2025 GSA Winter Meeting

Hyatt Regency Atlanta Perimeter at Villa Christina
February 8

Syllabus

Activity Directors:

Andrew Anderson, MD
Lee Whitton, MD

Jointly Provided by... American Society of Anesthesiologists™

EMORY UNIVERSITY SCHOOL OF MEDICINE
Department of Anesthesiology
Division of Cardiothoracic Anesthesiology

Anesthesia for Structural Heart Procedures

Ratna Vadlamudi, MD, FASE
Program Director, Adult Cardiothoracic Anesthesiology Fellowship
Associate Professor, Department of Anesthesiology

DISCLOSURES

None

OBJECTIVES

Recognize the indications and procedural considerations for TAVR, MitraClip, and Watchman left atrial appendage occluder device (LAA OD)

Identify the indications for general anesthesia and monitored anesthesia care for structural heart procedures

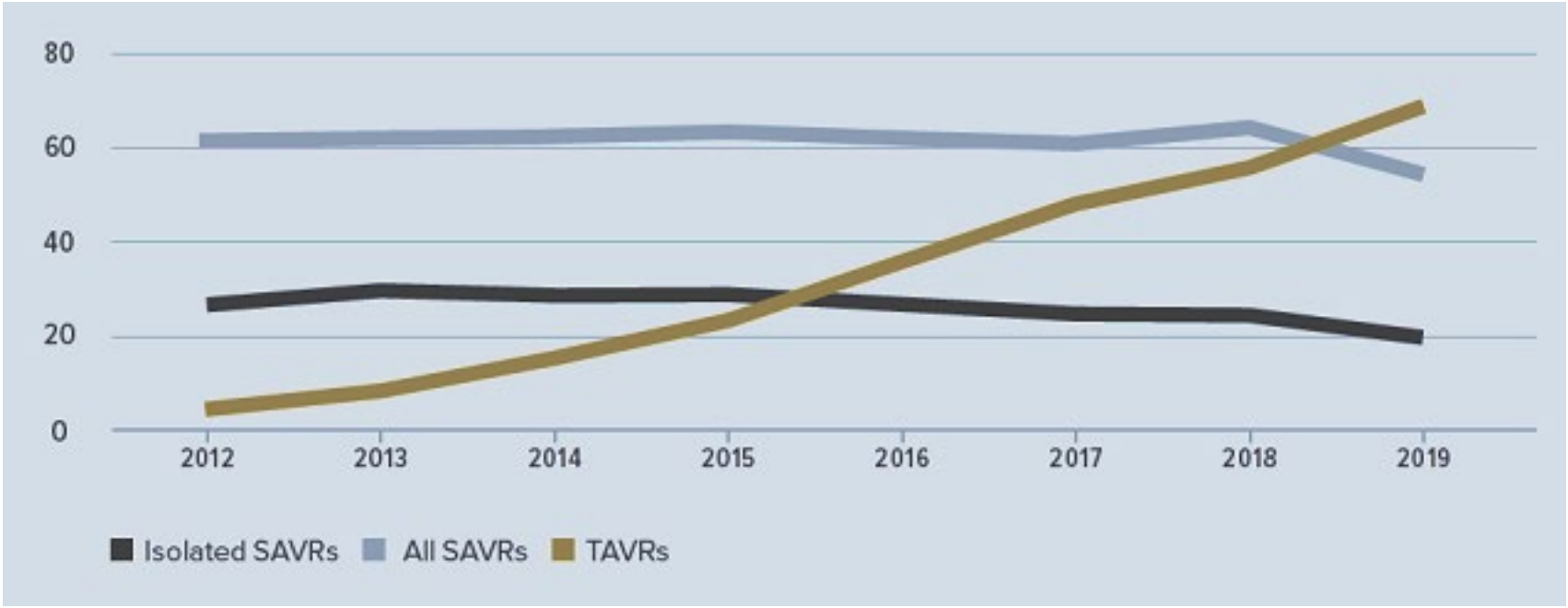
Describe the anesthetic considerations for specific structural heart procedures, including possible need for invasive monitoring

Manage potential complications associated with structural heart procedures, including ventricular perforation, tamponade, stroke, and arrhythmias

BACKGROUND

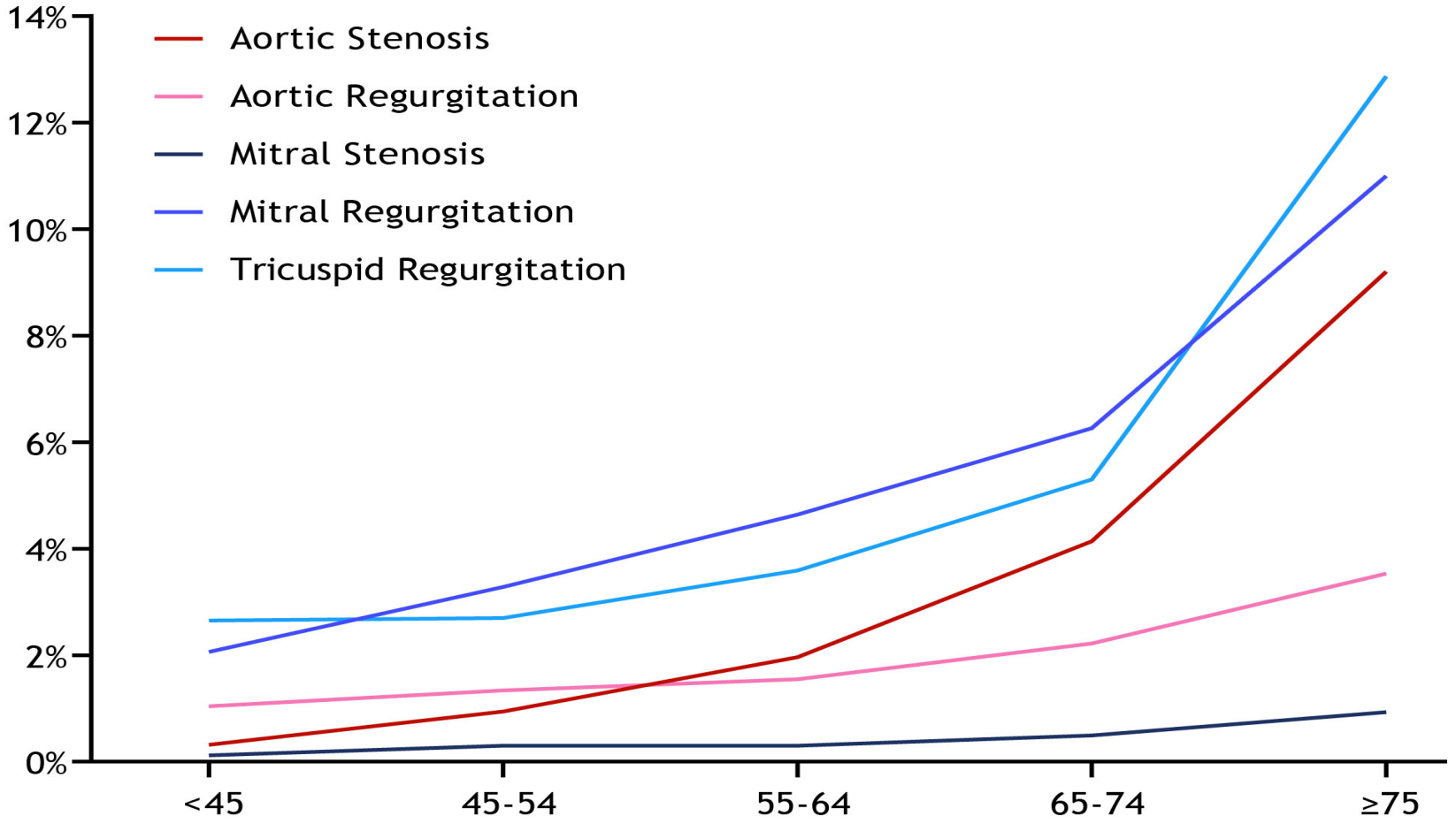
> 6 million + patients with heart failure

- 6.5 million hospital days annually
- 1 year mortality 30%
- 5 year mortality 40%



Agarwal MA, Fonarow GC, Ziaeian B. National Trends in Heart Failure Hospitalizations and Readmissions From 2010 to 2017. *JAMA Cardiol*. 2021 Aug 1;6(8):952-956
Osenenko KM, Kuti E, Deighton AM, Pimple P, Szabo SM. Burden of hospitalization for heart failure in the United States: a systematic literature review. *J Manag Care Spec Pharm*. 2022 Feb;28(2):157-167
https://www.sts.org/publications/sts-news/tavr-surges-past-surgery-us-avr-treatment-volume

BACKGROUND



Brennan, JM et al. Contemporary Prevalence of Valvular Heart Disease and Diagnostic Variability Across Centers. ACC Scientific Session 2022

BACKGROUND

Structural heart

Transcatheter valve procedures

Novel procedures

Electrophysiology

Left atrial appendage occluder devices

Catheter ablations

CIED implant vs revision vs extraction

Novel procedures

BACKGROUND

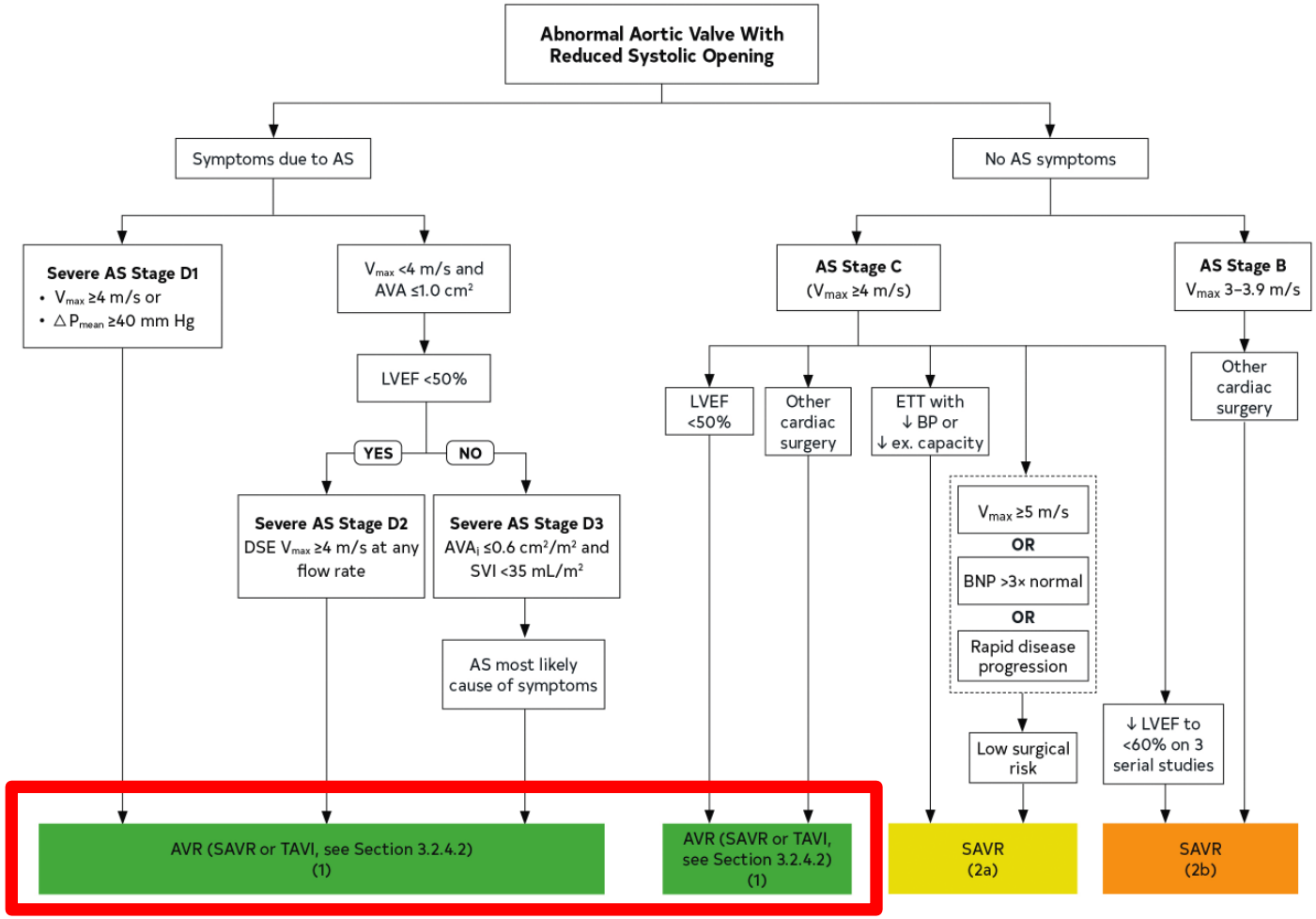
2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease

A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

Circulation 2021; 143: e72-e227

TAVR

BACKGROUND



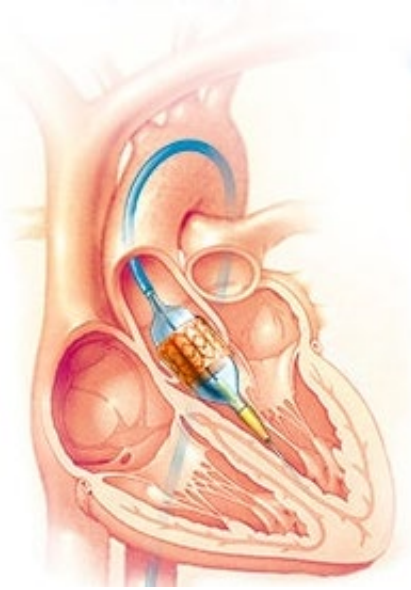
Circulation 2021; 143: e72-e227

TAVR

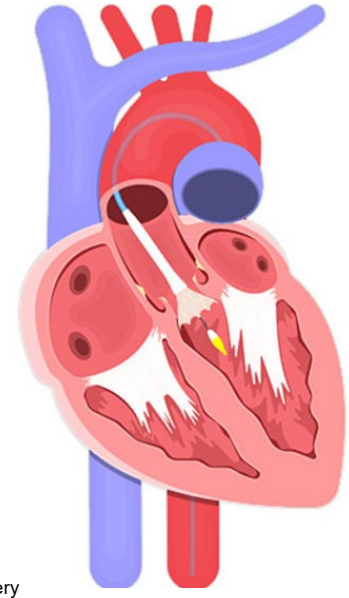
- FDA approved in 2011
- Approved for low-risk patients in 2019

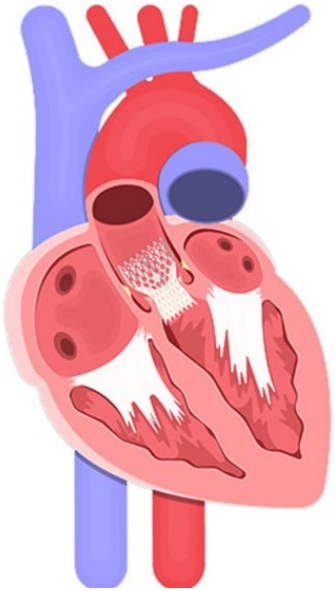
Mahmaljy H, Tawney A, Young M. Transcatheter Aortic Valve Replacement. [Updated 2023 Jul 24]. In: StatPearls [Internet]

