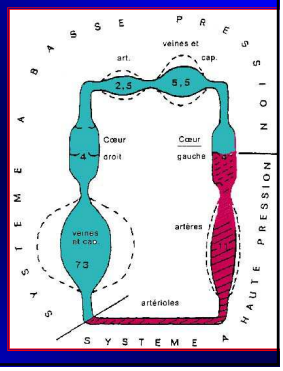
Retour Veineux Physiologie hémodynamique et Applications cliniques

Mazerolles Michel
Département d'anesthésie-réanimation
CHU Rangueil
TOULOUSE

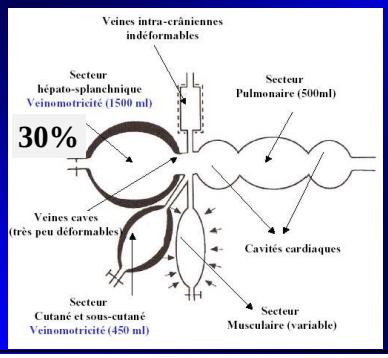
1-Anatomie du système veineux

Répartition de la volémie

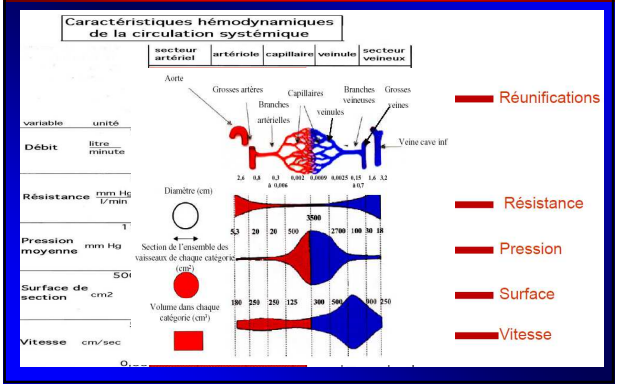
- **veines** = *70 %*
- artères = 15%
- circulation pulm = 10%
- ventricules = *5%*



Fonction réservoir des territoires veineux

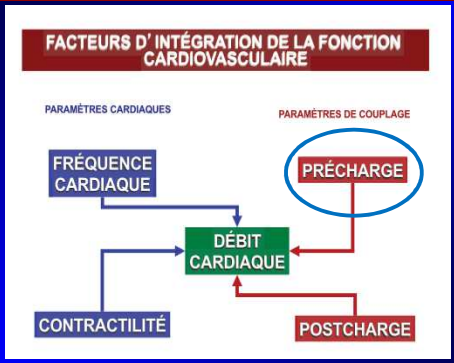


Caractéristiques du système à basse pression



2-Déterminants du débit cardiaque

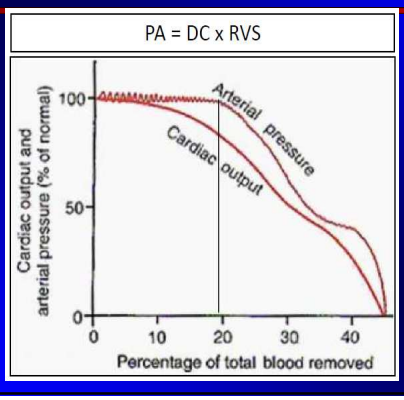
Les 4 déterminants du débit cardiaque

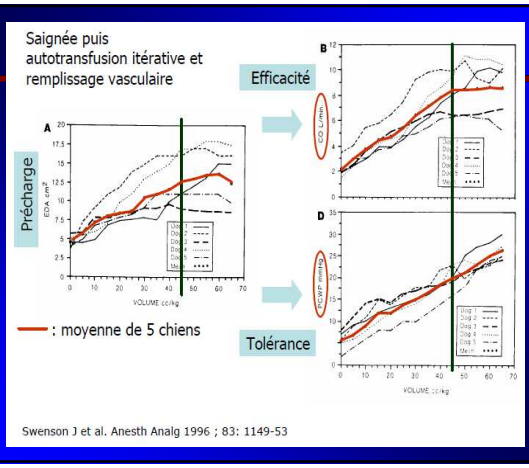


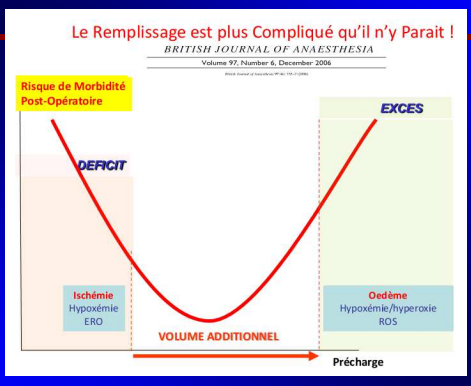
A l'équilibre Débit Cardiaque = Retour Veineux

- Qc = VES x FC mais ces 2 données sont dépendantes
- **Chez le sujet normal**, VES dépend exclusivement du retour veineux

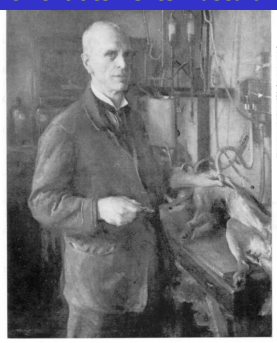
Pression artérielle ≠ Débit cardiaque

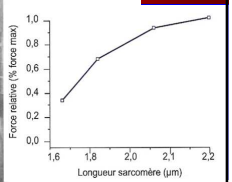






La force de contraction du myocarde croît en réponse à un étirement des fibres musculaires



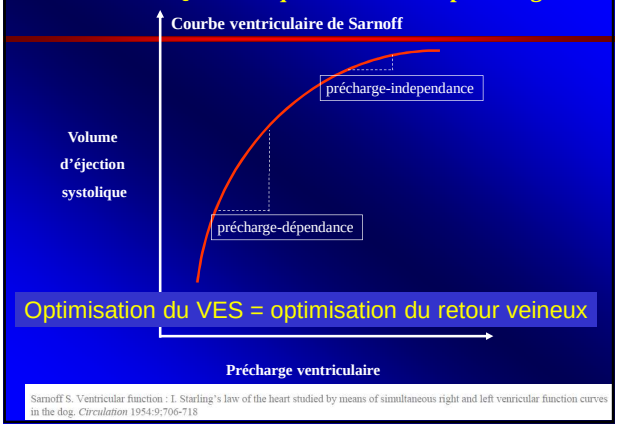


Patterson SW, Starling EH. On the mechanical factors which determine the output of the ventricles. J Physiol (Lond) 1914

E. H. Starling

« The mechanical energy set free on passage from the resting to the contraction state depends on the area of chemically active surfaces, i.e. on the length of muscle fibres »

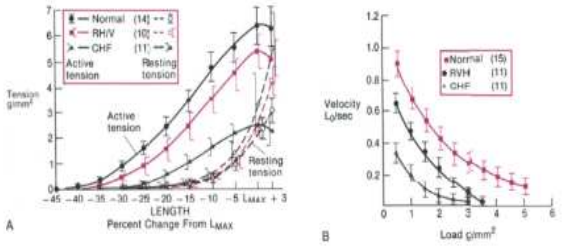
Qu'est-ce que la réserve de précharge ?



