Evaluation clinique de la réserve de précharge

Martin Girard, MD
Hôpital Notre-Dame du CHUM
Université de Montréal

Evaluation clinique de la réserve de précharge

- Approche « classique » de la gestion liquidienne
- Restrictif vs optimisé?
- Evaluation de la réserve de précharge
  - Paramètres statiques
    - PVC, PAPO et autres
  - Paramètres dynamiques
    - Intéractions cardiopulmonaires
      - Test d'occlusion télé-expiratoire
    - Epreuve de levée de jambes
  - « Challenge volémique »

Approche « classique » de la gestion liquidienne

- Historique
- Recommandations actuelles
- Fondements scientifiques
- Problèmes

Historique

- Moore, 1959
  Metabolic Care of the Surgical Patient
- Shires et al, Annals of Surgery, 1961
  Acute Change in Extracellular Fluids Associated with Major Surgical Procedures
- Shoemaker et al, Chest, 1988
  Prospective Trial of Supranormal Values of Survivors as Therapeutic Goals in High-Risk Surgical Patients
- Brandstrup et al, Annals of Surgery, 2003
  Effect of Intravenous Fluid Restriction on Postoperative Complications: Comparison of Two Perioperative Fluid Regimens

Recommandations actuelles

- Miller 7e édition
  - Jeune
    - 0 - 10 kg: 4 cc / kg / h
    - 10 - 20 kg: 40 cc / h + 2 cc / kg / h (kg - 10)
    - > 20 kg: 60 cc / h + 1 cc / kg / h (kg - 20)
  - Pertes 3e espace
    - Trauma minime: 2 cc / kg / h (anciennement 4)
    - Trauma modéré: 4 cc / kg / h (anciennement 6)
    - Trauma extrème: 6 cc / kg /h (anciennement 8)
  - Pertes sanguines
    - 3 : 1 si crystalloïdes
    - 1 : 1 si colloïdes

Fondement scientifique

- Jeune
  - Darrow & Pratt, JAMA, 1950
  - Holliday & Segar, Pediatrics, 1957
  - Furman et al., Anesthesiology, 1975
- Perte 3e espace
  - Shires et al., *Ann Surg*, 1961
    - 13 pts, cholécystectomies ouvertes surtout
    - Aucun apport IV durant étude
  - Robert et al., *Ann Surg*, 1985
    - Vagotomie/antrectomie ou cholécystectomie
    - 5 pts, LR 300 - 500 cc/h (6 - 8 cc/kg/h)
    - 10 pts, D_5W 350 - 1150 cc/h
    - Vol EC inchangé chez LR, mais diminué 1.9L D_5W
  - Campbell et al., *Br J Anaesth*, 1990
    - Étude de la fonction rénale chez pts subissant résections intestinales
    - 6 pts D_5W 10 cc/kg/h
    - 6 pts LR 10 cc/kg/h
    - Meilleure stabilité HD avec 15 cc/kg/h dans la chirurgie abdominale « majeure »

Et puis tout a changé…

Résections intestinales

- 141 pts, ASA I-III, chirurgie colorectale pour néoplasie
  - Exclus: grossesse, allaitement, alcoolisme, diabète, IRC, cancer métastatique ou co-existant, IBD, contre-indication à l'épidurale
- Randomisée, simple insu (observateur), multi-centrique
- Hypothèse
  - 20% réduction complications postop à 30 jours

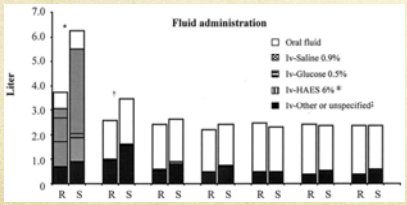
Brandstrup et al., *Ann Surg*, 2003;238:641-8

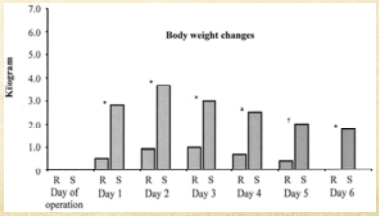
Résections intestinales (II)

TABLE 1. Intraoperative Fluid Therapy

	Restricted Regimen	Standard Regimen
Preloading of epidural analgesia	No preloading.	500 mL HAES 6%.*
Third space loss	No replacement	Normal saline 0.9%: 7 mL/kg/h first hour; 5 mL/kg/h second and third hour; 3 mL/kg/h following hours.
Loss during fast (maintenance)	500 mL of glucose 5% in water less oral fluid intake during fast.	500 mL of normal saline 0.9% independent of oral intake.
Blood loss	Volume-to-volume with HAES 6% with allowance for max. 500 mL extra.	Loss up to 500 mL: 1000–1500 mL of normal saline; Loss >500 mL, additional HAES 6%.
	Blood component therapy started at approximate loss >1500 mL dependent on hematocrit.	Blood component therapy started at approximate loss >1500 mL dependant on hematocrit.

*Hydroxyethyl starch 6% in normal saline.





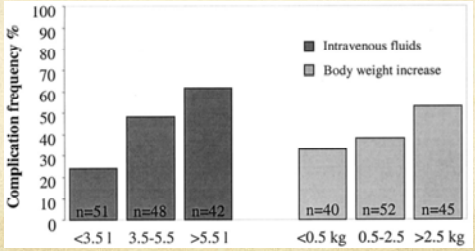
Brandstrup et al., *Ann Surg*, 2003;238:641-8

Résections intestinales (III)

TABLE 3. Number of Patients With Complications (Per-Protocol Analysis)

	Blinded Assessment			Unblinded Assessment		
	Restricted Group	Standard Group	*P* value	Restricted Group	Standard Group	*P* value
Overall complications	21	40	0.003	21	43	0.000
Major complications†	8	18	0.040	8	19	0.026
Minor complications†	15	36	0.000	15	37	0.000
Tissue-healing complications†	11	22	0.040	10	24	0.009
Cardiopulmonary complications†	5	17	0.007	4	18	0.002

n = 69 in restricted group and n = 72 in standard group.
†Number of patients in subgroups does not add up to number of overall complications because some patients had more than 1 complication.



Brandstrup et al., *Ann Surg*, 2003;238:641-8

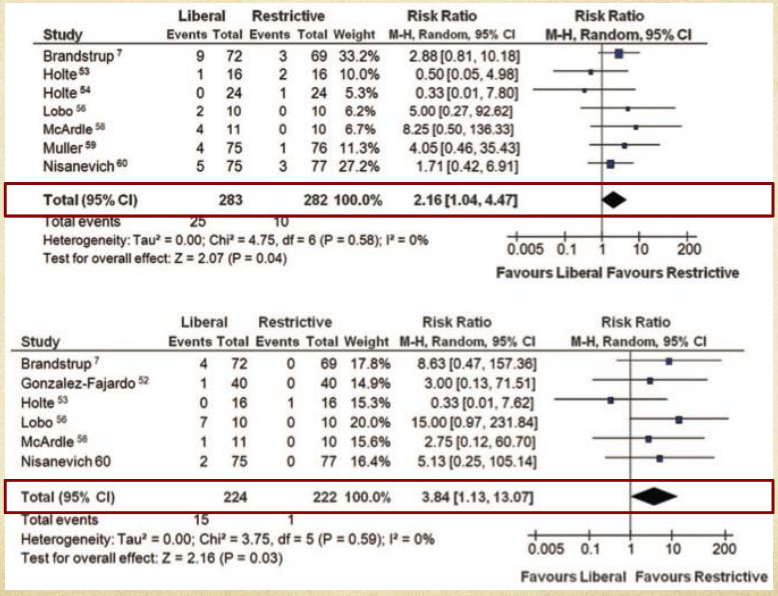
Restrictif vs optimisé

- Deux courants de pensée
  - Restrictif
    - Chirurgies électives, surtout coliques
      - Ultra-fast track
      - Protocole ERAS
    - « How low can you go? »
  - Optimisé
    - Patients avec classe ASA élevé ou chirurgies à haut risque
    - « Ni trop, ni pas assez »

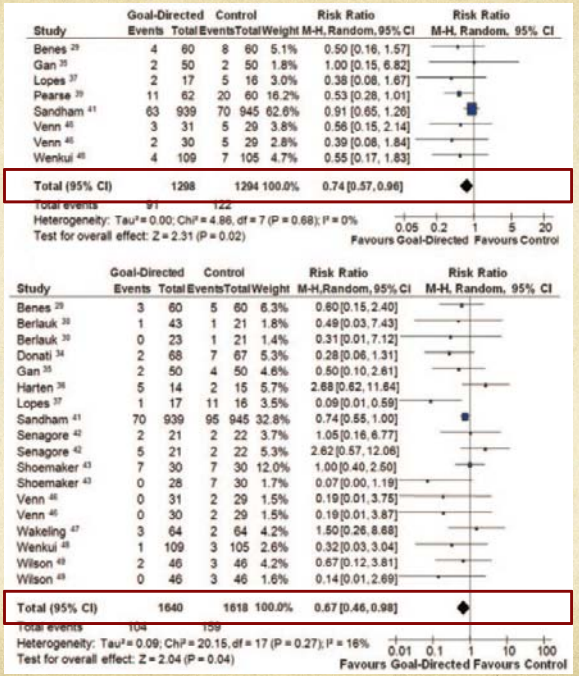
Table 1. Details of Studies Subjected to Meta-Analysis

