

THE “EXACT SCIENCE” OF PERIOPERATIVE FLUID MANAGEMENT

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OBJECTIVES

- WHY THIS IS SUCH A RELEVANT TOPIC
- HOW DID WE GET HERE?
- ARE WE HARMING PATIENTS?
- WHAT CAN WE DO TO FIX IT?
- LOOK AT GOAL DIRECTED THERAPY

WVU Medicine.

UNIVERSITY HEALTH
ASSOCIATES



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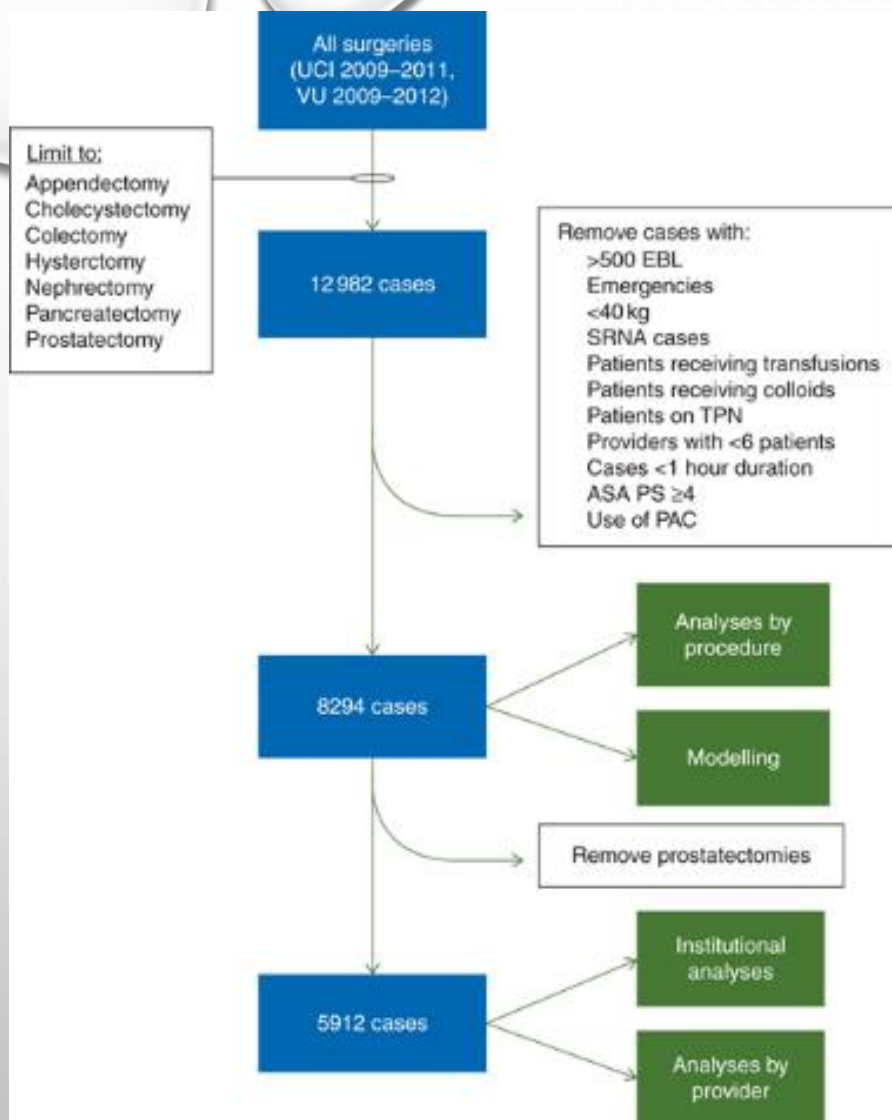
DISCLAIMERS

- FORMER CONSULTANT FOR EDWARDS LIFESCIENCES

**LET'S GET
STARTED**



WHY IS THIS RELEVANT?



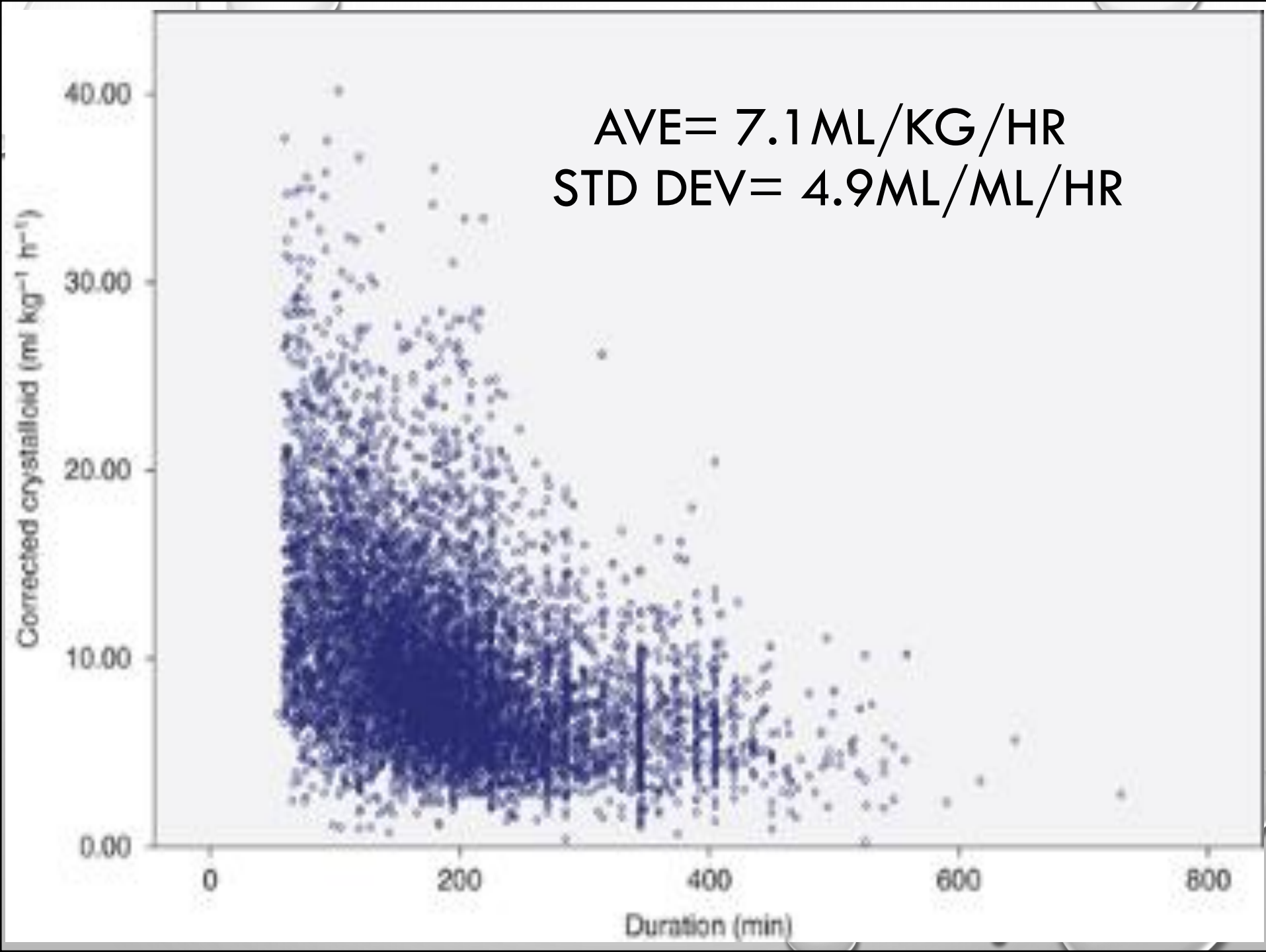
- RETROSPECTIVE OBSERVATIONAL STUDY
- COMMON ABDOMINAL SURGERIES
- N=5912

[Br J Anaesth](#). 2015 May;114(5):767-76. doi: 10.1093/bja/aeu452. Epub 2015 Jan 13.

