ANESTHESIOLOGY FOR THE TRAUMA PATIENT

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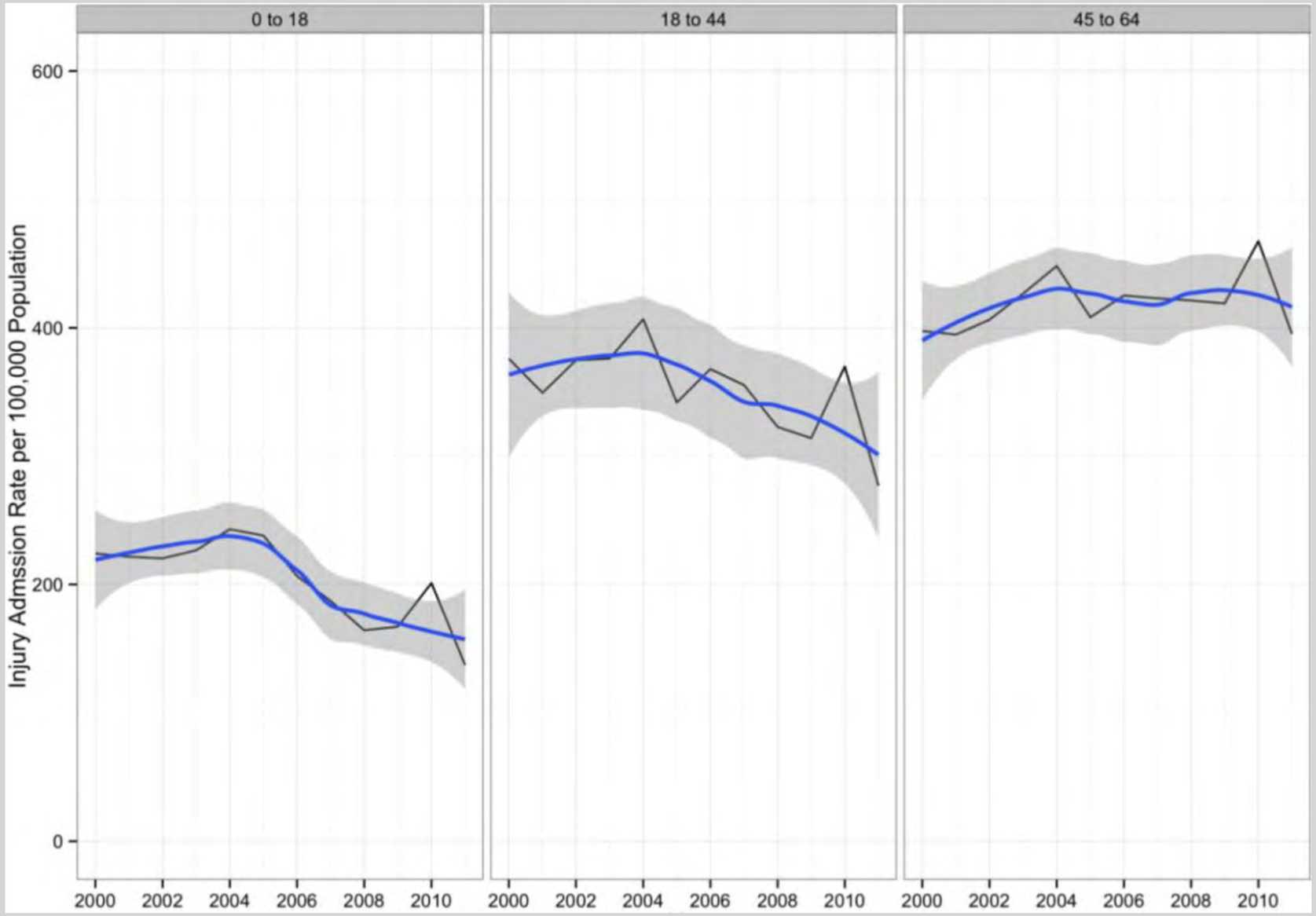
WHAT DOES THE TRAUMA PATIENT LOOK LIKE?



Older in age

DiMaggio C, Ayoung-Chee P, Shinseki M, et al. Traumatic injury in the United States: In-patient epidemiology 2000–2011. *Injury*. 2016;47(7):1393-1403. doi:10.1016/j.injury.2016.04.002.

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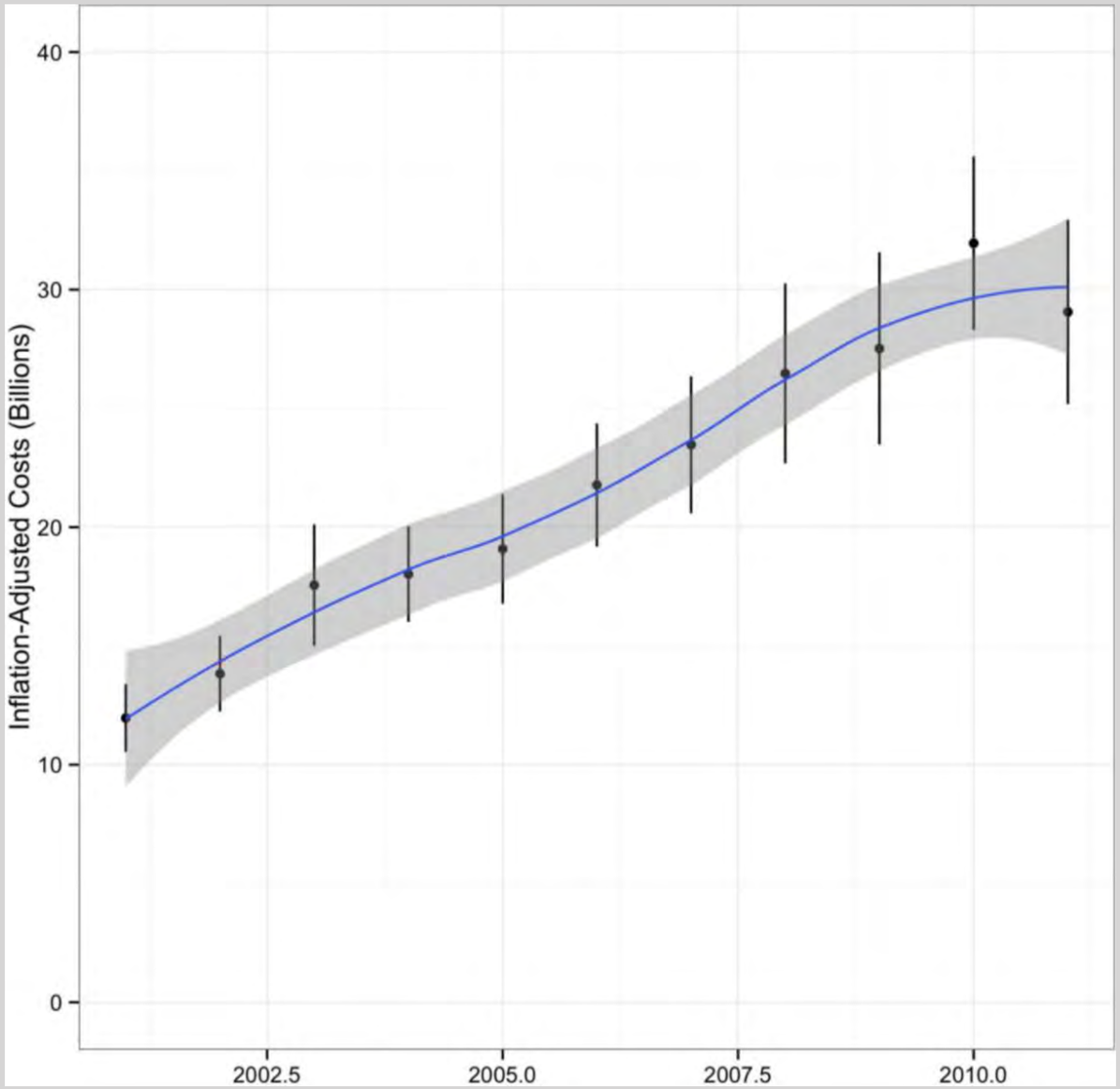

More expensive to take care of

DiMaggio C, Ayoung-Chee P, Shinseki M, et al. Traumatic injury in the United States: In-patient epidemiology 2000–2011. *Injury*. 2016;47(7):1393-1403. doi:10.1016/j.injury.2016.04.002.

WHAT DOES THE TRAUMA PATIENT LOOK LIKE?

AGE	NUMBER	PERCENT	DEATHS	CASE FATALITY RATE
<1 year	9,275	1.08	203	2.19
1-4	24,734	2.87	540	2.18
5-9	28,094	3.26	618	2.20
10-14	28,065	3.26	559	1.99
15-19	50,883	5.90	1,541	3.03
20-24	66,103	7.67	2,562	3.88
25-34	107,762	12.50	3,847	3.57
35-44	82,781	9.60	2,776	3.35
45-54	97,233	11.28	3,326	3.42
55-64	101,825	11.81	4,058	3.99
65-74	88,158	10.23	4,265	4.84
75-84	90,960	10.55	6,056	6.66
>84	85,932	9.97	7,418	8.63
NK/NR	83	0.01	56	67.47
Total	861,888	100	37,825	4.39

Over 50% of trauma patients 45 or older

https://www.facs.org/~/media/files/quality%20programs/trauma/ntdb/ntdb%20annual%20report%202016.ashx

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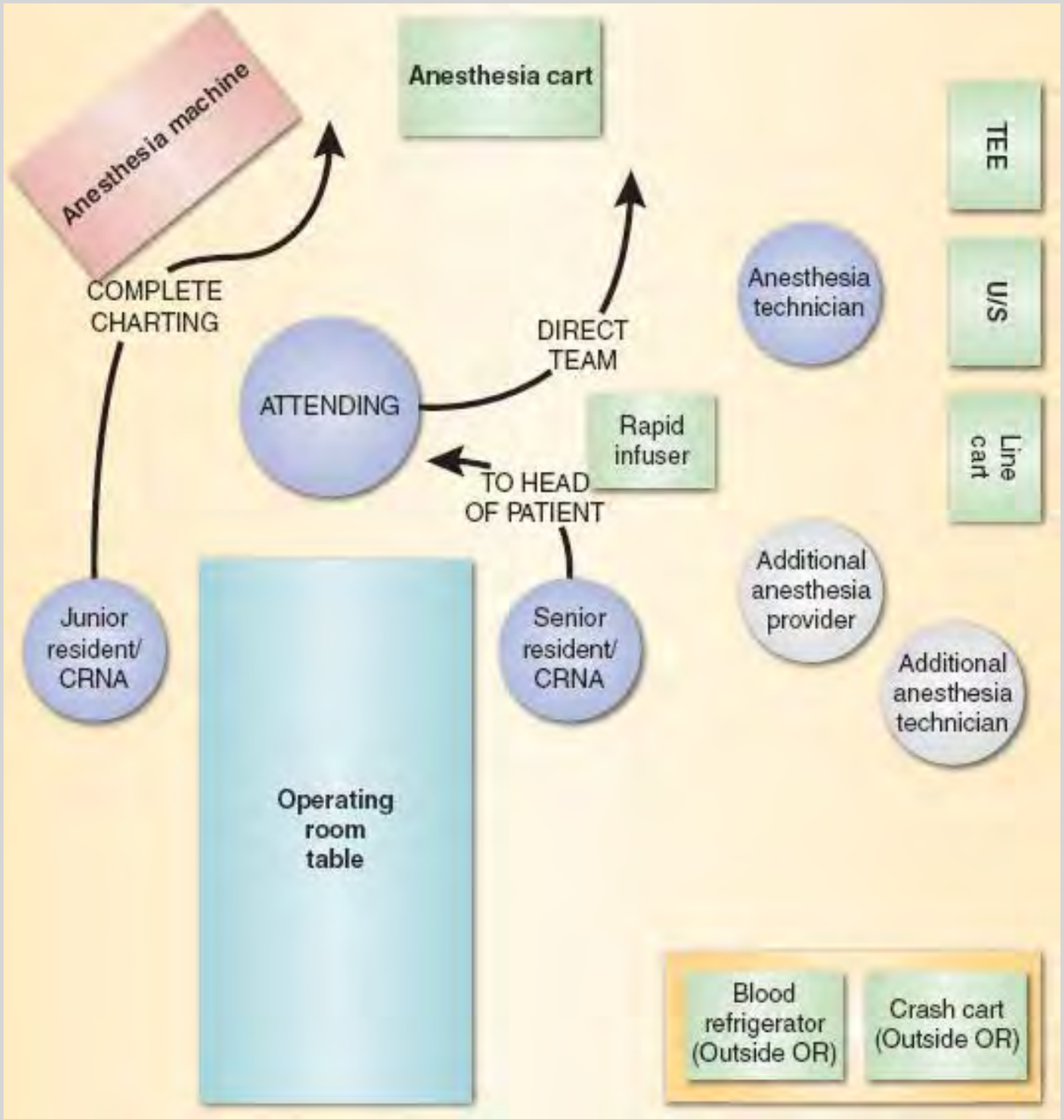
Higher mortality rate in >45 age group

https://www.facs.org/~/media/files/quality%20programs/trauma/ntdb/ntdb%20annual%20report%202016.ashx

WHAT DOES THE TRAUMA PATIENT LOOK LIKE?

- Young, but getting older
- Still mostly blunt trauma
- More comorbidities
- More likely to survive to the ED
- More likely to make it to the OR
- More opportunity

WHAT DOES THE TRAUMA OR LOOK LIKE?



https://aneskey.com/trauma-and-burn-anesthesia/

WHAT NEEDS TO HAPPEN BEFORE SURGERY?

- Rapid history
  - **“Do you have any allergies to medications?”**
  - **“Have you ever had problems with anesthesia?”**
  - **“Do you have problems with your heart or lungs?”**
  - **“Do you have any major medical problems?”**
  - **“What was the last thing you had to eat?”**

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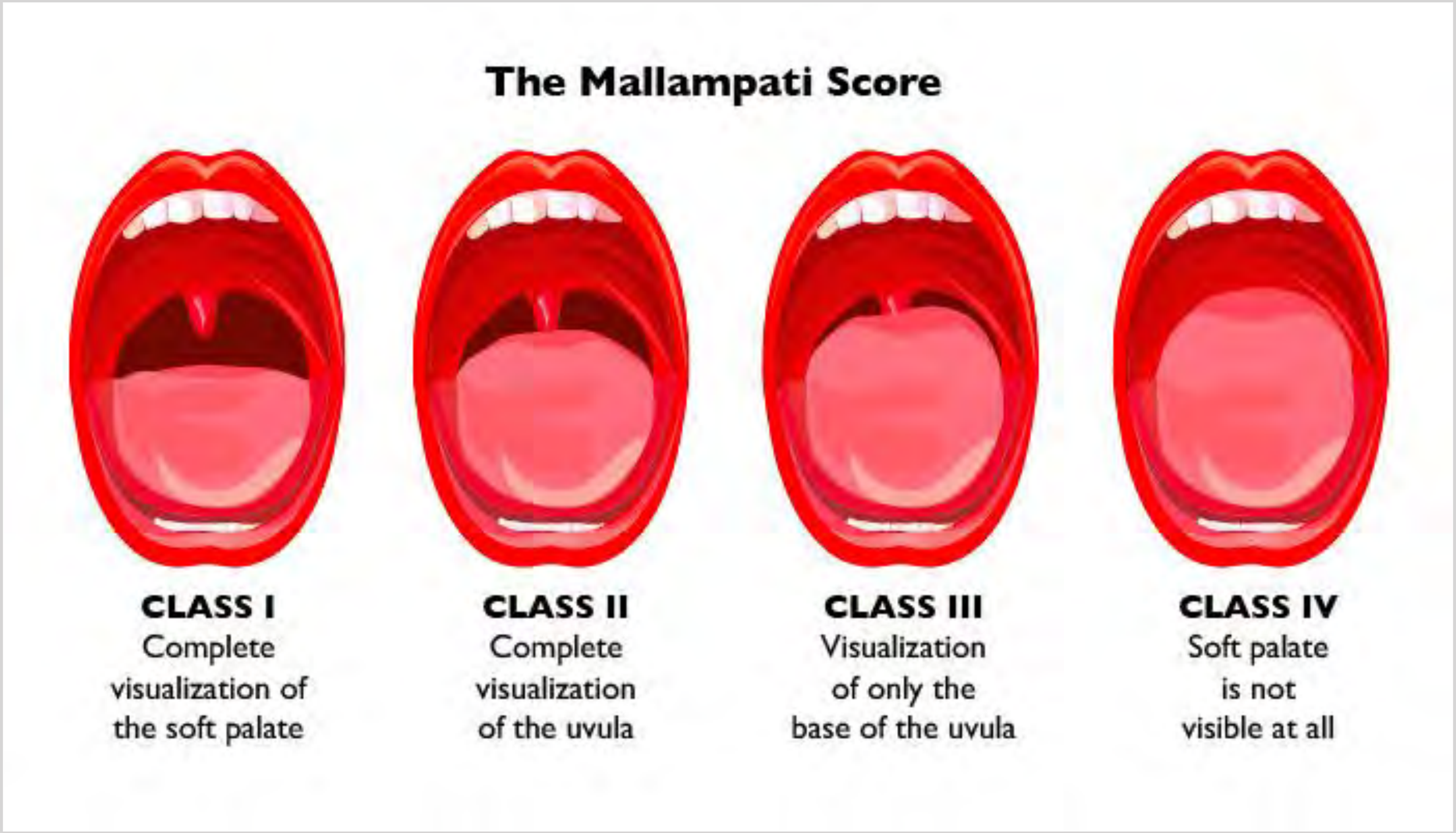
  - **“Have you ever had problems with anesthesia?”**
  - **“Do you have problems with your heart or lungs?”**
  - **“Do you have any major medical problems?”**
  - **ALL TRAUMA PATIENTS HAVE “FULL STOMACHS”**

WHAT NEEDS TO HAPPEN BEFORE SURGERY?

- Rapid history
- Focused physical exam (airway+)
  - **Rapid "ABCDE"**
  - **"Open your mouth wide"**
  - **Presence of cervical collar**
  - **Distracting injuries**
  - **Where are the holes (if any)?**

AIRWAY ASSESSMENT



https://www.clinicaladvisor.com/home/the-waiting-room/understanding-the-mallampati-score/

PRESENCE OF C-COLLAR LIMITS EXAM

Yuk M, Yeo W, Lee K, Ko J, Park T. Cervical collar makes difficult airway: a simulation study using the LEMON criteria. *Clin Exp Emerg Med*. 2018;5(1):22-28. doi:10.15441/ceem.16.185.

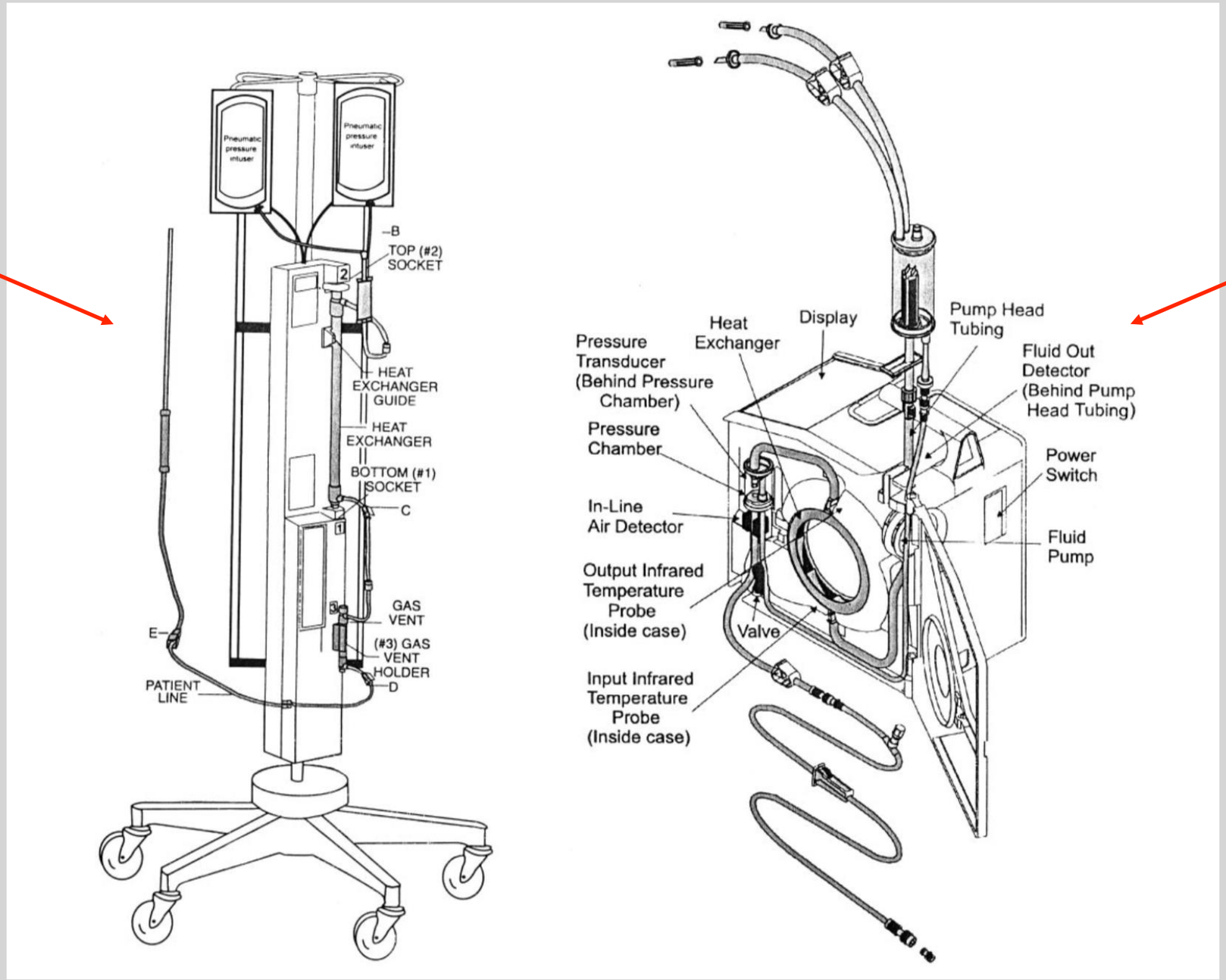
WHAT NEEDS TO HAPPEN BEFORE SURGERY?