Author, country, journal, year	Fluid management strategy	Type of surgery	Elective/ emergency	Risk category
Benes et al.[29]	GD	Major abdominal	Elective	High risk (ASA 2–4)
Berlauk et al., USA, Ann Surg 1991[30]	GD	Vein bypass for limb salvage	Elective	High risk (vasculopaths)
Buettner et al., Germany, BJA 2008[32]	GD	Major bowel resection	Elective	High risk (ASA 1–3)
Conway et al., UK, Anaesthesia 2002[33]	GD	Major bowel resection	Elective	High risk (ASA 1–3)
Donati et al., Italy, Chest 2007[34]	GD	Extensive abdominal	Elective	High risk (ASA 2–4)
Gan et al., USA, Anesthesiology 2002[35]	GD	Major abdominal (general/gyne/urology)	Elective	High risk (ASA 1–3)
Harten et al., Scotland, Int J Surgery 2008[36]	GD	Major abdominal	Emergency	High risk (ASA 1–4)
Senagore et al., USA, Dis Colon Rectum 2009[37]	GD	Laparoscopic segmental colectomy	Elective	High risk (ASA 1–3)
Shoemaker et al., USA, Chest 1988[43]	GD	High-risk surgical operations	Both	High risk
WenKui et al., China, Surgery 2010[38]	GD	GI operations for malignancy	Elective	High risk (ASA 1–3)
Bonazzi et al., Italy, Eur J Vasc Surg 2002[21]	GD	Infrarenal AAA repair	Elective	High risk
Ramsingh et al., California, ASA Annual Meeting 2010 (abstract)[40]	GD	Major abdominal	Elective	Low–moderate risk
Brandstrup et al., Denmark, Annals of Surgery 2003[8]	LVR	Colorectal	Elective	High risk (ASA 1–3)
Gonzalez-Fajardo et al., Spain, Eur J Endovasc Surg 2009[22]	LVR	Infrarenal graft repair	Elective	High risk (ASA 1–3)
Holte et al., Denmark, Br J Anaesth 2007[13]	LVR	Colon	Elective	High risk (ASA 1–3)
Holte et al., Denmark, Anesth Analg 2007[14]	LVR	Knee arthroplasty	Elective	Low risk (ASA 1–3)
Hubner[42]	LVR	Colon resection	Elective	High risk (ASA 1–4)
Kabon et al., USA/Austria/Switzerland, Anesth Analg 2005[15]	LVR	Colon resection	Elective	High risk (ASA 1–3)
Lobo et al., UK, Lancet 2002[16]	LVR	Hemicolectomy or sigmoidectomy for carcinoma	Elective	High risk
McArdle et al., Northern Ireland, Ann Surg 2009[18]	LVR	Open infrarenal AAA repair	Elective	High risk
Vermeulen, The Netherlands, Trials, 2009[41]	LVR	Elective general abdominal surgery	Elective	High risk (ASA 1–3)
Nisanevich, Israel, Anaesthesiology, 2005[20]	LVR	Major elective abdominal surgery	Elective	High risk (ASA 1–3)
Muller, Switzerland, Gastroenterology, 2009[44]	LVR	Open elective colonic resection with a primary anastomosis	Elective	High risk (ASA 1–3)
MacKay, UK, Br J Surg, 2006[17]	LVR	Elective colorectal resection with primary anastomosis	Elective	High risk (ASA 1–4)
Sandham, Canada, N Engl J Med, 2003[11]	GD	Urgent or elective major abdominal, thoracic, vascular, or hip fracture surgery	Urgent and elective	High risk (ASA 3–4)
Pearse, UK, Crit Care, 2005[39]	GD	Major general surgery at high risk of postoperative complications	Urgent and elective	High risk (ASA 3 or 4)
Noblett, UK, Br J Surg, 2006[28]	GD	Elective colorectal resection	Elective	High risk
Sinclair, UK, BMJ, 1997[45]	GD	Emergency femoral neck fracture surgery	Emergency	High risk (ASA 2–3)
Szakmany, Hungary, Intens Care Med, 2006[19]	GD	Elective esphagectomy, total gastrectomy, pancreatectomy, or liver resection due to tumor removal	Elective	High risk
Venn, UK, Br J Anaesth, 2002[46]	GD	Proximal femoral fracture repair under GA	Urgent	High risk (ASA 2–4)
Wakeling, UK, Br J Anaesth, 2005[47]	GD	Elective or semielective large bowel surgery	Elective	High risk
Lopes, Brazil, Crit Care, 2007[27]	GD	Elective high-risk surgery (GI/ hepatobiliary/urological)	Elective	High risk (ASA 1–3)
Bender, USA, Ann Surg, 1997[26]	GD	Elective vascular surgery	Elective	High risk
Wilson, UK, BMJ, 1999[23]	GD	Major elective surgery	Elective	High risk
Ziegler, USA, Surgery, 1997[50]	GD	Elective aortic reconstruction or limb salvage procedures	Elective	High risk

Corcoran et al., *Anesth Analg*, 2012;114:640-51



Corcoran et al., *Anesth Analg*, 2012;114:640-51

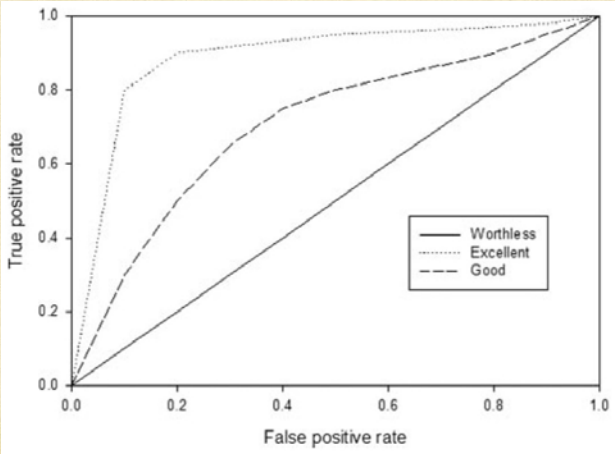


Corcoran et al., *Anesth Analg*, 2012;114:640-51

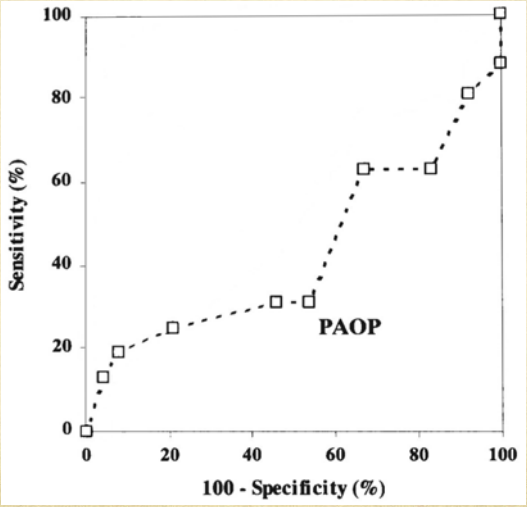
Restrictif vs optimisé?

- Brandstrup, Br J Anaesth 2012
  - Pas de différence dans aucun des objectifs
- Optimisation de quoi au juste?
  - Débit cardiaque / DO_2
    - **Précharge**
    - Postcharge
    - Contractilité
    - Fréquence cardiaque
    - Hémoglobine
    - PaO_2

Courbes de ROC



PAPO



Michard et al., *Am J Respir Crit Care Med*, 2000;162:134-8.

PAPO

Table 3—*PAOP Before Volume Expansion in Responders and Nonresponders

Source	PAOP, mm Hg	
	Responders	Nonresponders
Calvin et al[2]	8 ± 1	7 ± 2
Schneider et al[3]	10 ± 1	10 ± 1
Reuse et al[4]	10 ± 4	10 ± 3
Diebel et al[6]	14 ± 7	7 ± 2†
Diebel et al[7]	16 ± 6	15 ± 5
Wagner and Leatherman[8]	10 ± 3	14 ± 4†
Tavernier et al[9]	10 ± 4	12 ± 3
Tousignant et al[11]	12 ± 3	16 ± 3†
Michard et al[12]	10 ± 3	11 ± 2

*Values are expressed as mean ± SD, except for the study of Schneider et al[3] (mean ± SEM).
†$p < 0.05$ responders vs nonresponders.

Michard et al., *Chest*, 2002;121:2000-8.

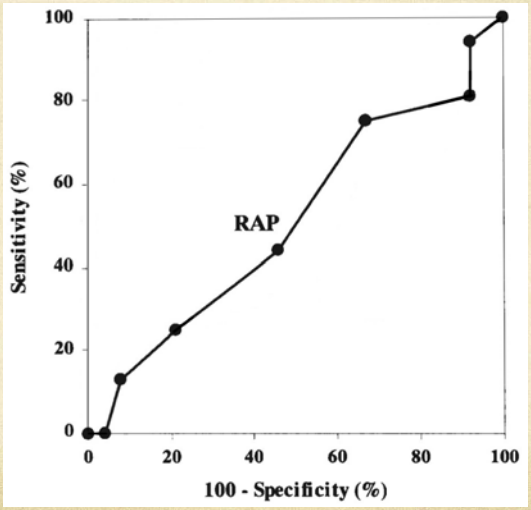
PVC

A. Initial Resuscitation

1. Protocolized, quantitative resuscitation of patients with sepsis- induced tissue hypoperfusion (defined in this document as hypotension persisting after initial fluid challenge or blood lactate concentration ≥ 4 mmol/L). Goals during the first 6 hrs of resuscitation:
   a) Central venous pressure 8–12 mm Hg
   b) Mean arterial pressure (MAP) ≥ 65 mm Hg
   c) Urine output ≥ 0.5 mL/kg/hr
   d) Central venous (superior vena cava) or mixed venous oxygen saturation 70% or 65%, respectively (grade 1C).