Variability in practice and factors predictive of total crystalloid administration during abdominal surgery: retrospective two-centre analysis.

Lilot M¹, Ehrenfeld JM², Lee C³, Harrington B³, Cannesson M³, Rinehart J⁴.

AVE= 7.1 ML/KG/HR
STD DEV= 4.9 ML/ML/HR



THE GREATEST PREDICTOR

- THE PROVIDER IN THE CASE
- 75KG 4-HOUR PROCEDURE WITH 400CC EBL AND 1 ML/KG/HR UOP



or



Long story short,
I'm right and all
of you are wrong.

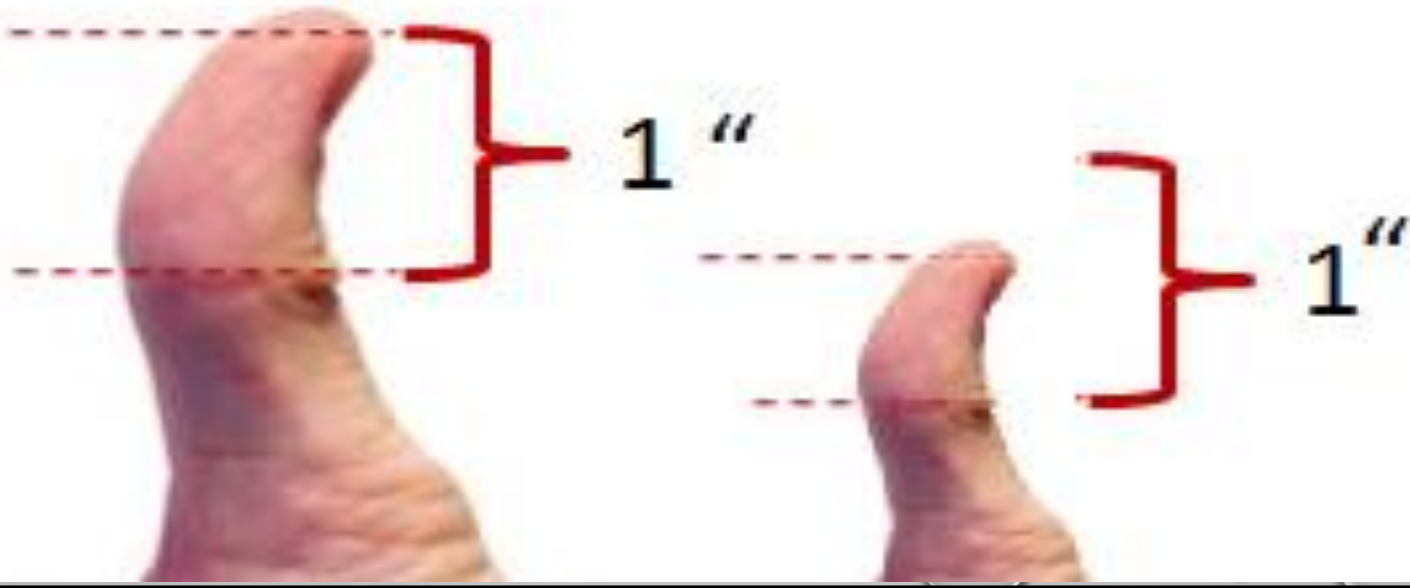


Difference of Opinion
Or
Lack of Vigilance



HOW DID WE GET HERE?

The "Rule of Thumb" just doesn't always work!



ARE THEY REALLY HYPOVOLEMIC?

Table 1. Fasting and Pharmacologic Recommendations

A. Fasting Recommendations*

Ingested Material	Minimum Fasting Period†
• Clear liquids‡	2h
• Breast milk	4h
• Infant formula	6h
• Nonhuman milk§	6h
• Light meal**	6h
• Fried foods, fatty foods, or meat	Additional fasting time (e.g., 8 or more hours) may be needed

Practice Guidelines for Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration: Application to Healthy Patients Undergoing Elective Procedures: An Updated Report by the American Society of Anesthesiologists Task Force on Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration* *Anesthesiology* 3 2017, Vol.126, 376-393.

Br J Anaesth. 2014 May;112(5):835-41. doi: 10.1093/bja/aet478. Epub 2014 Feb 3.

Preoperative fasting does not affect haemodynamic status: a prospective, non-inferiority, echocardiography study.

Muller L¹, Brière M, Bastide S, Roger C, Zoric L, Seni G, de La Coussaye JE, Ripart J, Lefrant JY.



“RULE OF THUMB” NPO REPLACEMENT

- HOLLIDAY SEGAR NOMOGRAM (1957)
 - 4CC/KG FOR THE FIRST 10KG
 - 2CC/KG FOR THE NEXT 10KG
 - 1CC/KG FOR REMAINDER OF THE DIFFERENCE
 - FOR ADULTS IT USUALLY EQUALS WT (KG) +40CC
- REPLACE 50% OF THE NPO LOSS WITHIN 1ST HOUR
- REPLACE 25% IN THE NEXT HOUR
- REPLACE REMAINING 25% IN THE 3RD HOUR



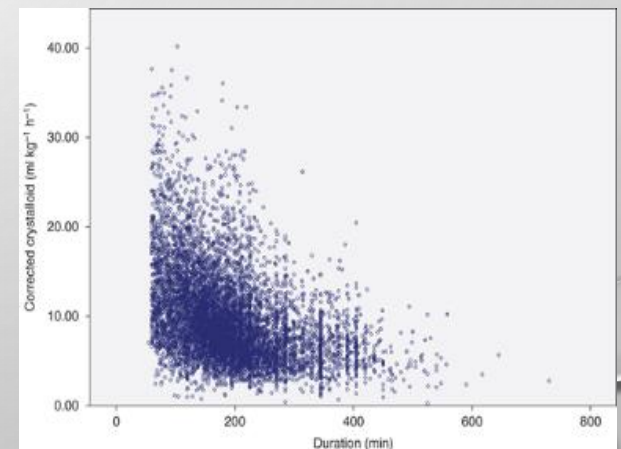


INTRAOPERATIVE MAINTENANCE

- NON QUANTIFIABLE INTRAOPERATIVE LOSSES
- **SMALL SURGICAL PROCEDURES:** 1 TO 3 ML/KG/HR [SUCH AS HAND SURGERY OR TUBAL LIGATIONS]
- **MEDIUM PROCEDURES:** 3 TO 6 ML/KG/HR [SUCH AS A CHOLECYSTECTOMY]
- **LARGE PROCEDURES:** 6 TO 10 ML/KG/HR [SUCH AS COLON RESECTION OR A WHIPPLE OPERATION]
- **SUBJECTIVE ESTIMATION OF BLOOD LOSS**

RELIABLE INDICES AND RELIABLE RESPONSE?

- HEART RATE
 - NOT SENSITIVE OR SPECIFIC
- BLOOD PRESSURE
 - BLOOD VOLUME OF UP TO 20-30% WITH MINIMAL CHANGE IN BP DESPITE MEASURABLE IMPAIRMENT TO END ORGANS
- CENTRAL VENOUS PRESSURE
- “GUT FEEL” AND ASSESSMENT OF THE SITUATION
- FLUID VS VASOACTIVE VS INOTROPIC
- LACK OF SYSTEMATIC APPROACH

