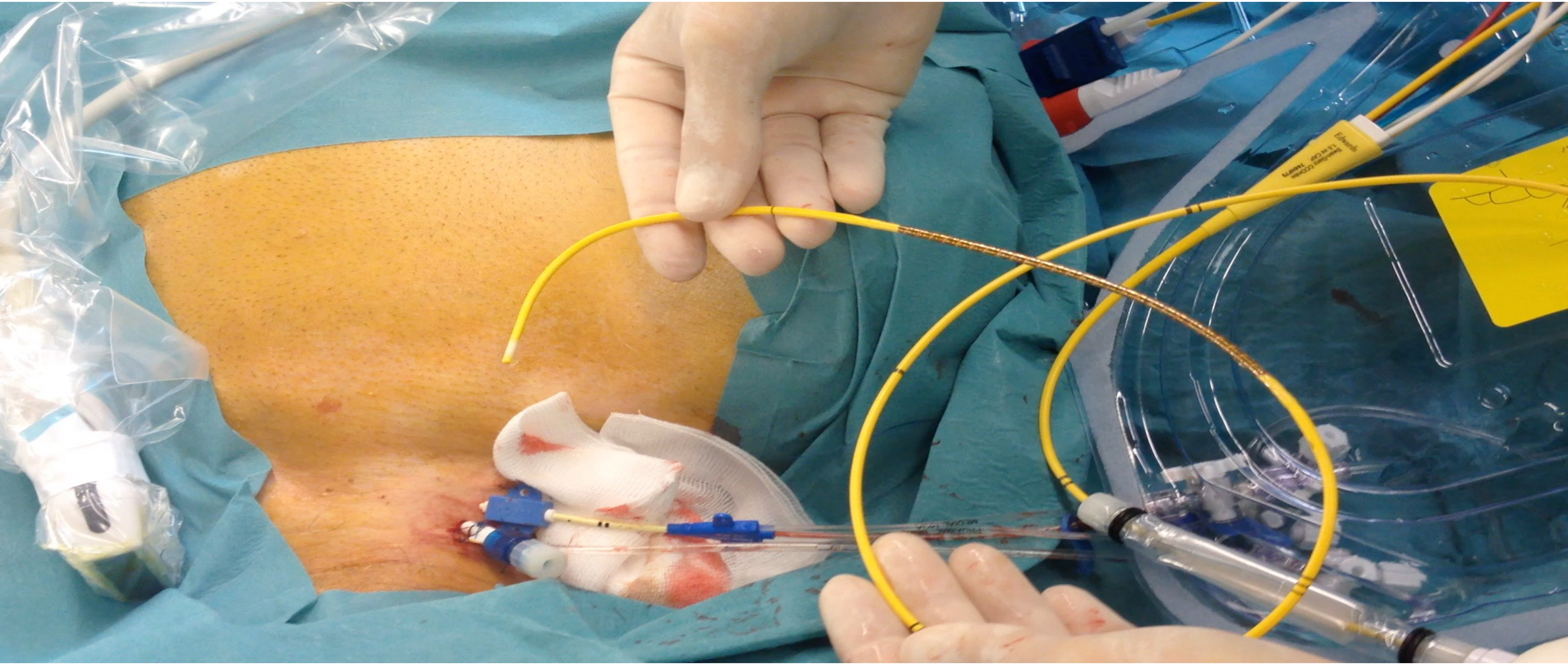
- SWAN GANZ
- PiCCO
- VIGILEO / FloTrac
- Echocardiographie
- Doppler oesophagien
- NiCO
- Bio-impédance thoracique
- …….

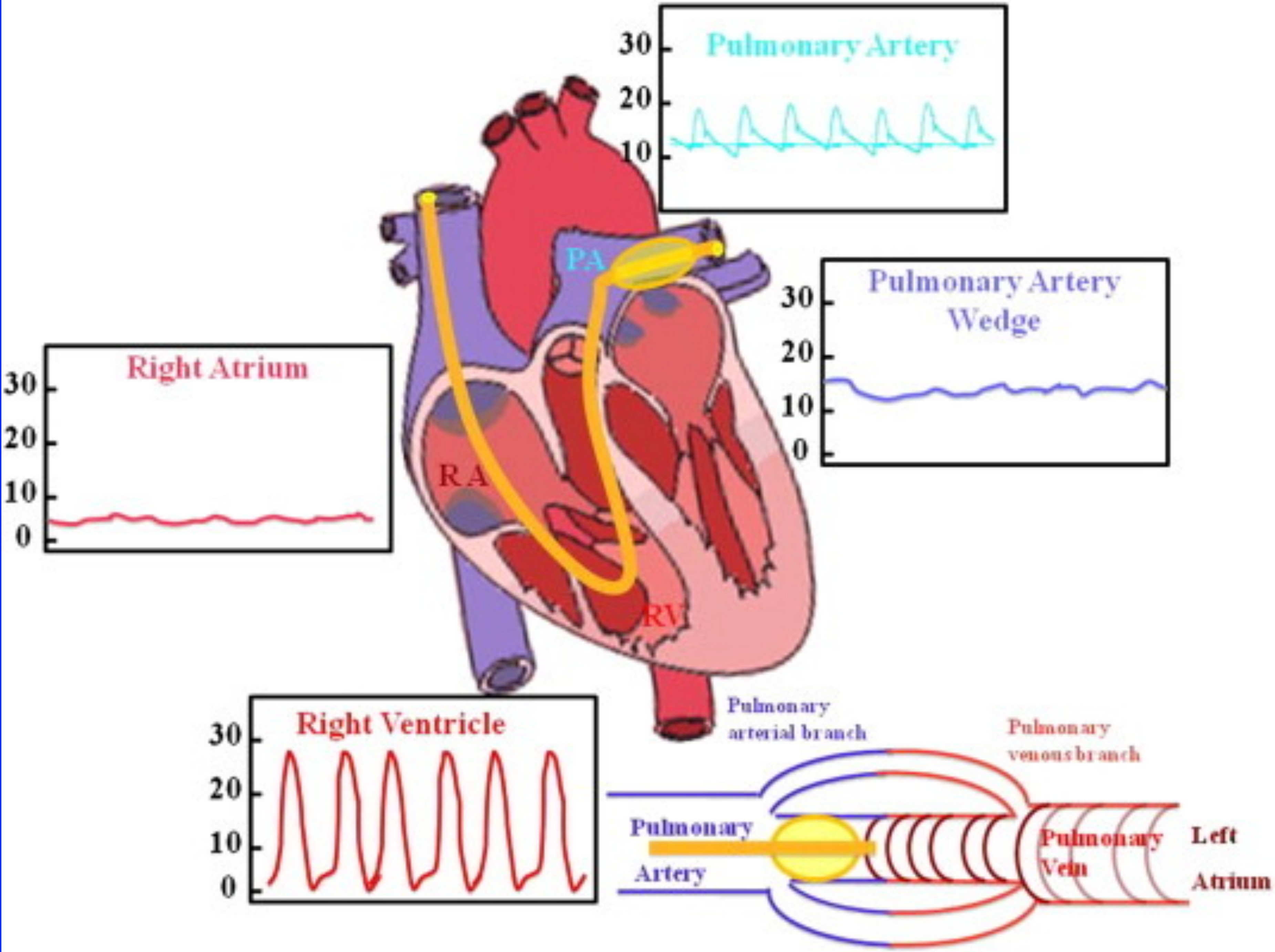
Le cathéter artériel pulmonaire






TOP





Pulmonary Artery
30
20
10
PA
Pulmonary Artery Wedge
30
20
10
0
Right Atrium
30
20
10
0
RA
RV
Right Ventricle
30
20
10
0
Pulmonary arterial branch
Pulmonary venous branch
Pulmonary Artery
Pulmonary Vein
Left Atrium

Variables

Variables mesurées:

FC
POD ou PVC
PAP (S/D/M)
PAPO ou PCP
DC

Variables calculées :

IC (Nécessité de rentrer taille et poids)
IS (Index systolique en mL/battements)
RVS
RVP
TSVG
TSVD

SVO2: rapport entre SaO2 et SvO2 ⇨ consommation en O2 de l'organisme (en rapport avec le dosage de l'acide lactique)

INDICATIONS DES SWAN

- **Anesthésie :**
  - Si forte probabilité d'anomalies hémodynamiques en périopératoire :
    - Selon acte chirurgical
    - Selon statut ASA du patient
  - Chir cardiaque
    - CABG avec fct VG altérée
    - Valvulopathie mitrale et/ou aortique au stade III et IV NYHA
    - Chir cardiaque en urgence
    - Redo
    - Insuff tricuspide
    - Tansplantation cardiaque et/ou pulm

INDICATIONS DES SWAN

- **Anesthésie** :
  - Chir aorte abdo et chir vasc artérielle :
    - En urgence
    - Comorbidité patient (insuff coronaire , cardiaque,…)
  - Neurochir :
    - Position assise : détection et traitement embolies gazeuses
  - Transplantation hépatique et chir hépatique majeure :
    - Variations hémodynamiques (mécaniques et volumétriques)
    - Statut ASA