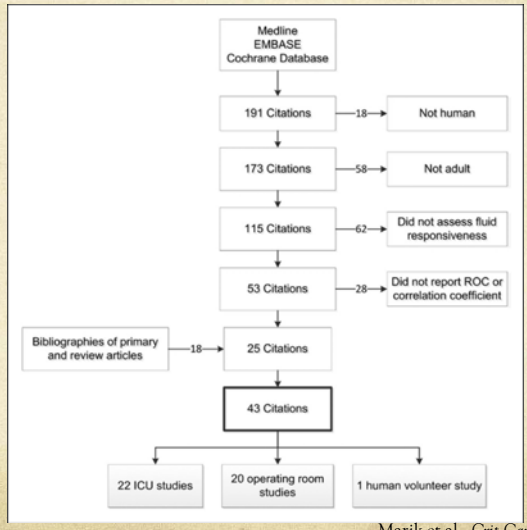
Dellinger et al., *Crit Care Med*, 2012;41:580-637.

PVC



Michard et al., *Am J Respir Crit Care Med*, 2000;162:134-8.

PVC

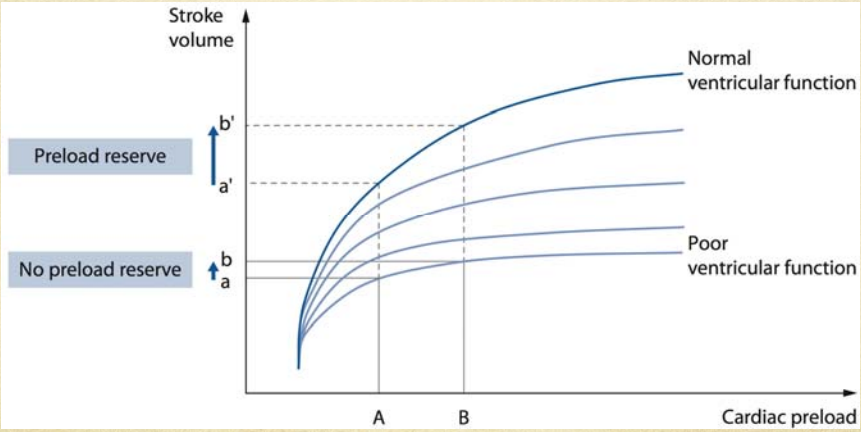


Marik et al., *Crit Care Med*, 2013;41:1774-81.

Autres marqueurs « statiques »

Echographic parameter	Studied population	Cutoff for positive response to fluid	Sensitivity (%)	Specificity (%)	ROC AUC
Static volumetric indices					
LVEDA	21 Post-op CABG 20 Mixed ICU	Could not define	-	-	-
	19 CABG	Could not define	-	-	-
	33 CABG 3 AVR	Could not define	-	-	0.58
	19 OPCAB	Could not define	-	-	-
LVEDAI	15 septic patients	< 9 cm^2/m^2	-	-	0.77
	19 septic patients	Could not define	-	-	-
	26 Post-op CABG	LVEF < 35% < 26.5 cm^2/m^2	64	90	0.78
		LVEF > 50% < 16.7 cm^2/m^2	60	61	0.73
	35 OPCAB	Could not define	-	-	0.64
	18 CABG	< 9.05 cm^2/m^2	63	69	0.71
	21 SICU patients	< 11.3 cm^2/m^2	89	58	0.76
	8 hepatectomies	< 10.5 cm2/m2	-	-	0.70
	24 MICU patients	Could not define	-	-	0.58
LVEDV	19 OPCAB	Could not define	-	-	-
Doppler indices					
Mitral E/A	33 CABG 3 AVR	< 1.26	75	60	0.71
	8 hepatectomies	< 1.84	-	-	0.62
Systolic fraction	8 hepatectomies	Could not define	-	-	0.42
Mitral deceleration time	8 hepatectomies	> 234 ms	-	-	0.68
Mitral E/Ea	24 MICU patients	Could not define	-	-	0.65

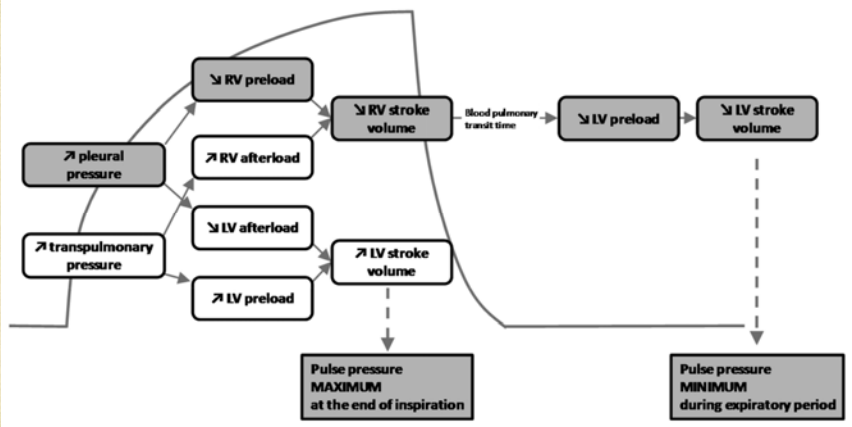
Pourquoi ?



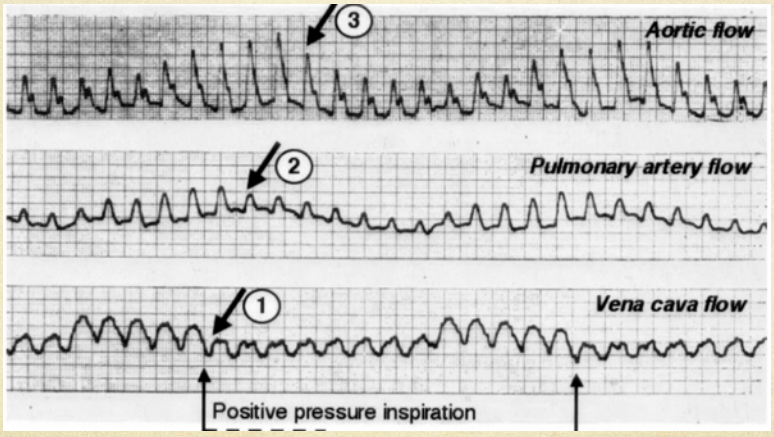
Intéractions cardio-respiratoires

- Variations volume d'éjection systolique
  - Principe
  - Outil de mesure
  - Critères de fiabilité
- Variations taille VCS / VCI
- Test d'occlusion télé-expiratoire

Principe



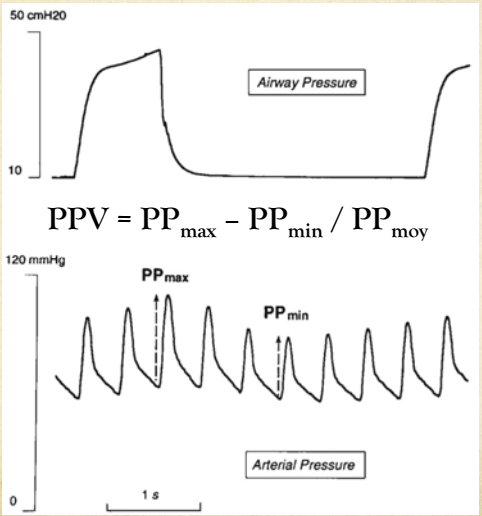
Marik et al., *Ann Intensive Care*, 2011;1:1-9.



Outils de mesure du VES

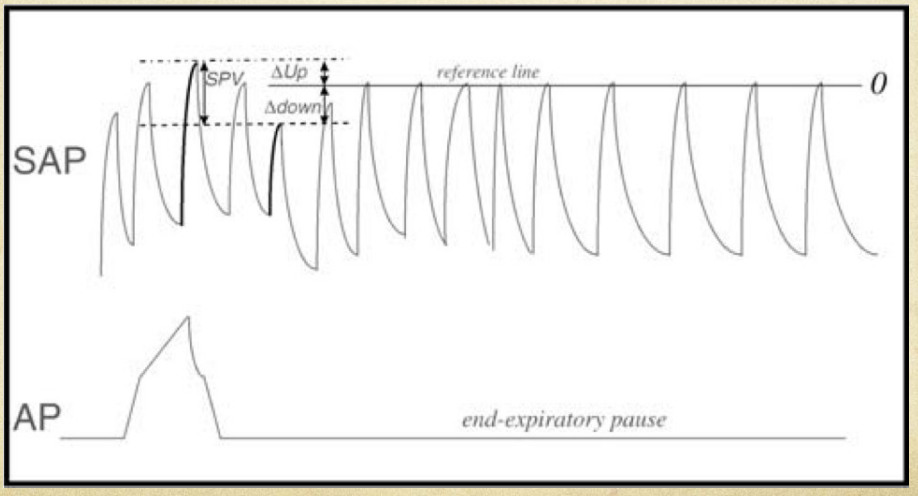
- Mesure directe
  - Echocardiographie (ITV_{CCVG})
  - Doppler oesophagien
- Mesure estimée
  - Méthodes « pulse-contour »
    - PiCCO, LiDCO, FloTrac
  - Pression de pouls
    - PPV, ΔP_{pleth}
  - $EtCO_2$