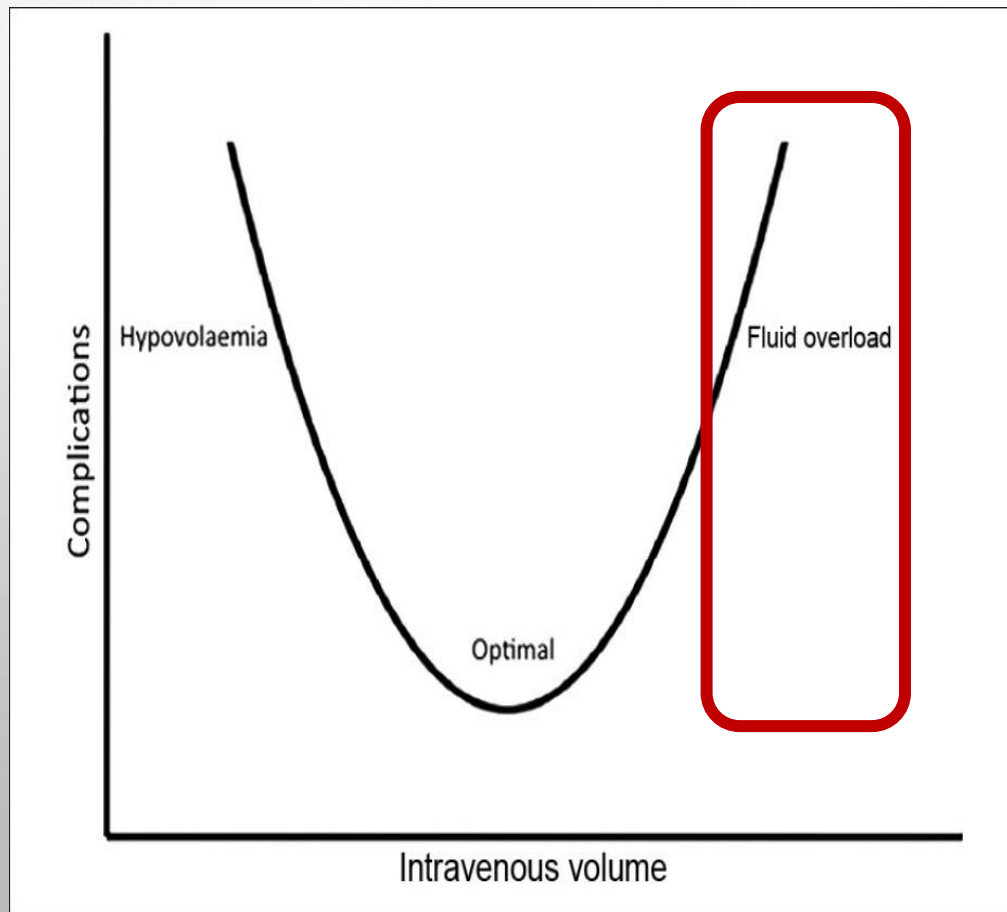




" I thought you were supposed to do no harm ! "

**ARE WE
HARMING
THE
PATIENT?**

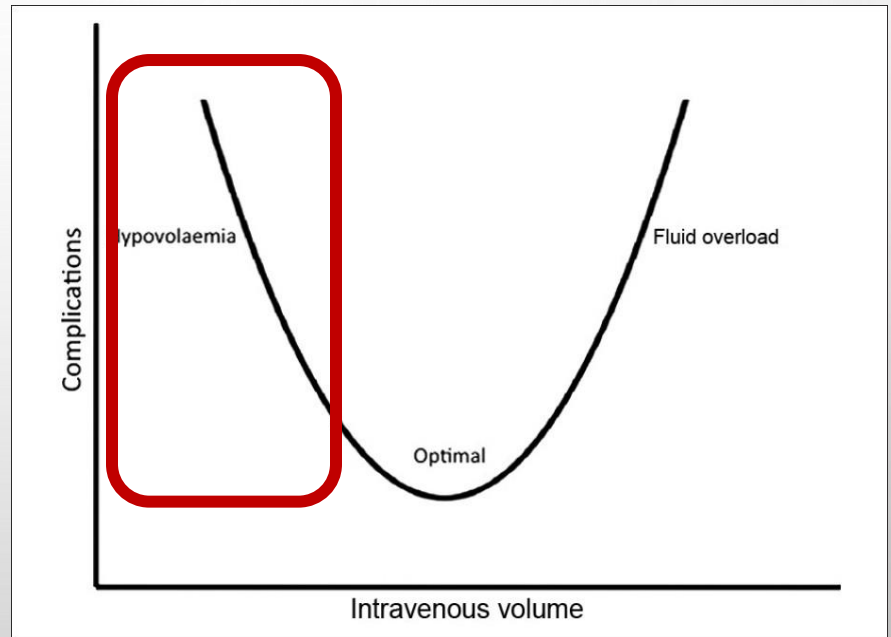
UNRESTRICTED APPROACH



- INTERSTITIAL EDEMA
- DECREASED CELLULAR METABOLISM
- RISK FOR PULM EDEMA AND HEART FAILURE
- HEMODILUTION
- COAGULOPATHY
- INCREASED INFLAMMATORY RESPONSE
- INCREASED HEALING TIME
- DECREASE PATIENT SATISFACTION
- INCREASED HLOS
- INCREASE COST

“KEEP FLUID TO A MINIMUM”

- ASSOCIATED WITH LESS POSTOPERATIVE COMPLICATIONS
 - LESS WOUND INFECTIONS
 - DECREASED HEALING TIMES
 - CARDIOPULMONARY SEQUELAE
- BIG PUSH IN CURRENT LITERATURE



KEEP FLUID TO A MINIMUM

Clinics in Colon
and Rectal Surgery

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Clin Colon Rectal Surg. 2013 Sep; 26(3): 197–202.

PMCID: PMC3747278

doi: [10.1055/s-0033-1351139](https://doi.org/10.1055/s-0033-1351139)

Perioperative Fluid Restriction

[Joshua I.S. Bleier](#), MD, FACS, FASCRS¹ and [Cary B. Aarons](#), MD¹

Table 1

Recent randomized trials assessing intraoperative fluid administration with restrictive and liberal strategies

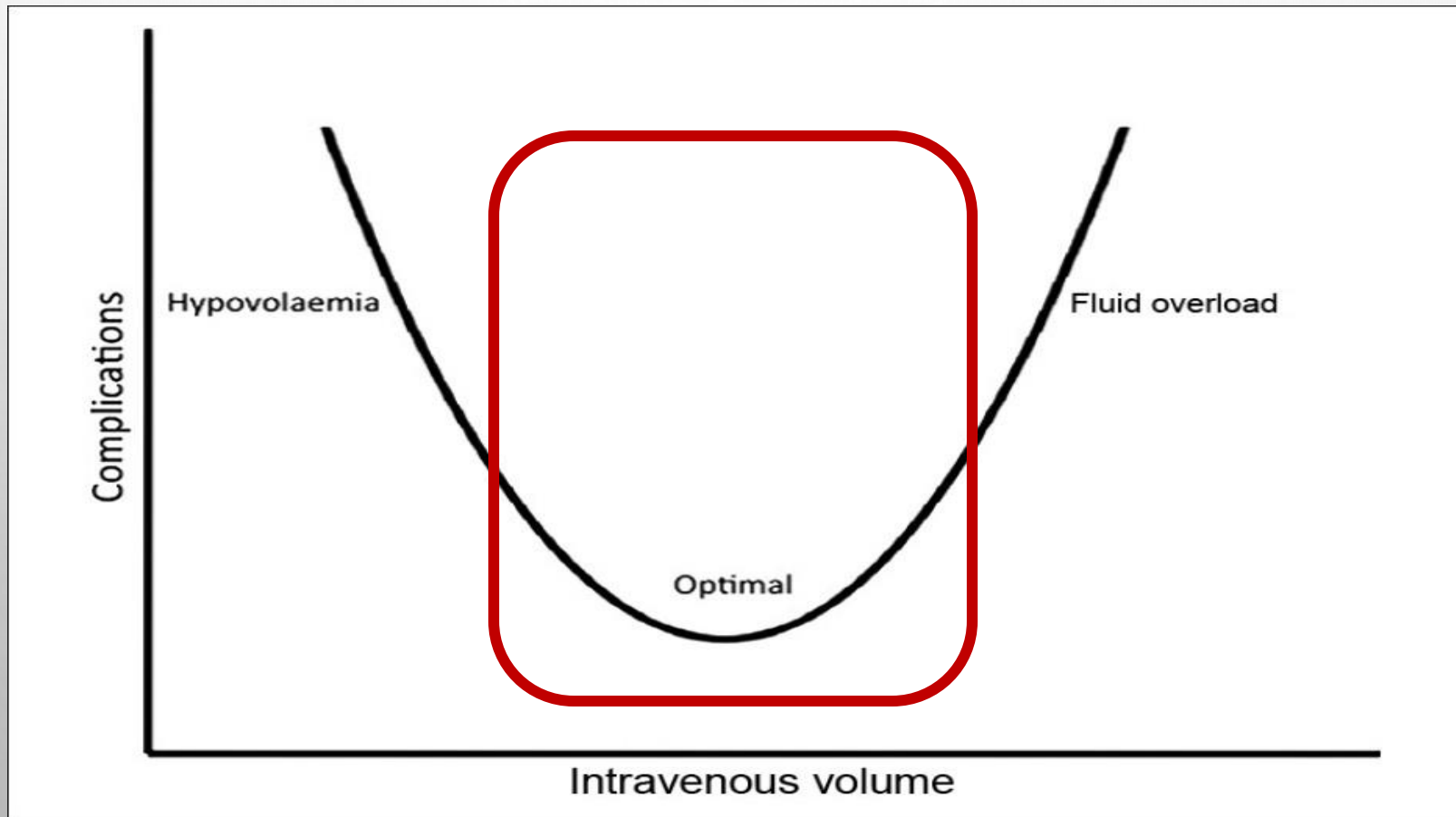
Study	# of patients	Procedures performed	Volume of fluid administered	Type of fluid administered	Primary end point(s)	Result(s)
Arkilic et al (2003) ²¹	56	Elective colon surgery	2.2 L vs. 3.8 L (mean)	Crystalloid	Tissue perfusion & oxygen tension	Liberal regimen increased oxygen tension & tissue perfusion
Brandstrup et al (2003) ¹⁵	172	Elective colon surgery	2.7 L vs. 5.4 L (median)	Colloid and crystalloid	Postoperative complications	Restrictive regimen decreased complications
Nisanevich et al (2005) ²⁰	152	Major intraabdominal surgery	1.4 L vs. 3.9 L (mean)	Crystalloid	Mortality & complications	Restrictive regimen decreased complications. No difference in mortality
Holte et al (2007) ¹⁸	32	Elective colon surgery	1.6 L vs. 5 L (median)	Colloid and crystalloid	Pulmonary function	Restrictive regimen improved pulmonary function