- Rapid history
- Rapid physical exam (airway+)
- Assessment of haves/needs
  - **Vital signs**
  - **Access**

RAPID INFUSION DEVICES

Level 1

Belmont



Comunale ME. A laboratory evaluation of the level 1 rapid infuser (H1025) and the Belmont instrument fluid management system (FMS 2000) for rapid transfusion. *Anesth Analg*. 2003;97(4):1064–9–tableofcontents. doi:10.1213/01.ane.0000077078.53242.29.

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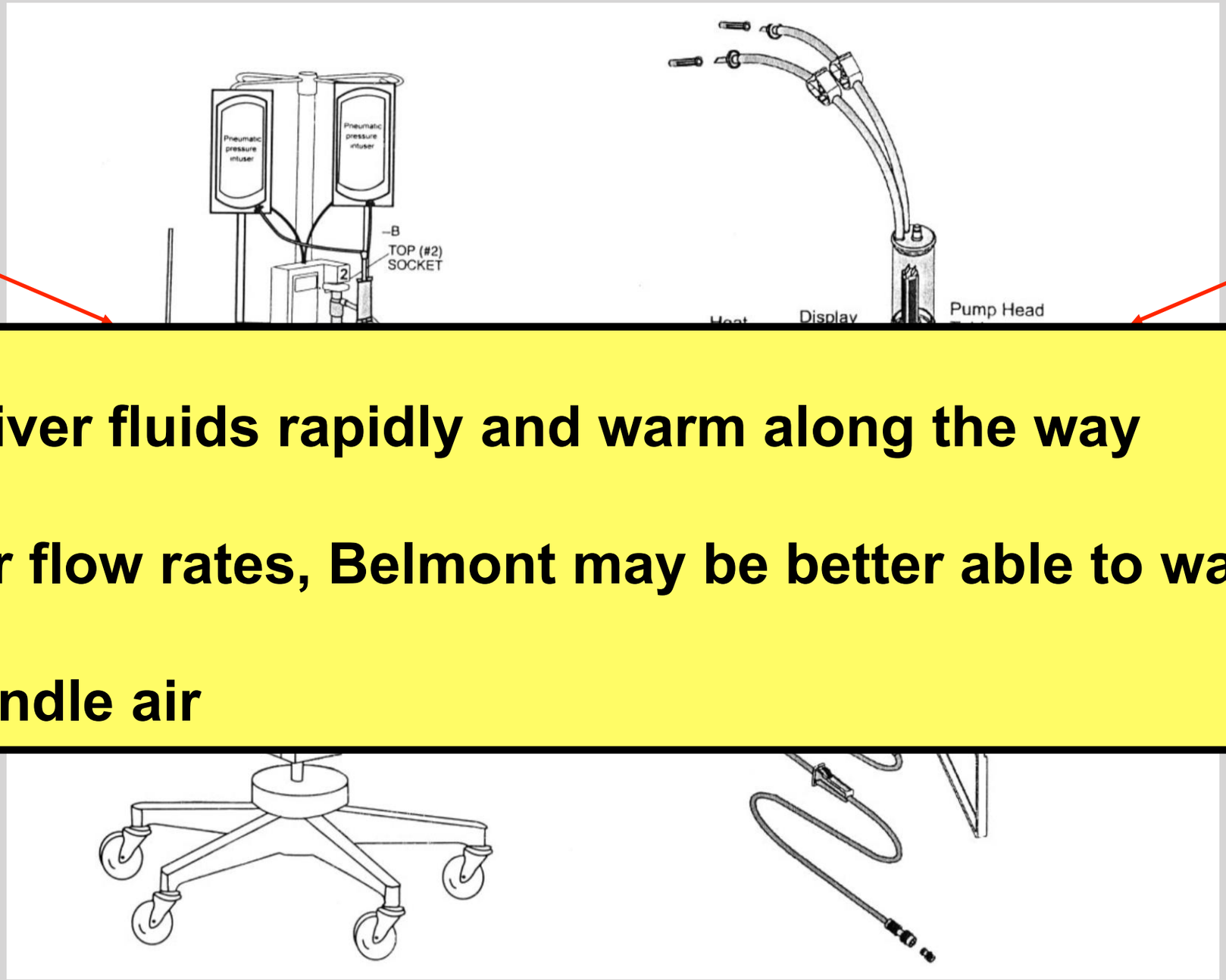

- **Both deliver fluids rapidly and warm along the way**
- **At higher flow rates, Belmont may be better able to warm fluids/handle air**

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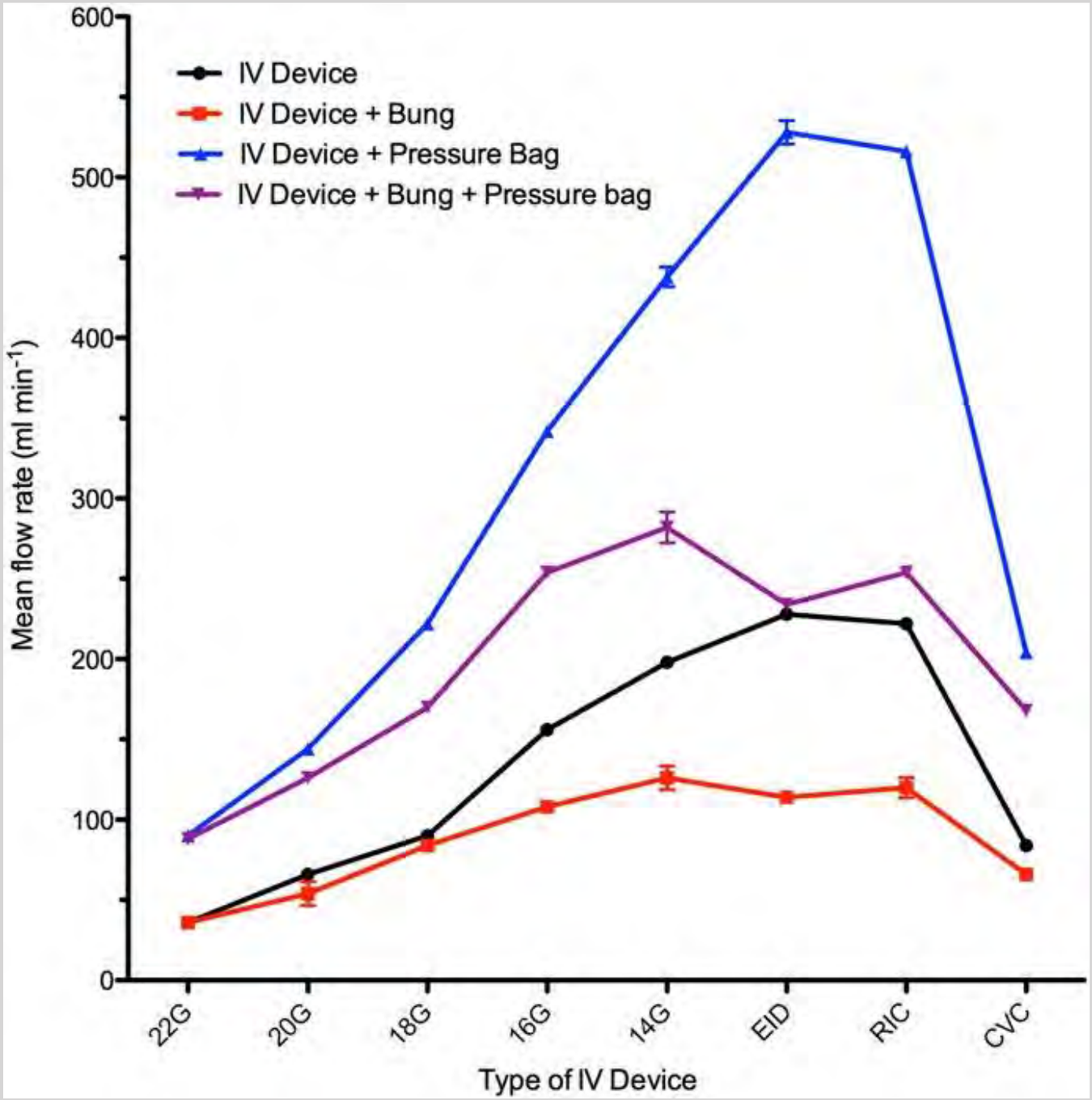
INTRAVENOUS ACCESS CHOICES

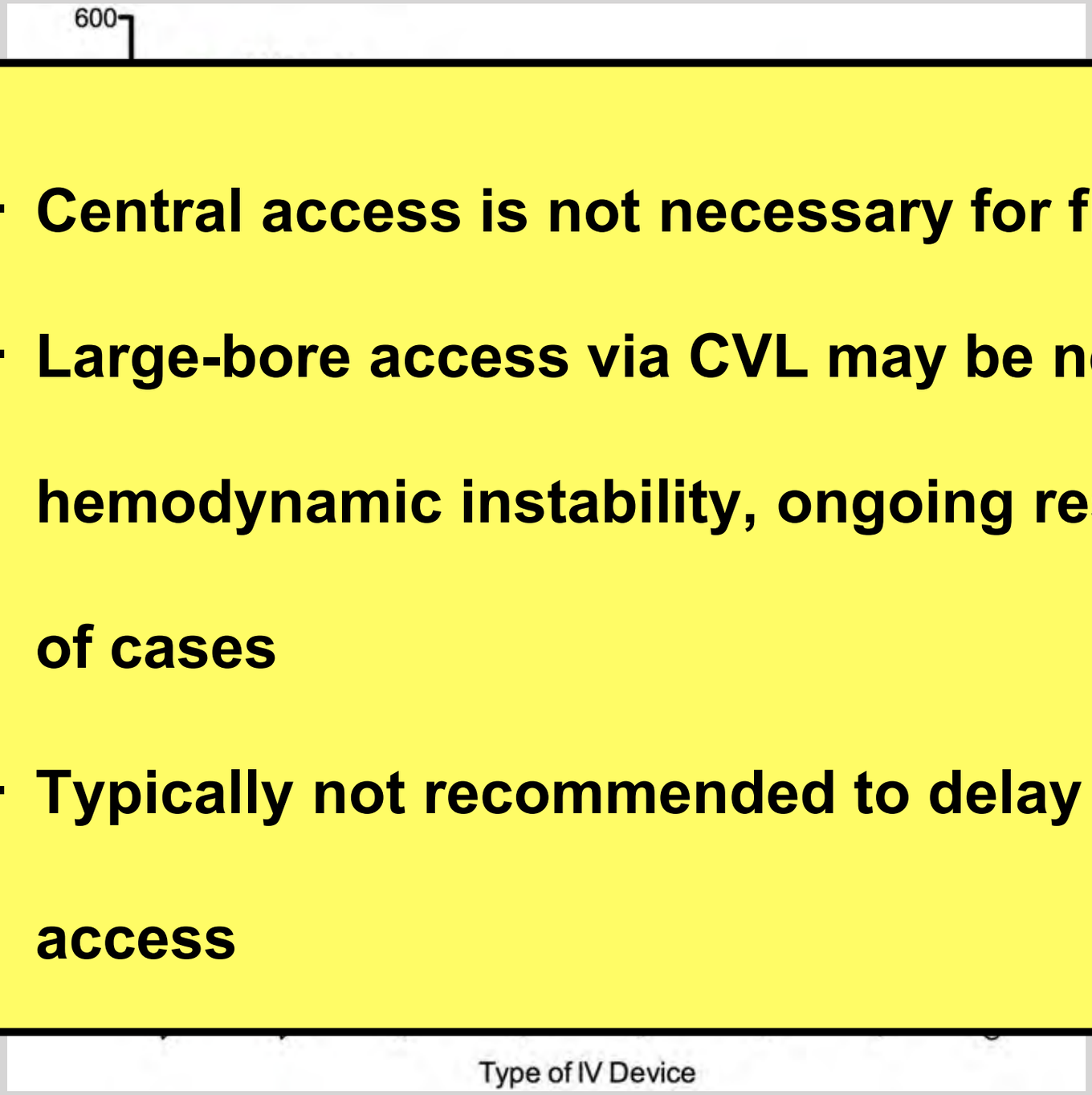


- **In vitro flow through access devices improves as diameter increases**
- **At some point, length becomes more important than diameter (why, for instance 14 gauge and 8.5 Fr RIC are similar)**
- **Addition of pressure bag allows for better utilization of diameter**

Khoyratty SI, Gajendragadkar PR, Polisetty K, Ward S, Skinner T, Gajendragadkar PR. Flow rates through intravenous access devices: an in vitro study. *J Clin Anesth*. 2016;31:101-105. doi:10.1016/j.jclinane.2016.01.048.

INTRAVENOUS ACCESS CHOICES

- Central access is not necessary for fluid resuscitation
- Large-bore access via CVL may be necessary for severe hemodynamic instability, ongoing resuscitation, certain types of cases
- Typically not recommended to delay urgent case for central access



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DO WE NEED ARTERIAL ACCESS?

- Noninvasive blood pressure (i.e. cuff) is **probably** going to correlate with actual blood pressure to a point

- SBP of 80 is a reasonable cutoff above which BP cuff appears to be reliable

- In some shock states, peripheral vasoconstriction and centralization of blood volume is so profound that radial arterial access will not give more accurate numbers

- Consider more proximal site (axillary or femoral) if you need a more accurate measure of blood pressure

CAN WE USE PERIPHERAL VBG IN SHOCK?

Assessing Acid–Base Status in Circulatory Failure: Relationship Between Arterial and Peripheral Venous Blood Gas Measurements in Hypovolemic Shock

Scott E. Rudkin, MD, MBA[1], Craig L. Anderson, MPH, PhD[1], Tristan R. Grogan, MS[2,3], David A. Elashoff, PhD[2,3], and Richard M. Treger, MD[3,4]

Conclusions

In the presence of hypovolemic shock, unlike central and mixed venous blood, the peripheral venous blood fails to exhibit a selective respiratory acidosis and is therefore a poor reflection of acid–base status of critical tissues. Further work needs to be done to better define the relationship between ABG and both central and peripheral VBG values in various types of shock due to decreased cardiac output versus decreased systemic vascular resistance.

Probably not accurate in hypovolemic shock/trauma

Rudkin SE, Anderson CL, Grogan TR, Elashoff DA, Treger RM. Assessing Acid-Base Status in Circulatory Failure: Relationship Between Arterial and Peripheral Venous Blood Gas Measurements in Hypovolemic Shock. *J Intensive Care Med*. January 2018:885066618762335. doi:10.1177/0885066618762335.

CAN WE USE PERIPHERAL VBG IN SHOCK?

Assessing Acid–Base Status in Circulatory Failure: Relationship Between Arterial and Peripheral Venous Blood Gas Measurements in Hypovolemic Shock

- **Arterial line in most trauma cases**

- **Can be post-induction depending on stability**

reflection of acid–base status of critical tissues. Further work needs to be done to better define the relationship between ABG and both central and peripheral VBG values in various types of shock due to decreased cardiac output versus decreased systemic vascular resistance.

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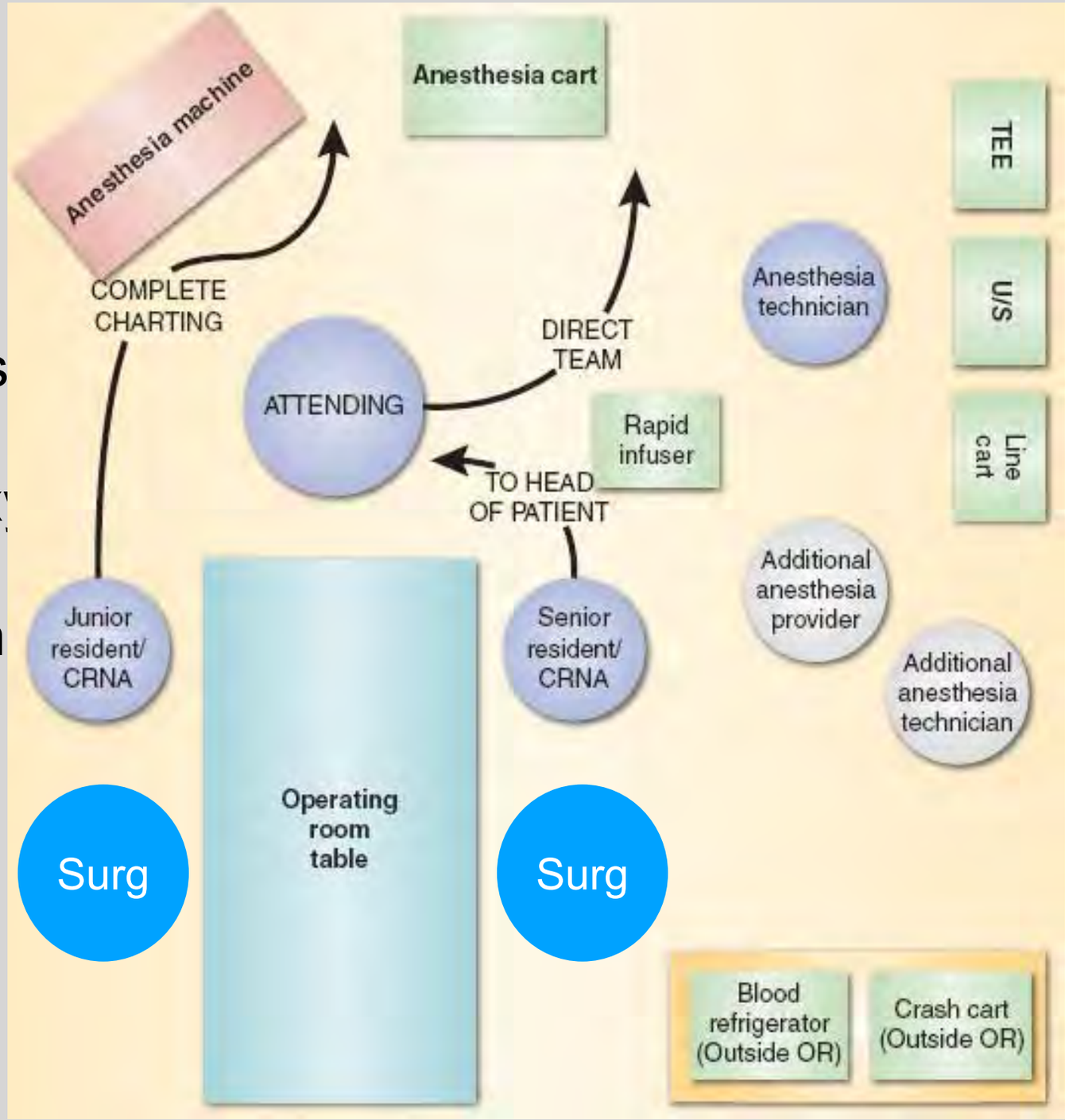
WHAT NEEDS TO HAPPEN BEFORE SURGERY?

- Rapid history
- Rapid physical exam (airway+)
- Assessment of haves/needs
- Preoxygenation
- Preanesthetic time-out
  - **Patient/plan/allergies/consent (blood also…)**
  - **“Everyone ready?”**

WHAT NEEDS TO HAPPEN BEFORE SURGERY?

- Rapid
- Rapid
- Asses
- Preox
- Prean



HOW IS ANESTHESIA INDUCED/MAINTAINED?

- What are the concerns?