Pulse Pressure Variation (PPV)

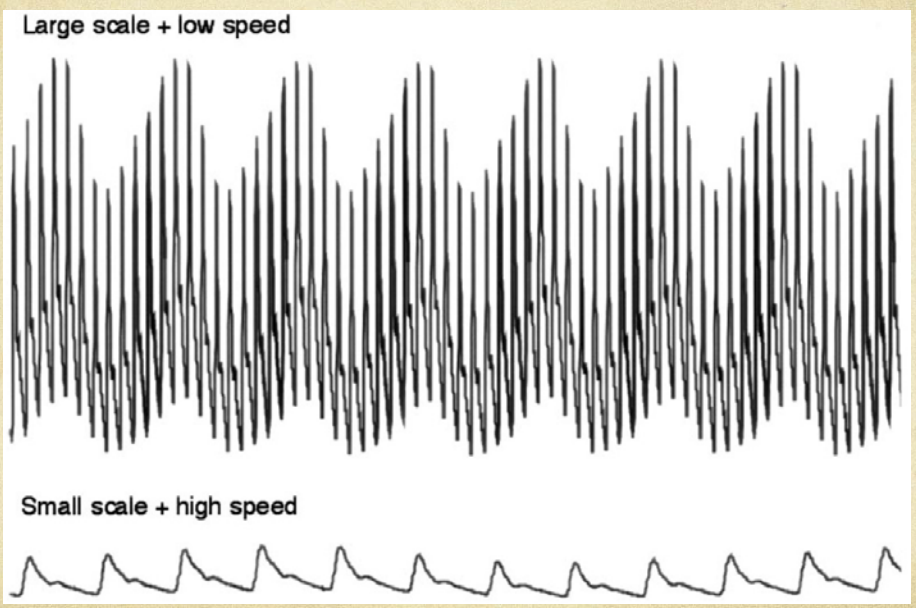


Michard et al., *Am J Respir Crit Care Med*, 1999;159:935-9.

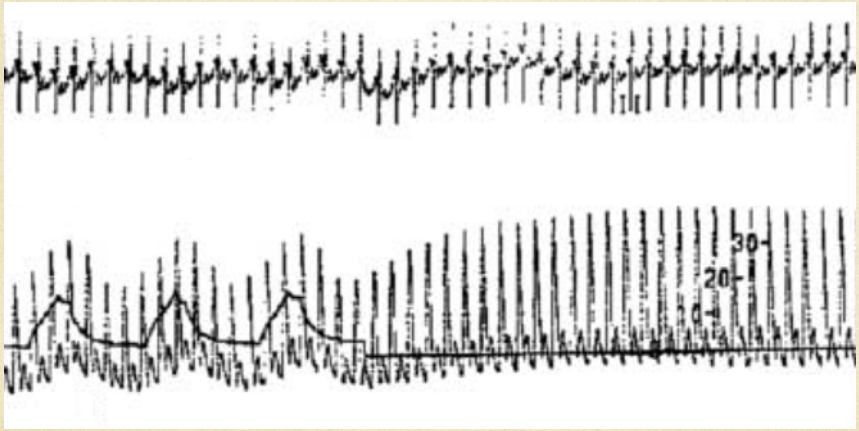
Systolic Pressure Variation (SPV)



Bendjelid et al., *J Appl Physiol*, 2003;96:337-42.



Δdown



Vieillard-Baron et al., *Am J Respir Crit Care Med*, 2003;168:671-6.

Author	Year	n	Patient	Dynamic Variable			Fluid Challenge	TV (mL/kg)	Device	Cardiac End Point
				SPV	PPV	SVV				
Tavernier (31)	1998	15	ICU-sepsis	Y	N	N	500 mL HES	8–11	PAC	SVI
Michard (32)	1999	14	ICU-ARDS	N	Y	N	10 PEEP[c]	7–12	PAC	CI
Michard (33)	2000	40	ICU-sepsis	Y	Y	N	500 mL HES	8–12	PAC	CI
Berkenstadt (34)	2001	15	Neurosurg[a]	N	N	Y	100 mL HES[b]	10	PiCCO[e]	SV
Reuter (35)	2002	20	Post C.Surg	Y	N	Y	20 mL × BMI gelatin	—	PiCCO	SVI
Reuter (36)	2002	20	Post C.Surg	N	N	Y	20 mL × BMI gelatin	13–15	PiCCO	CI
Reuter (37)	2003	12	Post C.Surg-a	N	N	Y	10 mL × BMI HES[b]	10	PiCCO	SVI
		14	Post C.Surg-b				10 mL × BMI HES[b]	10	PiCCO	SVI
Bendjelid (38)	2004	16	Post C.Surg	Y	Y	N	10 PEEP[c]	8–10	PAC	SVI
Rex (39)	2004	14	Post C.Surg	N	N	Y	Trendelenburg	8	PiCCO	SVI
Kramer (40)	2004	21	Post C.Surg	Y	Y	N	500 mL blood	8–10	PAC	CO
Marx (41)	2004	10	ICU-sepsis	N	N	Y	500 mL HES	8–10	PiCCO	—
Hofer (42)	2005	35	Post C.Surg	N	Y	Y	10 mL/kg HES	10	PiCCO	SVI
Preisman (43)	2005	18	Post C.Surg	Y	Y	Y	250 mL gelatin × 2	PCV	PiCCO	SVI
De Backer (44)[d]	2005	27	ICU-mixed	N	Y	N	1000 mL CR/500 HES	8–10	PAC	CI
Wiesenack (45)	2005	20	C.Surg[a]	N	Y	Y	7 mL/kg HES	7	PiCCO/PAC	SVI
Feissel (46)	2005	20	ICU-sepsis	N	Y	N	8 mL/kg HES	8–10	TTE	CI
Solus-Biguenet (47)	2006	8	Hepatic surgery	N	Y	N	250 mL gelatin[b]	8–10	PAC	SVI
Charron (48)	2006	21	ICU-mixed	N	Y	N	100 mL HES	8–10	TEE	SV
Natalini (49)	2006	22	ICU-mixed	Y	Y	N	500 mL HES	8	PAC	CI
Wyffels (50)	2007	32	Post C.Surg	N	Y	N	500 mL HES	8–10	PAC	CI
Feissel (51)	2007	23	ICU-sepsis	N	Y	N	8 mL/kg HES	8–10	TEE	CI
Lee (52)	2007	20	Neurosurg[a]	N	Y	N	7 mL/kg HES	10	Esophageal Doppler	SVI
Cannesson (53)	2007	25	C.Surg[a]	N	Y	N	500 mL HES	8–10	PAC	CI
Cannesson (54)	2008	25	C.Surg[a]	N	Y	N	500 mL HES	8–10	PAC	CI
Auler (55)	2008	59	Post C.Surg	N	Y	N	20 mL/kg LR	8	PAC	CO
Belloni (56)	2008	19	C.Surg[a]	Y	Y	Y	7 mL/kg HES	8	LiDCO[f]/PAC	CI
Cannesson (57)	2008	25	C.Surg[a]	N	Y	N	500 mL HES	8–10	PAC	CI
Hofer (58)	2008	40	Post CABG	N	Y	Y	Trendelenburg	8–10	FloTrac[g]/PiCCO	SV
Biasis (59)	2008	35	Liver transplant	N	Y	Y	Albumin 20 mL × BMI	8–10	FloTrac/TEE	CO

Marik et al., *Crit Care Med*, 2009;37:2642-7.

PPV / SPV

	Correlation (r)	AUC
PPV	.78 (.74–.82)	0.94 (0.93–0.95)
SPV	.72 (.65–.77)	0.86 (0.82–0.90)

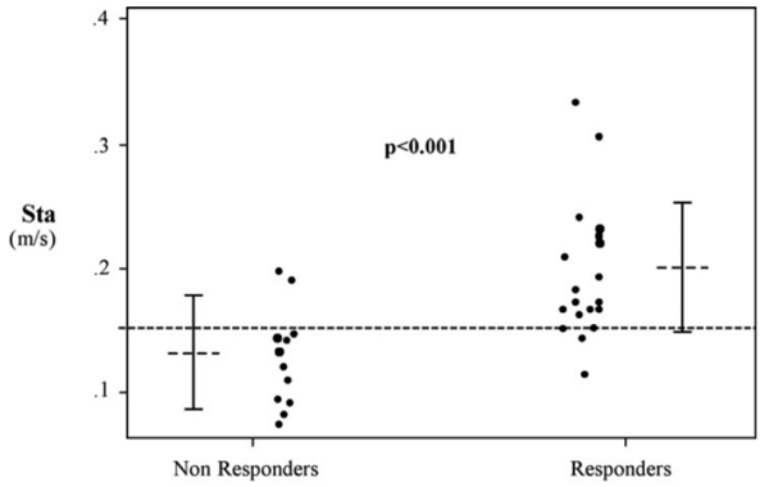
Parameter	PPV (n = 14)
ROC area	0.94 (0.92–0.96)
Sensitivity	0.89 (0.82–0.94)
Specificity	0.88 (0.81–0.92)
Positive likelihood ratio	7.26 (4.46–11.80)
Negative likelihood ratio	0.12 (0.07–0.21)

Marik et al., *Crit Care Med*, 2009;37:2642-7.