Sarnoff S. Ventricular function : I. Starling's law of the heart studied by means of simultaneous right and left venricular function curves in the dog. *Circulation* 1954:9;706-718

LOI DE STARLING ET PERTURBATIONS DES RELATIONS TENSION / LONGUEUR ET FORCE / VITESSE

Influences de l'hypertrophie et de l'insuffisance cardiaque

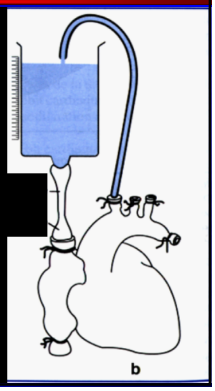


3-Déterminants du Retour Veineux

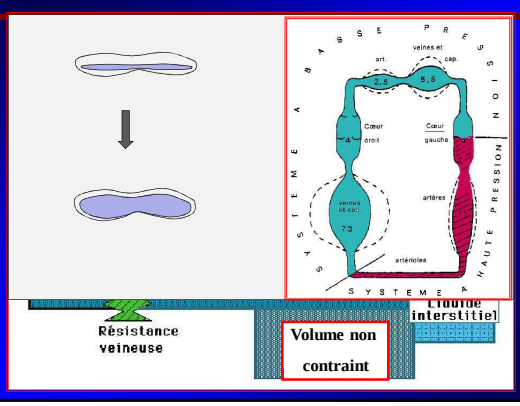
Théorie du retour veineux

Le cœur éjecte dans le circuit artériel tout ce qu'il reçoit par le circuit veineux :
- Loi de Frank Starling (pré-charge => VES)

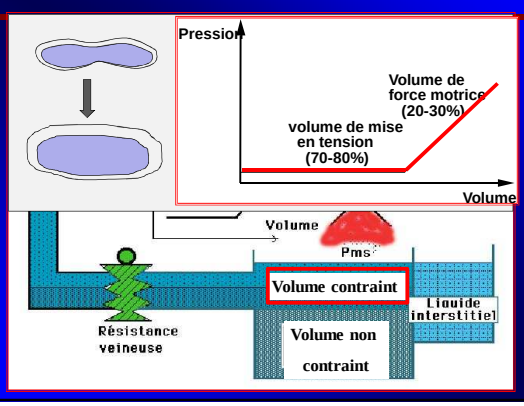
Le cœur ne peut pomper plus qu 'il ne reçoit
Une ↑ RV (remplissage) entraîne un ↑ DC,
jusqu 'à 4 à 5 fois …
Une ↓ du retour veineux entraîne une ↓ du DC



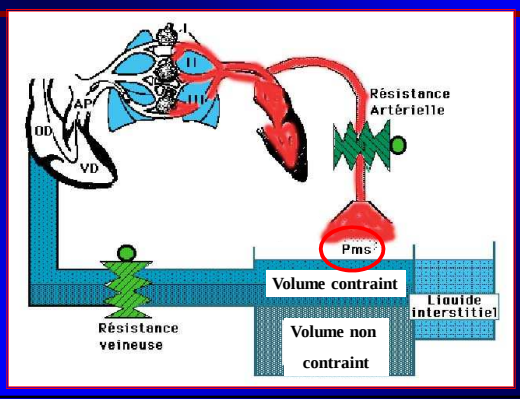
VOLUME NON CONTRAINT



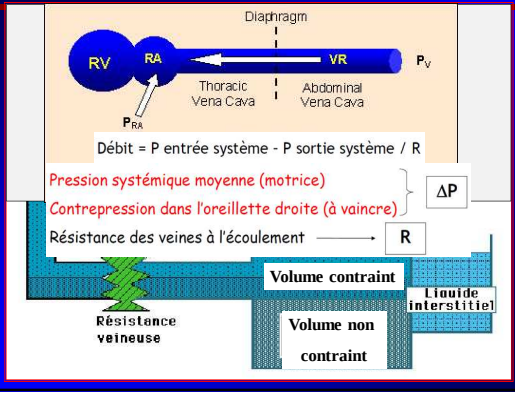
VOLUME CONTRAINT



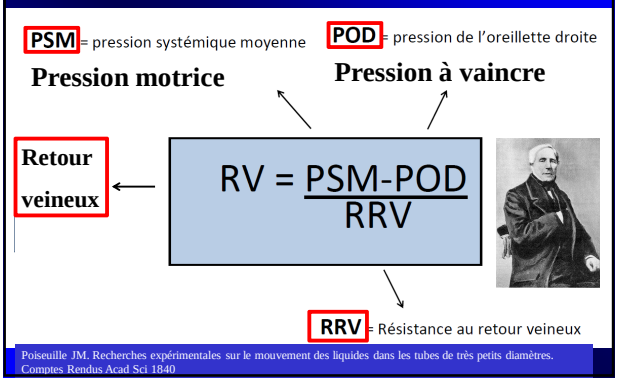
Débit = 0 ➔ PSM



Retour veineux = Force motrice contre ODt

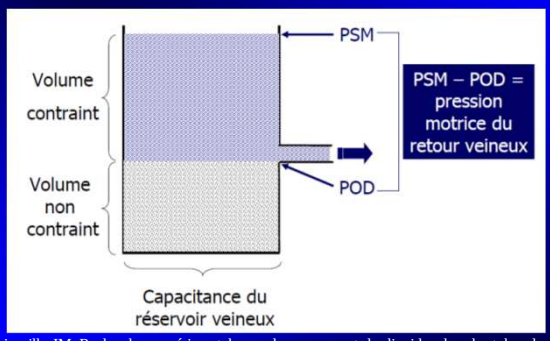


Déterminants du retour veineux
Loi de Poiseuille



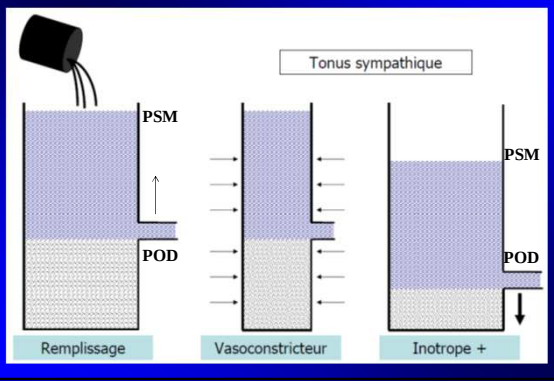
Poiseuille JM. Recherches expérimentales sur le mouvement des liquides dans les tubes de très petits diamètres. Comptes Rendus Acad Sci 1840

Réservoir veineux



Poiseuille JM. Recherches expérimentales sur le mouvement des liquides dans les tubes de très petits diamètres. Comptes Rendus Acad Sci 1840

Augmentation du retour veineux



Courbes de retour veineux d'Arthur Guyton 1955

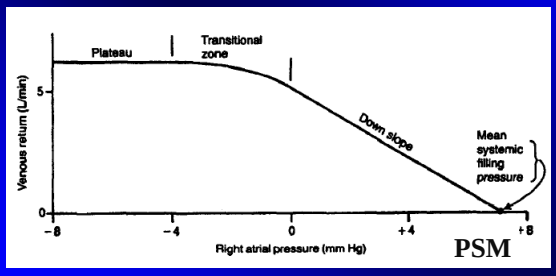
- Etude chez des chiens privés de réflexes
- Mise en place d'une circulation extracorporelle entre OD et cavités gauches
- Etude des modifications du RV en fonction de différents niveaux de POD

Guyton AC, Lindsey AW, Abernathy B, Richardson T. Venous return at various right atrial pressures and the normal venous return curve. Am J Physiol 1957.