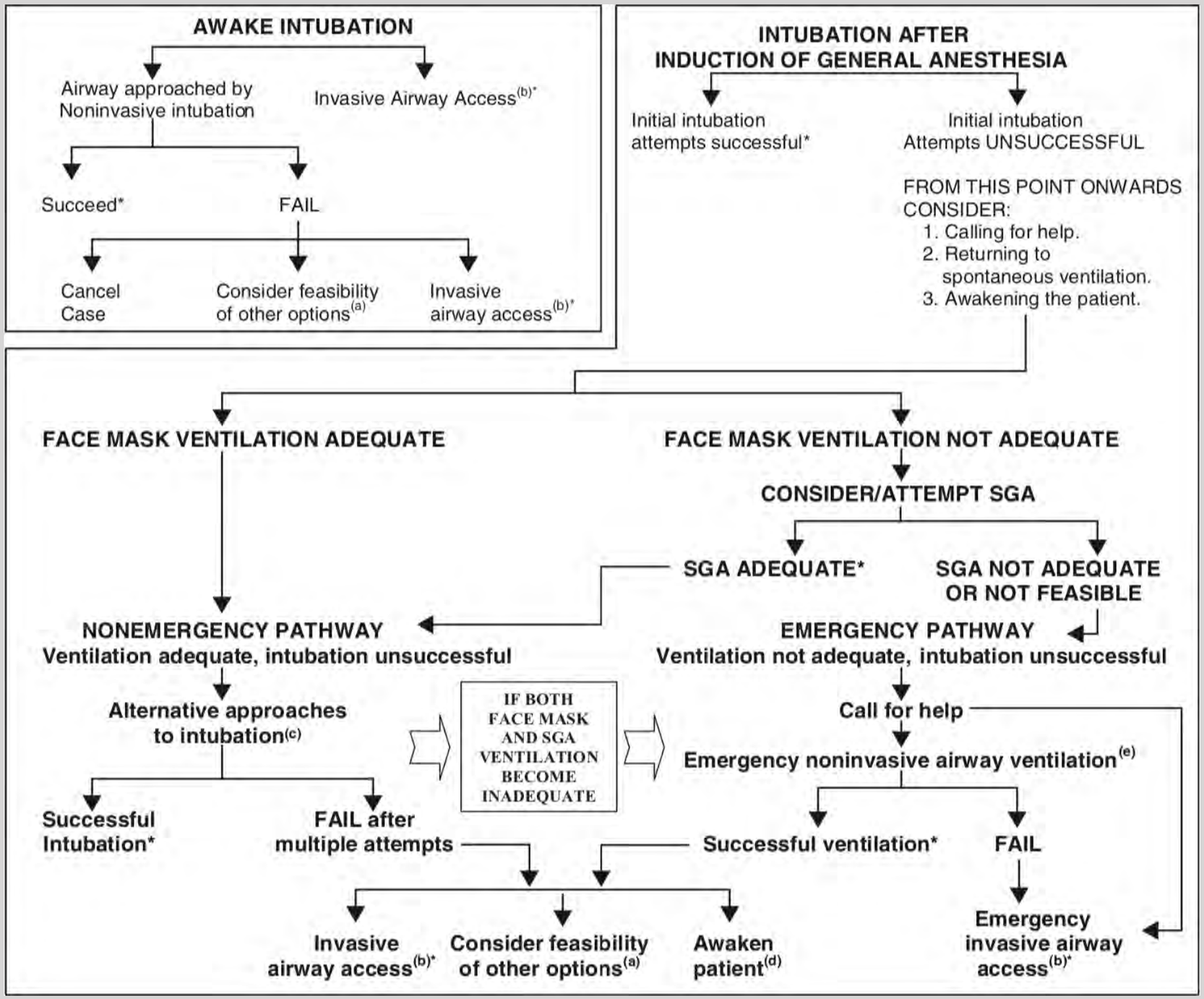
HOW IS ANESTHESIA INDUCED/MAINTAINED?

- What are the concerns?
  - **Difficult airway**
  - **Pulmonary aspiration**
  - **Medication choices**
  - **Hypotension/low cardiac output**

DIFFICULT AIRWAY

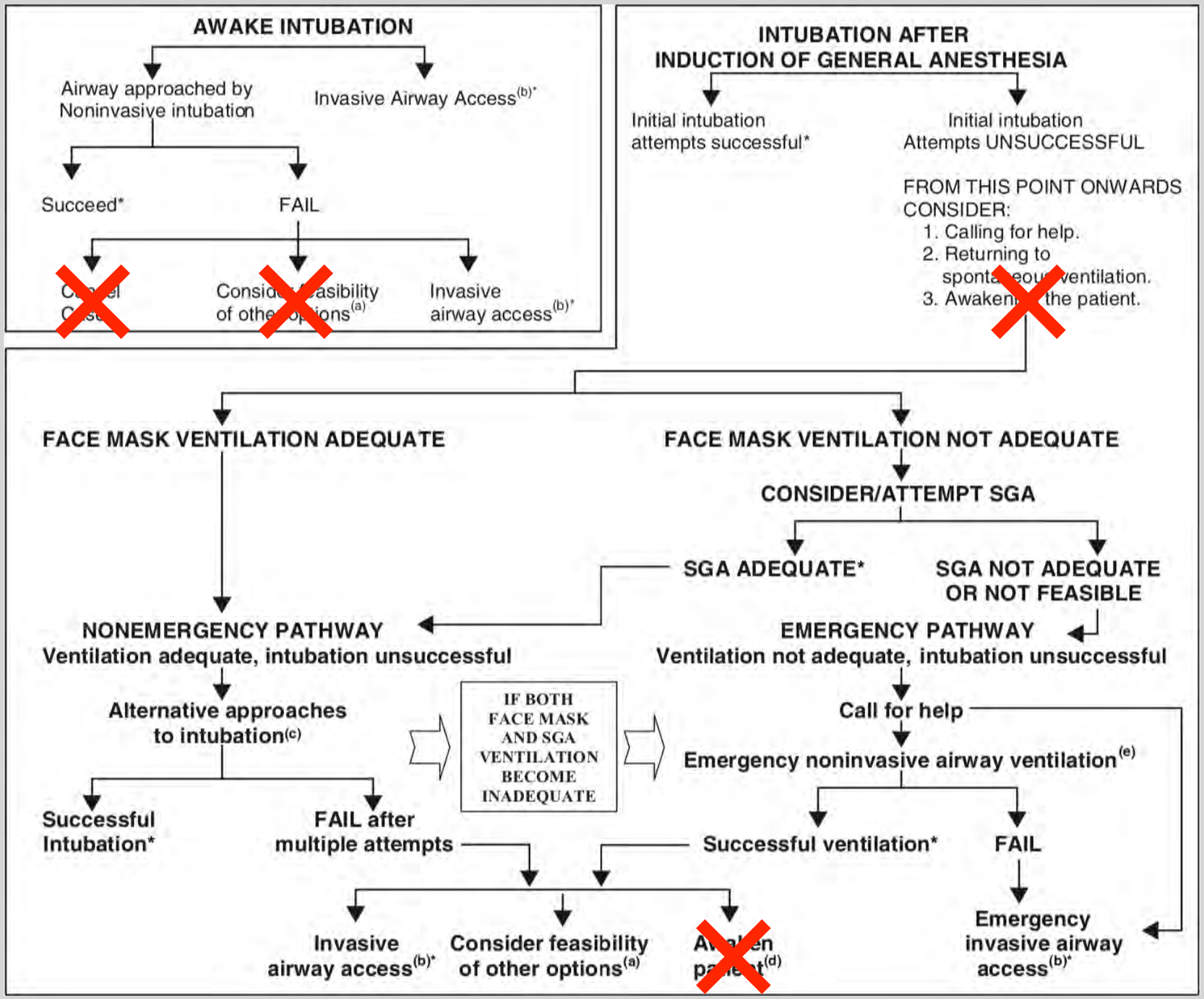
- Primarily mitigated by careful exam and plan prior to induction

AIRWAY ALGORITHM



Apfelbaum JL, Hagberg CA, Caplan RA, et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology*. 2013;118(2):251-270. doi:10.1097/ALN.0b013e31827773b2.

AIRWAY ALGORITHM (MODIFIED FOR TRAUMA)



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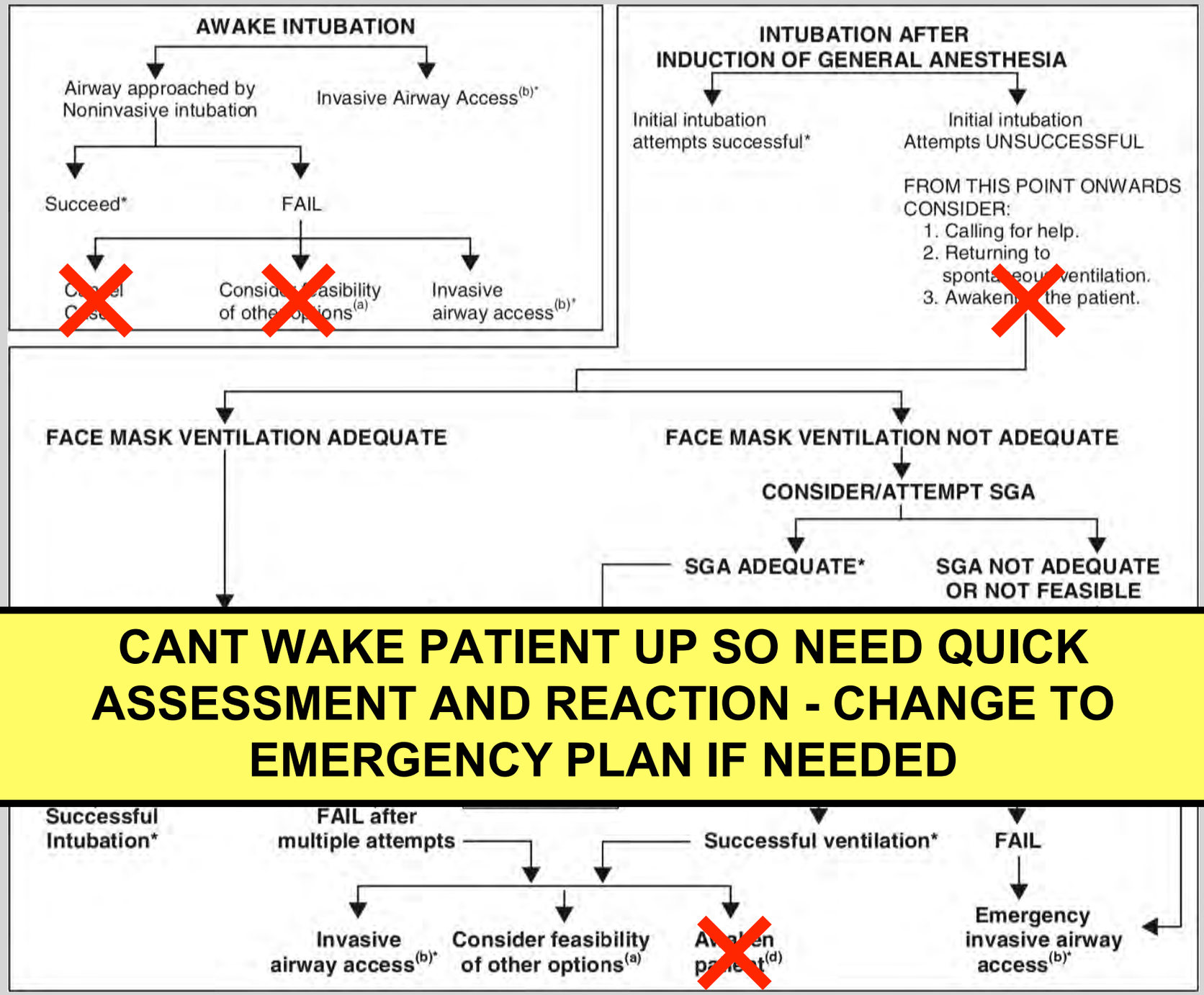


CANT WAKE PATIENT UP SO NEED QUICK ASSESSMENT AND REACTION - CHANGE TO EMERGENCY PLAN IF NEEDED

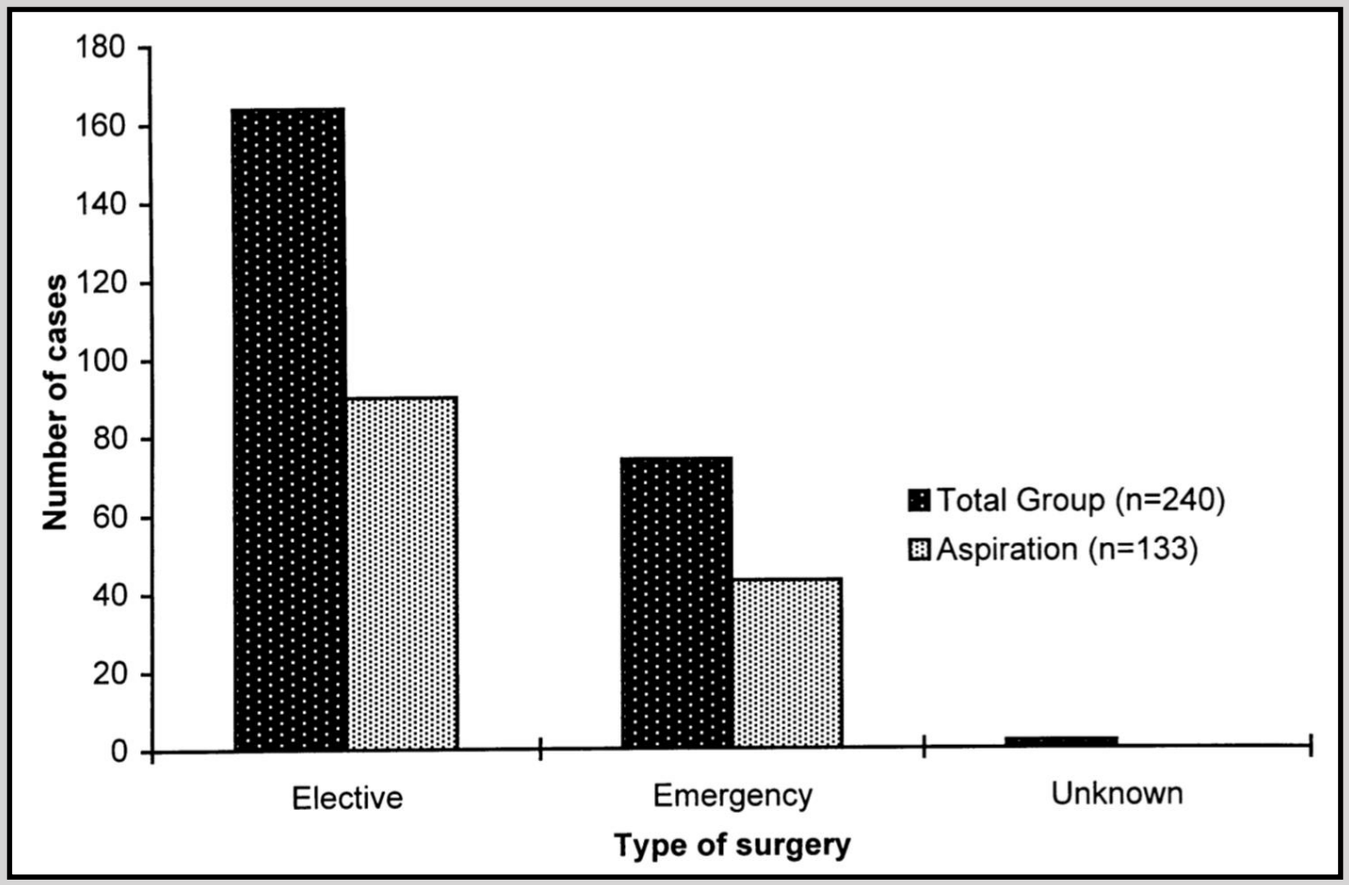
Apfelbaum JL, Hagberg CA, Caplan RA, et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology*. 2013;118(2):251-270. doi:10.1097/ALN.0b013e31827773b2.

PULMONARY ASPIRATION

- What are the real risks and how can we reduce them or optimize patient?

Aspiration during anaesthesia: a review of 133 cases from the Australian Anaesthetic Incident Monitoring Study (AIMS)

M. T. Kluger[1] and T. G. Short[2]



Retrospective data suggesting that emergency surgery might not be strongly associated with aspiration

Kluger MT, Short TG. Aspiration during anaesthesia: a review of 133 cases from the Australian Anaesthetic Incident Monitoring Study (AIMS). *Anaesthesia*. 1999;54(1):19-26. doi:10.1046/j.1365-2044.1999.00642.x.

Aspiration during anaesthesia: a review of 133 cases from the Australian Anaesthetic Incident Monitoring Study (AIMS)

M. T. Kluger[1] and T. G. Short[2]

	Aspiration ($n = 133$)	
1	Emergency†	21
2	Inadequate anaesthesia*	18
3	Abdominal pathology§	17
4	Obesity	15
5	Opioid medication‡	13
6	Neurological deficit**	10
7	Lithotomy	8
8	Difficult intubation/airway	8
9	Reflux¶	7
10	Hiatus hernia	6

In defined cases of aspiration, emergency and associated problems the most common risk factor

Kluger MT, Short TG. Aspiration during anaesthesia: a review of 133 cases from the Australian Anaesthetic Incident Monitoring Study (AIMS). *Anaesthesia*. 1999;54(1):19-26. doi:10.1046/j.1365-2044.1999.00642.x.

Acute Intraoperative Pulmonary Aspiration

Katie S. Nason, MD, MPH

The technique for RSI includes the following:

- Preoxygenation
- Rapid administration of induction and paralytic agents that are not titrated to effect
- Cricoid pressure (originally described but not currently recommended for all patients)
- Avoidance of bag and mask ventilation
- Transoral insertion of an endotracheal tube using direct or video laryngoscopy

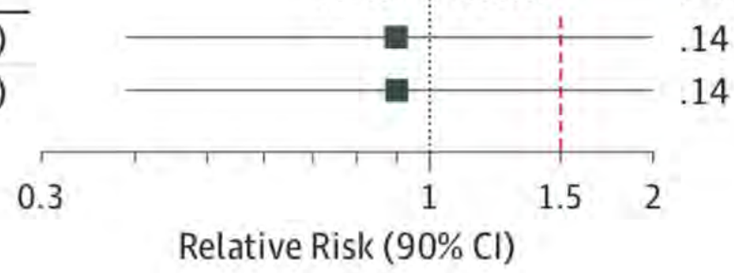
- "impact of RSI on prevention of aspiration…is unclear"
- "literature…insufficient to determine whether RSI reduces aspiration"
- "no data to support the routine use of cricoid pressure"

Nason KS. Acute Intraoperative Pulmonary Aspiration. *Thorac Surg Clin*. 2015;25(3):301-307. doi:10.1016/j.thorsurg.2015.04.011.

Effect of Cricoid Pressure Compared With a Sham Procedure in the Rapid Sequence Induction of Anesthesia
The IRIS Randomized Clinical Trial

Aurélie Birenbaum, MD; David Hajage, MD, PhD; Sabine Roche, MD; Alexandre Ntouba, MD; Mathilde Eurin, MD; Philippe Cuvillon, MD, PhD; Aurélien Rohn, MD; Vincent Compere, MD, PhD; Dan Benhamou, MD; Matthieu Biais, MD, PhD; Remi Menut, MD; Sabiha Benachi, MD; François Lenfant, MD, PhD; Bruno Riou, MD, PhD; for the IRIS Investigators Group

	No. of Events/Total No. (%)		Relative Risk (90% CI)	Sham Better	Sellick Better	*P* Value
	Sellick	Sham				
Intention-to-treat analysis	10/1784 (0.6)	9/1736 (0.5)	0.90 (0.39-1.99)			.14
Per-protocol analysis	10/1729 (0.6)	9/1730 (0.5)	0.90 (0.39-2.00)			.14



- Sham procedure not inferior to cricoid pressure in preventing aspiration during RSI
- Findings similar in post hoc analysis of emergency cases

Birenbaum A, Hajage D, Roche S, et al. Effect of Cricoid Pressure Compared With a Sham Procedure in the Rapid Sequence Induction of Anesthesia: The IRIS Randomized Clinical Trial. *JAMA Surg*. 2019;154(1):9-17. doi:10.1001/jamasurg.2018.3577.

Effect of Cricoid Pressure Compared With a Sham Procedure in the Rapid Sequence Induction of Anesthesia

The IRIS Randomized Clinical Trial

- **Patients with recent trauma definitely have delayed gastric emptying**

- **Use of RSI and cricoid pressure remains standard, although situation and context important**

- **Patient status and complicating factors may necessitate consideration of modified approach**

preventing aspiration during RSI

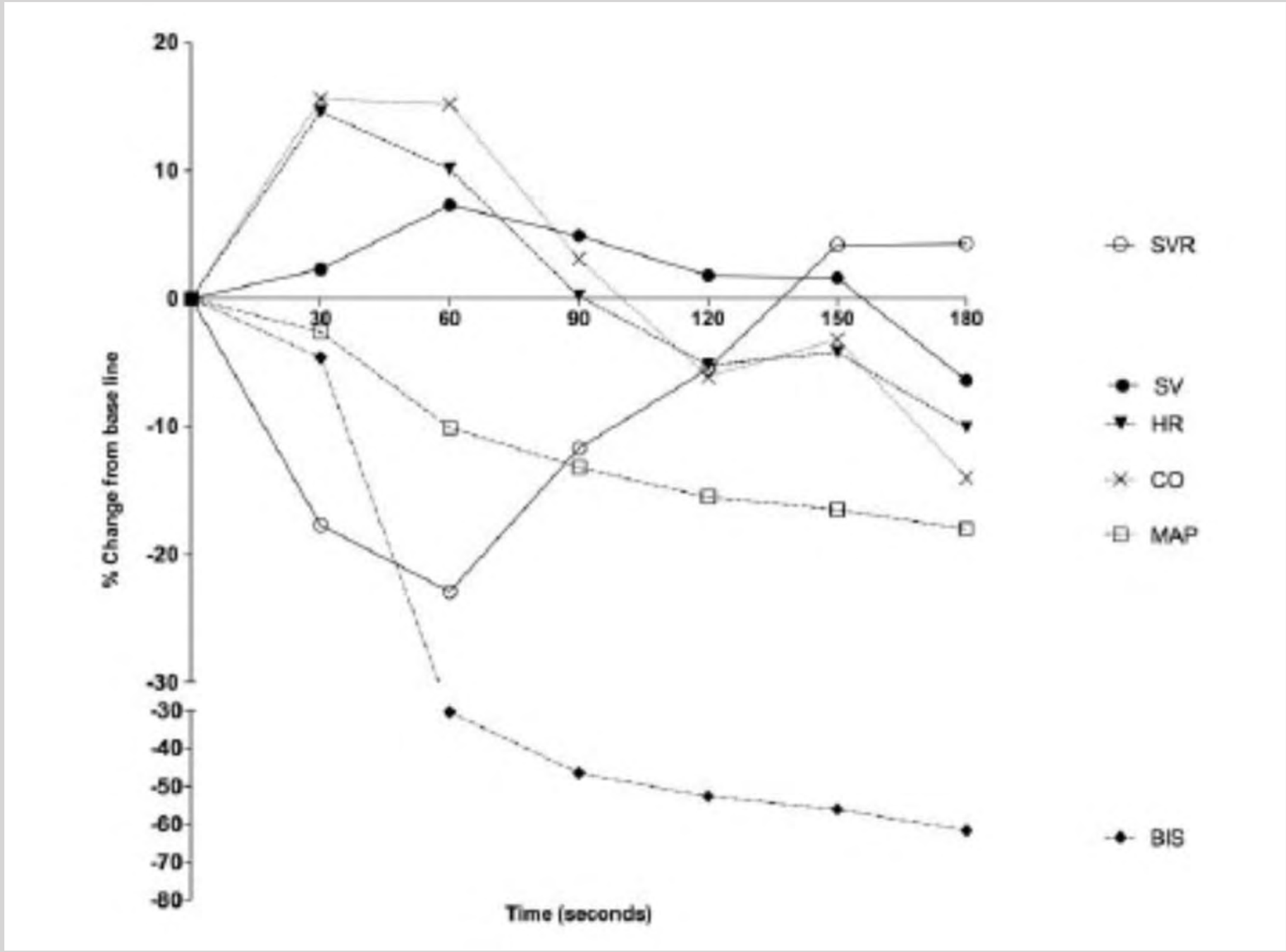
- Findings similar in post hoc analysis of emergency cases

Birenbaum A, Hajage D, Roche S, et al. Effect of Cricoid Pressure Compared With a Sham Procedure in the Rapid Sequence Induction of Anesthesia: The IRIS Randomized Clinical Trial. *JAMA Surg*. 2019;154(1):9-17. doi:10.1001/jamasurg.2018.3577.