TAVR



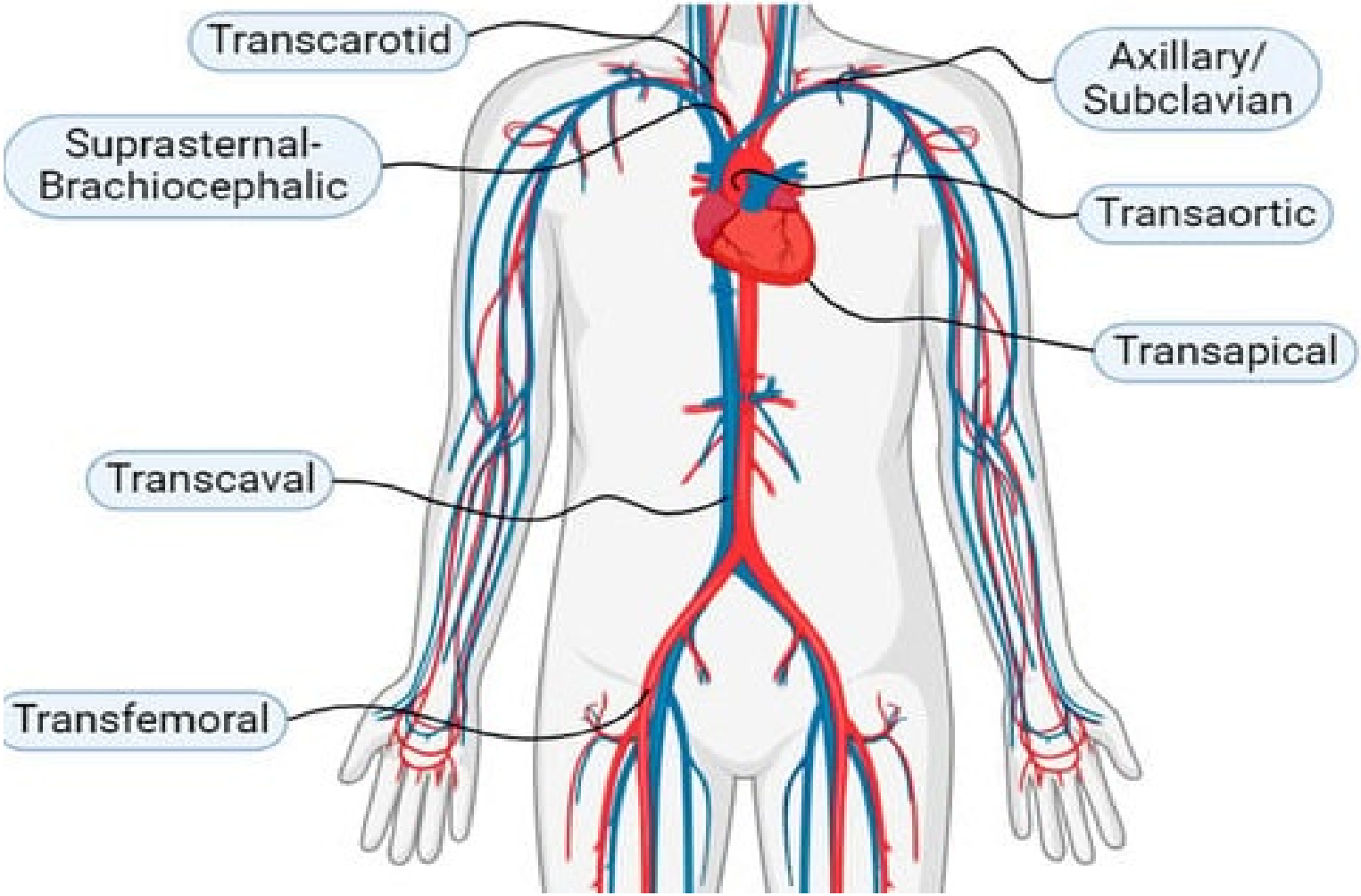
- Severe AS
  - With or without symptoms
  - Low risk
  - Valve-in-valve for failed bioprosthesis
- Commonest approach is retrograde transfemoral
  - Echocardiographic and fluoroscopic guidance





https://www.mayoclinic.org/tests-procedures/transcatheter-aortic-valve-replacement/multimedia/img-20303164
https://cv.prismahealth.org/news/transcatheter-aortic-valve-replacement-tavr-an-advanced-alternative-to-open-heart-surgery

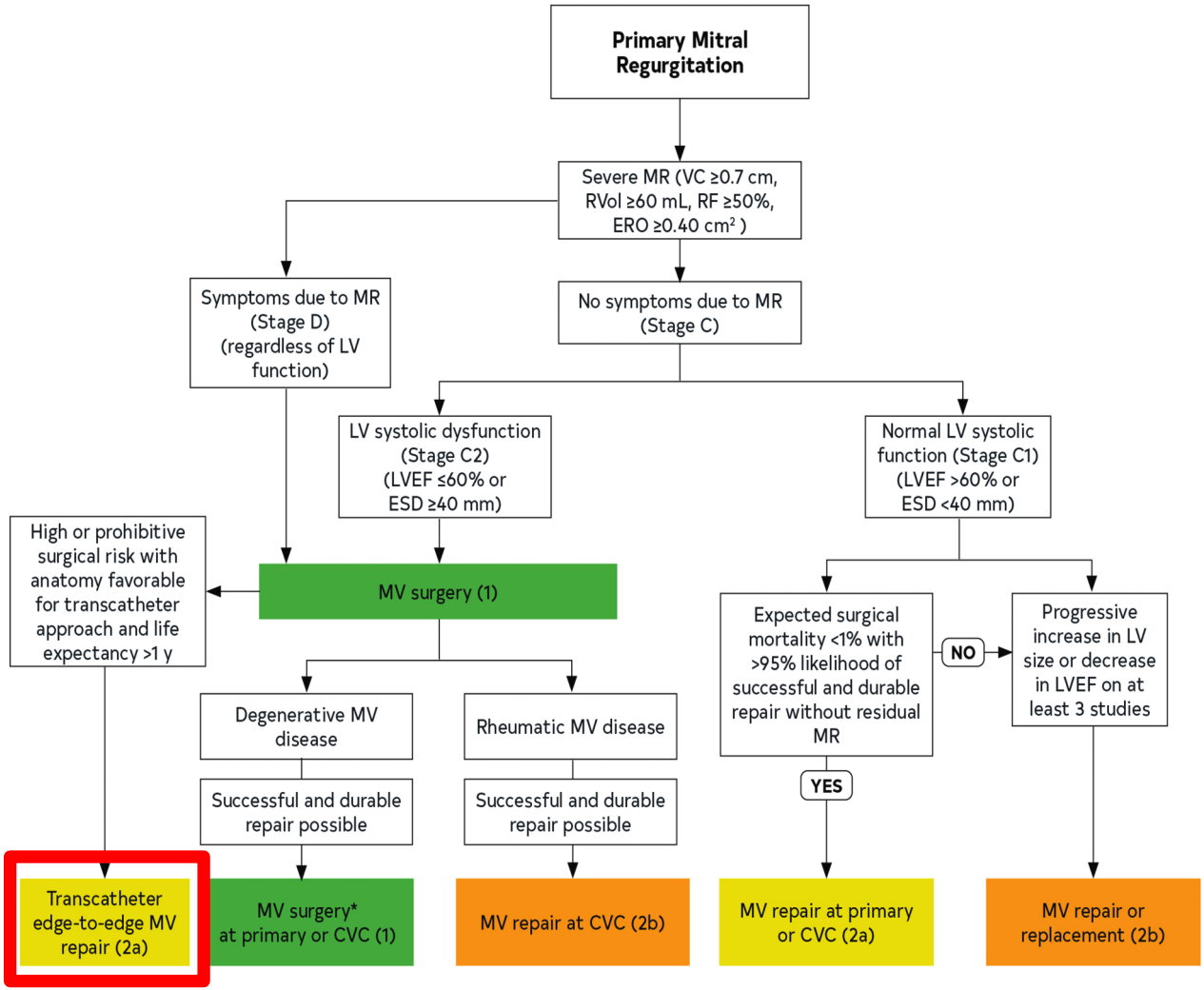
TAVR



Lutz K, Asturias KM, Garg J, Poudyal A, Lantz G, Golwala H, Doberne J, Politano A, Song HK, Zahr F. Alternative Access for TAVR: Choosing the Right Pathway. *Journal of Clinical Medicine*. 2024; 13(12):3386

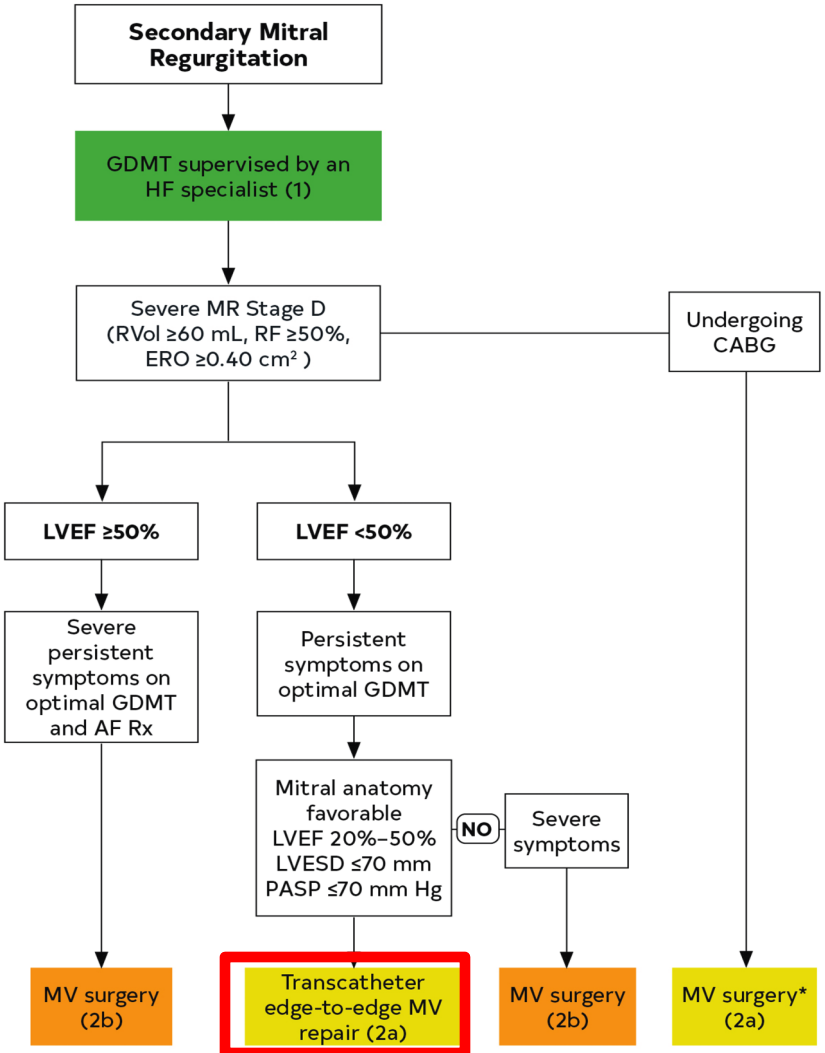
MitraClip

MITRACLIP



Circulation 2021; 143: e72-e227

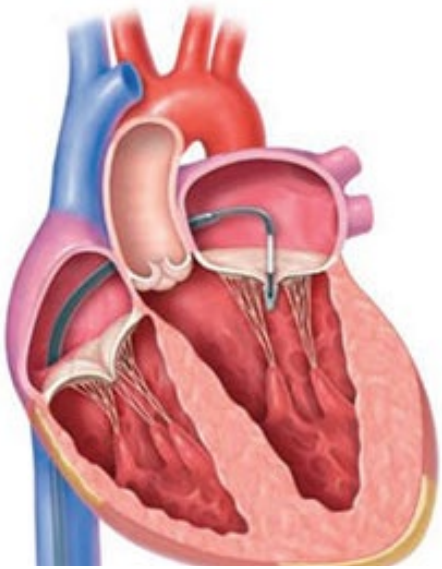
MITRACLIP

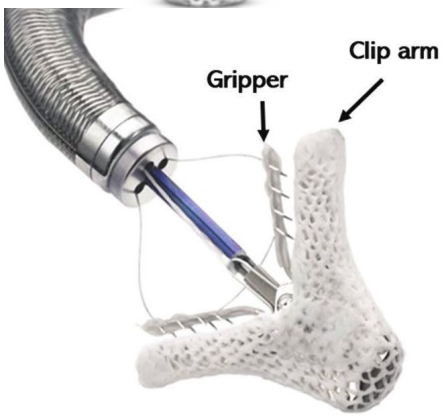


Circulation 2021; 143: e72-e227

MITRACLIP

FDA approved in 2013	Primary MR in prohibitive risk patients
Approved in 2019	Secondary MR



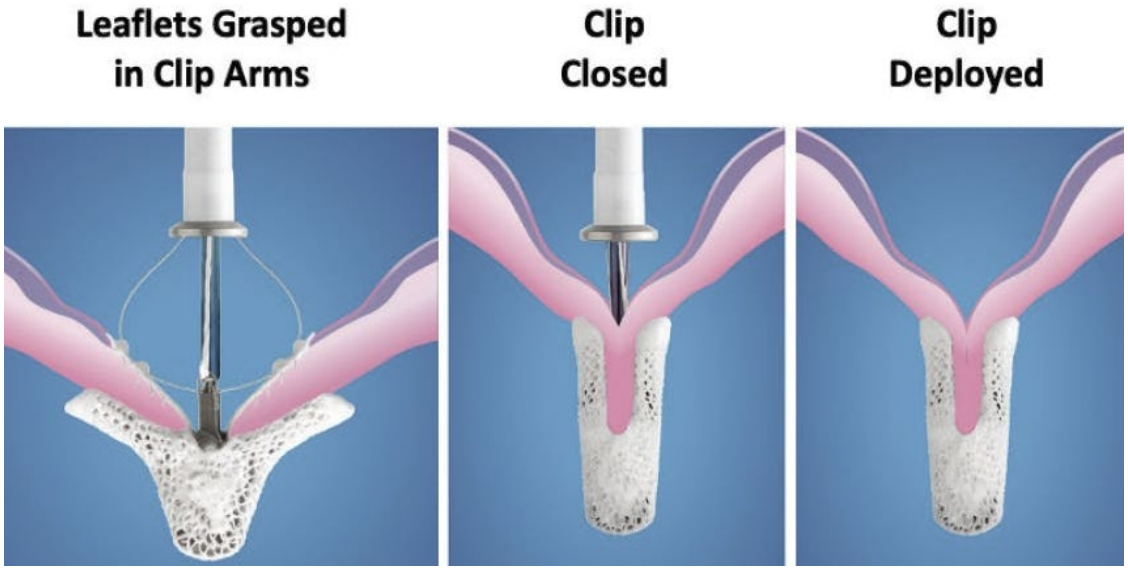


Burkule Nj, Bansal M. Transesophageal Echocardiography for Mitral Valve Transcatheter Edge-to-Edge Repair. *J Indian Acad Echocardiogr Cardiovasc Imaging*. 2022; 6: 227-35.

MITRACLIP

Femoral venous access followed by transseptal puncture

TEE and fluoroscopic guidance of clip arms to grasp leaflet pathology



https://citoday.com/articles/2023-sept-oct-supplement/design-development-and-clinical-experience-of-four-mitraclip-device-generations

WATCHMAN

WATCHMAN

Non-valvular atrial fibrillation is the most common arrhythmia
- Up to 5x increased risk for CVA

Majority of thrombus is localized in LAA in patients with atrial fibrillation

Warfarin/DOAC is effective at reducing stroke risk
- Chronic anti-coagulation can be problematic

☑ FDA approved in 2015

WATCHMAN

Femoral venous access followed by transeptal puncture

TEE and fluoroscopic assessment of LAA and guidance for device placement

COMPLICATIONS

COMPLICATIONS

Procedure related

Major vascular damage

Device embolization

Arrhythmia

Escalating need for cardiopulmonary support

Inadvertent vascular puncture

Coronary artery blockage

Unsuccessful procedure

Anesthetic related

Respiratory depression/arrest

Conversion from MAC to GA

TEE Complications

Safety of Transesophageal Echocardiography to Guide Structural Cardiac Interventions

