# Volumenstatus, Volumenansprechbarkeit, Volumentoleranz

## was wirklich zählt

Jubiläumskongress Notfallpflege, 11.03.2023

Dr. med. Bruno Minotti, Oberarzt
Notfallzentrum, Universitätsspital Basel

Universitätsspital Basel


# 01

## Volumenstatus

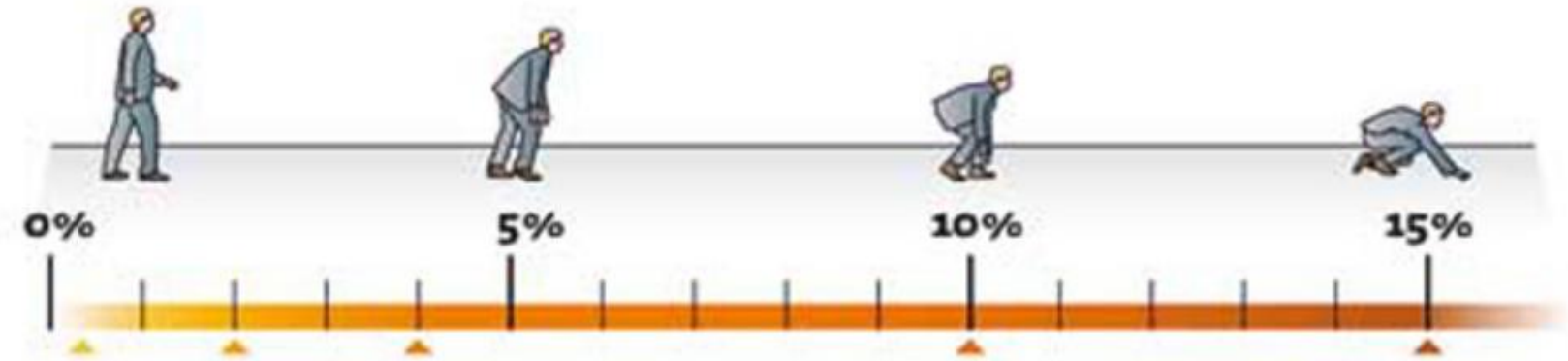
# Volumenstatus?

Sefrin, M. *Geriatr Rep* **13**, 27 (2018).

# Volumenmangel

## Leistungsminderung durch Flüssigkeitsverlust

Trinkbalance
Initiative für mehr Trinkgenuss




**Mehr als 0,5 Prozent:** Durstempfinden (bei einem Erwachsenen ca. 300 bis 400 ml Flüssigkeitsverlust)

**Ab 2 Prozent:** Die körperliche und gesitige Leistungsfähigkeit sinkt um etwa ein Fünftel, das Blut fließt langsamer, die Versorgung der Muskel- und Gehrinzellen mit Sauerstoff und Nährstoffen ist herabgesetzt

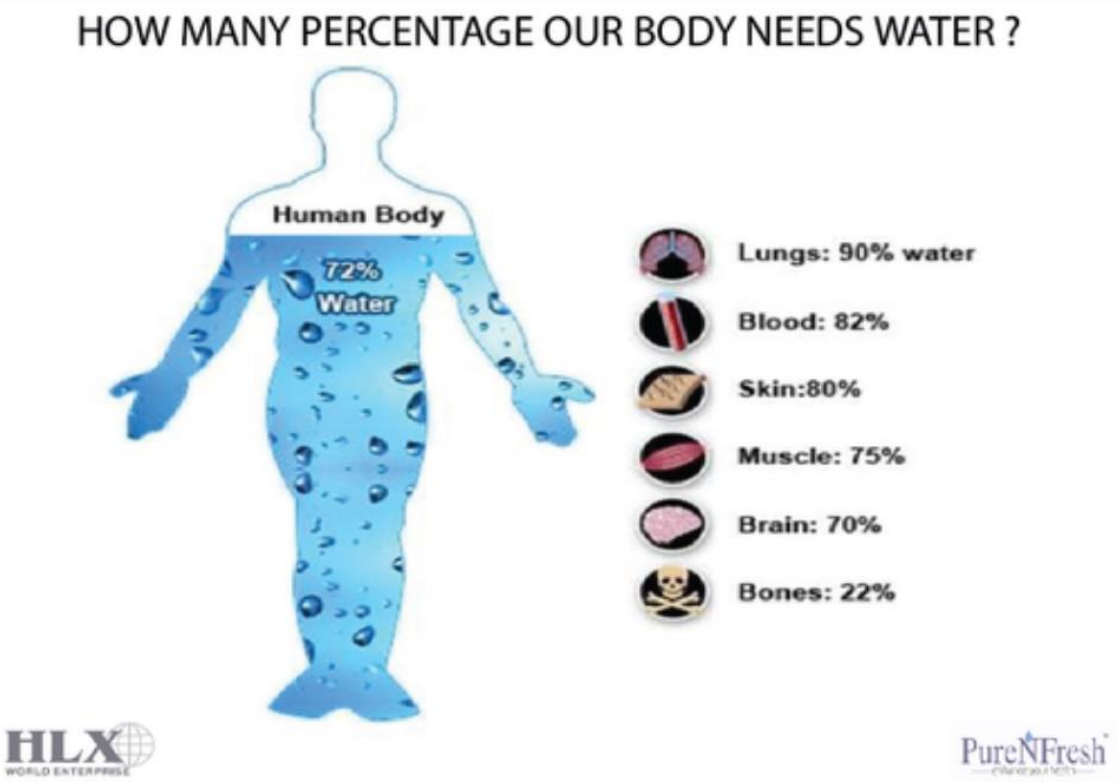
**Ab etwa 3-5 Prozent:** Mundtrockenheit, Kopfschmerzen, der Körper baut kräftemäßig ab, beschleunigter Puls, steigende Körpertemperatur

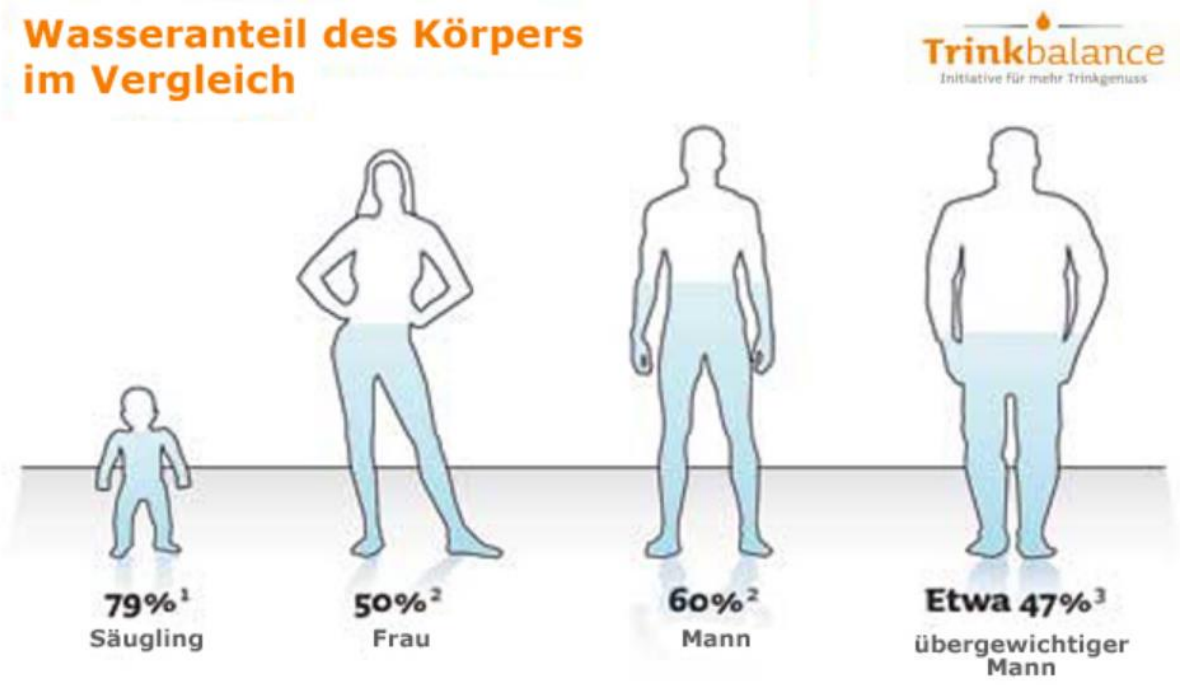
**Ab 10 Prozent:** psychische Störungen wie Desorientierung und Verwirrtheit

**Defizit von 15 Prozent:** kann zum Tode führen

Quelle: Ökotest 8/2008; Prof. Dr. oec troph Helmut Heseker, Prof. Dr. med. Michael Weiß: Trinken und Leistungsfähigkeit in Beruf und Freizeit, 2003

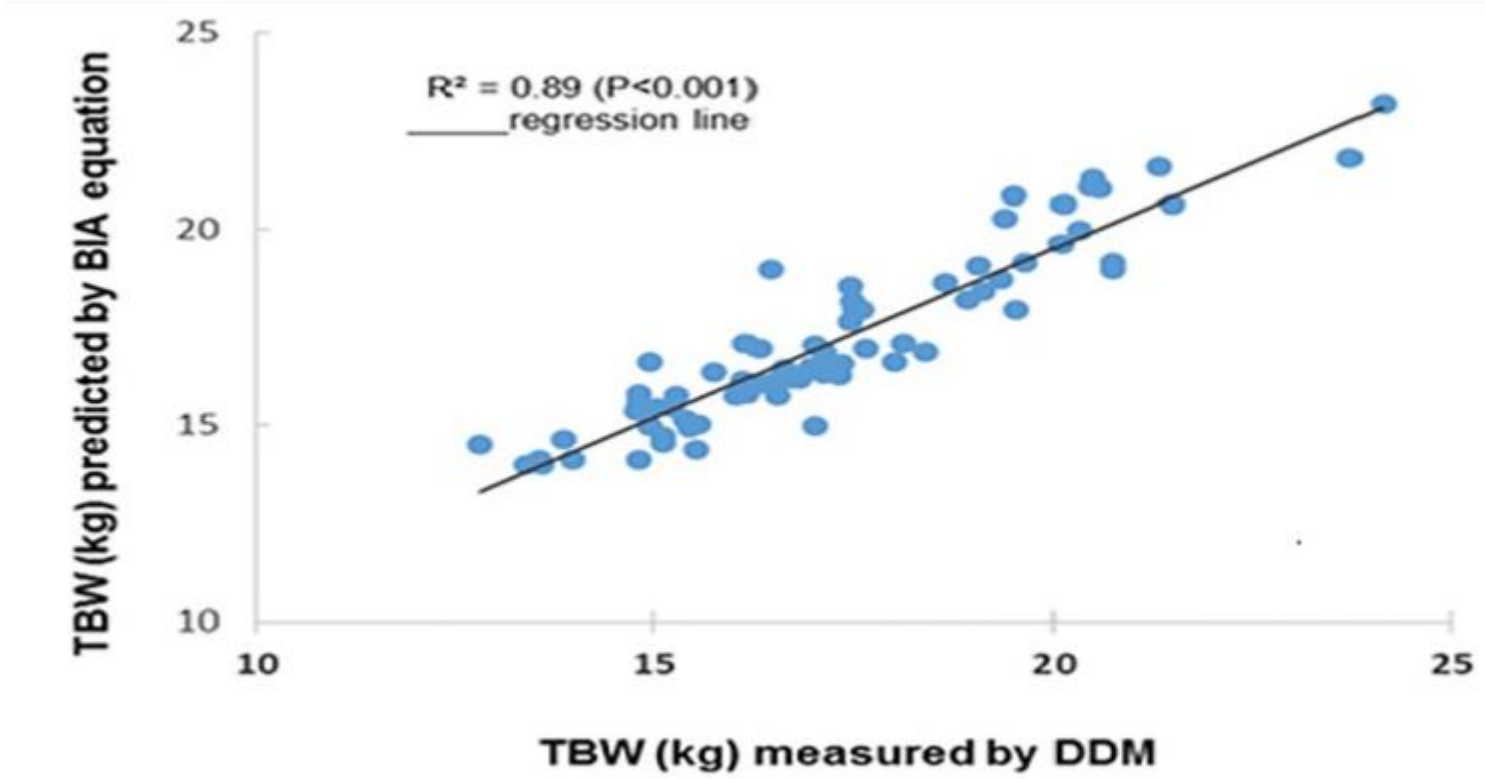
# Wie viel Volumen (d.h. Wasser) haben wir




Quellen:
1. Schumm, Wagner: Wasser als Lebensmittel, 2004
2. Herold et al.: Innere Medizin, 2008
3. Elmadfa, Leitzmann: Ernährung des Menschen, 3. Aufl., Stuttgart: Ulmer, 1998