INDUCTION MEDICATIONS

- Two primary classes: sedative/hypnotic and paralytics
- Choice of induction/management agents should be based upon patient stability and expectations
- Main goal of induction agent is to provide enough sedative to facilitate safe endotracheal intubation and initiation of surgery
- Major risks are hypotension from vasodilation and myocardial depression

PROPOFOL INDUCTION (HEALTHY)



Hua A, Balogun-Lynch J, Williams H, Loganathan V, Dob D, Vizcaychipi MP. Assessment of Haemodynamic Response to Induction of General Anaesthesia in Healthy Adult Patients Undergoing Elective Orthopaedic Surgery by Using a Continuous Non-invasive Cardiovascular Monitoring. *TOATJ*. 2017;11(1):75-82. doi:10.2174/1874321801711010075.

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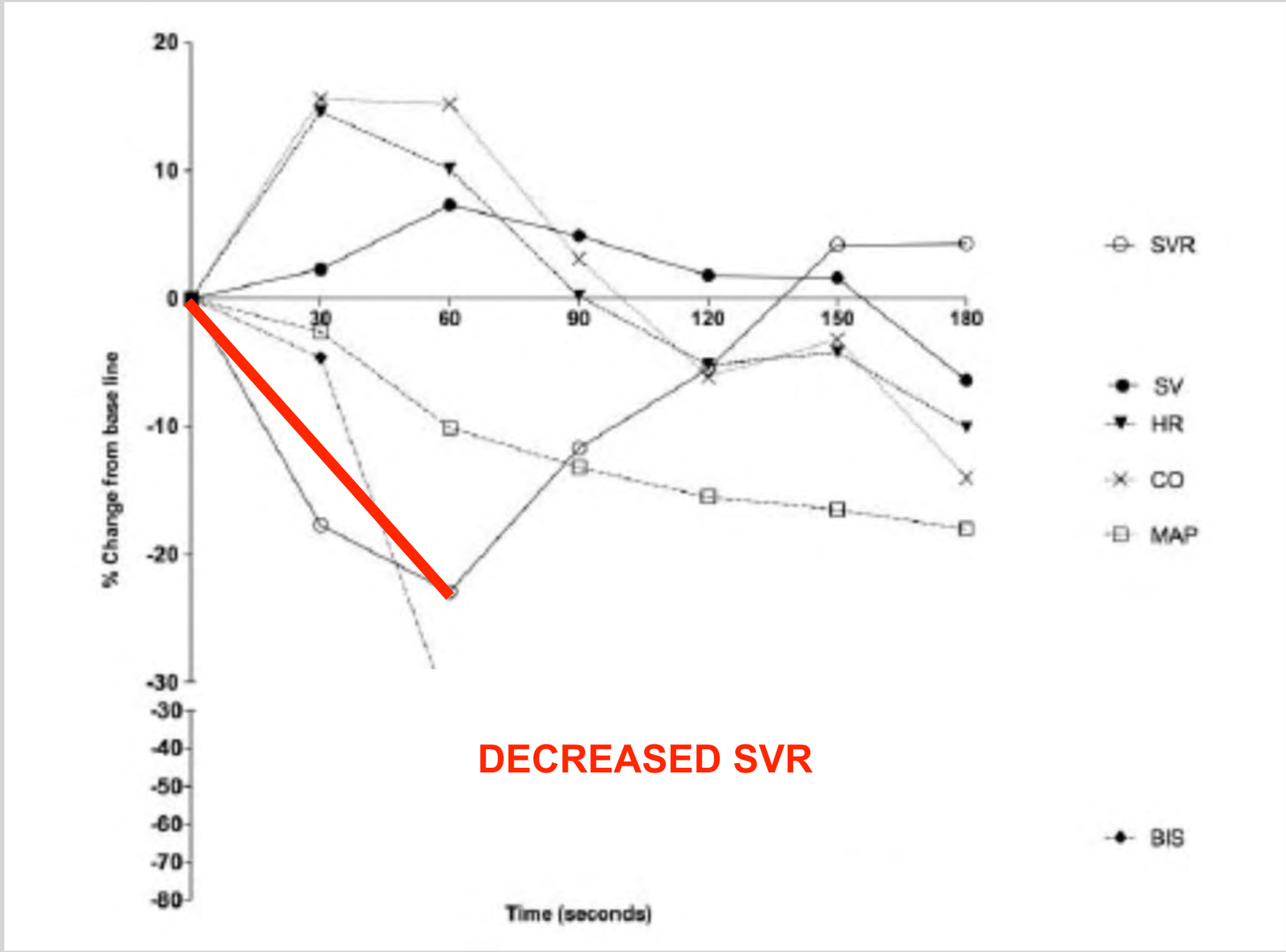

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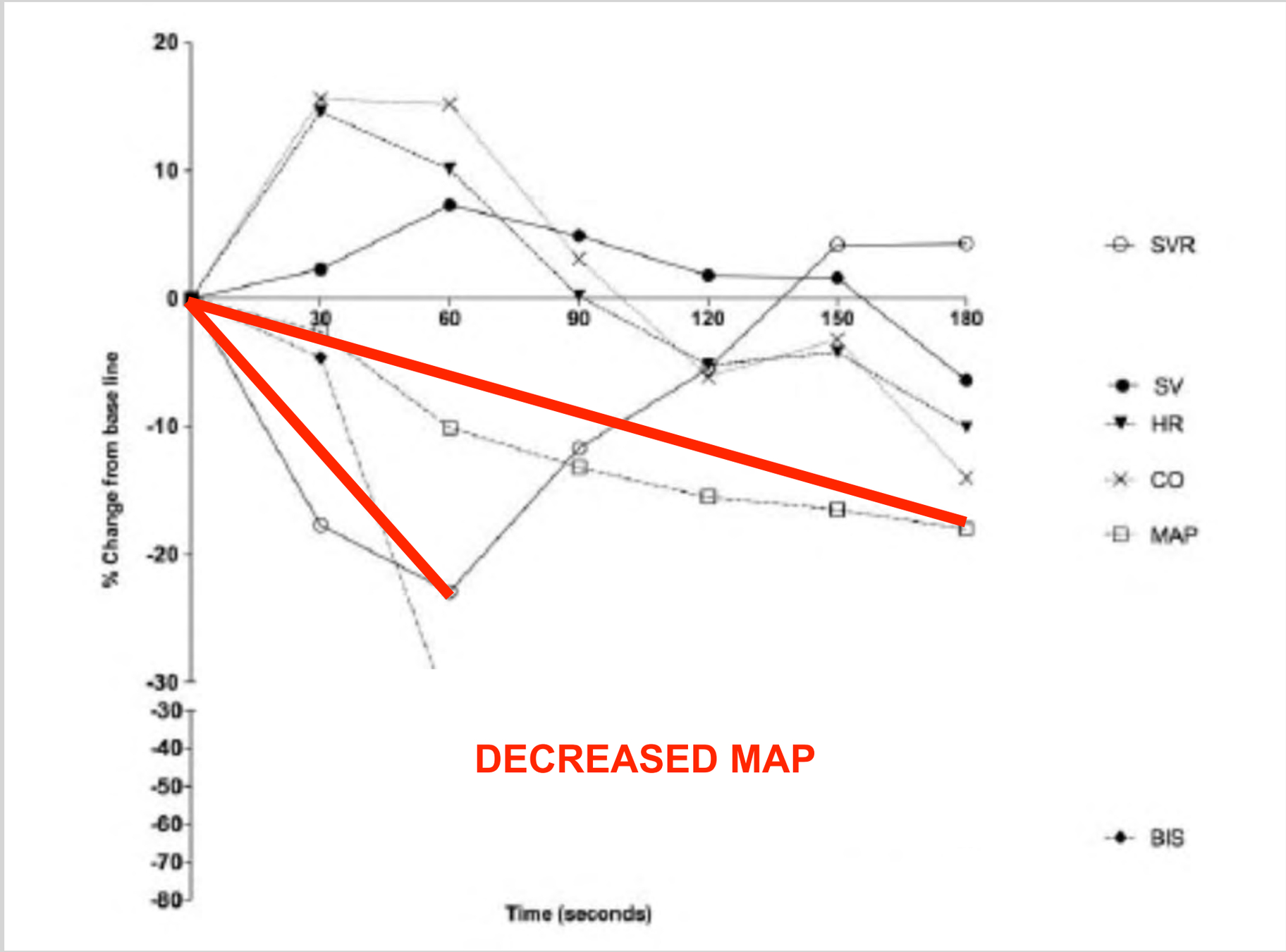

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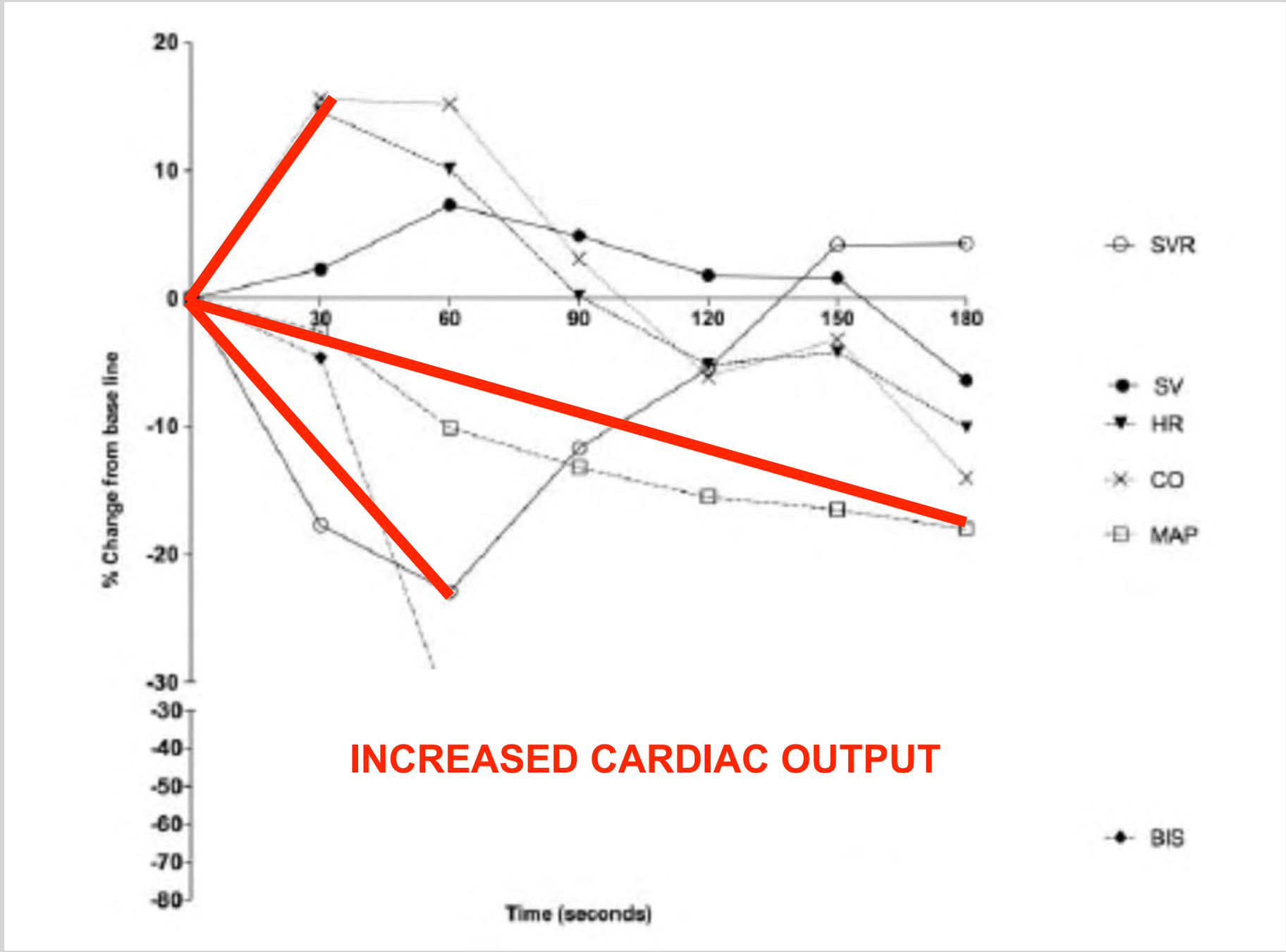

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INDUCTION

- Many induction drug challenges can be mitigated by thoughtful and slow dosing (i.e. hypotension with propofol)

- However, induction might take 2-3 minutes during which time patient is unstable, at risk of aspiration, etc.

- Ketamine and etomidate avoid many of the problems with decreased SVR/MAP and patients typically will tolerate higher doses delivered more rapidly

- As with anything, dose is paramount, and patients in shock typically have altered responses

- Decreased circulation times coupled with centralization of blood volume result in altered timing

NEUROMUSCULAR BLOCKADE

- Equivalent response/adequate intubating conditions in 45-60 seconds after high dose rocuronium or succinylcholine

- Risks/rewards should factor into choice (sux problems, availability of rapid roc reversal with suggammadex)

- Can consider dissociated/“awake” intubations without paralytic or with lower dose sedative+topicalization depending on needs

- Given the needs in the operating room, there is probably little utility in this EXCEPT in certain types of obstructive shock (tamponade, tension, PE) where maintenance of spontaneous ventilation may be important

NEUROMUSCULAR BLOCKADE

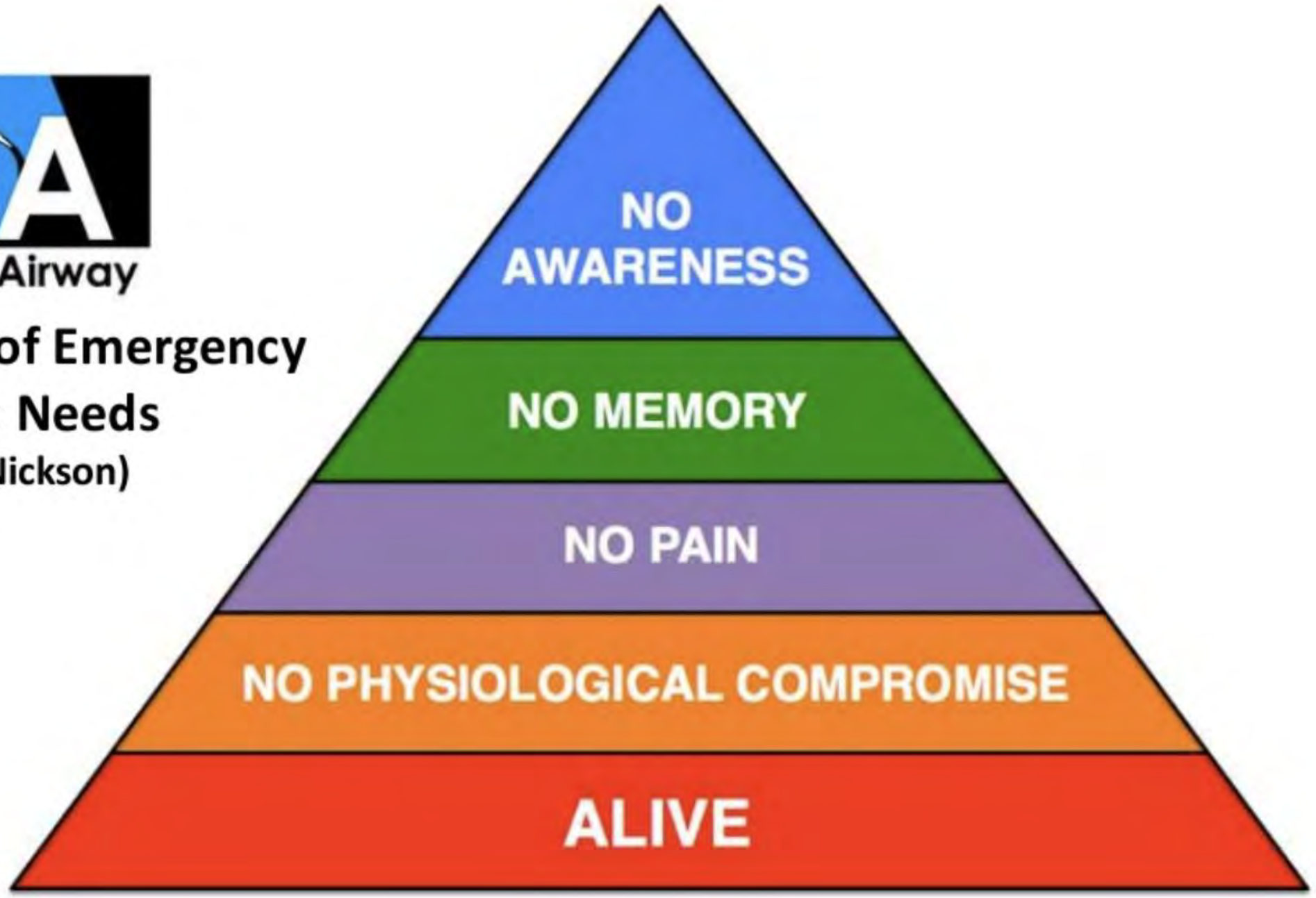
- **“Ive never seen an airway that was easier without paralytics”**
- **First shot=best shot**
- **Remember some patients depend heavily on preload and cardiac output may suffer with positive pressure ventilation**

- Given the needs in the operating room, there is probably little utility in this EXCEPT in certain types of obstructive shock (tamponade, tension, PE) where maintenance of spontaneous ventilation may be important

Critically Ill Airway

Hierarchy of Emergency Intubation Needs

(Weingart & Nickson)

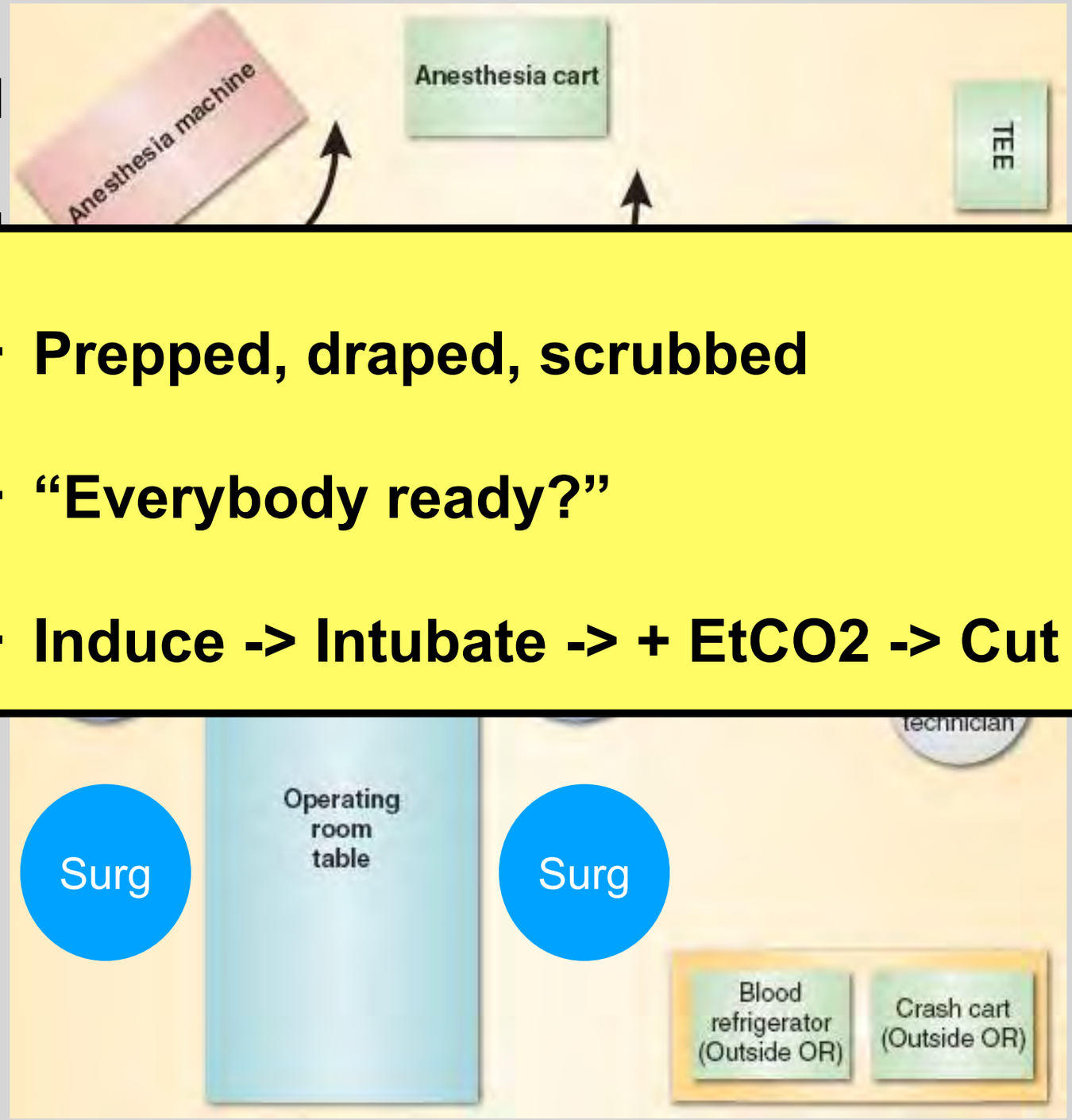


(Credit: Scott Weingart, Chris Nickson (EMCrit))

https://litfl.com/intubation-hypotension-and-shock/

WHAT NEEDS TO HAPPEN BEFORE SURGERY?