INDICATIONS DES SWAN

- **Anesthésie** :
  - Gynéco-obstétrique :
    - Parturiente avec cardiopathie décompensée
    - HTAP fin grossesse
    - Prééclamptiques en décompensation pulmonaire
  - Chir générale
    - Cardiopathie sévère chez patient devant subir acte chir entrainant des variations hémodynamiques importantes

COMPLICATIONS DES SWAN

- Pneumothorax, ponction artérielle
- Embolie gazeuse, lésions nerveuses
- Fistule artério-veineuse, lésion canal thoracique
- Perforation cardiaque ou vasculaire par le cordis
- Troubles du RC, Infarctus pulmonaire
- Complications thrombo-emboliques
- Lésions endocardiques
- Allergie latex : cf ballonnet
- Mauvaise interprétation valeurs hémodynamiques fournies, mauvais management

QUATRES RECOMMANDATIONS SIMPLES

- Réserver l'utilisation des Swan pour les patients les plus graves
- Être certain de recueillir et d'interpréter correctement les données
- Connaître les principes élémentaires de physiologie cardiaque et de pharmacologie cardiovasculaire
- Retirer Swan le plus rapidement possible !
- *htpp://www.asahq.org/publicationsAndServices/pulm.artery.pdf*

Trends in the Use of the Pulmonary Artery Catheter in the United States, 1993-2004

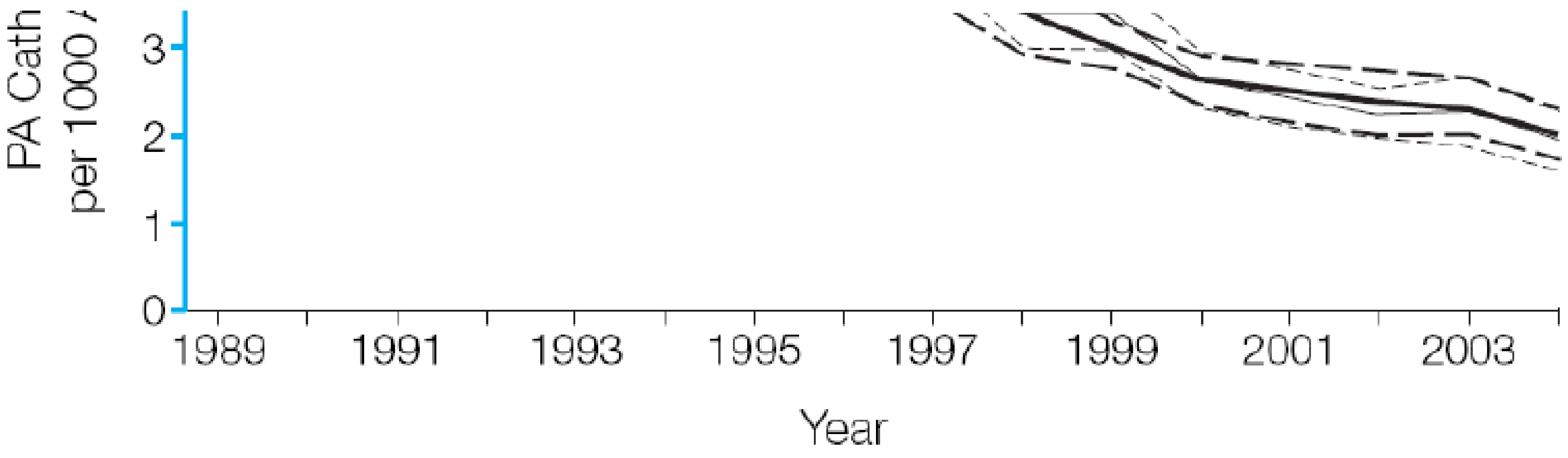
Renda Soylemez Wiener, MD
H. Gilbert Welch, MD, MPH

JAMA. 2007;298(4):423-429

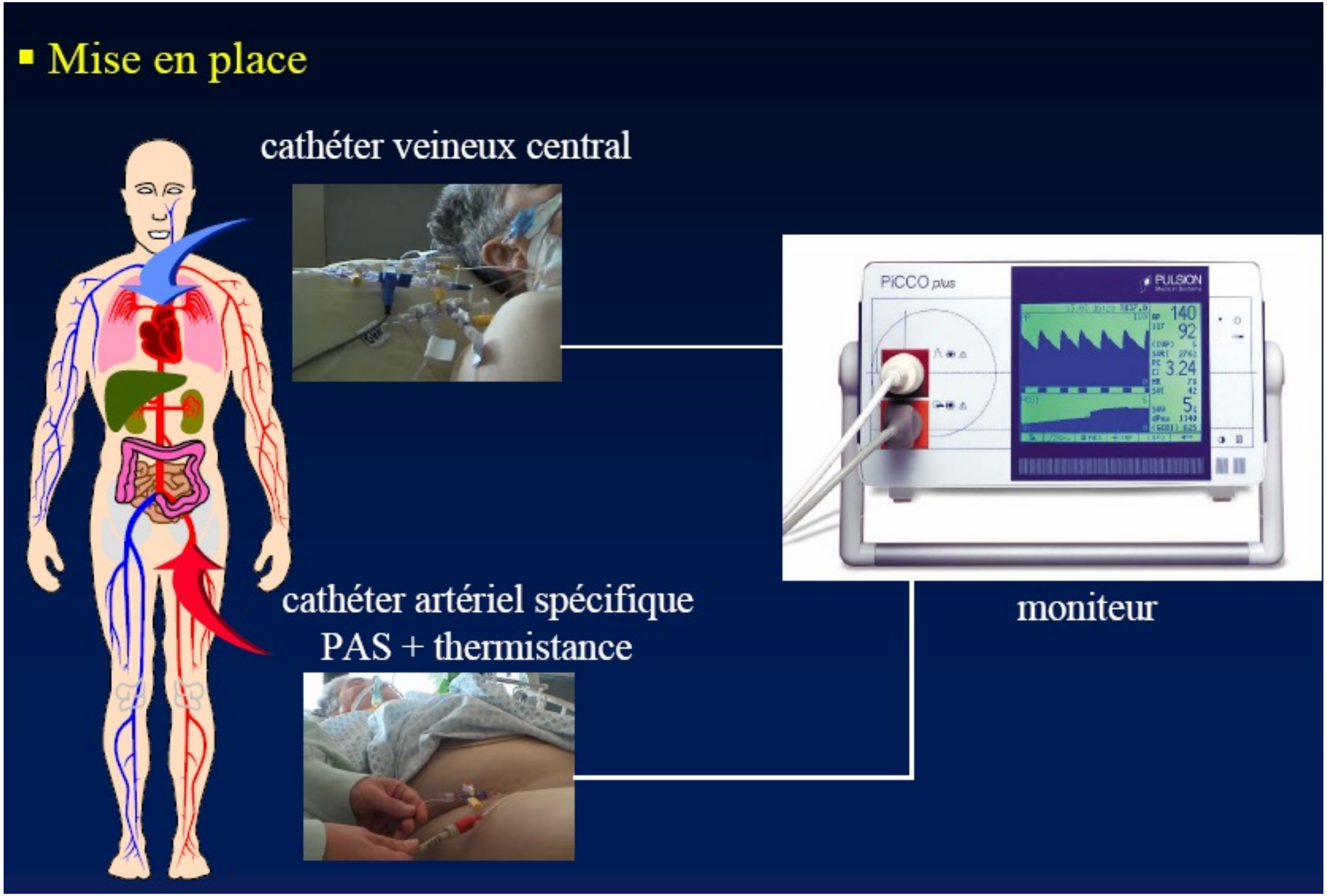
The Pulmonary Artery Catheter, 1967–2007

Gordon D. Rubenfeld, MD, MSc
Elizabeth McNamara-Aslin, BSN, RN, CCRN
Lewis Rubinson, MD, PhD