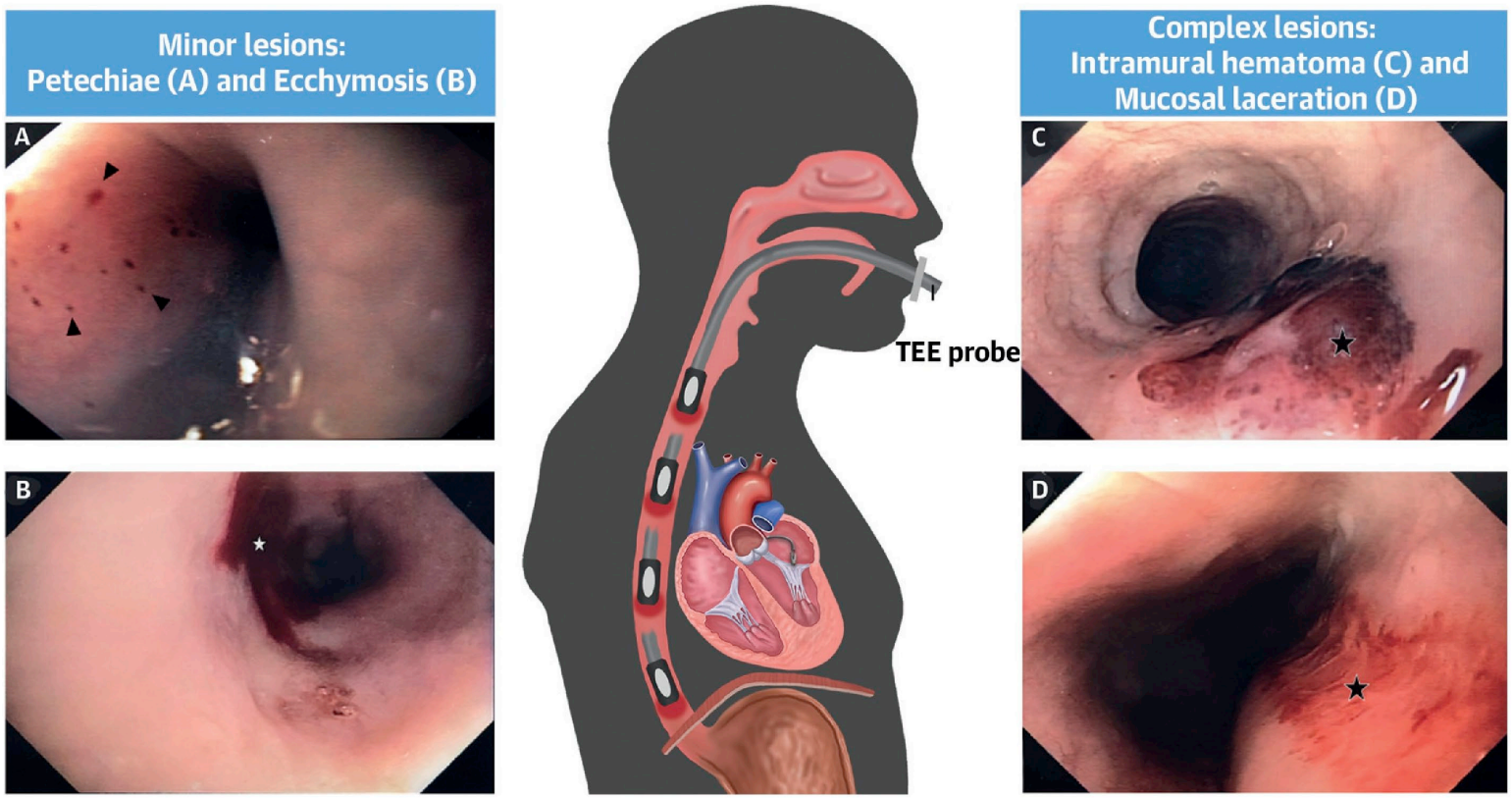
Prospective study of 50 patients planned for structural heart procedures with TEE guidance

Pre and post procedure EGD

86% of patients had a new injury on post procedure EGD

Freitas-Ferraz, A, Bernier, M, Vaillancourt, R. et al. Safety of Transesophageal Echocardiography to Guide Structural Cardiac Interventions. *JACC*. 2020 Jun, 75 (25) 3164–3173

TEE COMPLICATIONS



Freitas-Ferraz, A, Bernier, M, Vaillancourt, R. et al. Safety of Transesophageal Echocardiography to Guide Structural Cardiac Interventions. *JACC*. 2020 Jun, 75 (25) 3164–3173

ANESTHETIC MANAGEMENT

Role of The Anesthesiology Team

Patient comfort and cooperation

Perioperative management of high-risk patients

- Active cardiac conditions
- Frequent (and multiple) co-morbid conditions
- Failed sedation previously
- Urgent or emergent procedures

Guiding aspects of the procedure

ANESTHETIC CHOICE

GA	MAC
Complex/novel procedures	Planned straightforward procedure
Need for prolonged TEE	Noninvasive imaging
Complicated vascular access	Cooperative patient

Monitoring Choice

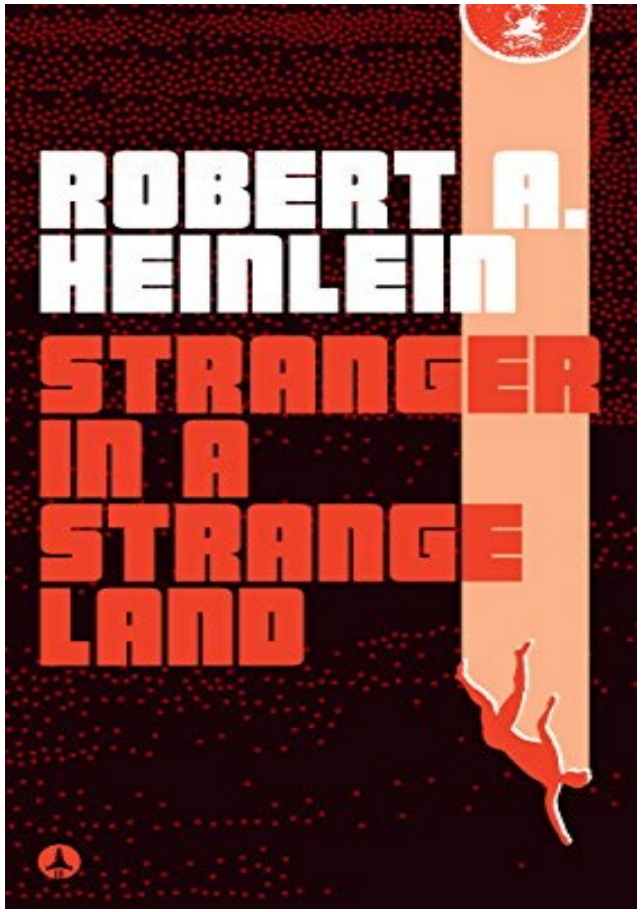
Patient considerations

Anticipated complexity of the procedures

Experience of teams

CHALLENGES

CHALLENGES



Off site anesthesia care

Decreased resources

Less familiarity with personnel and procedures

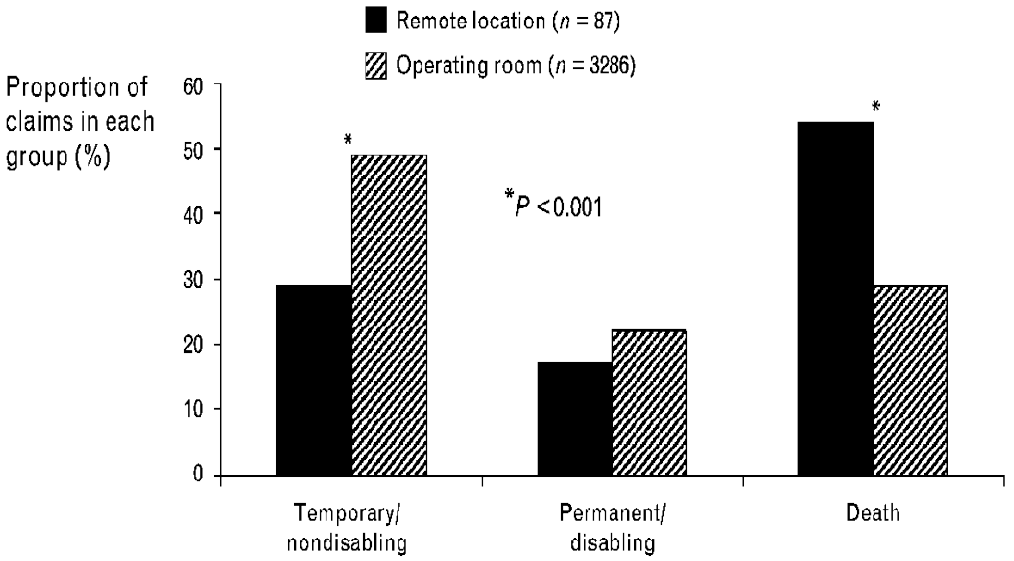
Space limitations

CHALLENGES

"Anesthesia outside the traditional operating-room setting continues to represent a challenging field and a growing area of liability…"

"Analysis of closed claims suggests that administration of anesthesia and sedation at remote locations is associated with a significant risk of adverse effects"

Injury	Remote location ($n=87$) n (%)	Operating room ($n=3287$) n (%)
Death	47 (54%)*	949 (29%)*
Permanent brain damage	12 (14%)	321 (10%)
Airway injury	10 (11%)	309 (9%)
Nerve damage	6 (7%)†	618 (19%)†
Aspiration pneumonitis	6 (7%)	117 (4%)
Burn injury	5 (6%)	141 (4%)
Stroke	3 (3%)	118 (4%)
Eye injury	2 (2%)	183 (6%)
Pneumothorax	2 (2%)	82 (2%)
Myocardial infarction	1 (1%)	123 (4%)



Metzner J, Posner KL, Lam MS, Domino KB. Closed claims' analysis. *Best Pract Res Clin Anaesthesiol*. 2011 Jun;25(2):263-76
Metzner J, Posner KL, Domino KB. The risk and safety of anesthesia at remote locations: the US closed claims analysis. *Curr Opin Anaesthesiol*. 2009 Aug;22(4):502-8

RADIATION SAFETY

RADIATION SAFETY

health of man.

Neither the danger nor the concern, however, is entirely new. It will be evident to those who are familiar with or willing to explore the older literature on the subject that radiologists have been concerned with these hazards since shortly after the first medical use of x-rays and radium some 60 years ago. To those who will read the paper of Desjardins,[1] written in 1923, it will also be evident that most of the problems alluded to in current discussions of radiation hazards were considered by radiologists at least 35 years ago. It is also

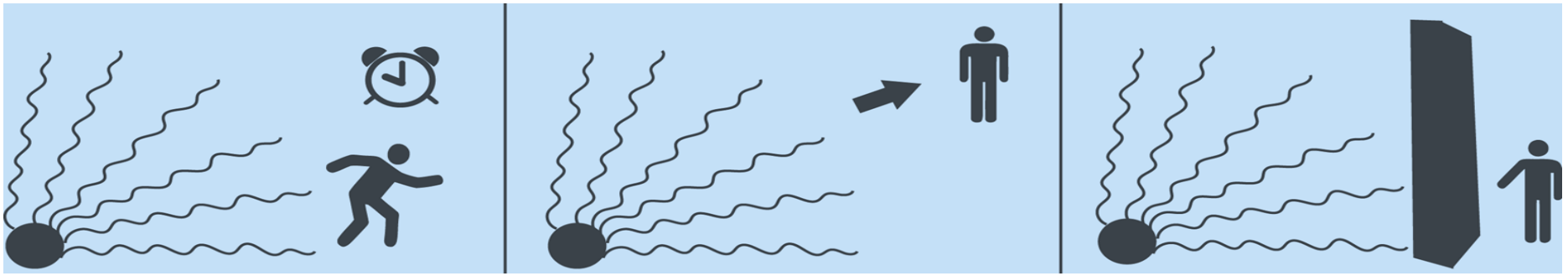
essary medical radiation is to be avoided.

One of the obligations of the radiologist is to inform his colleagues as best he can, so that the entire medical profession may act with understanding and judicial composure and without being swayed by the hysteria of public half knowledge. With this obligation in mind, this paper on the subject of radiation hazards, particularly as they are encountered in the practice of anesthesiology, is presented.

NATURE OF RADIATION AND ITS BIOLOGIC EFFECTS

Intelligent discussion and understand

Time
Distance
Shielding



Kincaid OW. The Problem of Repeated Exposure to Radiation by Anesthesiologists. *Anesth Analg* 1958; 37: 361-70
https://www.epa.gov/radiation

RADIATION SAFETY

Average Americans receive about 620 mrem annually

1 mrem from 3 days of living in Atlanta

1 mrem/1000 miles air travel

5 rem limit/year for occupational exposure

500 mrem/duration of pregnancy

https://www.epa.gov/radiation
https://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html

BEST PRACTICE

Electrophysiology and interventional cardiology technology and procedures are advancing rapidly
- Off site locations are increasingly used as mini-ORs
- “Routine” procedures now were unicorns 5-10 years ago

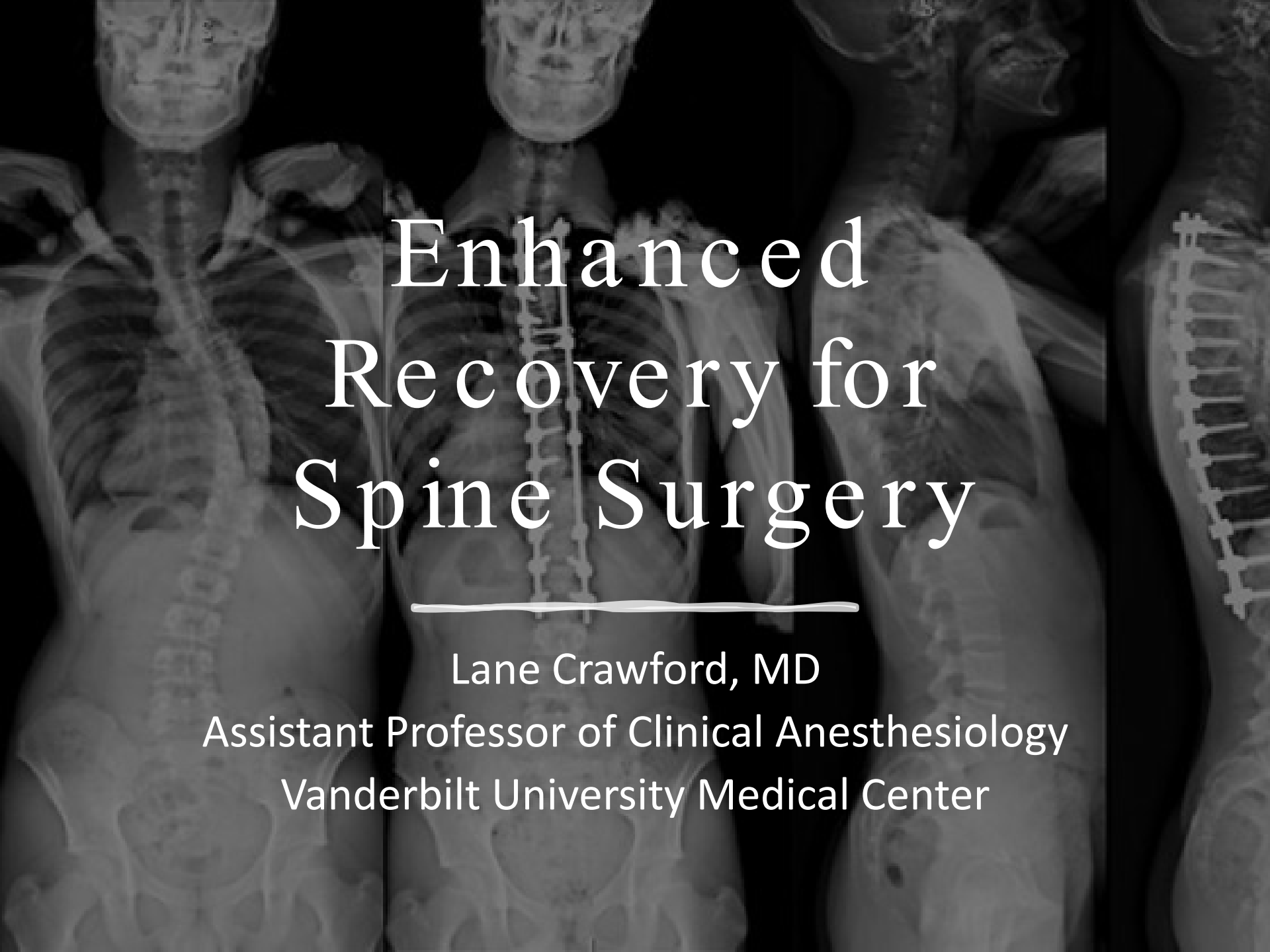
Proper understanding of procedures and anticipating challenges can ensure safe and effective anesthetic care

Guidelines are scarce

Collaborative care and excellent communication are they keys to success

QUESTIONS

?