# Wie viel Volumen (d.h. Wasser) haben wir



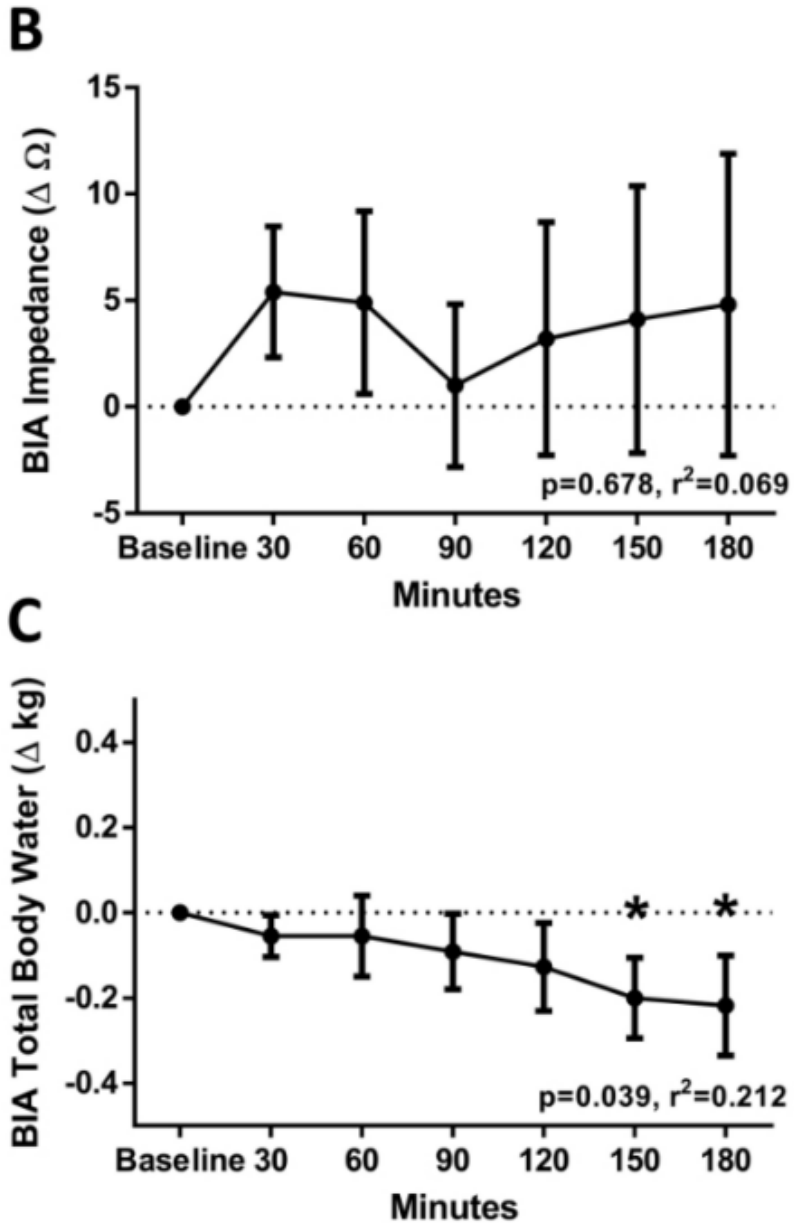

Diouf A et al, PLoS One. 2018 Oct 11;13(10):e0204486.

# Bioelektrische Impedanzanalyse (BIA)


TABLE VIEW

| | IN KG | IN % | IN % | IN % | KCAL |
|---|---|---|---|---|---|
| 07.03.2023 12:29 TIME | 69.7 | 24.4 | 51.1 | 37.7 | 2182.4 |
| 07.03.2023 12:30 TIME | 69.7 | 23 | 52.2 | 38.7 | 2227.8 |
| 07.03.2023 12:35 TIME | 70.7 | 25.1 | 50.6 | 37.4 | 2192 |
| 07.03.2023 12:36 TIME | 70.7 | 22.6 | 52.4 | 39.2 | 2273 |

# Bioelektrische Impedanzanalyse (BIA)




**Bioelectrical impedance analysis does not detect an increase in total body water following isotonic fluid consumption.**

Matthews EL, Hosick PA. Appl Physiol Nutr Metab. 2019 Oct;44(10):1116-1120.

# Volumenstatus

- Hydratation («Gesamtkörperwasser»)
- Intravasale Volumen («Blutvolumen»)
- Verhältnis zwischen extra- und intravasale Volumen
- Volumenansprechbarkeit
- Volumentoleranz

# 02

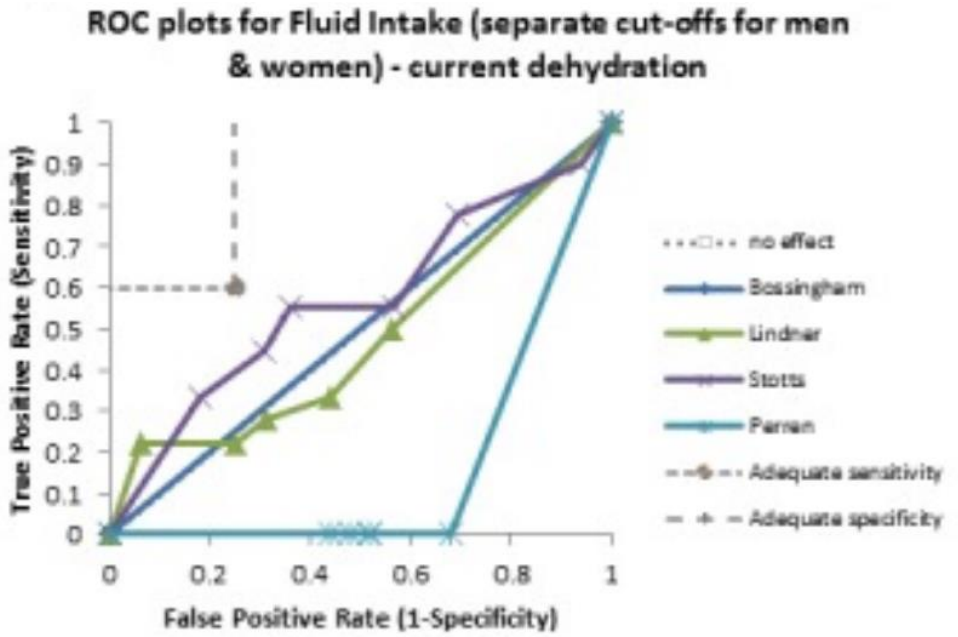
## (De)Hydratation

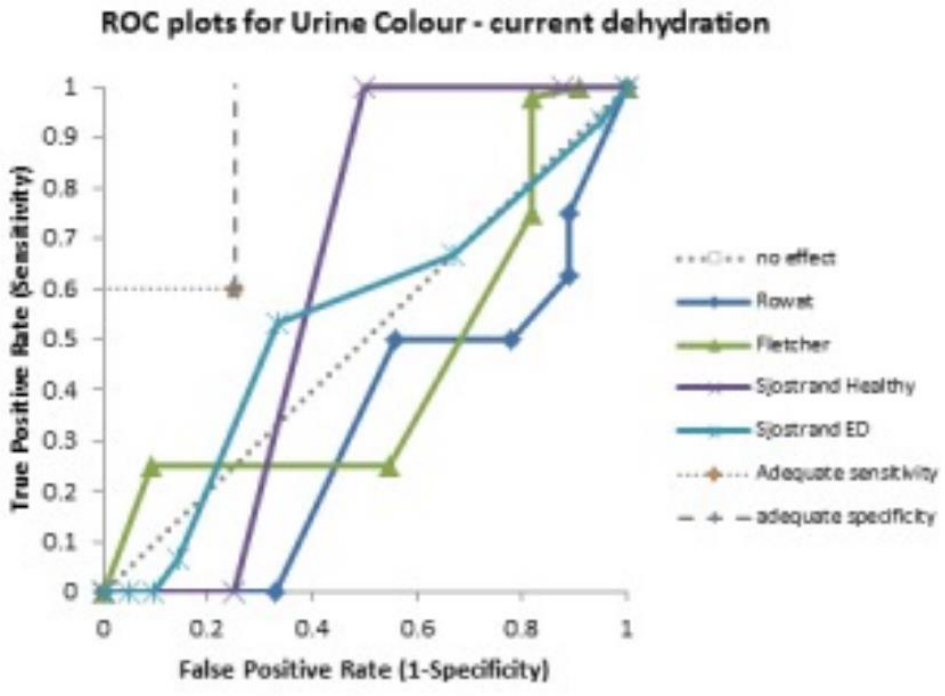
# Dehydratation («water-loss dehydration»)

- Hitzeschädigungen
- Harnwegsinfekte, Niereninsuffizienz
- Elektrolytstörungen
- **Tiefe Blutvolumen, bzw. Schock**

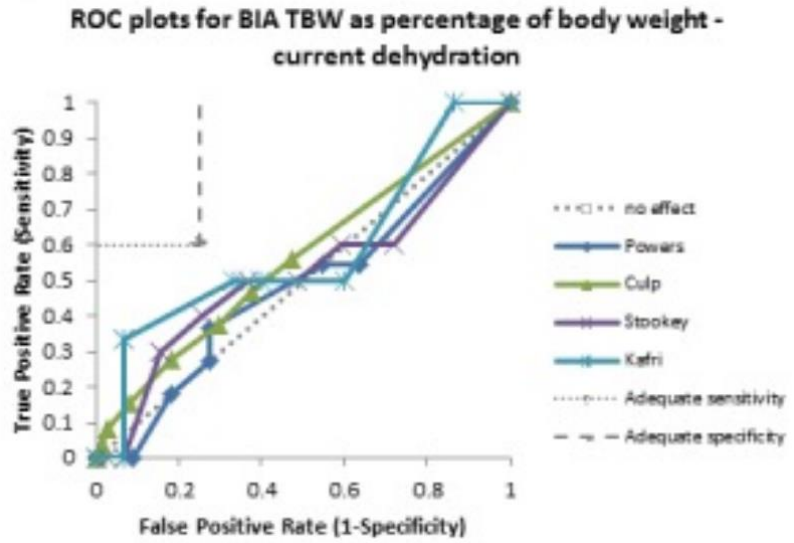
# Dehydratation assessment

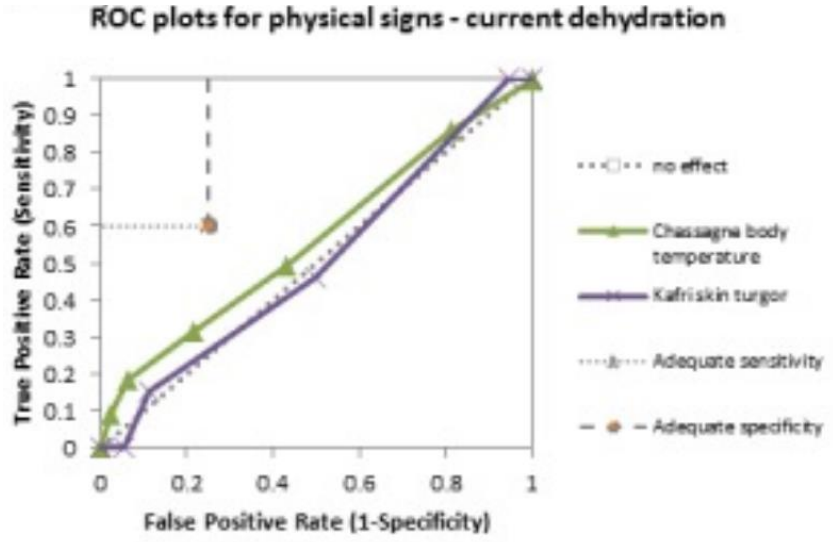
- Flüssigkeitszufuhr/Durst
- Urinfarbe, bzw. –dichte und -osmolalität
- Klinische Zeichen (insbesondere Hautturgor)




Hooper L et al. Cochrane Database Syst Rev. 2015 Apr 30;2015(4):CD009647.