JAMA, July 25, 2007

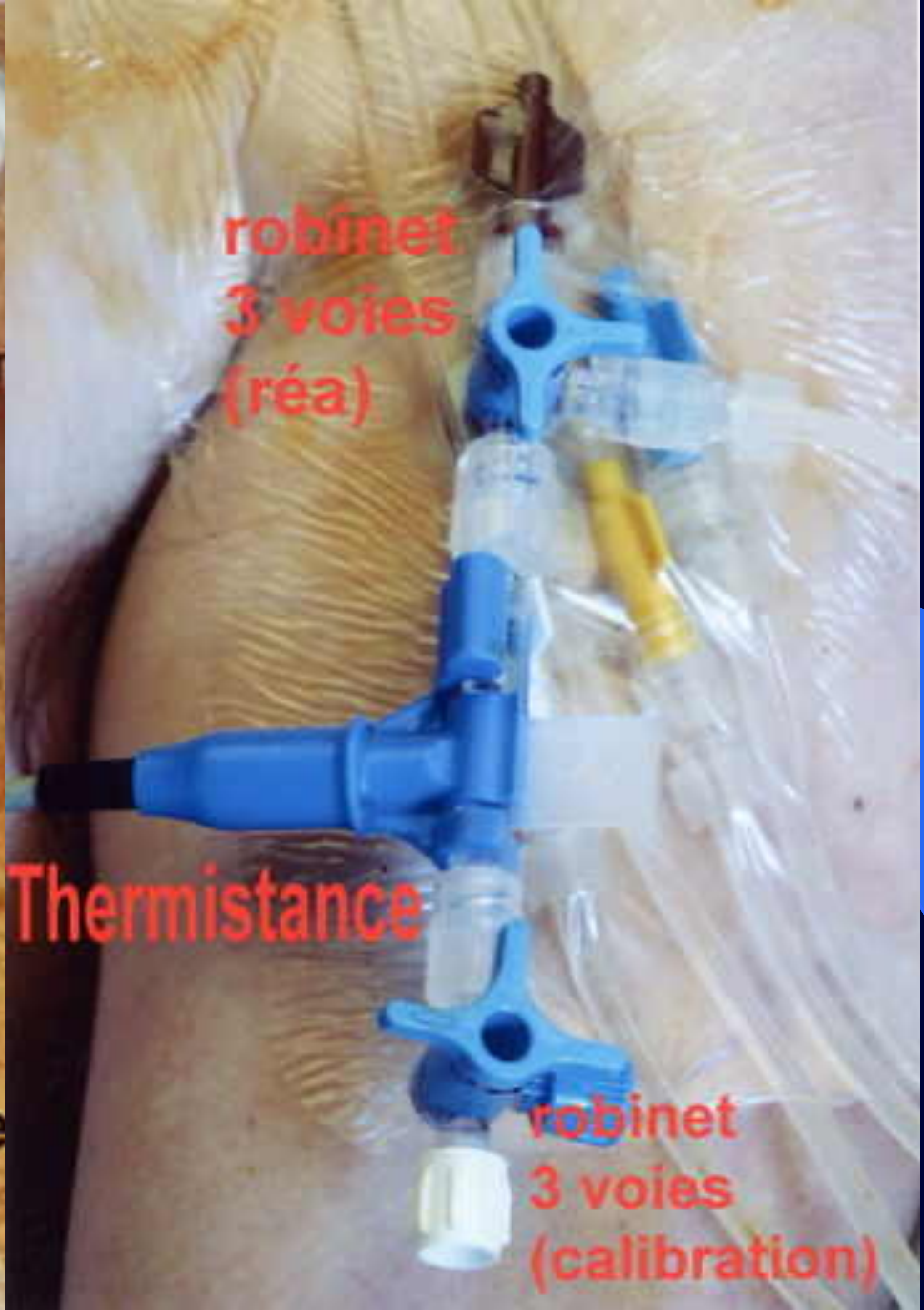


PiCCO



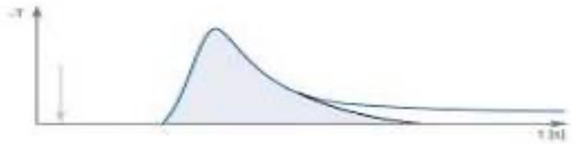
▪ Mise en place
cathéter veineux central
PiCCO plus
PULSION
140
92
3.24
cathéter artériel spécifique
PAS + thermistance
moniteur


VOIE FEMORALE
sortie vers la tête de pression
Thermistance artérielle

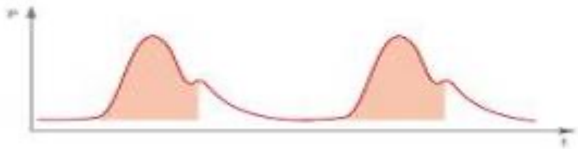

robinet
3 voies
(réa)
Thermistance
robinet
3 voies
(calibration)

Mesure du Débit Cardiaque

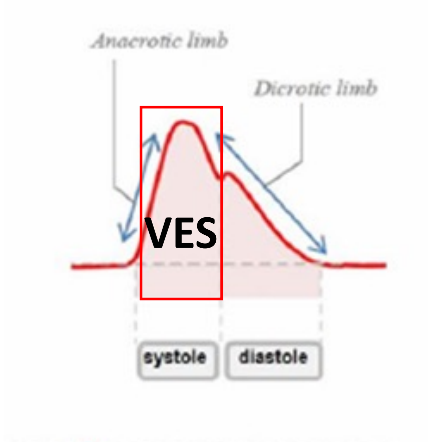
Thermodilution Transpulmonaire



Analyse du contour de l'onde de pouls



Continue (Battement par battement)



Combinaison de deux techniques de mesures pour une précision et une détermination du DC optimale

PiCCO: limites et avantages

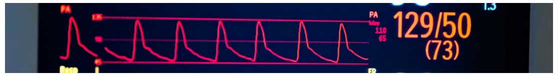
- 2 cathéters VVC et PAS fémorale
- Calibrations fréquentes
- Monitorage continu
- Monitorage complet:
  - Précharge, SVV
  - débit cardiaque continu

Variables mesurées (calibration)

- **DC et IC** : Index cardiaque ⇨ 3-5 L/m²
- **VTDI** : Volume Télédiastolique Global Indexé ⇨ 680-800 mL/m²
- **VSTI** : Volume Sanguin Intra Thoracique Indexé ⇨ 850-1000 mL/m²
- **EPEI** : Eau Pulmonaire Extra Vasculaire Indexée ⇨ 3-10 mL/kg
- **IPVP** : Index de perméabilité vasculaire pulmonaire ⇨ 1-3
- **RVSI** : Résistances vasculaires systémiques indexées ⇨ 1700-2400Dyn.s.cm-5.m²]
- VEI : Volume d'éjection indexé ⇨ 40-60mL/m²
- VVE : Variation du volume d'éjection ⇨ <10%
- **VPP** : Variation de la pression pulsée ⇨ <10%
- **FEG** : Fraction d'éjection globale ⇨25-35%
- **dPmax** :Différence de pression entre début et fin de systole ⇨ 1200-2000 mmHg/s
- **IFC** : Index de Fonction Cardiaque ⇨ 4,5 - 6,5

VIGILEO / FloTrac

Composants



Edwards
LIFESCIENCES

FloTrac Sensor

New minimally invasive approach to monitoring CCO

Vigileo Monitor

Uses its proprietary algorithm to calculate and display key flow parameters every 20 seconds

Edwards PreSep Catheter

Vigileo monitor can also be used with the PreSep catheter to monitor $ScvO_2$ using fiberoptic venous oximetry

VIGILEO / FloTrac

- L'onde artérielle est déterminée à 100Hz et les variables hémodynamiques sont enregistrées toutes les **20 sec**
- **DC, VE, VVE**
- Pour calculer le **DC**, l'appareil utilise un **algorithme** basé sur la relation entre la pression de pouls artériel et le volume d'éjection et prend en compte la compliance des vaisseaux et la résistance périphérique (**PP**)
- La **compliance** est estimée à partir d'**abaques** basés sur l'âge, le sexe, la taille et le poids
- La **résistance périphérique** est déterminée à partir des caractéristiques de l'onde artérielle

M. Canneson et al. Eur J Anaest 2007; 24: 832-39

JR Heerman et al. Am J Physiol Heart Circ Physiol 2005; 288: H2504-11

VVE et VPP - Limitations

Check-list des critères de validité

1	Le patient est-il ventilé en ventilation contrôlée sans effort spontané ?
2	Le patient est-il ventilé avec un volume courant d'au moins 7–8 mL/kg de poids idéal ?
3	Le patient est-il en état de thorax fermé ?
4	Le patient est-il en rythme sinusal ?
5	La compliance pulmonaire est-elle normale ?
6	Le patient n'est-il pas affecté par une valvulopathie ?
7	Le patient n'est-il pas affecté par un dysfonctionnement du ventricule droit/gauche ?
8	Le patient a-t-il une pression abdominale normale ?
9	Le rapport FC/FR est-il ≥ 3,6 ?
10	Pouvez-vous évaluer en toute sécurité l'efficacité du remplissage vasculaire sans modification de la FC ou du tonus vasomoteur ?