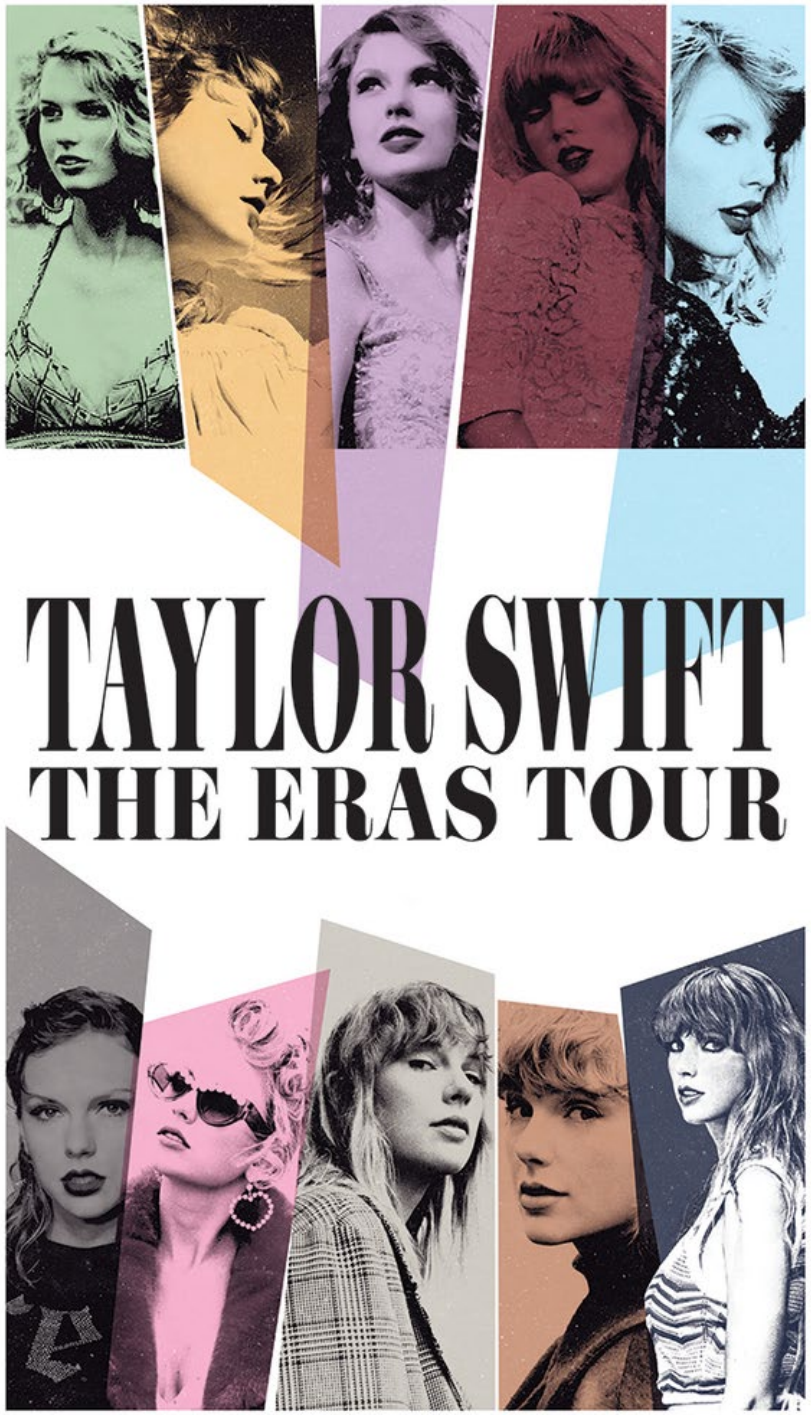


Enhanced Recovery for Spine Surgery

Lane Crawford, MD
Assistant Professor of Clinical Anesthesiology
Vanderbilt University Medical Center

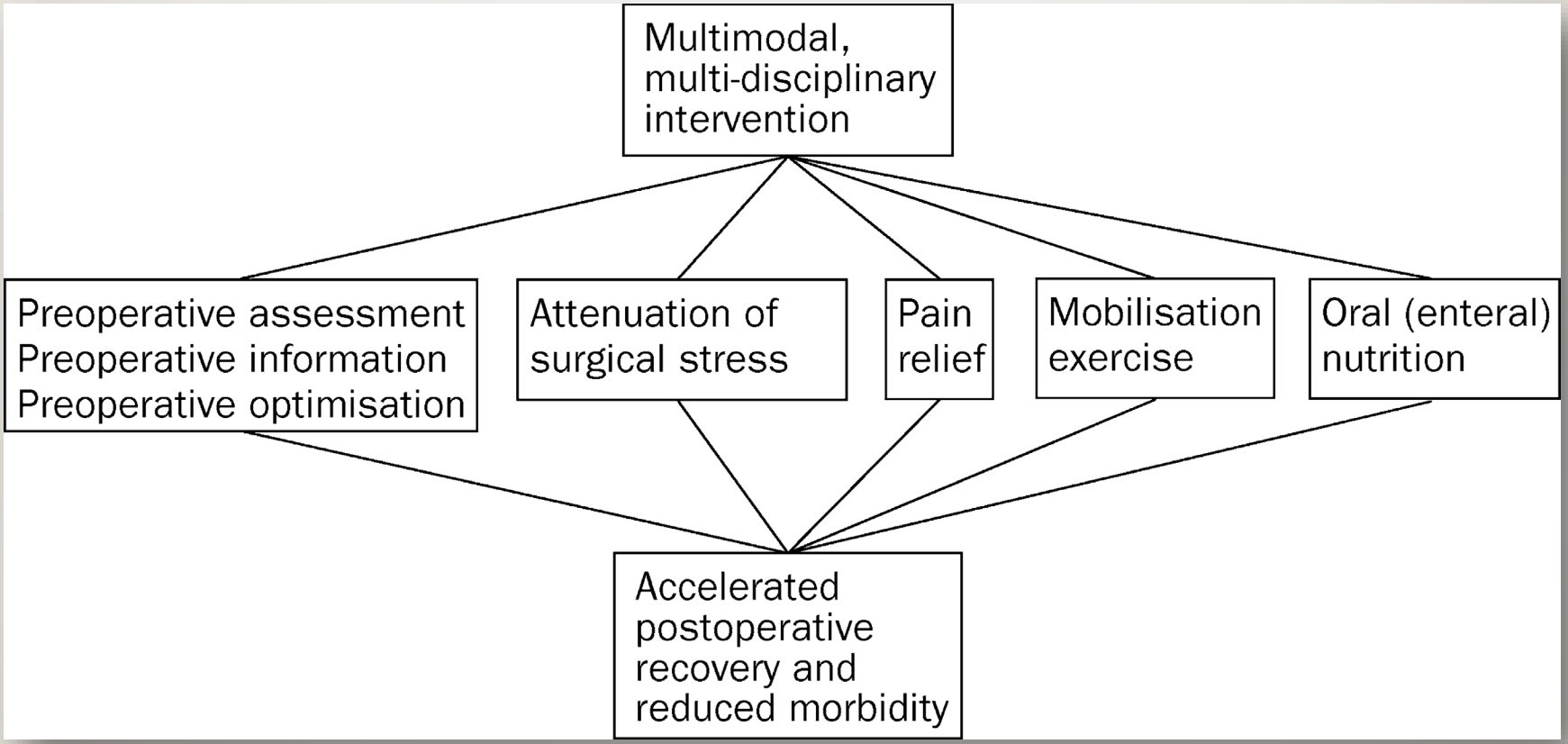
Learning Objectives

- Summarize the rationale for application of enhanced recovery principles to spine surgery
- Review several components of ERAS for spine with an emphasis on pain management
- Give an overview of the ERAS development process



VANDERBILT UNIVERSITY
MEDICAL CENTER

Enhanced Recovery After Surgery



Kehlet & Dahl, Lancet, 2003

Benefits of ERAS

- Faster functional recovery
- Improved pain control, fewer opioid-related adverse effects
- Decreased complication/readmission rates
- Shorter LOS
- Increased patient satisfaction
- Cost savings

ERAS at Vanderbilt

	Phase 0 (*N* = 179)	Phase 1 (*N* = 124)	Phase 2 (*N* = 241)	*P*		
				0 v. 1	1 v. 2	0 v. 2
Mean resource LOS (days)	5.26		4.36	0.47	0.15	<0.01[a]
Median resource LOS (days)	4.24	3.32	3.32	<0.01[a]	0.61	<0.001[a]
Reoperation	18 (10.1 %)	13 (10.5 %)	15 (6.22 %)	1	0.15	0.20
Readmissions	21 (11.7 %)	18 (14.5 %)	34 (14.1 %)	0.49	0.92	0.48
Hospital cost	100 %		83 %	0.05[a]		

[a]Significant at 5 % level; % non-parametric median test for no difference in median cost among all phases

McEvoy et al, Perioperative Med 2016

ERAS for Spine Surgery

Applicability

- Increasing demand
- High levels of postop pain
- Wide variation in practice and outcomes

Early Evidence

- Fewer complications
- Minimize postop pain/opioid use
- Reduced length of stay

Unknowns

- Which components are effective
- What combination is ideal
- How to customize for different surgeries, populations

VANDERBILT UNIVERSITY MEDICAL CENTER

Tong et al, Internatl J of Spine Surg 2023; Licina et al, BMC Anesthesiology 2021; Pennington et al, J of Neurosurgery: Spine 2020

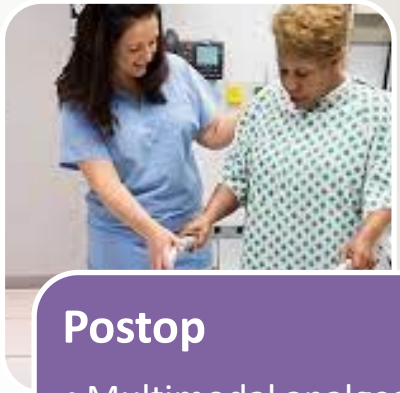
Pathway Components

Preop

- Education
- Comorbidity optimization
- Nutrition
- Fasting guidance

Intraop

- Minimally invasive approach
- Multimodal analgesia
- PONV ppx
- Blood/fluid mgmt
- Normothermia
- SSI prevention

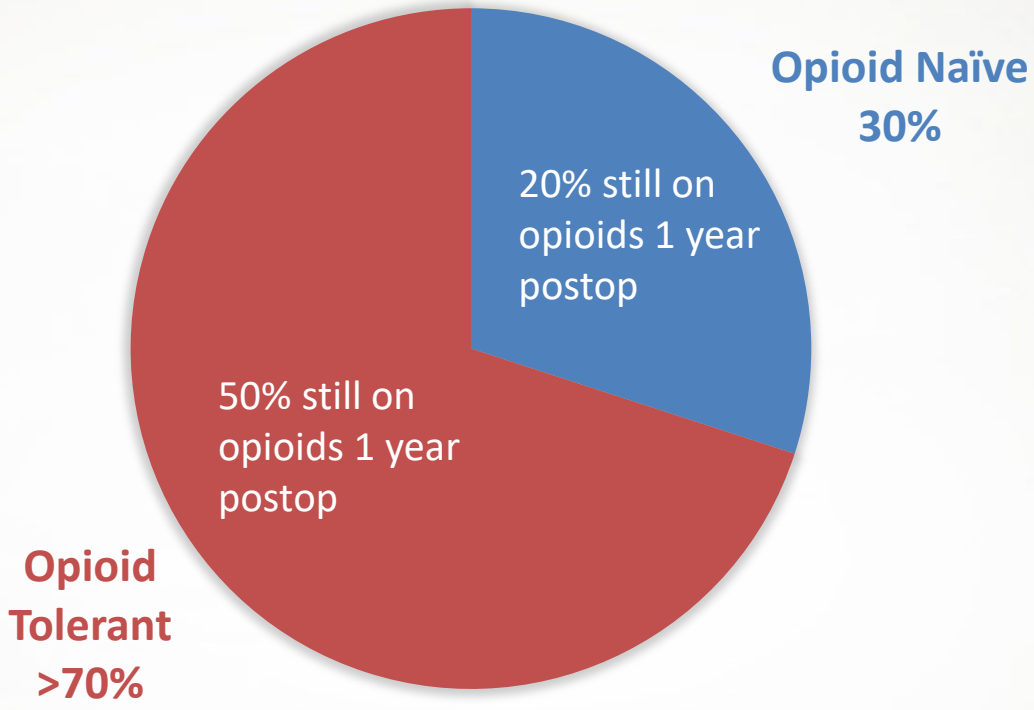


Postop

- Multimodal analgesia
- Early PO
- Early mobilization
- Foleys, drains out

- Encourage pt/provider adherence
- Track compliance rates, outcomes

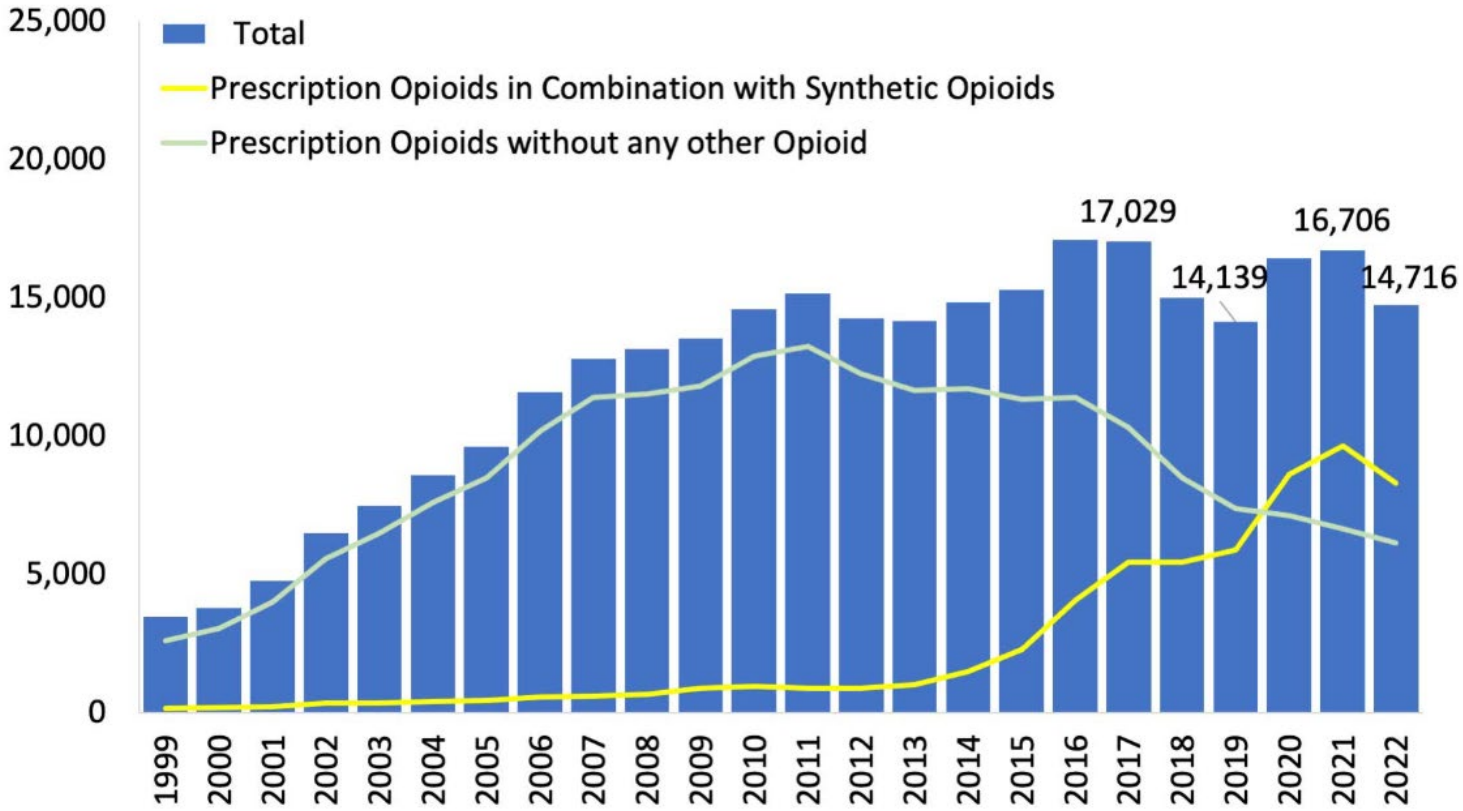
ELECTIVE SPINE SURGERY PATIENTS



Higher postop pain scores→ Higher rate of chronic opioid use

Dunn et al,. Anesth Analg, 2018

Figure 4. U.S. Overdose Deaths Involving Prescription Opioids*, 1999-2022



*Among deaths with drug overdose as the underlying cause, the prescription opioid subcategory was determined by the following ICD-10 multiple cause-of-death codes: natural and semi-synthetic opioids (T40.2) or methadone (T40.3). Source: Centers for Disease Control and Prevention, National Center for Health Statistics. Multiple Cause of Death 1999-2022 on CDC WONDER Online Database, released 4/2024.