“KEEP FLUID TO A MINIMUM”

- NON STANDARDIZED DEFINITIONS OF THESE TERMS
 - UNABLE TO COMPARE STUDIES LOOKING AT RESTRICTIVE VS STANDARD
- RESTRICTIVE “GUIDELINES”
 - BASED ON EVIDENCE BASED PRINCIPLES
 - CAN BE MISINTERPRETED AND OFTEN DO NOT PROVIDE ENOUGH STRUCTURE TO REDUCE VARIABILITY
- PATIENT RESPONSES TO FLUID IS A VARIABLE IN OF ITSELF
- INCREASE DIZZINESS
- PONV
- DECREASED PATIENT SATISFACTION
- SENSE OF GENERAL “MALAISE”

WHAT I THINK THE ANSWER IS



WHAT THE **PATIENT** LIKES ABOUT OPTIMAL FLUID RESUSCITATION

- DECREASED PONV
- POTENTIALLY IMPROVED PULM
FUNCTION
- DECREASED NEUROHUMORAL STRESS
RESPONSE
- DECREASED DROWSINESS
- DECREASED DIZZINESS
- DECREASED THIRST
- INCREASED SENSE OF WELL-BEING



WHAT **HOSPITAL ADMINISTRATORS** LIKE ABOUT OPTIMAL FLUID RESUSCITATION

- DECREASE HLOS
- DECREASED VENTILATOR DAYS
- DECREASED TIME TO AMBULATION
- DECREASED COST
- DECREASED MORBIDITY AND MORTALITY
- OVERALL INCREASED SATISFACTION POSTOPERATIVELY

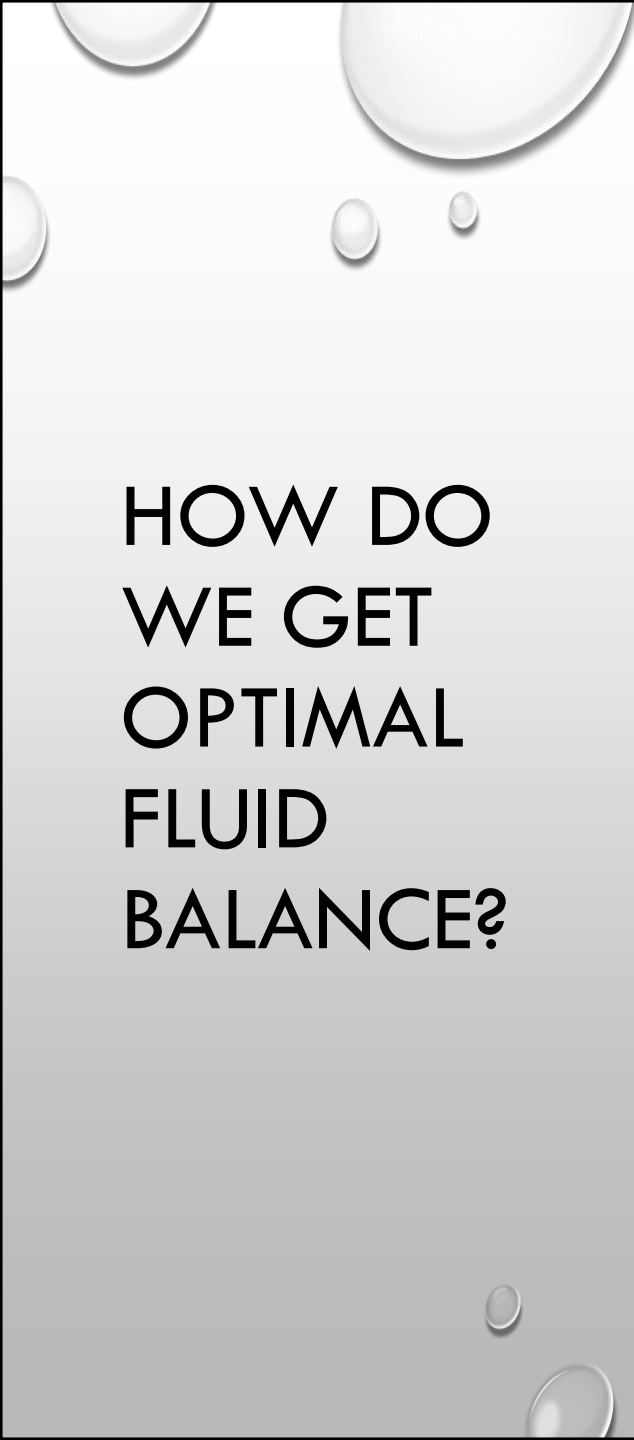
TO
RECAPITULATE



Dramatic variability in
care



If we don't hit it right the
consequences are
substantial



HOW DO
WE GET
OPTIMAL
FLUID
BALANCE?

GOAL DIRECTED THERAPY
THE RIGHT FLUID TO THE RIGHT
PATIENT AT THE RIGHT TIME



perioperative goal directed therapy



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Scholarly articles for perioperative goal directed therapy

Perioperative goal-directed therapy - Waldron - Cited by 10

Early goal-directed therapy in the treatment of severe ... - Rivers - Cited by 9611

Early goal-directed therapy after major surgery reduces ... - Pearse - Cited by 730



Changing medical culture where we reduce variability



Pay for quality not quantity



Outcomes oriented reimbursement



Bundled payments



Protocolized care coming down the pike

GDT

First started really building a literature presence in the early 2000s

Potentially a major component of Enhanced Recovery after surgery (ERAS)

Professor Henrik Kehlet- Denmark 1990'S

Reduced LOS for major colorectal surgery from 5-10 to median of 2

Searching for the “optimal” space between bowel ischemia and bowel edema- GDT

[Perioper Med \(Lond\)](#). 2015; 4: 3.