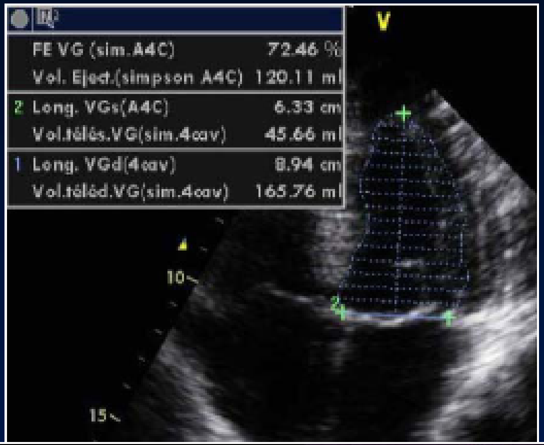
Gayat E, Anesth Reanim. 2022; 8: 152–157

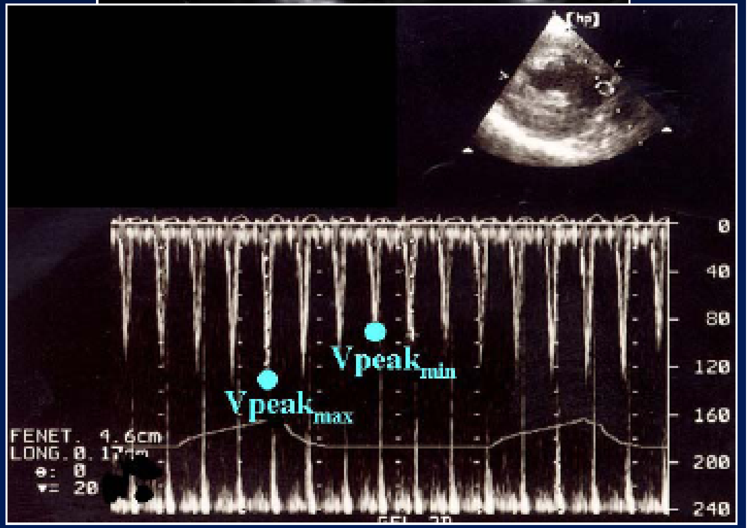
ECHOCARDIOGRAPHIE:

Transthoracique et Transoesophagienne

▪ Paramètres fournis

- débit cardiaque
- contractilité myocardique
- précharge
- précharge-dépendance:
    - ➔ Δ Vmax Aortique = Δ V Peak
    - ➔ Δ Diamètre Veine cave
- pressions artérielles pulmonaires
    + bilan cardiopathie sous-jacente





▪ Limites

- mesures discontinues
- opérateur entraîné
- formation longue

Avantages

- non-invasif
- à portée de mains
- informations real-time compréhensibles
- ↓ risque

ETO

Indications:

- patients bénéficiant des interventions non cardiaques á risque élevé

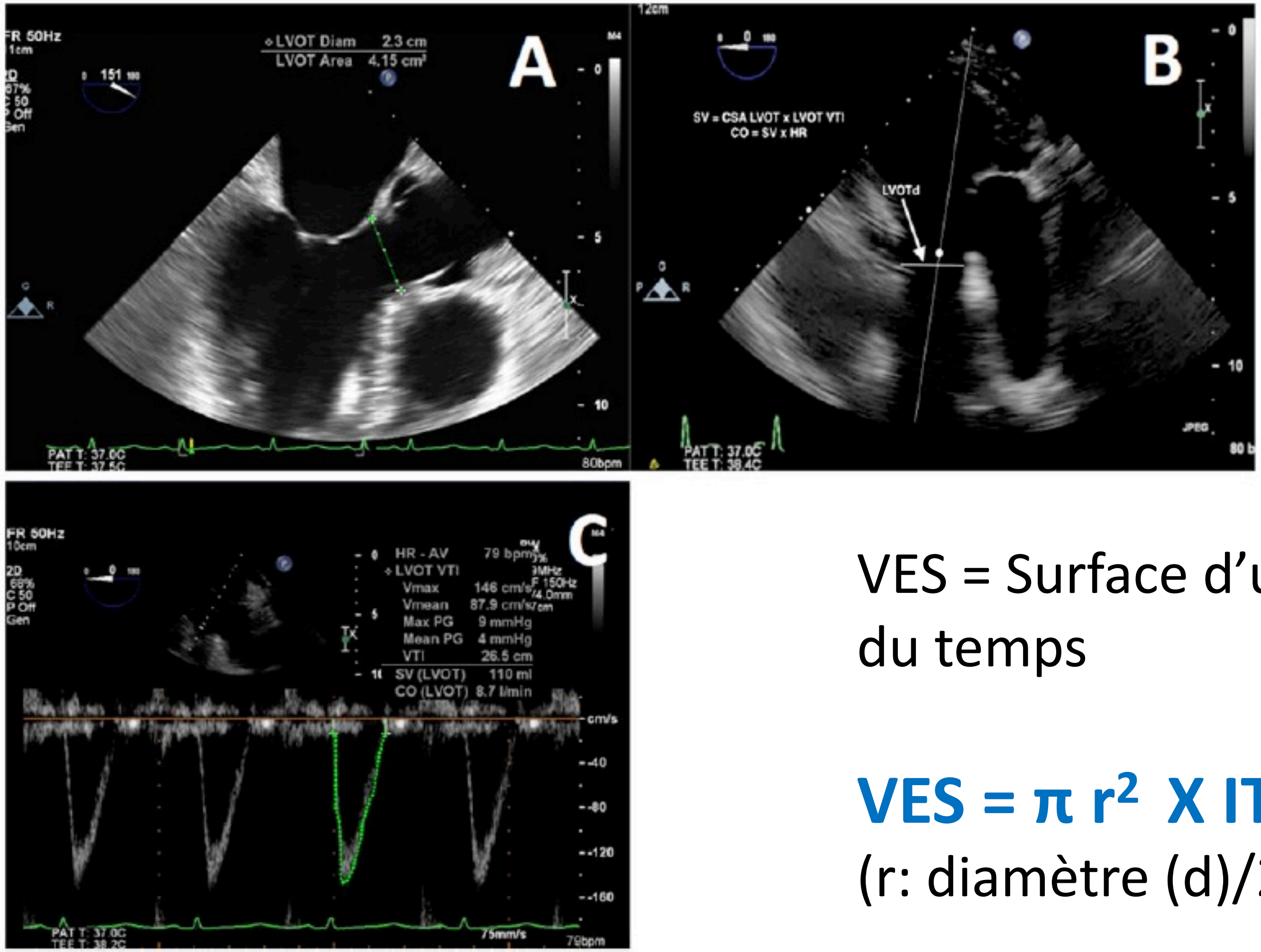
- patients souffrant de cardiopathie grave subissant une chirurgie non cardiaque

Évaluation:

- la volémie
- la fonction ventriculaire
- de poser un diagnostic préliminaire de pathologie valvulaire et de tamponnade péricardique
- un monitorage précis du DC
- de la réponse au traitement
- de l’impact des manipulations chirurgicales en cours

- « ETO de sauvetage »: diagnostique en urgence!

ETO: VES et DC



Transesophageal echocardiography (TEE) estimation of left-sided cardiac output utilizing pulsed wave (PW) Doppler of the left ventricular outflow tract (LVOT) and LVOT diameter (LVOTd). Left ventricular outflow tract diameter is best measured at the mid-esophageal long-axis view just adjacent to the aortic annulus during systole (A). The deep transgastric (TG) view is then obtained, and the PW cursor is positioned in the LVOT close to the aortic valve (AV) leaflets (B). The velocity time integral (VTI) is traced and the stroke volume (SV) is obtained (C). Heart rate (HR) is shown and cardiac output (CO) is calculated

VES = Surface d'un orifice X intégrale de Vitesse en fonction du temps

VES = πr^2 X ITV

(r: diamètre (d)/2 de la chambre de chasse du VG)

DC = VES X FC

European Heart Journal (2014) 35, 2383–2431
doi:10.1093/eurheartj/ehu282
ESC/ESA GUIDELINES

2014 ESC/ESA Guidelines on non-cardiac surgery: cardiovascular assessment and management

Recommendations on intra-operative and/or perioperative TOE for detection of myocardial ischaemia

Recommendations	Class[a]	Level[b]	Ref.[c]
The use of TOE should be considered in patients who develop ST-segment changes on intra-operative or peri-operative ECG monitoring.	IIa	C	230
The use of TOE may be considered in patients at high risk of developing myocardial ischaemia, who undergo high-risk non-cardiac surgery.	IIb	C	230

ECG = electrocardiogram; TOE = transoesophageal echocardiography.
[a]Class of recommendation.
[b]Level of evidence.
[c]Reference(s) supporting recommendations.

Recommendations on intra-operative and/or perioperative TOE in patients with or at risk of haemodynamic instability

Recommendations	Class[a]	Level[b]	Ref.[c]
TOE is recommended when acute sustained severe haemodynamic disturbances develop during surgery or in the peri-operative period.	I	C	235
TOE monitoring may be considered in patients at increased risk of significant haemodynamic disturbances during and after high-risk non-cardiac surgery.	IIb	C	
TOE monitoring may be considered in patients who present severe valvular lesions during high-risk non-cardiac surgery procedures accompanied by significant haemodynamic stresses.	IIb	C	

TOE = transoesophageal echocardiography.
[a]Class of recommendation.
[b]Level of evidence.
[c]Reference(s) supporting recommendations.

Instabilité hémodynamique aigüe et sévère

Recommandé en peropératoire ou en postopératoire en cas d'hypotension sévère !

SPECIAL ARTICLES
Anesthesiology 2010; 112:1084–96

Practice Guidelines for Perioperative Transesophageal Echocardiography

*An Updated Report by the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists Task Force on Transesophageal Echocardiography**

In a prospective study including 42 adults, TOE was performed before any other haemodynamic monitoring when severe hypotension developed. It was useful for determining the **cause** of severe hypotension, hypovolaemia, low ejection fraction, severe embolism, myocardial ischaemia, cardiac tamponade, or dynamic LV outflow tract obstruction

Monitorage hémodynamique systématique pour la stratification du risque ou la prediction de l'outcome: controversé !