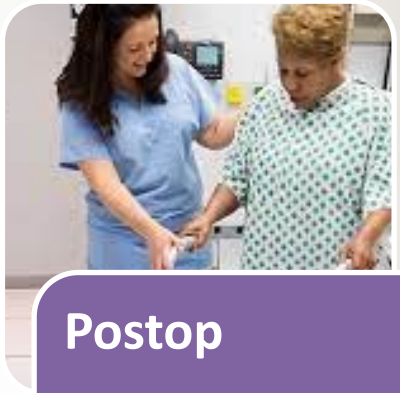
Pathway Components: Analgesia

Preop

- Expectation setting
- Wean chronic opioids (TPS)
- PO multimodals in holding room

Intraop

- Minimally invasive approach
- IV multimodal analgesia



Postop

- Multimodal analgesia
- Pain service consult (APS, TPS)

- Track metrics: pain scores, opioid use, opioid prescribing and refills, med side effects

Oral multimodals

Acetaminophen

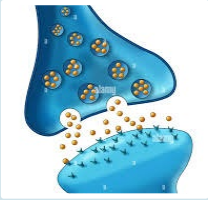
Well-established benefit

Safe, cheap

NSAIDs

Well-established benefit

2 weeks safe for fusion



Gabapentinoids

Tempered enthusiasm

Consider radicular pain

Sivaganesan et al, Eur Spine J 2017; Liu et al, Medicine 2017; Ma et al, Pain Phys 2017; Verret et al, Anesthesiology 2020

Infusions: Ketamine

CLINICAL INVESTIGATION

Comparison of Small Dose Ketamine and Dexmedetomidine Infusion for Postoperative Analgesia in Spine Surgery—A Prospective Randomized Double-blind Placebo Controlled Study

Neha Garg, MD, Nidhi B. Panda, MD, Komal A. Gandhi, MD, Hemant Bhagat, MD, DM, Yatindra K. Batra, MD, Vinod K. Grover, MD, and Rajesh Chhabra, MS, Mch

Perioperative Ketamine for Analgesia in Spine Surgery: A Meta-analysis of Randomized Controlled Trials

Arif Pendi, MS[1], Ryan Field, MD[2], Saifal-Deen Farhan, MD[1], Martin Eichler, MD[3], and S. Samuel Bederman, MD PhD FRCSC[4]

Perioperative Methadone and Ketamine for Postoperative Pain Control in Spinal Surgical Patients: A Randomized, Double-blind, Placebo-controlled Trial FREE

Glenn S. Murphy, M.D.; Michael J. Avram, Ph.D.; Steven B. Greenberg, M.D.; Jessica Benson, B.S.; Sara Bilimoria, B.S.; Colleen E. Maher, B.S.; Kevin Teister, B.S.; Joseph W. Szokol, M.D.

+ Author and Article Information

Anesthesiology May 2021, Vol. 134, 697–708.

Intraoperative S-ketamine for the reduction of opioid consumption and pain one year after spine surgery: A randomized clinical trial of opioid-dependent patients

Rikke Vibeke Nielsen[1] | Jonna Storm Fomsgaard[1] | Lone Nikolajsen[2] | Jørgen Berg Dahl[3] | Ole Mathiesen[4]

PAIN MEDICINE

Anesthesiology 2010; 113:639–46

Intraoperative Ketamine Reduces Perioperative Opiate Consumption in Opiate-dependent Patients with Chronic Back Pain Undergoing Back Surgery

Randy W. Loftus, M.D.,* Mark P. Yeager, M.D.,† Jeffrey A. Clark, M.D.,* Jeremiah R. Brown, M.S., Ph.D.,‡ William A. Abdu, M.S., M.D.,§ Dilip K. Sengupta, M.D., Ph.D.,‖ Michael L. Beach, M.D., Ph.D.†

VANDERBILT UNIVERSITY MEDICAL CENTER

Garg et al, J Neurosurg Anesthesiol, 2016; Pendi et al, Spine, 2018; Loftus et al, Anesthesiology, 2010; Nielsen et al, Eur J Pain, 2019

Infusions: Lidocaine

Effect of Perioperative Intravenous Lidocaine Administration on Pain, Opioid Consumption, and Quality of Life after Complex Spine Surgery

Ehab Farag, M.D., F.R.C.A.; Michael Ghobrial, M.D.; Daniel I. Sessler, M.D.; Jarrod E. Dalton, Ph.D.; Jinbo Liu, M.D.; Jae H. Lee, B.A.; Sherif Zaky, M.D.; Edward Benzel, M.D.; William Bingaman, M.D.; Andrea Kurz, M.D.

+ Author and Article Information

Anesthesiology October 2013, Vol. 119, 932–940.

Intraoperative systemic infusion of lidocaine reduces postoperative pain after lumbar surgery: a double-blinded, randomized, placebo-controlled clinical trial

Kyoung-Tae Kim, MD, PhD[a], Dae-Chul Cho, MD, PhD[a], Joo-Kyung Sung, MD, PhD[a], Young-Baeg Kim, MD, PhD[b], Hyun Kang, MD, PhD[c,*], Kwang-Sup Song, MD, PhD[d], Geun-Joo Choi, MD[c]

Systemic lidocaine fails to improve postoperative morphine consumption, postoperative recovery and quality of life in patients undergoing posterior spinal arthrodesis. A double-blind, randomized, placebo-controlled trial

G. Dewinter[1,*], P. Moens[2], S. Fieuws[3], B. Vanaudenaerde[4], M. Van de Velde[1,5] and S. Rex[1,5]

Farag et al, Anesthesiology 2013;
Kim et al, The Spine J 2014;
Dewinter et al, BJA 2017

Choosing an Opioid

Pain Medicine

Section Editor: Spencer S. Liu

Intraoperative Methadone Improves Postoperative Pain Control in Patients Undergoing Complex Spine Surgery

Antje Gottschalk, MD,*† Marcel E. Durieux, MD, PhD,* and Edward C. Nemergu

Clinical Effectiveness and Safety of Intraoperative Methadone in Patients Undergoing Posterior Spinal Fusion Surgery

d, Double-blinded, Controlled Trial

, Joseph W. Szokol, M.D., Michael J. Avram, Ph.D., Steven B. Greenberg, M.D., Mark A. Deshur, M.D., Jeffery S. Vender, M.D., Jessica Benson, B.S., B.A.

Anaesthesia 2016, 71, 1347–1362 doi:10.1111/anae.13602

Review Article

Remifentanil tolerance and hyperalgesia: short-term gain, long-term pain?

E. H. Y. Yu,[1] D. H. D. Tran,[2] S. W. Lam[2] and M. G. Irwin[3]

Journal of Anesthesia (2018) 32:886–892
https://doi.org/10.1007/s00540-018-2569-6

ORIGINAL ARTICLE

High-dose intraoperative remifentanil infusion increases early postoperative analgesic consumption: a prospective, randomized, double-blind controlled study

Deokkyu Kim[1] · Hyung-Sun Lim[1,2] · Myung-Jong Kim[1] · WooJoo Jeong[1] · Seonghoon Ko[1,2]

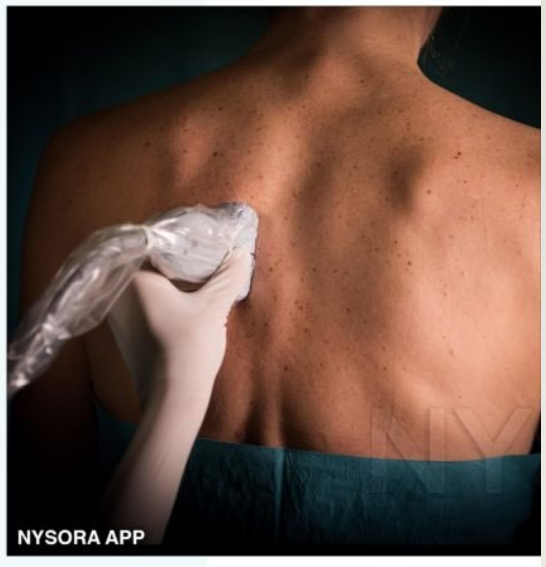
VANDERBILT UNIVERSITY MEDICAL CENTER

Gottschalk, Anesth Analg, 2011; Murphy et al, Anesthesiology, 2017; Yu et al, Anaesthesia, 2016; Kim et al, J Anesth, 2018

The Next Big Thing?

Erector Spinae Blocks for Spine Surgery: Fact or Fad? Systematic Review of Randomized Controlled Trials

Elias Elias [1], Zeina Nasser [2], Charbel Elias [3], Ata Rahman [4], Ravi Nunna [1], Rod J. Oskouian [1], Jens R. Chapman [1]

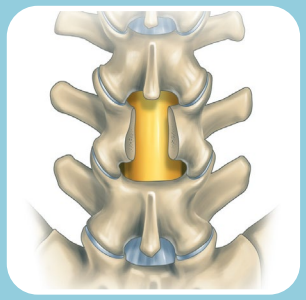


Analgesic efficacy of erector spinae plane block in lumbar spine surgery: A systematic review and meta-analysis

Seok Kyeong Oh, MD, PhD, Byung Gun Lim, MD, PhD *, Young Ju Won, MD, PhD, Dong Kyu Lee, MD, PhD, Seong Shin Kim, MD

Department of Anesthesiology and Pain Medicine, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Republic of Korea

Elias et al, World Neurosurg 2022;
Oh et al, J Clin Anesth. 2022



Laminectomy/Discectomy, ACDF, Same-Day Surgery

- No complicating factors

Simple Fusion

- ≤ 3 Levels
- No complicating factors

Complex Spine

- ≥ 4 Levels *OR*
- Complicating surgical or pt factors

Tier 3 Overview

PRE-OP

Analgesics

Ordered by Anesthesia

- Tylenol 1000 mg
- Gabapentin 300 mg

Abx and TXA

Ordered by Surgery

- Vancomycin: Start in OR within 2 hrs and at least 15 min pre-incision.
- Cefazolin: Within 1 hr pre-incision
- TXA: Start bolus prior to incision

INTRA-OP

Multimodals

- Ketamine 0.5-1 mg/kg at induction
- Dexamethasone 8 mg after induction
- Ketorolac 30 mg at fascial closure

Opioids

- Methadone 0.2-0.3 mg/kg IBW

+/- Sufentanil 0.1-0.5 mcg/kg/hr

Maintenance

- *No IONM:* Choice
- *EMG:* Choice, no NMB
- *SSEPs:* ≤0.5 MAC gas
- *MEPs:* TIVA, no NMB

Infusions

- Lidocaine 1.5 mg/kg, then 2 mg/min
- Ketamine 5 mcg/kg/min
- TXA 30 mg/kg, then 3 mg/kg/hr

+/- Dexmedetomidine 0.2-0.7 mcg/kg/hr

Antiemesis *(per risk factors)*

- Ondansetron 4 mg
- Dexamethasone as above
- Haloperidol 0.5-1 mg
- Propofol gtt/TIVA

PACU

Analgesia

- Oxycodone 2.5-15 mg prn
- Hydromorphone 0.25-0.5 mg prn
- +/- Robaxin 500-1000 mg IV x1 prn

- APS will evaluate all Tier 3 patients

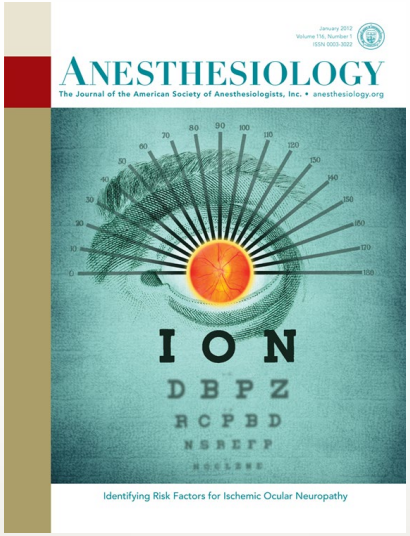
Antiemesis

- Haloperidol 0.5-1 mg prn
- Promethazine 6.25-12.5 mg prn
- Ondansetron 4 mg prn

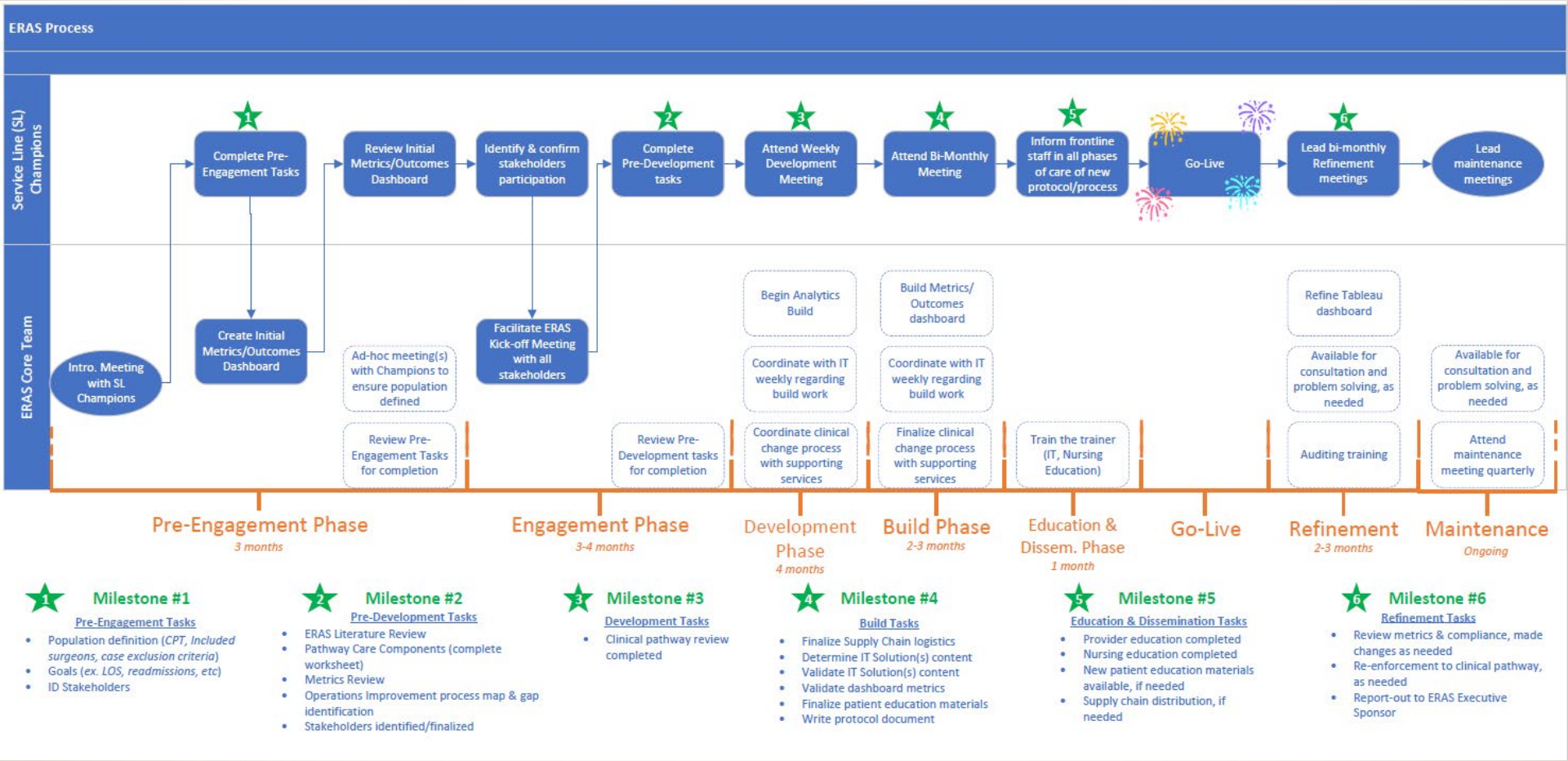
Adjust medication dosage based on patient age, comorbidities, and opioid tolerance

What Else?