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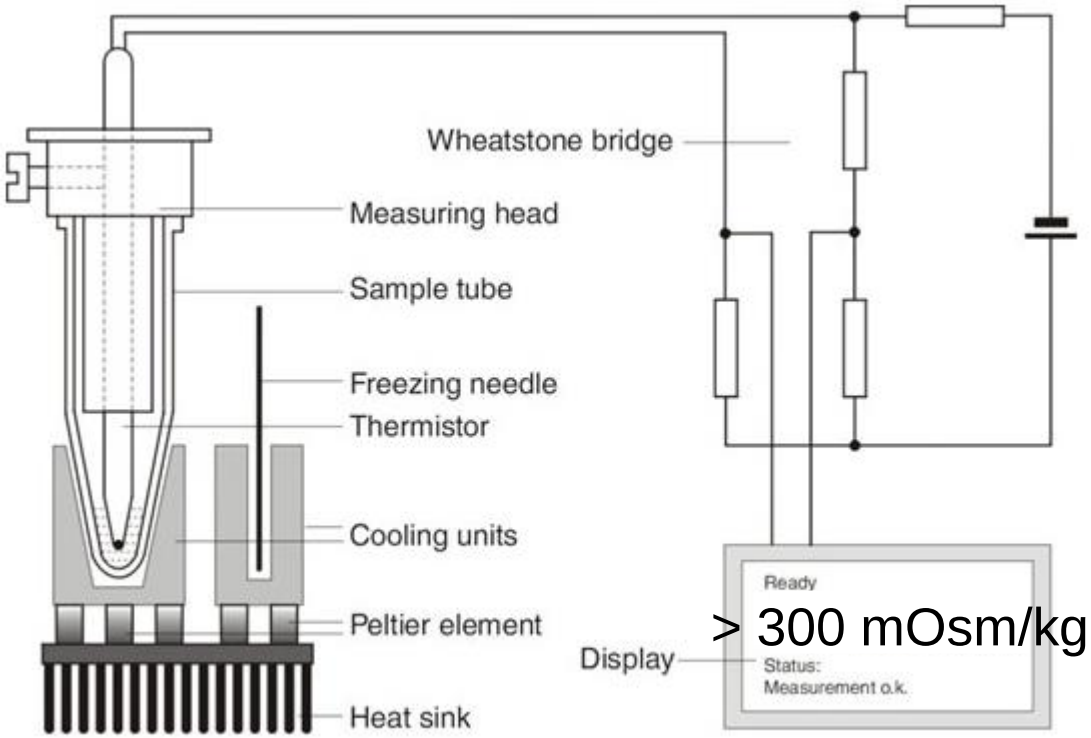
# (Hyperosmolare) Dehydratation


> 300 mOsm/kg



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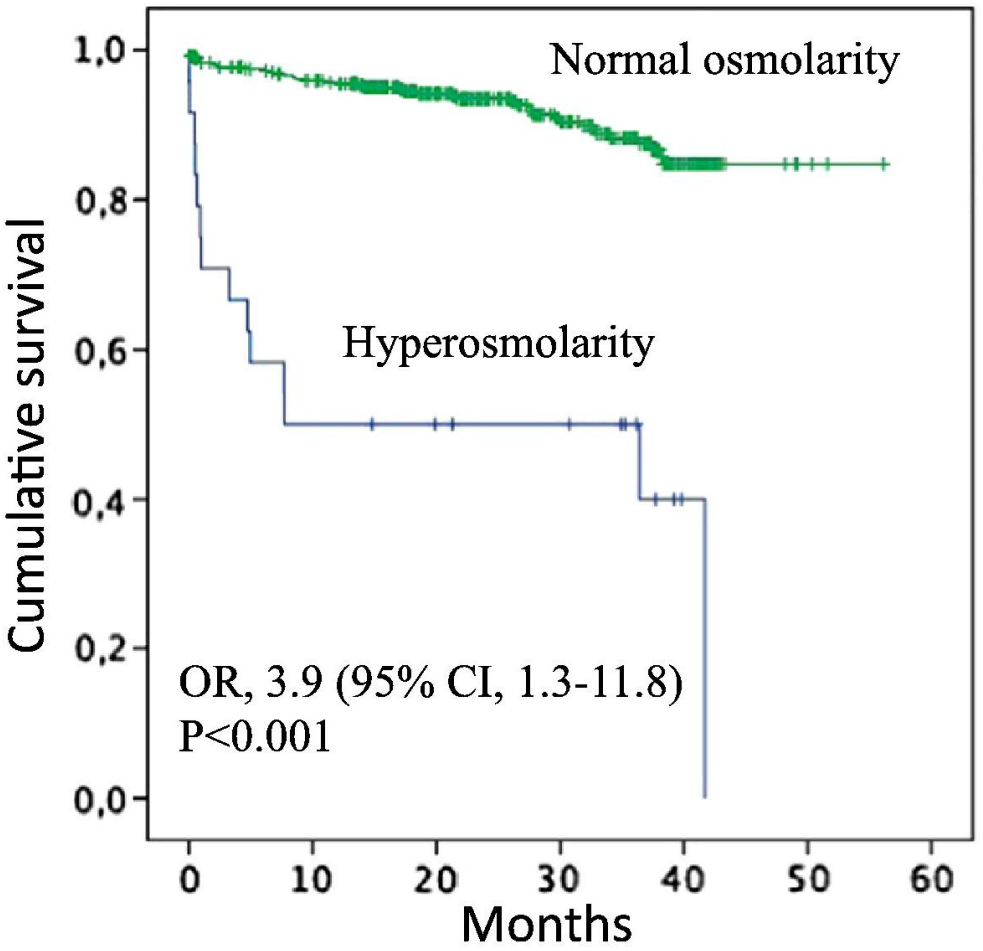
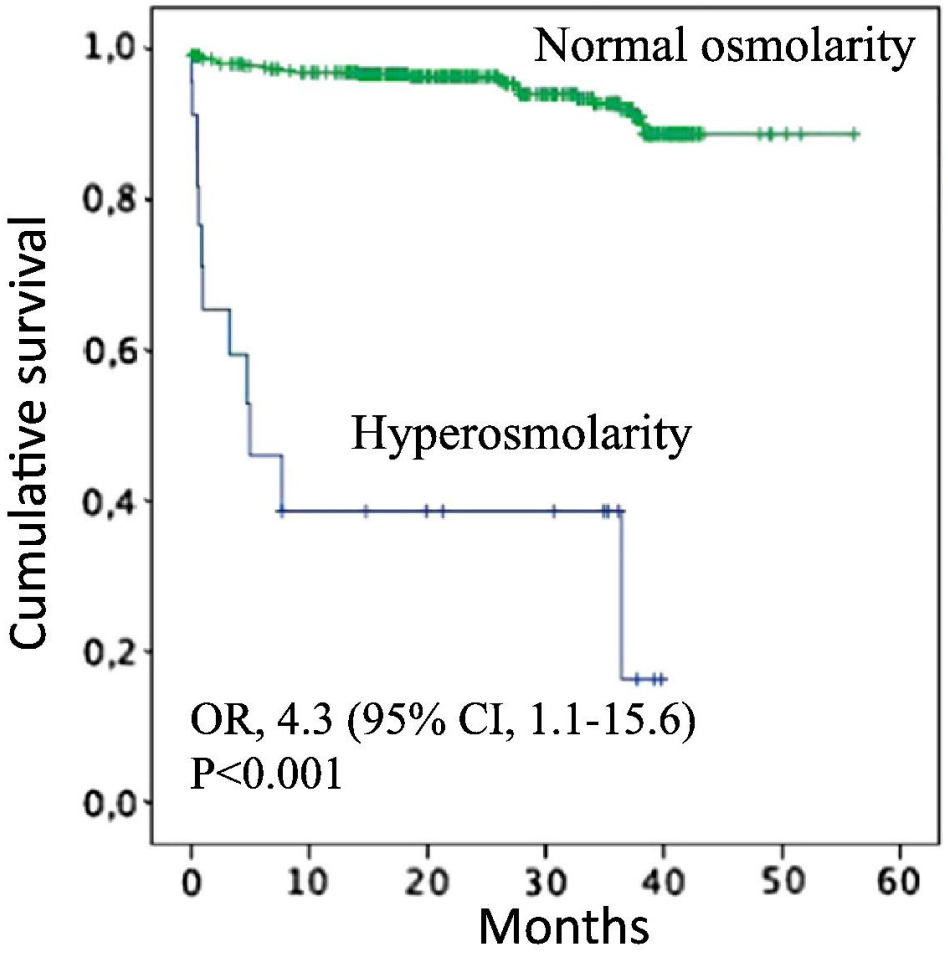
# (Hyperosmolare) Dehydratation




Briongos Figuero S et al. Int J Cardiol. 2014 Apr 1;172(3):e472-4.



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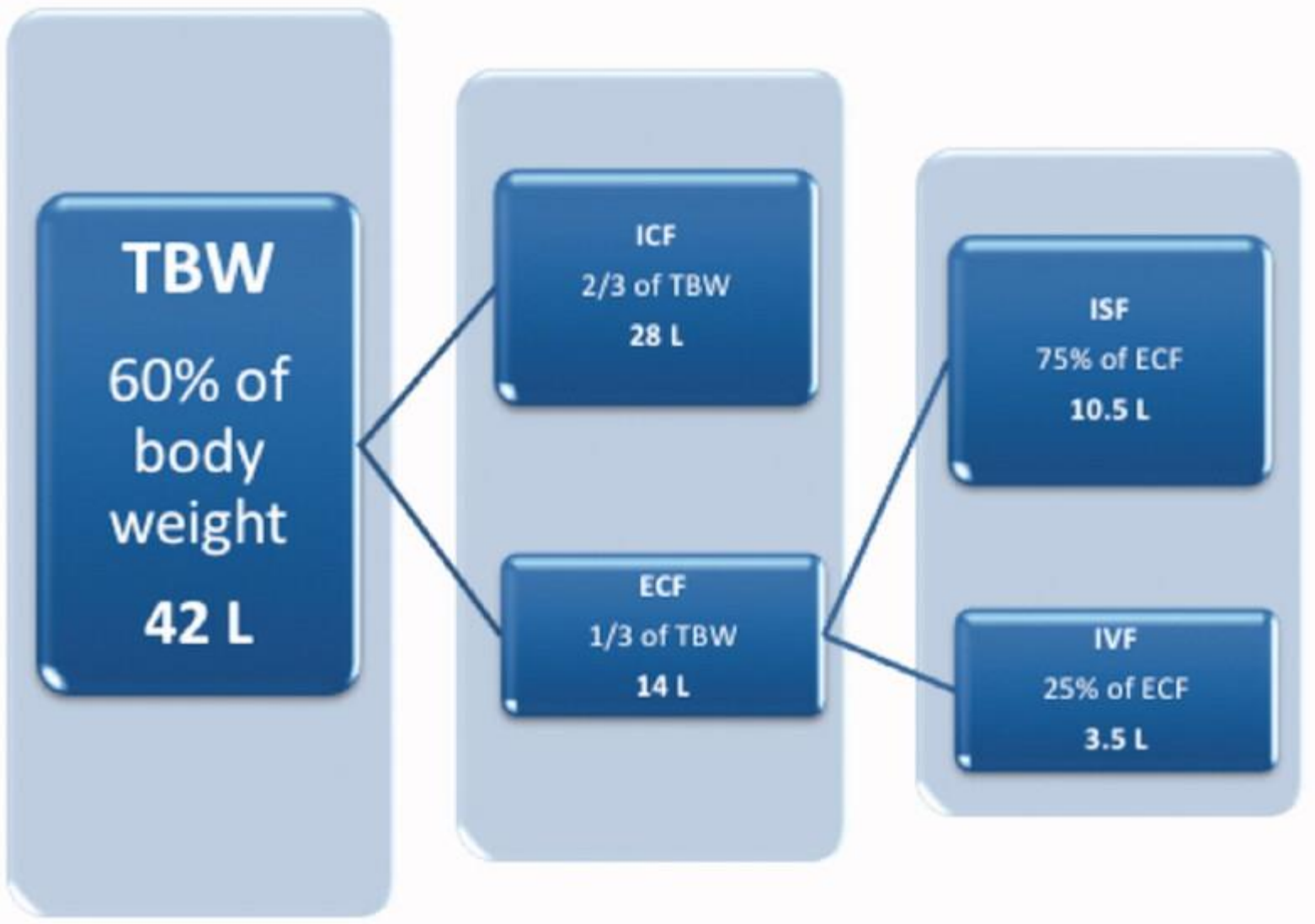
# Dehydratation - Therapie

**Primum non nocere**

# 03

## Blutvolumen

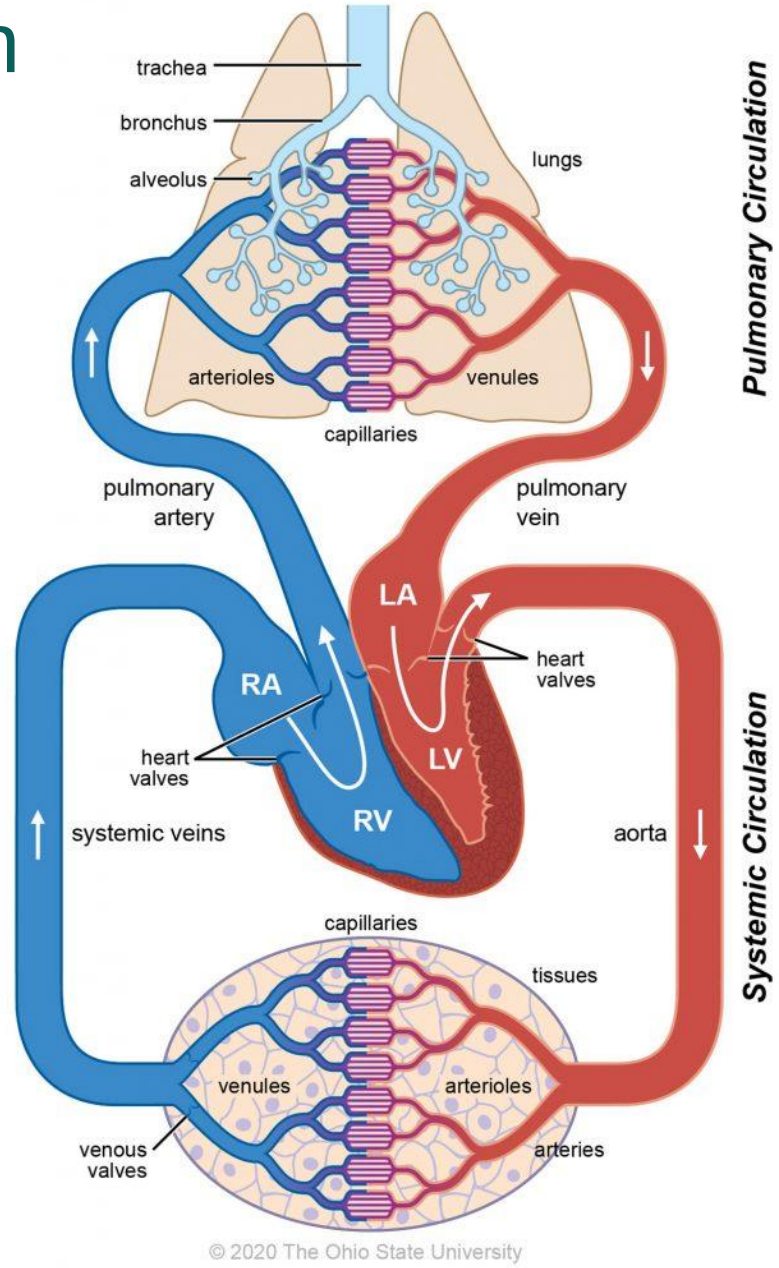
# Volumen Verteilung




Lacey J et al. Ann Med. 2019 May-Jun;51(3-4):232-251.