ETO de « sauvetage »

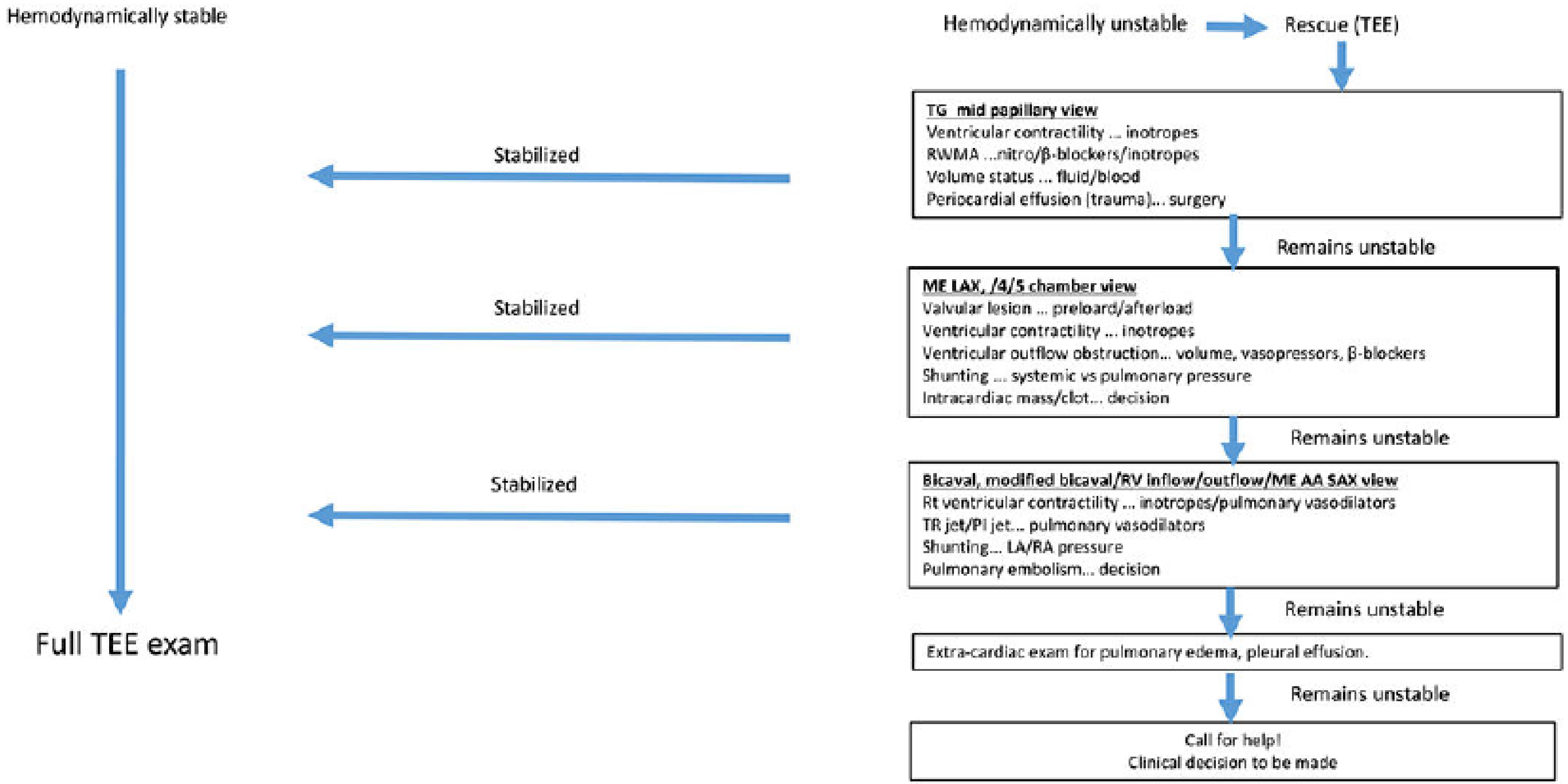


Fig. 8.

Recommended approach and views for rescue transesophageal echocardiography (TEE) exam.[4,33] LA = left atrium; LAX = long axis; ME = mid-esophageal; PI = pulmonary insufficiency; RA = right atrium; Rt = right; RV = right ventricle; RWMA = regional wall motion abnormality; TG = transgastric; TR = tricuspid regurgitation; 4/5 = four & five chamber

Society of Cardiovascular Anesthesiologists

Cardiovascular Anesthesiology Section Editor: Charles W. Hogue, Jr.
Perioperative Echocardiography and Cardiovascular Education Section Editor: Martin J. London
Hemostasis and Transfusion Medicine Section Editor: Jerrold H. Levy

SPECIAL ARTICLE

Basic Perioperative Transesophageal Echocardiography Examination: A Consensus Statement of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists

Scott T. Reeves, MD, FASE, Alan C. Finley, MD, Nikolaos J. Skubas, MD, FASE, Madhav Swaminathan, MD, FASE, William S. Whitley, MD, Kathryn E. Glas, MD, FASE, Rebecca T. Hahn, MD, FASE, Jack S. Shanewise, MD, FASE, Mark S. Adams, BS, RDCS, FASE, and Stanton K. Shernan, MD, FASE, for the Council on Perioperative Echocardiography of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists, *Charleston, South Carolina; New York, New York; Durham, North Carolina; Atlanta, Georgia; Boston, Massachusetts*

Formation de base

Table 2 The NBE's Basic PTE training pathways

	Clinical experience in basic PTE echocardiography	Continuing medical education	Supervision of training
Supervised training pathway	≥150 basic PTE echocardiographic examinations studied under supervision	≥50 of the 150 basic intraoperative transesophageal echocardiographic examinations must be performed and interpreted under supervision throughout the procedure	No requirement
Practice experience pathway*	≥150 basic intraoperative transesophageal echocardiographic examinations performed and interpreted within 4 y of application, with ≥25 examinations in any 1 y	Supervision not required	≥40 American Medical Association Physician Recognition Award Category 1 Credits focused perioperative TEE and completed within the same period as the clinical experience

Adapted with permission from Anesthesiology.[4]
*The practice experience pathway will not be available to those completing their anesthesiology residency training after June 30, 2016.

Published in final edited form as:
Can J Anaesth. 2018 April ; 65(4): 381–398. doi:10.1007/s12630-017-1017-7.

Perioperative transesophageal echocardiography for non-cardiac surgery

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Sasha K. Shillcutt, MD, MS, FASE
Department of Anesthesiology, University of Nebraska Medical Center, Omaha, NE, USA

Abstract

Purpose—The use of transesophageal echocardiography (TEE) has evolved to include patients undergoing high-risk non-cardiac procedures and patients with significant cardiac disease undergoing non-cardiac surgery. Implementation of basic TEE education in training programs has increased across a broad spectrum of procedures in the perioperative arena. This paper describes the use of perioperative TEE in non-cardiac surgery and provides an overview of the basic TEE examination.

Principal findings—Perioperative TEE is used to monitor hemodynamic parameters in non-cardiac procedures where there is a high risk of hemodynamic instability. Its use extends to include moderate-risk procedures for patients with significant cardiac diseases such as low ejection fraction, hypertrophic cardiomyopathy, severe valve lesions, or congenital heart disease. Vascular procedures involving the aorta, blunt trauma, and liver transplantation are all examples of procedures that may benefit from TEE. Transesophageal echocardiography examination allows assessment of volume status, ventricular function, diagnosis of gross valvular pathology and pericardial tamponade, as well as close monitoring of cardiac output, response to therapy, and the impact of ongoing surgical manipulation. In patients with unexplained and unexpected hemodynamic instability, ''rescue TEE'' can be used to help identify the underlying cause.

Conclusions—Perioperative TEE is emerging as a preferred tool to manage hemodynamics in high-risk procedures and in high-risk patients undergoing non-cardiac surgery. A rescue TEE examination protocol is a helpful approach for early identification of the etiology of hemodynamic instability.