Critères de fiabilité

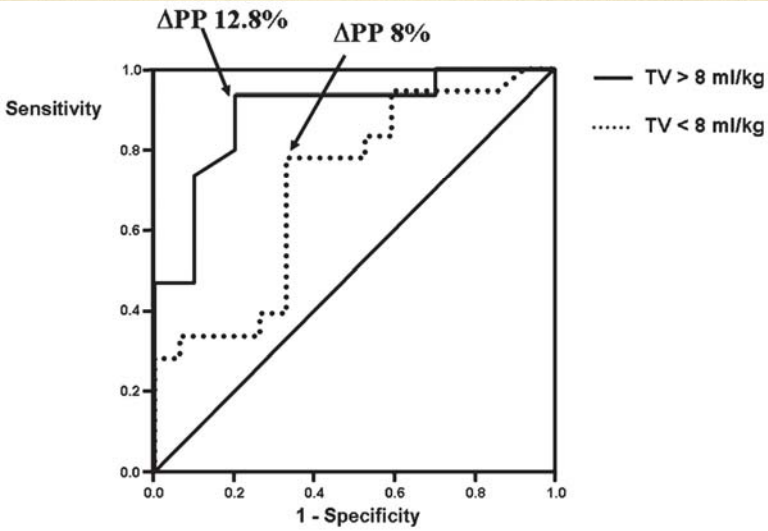
- Faux-positifs
  - Défaillance VD
  - Hypertension intra-abdominale (Mahjoub, Crit Care Med 2010)
- Faux-négatifs
  - Vc < 8 cc/kg
  - Compliance pulmonaire basse
  - Ratio FR / FC
  - Thorax ouvert
- Ininterprétable
  - Arythmie cardiaque
  - Efforts respiratoires

Défaillance VD



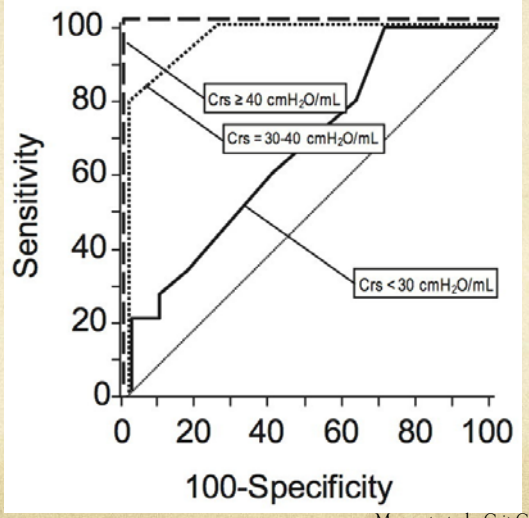
Mahjoub et al., *Crit Care Med*, 2009;37:2570-5.

Volume courant



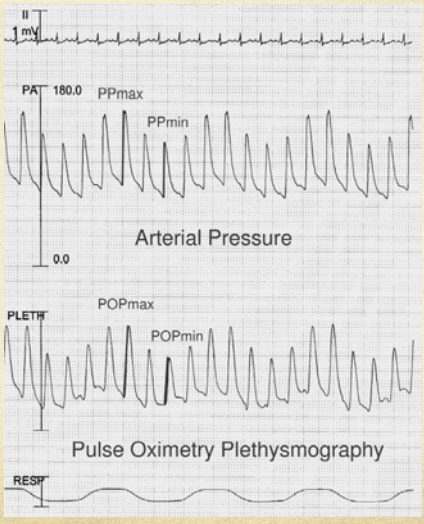
De Backer et al., *Intensive Care Med*, 2005;31:517-23.

Compliance diminuée



Monnet et al., *Crit Care Med*, 2012;40:152-7.

Δp_{pleth} ou ΔPOP



Cannesson et al., *Crit Care*, 2005;9:R562-8.

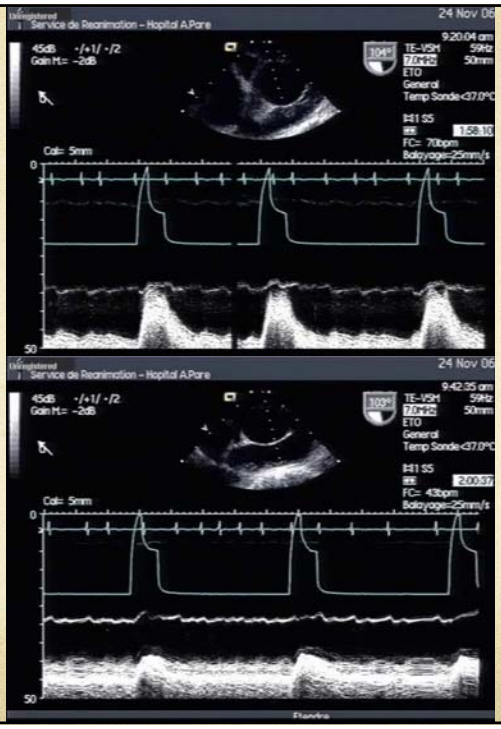
Δp_{pleth} ou ΔPOP

References (first author)	Index	Number of patients/boluses	% Responders	Best threshold	r	AUC (SE)	Sensitivity	Specificity
Natalini [22]	ΔPOP	22/31	61.0	15.0	–	0.70 (0.094)	0.63	0.83
Solus-Biguenet [23]	ΔPOP	8/54	42.0	9.5	0.29	0.68 (0.071)	0.64	0.68
Cannesson [17]	ΔPOP	25/25	60.0	13.0	0.62	0.85 (0.081)	0.93	0.90
Feissel [19]	ΔPOP	23/28	64.0	14.0	0.70	0.94 (0.050)	0.94	0.80
Wyffels [24]	ΔPOP	32/32	62.5	11.8	0.65	0.89 (0.061)	0.90	0.83
Hoiseth [20]	ΔPOP	25/34	64.7	11.4	–	0.72 (0.082)	0.86	0.67
Cannesson [11]	ΔPOP[b]	25/25	64.0	12.0	0.69	0.94 (0.043)	0.87	0.89
	PVI	25/25	64.0	14.0	0.67	0.93 (0.051)	0.81	1.00
Zimmermann [12]	PVI	20/20	75.0	9.5	0.61	0.97 (0.033)	0.93	1.00
Desgranges [18]	PVI	28/28	68.0	12.0	–	0.84 (0.077)	0.74	0.67
Hood [21] (large bolus)	PVI	25/25	88.0	10.0	–	0.96 (0.031)	0.86	1.00
Hood [21] (small bolus)	PVI	25/63	36.5	10.0	–	0.71 (0.071)	0.65	0.67
Overall[a]		233/365	62.3 ± 14.0	9.5–15.0 (range)	0.58 [0.43–0.70]	0.85 [0.79–0.92]	0.80 [0.74–0.85]	0.76 [0.68–0.82]

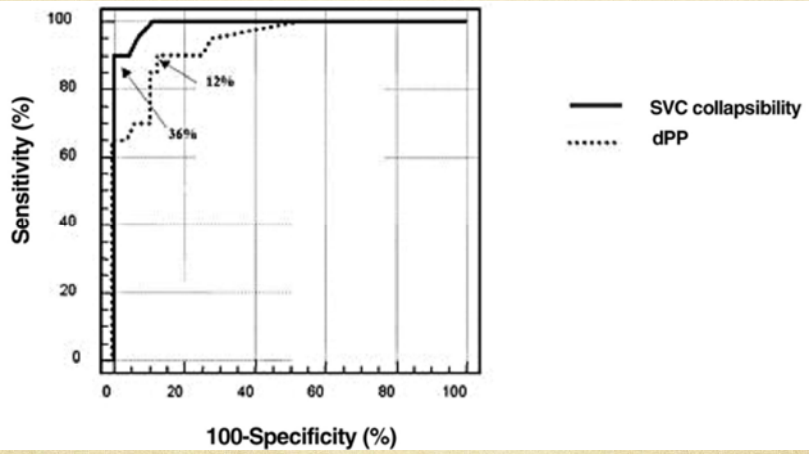
Sandroni et al., *Intensive Care Med*, 2012;38:1429-37.