# 2 Ähnliche Geschichten

Hypovolämie




Relative Hypovolämie



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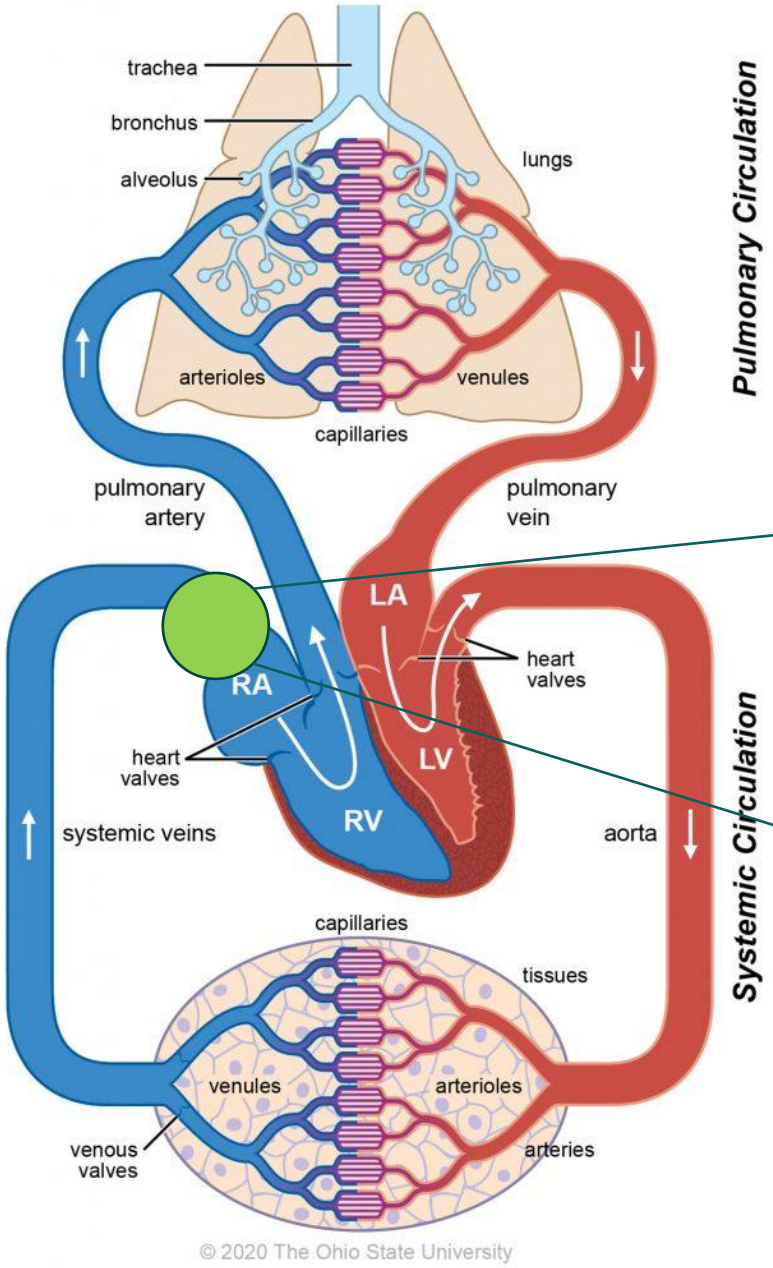
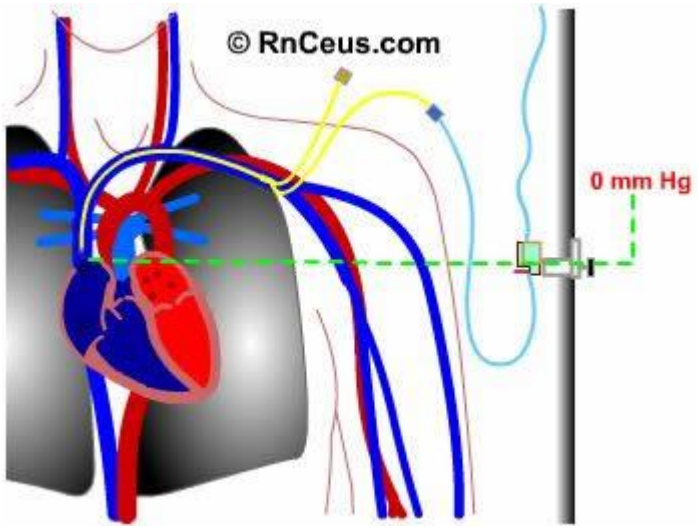
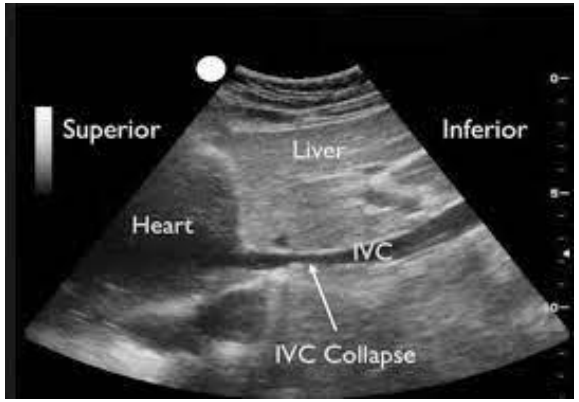
# ZVD messen, bzw. schätzen



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# ZVD

De Backer D, Vincent JL

**Should we measure the central venous pressure to guide fluid management? Ten answers to 10 questions**

Crit Care. 2018 Feb 23;22(1):43

| | Pro | Con |
|---|---|---|
| Measurements | Easy to measure | Errors in measurements |
| | Minimal apparatus | Influence of mechanical ventilation |
| | Cheap | Influence of abdominal pressure |
| CVP for fluid responsiveness | The predictive value of extreme CVP values (CVP < 6–8 mmHg and CVP > 12–15 mmHg) is satisfactory [7, 8] | The predictive value for fluid responsiveness is lower with CVP than with dynamic indices |
| CVP as a safety value | During a fluid challenge, a given CVP value can be used as a safety value | This safety value should be individually determined as there is no predefined safe upper level of CVP |
| CVP as a target value | In circulatory failure, this population-based approach may be used to ensure that the majority of the patients achieve a satisfactory hemodynamic goal | In circulatory failure, a significant number of patients may be submitted to excessive fluid administration whereas other patients may require additional fluid administration |
| | | In patients without indices of hypoperfusion, this approach is not recommended as it could lead to unnecessary fluid administration [19] |
| Influence of mechanical ventilation | The CVP represents the back pressure of all extrathoracic organs | The CVP may fail to reflect intravascular pressure during mechanical ventilation |
| CVP can be used to evaluate the response to fluids | An increase in CVP indicates an increase in preload | The increase in CVP indicates the increase in preload but does not indicate the response to fluids; in fluid responders the increase in CVP should be minimal (with a large increase in cardiac output) while in nonresponders the increase in CVP is larger |
| | An absence of change in CVP during fluid administration indicates that insufficient fluids were administered to manipulate preload | |

# VCI

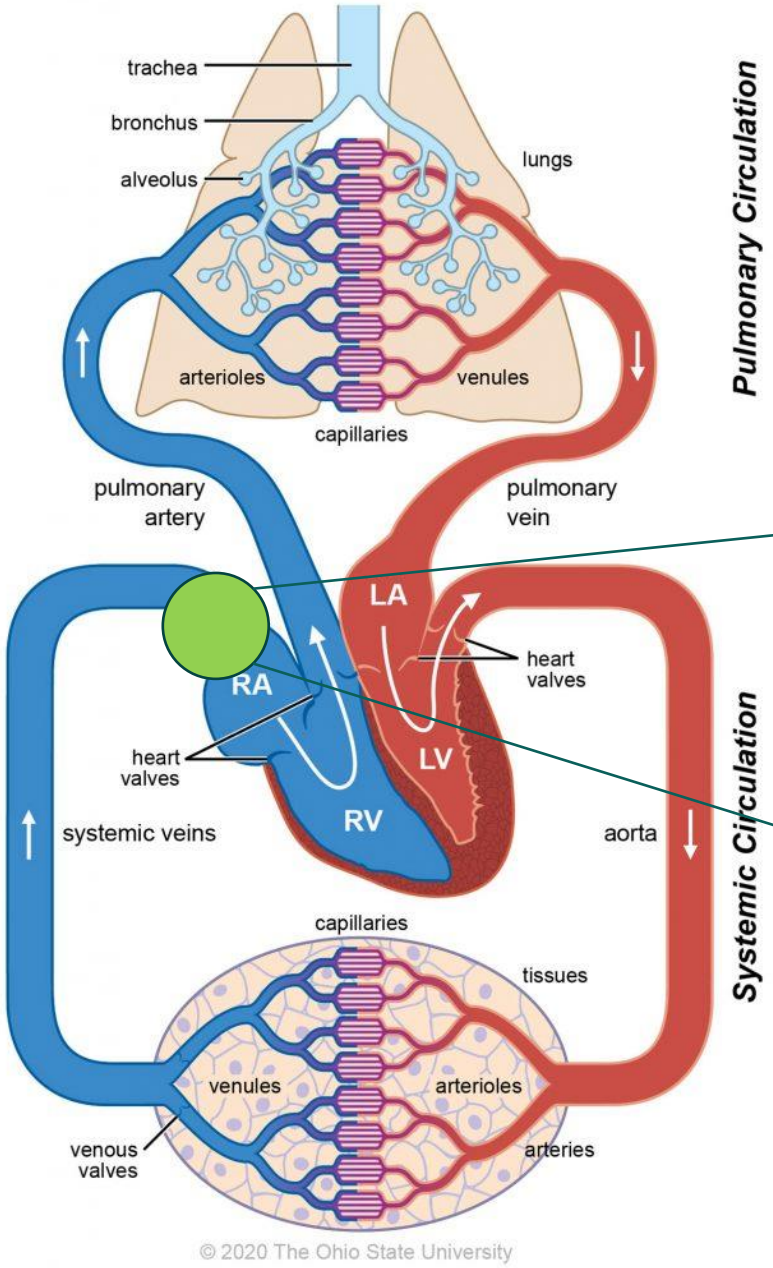
Via G, Tavazzi G, Price S.