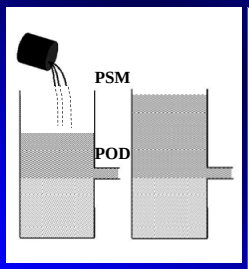
Courbe du Retour Veineux

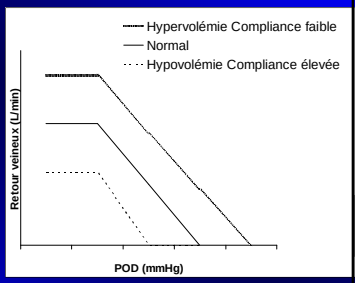
Retour veineux = Psm – POD / RRV

Absence d'innervation sympathique



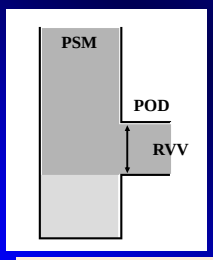
Déterminants du retour veineux

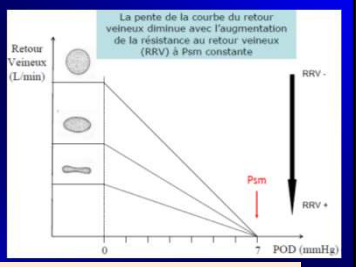




Loi de Poiseuille
$RV = (PSM-POD)/R_{RV}$

Déterminants du retour veineux





α-agonistes : Mobilise volume non contraint *Trippodo 1981*

β-agonistes : ↓compliance veineuse ↓volume non contraint *Arimura 1992*

Autres déterminants du retour veineux

- **Pompe cardiaque** : succion / descente valve A-V
- **Pompe respiratoire** : pression pleurale ↓ à l'inspiration d'où ↑ (cyclique) du retour veineux
- **Pompe musculaire** : écrasement des veines MI par la contraction des muscles squelettique (semelle plantaire, marche)
- **Valvules anti-retour**

Différents compartiments influençant le retour veineux

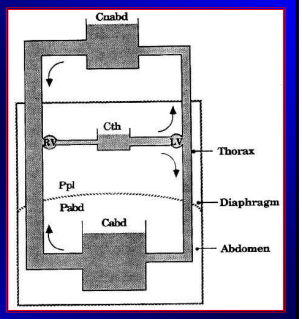
1 - Réservoir intra-thoracique

ventilation mécanique

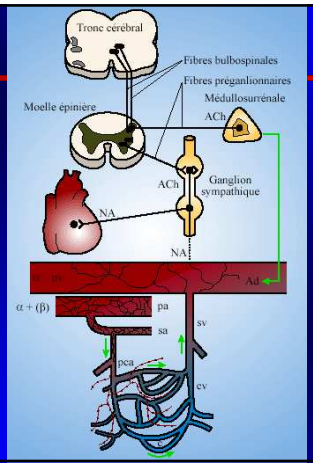
2- Circulation systémique

-circuit intra-abdominal

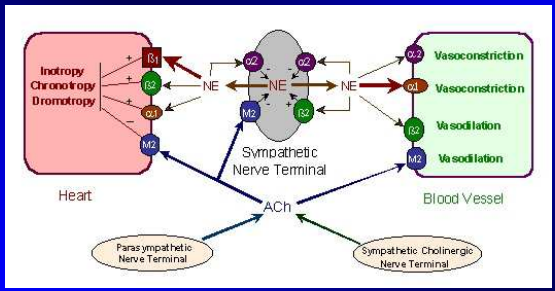
-circuit extra-abdominal



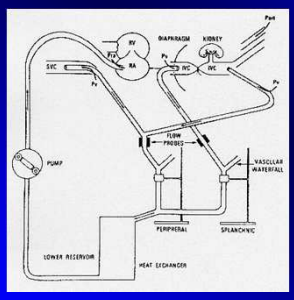
4-Récepteurs du Retour Veineux



Récepteurs vasculaires



Baroréflexe et Retour veineux



Hypotension carotidienne

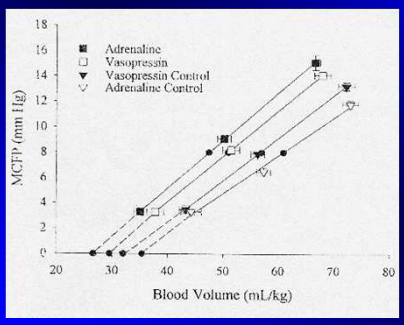
- ↘ résistance veineuse splanchnique,
- ↘ volume non contraint
- ↘ compliance veineuse

==> ↑ le retour veineux

HTA stimule le réflexe carotidien ==> diminution des résistances artérielles et veineuses, ↑ le volume non contraint ==> hypotension

Deschamps, A., & Magder, S. 1992. *Am J Physiol 263*, H1755-H1763

α-agonistes



Adrénaline mobilise le « volume non contraint »

Trippodo, N. C. 1981 *Circ Res 49*, 923-931

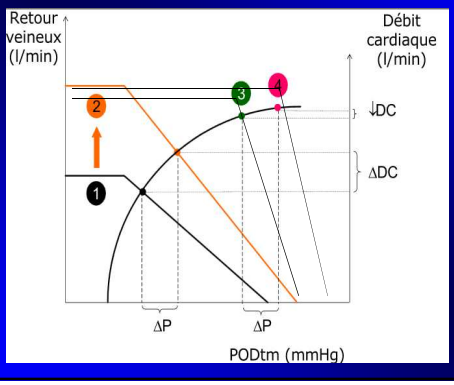
β-agonistes

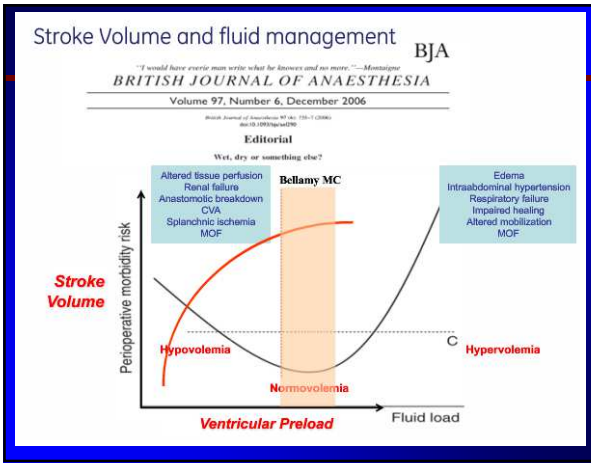
- **Adrénaline, dopamine, dobutamine entrainent tous une veino constriction par leur effet β**
- **diminuent la compliance veineuse, diminuent le volume non contraint**

Arimura H., et al. 1992 Can *J Physiol Pharmacol 70*, 1021-1031

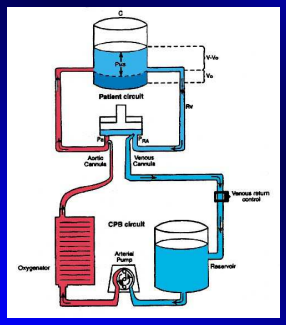
5-Rapport Débit Cardiaque / Retour Veineux