Variations VCS / VCI

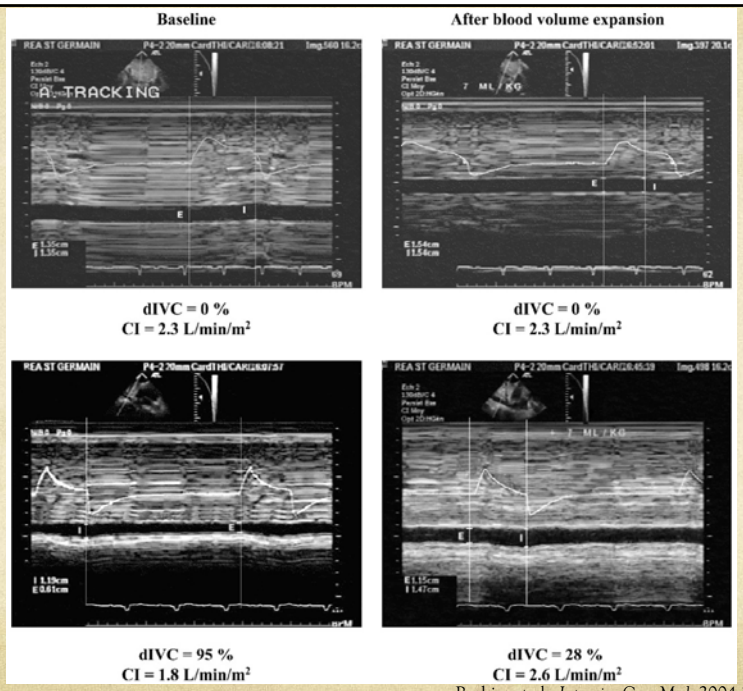
- Mécanisme…
- Méthode de mesure
  - VCS
    - Vue ME court-axe VA, puis tourner la sonde vers VCS
  - VCI
    - 3 cm sous l'oreillette droite
    - Juste « au-dessus » des veines sus-hépatiques
- Différentes méthodes de calcul
  - Feissel: $D_{IVC}(max) - D_{IVC}(min) / D_{IVC}(moyenne)$
  - Barbier: $D_{IVC}(max) - D_{IVC}(min) / D_{IVC}(min)$



VCS

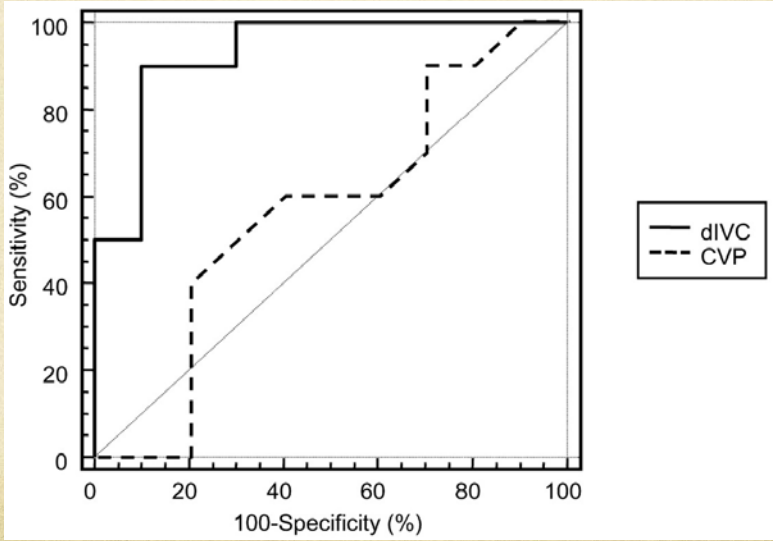


Vieillard-Baron et al., *Intensive Care Med*, 2004;30:1734-9.



Barbier et al., *Intensive Care Med*, 2004;30:1740-6.

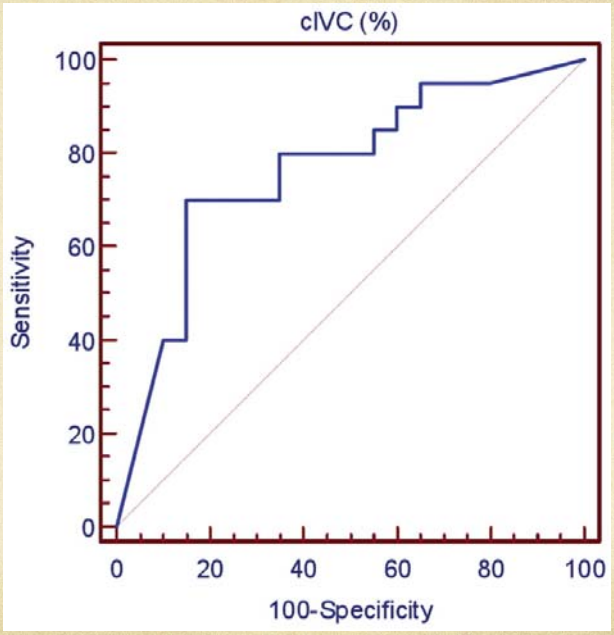
VCI



Barbier et al., *Intensive Care Med*, 2004;30:1740-6.

Critères de fiabilité

- Hypertension intra-abdominale
- Vc < 8 cc/kg
- Efforts respiratoires (Muller, Crit Care 2012)
- ? arythmies

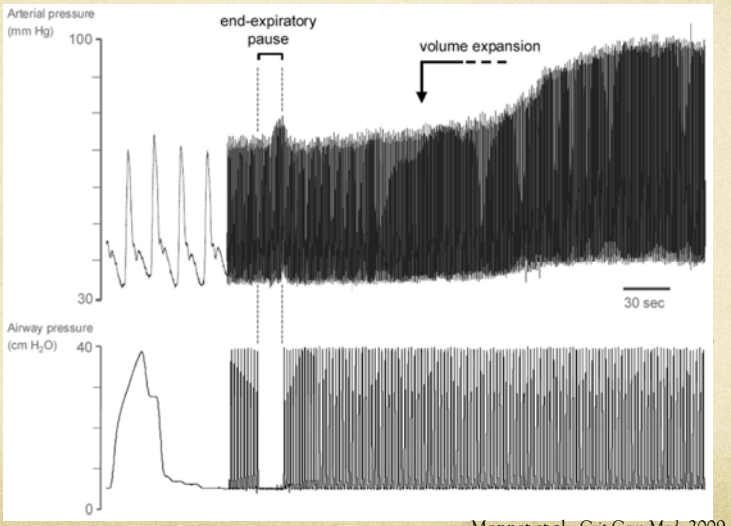


Muller et al., *Crit Care*, 2012;16:R188-.

ΔPression veineuse centrale

Magder et al., *J Crit Care*, 1992;7:76-85.

Test d'occlusion télé-expiratoire



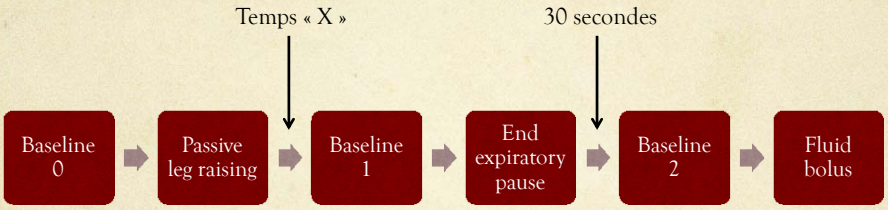
Monnet et al., *Crit Care Med*, 2009;37:951-6.

Test d'occlusion télé-expiratoire

- 34 patients
  - Insuffisance circulatoire aiguë
    - 32 patients avec choc septique
    - 2 patients avec intoxication médicamenteuse
  - Non candidats à une évaluation de leur réserve de précharge via interactions cardio-pulmonaires
    - 11 patients avec arythmies
    - 23 patients avec efforts respiratoires minimes
      - 10 pts supplémentaires exclus re: efforts respiratoires trop importants
    - Aucun patient avec arythmies **et** efforts respiratoires

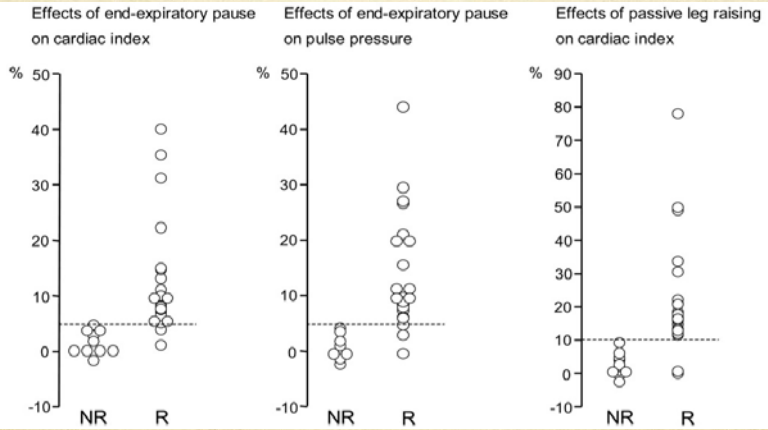
Monnet et al., *Crit Care Med*, 2009;37:951-6.

Test d'occlusion télé-expiratoire



Monnet et al., *Crit Care Med*, 2009;37:951-6.

Test d'occlusion télé-expiratoire



Monnet et al., *Crit Care Med*, 2009;37:951-6.

Test d'occlusion télé-expiratoire

	ROC Area	95% CI	Threshold Value	Sensitivity (%)	Specificity (%)	p^a
Effects of the end-expiratory pause on arterial pulse pressure	0.957	0.825–0.994	5%	87	100	—
Effects of the end-expiratory pause on pulse contour-derived cardiac index	0.972	0.849–0.995	5%	91	100	0.587
Effects of the end-expiratory pause on arterial systolic pressure	0.714	0.528–0.859	4%	67	82	0.001
Effects of passive leg raising on pulse contour-derived cardiac index	0.937	0.797–0.990	10%	91	100	0.672
Effects of passive leg raising on arterial pulse pressure	0.675	0.497–0.829	11%	48	91	0.002
Cardiac index at base 2	0.648	0.466–0.803	2.8 L/min/m²	78	54	<0.001

- Pts avec efforts respiratoires (23, R16/NR7)
  - PPV: si Δ >= 11%
    - Sensibilité: 100%
    - Spécificité: 37%
    - ROC: 0,679

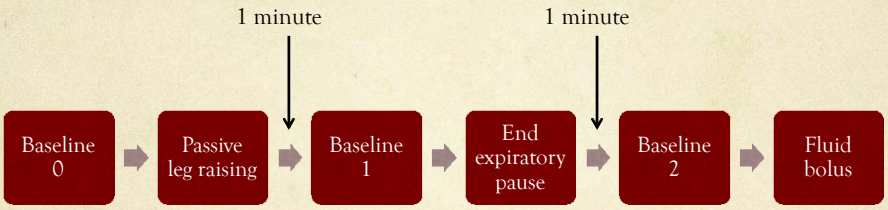
Monnet et al., *Crit Care Med*, 2009;37:951-6.