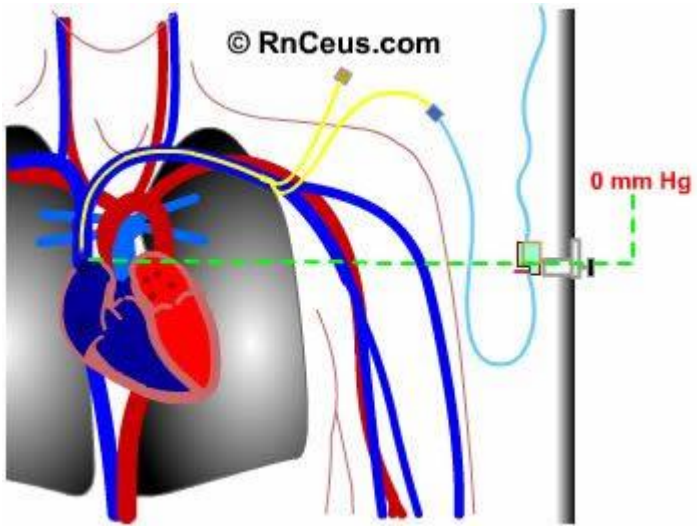
**Ten situations where inferior vena cava ultrasound may fail to accurately predict fluid responsiveness**

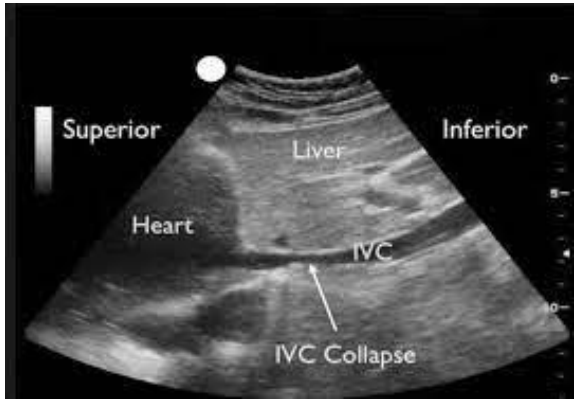
Intensive Care Med. 2016 Jul;42(7):1164-7

| Physiological determinant | Condition affecting IVC ultrasound reliability for FR | Cause of inaccuracy for FR | Type of inaccuracy for FR |
|---|---|---|---|
| Ventilator settings | 1. Mechanical ventilation with high PEEP and/or low tidal volumes | Larger IVC size, potentially with systemic venous congestion and low respiratory variations, but coexisting with FR | FN |
| Patient's inspiratory efforts | 2. Assisted ventilation modalities, NIV, CPAP | Spontaneous breathing activity makes IVC variation unpredictable | FP and FN |
| | 3. Varying respiratory pattern in spontaneous breathing | Significant inspiratory effort, producing markedly negative intrathoracic pressures may induce IVCc in absence of FR | FP |
| | | Shallow breathing, with small intrathoracic pressure changes, may induce absence of IVCc in presence of FR | FN |
| Lung hyperinflation | 4. Asthma/COPD exacerbation | Lung hyperinflation and auto-PEEP simultaneously reduce venous return and induce IVC distension: this may mimic absence of FR | FN |
| | | Forced expiration ("abdominal breathing" causing expiratory collapse) may mimic IVCc | FP |
| Cardiac conditions impeding venous return | 5. Chronic RV dysfunction, severe TR | Chronic enlargement of IVC and reduced IVCc may erroneously rule out FR | FN |
| | 6. RV myocardial infarction | RV dilatation and systemic venous congestion (large IVC) may be associated with FR | FN |
| | 7. Cardiac tamponade | Marked venous return hindrance: fluid challenge may be a beneficial haemodynamic intervention despite IVC plethora | FN |
| Increased abdominal pressure | 8. Intra-abdominal hypertension | Smaller IVC size, IVCd or IVCc abolition (depending on type respiration/ventilation mode) | FP and FN |
| Other factors | 9. Local mechanical factors | Venous return hindrance, IVC dilatation (stenosis, thrombosis) | FN |
| | | IVC compression (masses) | FP |
| | | Hindrance to IVC size change (ECMO cannulae, cava filters) | FN |
| | 10. Patients with pronounced IVC inspiratory lateral displacement | Migration of IVC imaging plane, false inspiratory size reduction | FP |

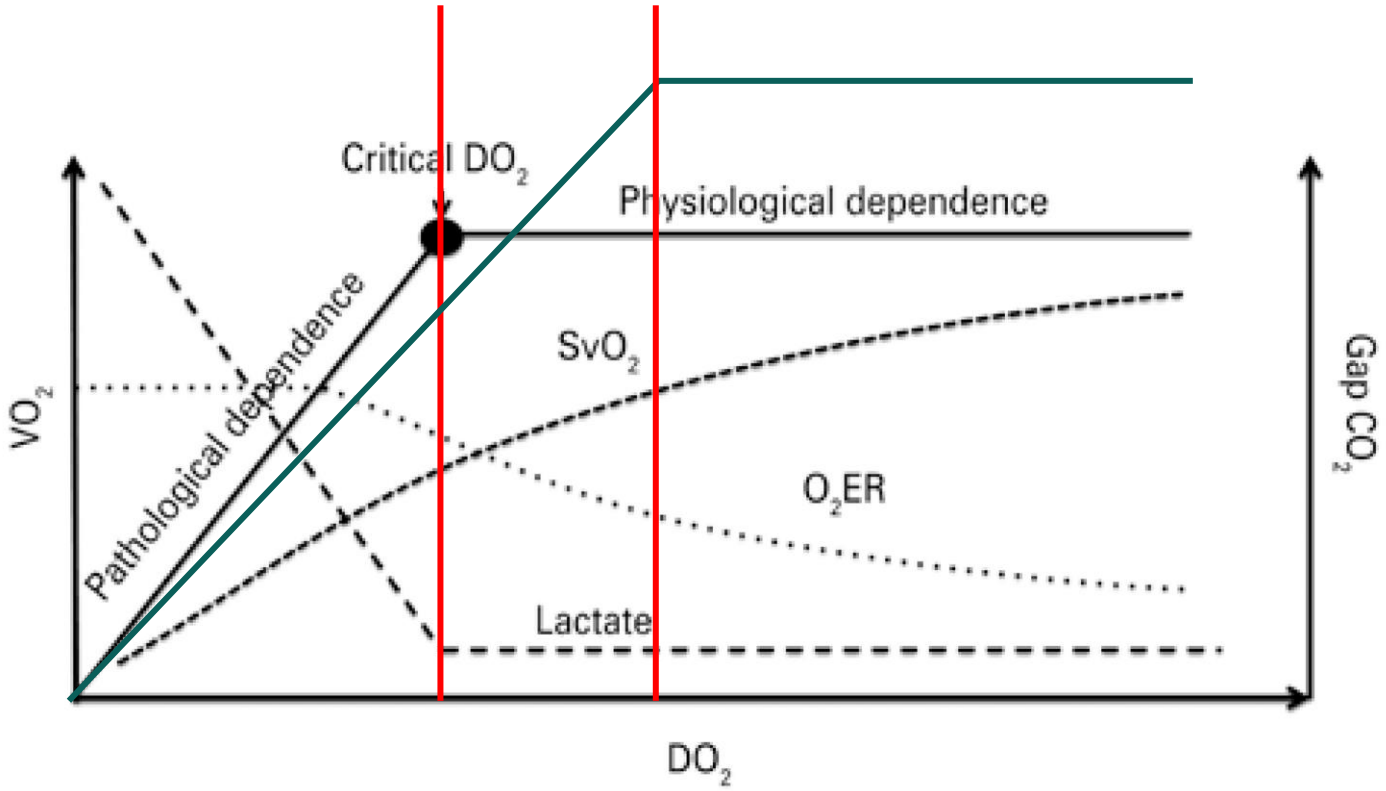
# ZVD messen, bzw. schätzen



# Ziel: hemodynamische homeostase




$DO_2$: oxygen delivery; $VO_2$: oxygen consumption; $O_2ER$: relation with oxygen extraction ratio; $SvO_2$; mixed venous oxygen saturation; Gap $CO_2$: gradient of partial carbon dioxide pressure in the gastric mucosa.

$DO_2 = CO \times CaO_2$

$CO = SV \times HF$

$CaO_2 = Hb \times SaO_2$

$VO_2 = CO \times CaO_2\text{-}CvO_2$

$CvO_2 = Hb \times SvO_2$

$O_2ER = VO_2 / DO_2$



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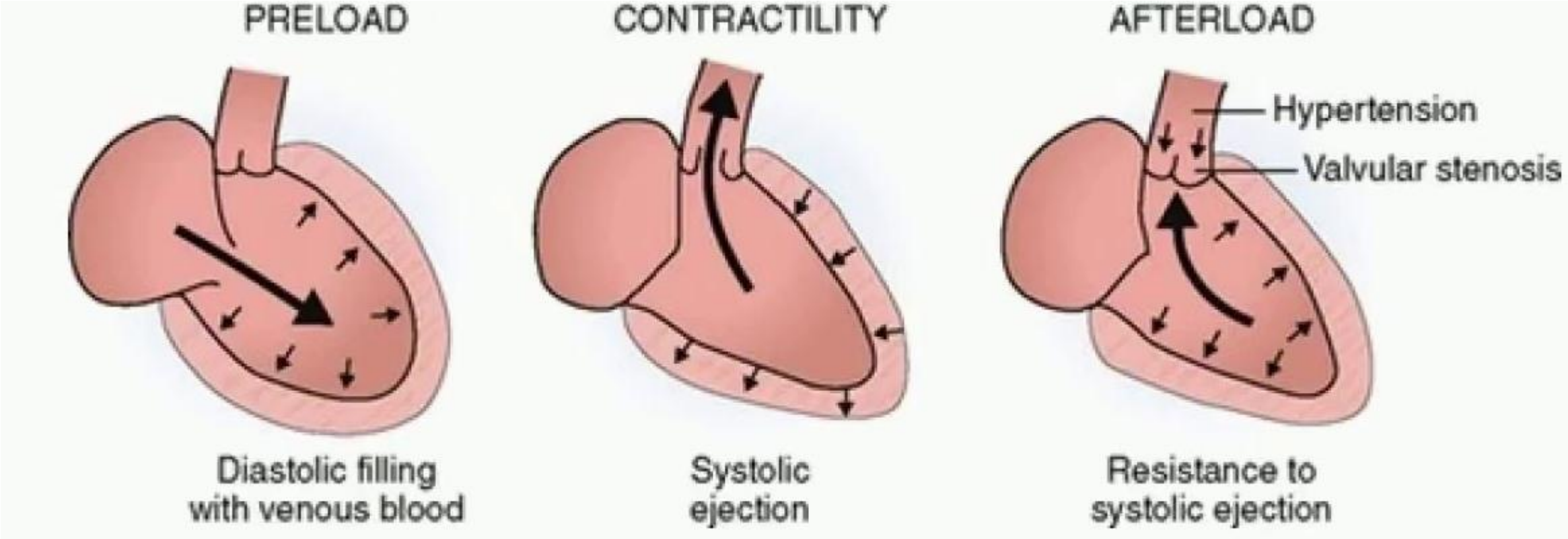
# Schlagvolumen

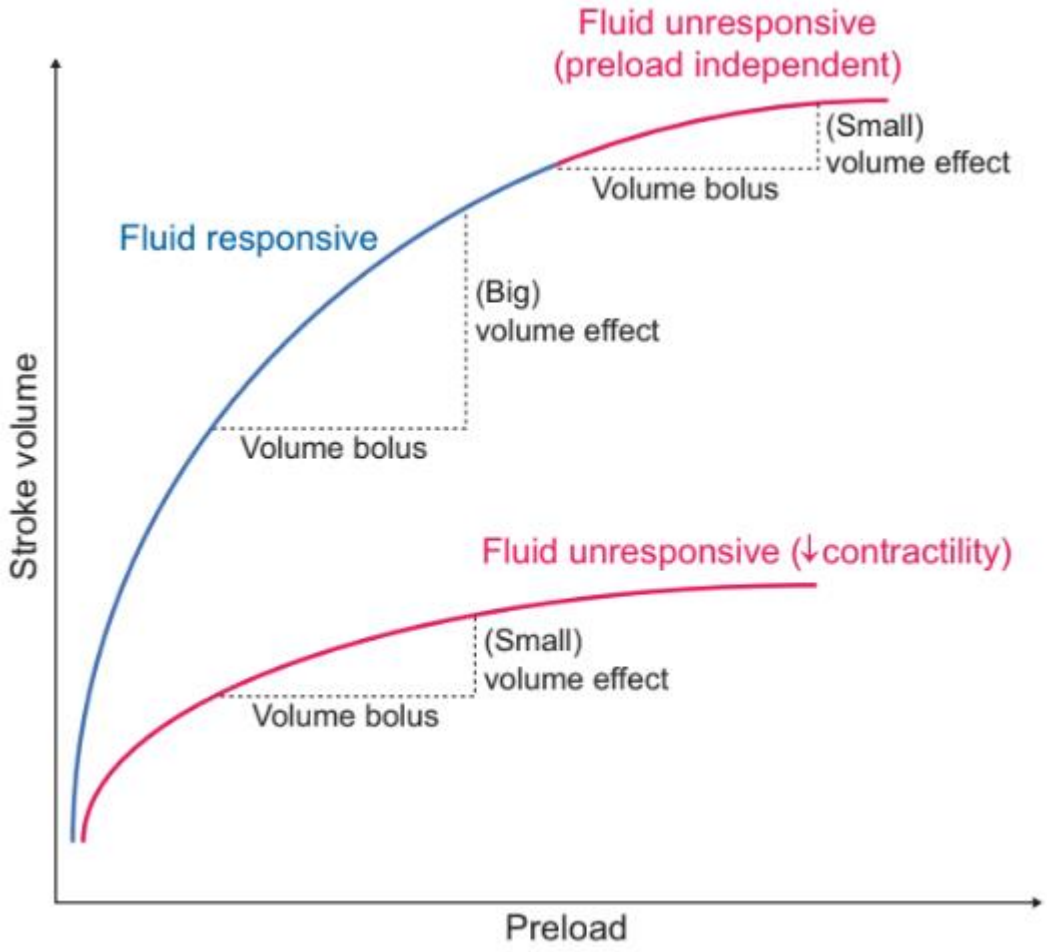



Air to air
@u-l
6.07K subscribers

# 03

## Volumenansprechbarkeit

# Frank-Starling




Mayerhöfer T et al. Nephrol Dial Transplant. 2022 Sep 28:gfac279.