PMCID: PMC4403901

Published online 2015 Apr 10. doi: [10.1186/s13741-015-0014-z](https://doi.org/10.1186/s13741-015-0014-z)

Perioperative fluid therapy: a statement from the international Fluid Optimization Group

[Lais Helena Camacho Navarro](#), [Joshua A Bloomstone](#), [Jose Otavio Costa Auler, Jr](#), [Maxime Cannesson](#), [Giorgio Della Rocca](#), [Tong J Gan](#), [Michael Kinsky](#), [Sheldon Magder](#), [Timothy E Miller](#), [Monty Mythen](#), [Azriel Perel](#), [Daniel A Reuter](#), [Michael R Pinsky](#), and [George C Kramer](#)

- 72 INDUSTRY LEADERS INVITED. 14 ATTENDED
- REVIEW OF ALL RELEVANT LITERATURE REGARDING COMMON TECHNIQUES
- 2015 RELEASED THIS STATEMENT WITH THEIR RECOMMENDATIONS



INTERNATIONAL
FLUID
OPTIMIZATION
GROUP
STATEMENT

Find the sweet spot

Lots of variability amongst the studies

Common theme- Improved outcomes come from how and when volume therapy is administered to a given patient.

INTERNATIONAL FLUID OPTIMIZATION GROUP CONCLUSION

CONCLUSIONS:

“WE RECOMMEND THAT BOTH PERIOPERATIVE FLUID CHOICE AND THERAPY BE **INDIVIDUALIZED**. PATIENTS SHOULD RECEIVE FLUID THERAPY **GUIDED BY PREDEFINED PHYSIOLOGIC TARGETS**. SPECIFICALLY, FLUIDS SHOULD BE ADMINISTERED WHEN PATIENTS REQUIRE AUGMENTATION OF THEIR PERFUSION AND ARE ALSO VOLUME RESPONSIVE.”

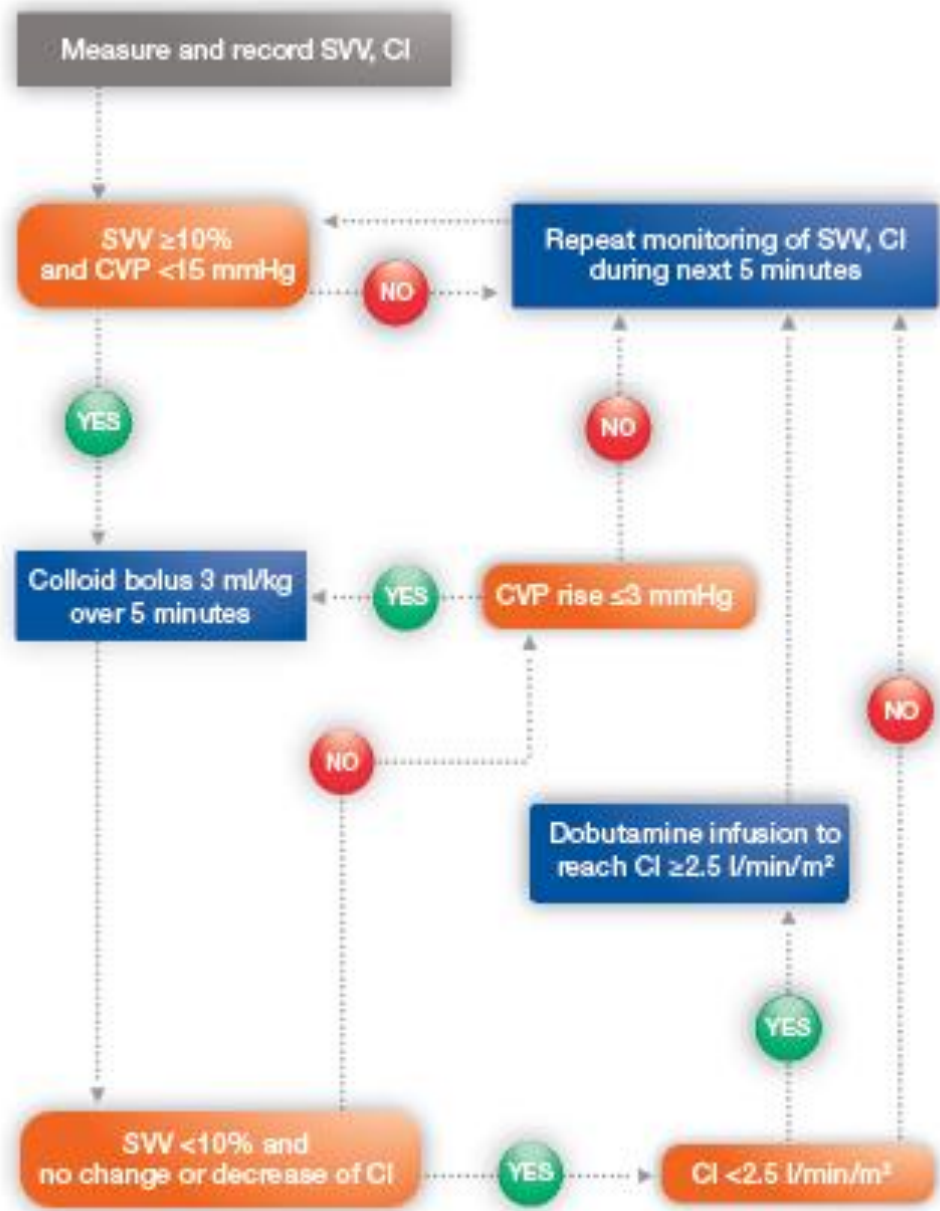


FIND A ROAD MAP

- EVIDENCE-BASED PROTOCOL
 - **GUIDELINES** VS **ALGORITHM**
- ALGORITHMS SHOULD NOT BE “FIXED”
- ALLOW FOR INDIVIDUALIZING FLUID THERAPY
- DEVIATION FROM AN ALGORITHM IS OK.