- Rapid
- Rapi
- Asse
- Prec
- Prea

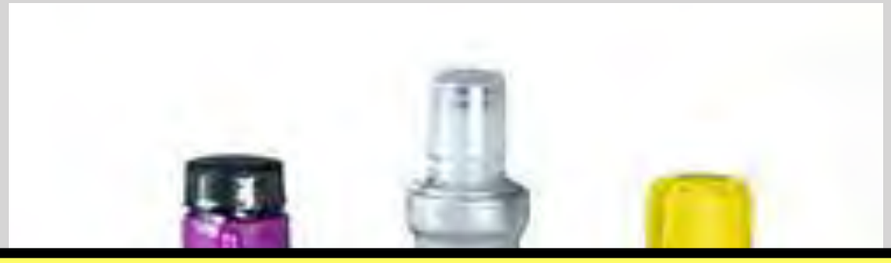


- **Prepped, draped, scrubbed**
- **“Everybody ready?”**
- **Induce -> Intubate -> + EtCO2 -> Cut**

MAINTENANCE OF ANESTHESIA

- Volatile anesthetics are reliable, but vasodilate
- Midazolam and ketamine are potent, but wear off
- Scopolamine at higher doses inhibits memory formation and is vagolytic but maybe not in TBI and hard to get

MAINTENANCE OF ANESTHESIA



- **Long story short: “without sedation, patients remember surgery”**

- **High rate of PTSD in trauma patients -> also high rate of awareness during surgery for trauma (1:100 - 1:1000)**

- **Should make every effort to maintain a level general anesthesia during trauma surgery, but can be difficult**

- Volatile anesthetics are reliable, but vasodilate
- Midazolam and ketamine are potent, but wear off
- Scopolamine at higher doses inhibits memory formation and is vagolytic but maybe not in TBI and hard to get

MAINTENANCE OF ANESTHESIA

- **Long story short: remember surgery”**
- **High rate of PTSD igh rate of awareness during 1:1000)**
- **Should make eve eneral anesthesia during trauma su**
- **Bispectral index monitoring (BIS) may allow for some titration of sedation depth, but still debatable**

- Volatile anesthetics are reliable, but vasodilator
- Midazolam and ketamine are potent, but wear off
- Scopolamine at higher doses inhibits memory formation and is vagolytic but maybe not in TBI and hard to get

HYPOTENSION

- Causes of hypotension?
  - **Absolute hypovolemia**
  - **Relative hypovolemia**
  - **Cardiac dysfunction**
  - **Vasodilation**

Predictors of Hypotension After Induction of General Anesthesia

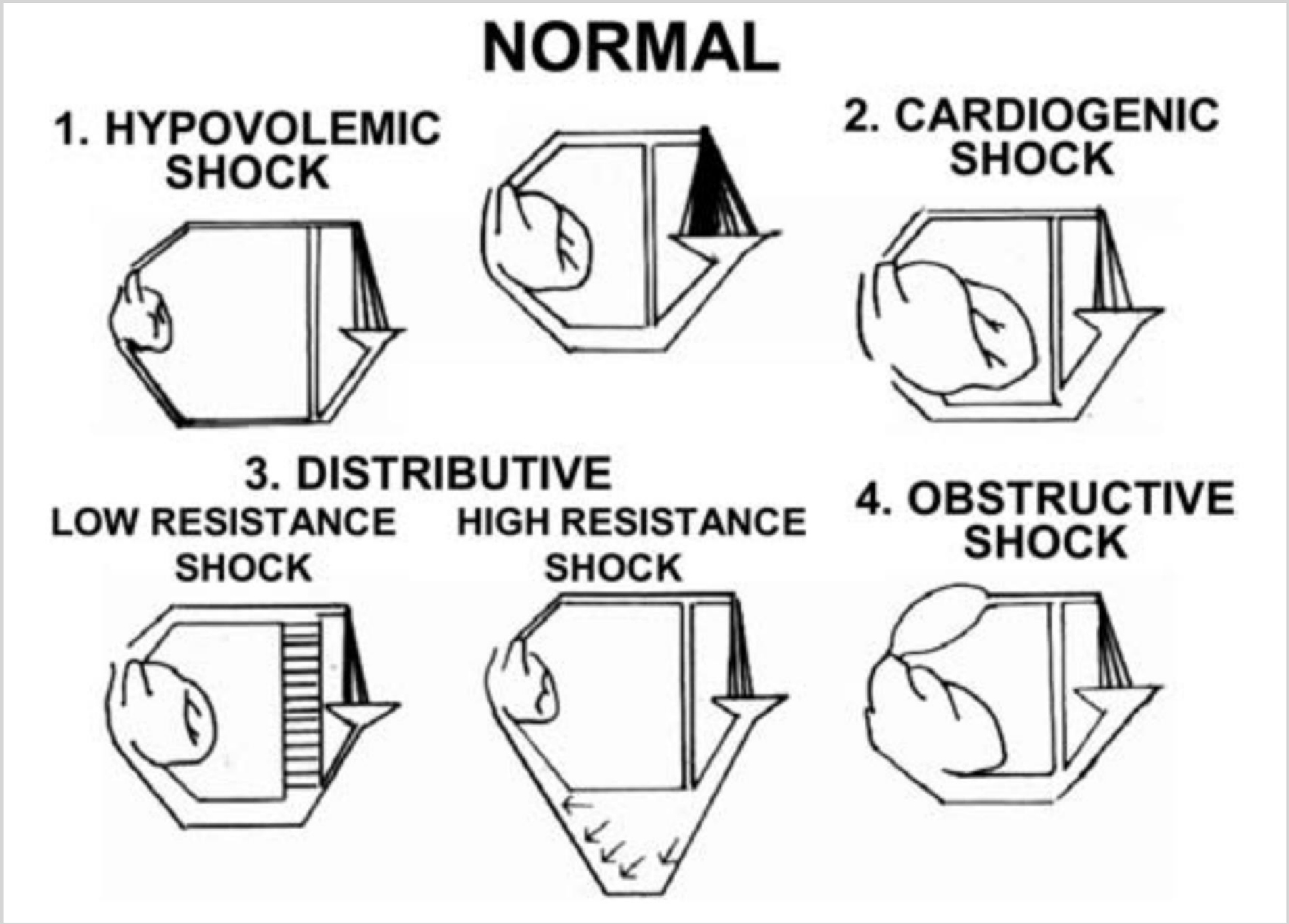
David L. Reich, MD, Sabera Hossain, MA, Marina Krol, PhD, Bernard Baez, MD, Puja Patel, Ariel Bernstein, and Carol A. Bodian, DrPH

Table 6. Independent Predictors of Hypotension 0–10 Minutes after Anesthetic Induction

	OR [95% CI]	*P* value
Baseline MAP <70 mm Hg	5.00 [2.78–9.02]	<0.0001
Age ≥50 yr	2.25 [1.75–2.89]	<0.0001
Propofol induction (versus thiopental or etomidate)	3.94 [2.42–6.43]	<0.0001
Increasing fentanyl dosage*	1.32 [1.13–1.56]	0.0008
ASA III–V (versus ASA I–II)	1.55 [1.22–1.99]	0.0004

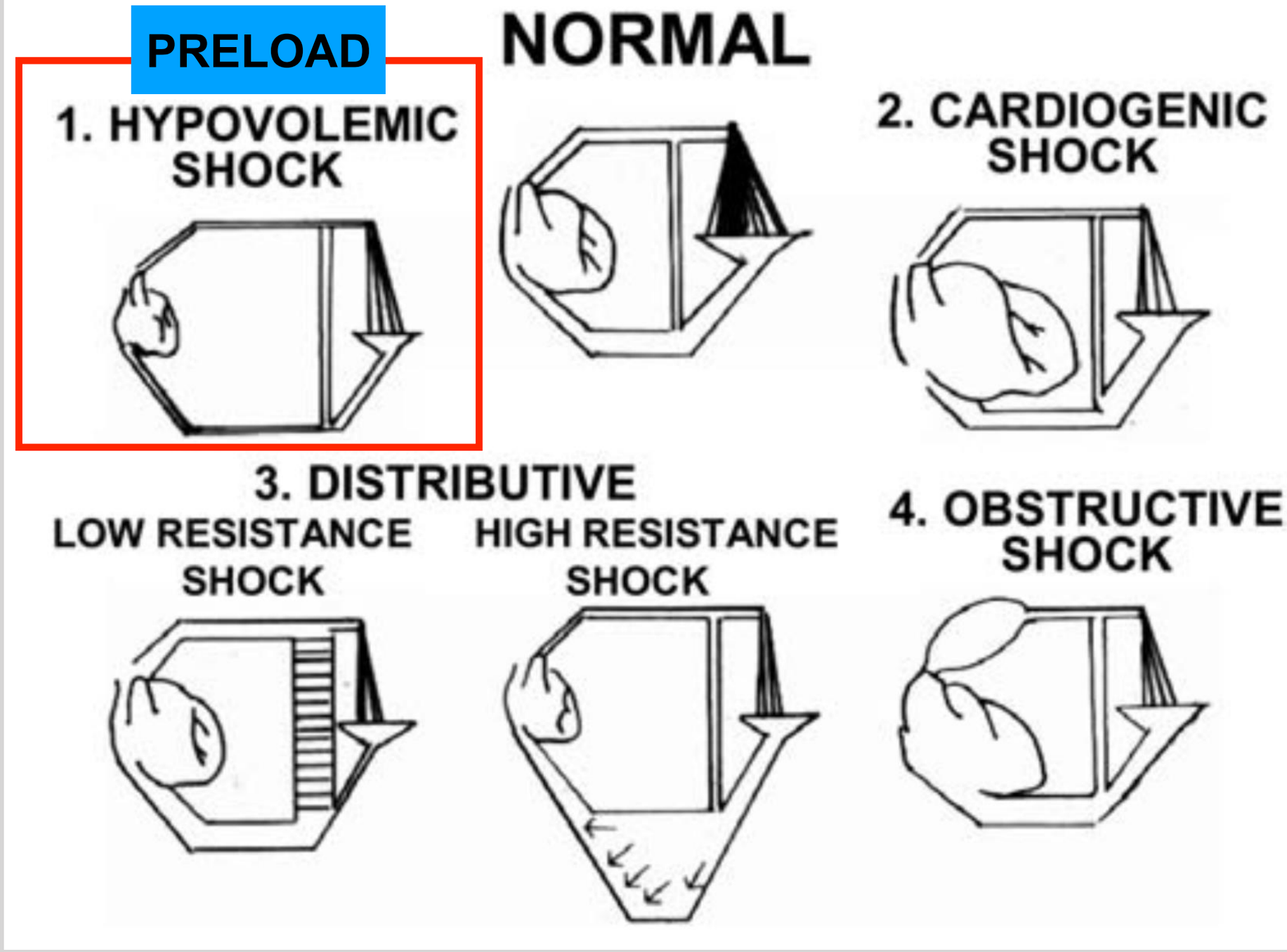
Reich DL, Hossain S, Krol M, et al. Predictors of hypotension after induction of general anesthesia. *Anesth Analg*. 2005;101(3):622–8–tableofcontents. doi:10.1213/01.ANE.0000175214.38450.91.

CAUSES OF HYPOTENSION



Weil MH. Defining Hemodynamic Instability. *Functional hemodynamic monitoring*. July 2005:1-9.

CAUSES OF HYPOTENSION



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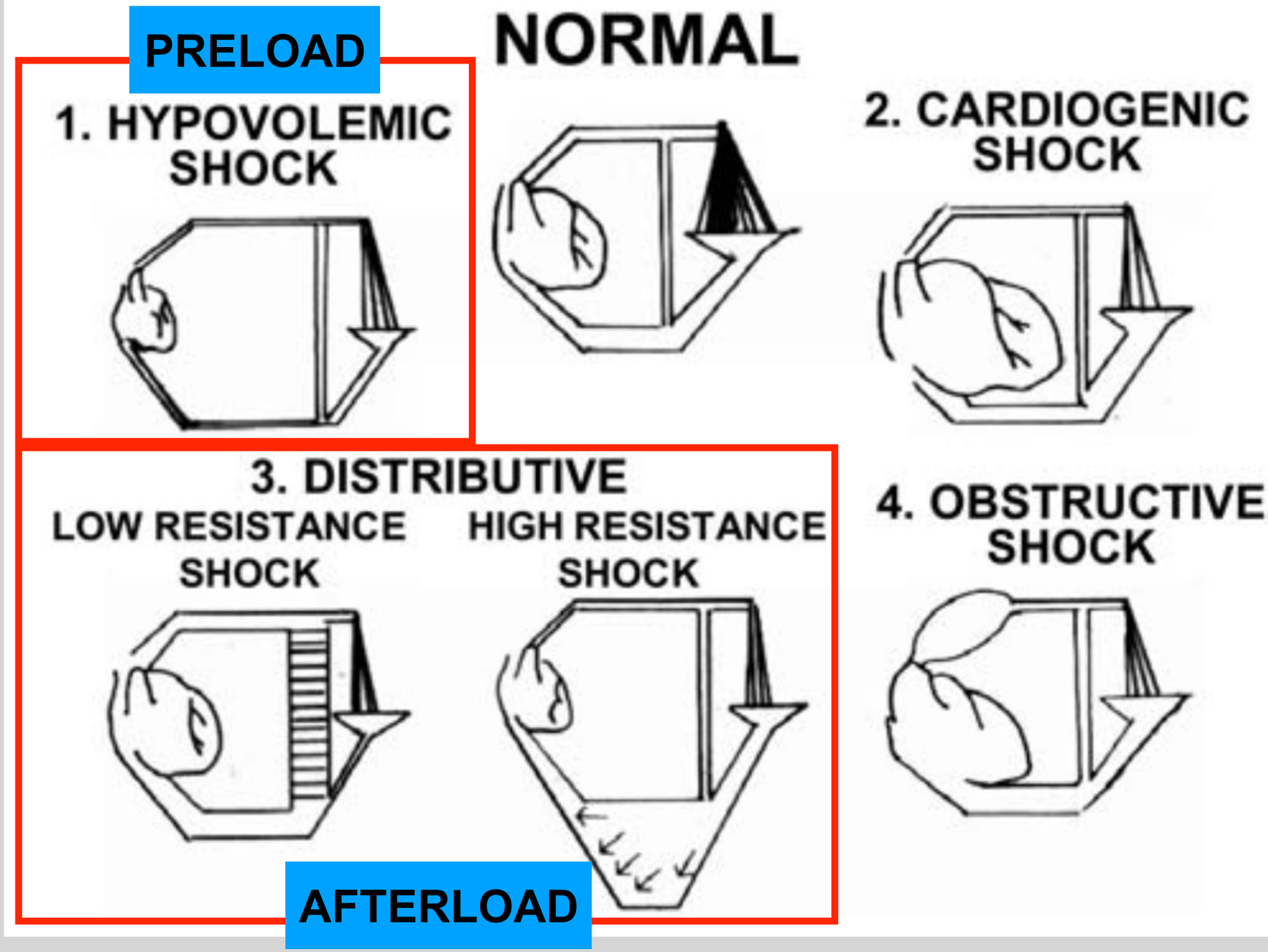
CAUSES OF HYPOTENSION



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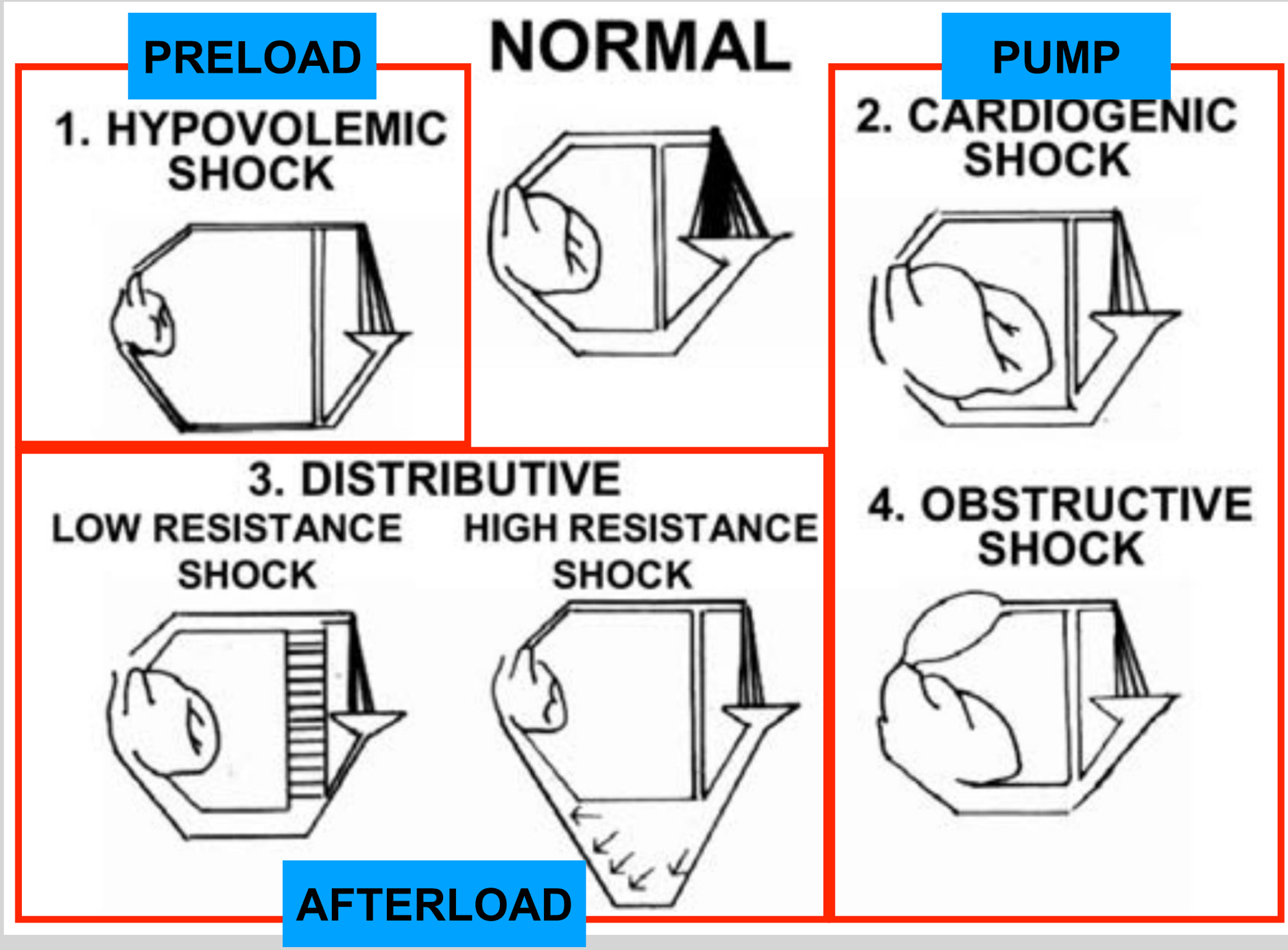
CAUSES OF HYPOTENSION



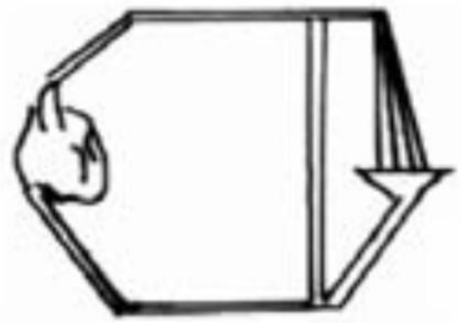
Weil MH. Defining Hemodynamic Instability. *Functional hemodynamic monitoring*. July 2005:1-9.

CAUSES OF HYPOTENSION

NORMAL

ITS ALL VOLUME, REALLY

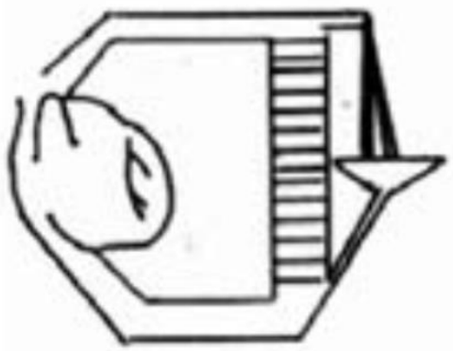
1. HYPOVOLEMIC SHOCK



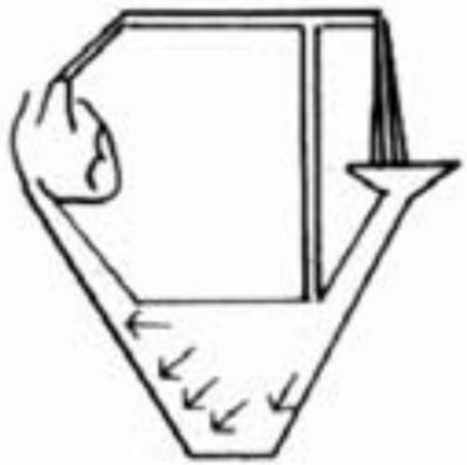
2. CARDIOGENIC SHOCK

3. DISTRIBUTIVE

LOW RESISTANCE SHOCK



HIGH RESISTANCE SHOCK



4. OBSTRUCTIVE SHOCK

Weil MH. Defining Hemodynamic Instability. *Functional hemodynamic monitoring*. July 2005:1-9.