Débit Cardiaque / Retour Veineux

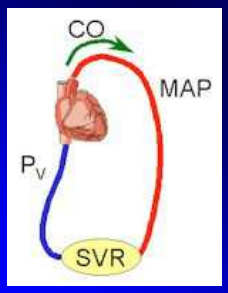


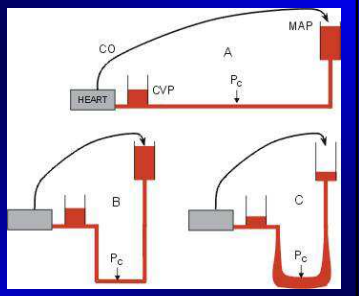


Circulation Extra Corporelle



Cœur droit = pompe aspirante
Cœur gauche = pompe refoulante





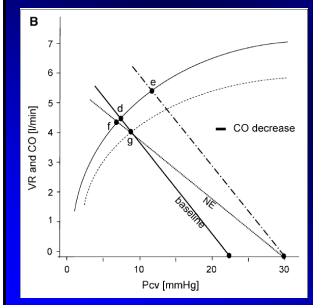
6-Norépinéphrine et Retour Veineux

Noradrénaline

Risques d'ischémie

Cardiac Output Response to Norepinephrine in Postoperative Cardiac Surgery Patients: Interpretation With Venous Return and Cardiac Function Curves*

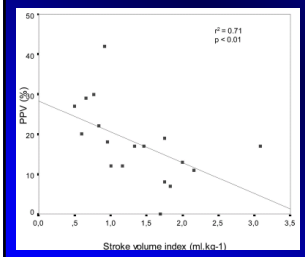
Jacinta J. Maas, MD[1]; Michael R. Pinsky, MD, MCCM[2]; Rob B. de Wilde, PhD[1]; Evert de Jonge, MD, PhD[1]; Jos R. Jansen, MS, PhD[1]

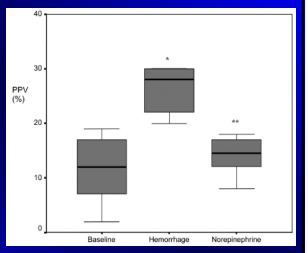


- ***d*** indicates working point of the circulation during baseline condition;
- ***e*** indicates volume effect of generalized venoconstriction on CO by NE;
- ***f*** indicates additional effect of venoconstriction on RVR;
- ***g*** indicates effect of decreased heart function

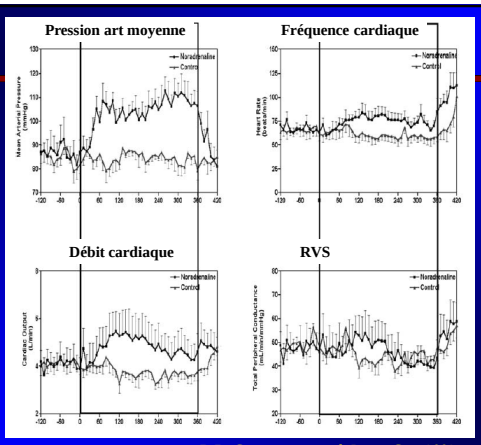
Crit Care Med 2013; 41:143–150

Effects of norepinephrine on static and dynamic preload indicators in experimental hemorrhagic shock*

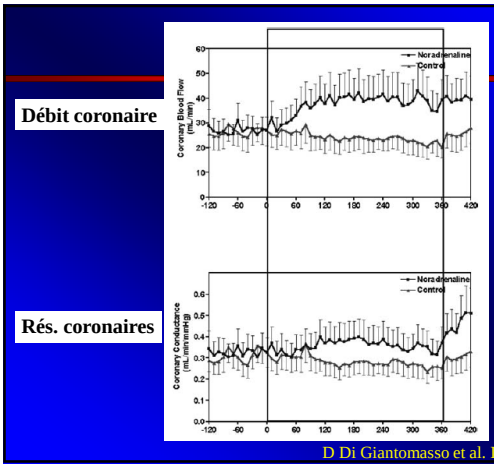




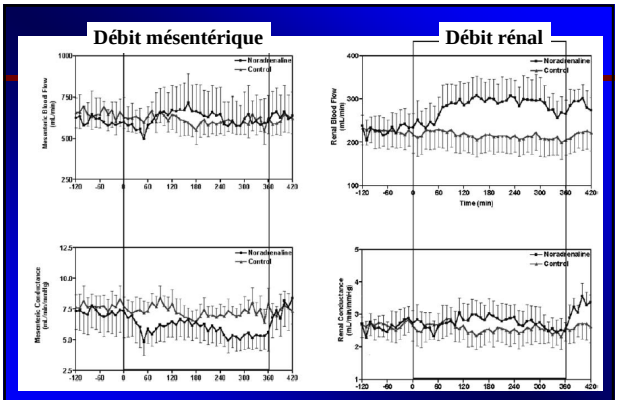
Semir Nouira et al. Crit Care Med 2005; 33:2339 –2343



D Di Giantomasso et al. Intens Care 2002



D Di Giantomasso et al. Intens Care 2002



D Di Giantomasso et al. Intens Care 2002

Hypotension during Fluid-restricted Abdominal Surgery

Effects of Norepinephrine Treatment on Regional and Microcirculatory Blood Flow in the Intestinal Tract

Variable	Control Group			Norepinephrine Group		
	Baseline	P65	P75	Baseline	P65	P75
MAP, mmHg*	58.3 ± 3.5	60.5 ± 6.3	58.5 ± 7.1	59.3 ± 3.9	66.0 ± 4.2	73 ± 3.6†
CI, ml · kg^{-1} · min^{-1}*	79.3 ± 8.5	71.7 ± 7.9	68.8 ± 7.3	79.6 ± 12.3	71.7 ± 7.2	78.7 ± 11.2†
Heart rate, beats/min	116.9 ± 1.7	119.9 ± 8.7	128.1 ± 18.4	117.3 ± 16.1	124.3 ± 21.1	116.5 ± 26.7
SVI, ml · beat^{-1}kg^{-1}	0.68 ± 0.08	0.61 ± 0.09	0.55 ± 0.09	0.68 ± 0.12	0.58 ± 0.11	0.68 ± 0.13†
SVRI, mmHg · kg^{-1} · min^{-1}	711 ± 75	813 ± 132	822 ± 146	764 ± 131	932 ± 169	986 ± 203
PAP, mmHg	13.5 ± 1.5	14.5 ± 1.7	14.5 ± 1.7	13.1 ± 2.6	13.5 ± 2.3	14.2 ± 2.3
CVP, mmHg	2.8 ± 1.0	3.2 ± 0.8	2.9 ± 0.9	2.5 ± 0.5	2.6 ± 0.8	2.5 ± 0.8
HVP, mmHg	3.8 ± 1.4	4.0 ± 1.4	3.9 ± 1.1	3.9 ± 1.1	3.9 ± 1.2	4.1 ± 1.1
PCWP, mmHg	3.1 ± 0.6	3.1 ± 0.8	3.0 ± 0.7	3.4 ± 0.7	3.3 ± 1.3	3.1 ± 1.1
SvO_2, %*	49.5 ± 4.3	48.0 ± 4.4	48.2 ± 3.5	48.8 ± 4.7	49.3 ± 5.1	52.5 ± 4.5†
$HvSO_2$, %	31.9 ± 5.5	29.5 ± 5.8	30.2 ± 5.1	33 ± 7.0	33.1 ± 5.0	30.6 ± 6.1
sDO_2, ml O_2/min*	108 ± 13	101 ± 9	96 ± 12	109 ± 23	100 ± 17	126 ± 21†
Urine output, ml/h	25.8 ± 13.7	15.8 ± 8.7	12.1 ± 5.4	12.5 ± 10.2	15.0 ± 6.0	17.1 ± 6.9
Glucose, mM	4.8 ± 1.0	4.7 ± 0.76	4.2 ± 0.69	4.8 ± 0.65	4.8 ± 0.62	4.9 ± 0.55
aHb, g/l*	102 ± 7	101 ± 6	102 ± 6	101 ± 11	107 ± 10	115 ± 6†