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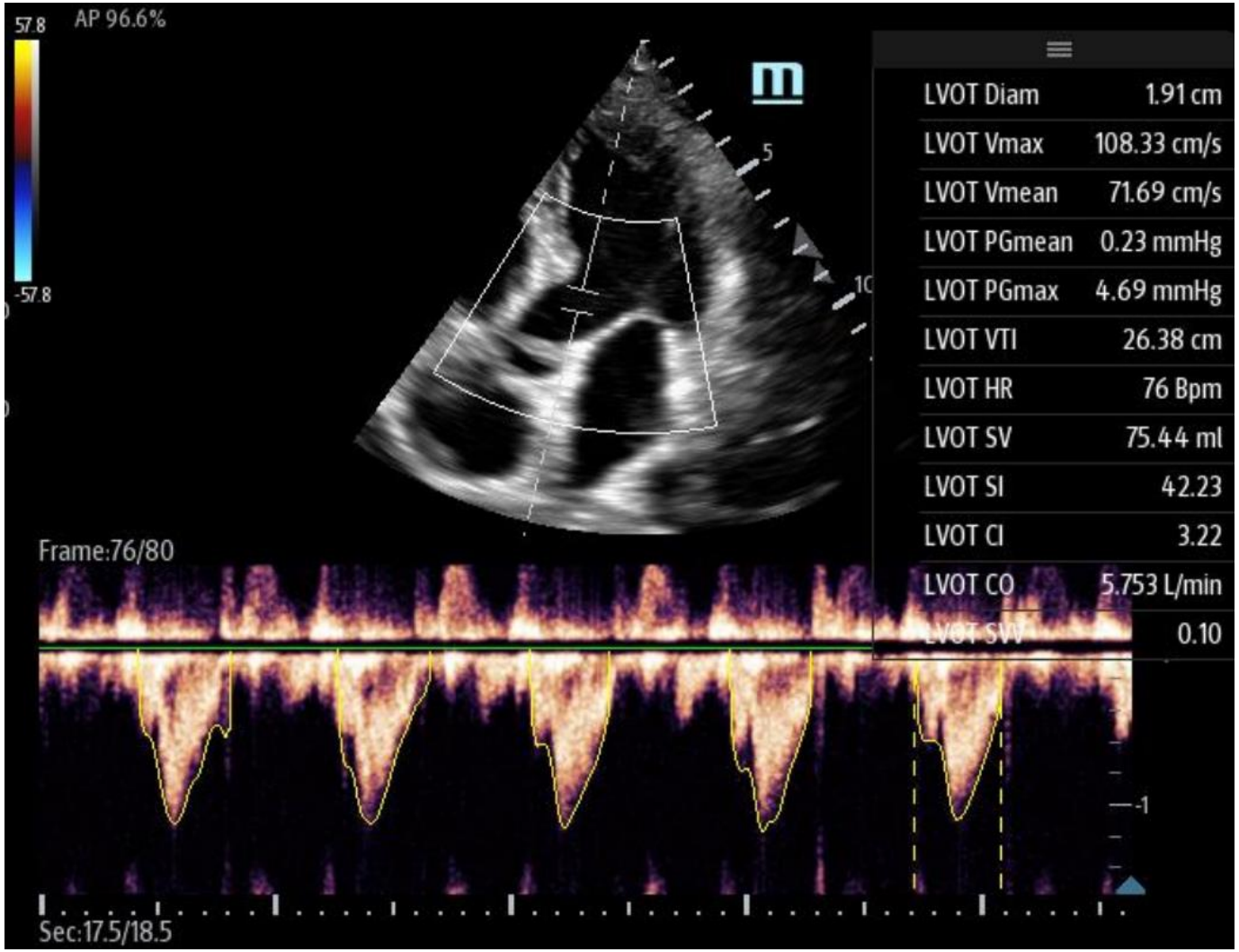
# Nicht-invasive Messung des Schlagvolumen



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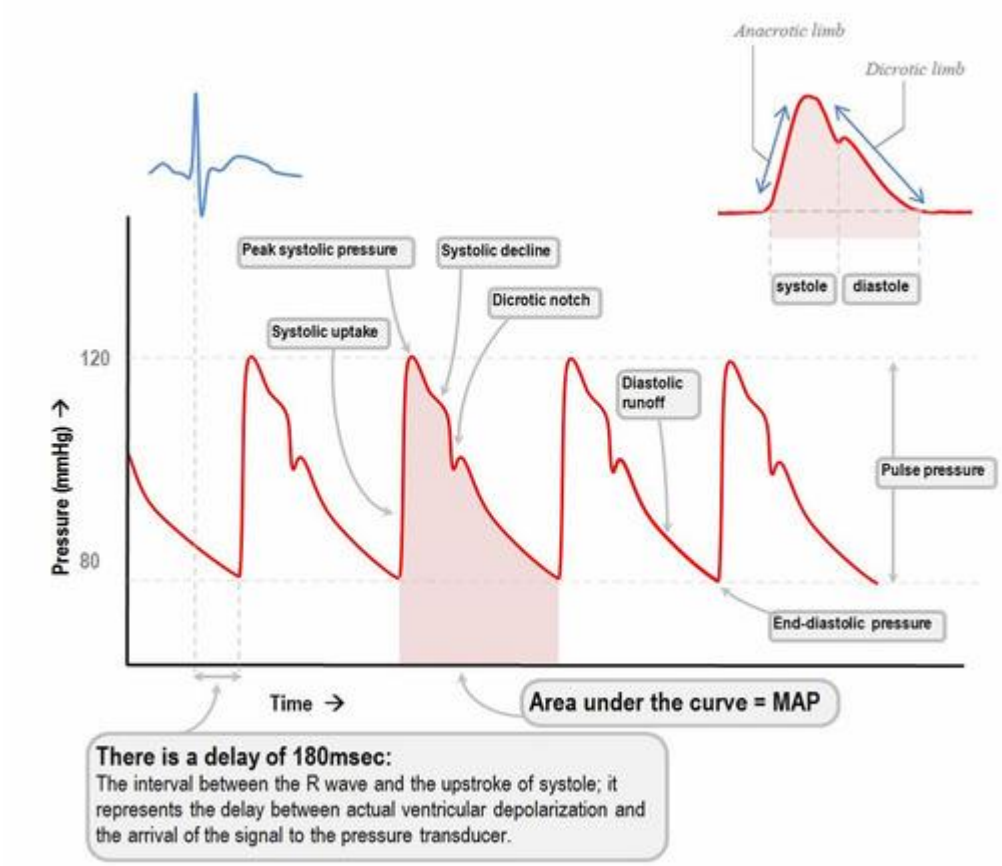
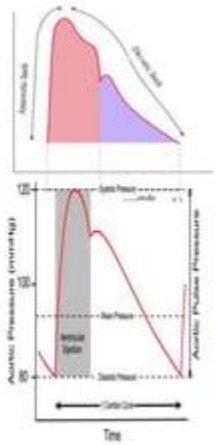
# Semi-invasive Messung des Schlagvolumen

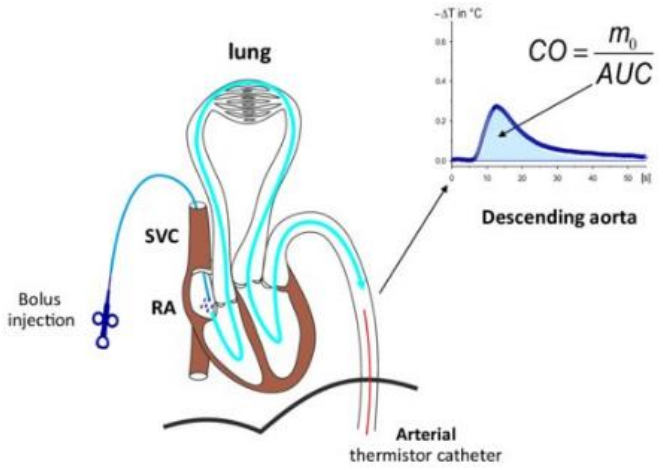


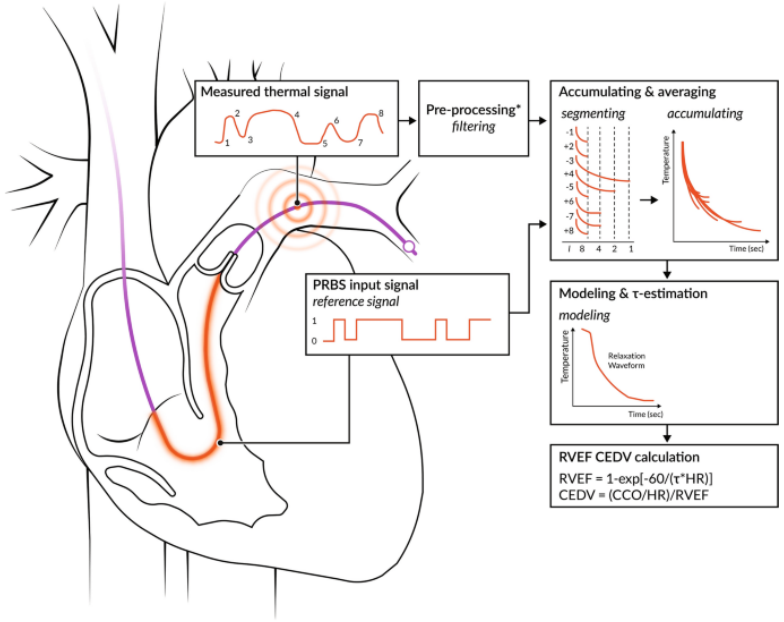

## Pulse contour analysis

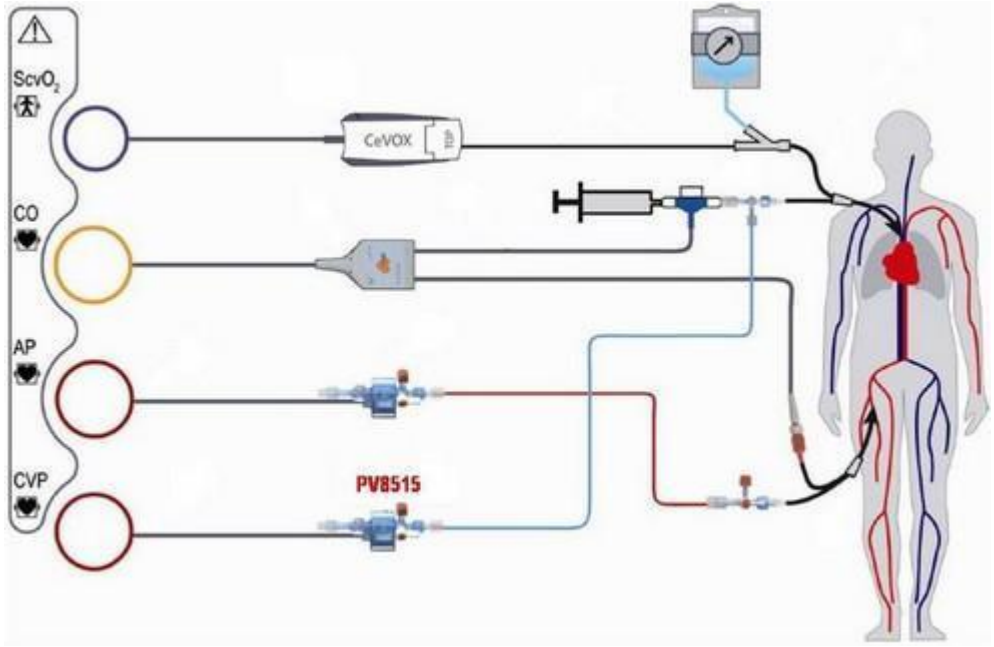
- based on the principle that area under the systolic part of the arterial pressure waveform is proportional to the SV.
- CO was proportional to arterial pulse pressure.
- In this method the area is measured post diastole to end of ejection phase divided by aortic impedance that measures SV.



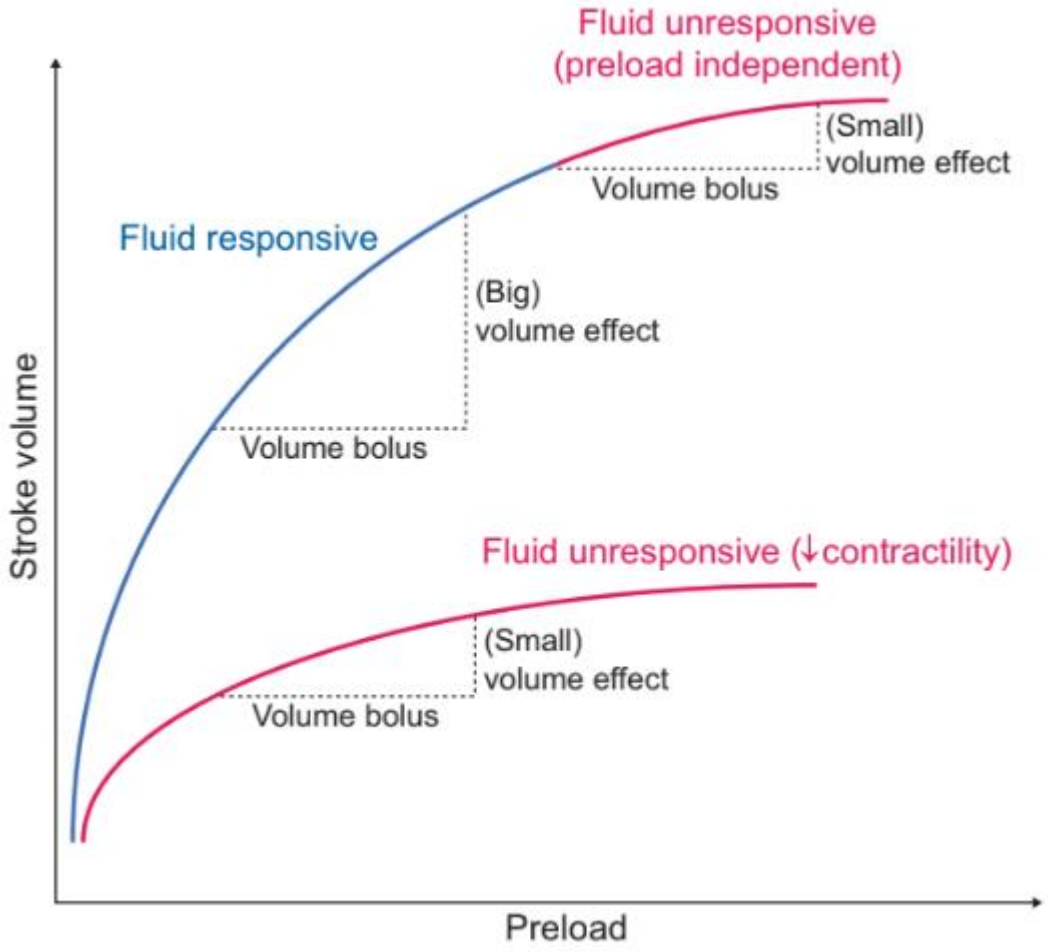
# Invasive Messung des Schlagvolumen



# Frank-Starling




Mayerhöfer T et al. Nephrol Dial Transplant. 2022 Sep 28:gfac279.