BENES PROTOCOL

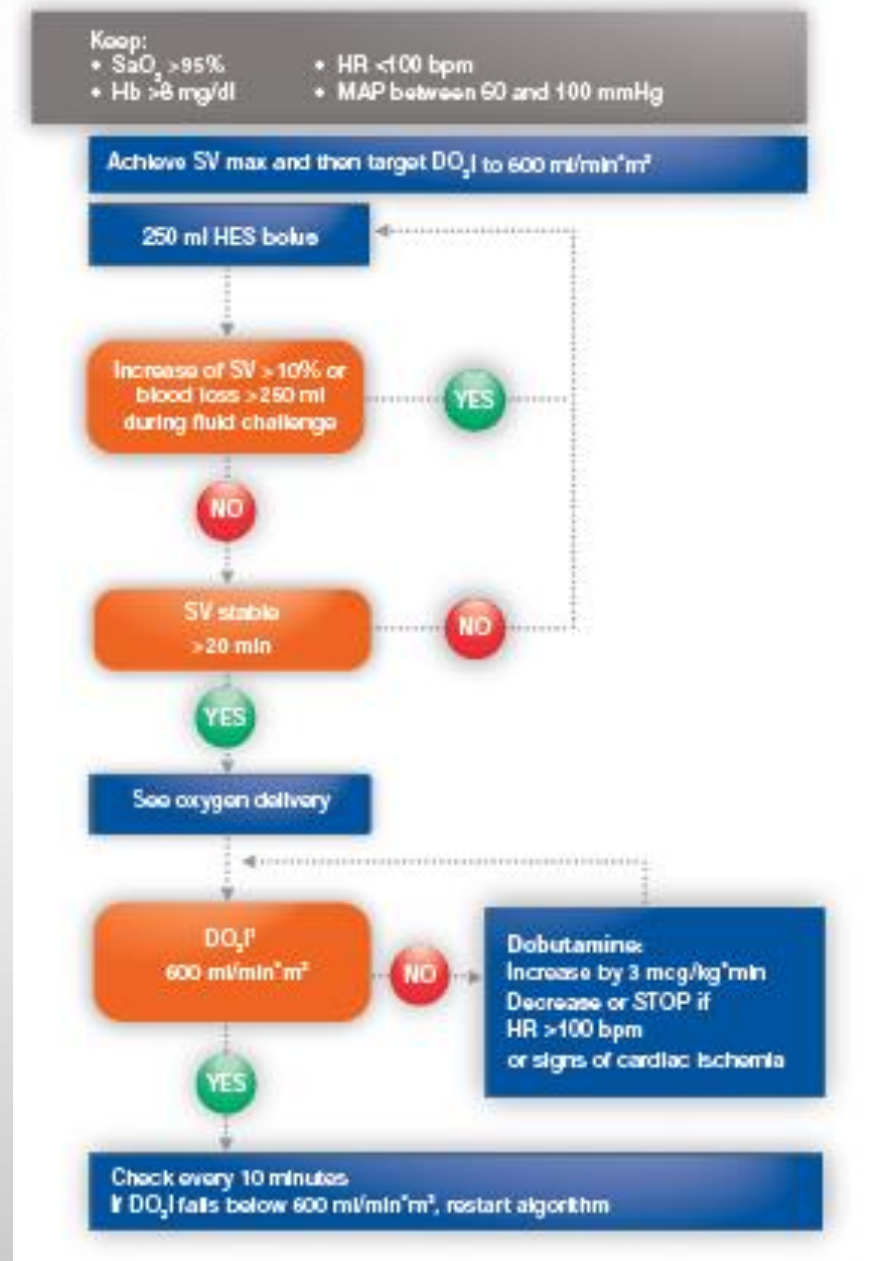
- MAJOR ABD SURGERY
- SVV, CVP, CI
- 50% REDUCTION IN 30-DAY COMPLICATIONS
- 10% REDUCTION IN LOS



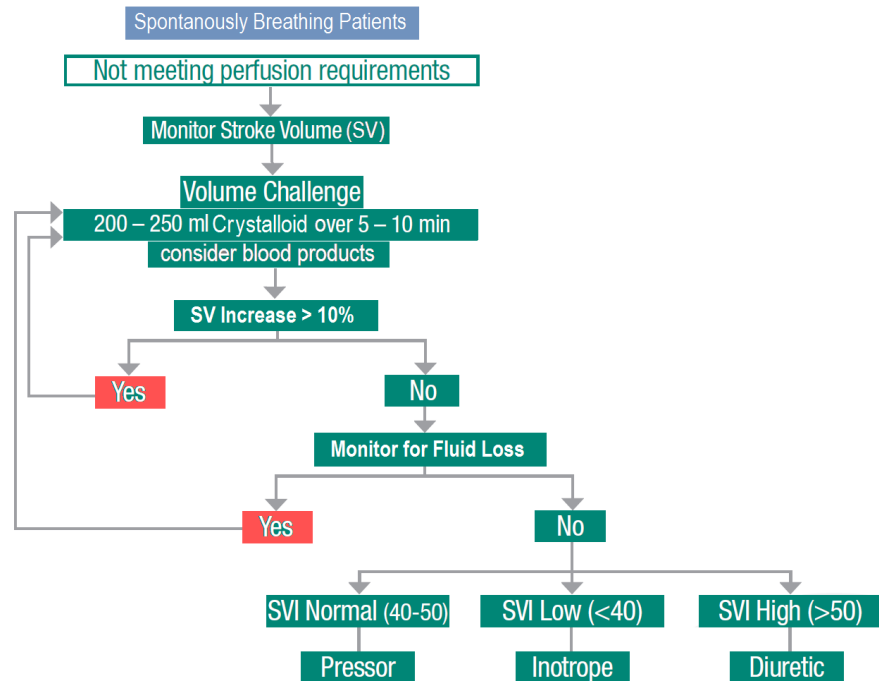
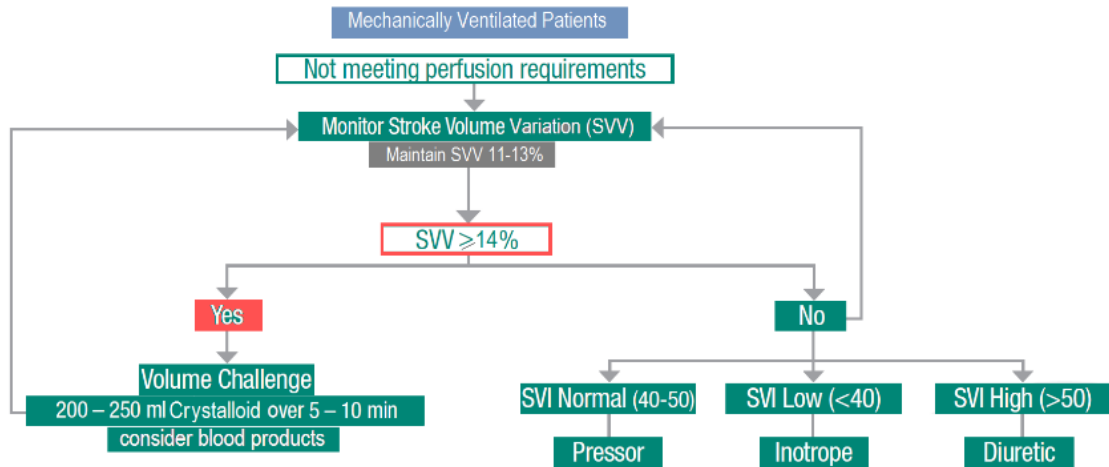
1. Benes J, Chytra I, Altmann P, et al. Intraoperative fluid optimization using stroke volume variation in high risk surgical patients: results of prospective randomized study. *Crit Care*. 2010;14(3):R118.

CECCONI PROTOCOL

- TOTAL HIPS UNDER REGIONAL
- ASA II
- SV AND O₂ DELIVERY
- 20% REDUCTION IN POST COMPLICATIONS

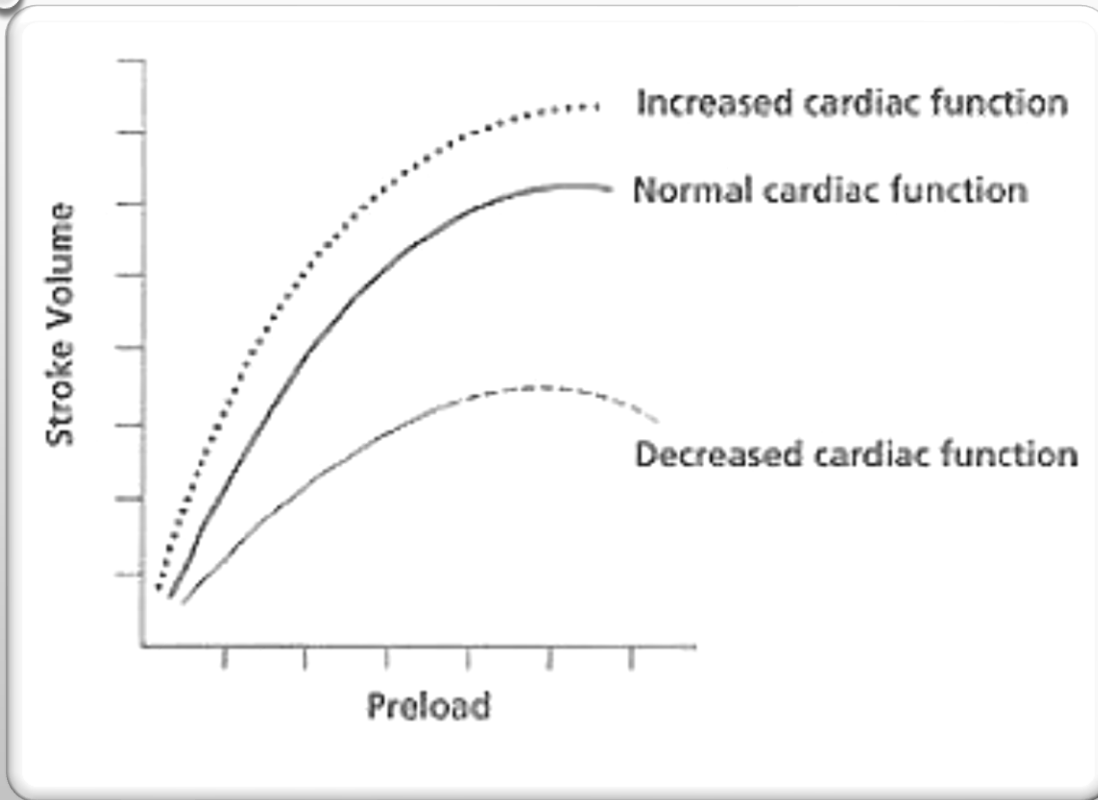


2. Cecconi M, Fasano N, Langiano N, et al. Goal directed haemodynamic therapy during elective total hip arthroplasty under regional anaesthesia. *Crit Care*. 2011;15(3):R132.