Hiltebrand Anesthesiology, V 114 • No 3

Restrictive Deferred Hydration Combined with Preemptive Norepinephrine Infusion during Radical Cystectomy Reduces Postoperative Complications and Hospitalization Time

Table 3. Postoperative Fluid Administration, Body Weight Differences, Renal, Metabolic, Inflammatory, and Cardiac Biomarkers

Characteristic	Low-volume Group (n = 83)	Control Group (n = 83)	*P* Value
Postoperative day 1			
Total fluid volume perfused (ml)	2,100 [800–4,000]	2,050 [1,000–4,100]	0.90
Weight difference *vs.* preop (kg/BW)	+0.0 [−3 to +4]	+2 [−2 to +7]	<0.0001
$S_{a-v}O_2$ (%)	80 [43–98]	80 [68–98]	0.14
Serum lactate (mM)	1.1 [0.6–2.3]	1.0 [0.5–5.1]	0.81
Number of patients with lactate level >2 mM	3 (4%)	2 (2%)	
Hemoglobin (g/dl)	8.5 [5.4–12.6]	8.2 [5.3–11.7]	0.47
Hematocrit	0.25 [0.16–0.37]	0.25 [0.16–0.34]	0.52
Serum creatinine (μM)	94 [53–269]	84 [43–200]	0.02
eGFR (MDRD)/1.73 m^2 (ml/min)	67 [19–90]	74 [26–90]	0.02
Serum osmolality (mosmol/kg)	288 [278–300]	289 [267–297]	0.15
Urine osmolality (mosmol/kg)	510 [216–979]	553 [244–843]	0.64
Albumin (g/l)	32 [23–48]	31 [20–54]	0.0027
Procalcitonin (ng/ml)	1.1 [0.1–25.1]	1.1 [0.1–9.2]	0.95
C-reactive protein (mg/l)	85 [42–171]	81 [3–242]	0.64
Brain natriuretic peptide (pg/ml)	50 [5–419]	72 [5–962]	0.0187
High-sensitive troponin T (μg/l)	0.01 [0.001–0.22]	0.01 [0.001–0.065]	0.46

Wuethrich Anesthesiology. 2014 Feb;120(2):365-77

Eur Urol. 2014 Aug;66(2):352-60. doi: 10.1016/j.eururo.2013.08.046. Epub 2013 Aug 28.

Intraoperative continuous norepinephrine infusion combined with restrictive deferred hydration significantly reduces the need for blood transfusion in patients undergoing open radical cystectomy: results of a prospective randomised trial.

Wuethrich PY[1], Studer UE[2], Thalmann GN[2], Burkhard FC[3].

Median blood loss = NAD **800 ml vs 1200 ml** groupe control (p<0.0001).
Unités globulaires = **1.8 U NAD vs 2.9 U** groupe control
The absolute reduction in transfusion rate throughout hospitalisation was 28% (95% CI, 12-45).

Continuous norepinephrine administration combined with restrictive hydration significantly reduces intraoperative blood loss, the rate of blood transfusions, and the number of PRBC units required per patient undergoing ORC with UD.

Sondes Transonic*

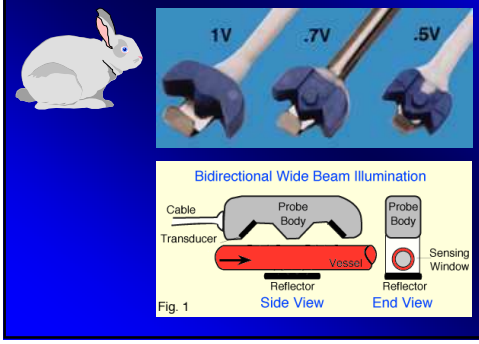
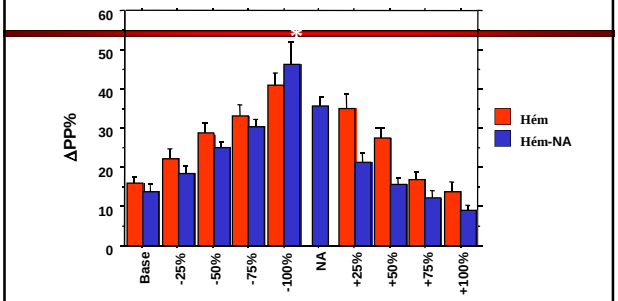
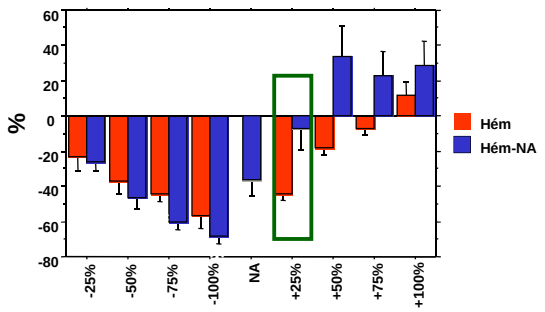


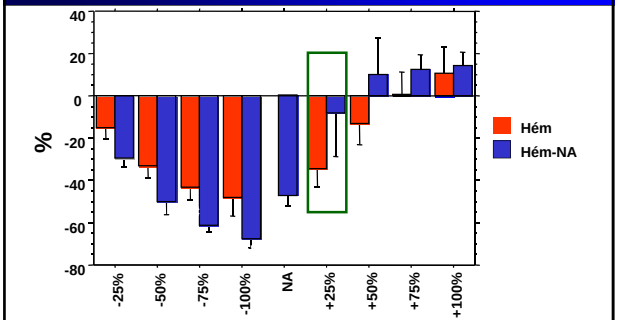
Fig. 1



Variations de ΔPP% lors du saignement et de la retransfusion
après une perfusion de NA ; Hém : groupe hémorragie (n = 20) ;
Hém-NA : groupe hémorragie + perfusion de noradrénaline (n = 20) ;
*p <0.05 vs valeurs basales

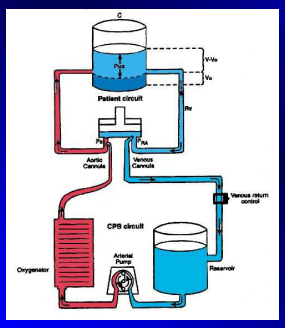


Variations du débit cardiaque lors du saignement et de la retransfusion
après une perfusion de NA ; Hém : groupe hémorragie (n = 20) ;
Hém-NA : groupe hémorragie + perfusion de noradrénaline (n = 20) ;
*p <0.05 vs valeurs basales