Contre-indications

Contraindications for perioperative transesophageal echocardiography

Medical conditions

- Lack of patient consent
- Esophageal stricture or history of dysphagia
- Post-esophageal or gastric surgery
- Esophageal or gastric tumour
- Active/recent upper gastrointestinal bleeding
- Tracheoesophageal fistula
- Other esophageal/gastric diseases (e.g., Mallory-Weiss tear, scleroderma)

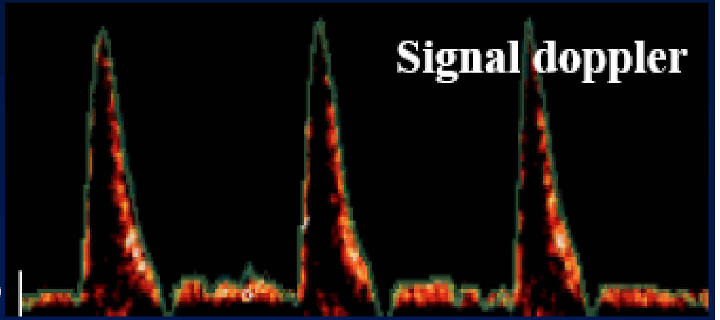
Trauma-related

- Active upper gastrointestinal bleeding
- Patient with unprotected airway
- Basal skull fracture
- Esophageal or mouth trauma

DOPPLER OESOPHAGIEN

- Technique et paramètres

- mesure du débit dans aorte thoracique descendante = 70% du DC
- sonde dans 1/3 moyen oesophage
- calcul du VES aorte descendante
  VES = ITV x surface aortique
- ITV → doppler
- surface→ abaque, mesure TM/ appareils



1. Débit cardiaque continu
2. Précharge-dépendance = Δ VES

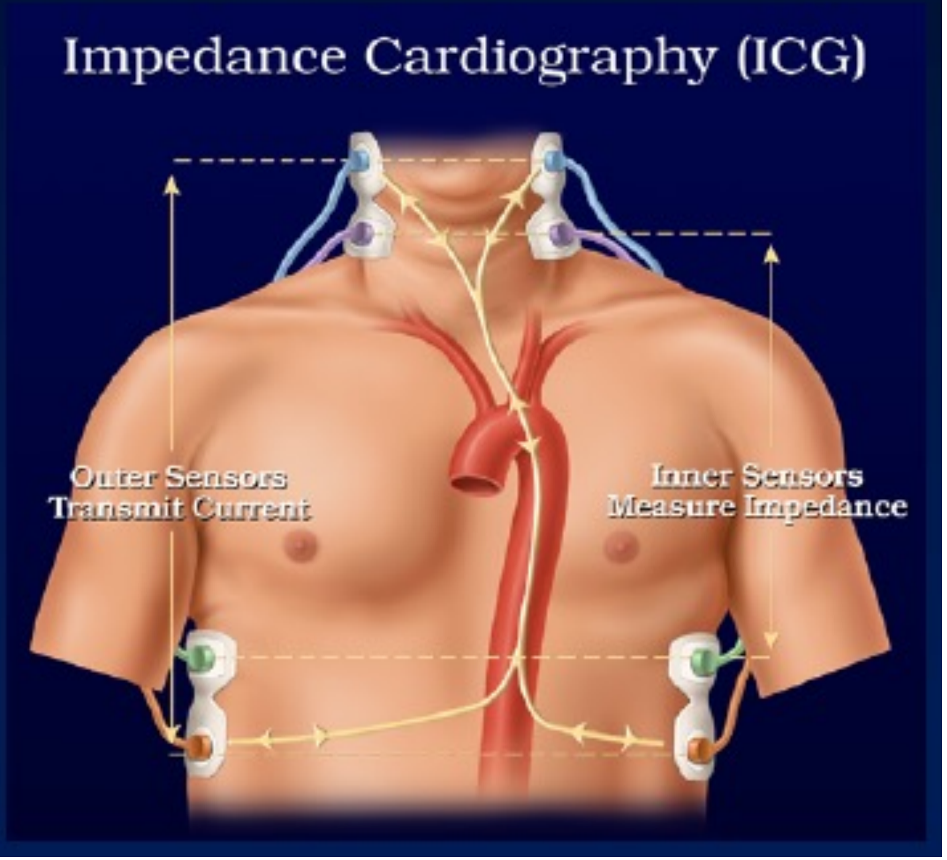
Monitorage non-invasif du DC/VES

- Bio-impédance électrique thoracique
- Bio-réactance
- NICO
- Clearsight/Nexfim et CNAP (pulsatilité digitale)
- esCCO (Temps de transit de l'onde de pouls)
- …

BIO-IMPEDANCE THORACIQUE

- Technique

- mesure non invasive du débit cardiaque utilisant la variation d'impédance thoracique



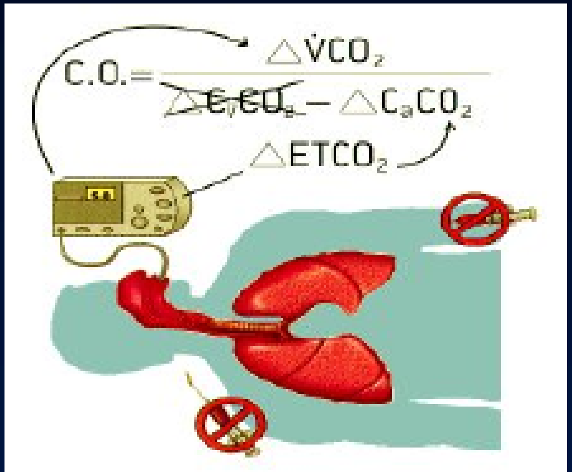
- Limites

- peu d'expérience d'utilisation
- difficultés d'acquisition du signal
- manque de validation

NICO ™ (Non Invasive Cardiac Output)

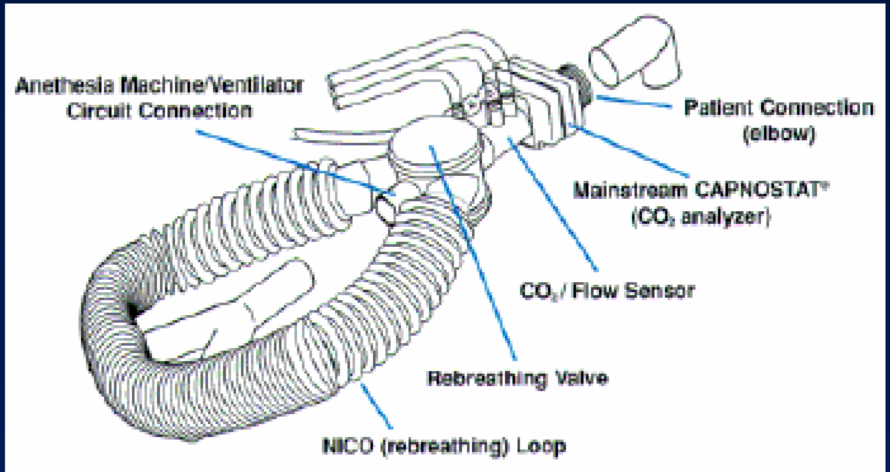
- Technique

- mesure DC selon principe de Fick adapté à l'analyse des variations du CO2 expiratoire
- système branché sur le circuit respiratoire



- Avantages

- non invasif
- simple
- opérateur-indépendant
- utilisable si non-accès à la tête du patient



Pulsatilité digitale

A Randomized Trial of Continuous Noninvasive Blood Pressure Monitoring During Noncardiac Surgery

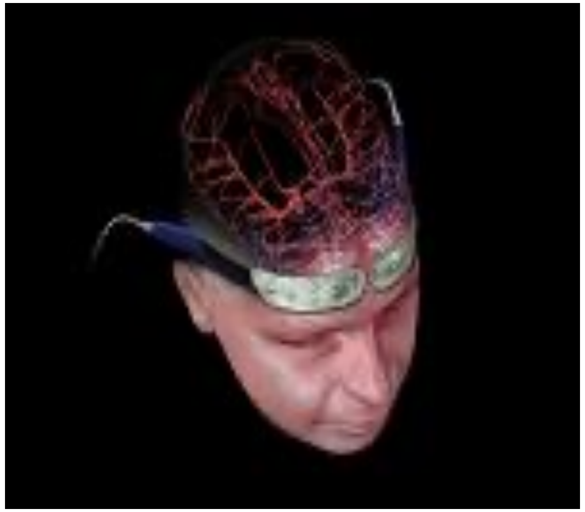
Kamal Maheshwari, MD, MPH,*† Sandeep Khanna, MD,† Gausan Ratna Bajracharya, MD,*
Natalya Makarova, MS,‡ Quinton Riter, BS,* Syed Raza, BS,* Jacek B. Cywinski, MD,†
Maged Argalious, MD, MBA, MEd, FASE,† Andrea Kurz, MD,*† and Daniel I. Sessler, MD* Anesth Analg 2018;127:424–31)

Clearsight/Nexfin
(Edwards)

CNAP
(Datex-Ohmeda)

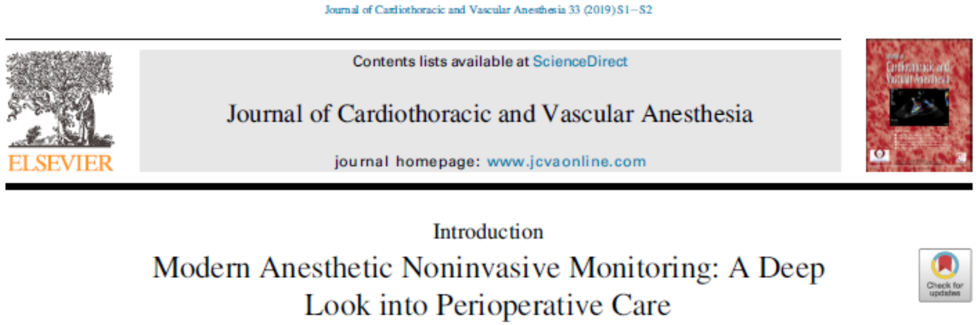
CONCLUSIONS: Continuous noninvasive hemodynamic monitoring nearly halved the amount of intraoperative hypotension. Hypotension reduction with continuous monitoring, while statistically significant, is currently of uncertain clinical importance. (Anesth Analg 2018;127:424–31)

Perfusion régionale!