- PONV ppx
- Blood and fluid management
- SSI prevention bundle
- Guidance for IONM and myelopathy

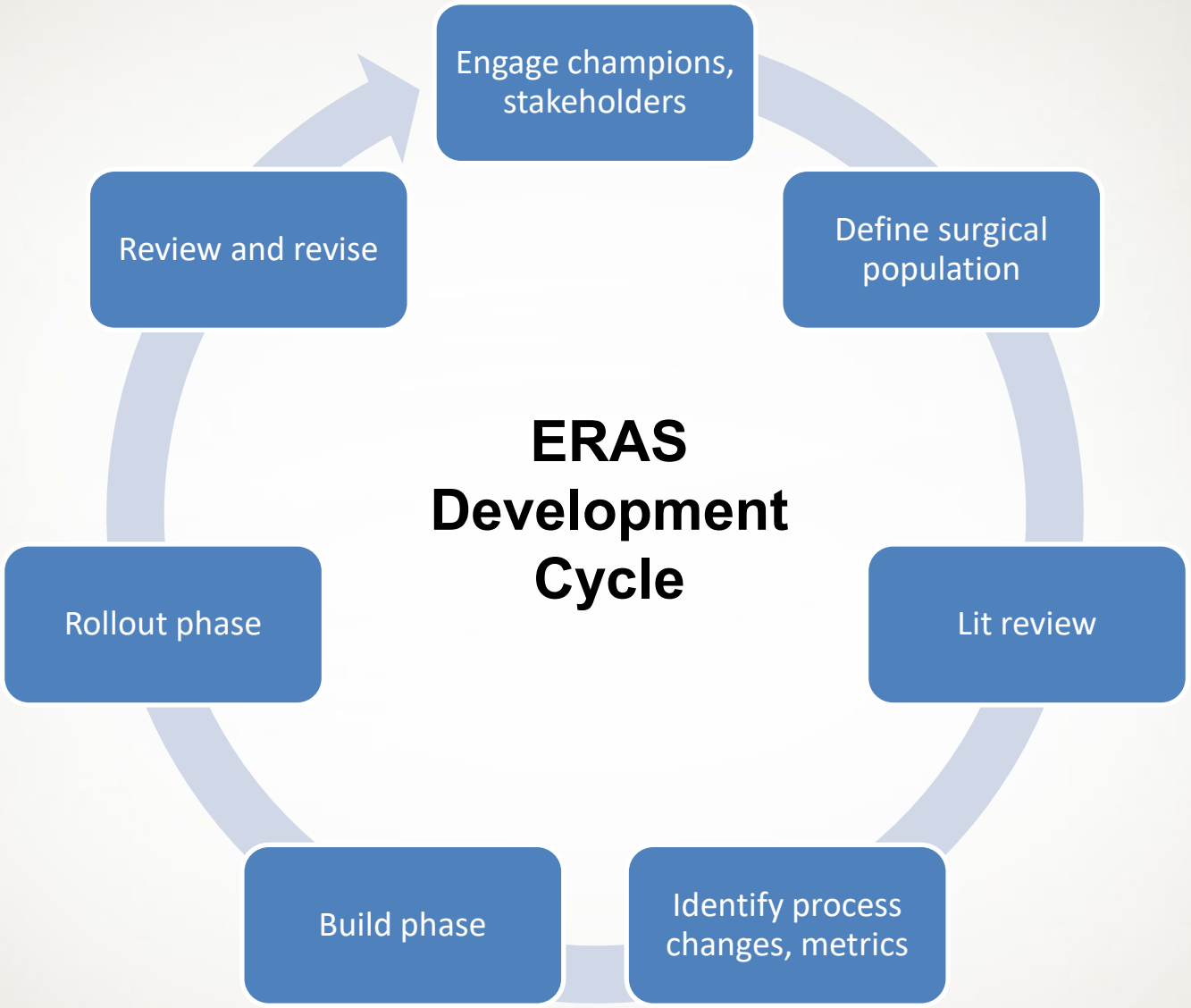


Comprehensive ERAS Process

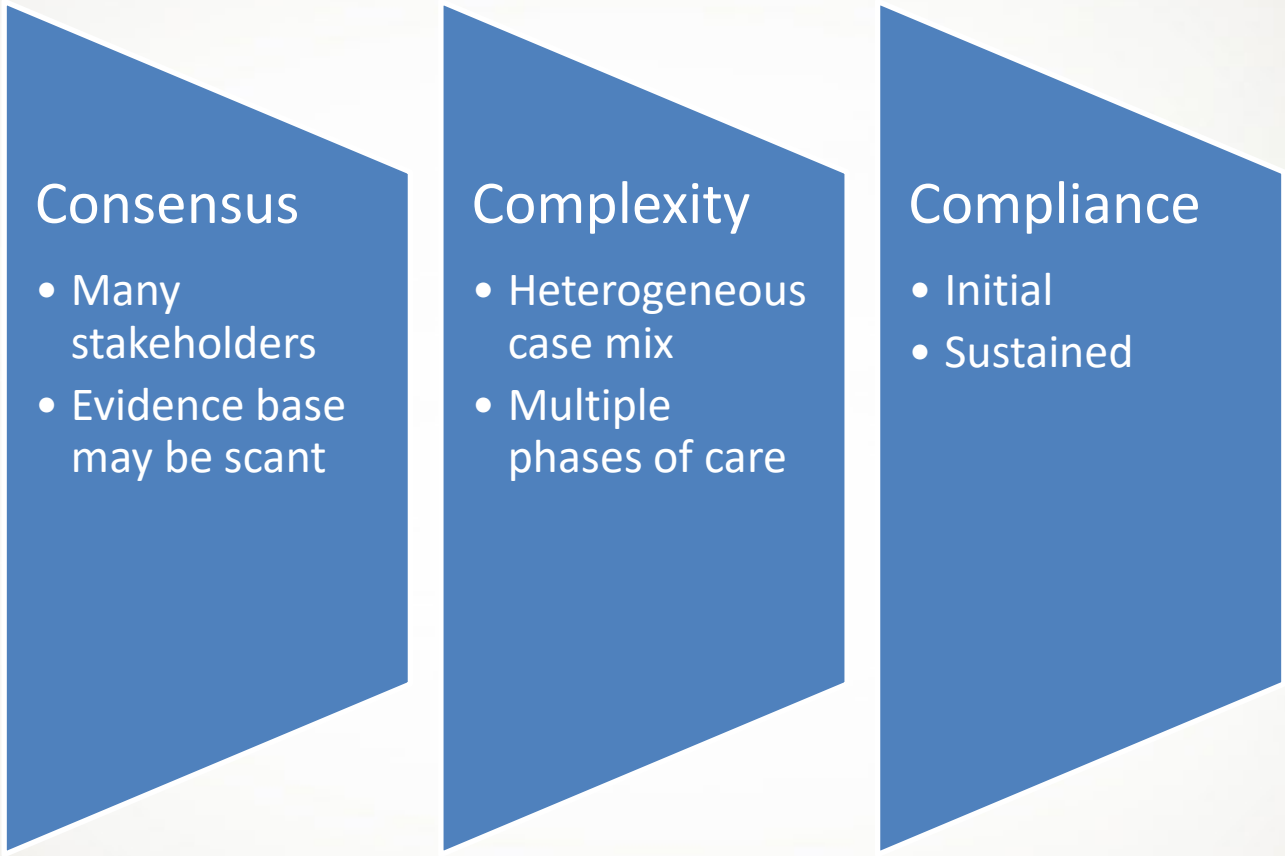


VANDERBILT UNIVERSITY MEDICAL CENTER

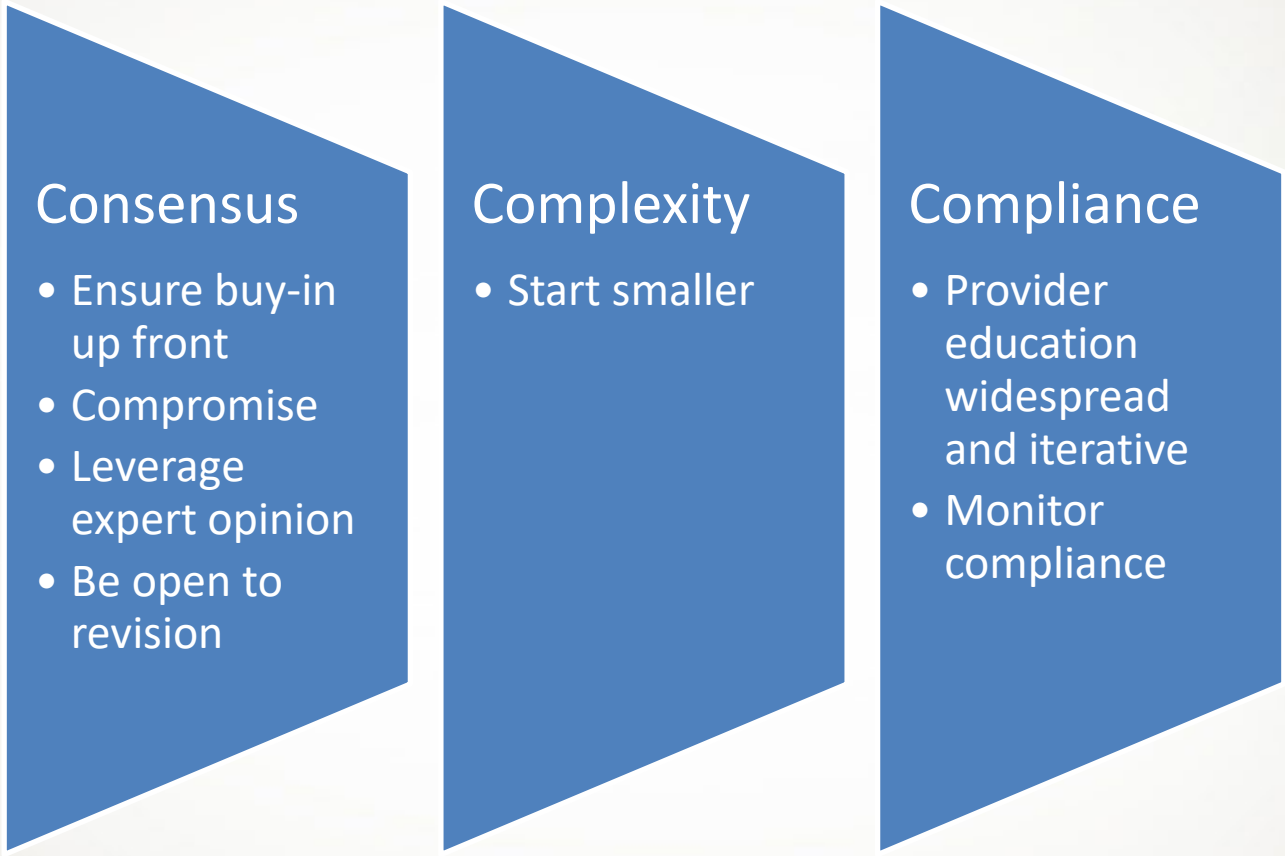
Image credit Dana Andersen, MBA


ERAS Development Cycle
Engage champions, stakeholders
Define surgical population
Lit review
Identify process changes, metrics
Build phase
Rollout phase
Review and revise

Challenges

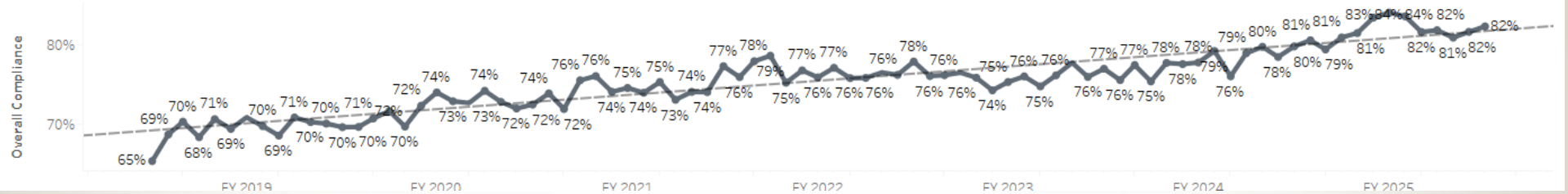

Consensus
• Many stakeholders
• Evidence base may be scant
Complexity
• Heterogeneous case mix
• Multiple phases of care
Compliance
• Initial
• Sustained

Challenges

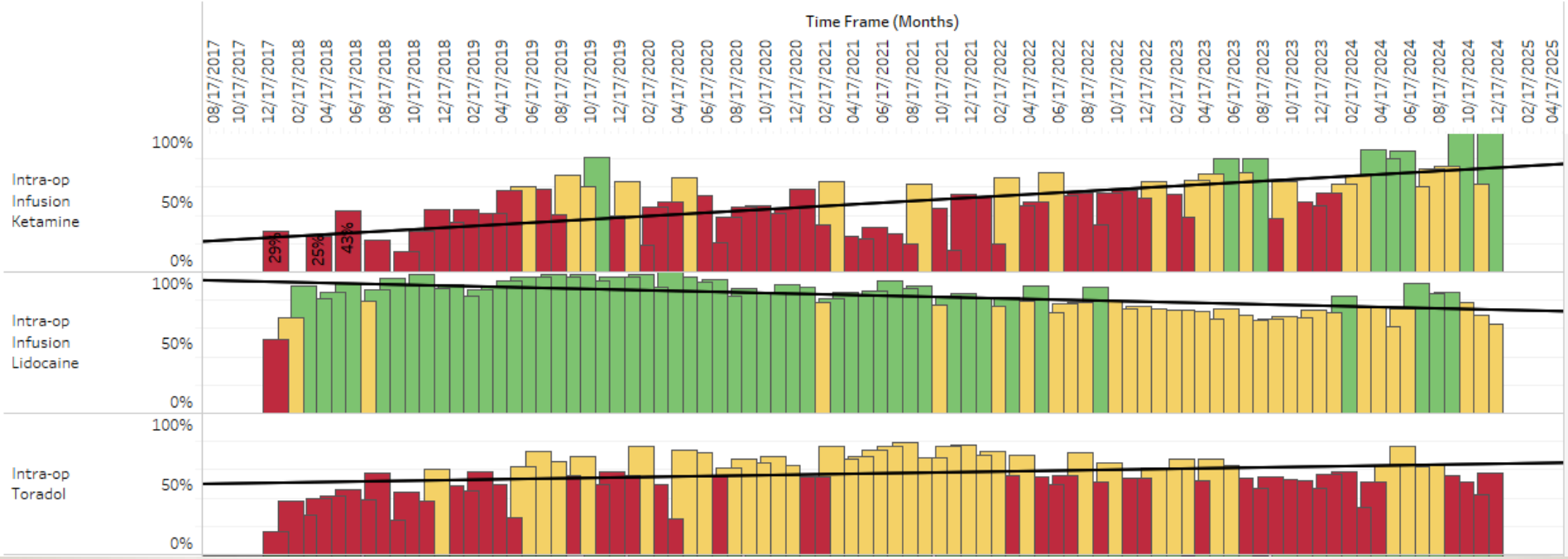

Consensus
• Ensure buy-in up front
• Compromise
• Leverage expert opinion
• Be open to revision
Complexity
• Start smaller
Compliance
• Provider education widespread and iterative
• Monitor compliance

Overall Compliance Trending

Updated as of: 1/31/2025 3:47:59 AM



Scale for scored metrics: 0%-59% | 60%-79% | 80%-100%



VANDERBILT UNIVERSITY MEDICAL CENTER

Take-Home Points

- ERAS for spine surgery is feasible and has the potential to improve outcomes and resource utilization
- Evidence-informed multimodal pain management should be major priority in any ERAS protocol for spine
- Anesthesiologists are ideally positioned to be leaders in ERAS pathway development and implementation

VANDERBILT UNIVERSITY MEDICAL CENTER

Lane.c.crawford@vumc.org

References

Dunn, L. K., Yerra, S., Fang, S., Hanak, M. F., Leibowitz, M. K., Tsang, S., … Naik, B. I. (2018). Incidence and risk factors for chronic postoperative opioid use after major spine surgery: A cross-sectional study with longitudinal outcome. Anesthesia and Analgesia, Vol. 127, pp. 247–254. https://doi.org/10.1213/ANE.0000000000003338

Elsarrag, M., Soldozy, S., Patel, P., Norat, P., Sokolowski, J. D., Park, M. S., … Kalani, M. Y. S. (2019). Enhanced recovery after spine surgery: a systematic review. Neurosurgical Focus, 46(4), E3. https://doi.org/10.3171/2019.1.FOCUS18700

Garg, N., Panda, N. B., Gandhi, K. A., Bhagat, H., Batra, Y. K., Grover, V. K., & Chhabra, R. (2016). Comparison of Small Dose Ketamine and Dexmedetomidine Infusion for Postoperative Analgesia in Spine Surgery--A Prospective Randomized Double-blind Placebo Controlled Study. Journal of Neurosurgical Anesthesiology, 28(1), 27–31. https://doi.org/10.1097/ANA.0000000000000193

Glenn S. Murphy, M.D., Joseph W. Szokol, M.D., Michael J. Avram, Ph.D., Steven B. Greenberg, M. D., Torin D. Shear, M.D., Mark A. Deshur, M.D., Jeffery S. Vender, M.D., Jessica Benson, B. S., & Rebecca L. Newmark, B. A. (2017). Clinical Effectiveness and Safety of Intraoperative Methadone in Patients Undergoing Posterior Spinal Fusion Surgery. Anesthesiology, 126(5), 822–833. https://doi.org/10.1097/ALN.0000000000001609