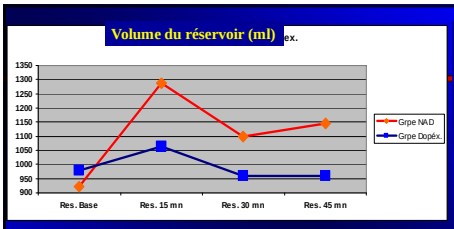
Variations du débit mésentérique lors du saignement et de la retransfusion
après une perfusion de NA ; Hém : groupe hémorragie (n = 20) ;
Hém-NA : groupe hémorragie + perfusion de noradrénaline (n = 20) ;
*p <0.05 vs valeurs basales

Circulation Extra Corporelle

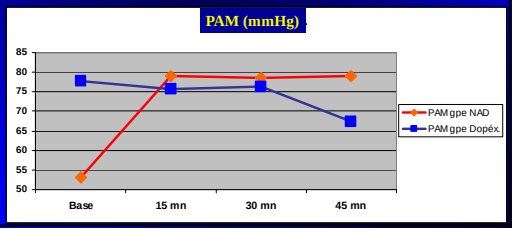


Matériel et méthode

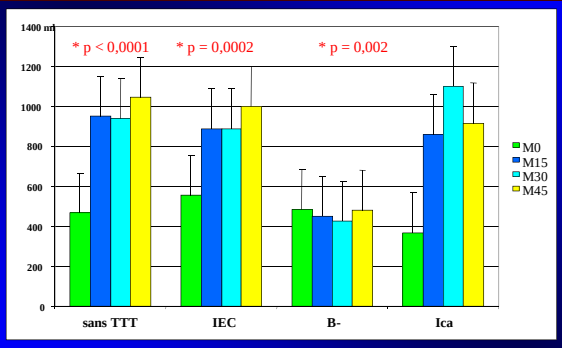
- 22 patients sous CEC pour chirurgie cardiaque (valves aortiques)
- Débit pompe constant
- Evaluation des variations du contenu du réservoir de CEC avec et sans noradrénaline (< 0,5 µg/kg/mn) à 15, 30 et 45 minutes
- Analyse des résultats en fonction de l'imprégnation par β bloquant



NAD / Dopexamine sous CEC

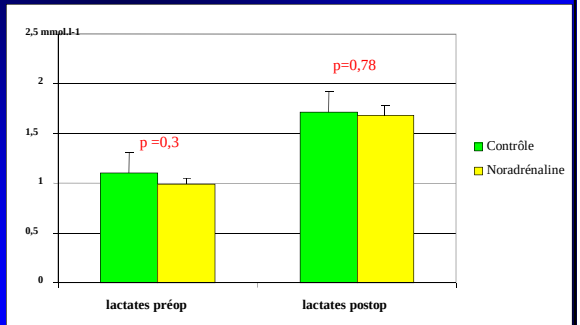


Volume du réservoir de CEC

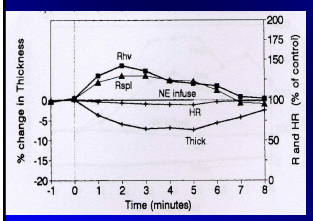


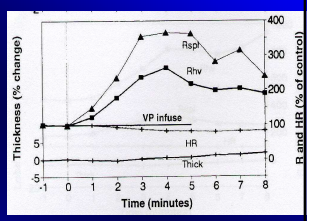
* Par rapport au groupe B-

Lactatémies pré et postopératoires



Réponses microvasculaires hépatiques

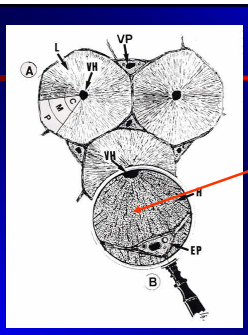


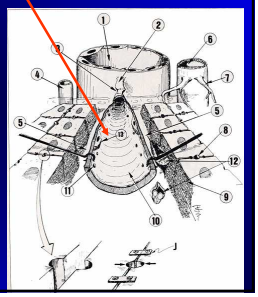


Noradrénaline Vasopressine

Rothe et al. Am J Physiol Heart Circ Physiol 2000

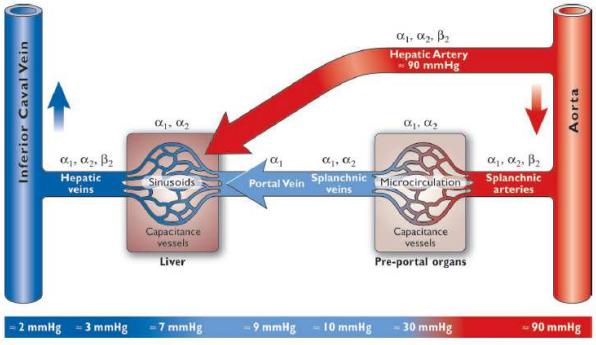
Veinomotricité à partir des cellules stellaires des sinusoïdes



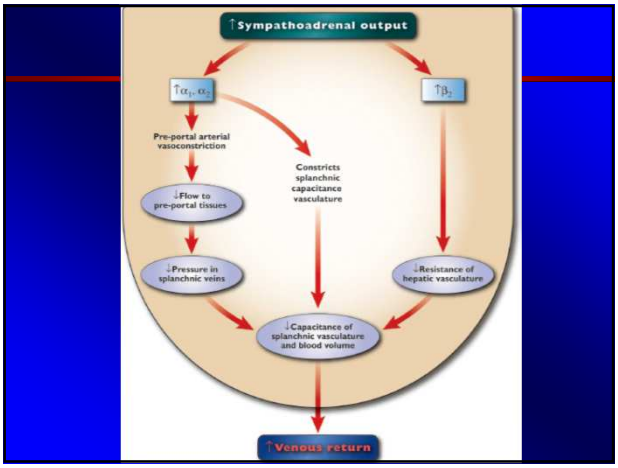


Rothe et al. Am J Physiol Heart Circ Physiol 2000

Catecholamine-induced Changes in the Splanchnic Circulation Affecting Systemic Hemodynamics



Richard B Weiskopf, Anesthesiology 2004; 100:434–9



7-Retour veineux

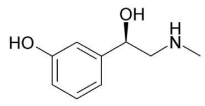
Vasopressine

Néosynéphrine

Retour veineux

Néosynéphrine

Phényléphrine



Myocarde			Vaisseaux		
β_1	β_2	α_1	α_1	β_2	D_1
		X	X		

Agent synthétique

Non tachycardisant : coronarien

Anti arythmique par action quinidine-like

Tachyphylaxie modérée, fréquente

Pas de vasconstriction utérine

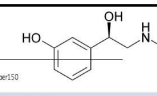
Problèmes

Augmentation travail cardiaque par postcharge

Quid du débit cardiaque ?