Cérébrale

INVOS®



Journal of Cardiothoracic and Vascular Anesthesia 33 (2019) S1−S2

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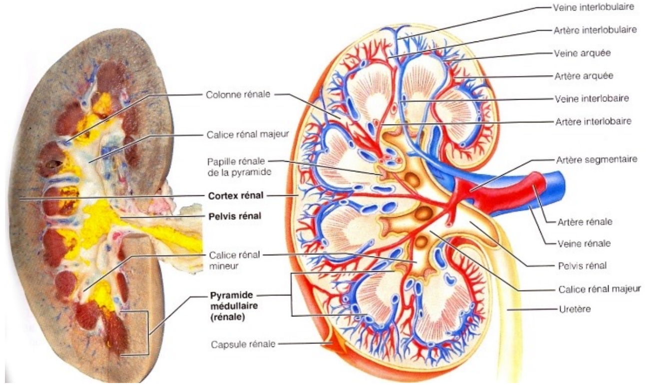
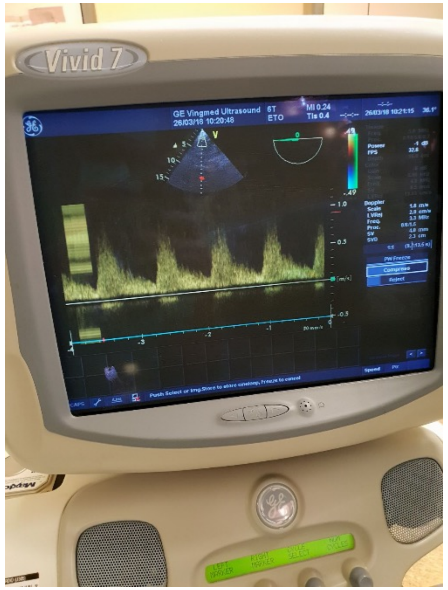
journal homepage: www.jcvaonline.com

Introduction

Modern Anesthetic Noninvasive Monitoring: A Deep Look into Perioperative Care

Rénale





« Modified Fluid Challenge »

Epreuve du Lever de Jambes:

- Pooling des Jambes = +/- 300 ml « colloïde »
- Réversible en cas d'intolérance
- Délai d'effet 30-90 sec
- ↑ **10-15%** VES: répondeur

Passive leg raising predicts fluid responsiveness in the critically ill*

Xavier Monnet, MD, PhD; Mario Rienzo, MD; David Osman, MD; Nadia Anguel, MD; Christian Richard, MD; Michael R. Pinsky, MD, Dr hc; Jean-Louis Teboul, MD, PhD

Objective: Passive leg raising (PLR) represents a "self-volume challenge" that could predict fluid response and might be useful when the respiratory variation of stroke volume cannot be used for that purpose. We hypothesized that the hemodynamic response to PLR predicts fluid responsiveness in mechanically ventilated patients.

Design: Prospective study.

Setting: Medical intensive care unit of a university hospital.

Patients: We investigated 71 mechanically ventilated patients considered for volume expansion. Thirty-one patients had spontaneous breathing activity and/or arrhythmias.

Interventions: We assessed hemodynamic status at baseline, after PLR, and after volume expansion (500 mL NaCl 0.9% infusion over 10 mins).

Measurements and Main Results: We recorded aortic blood flow using esophageal Doppler and arterial pulse pressure. We calculated the respiratory variation of pulse pressure in patients without arrhythmias. In 37 patients (responders), aortic blood flow increased by ≥15% after fluid infusion. A PLR increase of aortic blood flow ≥10% predicted fluid responsiveness with a sensitivity of 97% and a specificity of 94%. A PLR increase of pulse pressure ≥12% predicted volume responsiveness with significantly lower sensitivity (60%) and specificity (85%). In 30 patients without arrhythmias or spontaneous breathing, a respiratory variation in pulse pressure ≥12% was of similar predictive value as was PLR increases in aortic blood flow (sensitivity of 88% and specificity of 93%). In patients with spontaneous breathing activity, the specificity of respiratory variations in pulse pressure was poor (46%).

Conclusions: The changes in aortic blood flow induced by PLR predict preload responsiveness in ventilated patients, whereas with arrhythmias and spontaneous breathing activity, respiratory variations of arterial pulse pressure poorly predict preload responsiveness. (Crit Care Med 2006; 34:1402–1407)

Key Words: fluid responsiveness; leg raising; pulse pressure variation; aortic blood flow

It is important to be able to predict which hemodynamically unstable patients will increase their systemic blood flow in response to volume expansion, because fluid loading in a non-volume-responsive patient delays definitive therapy and may be detrimental. In this regard, respiration-induced changes in arterial pulse pressure (ΔPP) have been demonstrated to accurately predict preload responsiveness in mechanically ventilated patients who are making no inspiratory efforts (1). However, not studied is whether such respiration-induced pulse pressure variation may not accurately predict preload responsiveness when the patients are triggering the ventilator or in the presence of arrhythmias (2).

We hypothesized that the transient hemodynamic effect of passive leg raising (PLR) on left ventricular stroke volume or its surrogates could be an alternative method to detect preload responsiveness in all categories of patients receiving mechanical ventilation because the effect persists over several breaths. PLR induces a translocation of venous blood from the legs to the intrathoracic compartment (3, 4), resulting in a transient increase in right ventricular (5) and left ventricular (6, 7) preload. PLR as a "reversible-volume challenge" (8) is attractive because it is easy to perform at the bedside, induces a reversible volume challenge that is proportional to body size, and does not result in volume overload in non-preload-responsive subjects. The effects of PLR on cardiac output are variable (5, 8, 9), presumably depending on the existence of cardiac preload reserve. In this regard, our group previously proposed to predict fluid responsiveness in patients fully synchronized to their ventilator by examining the effects of PLR on pulse pressure, taken as a surrogate for stroke volume (10). However, the predictive value of PLR in that previous study was only fair, presumably because stroke volume was estimated from peripheral pulse pressure, which also depends on arterial compliance and vasomotor tone (11). Estimating stroke volume by a more reliable surrogate, such as descending aortic flow, may improve the predictive value of PLR for preload-responsiveness.

Esophageal Doppler is a minimally invasive method allowing real-time monitoring of the descending aortic blood flow, an estimate of cardiac output (12–16). Esophageal Doppler tracks changes in cardiac output induced either by inotropic drugs (17) or by volume replacement (18).

We performed the present study in patients receiving mechanical ventilation. We hypothesized that changes in aortic blood flow during PLR a) could predict fluid responsiveness as reliably as ΔPP and better than changes in mean pulse pressure during PLR in patients well synchronized to the ventilator and in sinus rhythm; and b) would be better

*See also p. 1559.

From Service de réanimation médicale, Centre Hospitalier Universitaire de Bicêtre, Assistance Publique-Hôpitaux de Paris, Université Paris 11, Le Kremlin-Bicêtre, France (XM, MR, DO, NA, CR, J-LT); and Department of Critical Care Medicine, University of Pittsburgh, Pittsburgh, PA (MRP).

Supported, in part, by grants HL67181 and HL073198 from the National Institutes of Health (MRP).

Prof. M.R. Pinsky is a consultant for Arrow International and received speaking fees from Edwards Lifesciences in 2004. The other authors have no financial interests to disclose.

DOI: 10.1097/01.CCM.0000215453.11735.06

Figure 1. Study design. PLR, passive leg raising; VE, volume expansion.

Perspectives: outils d'aide à la décision et intelligence artificielle

HPI: hypotension prediction index

PERIOPERATIVE MEDICINE

ANESTHESIOLOGY

Hypotension Prediction Index for Prevention of Hypotension during Moderate- to High-risk Noncardiac Surgery

A Pilot Randomized Trial

Kamal Maheshwari, M.D., M.P.H., Tetsuya Shimada, M.D., Ph.D., Dongsheng Yang, M.S., Sandeep Khanna, M.D., Jacek B. Cywinski, M.D., Samuel A. Irefin, M.D., Sabry Ayad, M.D., Alparslan Turan, M.D., Kurt Ruetzler, M.D., Yuwei Qiu, M.D., Partha Saha, M.D., Edward J. Mascha, Ph.D., Daniel I. Sessler, M.D.

ANESTHESIOLOGY 2020; 133:1214–22

ABSTRACT

Background: The Hypotension Prediction Index is a commercially available algorithm, based on arterial waveform features, that predicts hypotension defined as mean arterial pressure less than 65 mmHg for at least 1 min. We therefore tested the primary hypothesis that index guidance reduces the duration and severity of hypotension during noncardiac surgery.

Methods: We enrolled adults having moderate- or high-risk noncardiac surgery with invasive arterial pressure monitoring. Participating patients were randomized to hemodynamic management with or without index guidance. Clinicians caring for patients assigned to guidance were alerted when the index exceeded 85 (range, 0 to 100) and a treatment algorithm based on advanced hemodynamic parameters suggested vasopressor administration, fluid administration, inotrope administration, or observation. Primary outcome was the amount of hypotension, defined as time-weighted average mean arterial pressure less than 65 mmHg. Secondary outcomes were time-weighted mean pressures less than 60 and 55 mmHg.