Test d'occlusion télé-expiratoire

- 54 patients
  - 28 pts compliance <= 30 cm H_2O / mL
  - 26 pts compliance > 30 cm H_2O / mL
    - Absence d'arythmie et aucun effort respiratoire
  - Insuffisance circulatoire aiguë
    - 40 pneumonies
    - 6 chocs hypovolémiques
    - 4 ischémies mésentériques
    - 2 chocs hémorragiques
    - 2 chocs post-ACR

Monnet et al., *Crit Care Med*, 2012;40:152-7.

Test d'occlusion télé-expiratoire



Monnet et al., *Crit Care Med*, 2012;40:152-7.

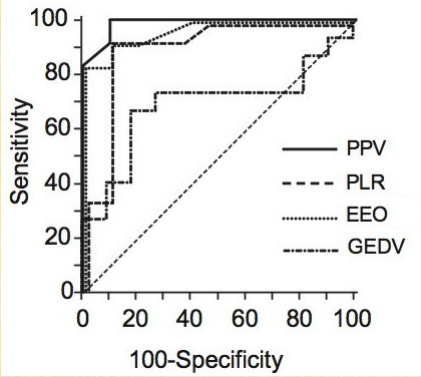
Test d'occlusion télé-expiratoire

	Compliance of Respiratory System ≤30 cm H_2O/mL (n = 28)				Compliance of Respiratory System >30 cm H_2O/mL (n = 26)			
	Responders (n = 15)		Nonresponders (n = 13)		Responders (n = 15)		Nonresponders (n = 11)	
	Before VE	After VE	Before VE	After VE	Before VE	After VE	Before VE	After VE
Heart rate (mean ± SD, beats/min)	79 ± 15	76 ± 14	85 ± 22	85 ± 22	96 ± 21	92 ± 20	87 ± 13	84 ± 14
Mean systemic arterial pressure (mean ± SD, mm Hg)	62 ± 18	81 ± 25[a]	85 ± 24[b]	87 ± 19	76 ± 24	90 ± 25[a]	69 ± 17	69 ± 20
Global end-diastolic volume index (mean ± SD, mL/m²)	734 ± 200	875 ± 364[a]	746 ± 199	823 ± 282[a]	596 ± 236	734 ± 326[a]	696 ± 126	769 ± 157[a]
Cardiac index (mean ± SD, L/min/m²)	3.2 ± 2.8	4.3 ± 2.7[a]	4.2 ± 2.7	4.4 ± 2.7	3.1 ± 2.2	4.4 ± 2.1[a]	3.6 ± 2.6	3.7 ± 2.6
Pulse pressure variation (mean ± SD, %)	8 ± 3	6 ± 3	6 ± 2	7 ± 7	18 ± 5	10 ± 4[a]	6 ± 3[b]	8 ± 5
Changes in cardiac index during passive leg-raising (mean ± SD, %)	28 ± 21	—	3 ± 3[b]	—	24 ± 16	—	4 ± 9[b]	—
Changes in cardiac index during end-expiratory occlusion (mean ± SD, %)	9 ± 5	—	2 ± 1[b]	—	10 ± 9	—	2 ± 2[b]	—

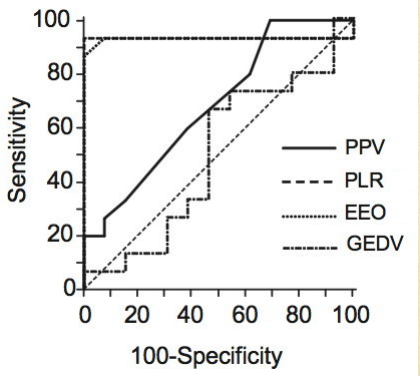
Monnet et al., *Crit Care Med*, 2012;40:152-7.

Test d'occlusion télé-expiratoire

Compliance > 30



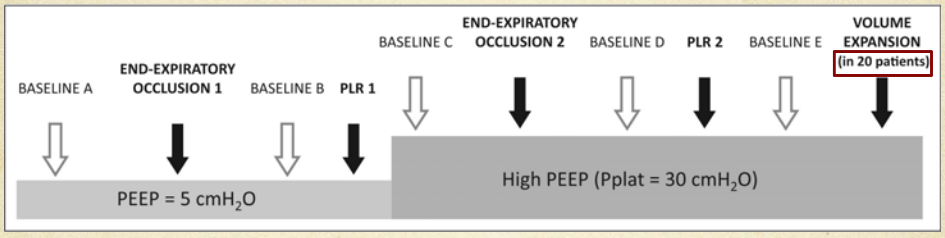
Compliance <= 30



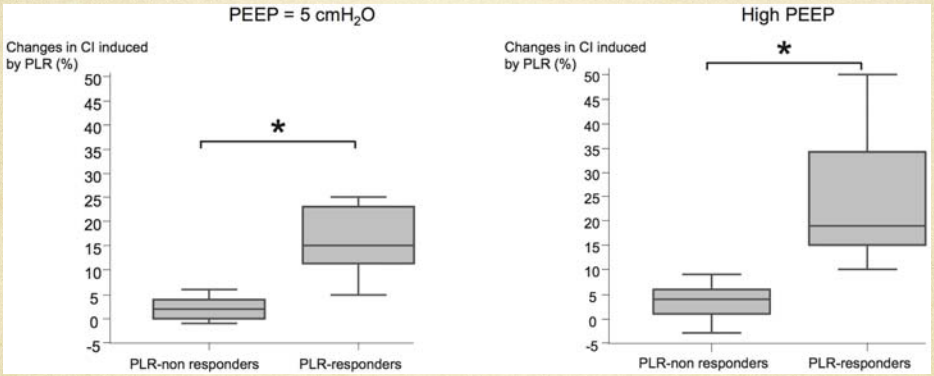
Monnet et al., *Crit Care Med*, 2012;40:152-7.

- 34 patients
  - Insuffisance circulatoire aiguë
  - ARDS
    - 28 pneumonie
    - 4 pancréatites
    - 1 ischémie mésentérique
    - 1 péritonite bactérienne spontanée
  - 6 patients avec fibrillation auriculaire
  - 12 patients avec faibles efforts respiratoires spontanés

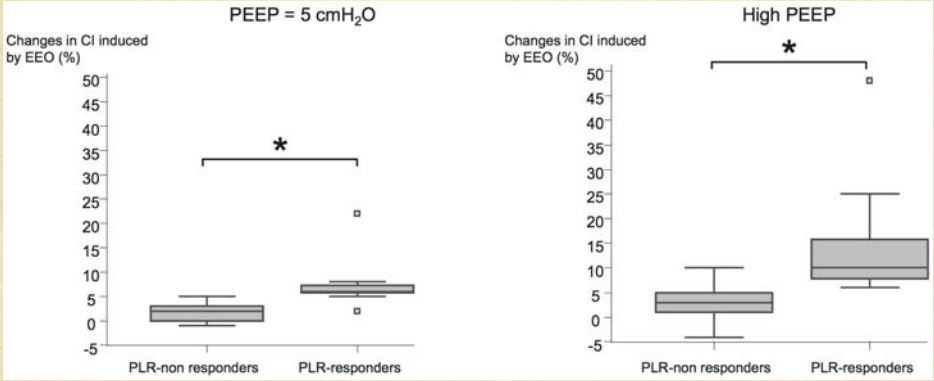
Silva et al., *Crit Care Med*, 2013;41:1692-701.



Silva et al., *Crit Care Med*, 2013;41:1692-701.

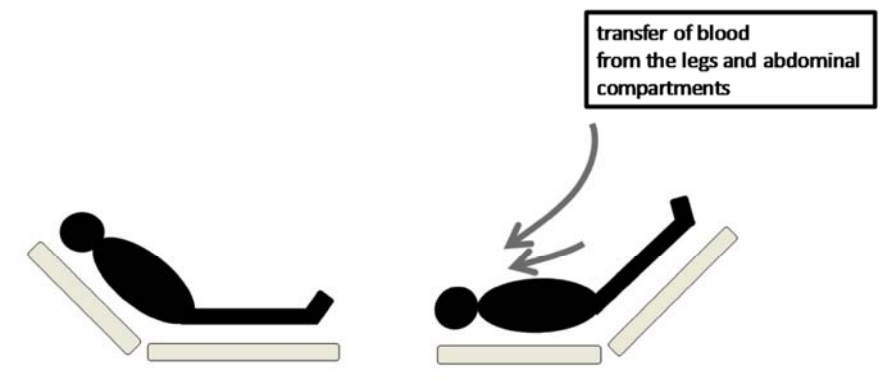


Silva et al., *Crit Care Med*, 2013;41:1692-701.



Silva et al., *Crit Care Med*, 2013;41:1692-701.

Epreuve de levée de jambes



Marik et al., *Ann Intensive Care*, 2011;1:1-9.