Diminution possible de la perfusion régionale

Phényléphrine



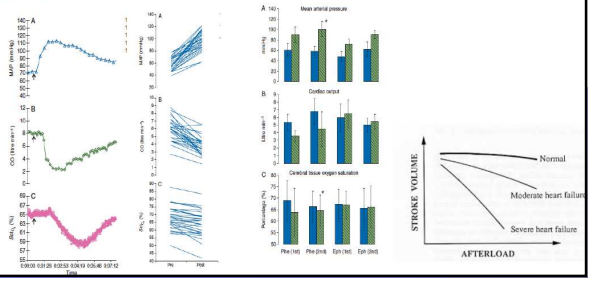
British Journal of Anaesthesia 107 (2): 209–17 (2011)
Advance Access publication 3 June 2011 · doi:10.1093/bja/aer150

BJA

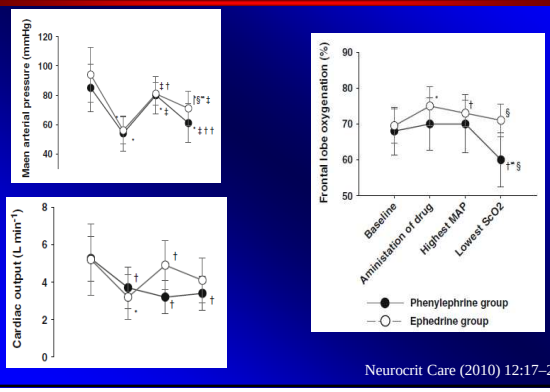
NEUROSCIENCES AND NEUROANAESTHESIA

Effect of phenylephrine and ephedrine bolus treatment on cerebral oxygenation in anaesthetized patients

L. Meng[1*], M. Cannesson[1], B. S. Alexander[1], Z. Yu[2], Z. N. Kain[1], A. E. Cerussi[3], B. J. Tromberg[3] and W. W. Mantulin[3]

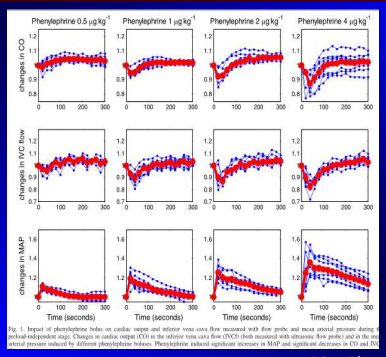


Phenylephrine but not Ephedrine Reduces Frontal Lobe Oxygenation Following Anesthesia-Induced Hypotension



Neurocrit Care (2010) 12:17–23

Effect of phenylephrine on cardiac output and venous return depend on the position of the heart



J App Physiol 2012,113: 281

The clinical implications of isolated alpha(1) adrenergic stimulation

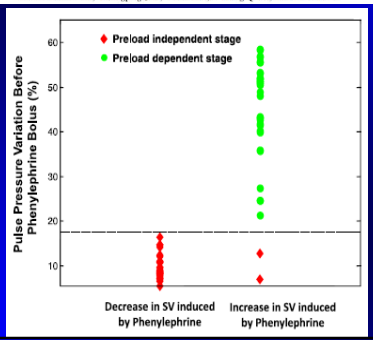
Thiele Anesth Analg 2011;113:297–304

- Cas spécifiques où la phényléphrine peut être un choix pharmacologique rationnel (sténose critique aortique, tétralogie de Fallot, hypotension lors de l'accouchement par césarienne) ➔ effets régionaux de la phényléphrine (diminution du rythme cardiaque, des modifications favorables rapport Q (p): Q (s), ↗ oxygène du fœtus: ratio de la demande) l'emportent sur ses effets globaux (diminution du débit cardiaque).
- Dans les états physiopathologiques dans lesquelles aucun avantage régional est obtenu en utilisant un alpha (1) agoniste, des vasopresseurs alternatifs doivent être recherchés.

J Appl Physiol 113: 281–289, 2012.
First published May 3, 2012; doi:10.1152/japplphysiol.00126.2012.

Effects of phenylephrine on cardiac output and venous return depend on the position of the heart on the Frank-Starling relationship

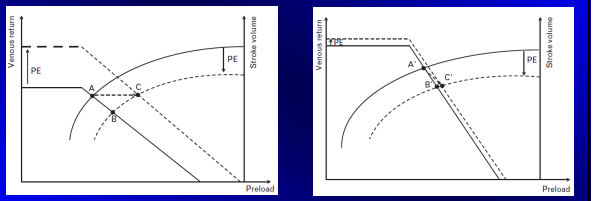
Maxime Cannesson,[1] Zhongping Jian,[2] Guo Chen,[1,3] Trung Q. Vu,[1] and Feras Hatib[2]



Preload dependency determines the effects of phenylephrine on cardiac output in anaesthetised patients

A prospective observational study

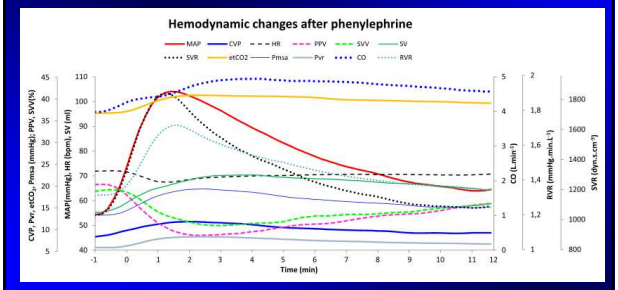
Olivier Rebet, Olivier Andremont, Jean-Louis Gérard, Jean-Luc Fellahi, Jean-Luc Hanouz and Marc-Olivier Fischer



Précharge dépendant | **Précharge indépendant**

Eur J Anaesthesiol 2016; 33:638–644

Phenylephrine increases cardiac output by raising cardiac preload in patients with anesthesia induced hypotension

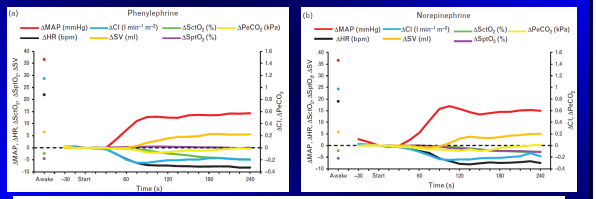


Journal of Clinical Monitoring and Computing (2018) 32:969–976

Differential effects of phenylephrine and norepinephrine on peripheral tissue oxygenation during general anaesthesia

A randomised controlled trial

Marieke Poterman, Jaap Jan Vos, Hugo E.M. Vereecke, Michel M.R.F. Struys, Henk Vanoverschelde, Thomas W.L. Scheeren and Alain F. Kalmar



mean arterial pressure (MAP), heart rate (HR), cardiac index (CI), end-tidal carbon dioxide partial pressure (PeCO2), cerebral tissue oxygen saturation (SctO2), peripheral tissue oxygen saturation (SptO2)

Eur J Anaesthesiol 2015; 32:571–580

Retour veineux

Vasopressine 0.03-12 U/mn

Annals of Cardiac Anaesthesia

Year : 2012 | Volume : 15 | Issue : 2 | Page : 128--133

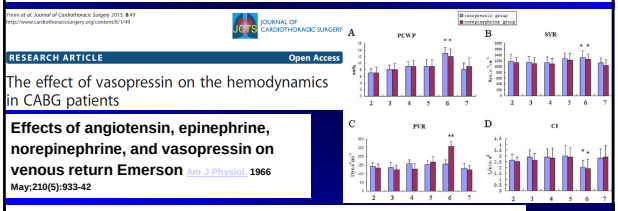
Infusion of low-dose vasopressin improves left ventricular function during separation from cardiopulmonary bypass: A double-blind randomized study