Gottschalk, A., Durieux, M. E., & Nemergut, E. C. (2011). Intraoperative methadone improves postoperative pain control in patients undergoing complex spine surgery. Anesthesia and Analgesia, 112(1), 218–223. https://doi.org/10.1213/ANE.0b013e3181d8a095

Kehlet, H., & Dahl, J. B. (2003). Anaesthesia, surgery, and challenges in postoperative recovery. Lancet, Vol. 362, pp. 1921–1928. https://doi.org/10.1016/S0140-6736(03)14966-5

Kim, D., Lim, H. S., Kim, M. J., Jeong, W. J., & Ko, S. (2018). High-dose intraoperative remifentanil infusion increases early postoperative analgesic consumption: a prospective, randomized, double-blind controlled study. Journal of Anesthesia, 32(6), 886–892. https://doi.org/10.1007/s00540-018-2569-6

Li, G., Sun, T.-W., Gan Luo, •, & Chao Zhang, •. (2017). Efficacy of antifibrinolytic agents on surgical bleeding and transfusion requirements in spine surgery: a meta-analysis. Eur Spine J, 26, 140–154. https://doi.org/10.1007/s00586-016-4792-x

Loftus, R. W., Yeager, M. P., Clark, J. A., Brown, J. R., Abdu, W. A., Sengupta, D. K., & Beach, M. L. (2010). Intraoperative Ketamine Reduces Perioperative Opiate Consumption in Opiate-dependent Patients with Chronic Back Pain Undergoing Back Surgery. In PAIN MEDICINE Anesthesiology (Vol. 113). Retrieved from www.anesthesiology.org

Lu, V. M., Ho, Y.-T., Nambiar, M., Mobbs, R. J., & Phan, K. (2018). The Perioperative Efficacy and Safety of Antifibrinolytics in Adult Spinal Fusion Surgery. SPINE, 43(16), E949–E958. https://doi.org/10.1097/BRS.0000000000002580

Naik, B. I., Nemergut, E. C., Kazemi, A., Fernández, L., Cederholm, S. K., McMurry, T. L., & Durieux, M. E. (2016). The Effect of Dexmedetomidine on Postoperative Opioid Consumption and Pain After Major Spine Surgery. Anesthesia & Analgesia, 122(5), 1646–1653. https://doi.org/10.1213/ANE.0000000000001226

Nielsen, R. V., Fomsgaard, J. S., Nikolajsen, L., Dahl, J. B., & Mathiesen, O. (2019). Intraoperative S-ketamine for the reduction of opioid consumption and pain one year after spine surgery: A randomized clinical trial of opioid-dependent patients. European Journal of Pain, 23(3), 455–460. https://doi.org/10.1002/ejp.1317

Pendi, A., Field, R., Farhan, S. D., Eichler, M., & Bederman, S. S. (2018). Perioperative Ketamine for Analgesia in Spine Surgery. Spine, Vol. 43, pp. E299–E307. https://doi.org/10.1097/BRS.0000000000002318

PERIOPERATIVE MEDICINE Risk Factors Associated with Ischemic Optic Neuropathy after Spinal Fusion Surgery The Postoperative Visual Loss Study Group*. (2011). Retrieved from http://depts.washington.edu/asaccp/eye/providers/packet.

Practice Advisory for Perioperative Visual Loss. (2018). Retrieved from www.anesthesiology.org

Soroceanu, A., Oren, J. H., Smith, J. S., Hostin, R., Shaffrey, C. I., Mundis, G. M., … Errico, T. J. (2016). Effect of Antifibrinolytic Therapy on Complications, Thromboembolic Events, Blood Product Utilization, and Fusion in Adult Spinal Deformity Surgery. Spine, 41(14), E879-86. https://doi.org/10.1097/BRS.0000000000001454

Tsaousi, G. G., Pourzitaki, C., Aloisio, S., & Bilotta, F. (2018). Dexmedetomidine as a sedative and analgesic adjuvant in spine surgery: a systematic review and meta-analysis of randomized controlled trials. European Journal of Clinical Pharmacology, Vol. 74, pp. 1377–1389. https://doi.org/10.1007/s00228-018-2520-7

Wainwright, T. W. (2016). Enhanced recovery after surgery (ERAS) and its applicability for major spine surgery. Best Practice & Research Clinical Anaesthesiology, 30. https://doi.org/10.1016/j.bpa.2015.11.001

Yu, E. H. Y., Tran, D. H. D., Lam, S. W., & Irwin, M. G. (2016). Remifentanil tolerance and hyperalgesia: short-term gain, long-term pain? Anaesthesia, 71(11), 1347–1362. https://doi.org/10.1111/anae.13602

Tier details

a. Tier 1 (Low Complexity):
    i. Any outpatient surgery
    ii. Any ACDF (1-4 levels)
    iii. Any decompression only
        1. Lumbar lami/discectomy
        2. Posterior cervical foraminotomy
b. Tier 2 (Moderate Complexity):
    i. Posterior cervical fusion 7 levels (e.g. C2-T2) and less
    ii. Lumbar/thoracic fusion 3 levels (e.g. L3-S1) or less
    iii. Cervical laminoplasty
    iv. Anterior cervical corpectomy
c. Tier 3 (High Complexity):
    i. Posterior cervical fusion 8 levels (e.g. C2-T3) and more
    ii. Any combined anterior/posterior cervical fusion
    iii. Lumbar/thoracic fusion 4 levels or more
    iv. L2-S1 fusion and more
    v. Anything else not in Tier 1 or 2

Tranexamic Acid

- Decreases:
  - Periop blood loss
  - Incidence and volume of transfusion
- No increase in major complications

- Best dosing regimen?

VANDERBILT UNIVERSITY MEDICAL CENTER

Lu et al, Spine, 2018; Li et al, Eur Spine J, 2017; Soroceanu et al, Spine, 2016

TXA

- 30 mg/kg loading bolus given over 30 minutes followed by a 3 mg/kg/hr infusion for the duration of the case until closure or until max dose has been administered

Dose adjust for renal dysfunction as follows:

SCr Value	Bolus Dose	Infusion Rate	Dose Reduction
Normal Renal Function	30 mg/kg	3 mg/kg/hour	N/A
1.6 to 3.3 mg/dL	20 mg/kg	2 mg/kg/hour	25%
3.4 to 6.6 mg/dL	15 mg/kg	1.5 mg/kg/hour	50%
>6.6 mg/dL or HD	10 mg/kg	1 mg/kg/hour or no infusion	75%

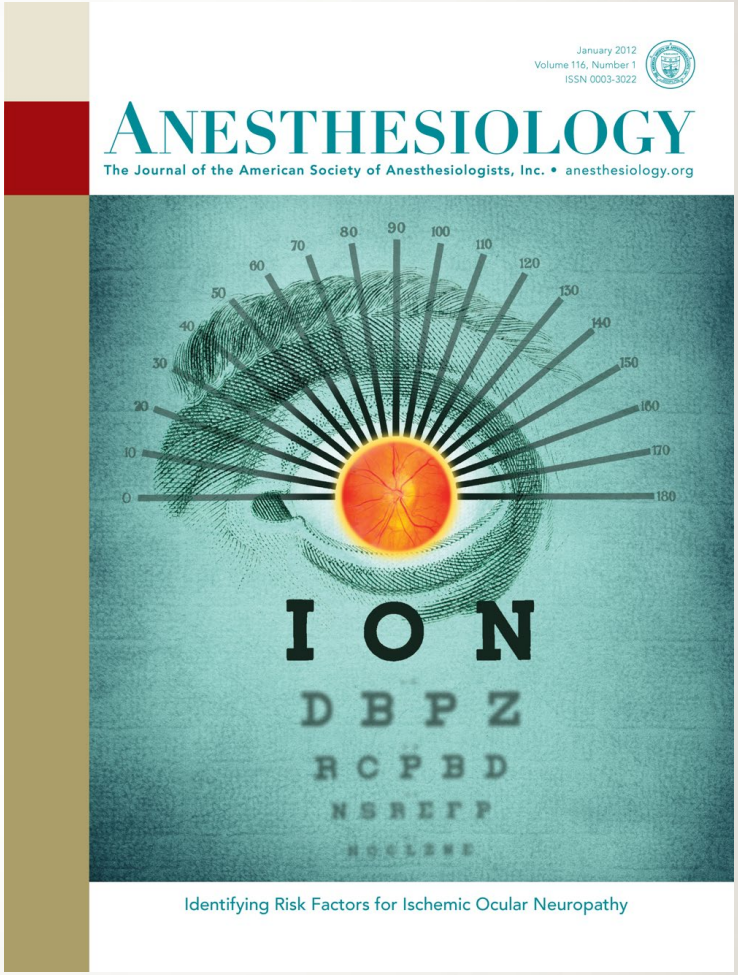
- Known allergy to Tranexamic Acid
- Acquired Defective Color Vision
- Active Hypercoagulable State- DIC
- BUN:Cr Ratio >20:1
- Seizure Disorder (relative)

- History of Venous or Art
- Deep Vein Thrombosis
- Pulmonary Embolus
- Embolic or Ischemic CV
- Factor V Leiden or Antit
- Mechanical Heart Valves
- Current Arrhythmias (at

*Consider a discussion with conditions exist to potentiall administration. Many studie have excluded patients with recent reviews of TXA use i undergoing joint arthroplast perioperative complications cohort.

Perioperative Visual Loss

- Risk factors: male, obese, duration prone, Wilson frame, high EBL, lower colloid use
- 2019 ASA Practice Advisory:
  - Positioning
  - BP mgmt
  - Transfusion/Fluid mgmt



POVL Study Group, Anesthesiology 2012; Practice Advisory for POVL Associated with Spine Surgery 2019, Anesthesiology, 2019

Postoperative Delirium

Dr. Pritee Tarwade

Disclosures

- None

What is POD?

- Onset of emergent cognitive impairment in the post surgical period that exceeds the expected length of time needed to recover from the acute effects of surgery and anesthesia.
- Multiple definitions overtime
- Now post op neurocognitive dysfunction

BRITISH MEDICAL ASSOCIATION.

FIFTY-FIFTH ANNUAL MEETING.

PROCEEDINGS OF SECTIONS.

INSANITY FOLLOWING THE USE OF ANÆSTHETICS IN OPERATIONS.

Read in the Section of Psychology at the Annual Meeting of the British Medical Association held in Dublin, August, 1887.

By GEORGE H. SAVAGE, M.D.Lond., F.R.C.P.,
Medical Superintendent and Resident Physician, Bethlem Royal Hospital; Lecturer on Mental Diseases, Guy's Hospital.

In treating this subject it will be first necessary to clear away, as much as possible, any fallacies which might induce us to attribute too much importance to any one cause in the production of mental disorder. All writers and observers have noticed that it is very rarely that one cause alone is efficient for the production of any attack of insanity, and that usually there are several predisposing causes which may have been in operation for a long time, as well as one or more exciting causes which may have been in action for much shorter periods.

In the subjoined paper I only point out that I have met with a series of cases of insanity in which the use of anæsthetics, in predisposed subjects, has been followed by insanity. To make the matter more clear I have collected together similar cases which have followed similar causes, such as alcohol, belladonna, etc. I think by this means to be able to show that the relationship is truly causal.

I will at once place before you several propositions which I hope to prove.

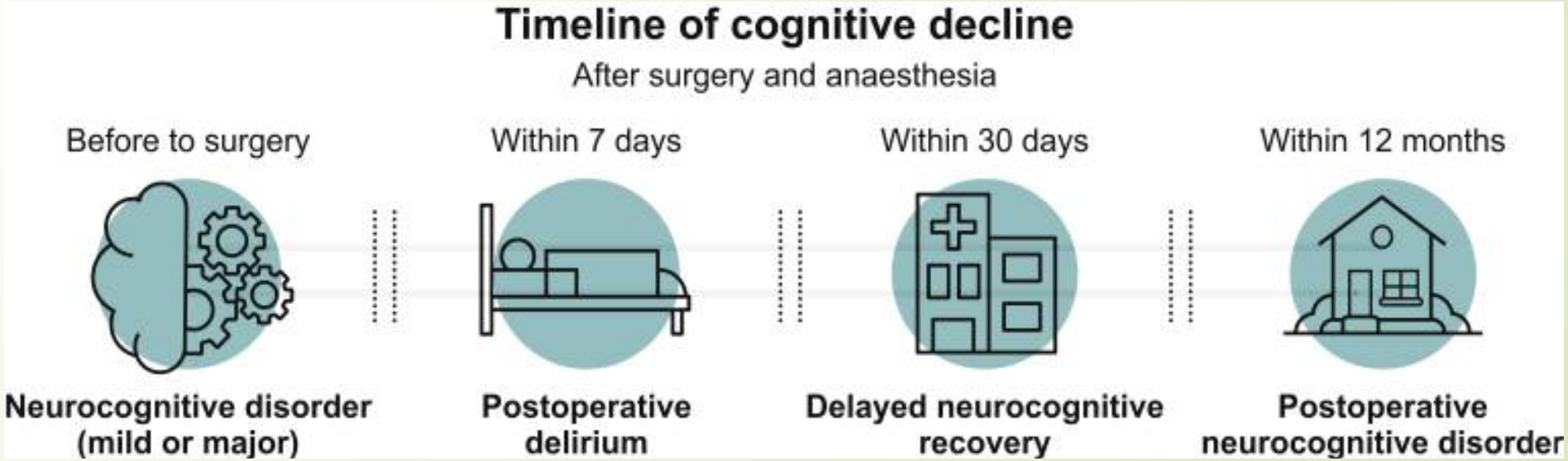
Any cause which will give rise to delirium may set up a more chronic form of mental disorder quite apart from any febrile disturbance. (*a*) The most common form of mental disorder which comes on in such cases is of the type of acute delirious mania; (*b*) though such mental disorder is generally of a temporary character, it may pass into chronic weak-mindedness, or it may pass into (*c*) progressive dementia which cannot be distinguished from general paralysis of the insane.

that delirium accompanying fevers may start a similar set of symptoms. After scarlet fever or measles I have several times met with such disorders. Thus, one girl aged 17, bright, intelligent, and active, two of whose sisters and one brother had been insane and recovered, and whose mother, though not actually insane, was subject to periods of extreme mental depression; this girl contracted scarlet fever, early in the disease became very delirious, and after several days of excited sleepless delirium, became maniacal. The noisy, senseless chatter assumed a more organised form; the excitement was greater, but with less incoherence; eroticism of a very painful kind developed, and it was difficult to prevent open masturbation. She refused food, and her condition rapidly passed into a very dangerous typhoid one; she was removed to Bethlem, where, after several weeks of extreme violence and weakness, she passed into a state of temporary mental exhaustion—stupor—from which she slowly but certainly recovered, and has remained well ever since. In another case, a girl of about the same age, two of whose sisters were insane, and one brother epileptic, with a very eccentric father, developed acute delirious mania after measles; of which she died in a few days.

After the delirium of pneumonia, I have seen similar symptoms arise in nervous patients. What I have already said makes clear what I believe to be an established fact, that any of those febrile conditions may start an insane attack. I am inclined to think that those who come of insane stock are very often unusually liable to infection, and that having contracted an acute disease, they are more likely to have early and severe delirium.

Besides alcohol and fever, I give one case in which delirium of belladonna proved efficient in starting the insane process. A young girl belonging to a very neurotic stock took by accident a dose of belladonna liniment instead of a dose of cough mixture. For two days the medical man treated her delirious condition as due simply to the drug; but at the end of that time she remained still wild and delirious, and I was called in to see her. She passed through a sharp attack of mania of the delirious type, though the bodily illness was not extreme. As in most of the cases to which I have already referred, in the end the girl recovered. From the above, I think I am justified in saying that any toxic agent, more especially those which directly affect the nutrition of the nervous system, such as alcohol, lead, and belladonna, will cause temporary disorder of the intellectual functions, especially in the nervously unstable, and that this temporary disorder may assume the form of true insanity; that this insanity generally, though not always, assumes the form of acute delirious mania. We must not, however, forget that shock of any kind may produce similar mental disorder, and therefore in considering the insanity which

Terminology



Why do we need to know about PND?

- Increasing life expectancy and increased proportion of elderly patients
- 19% patients 80-89 years and 26% patients >90 years showed functional decline that persisted >30days after surgery
- Danish study – followed 700 patients . Patient with POCD within 1 week left labor market prematurely and withdraw social benefits early,
- Increased risk of death 1 year after surgery.