CAUSES OF HYPOTENSION

Resuscitation inadequate
Acidaemia
Positive pressure (PPV)
Induction agents
Disease

Credit: Chris Nickson (LITFL blog)

https://litfl.com/intubation-hypotension-and-shock/

Does vasopressor therapy have an indication in hemorrhagic shock?

Beloncle F, Meziani F, Lerolle N, Radermacher P, Asfar P. Does vasopressor therapy have an indication in hemorrhagic shock? *Ann Intensive Care*. 2013;3(1):13-16. doi:10.1186/2110-5820-3-13.

Vasopressors for hypotensive shock (Review)

Aoki M, Abe T, Saitoh D, Hagiwara S, Oshima K. Use of Vasopressor Increases the Risk of Mortality in Traumatic Hemorrhagic Shock: A Nationwide Cohort Study in Japan. *Crit Care Med*. 2018;46(12):e1145-e1151. doi:10.1097/CCM.0000000000003428.

Vasopressin in Hemorrhagic Shock: A Systematic Review and Meta-Analysis of Randomized Animal Trials

Cossu AP, Mura P, De Giudici LM, et al. Vasopressin in hemorrhagic shock: a systematic review and meta-analysis of randomized animal trials. *Biomed Res Int*. 2014;2014(2):421291-421299. doi:10.1155/2014/421291.

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- **Not entirely clear that vasopressors are a problem**
- **An approach involving only vasopressors (no fluids) is unlikely to be best**
- **An approach entirely avoiding vasopressors (high fluids) is unlikely to be best**
- **Clearly defining SBP/MAP goals is key**

Aoki M, A de Cohort

Cossu A Biomed

Use of Vasopressor Increases the Risk of Mortality in Traumatic Hemorrhagic Shock: A Nationwide Cohort Study in Japan

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Aoki M, A de Cohort

Cossu A *Biomed*

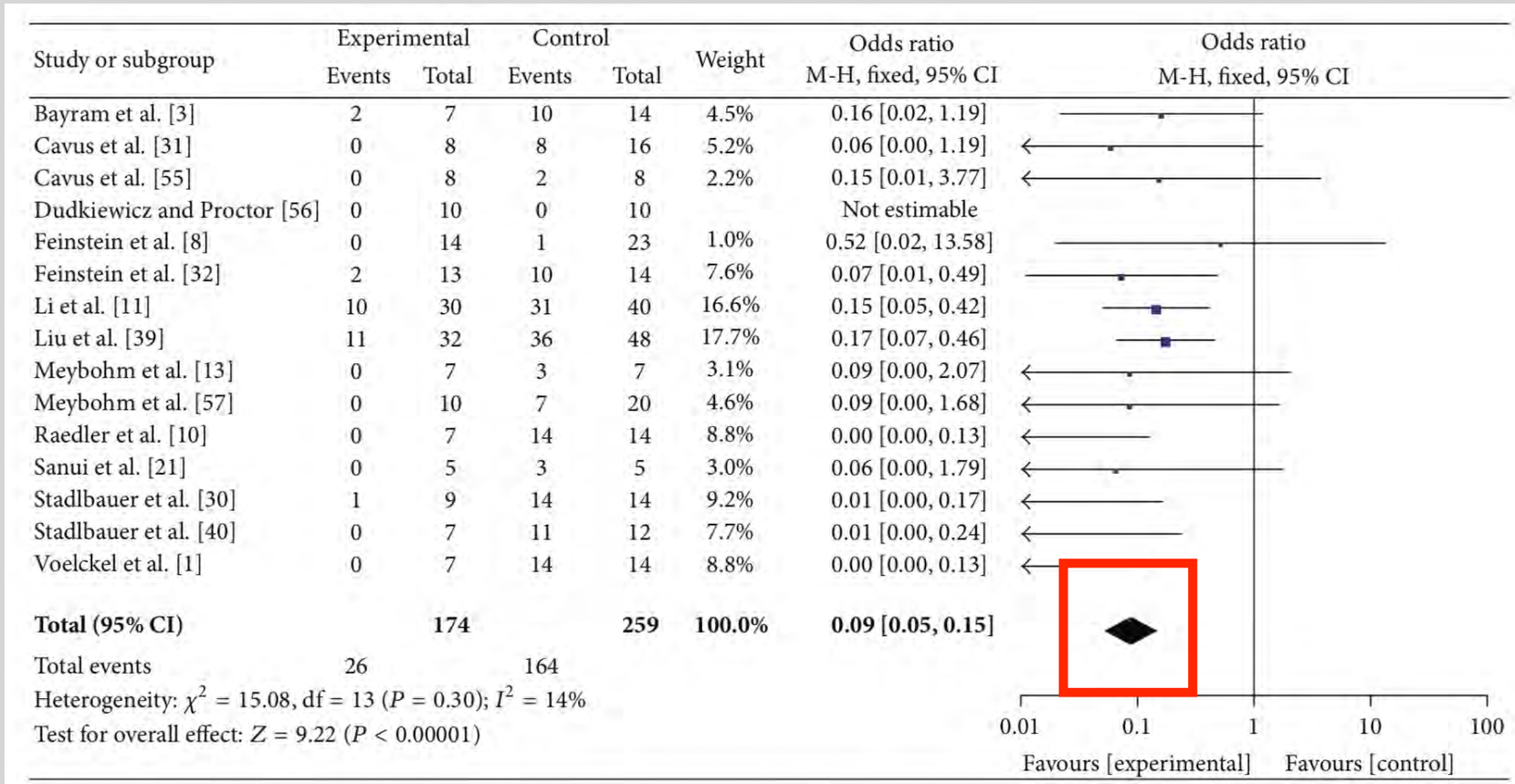
CONSIDER

- **SBP 80-90 WHILE SECURING HEMORRHAGE**
- **TBI: MAP>80**

Aoki M, Abe T, Saito A Nationwide Cohort

Vasopressin in Hemorrhagic Shock: A Systematic Review and Meta-Analysis of Randomized Animal Trials

Andrea Pasquale Cossu,[1] Paolo Mura,[1] Lorenzo Matteo De Giudici,[1] Daniela Puddu,[1] Laura Pasin,[2] Maurizio Evangelista,[3] Theodoros Xanthos,[4] Mario Musu,[1] and Gabriele Finco[1]



Study or subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Odds ratio M-H, fixed, 95% CI
Bayram et al. [3]	2	7	10	14	4.5%	0.16 [0.02, 1.19]
Cavus et al. [31]	0	8	8	16	5.2%	0.06 [0.00, 1.19]
Cavus et al. [55]	0	8	2	8	2.2%	0.15 [0.01, 3.77]
Dudkiewicz and Proctor [56]	0	10	0	10		Not estimable
Feinstein et al. [8]	0	14	1	23	1.0%	0.52 [0.02, 13.58]
Feinstein et al. [32]	2	13	10	14	7.6%	0.07 [0.01, 0.49]
Li et al. [11]	10	30	31	40	16.6%	0.15 [0.05, 0.42]
Liu et al. [39]	11	32	36	48	17.7%	0.17 [0.07, 0.46]
Meybohm et al. [13]	0	7	3	7	3.1%	0.09 [0.00, 2.07]
Meybohm et al. [57]	0	10	7	20	4.6%	0.09 [0.00, 1.68]
Raedler et al. [10]	0	7	14	14	8.8%	0.00 [0.00, 0.13]
Sanui et al. [21]	0	5	3	5	3.0%	0.06 [0.00, 1.79]
Stadlbauer et al. [30]	1	9	14	14	9.2%	0.01 [0.00, 0.17]
Stadlbauer et al. [40]	0	7	11	12	7.7%	0.01 [0.00, 0.24]
Voelckel et al. [1]	0	7	14	14	8.8%	0.00 [0.00, 0.13]
Total (95% CI)		**174**		**259**	**100.0%**	**0.09 [0.05, 0.15]**
Total events	26		164			

Heterogeneity: $\chi^2 = 15.08$, df = 13 ($P = 0.30$); $I^2 = 14\%$

Test for overall effect: $Z = 9.22$ ($P < 0.00001$)

FIGURE 2: AVP or terlipressin versus all other strategies (fluid resuscitation, vasoconstrictors, and placebo).

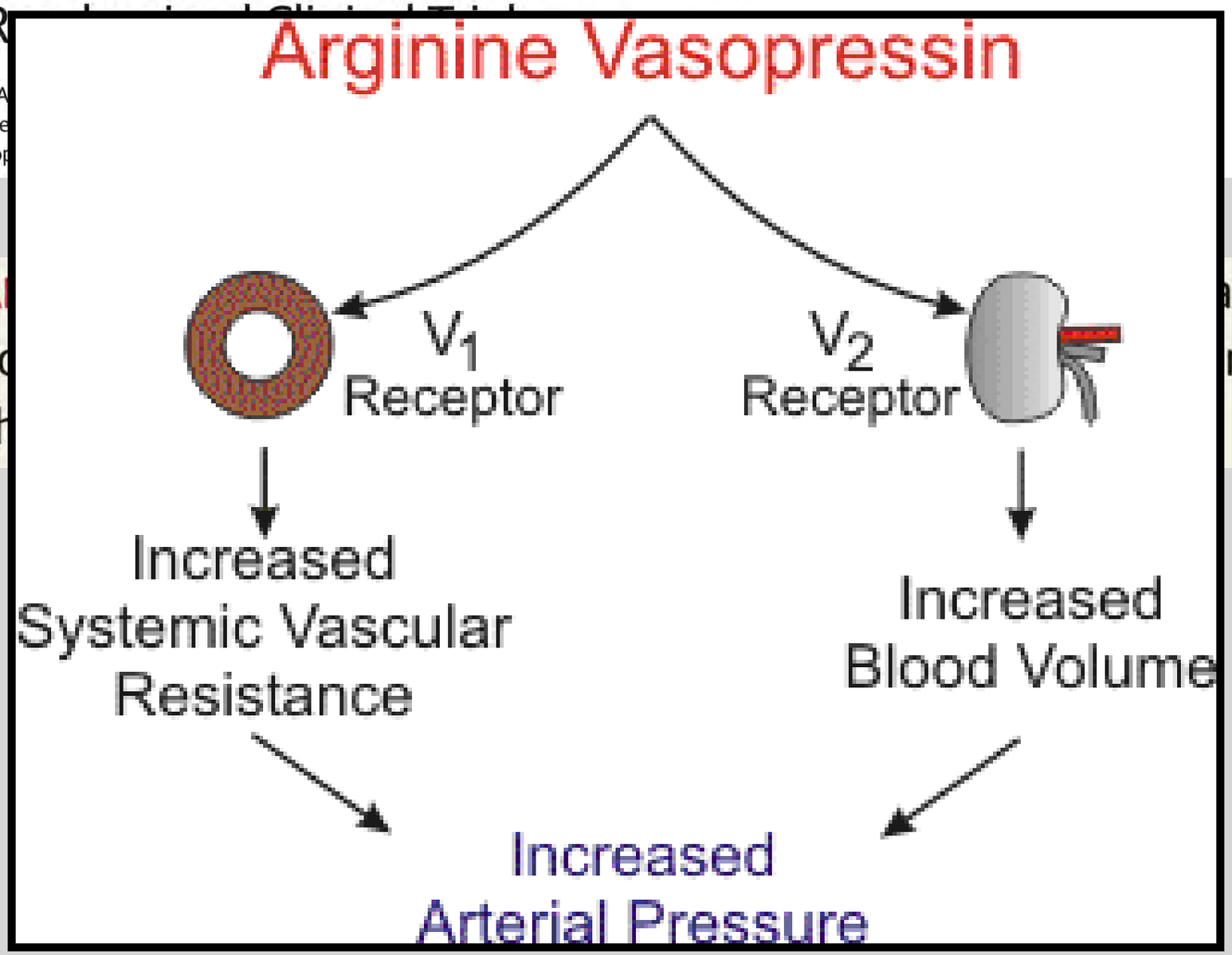
Big effect size (in animal studies) says: "maybe vasopressin in hemorrhagic shock?"

Cossu AP, Mura P, De Giudici LM, et al. Vasopressin in hemorrhagic shock: a systematic review and meta-analysis of randomized animal trials. *Biomed Res Int*. 2014;2014(2):421291-421299. doi:10.1155/2014/421291.

Effect of Low-Dose Supplementation of Arginine Vasopressin on Need for Blood Product Transfusions in Patients With Trauma and Hemorrhagic Shock

A R

Carrie A
Mark Se
Christop



CONCLUSIONS A

hemorrhagic sh

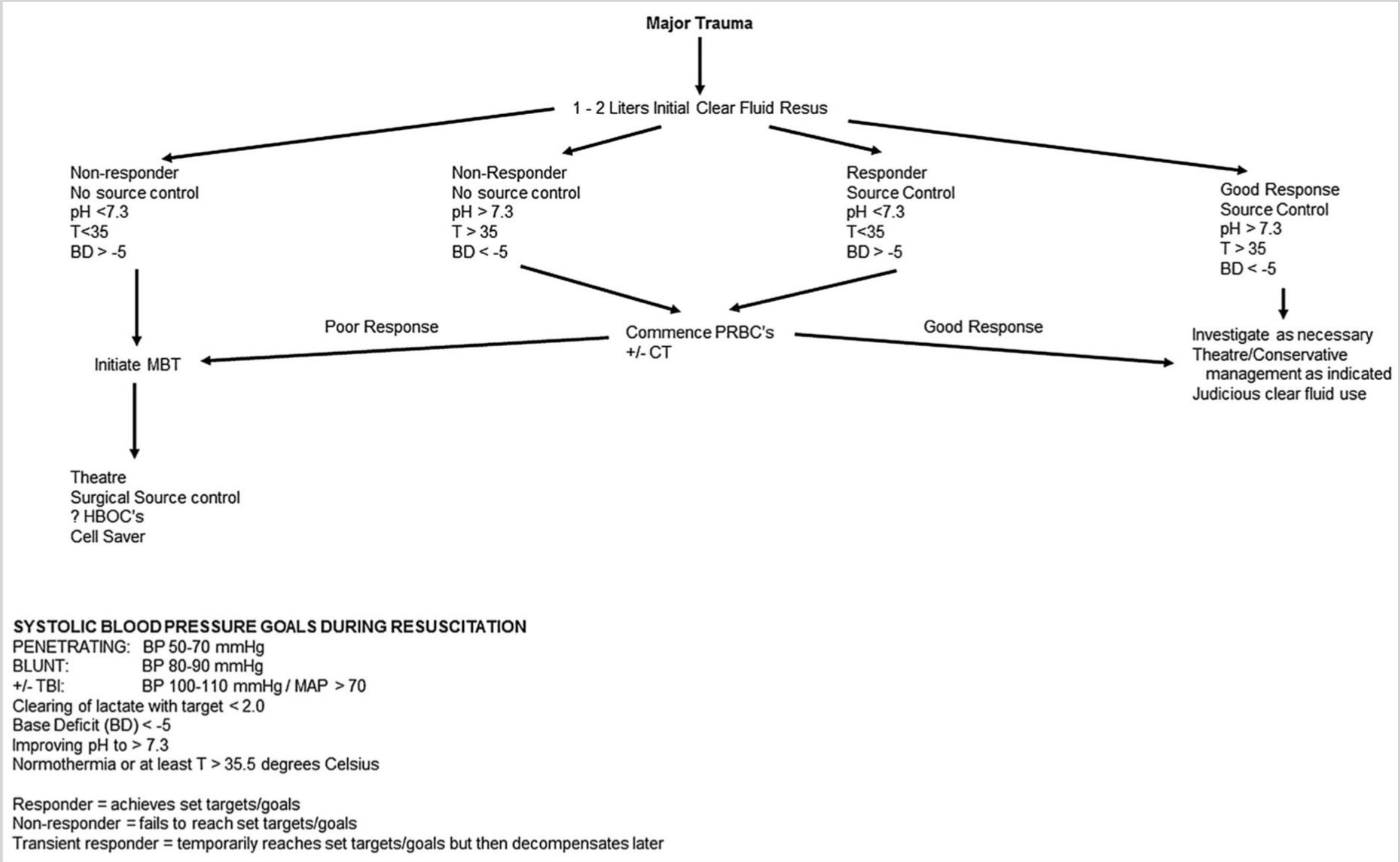
to determine wh

uma patients in

rch is necessary

Sims CA, Holena D, Kim P, et al. Effect of Low-Dose Supplementation of Arginine Vasopressin on Need for Blood Product Transfusions in Patients With Trauma and Hemorrhagic Shock: A Randomized Clinical Trial. *JAMA Surg*. August 2019. doi:10.1001/jamasurg.2019.2884.

FLUIDS



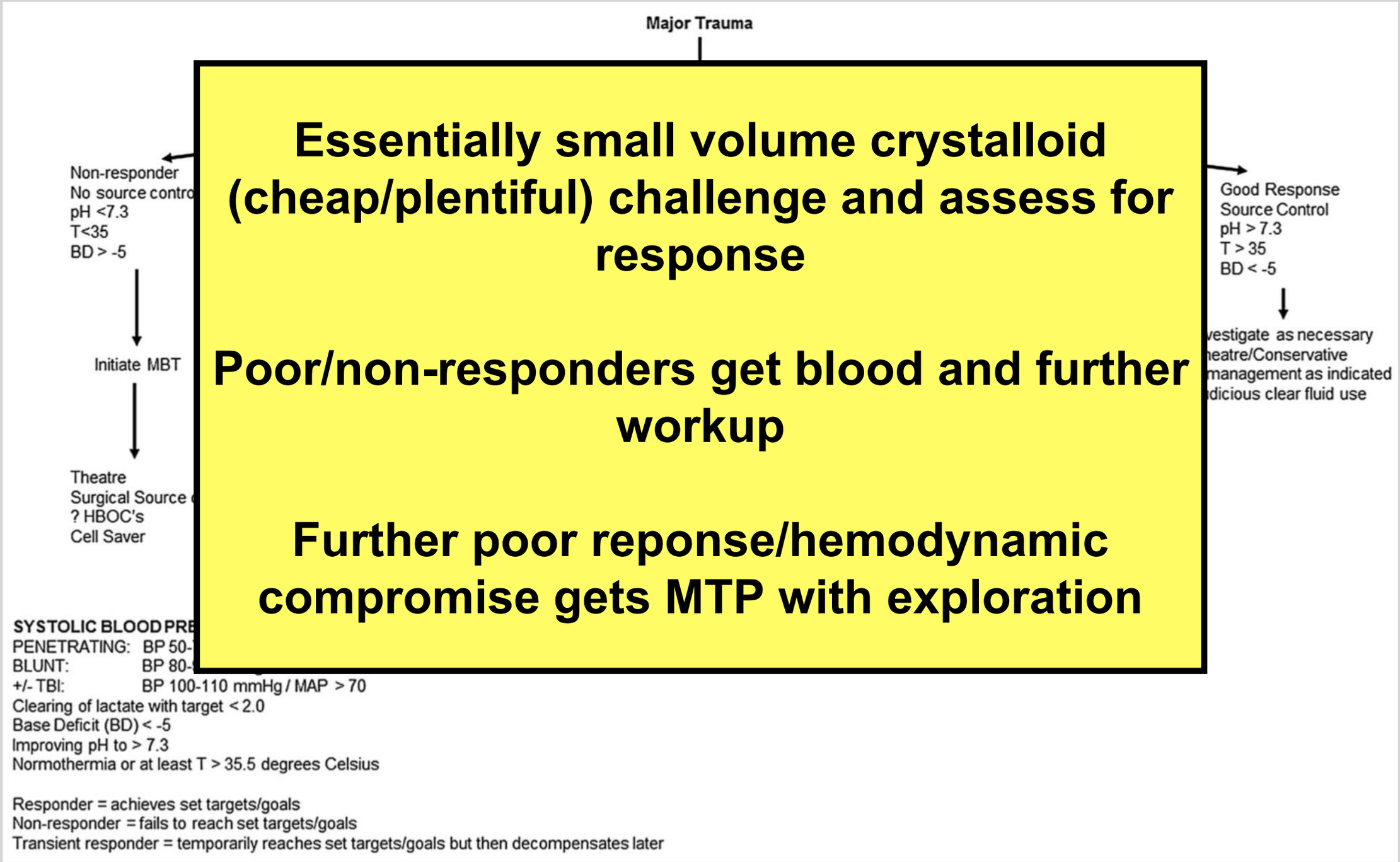
SYSTOLIC BLOOD PRESSURE GOALS DURING RESUSCITATION

PENETRATING: BP 50-70 mmHg
BLUNT: BP 80-90 mmHg
+/- TBI: BP 100-110 mmHg / MAP > 70
Clearing of lactate with target < 2.0
Base Deficit (BD) < -5
Improving pH to > 7.3
Normothermia or at least T > 35.5 degrees Celsius

Responder = achieves set targets/goals
Non-responder = fails to reach set targets/goals
Transient responder = temporarily reaches set targets/goals but then decompensates later

Wise R, Faurie M, Malbrain MLNG, Hodgson E. Strategies for Intravenous Fluid Resuscitation in Trauma Patients. *World J Surg*. 2017;41(5):1170-1183. doi:10.1007/s00268-016-3865-7.