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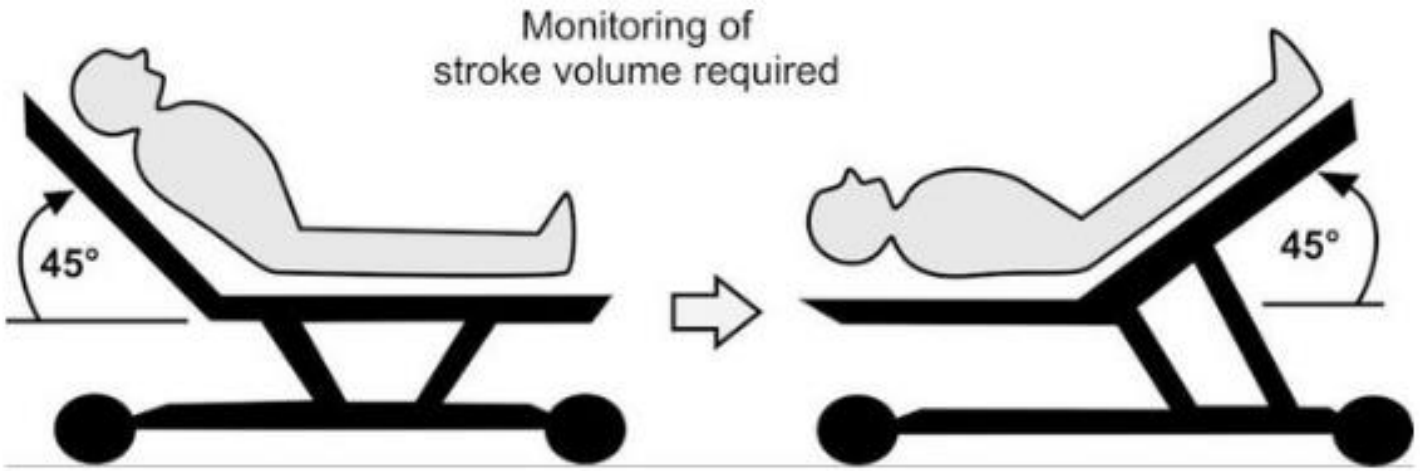
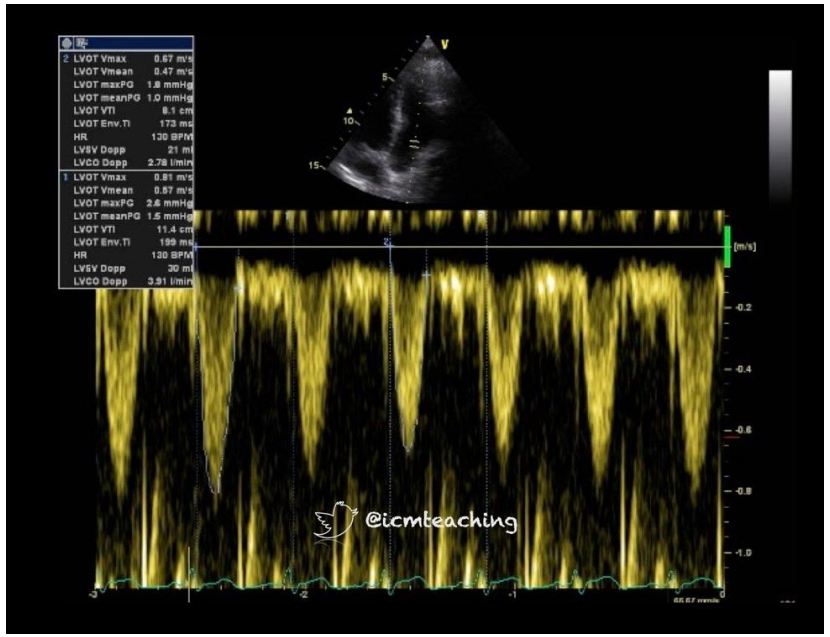
# «fluid challenge» / passive leg raising test




Um die Beurteilung des Volumenansprechbarkeit

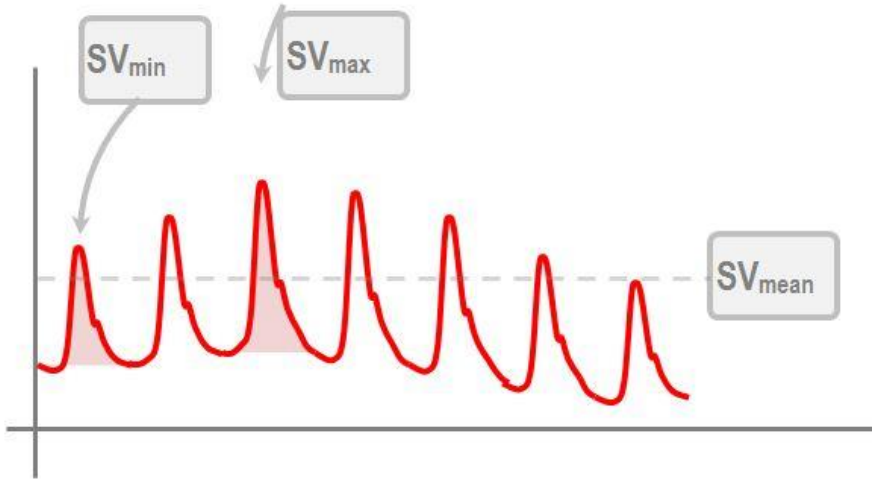
bei eine geschätzte «fluid challenge» von ca. 250 mL

# Stroke volume variation (SVV)




LVOT-VTI-V

**> 10-15% = Volumenansprechbarkeit**

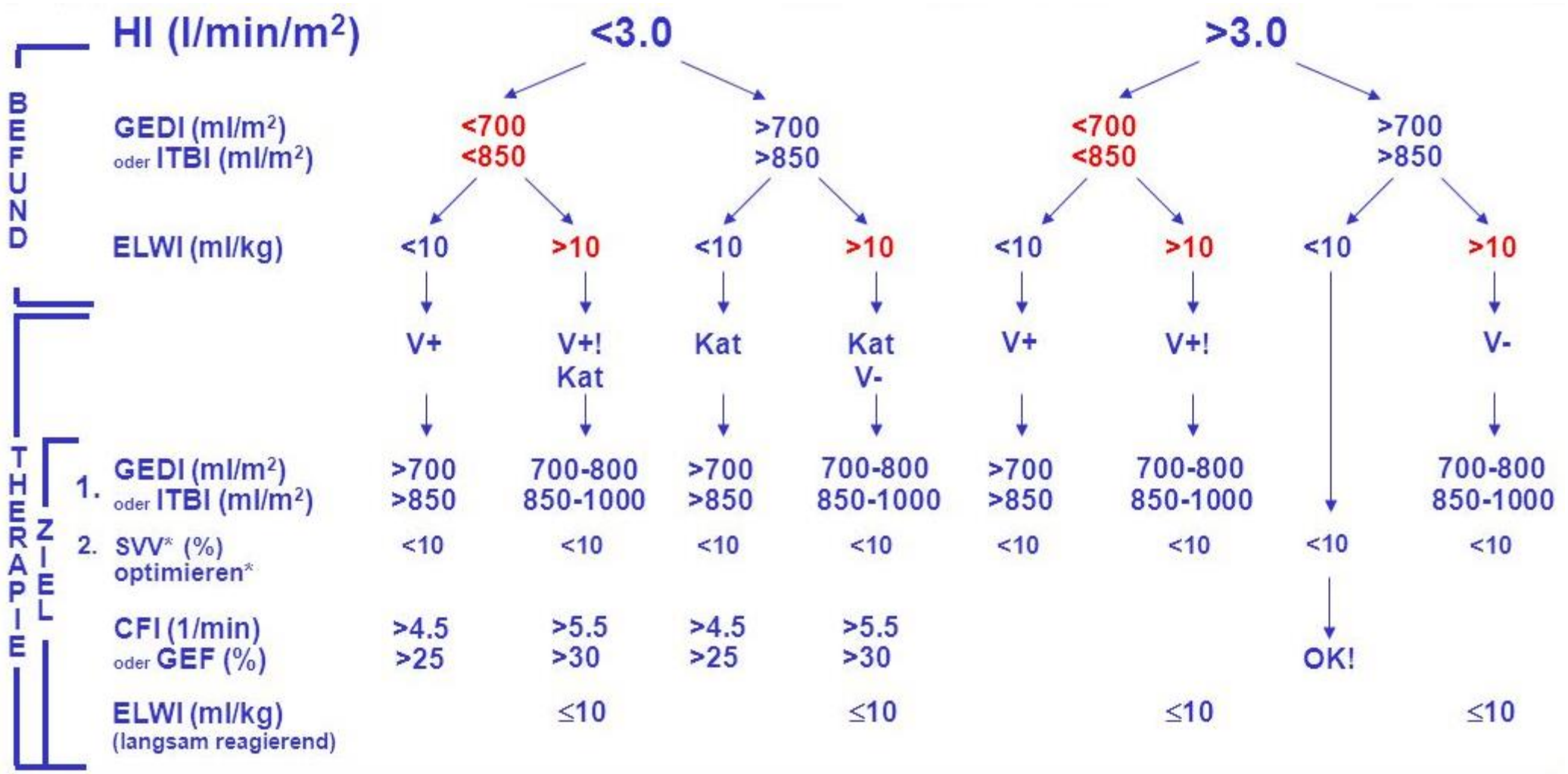



PPV

# CAVE

Volumenansprechbarkeit ≠ Hypovolämie ≠ Volumenbedarf !

# Der PICCO Algorithmus – «the fancy way»



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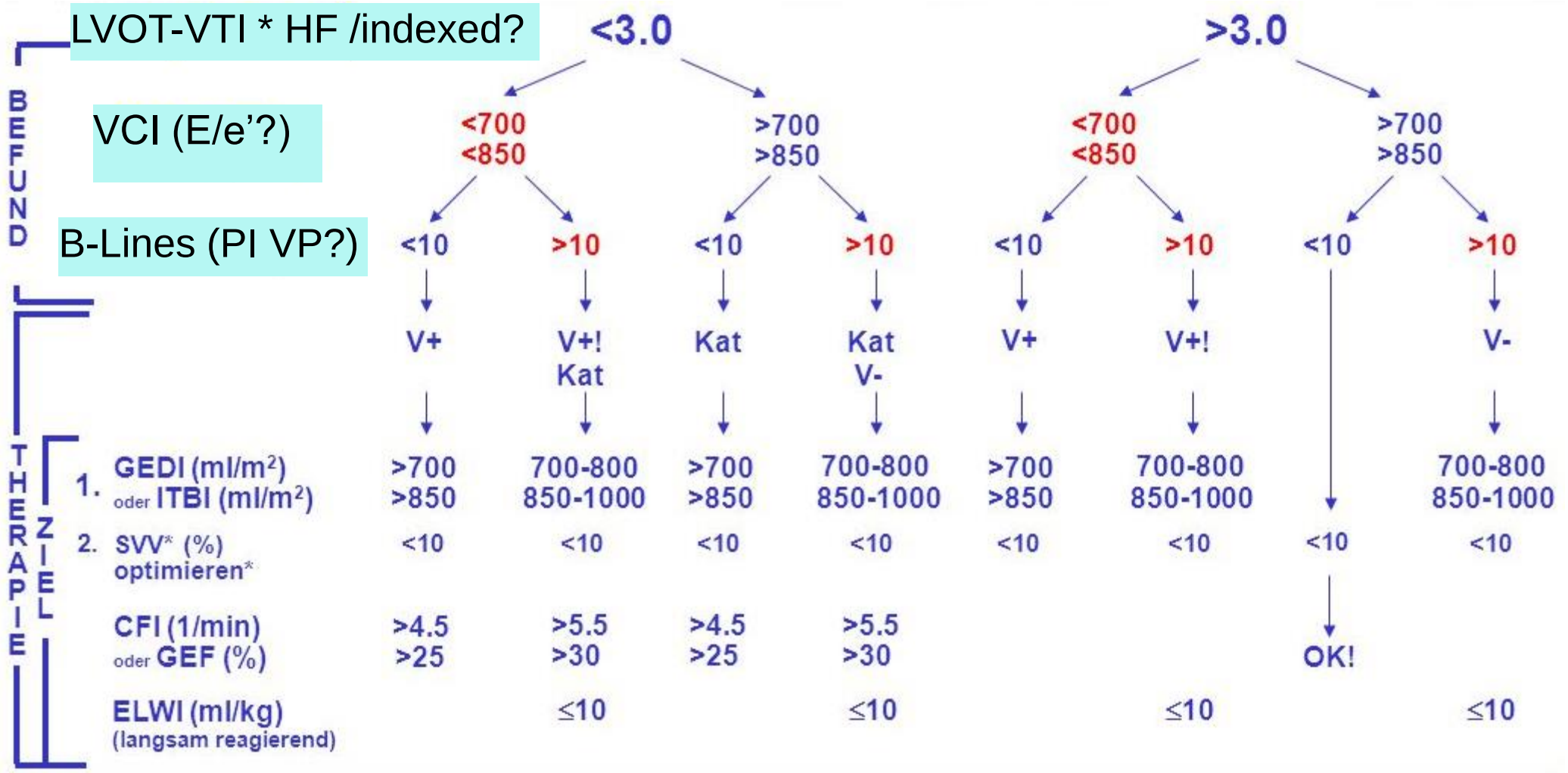
# Der PICCO adaptierte Algorithmus – «the new fancy way?»