WVUH

WHAT DO THEY HAVE IN COMMON

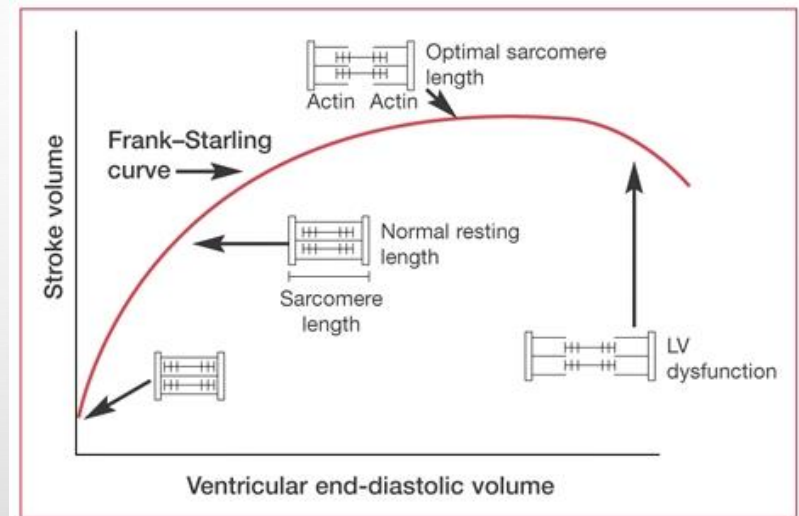


- OPTIMIZING THE FRANK STARLING CURVE
- FLUID CHALLENGES ARE THE MAINSTAY
- BASED ON ACHIEVING NORMALIZED FLUID STATUS
- STRONGEST PROTOCOLS HAVE AN ARM TO DEAL WITH NON-RESPONDERS.
- DEPENDENT UPON MEASUREMENT OF **DYNAMIC INDICES**

WHAT VEHICLE WILL YOU USE TO REACH YOUR GOAL?

- DYNAMIC INDICES

- CO DELTA
- SV DELTA
- PLETH VARIABILITY INDEX OR PLETH WAVEFORM VARIABILITY
- SYSTOLIC PRESSURE VARIATION
- STROKE VOLUME VARIABILITY
- LV INDEX
- MIXED VENOUS SATURATIONS



WHERE HAVE WE OBTAINED THAT INFO IN THE PAST?



Step up from Sodium Thiocyanate

Obituary: pulmonary artery catheter 1970 to 2013

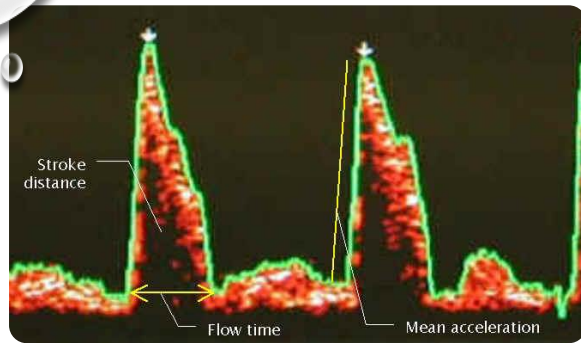
[Paul E Marik](#)¹

PAC grew rapidly, reaching manhood in 1986 where, in the US, he was shown to influence the management of over 40% of all ICU patients. His reputation, however, was tarnished in 1996 when Connors and colleagues suggested that he harmed patients.

It also became clear that he was poorly understood and misinterpreted. Pretty soon after that, a posse of rivals (bedside echocardiography, pulse contour technology) moved into the neighborhood and claimed they could assess cardiac output more easily, less invasively and no less reliably

While a handful of die-hard followers continued to promote his mission, the last few years of his existence were spent as a castaway until his death in 2013.

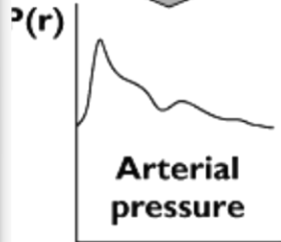
TIMES HAVE CHANGED



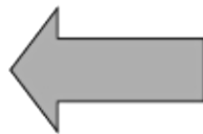
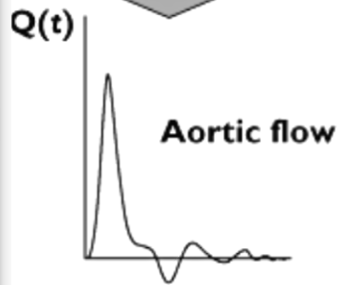
- “MINIMALLY-INVASIVE”
 - LIDCO
 - PICCO
 - FLOTRAC
 - ESOPHAGEAL DOPPLER
 - BIOIMPEDANCE
- “NON-INVASIVE”
 - MASSIMO RAD-7
 - CLEARLIGHT
 - LIDCO RAPID

radial / femoral artery

Pressure sensor



Algorithm
(Windkessel model)



Individual data;
weight, length, age, gender
or
Calibration;
thermo- or lithium dilutor



Cardiac output

PULSE CONTOUR ANALYSIS

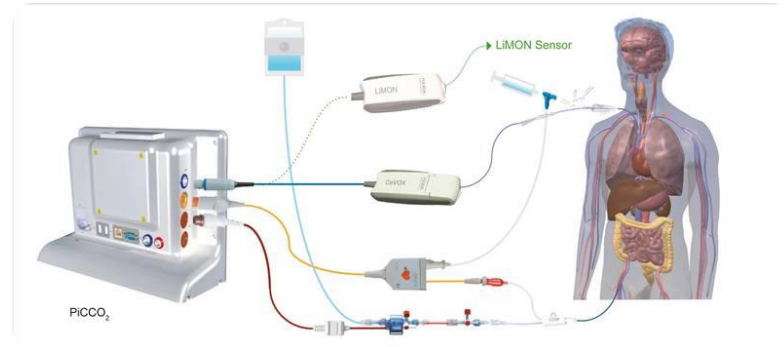
- CO
- SV
- SVR
- SVRI
- SVV
- SVI
- PVI
- AND SO MUCH MORE!!!!

○ LIMITATIONS WITH VARIABILITY INDICES

- LITERATURE ONLY SUPPORTS MECHANICAL VENTILATION WITH TV >8CC/KG
- ARRHYTHMIAS
- HIGHER PEEP
- VASODILATORS WILL INCREASE SVV
- OLD SVV STUDIES UTILIZED AN ALGORITHM THAT DID NOT ACCOUNT FOR PULSE TIME-
 - STUDIES INACCURATE COMPARED TO TODAY



FloTrac sensor



THIS DATA OBVIOUSLY COMES WITH A COST



COST: BENEFIT

DECREASED

- LOS
- COMPLICATIONS
- DAYS OF VENTILATION
- CRYSTALLOID USE
 - (INCREASED COLLOID)
- LACTATES
- RENAL COMPROMISE
- (INCREASED UOP)

WHAT ABOUT MAINTENANCE FLUIDS?