FLUIDS



Wise R, Faurie M, Malbrain MLNG, Hodgson E. Strategies for Intravenous Fluid Resuscitation in Trauma Patients. *World J Surg*. 2017;41(5):1170-1183. doi:10.1007/s00268-016-3865-7.

Optimal fluid resuscitation in trauma: type, timing, and total

Marcie Feinman[a], *Bryan A. Cotton*[b], *and Elliott R. Haut*[a]

Table 2. Determinants of resuscitation and perfusion

Basic measures of global resuscitation	Advanced measures of global resuscitation	Measures of global perfusion	Measures of regional perfusion
Heart rate	Bedside echocardiography	Initial lactate level	Near-infrared spectroscopy
Shock index	Mixed venous oxygen saturation	Rate of lactate clearance	Sidestream dark field video microscopy
Blood pressure	Pulse pressure variation	Base deficit	Regional capnography
Urine output	Stroke volume variation	Bicarbonate	St02 monitoring
Mental status	Pulmonary artery occlusion pressure	pH	CSF microdialysis
Capillary refill	Central venous pressure		

Feinman M, Cotton BA, Haut ER. Optimal fluid resuscitation in trauma: type, timing, and total. *Curr Opin Crit Care*. 2014;20(4):366-372. doi:10.1097/MCC.0000000000000104.

Optimal fluid resuscitation in trauma: type, timing, and total

Table 2. Determinants

Basic measures of global resuscitation	fusion
Heart rate	spectroscopy
Shock index	ark field video microscopy
Blood pressure	nography
Urine output	ng
Mental status	lysis
Capillary refill	

Advanced measures of global resuscitation
Bedside echocardiography
Mixed venous oxygen saturation
Pulse pressure variation
Stroke volume variation
Pulmonary artery occlusion pressure
Central venous pressure

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Hemodynamic parameters to guide fluid therapy

Paul E Marik[1*], Xavier Monnet[2], Jean-Louis Teboul[2]

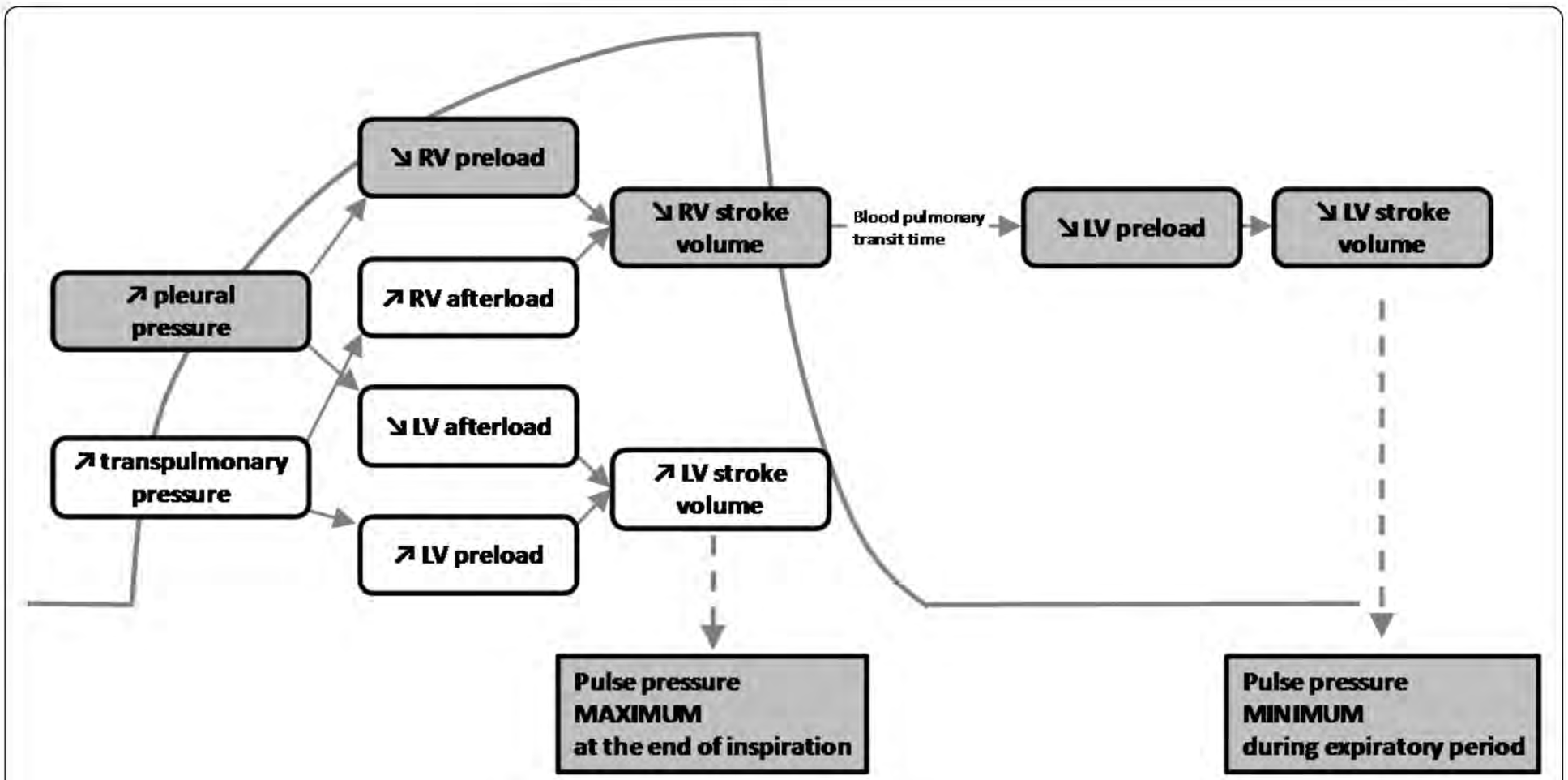
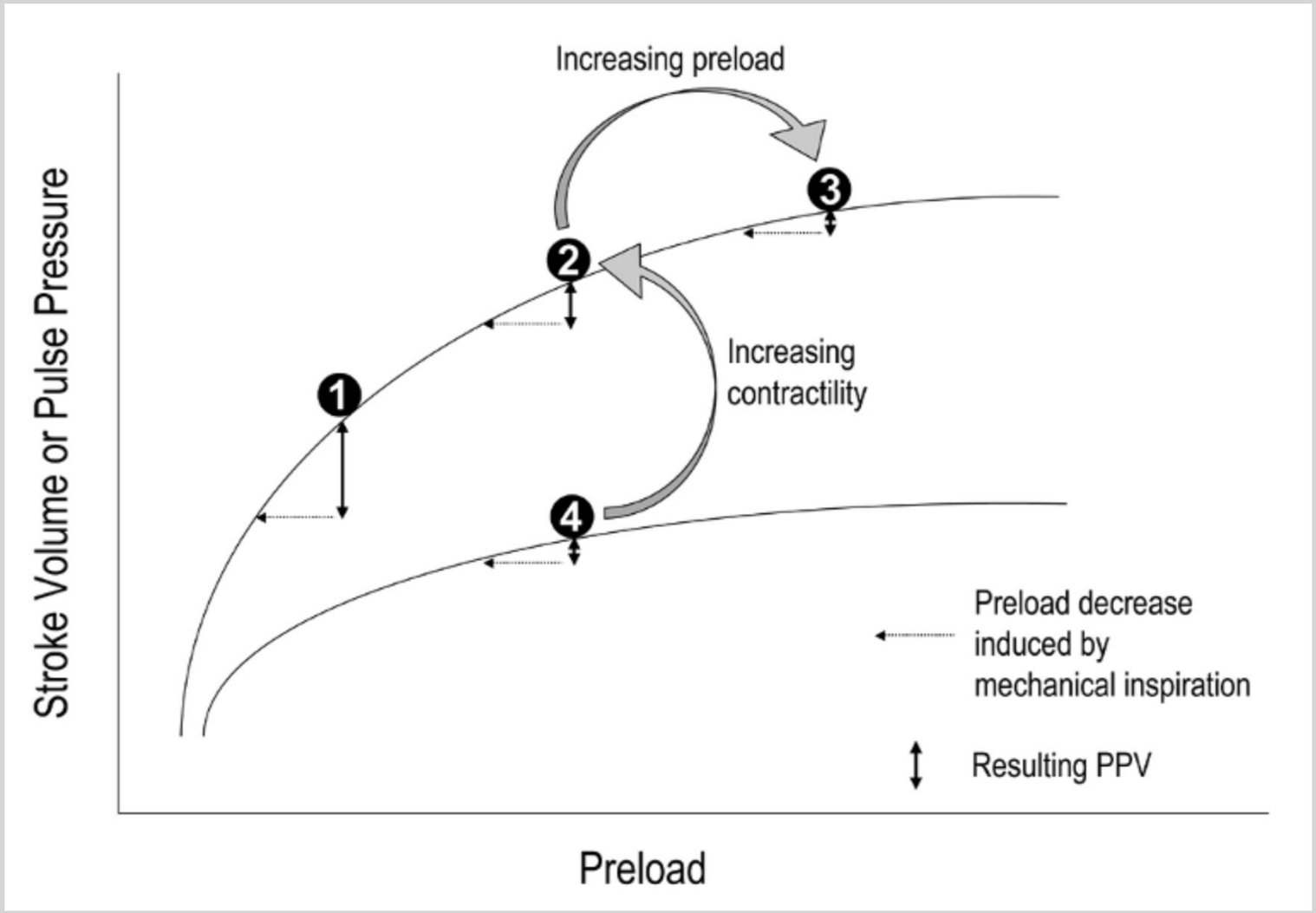


Figure 2 Heart-lung interactions. Hemodynamic effects of mechanical ventilation. The cyclic changes in left ventricular (LV) stroke volume are mainly related to the expiratory decrease in LV preload due to the inspiratory decrease in right ventricular (RV) filling. Reproduced with permission from Critical Care/Current Science Ltd [24].

Marik PE, Monnet X, Teboul J-L. Hemodynamic parameters to guide fluid therapy. *Ann Intensive Care*. 2011;1(1):1. doi:10.1186/2110-5820-1-1.

Pulse pressure variation: beyond the fluid management of patients with shock

Frédéric Michard[1], Marcel R Lopes[2] and Jose-Otavio C Auler Jr[3]



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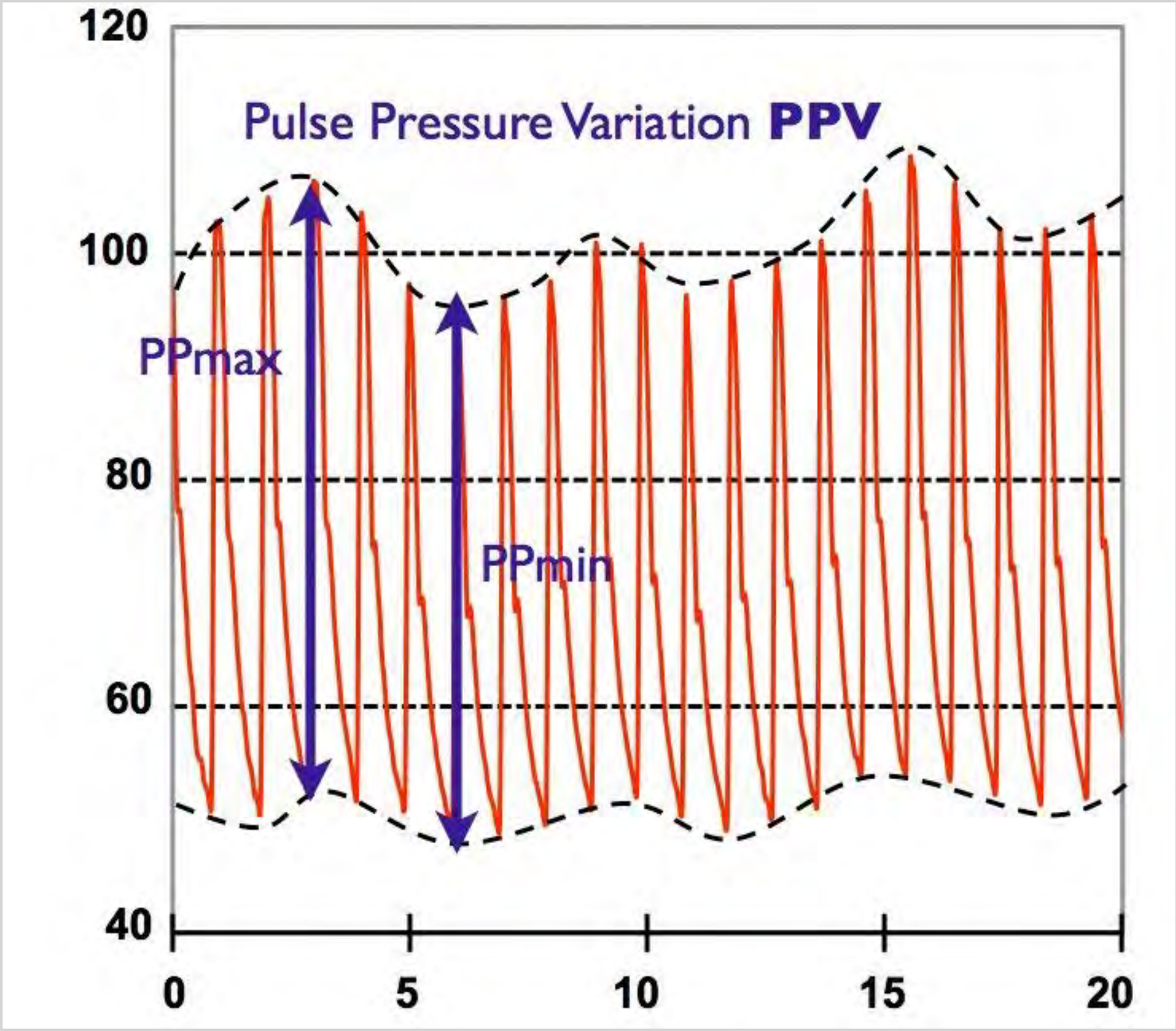


Marik PE, Cavallazzi R, Vasu T, Hirani A. Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients: a systematic review of the literature. 2009;37(9):2642-2647. doi:10.1097/CCM.0b013e3181a590da.

ASSESSMENT OF FLUID RESPONSIVENESS

Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients: A systematic review of the literature*

Paul E. Marik, MD, FCCM; Rodrigo Cavallazzi, MD; Tajender Vasu, MD; Amyn Hirani, MD

	Correlation (r)	AUC
PPV	.78 (.74–.82)	0.94 (0.93–0.95)
SPV	.72 (.65–.77)	0.86 (0.82–0.90)
SVV	.72 (.66–.78)	0.84 (0.78–0.88)
LVEDAI	—	0.64 (0.53–0.74)
GEDVI	—	0.56 (0.37–0.67)
CVP	.13 (−.01–.28)	0.55 (0.48–0.62)

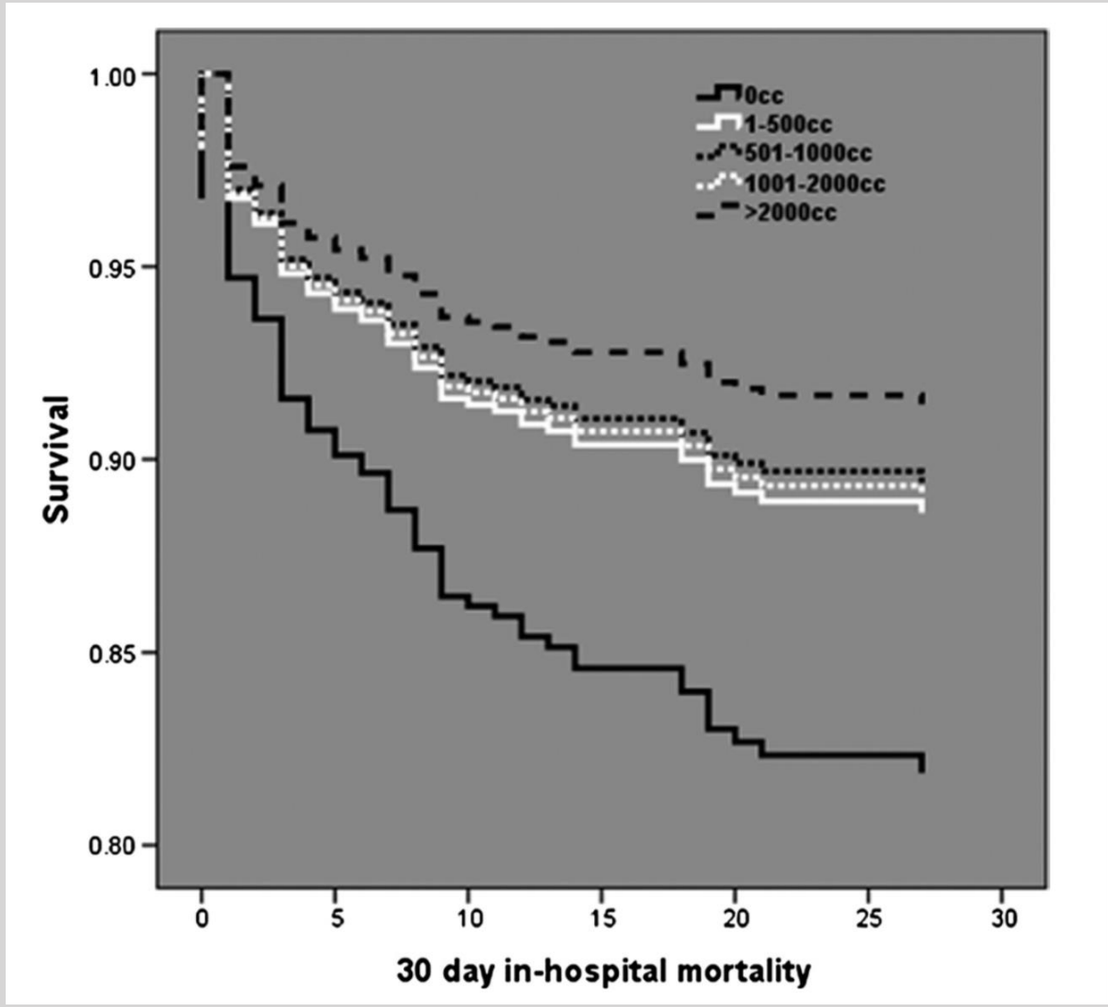
Higher AUC suggests higher specificity and sensitivity

Marik PE, Cavallazzi R, Vasu T, Hirani A. Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients: a systematic review of the literature. 2009;37(9):2642-2647. doi:10.1097/CCM.0b013e3181a590da.

Goal-directed resuscitation in the prehospital setting: A propensity-adjusted analysis

Joshua B. Brown, MD, Mitchell J. Cohen, MD, Joseph P. Minei, MD, Ronald V. Maier, MD, Michael A. West, MD, Timothy R. Billiar, MD, Andrew B. Peitzman, MD, Ernest E. Moore, MD, Joseph Cuschieri, MD, Jason L. Sperry, MD, MPH,
and **The Inflammation and the Host Response to Injury Investigators,** *Pittsburgh, Pennsylvania*

Not entirely clear what the optimal resuscitation goals are; normotensive patients who receive more fluids may do worse



Brown JB, Cohen MJ, Minei JP, et al. Goal-directed resuscitation in the prehospital setting: a propensity-adjusted analysis. *J Trauma Acute Care*. 2013;74(5):1207–12–discussion1212–4. doi:10.1097/TA.0b013e31828c44fd.

Damage control resuscitation in patients with severe traumatic hemorrhage: A practice management guideline from the Eastern Association for the Surgery of Trauma

Jeremy W. Cannon, MD, SM, Mansoor A. Khan, MBBS (Lond), PhD, Ali S. Raja, MD, Mitchell J. Cohen, MD, John J. Como, MD, MPH, Bryan A. Cotton, MD, Joseph J. Dubose, MD, Erin E. Fox, PhD, Kenji Inaba, MD, Carlos J. Rodriguez, DO, John B. Holcomb, MD, *and* **Juan C. Duchesne, MD**, *Philadelphia, Pennsylvania*

TABLE 1. Principles of Damage Control Resuscitation (DCR)

Principle	References
Avoid/reverse hypothermia	Gentilello,[1] Shafi[2]
Minimize blood loss with early hemorrhage control measures during transport and initial evaluation	Kragh,[3] Schroll,[4] Inaba,[5] Leonard,[6] Yong,[7] Dubose[8]
Delay resuscitation/target low-normal blood pressure before definitive hemostasis	Bickell,[9] Dutton[10]
Minimize crystalloid administration	Duchesne,[11] Schreiber[12]
Use MT protocol to ensure sufficient blood products are available in a prespecified ratio	O'Keeffe,[13] Cotton[14]
Avoid delays in surgical or angiographic hemostasis	Meizoso,[15] Schwartz,[16] Tesoriero[17]
Transfuse blood components that optimize hemostasis	Borgman,[18] Holcomb,[19] Holcomb[20]
Obtain functional laboratory measures of coagulation (e.g., TEG or TEM) to guide ongoing resuscitation	Gonzalez,[21] Tapia[22]
Give pharmacologic adjuncts to safely promote hemostasis	CRASH-2,[23] Morrison,[24] Hauser[25]

TEG, thromboelastography; TEM, thromboelastometry.

Cannon JW, Khan MA, Raja AS, et al. Damage control resuscitation in patients with severe traumatic hemorrhage: A practice management guideline from the Eastern Association for the Surgery of Trauma. *J Trauma Acute Care*. 2017;82(3):605-617. doi:10.1097/TA.0000000000001333.

Damage control resuscitation in patients with severe traumatic hemorrhage: A practice management guideline from the Eastern Association for the Surgery of Trauma

Jer… MD,
Jo… D,

WHAT CAN WE DO IN THE OPERATING ROOM?