Results: Among 214 enrolled patients, guidance was provided for 105 (49%) patients randomly assigned to the index guidance group. The median (first quartile, third quartile) time-weighted average mean arterial pressure less than 65 mmHg was 0.14 (0.03, 0.37) in guided patients versus 0.14 (0.03, 0.39) mmHg in unguided patients: median difference (95% CI) of 0 (–0.03 to 0.04), P = 0.757. Index guidance therefore did not reduce amount of hypotension less than 65 mmHg, nor did it reduce hypotension less than 60 or 55 mmHg. *Post hoc*, guidance was associated with less hypotension when analysis was restricted to episodes during which clinicians intervened.

Conclusions: In this pilot trial, index guidance did not reduce the amount of intraoperative hypotension. Half of the alerts were not followed by treatment, presumably due to short warning time, complex treatment algorithm, or clinicians ignoring the alert. In the future we plan to use a lower index alert threshold and a simpler treatment algorithm that emphasizes prompt treatment.

(ANESTHESIOLOGY 2020; 133:1214–22)

EDITOR'S PERSPECTIVE

What We Already Know about This Topic

- Hypotension prediction algorithms commonly use arterial waveform features derived from arterial blood pressure monitoring. Whether they reduce the duration and severity of hypotension, especially in noncardiac surgery, is unknown.

What This Article Tells Us That Is New

- Of 214 noncardiac surgical patients, 105 (49%) patients randomized to management with a hypotension prediction algorithm, intraoperative hypotension was not reduced compared with controls. A lower alert threshold enabling adequate warning time and a simpler treatment algorithm that emphasizes prompt treatment after alert may help.

Intraoperative hypotension is common during noncardiac surgery.[1] Most patients experience at least one episode during which mean arterial pressure (MAP) decreases to less than 65 mmHg, often shortly after anesthetic induction.[2,3] Intraoperative hypotension is associated with worse postoperative outcomes including myocardial infarction, acute kidney injury, and mortality.[4–7] In a recent randomized controlled trial, Futier *et al.* reported that preventing intraoperative hypotension reduces the risk of postoperative organ dysfunction by about 25%,[8] suggesting that the association between hypotension and organ injury is at least partially causal and therefore potentially amenable to intervention.

Presumably, reducing the frequency, depth, and duration of intraoperative hypotension would reduce organ injury. During surgery, anesthesia clinicians respond to blood pressure trends and treat hypotension as necessary, mostly when it occurs. It is difficult to predict hypotension; therefore,

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MDPI

Study Protocol

Hypotension Prediction Index Software to Prevent Intraoperative Hypotension during Major Non-Cardiac Surgery: Protocol for a European Multicenter Prospective Observational Registry (EU-HYPROTECT)

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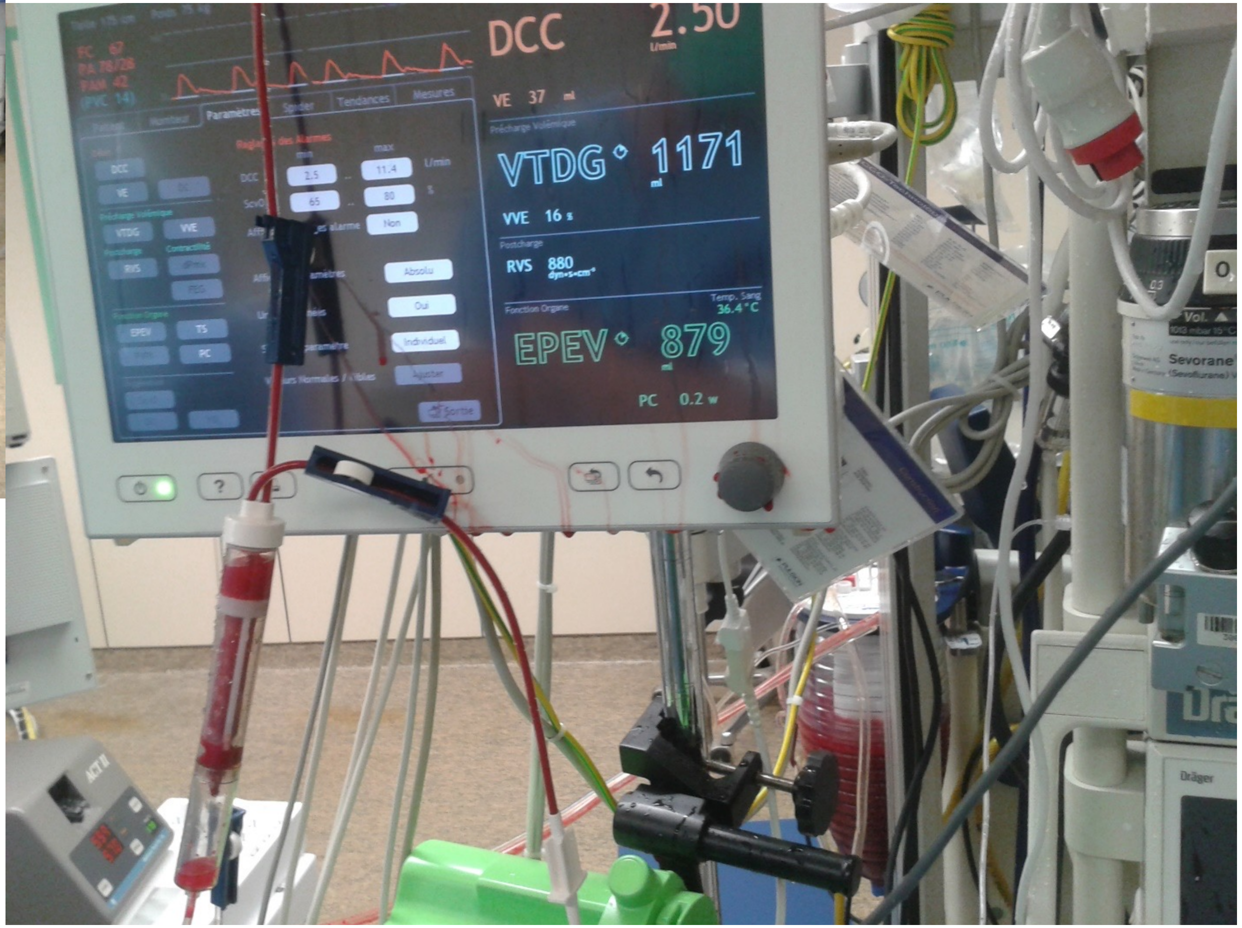
Abstract: Background: Intraoperative hypotension is common in patients having non-cardiac surgery and associated with postoperative acute myocardial injury, acute kidney injury, and mortality. Avoiding intraoperative hypotension is a complex task for anesthesiologists. Using artificial intelligence to predict hypotension from clinical and hemodynamic data is an innovative and intriguing approach. The Acumen™ Hypotension Prediction Index (HPI) software (Edwards Lifesciences; Irvine, CA, USA) was developed using artificial intelligence—specifically machine learning—and predicts hypotension from blood pressure waveform features. We aimed to describe the incidence, duration, severity, and causes of intraoperative hypotension when using HPI monitoring in patients having elective major non-cardiac surgery. Methods: We built up a European, multicenter, prospective, observational registry including at least 700 evaluable patients from five European countries. The registry includes consenting adults (≥18 years) who were scheduled for elective major non-cardiac surgery under general anesthesia that was expected to last at least 120 min and in whom arterial catheter placement and HPI monitoring was planned. The major objectives are to quantify and characterize intraoperative hypotension (defined as a mean arterial pressure [MAP] < 65 mmHg) when using HPI monitoring. This includes the time-weighted average (TWA) MAP < 65 mmHg, area under a MAP of 65 mmHg, the number of episodes of a MAP < 65 mmHg, the proportion of patients with at least one episode (1 min or more) of a MAP < 65 mmHg, and the absolute maximum decrease below a

CONCLUSIONS

- L'optimisation hémodynamique peropératoire diminue la morbi/mortalité
- L'optimisation hémodynamique peropératoire du DO2 implique le monitorage du VES et du DC:
- - VES: tout patient, risque chirurgical modéré/élevé (techniques mini-invasives)

  - DC: risque chirurgical élevé, patient à risque modéré/élevé
- Le maintien de la pression de perfusion est indispensable
- Le choix du monitorage est guidée par notre tolérance à l'erreur, par la sévérité du terrain patient et la complexité chirurgicale
- Le monitorage non-invasif est de plus en plus fiable mais manque actuellement de validation
- Un seul indice, ne peut pas guider GDT chez le patient en état hémodynamique critique…


SOMANE
Aquason


DCC
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L/min
VE 37 ml
Paramètres
Tendances
Mesures
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Postcharge
RVS 880
Fonction Organe
Temp. Sang
36.4°C
EPEV
879
ml
PC 0.2 w
Absolu
Oui
Individuel
Ajuster
Sortie
Sevorane

Merci pour votre attention !