- MAINTENANCE FLUIDS:

WE RECOMMEND THAT MAINTENANCE FLUIDS BE ADMINISTERED AT A RATE OF 1 TO 2 ML/KG/H FOR PATIENTS UNDERGOING PROCEDURES OF LONGER DURATION OR MAGNITUDE. PATIENTS UNDERGOING OUTPATIENT PROCEDURES MAY BENEFIT FROM HIGHER MAINTENANCE FLUID RATES

[Perioper Med \(Lond\)](#). 2015; 4: 3.

PMCID: PMC4403901

Published online 2015 Apr 10. doi: [10.1186/s13741-015-0014-z](https://doi.org/10.1186/s13741-015-0014-z)

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WHAT
FLUID WILL
YOU USE?



- AGE OLD ARGUMENT: CRYSTALLOID VS COLLOID

- LITERATURE IS STILL NOT CLEAR
- DEPENDENT UPON REGION AND CULTURE

- IMPORTANT CONSIDERATIONS:

- COLLOIDS:

- LONGER LASTING EFFECT
- SYNTHETICS ARE OUT. ALBUMIN IS IN
- HIGHER COST

- CRYSTALLOIDS:

- TRANSIENT EFFECT
- USE OF BALANCED SOLUTION IS ESSENTIAL
- HAVE A FULL UNDERSTANDING OF WHAT YOU ARE GIVING.....



There are consequences to **EVERYTHING** we give





A CLOSER LOOK AT THE LITERATURE

GOAL DIRECTED THERAPY OUTCOMES

Perioperative goal-directed therapy and postoperative

Outcome metrics in the pre- and post-implementation periods

	Pre-implementation (n=128)	Post-implementation (n=203)	p value	Odds ratio (95 % CI)
Primary outcome				
LOS in the hospital (nights)	10 (6-16)	7 (5-11)	NA	NA
LOS in the hospital (log transformed)	2.31 ± 0.62	2.03 ± 0.57	0.0002	NA
Secondary outcomes				
LOS in the ICU (nights)	1 (1-3)	1 (0-2)	NA	NA

Conclusion

These results suggest that the implementation of a PI program focusing on the implementation of PGDT can transform fluid administration patterns and improve postoperative outcome in patients undergoing high-risk abdominal surgeries.

Extubation within 6 hours after surgery (n (%))	102 (79.7)	174 (86.1)	0.21	1.66 (0.76 -3.63)
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The effects of goal-directed fluid therapy based on dynamic parameters on post-surgical outcome: a meta-analysis of randomized controlled trials

Jan Benes  , Mariateresa Giglio, Nicola Brienza and Frederic Michard

Critical Care 2014 18:584 | <https://doi.org/10.1186/s13054-014-0584-z> | © Benes et al.; licensee BioMed Central Ltd. 2014

Received: 3 March 2014 | Accepted: 9 October 2014 | Published: 28 October 2014

14 RCTs with 961 participants

Limitations: Heterogeneity within the study designs

Conclusions

In surgical patients, we found that GDFTdyn decreased post-surgical morbidity and ICU length of stay. Because of the heterogeneity of studies analyzed, large prospective clinical trials would be useful to confirm our findings.

CONTROVERSY

Body of literature that supports and body that does not.



Arguments against:

studies are heterogeneous

No definition of the best end point

No definition of the best technology

Could be costly

How much is ERAS and how much is GDT?

CONTROVERSY

- RECENT ANALYSIS MAY SHOW THAT GDT AND ERAS MAY BE INDEPENDENT OF EACH OTHER

[Br J Surg](#). 2015 May;102(6):577-89. doi: 10.1002/bjs.9747. Epub 2015 Mar 11.

Meta-analysis of the effect of goal-directed therapy on bowel function after abdominal surgery.

[Gómez-Izquierdo JC](#)¹, [Feldman LS](#), [Carli F](#), [Baldini G](#).

- 13 TRIALS 1399 PATIENTS

CONCLUSION: GDT facilitated the recovery of bowel function, particularly in patients not treated within enhanced recovery programmes and in those undergoing colorectal operations.

CON: Perioperative Goal-Directed Fluid Therapy Is an Essential Element of an Enhanced Recovery Protocol?

Joshi, Girish P. MBBS, MD, FFARCSI; Kehlet, Henrik MD, PhD

Anesthesia & Analgesia: May 2016 - Volume 122 - Issue 5 - p 1261–1263

What is my interpretation of the literature and which way do I sway?

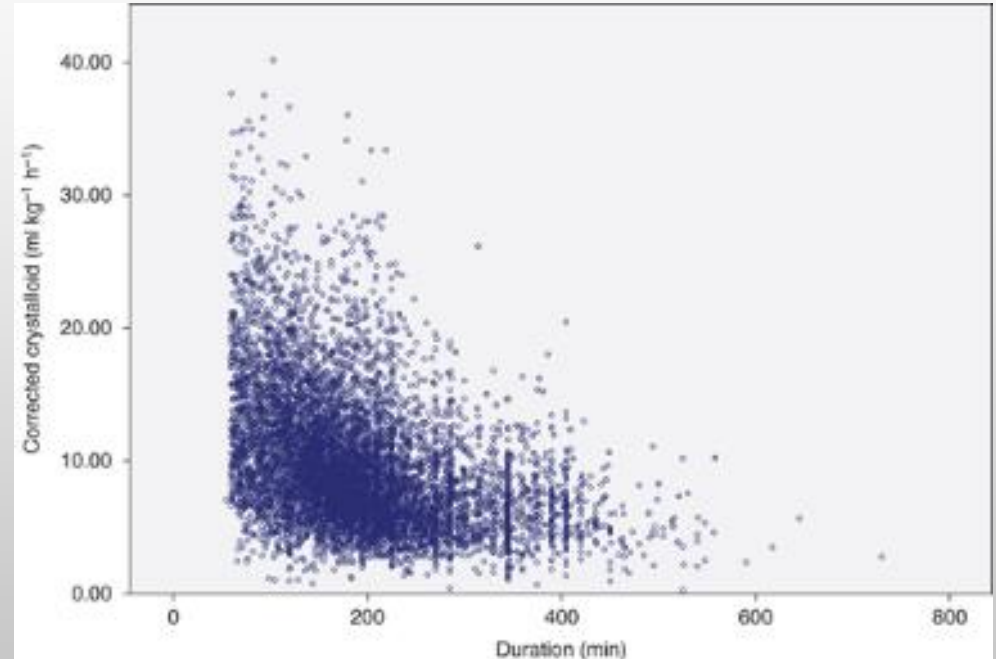
PRO: Perioperative Goal-Directed Fluid Therapy Is an Essential Element of an Enhanced Recovery Protocol

Cannesson, Maxime MD, PhD; Gan, Tong J. MD

Anesthesia & Analgesia: May 2016 - Volume 122 - Issue 5 - p 1258–1260

- “VARIABILITY IS THE ENEMY OF QUALITY”

- VARIABILITY OF PATIENTS IS EXPECTED
- VARIABILITY BETWEEN PROVIDERS AND INSTITUTIONS SHOULD NOT
- DEFINING A REASONABLE ENDPOINT CANNOT BE BAD
- DO WE WAIT TO IMPLEMENT GDT UNTIL ALL QUESTIONS ANSWERED?
- BASICS



CONCLUSION

- PROVIDER VARIABILITY LEADS TO DIVERSE OUTCOMES
- WE MAY BE HARMING MORE PATIENTS THAN WE THINK BY NOT HITTING THE SWEET SPOT.
- WE FIX IT BY STANDARDIZING OUR CARE BASED ON EVIDENCE BASED CONCEPTS THAT ARE PATIENT SPECIFIC AND DYNAMIC
- GDT WITH OR WITHOUT ERAS MAY IMPROVE OUTCOMES, REDUCE MORBIDITY, MORTALITY, LOS AND COST