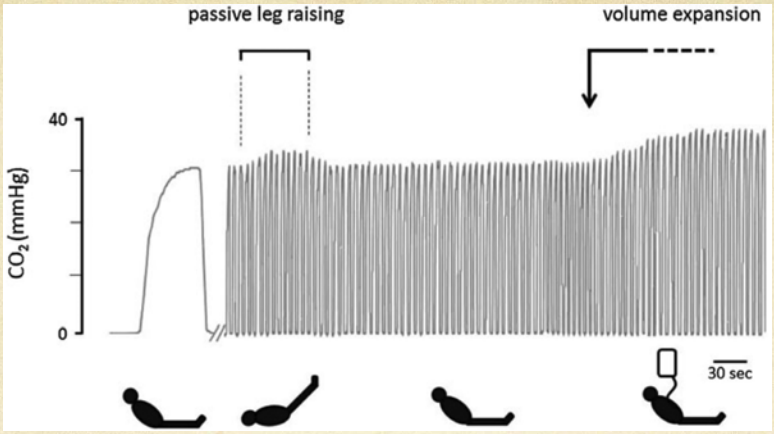
Epreuve de levée de jambes

- Comment
  - Position de départ semi-assise préférable, car meilleur recrutement (Jabot, Intensive Care Med 2009)
- Timing
  - Augmentation première minute post-ELJ (Monnet, Crit Care Med 2006)
- Moniteur de débit cardiaque
  - PVI (Keller, Crit Care 2008), ΔPP → **NON**
  - Moniteur de VES (doppler oesophagien, ETT, PiCCO, FlowTrac, ...)
  - Thermodilution (Swan-Ganz ou autre)
  - $EtCO_2$
- Moniteur de précharge
  - Si ΔPVC ≥ 2, améliore performance diagnostique → AUC 0,98 (0,89 – 1,00) vs AUC 0,83 (0,79 – 0,81) (Lakhal, Intensive Care Med 2010)
- Contre-indication
  - HTIC, utilisation de compression veineuse séquentielle, TPP, fractures, ...
- Bémol
  - Hypertension intra-abdominale (Mahjoub, Crit Care Med 2010)

Epreuve de levée de jambes

Reference	Index	No. of pts/ boluses	% Resp.	Mean (SD) resp.	Mean (SD) non-resp.	*r*	AUC (SE)	Best threshold	Sens.	Spec.
Boulain et al.	cSV	15/15				0.89				
Lafanechère et al.	cABF%	22/22	45			0.71	0.95 (0.040)	8.0	90	83
Monnet et al.	cABF%	71/71	52	28.4 (20.6)	1.2 (6.1)	0.83	0.96 (0.020)	10.0	97	94
Lamia et al.	cVTIAo	24/24	54	24.5 (9.7)	5.0 (5.5)	0.83	0.96 (0.040)	12.5	77	100
	cCO	24/24	54			0.79				
Maizel et al.	cSV%	34/34	50	14.8 (8.8)	1.3 (8.6)	0.56	0.89 (0.059)	8.0	88	83
	cCO%	34/34	50	12.0 (4.2)	−0.5 (10.0)	0.75	0.89 (0.060)	5.0	94	83
Thiel et al.	cSV%	89/102	46	21.0 (12.5)	3.2 (10.4)		0.89 (0.040)	15.0	81	93
Monnet et al.	cCI%	34/34	68	21.9 (17.9)	1.3 (0.7)		0.94 (0.050)	10.0	91	100
Biais et al.	cSV% (TTE)	30/30	67				0.96 (0.030)	13.0	100	80
	cSV% (Vigileo®)	30/30	67				0.92 (0.050)	16.0	85	90
Préau et al.	cSV%	34/34	41	17.0 (7.0)	4.0 (5.0)		0.94 (0.040)	10.0	86	90
Overall (95% CIs)		353/366	52.9	Pooled difference in means 17.7% (13.6–21.8%)		0.81 (0.75–0.86)	0.95 (0.92–0.97)		89.4 (84.1–93.4)	91.4 (85.9–95.2)

Cavallaro et al., *Crit Care Med*, 2013;1:1-9.



Variable	AUC	*p*-Value versus 0.50	Best cutoff value	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Positive likelihood ratio	Negative likelihood ratio
PLR-induced changes in cardiac index	0.98 (0.88–1.00)	<0.0001	10 %	95 (76–100)	95 (74–100)	95 (76–100)	95 (74–100)	19.0 (15.7–20.9)	0.1 (0.0–0.7)
PLR-induced changes in $EtCO_2$	0.93 (0.81–0.99)	<0.0001	5 %	71 (48–89)	100 (82–100)	100 (78–100)	76 (55–91)	4.5 (3.2–6.3)	0.3 (0.1–1.2)

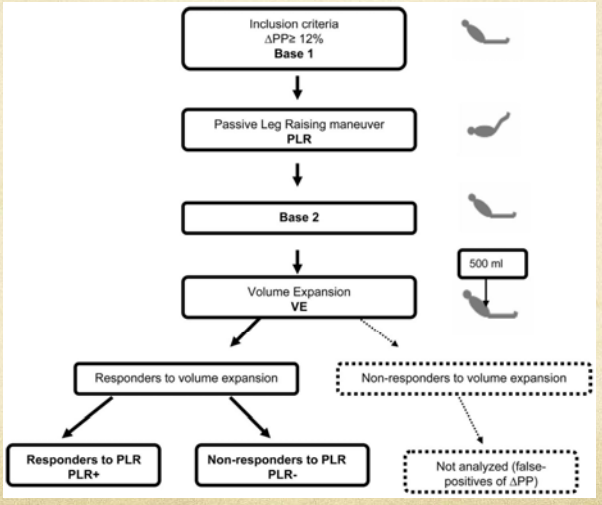
Monnet et al., *Intensive Care Med*, 2013;39:93-100.

ELJ et pression de pouls

Reference	Index	No. of pts/boluses	% Resp.	Mean (SD) resp.	Mean (SD) non-resp.	r	AUC (SE)	Best threshold	Sens.	Spec.
Boulain et al. [17]	cPP	39/39				0.74				
Monnet et al. [19]	cPP%	71/71	52	19.3 (18.8)	4.9 (14.6)		0.75 (0.060)	12.0	60	85
Monnet et al. [22]	cPP%	34/34	68	15.5 (19.9)	6.4 (6.2)		0.68 (0.085)	11.0	48	91
Préau et al. [24]	cPP%	34/34	41	12.0 (8.0)	3.0 (6.0)		0.86 (0.080)	9.0	79	85
Overall (95% CIs)		178/178	53.7	Pooled difference in means 10.3% (6.5–14.1%)			0.76 (0.67–0.86)		59.5 (47.4–70.7)	86.2 (75.3–93.5)

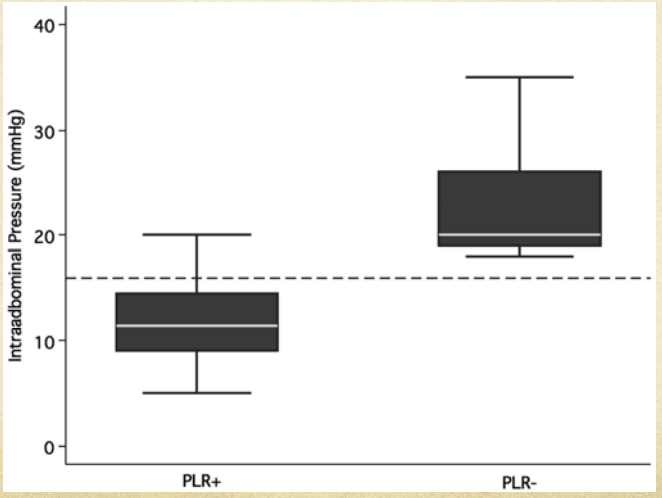
Cavallaro et al., *Crit Care Med*, 2013;1:1-9.

ELJ et hypertension intra-abdominale

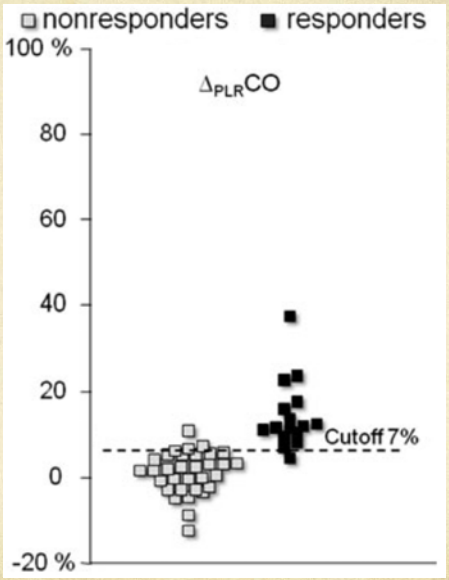


Mahjoub et al., *Crit Care Med*, 2010;38:1824-9.

ELJ et hypertension intra-abdominale



Mahjoub et al., *Crit Care Med*, 2010;38:1824-9.



Lakhal et al., *Intensive Care Med*, 2010;36:940-8.

En conclusion

- Stratégies actuelles de remplissage volémique dépassées
- Controverse entre stratégie de remplissage restrictive vs optimisée
  - Stratégie libérale sans monitoring de la réserve de précharge → délétère
- Evaluation de la réserve de précharge
  - Si ventilation spontanée (pré-induction)
    - ELJ 10%
  - Sous AG ($V_c \geq 8$ cc/kg, VD ok, compliance « globale » normale)
    - PPV 12,5%
      - ΔP_{pleth} 10 – 15%
    - Si arythmies
      - VCS 36%
      - TOTE 5% (problème technique au bloc)
      - VCI 12% vs 18% (plutôt SI)