- **Keep it warm**
- **Tolerate lower MAP**
- **Minimize/No crystalloid**
- **Balanced product resuscitation/MTP when appropriate**

TABLE 1. Prin…

Principle	
Avoid/reverse hy…	
Minimize blood …	Yong,[7] Dubose[8]
Delay resuscitati…	
Minimize crystal…	r[12]
Use MT protocol…	4
Avoid delays in surgical or angiographic hemostasis	Meizoso,… Schwartz,… Tesoriero[17]
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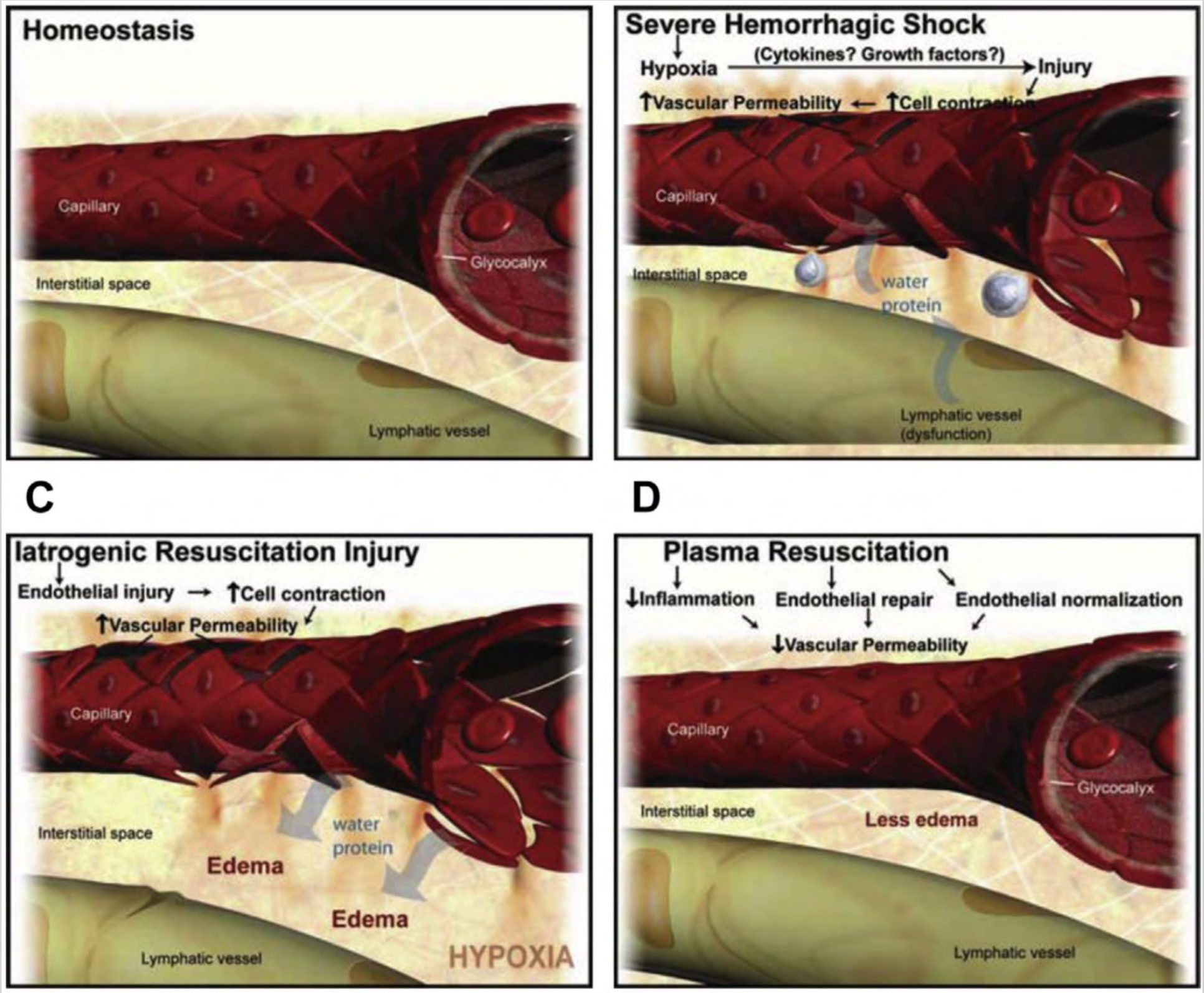
REVIEW OF PROBLEMS WITH CRYSTALLOIDS

- Dilutes RBC and clotting factors
- Worsens acidosis (notably normal saline) due to chloride load
- Promotes leakage of fluid and tissue edema
- Less “bang for the buck” in supporting circulation

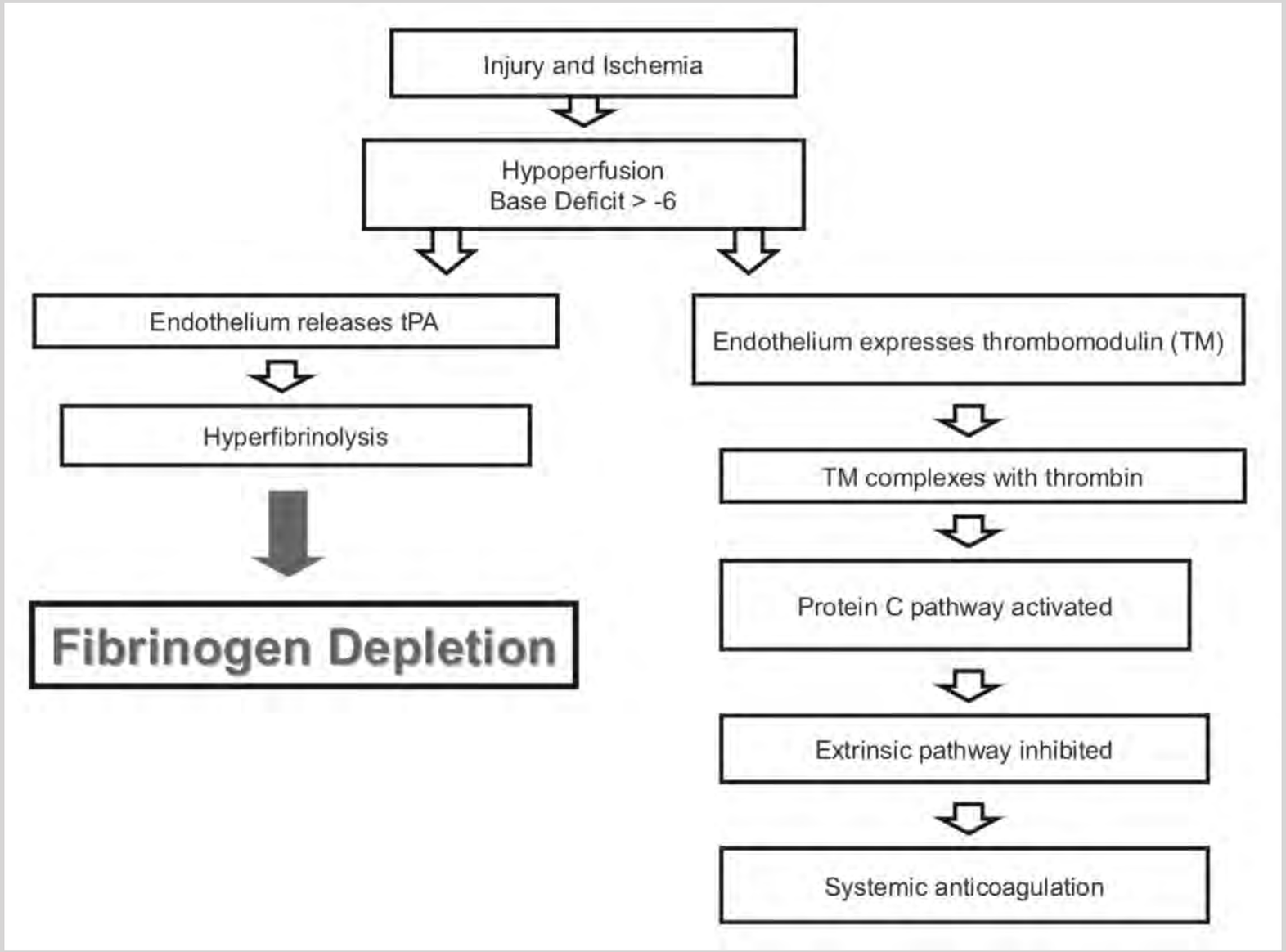
Cannon JW, Khan MA, Raja AS, et al. Damage control resuscitation in patients with severe traumatic hemorrhage: A practice management guideline from the Eastern Association for the Surgery of Trauma. *J Trauma Acute Care*. 2017;82(3):605-617. doi:10.1097/TA.0000000000001333.



Chang R, Holcomb JB. Optimal Fluid Therapy for Traumatic Hemorrhagic Shock. *Crit Care Clin*. 2017;33(1):15-36. doi:10.1016/j.ccc.2016.08.007.

Damage Control Resuscitation: The New Face of Damage Control

Juan C. Duchesne, MD, FACS, FCCP, Norman E. McSwain, Jr., MD, FACS, Bryan A. Cotton, MD, FACS, John P. Hunt, MD, MPH, FACS, Jeff Dellavolpe, MD, Kelly Lafaro, MD, MPH, Alan B. Marr, MD, FACS, Earnest A. Gonzalez, MD, FACS, Herb A. Phelan, MD, FACS, Tracy Bilski, MD, FACS, Patrick Greiffenstein, MD, James M. Barbeau, MD, JD, Kelly V. Rennie, MD, Christopher C. Baker, MD, FACS, Karim Brohi, MD, FRCS, FRCA, Donald H. Jenkins, MD, FACS, and Michael Rotondo, MD, FACS



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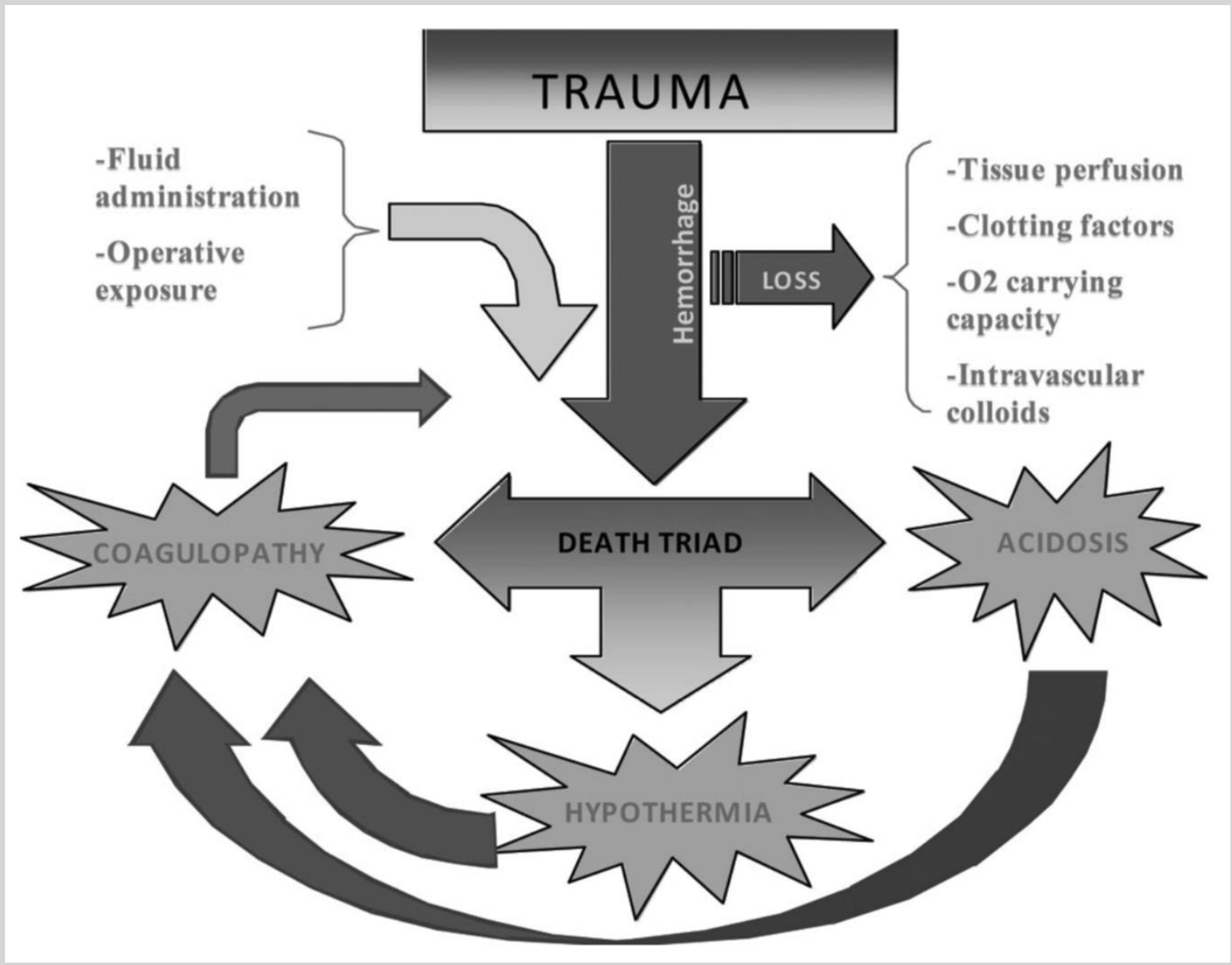

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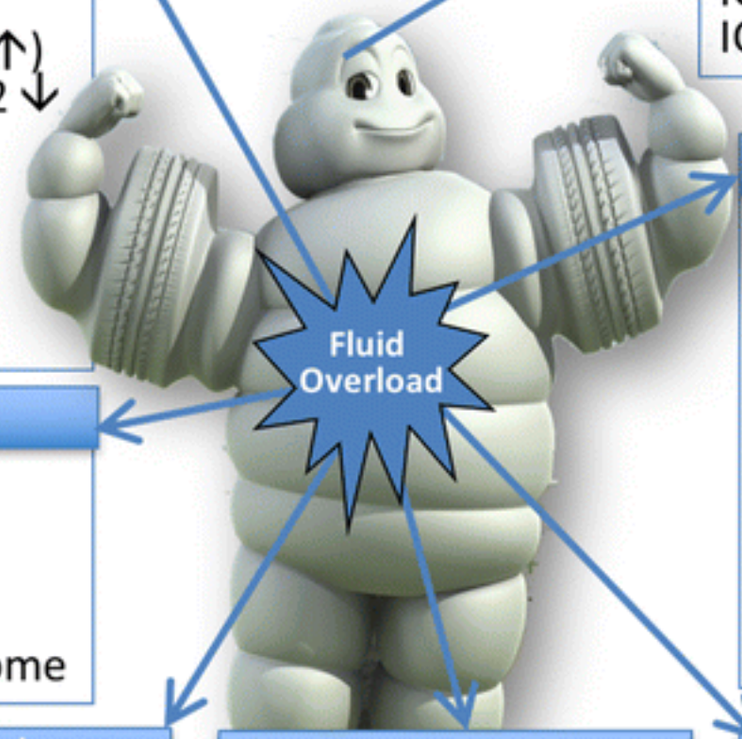
Respiratory

Pulmonary edema ↑
Pleural effusion ↑
Altered pulmonary and
chest wall elastance (cfr IAP ↑)
paO2 ↓ paCO2 ↑ PaO2/FiO2 ↓
Extra vascular lung water ↗
Lung volumes ↓ (cfr IAP ↑)
Prolonged ventilation ↑
Difficult weaning ↑
Work of breathing ↑

Central nervous system

Cerebral edema, impaired
cognition, delirium
ICP ↑ CPP ↓ IOP ↑
ICH, ICS, OCS



Cardiovascular

Myocardial edema ↑
Conduction disturbance
Impaired contractility
Diastolic dysfunction
CVP ↑ and PAOP ↑
Venous return ↓
SV ↓ and CO ↓
Myocardial depression
Pericardial effusion ↑
GEF ↓ GEDVI ↑ CARS ↑

Hepatic

Hepatic congestion ↑
Impaired synthetic function
Cholestatis ↑
Cytochrome P 450 activity ↓
Hepatic compartment syndrome

Gastrointestinal/visceral

Ascites formation ↑ Gut edema ↑
Malabsorption ↑ Ileus ↑
Bowel contractility ↓
IAP ↑ and APP (=MAP-IAP) ↓
Success enteral feeding ↓
Intestinal permeability ↑
Bacterial translocation ↑
Splanchnic microcirculatory flow ↓
ICG-PDR ↓, pHi ↓

Abdominal Wall

Tissue edema ↑
Poor wound
healing ↑
Wound infection ↑
Pressure ulcers ↑
Abdominal
compliance ↓

Renal

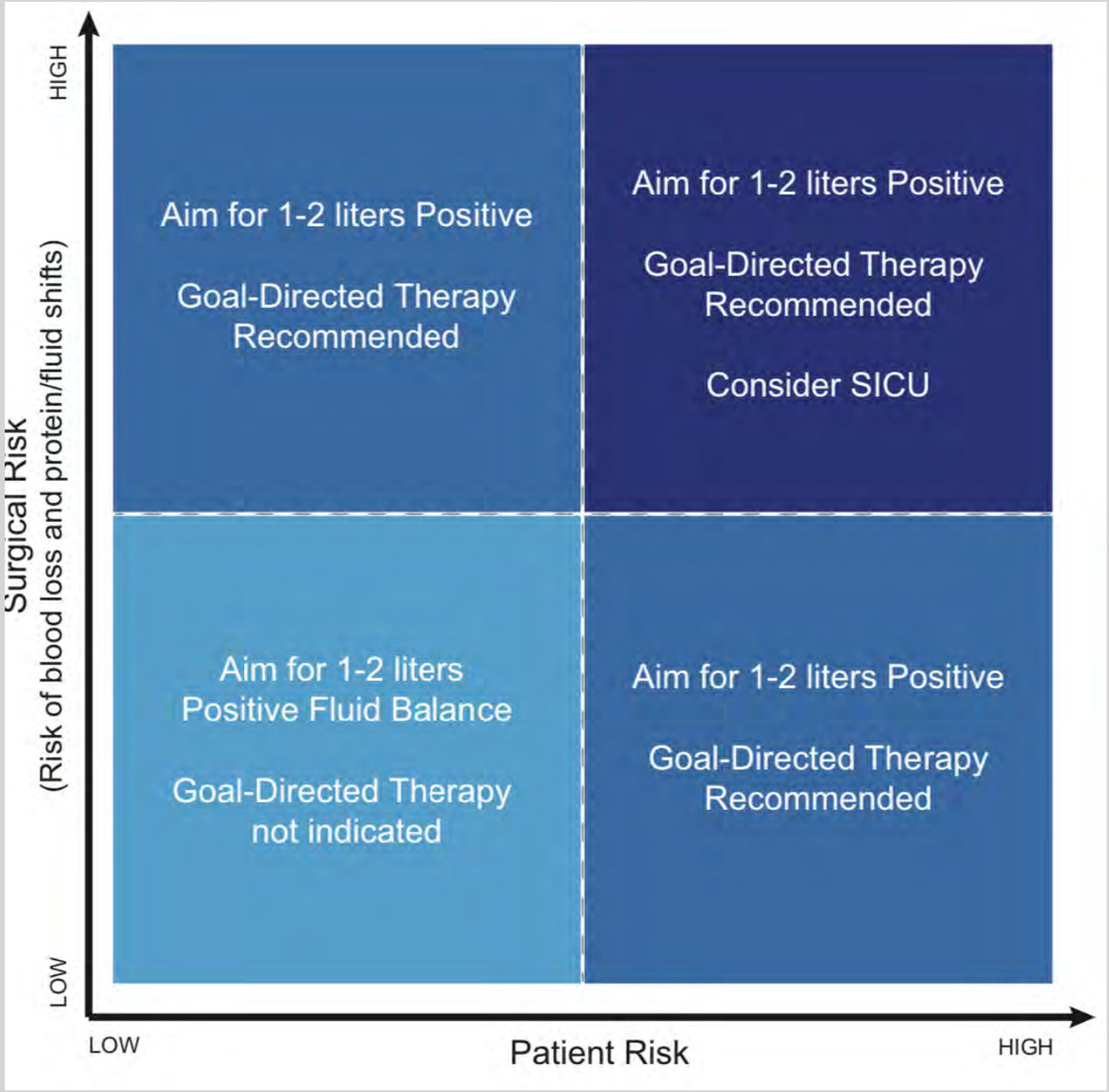
Renal interstitial edema
Renal venous pressure ↑
Renal blood flow ↓
Interstitial pressure ↑
Salt + water retention ↑
Uremia ↑ GFR ↓ RVR ↑
Renal CS

Type of IV Device

Perioperative Fluid Therapy for Major Surgery

Timothy E. Miller, M.B.,Ch.B., F.R.C.A., Paul S. Myles, M.B., B.S., M.P.H., D.Sc., F.A.N.Z.C.A.

Surgical resuscitation has shifted in general to a restrictive fluid approach



Miller TE, Myles PS. Perioperative Fluid Therapy for Major Surgery. *Anesthesiology*. 2019;130(5):825-832. doi:10.1097/ALN.0000000000002603.

- Trauma patients present many challenges to anesthesia team - consider dedicated teams with structured plans

- Upon arrival to OR, rapid assessment and safe transition to incision paramount

- May have to modify delivery of anesthetic to hemodynamics (risk of awareness)

- Most all hypotension is volume-responsive in trauma - must be careful to resist overresuscitation (goal-directed)

- Vasopressors are reasonable adjunct to judicious fluid replacement but are unlikely to benefit hemorrhagic shock alone (consider vasopressin?)

- Minimize crystalloid resuscitation in hemorrhagic trauma, transition to balanced blood product administration

- Dont forget about pain and emotional stressors postoperatively