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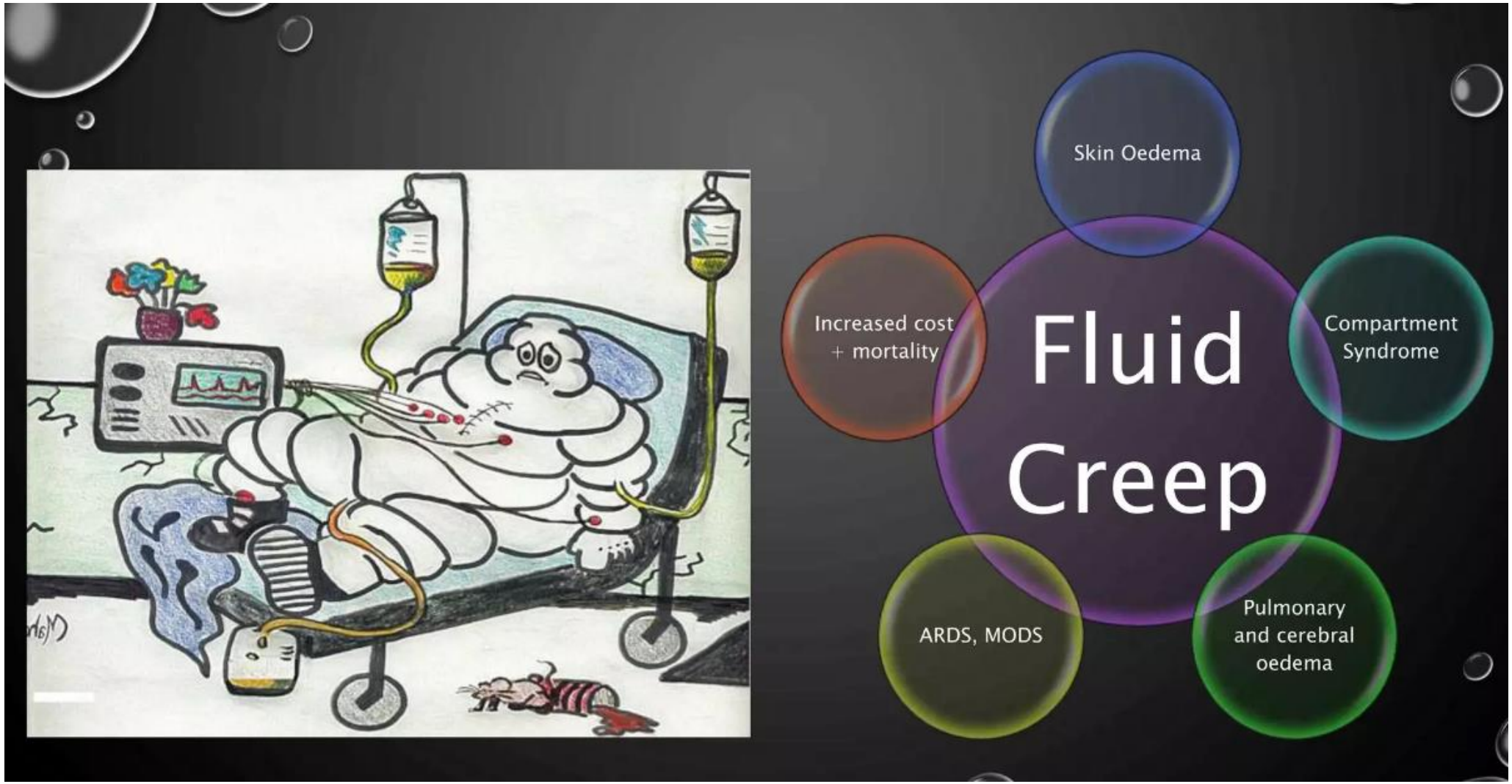
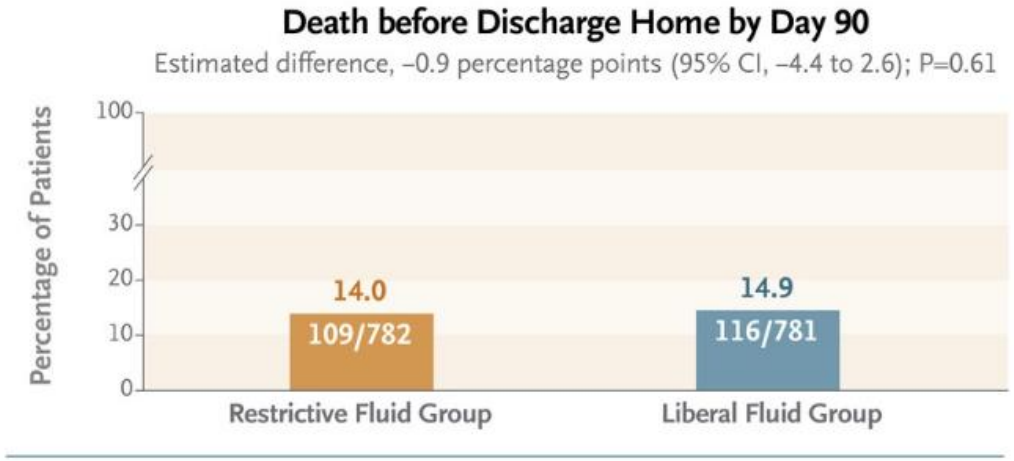
# 03

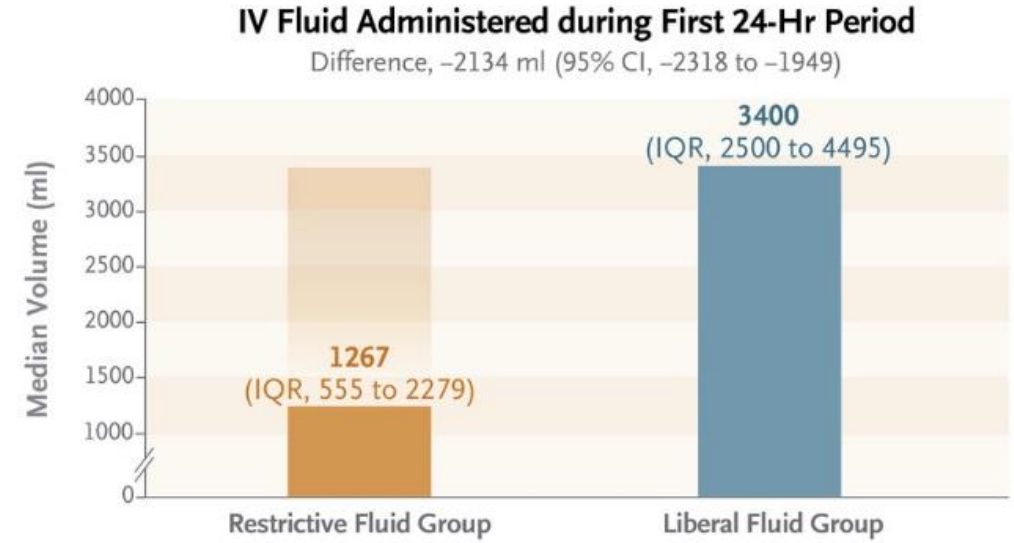
## Volumentoleranz

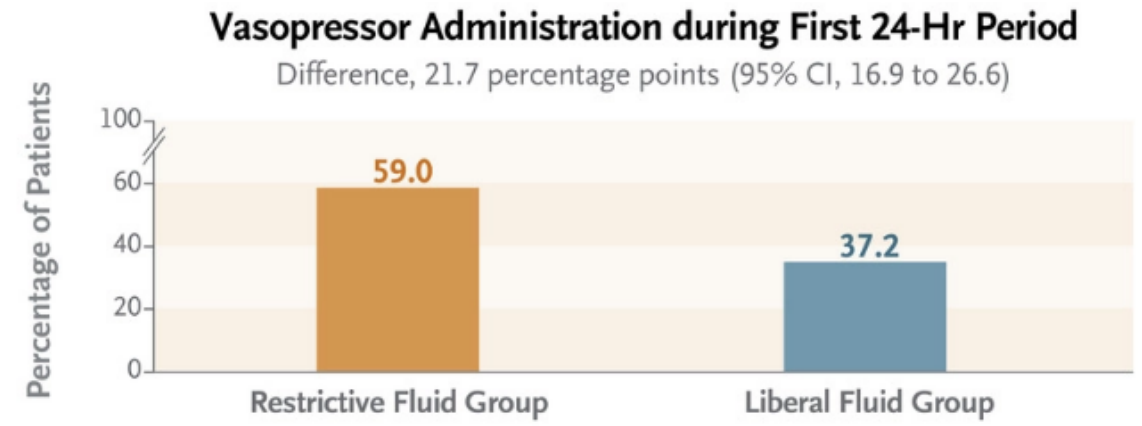
# Wie viel, ist zu viel…

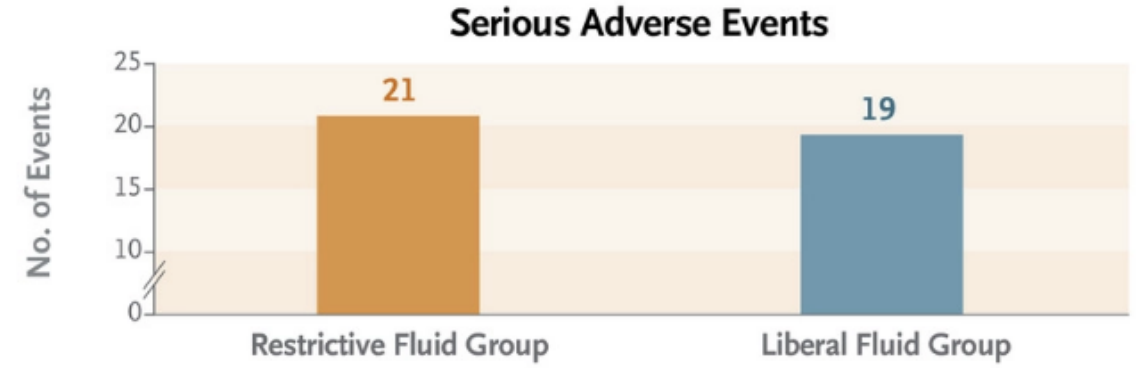


# Restrictive vs Liberal Fluid Management for Sepsis




Shapiro NI et al. N Engl J Med. 2023 Feb 9;388(6):499-510.



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# Take Home Messages

- Volumenstatus ist ein Überbegriff
- Dehydratation ist häufig, teuer und tödlich, jedoch (zu?) wenig gesucht und (längerfristig?) behandelt
- Hypovolämie muss in ein hemodynamisches/klinisches Bild betrachtet werden
- Ziel der Behandlung ist eine ausreichende Organperfusion, eventuell mit Volumen
- Volumentoleranz whs. wichtiger (und einfacher) als Volumenansprechbarkeit

# Ein pragmatisches approach

- Patienten trinken lassen
- Screenen für Schock (klinisch, d.h. Hypoperfusionszeichen, bzw. POCUS)
- Volumentoleranz vor Volumenansprechbarkeit
  - Abnahme der $SpO_2$, B-Lines in POCUS, ggf. PI Pfortader, bzw. «Rettungsmassnahmen»
- Keine «Wasserspiele»
- Frühzeitige Katecholamine (CAVE: Sensibilisierung an die Erkrankung)

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# Danke für die Aufmerksamkeit ☺