Ahmed Said Elgebaly[1], Mohab Sabry[2],

[1] Department of Anesthesia and SICU, Faculty of Medicine, Tanta University, Egypt

[2] Department of Cardiothoracic Surgery, Faculty of Medicine, Tanta University, Egypt

Perfusion de vasopressine à faible dose (vasopressine 0,03 UI / min) pour les patients avec une dysfonction ventriculaire gauche systolique légère à modérée lors de la séparation de la CEC est bénéfique pour le profil hémodynamique postopératoire, réduit les doses de catécholamines nécessaires et améliore la fonction systolique ventriculaire gauche



Effects of angiotensin, epinephrine, norepinephrine, and vasopressin on venous return Emerson Am J Physiol. 1966 May;210(5):933-42

Comparative effects of norepinephrine and vasopressin on internal thoracic arterial graft flow after off-pump coronary artery bypass grafting
The Journal of Thoracic and Cardiovascular Surgery 2011Volume 141, Number 1

Interactive CardioVascular and Thoracic Surgery 18 (2014) 360–370
doi:10.1093/icvts/ivt491 Advance Access publication 21 November 2013

BEST EVIDENCE TOPIC – ADULT CARDIAC

Desmopressin for reducing postoperative blood loss and transfusion requirements following cardiac surgery in adults

Brecon H. Wademan[a,*] and Sean D. Galvin[b]

Prophylactic Vasopressin in Patients Receiving the Angiotensin-Converting Enzyme Inhibitor Ramipril Undergoing Coronary Artery Bypass Graft Surgery

Suruchi Hasija, MD,* Neeti Makhija, MD,* Minati Choudhury, MD,* Milind Hote, MS, MCh,† Sandeep Chauhan, MD,* and Usha Kiran, MD*

Papadopoulos *et al. Journal of Cardiothoracic Surgery* 2010, **5**:17
http://www.cardiothoracicsurgery.org/content/5/1/17

JOURNAL OF CARDIOTHORACIC SURGERY

STUDY PROTOCOL Open Access

Perioperative infusion of low- dose of vasopressin for prevention and management of vasodilatory vasoplegic syndrome in patients undergoing coronary artery bypass grafting-A double-blind randomized study

Intensive Care Medicine
November 2018, Volume 44, Issue 11, pp 1816–1825 | Cite as

Terlipressin versus norepinephrine as infusion in patients with septic shock: a multicentre, randomised, double-blinded trial

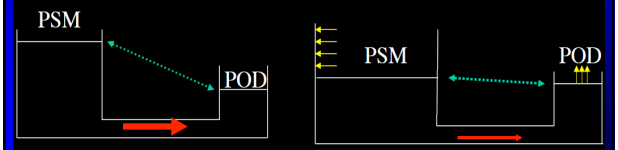
Results

Between 1 January 2013 and 28 February 2016, 617 patients were randomised (312 to the terlipressin group, 305 to the NE group). The modified intention-to-treat population comprised 526 (85.3%) patients (260 in the terlipressin group and 266 in the NE group). There was no significant difference in 28-day mortality rate between the terlipressin group (40%) and the NE group (38%) (odds ratio 0.93 [95% CI 0.55–1.56]; $p = 0.80$). Change in SOFA score on day 7 was similar between the two groups: − 7 (IQR − 11 to 3) in the terlipressin group and − 6 (IQR − 10 to 5) in the NE group. There was no difference between the groups in the number of days alive and free of vasopressors. Overall, serious adverse events were more common in the terlipressin group than in the NE group (30% vs 12%; $p < 0.001$).

8-Applications cliniques du retour veineux

Effet de l'anesthésie sur le retour veineux

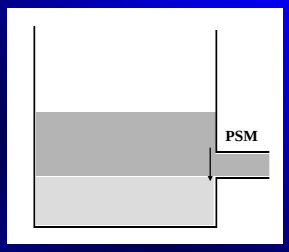
- Drogues d 'anesthésie:
  - Veinodilatation => baisse de la PSM
- Ventilation mécanique:
  - Augmentation des pressions intra-thoraciques
  - Augmentation de la POD



Baisse du retour veineux donc du débit cardiaque

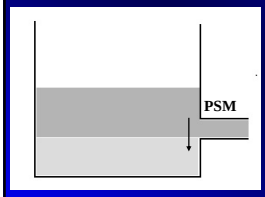
Rachianesthésie & Anesthésie générale

- ↓ SNA OΣ
- Veinoplégie
- ➔↓ Résistance veineuse
  ↓ PSM

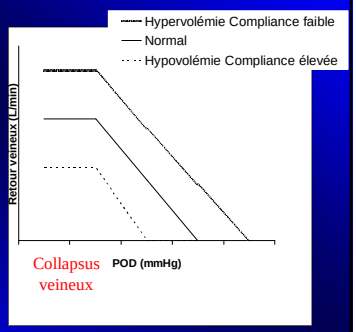


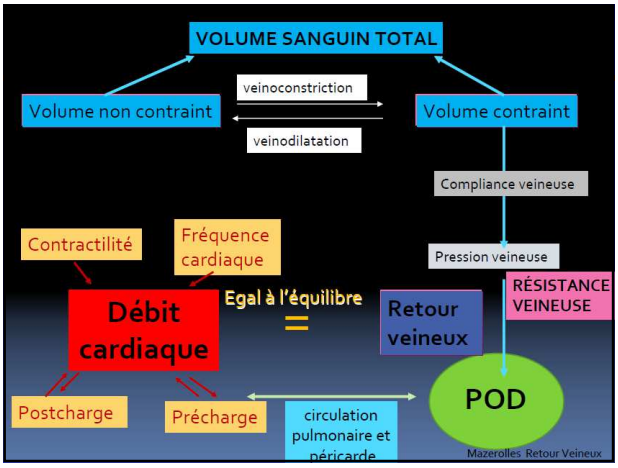
- Ephédrine
- Remplissage

CEC & SIRS

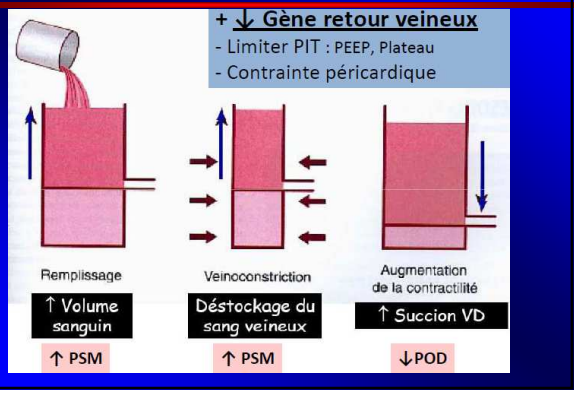


- ↘ SNA OΣ
- Veinodilatation
- SIRS





Augmentation du retour veineux



Au total

- **Système veineux = réservoir recrutable**
- **Recrutement veinulaire et hépatosplanchnique**
- **ΔPP% ou autres variations resp (Doppler)**
- **Index cardiaque ➔ Volo répondeurs ou pas**
- **Finalité = débit régionaux adaptés aux besoins**
  - **SvO2 < 50 % ➔ ↗ extraction**
  - **Gap CO2 > 20 ➔ Insuf circulatoire**