When should we think about it?

- Age
- Lower education
- Psycho-social status
- h/o CVA
- Preop cognitive impairment
- Type of surgery
- Duration of anesthesia
- Redo or re-exploration
- Post op complications – respiratory/infection
- FRAILTY

Frailty

- Multidimensional loss of reserve due to accumulation of age and disease related deficits.
- One of the strongest predictors of post op delirium increasing risk more than fourfold.

Components of Frail Questionnaire	Questions asked in survey/ Information from EMR	Score
Fatigue:	Are you too tired to exercise?	1
Resistance:	Can you climb one flight of stairs without assistance?	1
Aerobic:	Can you walk one block without assistance?	1
Illnesses:	Five or more illnesses (Confirmed with EMR)	1
Loss of weight:	>5% weight loss over the past year (Obtained from EMR)	1

Score 3 or greater = frail
Score 1-2 = pre-frail
Score 0 = not frail

Illnesses: Heart attack, Angina, Heart Failure, Stroke, Dementia, COPD, Diabetes, Malignancy, Osteoarthritis, Hypertension, Asthma, Kidney Disease

Risk Factors

Table 2. Summary of risk factors displaying significant ($p \leq 0.05$) associations with post-operative cognitive dysfunction.

Outcome	Evidence Class	Study, n	Participants, n	Effect Size (95% CI)	*p* Value	I^2
Pre-operative factors						
Age (coronary artery bypass)	III	22	2881	0.27 (0.14, 0.41)	9.47×10^{-5}	92%
Age (carotid endarterectomy)	IV	10	884	0.1 (0.03, 0.17)	3.19×10^{-3}	0%
Cognition: All tests (coronary artery bypass)	IV	3	155	0.2 (0.04, 0.36)	1.26×10^{-2}	0%
Cognition: MMSE (coronary artery bypass)	IV	2	120	0.23 (0.05, 0.41)	1.19×10^{-2}	0%
C-reactive protein (hip arthroplasty)	IV	8	744	0.23 (0.11, 0.35)	2.01×10^{-4}	55%
Depression (coronary artery bypass)	IV	2	330	0.68 (0.06, 1.3)	3.12×10^{-2}	62%
Diabetes	IV	13	2554	0.16 (0.01, 0.32)	4.13×10^{-2}	71%
Diabetes (coronary artery bypass)	III	17	2968	0.2 (0.1, 0.3)	4.63×10^{-5}	5%
Education	IV	8	2535	−0.06 (−0.09, −0.03)	3.74×10^{-5}	44%
Education (coronary artery bypass)	IV	6	538	0.14 (0.05, 0.22)	1.67×10^{-3}	0%
Euroscore (coronary artery bypass)	IV	4	582	0.23 (0.14, 0.31)	2.09×10^{-7}	10%
Hypertension (coronary artery bypass)	IV	15	2115	0.36 (0.21, 0.51)	4.91×10^{-6}	34%
Interleukin 1β (hip arthroplasty)	IV	5	247	0.19 (0.04, 0.34)	1.14×10^{-2}	26%
Interleukin 6	IV	16	986	0.15 (0.08, 0.22)	2.43×10^{-5}	17%
Interleukin 6 (hip arthroplasty)	IV	6	699	0.1 (0.03, 0.17)	7.78×10^{-3}	0%
LVEF% (coronary artery bypass)	IV	9	1225	0.14 (0.04, 0.24)	4.72×10^{-3}	62%
Previous stroke, TIA, CVA (coronary artery bypass)	IV	5	745	0.49 (0.21, 0.77)	5.82×10^{-4}	0%
S100b	IV	5	232	0.27 (0.02, 0.53)	3.57×10^{-2}	74%
S100b (hip arthroplasty)	IV	3	245	0.23 (0.1, 0.36)	5.96×10^{-4}	5%
Statin (carotid endarterectomy)	IV	3	1279	−0.31 (−0.49, −0.14)	4.31×10^{-4}	21%
Tumour necrosis factor alpha (hip arthroplasty)	IV	5	412	0.17 (0.08, 0.27)	4.65×10^{-4}	0%
Intra-operative factors						
Aortic cross-clamping time (coronary artery bypass)	IV	7	608	0.13 (0.05, 0.21)	2.46×10^{-3}	6%
CPB time (coronary artery bypass)	IV	13	1829	0.1 (0.06, 0.15)	8.88×10^{-8}	0%
Cross-clamping duration (carotid endarterectomy)	IV	10	893	0.1 (0.02, 0.19)	1.38×10^{-2}	29%
Hyperperfusion (carotid endarterectomy)	IV	5	417	1.97 (1.55, 2.39)	4.18×10^{-20}	0%
Number of grafts (coronary artery bypass)	IV	7	1113	0.07 (0.01, 0.12)	2.96×10^{-2}	0%
Surgery duration (coronary artery bypass)	IV	6	727	0.13 (0.06, 0.21)	3.17×10^{-4}	0%
Total microemboli (coronary artery bypass)	IV	4	791	0.09 (0.02, 0.15)	1.68×10^{-2}	0%
Post-operative factors						
Arrhythmia (coronary artery bypass)	IV	6	1045	0.19 (0.01, 0.36)	4.22×10^{-2}	0%
Delirium (coronary artery bypass)	IV	3	355	1 (0.46, 1.54)	2.54×10^{-4}	6%
Tumour necrosis factor alpha (hip arthroplasty)	IV	2	97	0.21 (0.01, 0.41)	3.97×10^{-2}	0%

Abbreviations: CPB = cardiopulmonary bypass, CVA = cerebrovascular accident, LVEF% = left ventricular ejection fraction, MMSE = Mini Mental State Examination, S100b = S100 calcium-binding protein B, TIA = transient ischemic attack.

What can we do about this?

- Preop testing
- Prehabilitation
- Premedications and drugs to be avoided
- Pharmacologic delirium prevention
- Anesthesia strategies

Preoperative testing

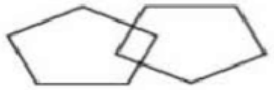
- Mini-Mental Status Examination
- Mini-Cog test
- Montreal cognitive assessment -10 min test
- Trail making test
- Digit symbol test
- Frailty screening test- Clinical frailty scale, Edmonton frail scale FRAIL question
- Psychosocial status
- Geriatric depression scale

Mini-mental State examination

Mini-Mental State Examination (MMSE)

Patient's Name: _____ Date: _____

Instructions: Score one point for each correct response within each question or activity.

Maximum Score	Patient's Score	Questions
5		"What is the year? Season? Date? Day? Month?"
5		"Where are we now? State? County? Town/city? Hospital? Floor?"
3		The examiner names three unrelated objects clearly and slowly, then the instructor asks the patient to name all three of them. The patient's response is used for scoring. The examiner repeats them until patient learns all of them, if possible.
5		"I would like you to count backward from 100 by sevens." (93, 86, 79, 72, 65, ...) Alternative: "Spell WORLD backwards." (D-L-R-O-W)
3		"Earlier I told you the names of three things. Can you tell me what those were?"
2		Show the patient two simple objects, such as a wristwatch and a pencil, and ask the patient to name them.
1		"Repeat the phrase: 'No ifs, ands, or buts.'"
3		"Take the paper in your right hand, fold it in half, and put it on the floor." (The examiner gives the patient a piece of blank paper.)
1		"Please read this and do what it says." (Written instruction is "Close your eyes.")
1		"Make up and write a sentence about anything." (This sentence must contain a noun and a verb.)
1		"Please copy this picture." (The examiner gives the patient a blank piece of paper and asks him/her to draw the symbol below. All 10 angles must be present and two must intersect.) 
30		TOTAL

Mini-cog test

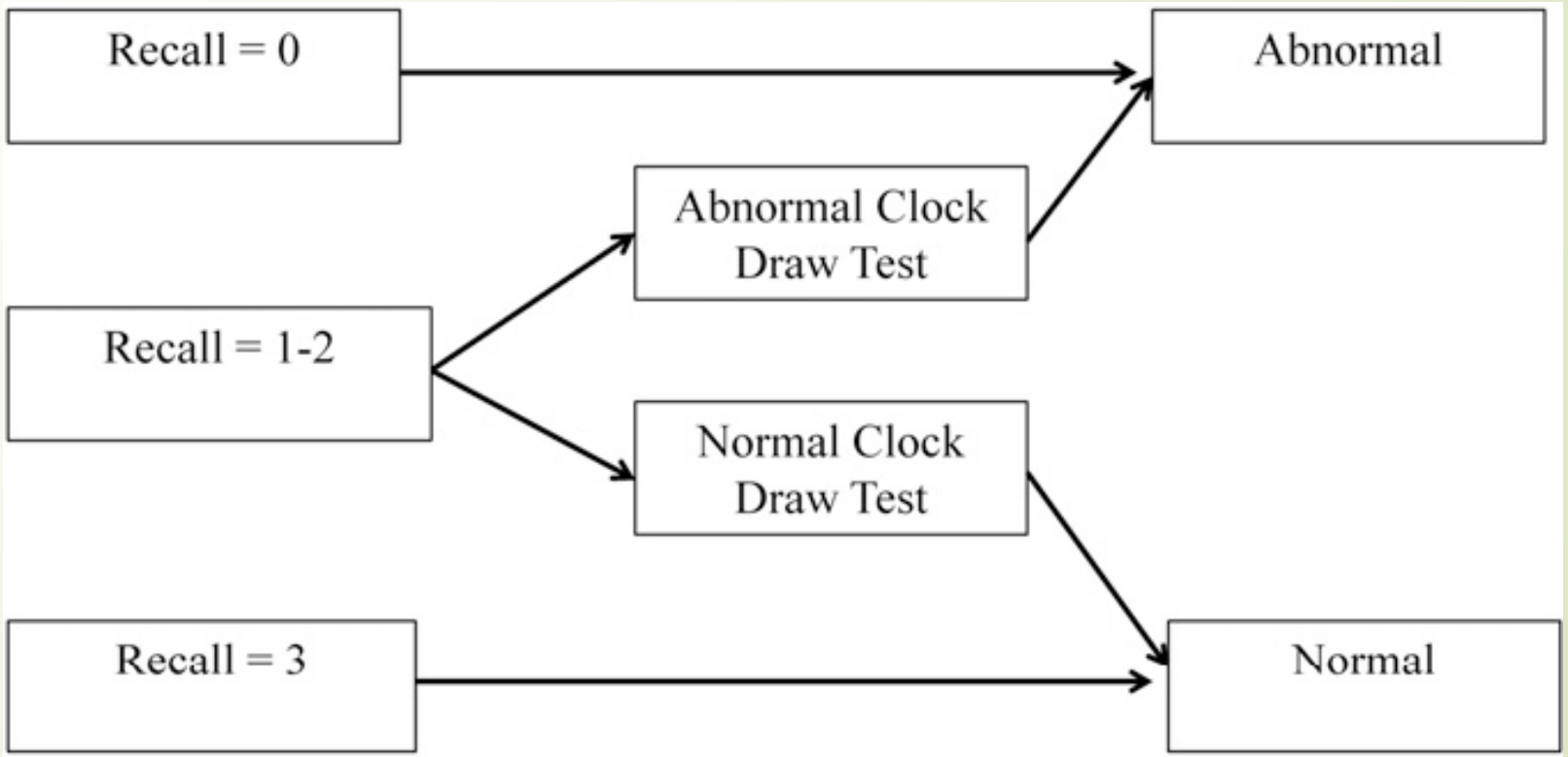
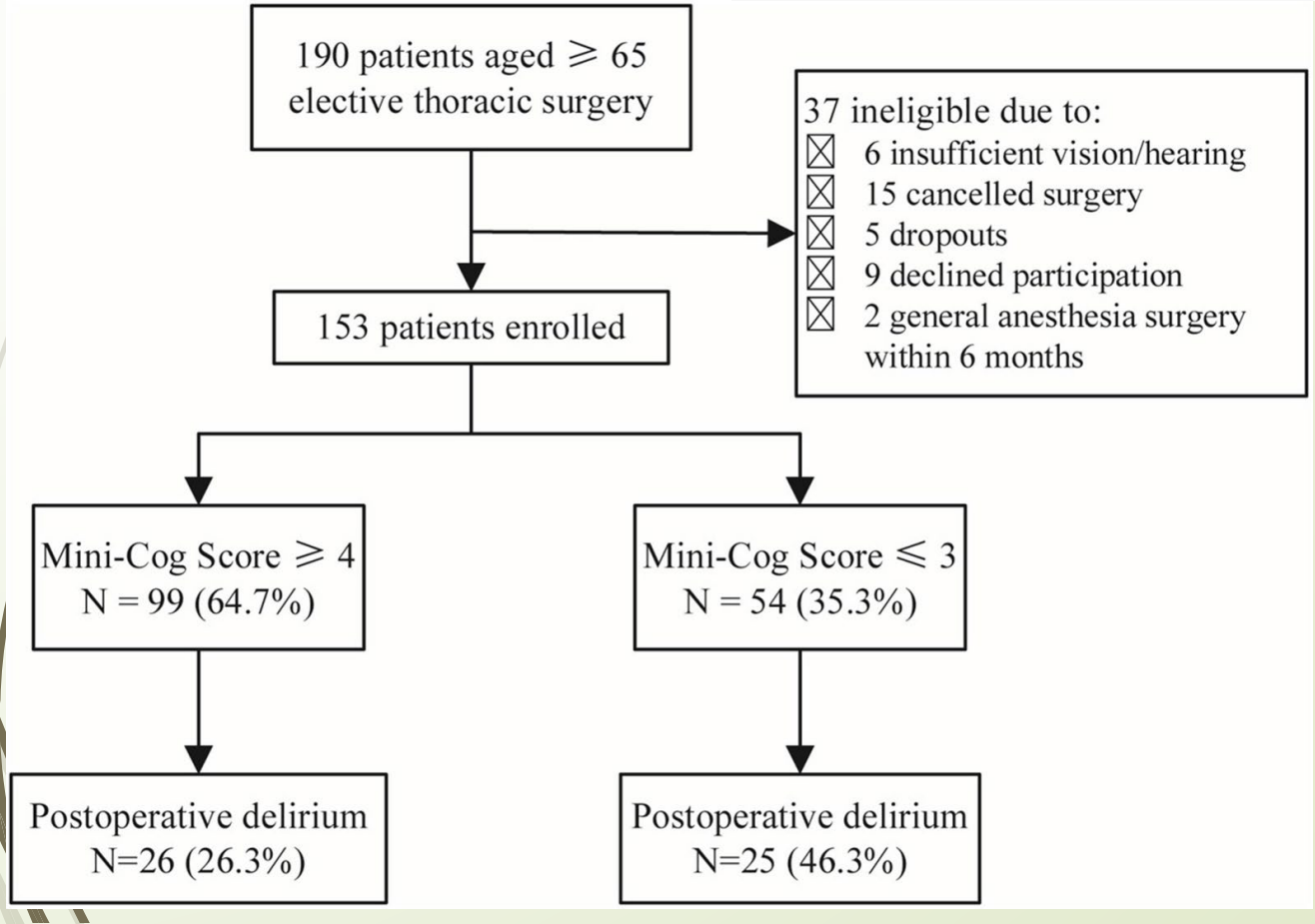


Fig. 1
Scoring algorithm of the Mini-Cog test.

Prevalence of preoperative cognitive impairment among elderly thoracic surgery patients and association with postoperative delirium: a prospective observational study

Fangfang Li, Mengrong Miao, Ningning Li, Jun Zhou, Mingyang Sun, Jiaqiang Zhang*

Department of Anesthesiology and Perioperative Medicine, People's Hospital of Zhengzhou University, Henan Provincial People's Hospital, Zhengzhou, Henan, China



Anesthesiology. 2025 Jan 1;142(1):22-51. doi: 10.1097/ALN.0000000000005172.

2025 American Society of Anesthesiologists Practice Advisory for Perioperative Care of Older Adults Scheduled for Inpatient Surgery

Frederick Sieber [1], Daniel I McIsaac [2], Stacie Deiner [3], Tangwan Azefor [1], Miles Berger [4], Christopher Hughes [5], Jacqueline M Leung [6], John Maldon [7], Julie R McSwain [8], Mark D Neuman [9], Marcia M Russell [10], Victoria Tang [11], Elizabeth Whitlock [6], Robert Whittington [12], Anne M Marbella [13], Madhulika Agarkar [13], Stephanie Ramirez [13], Alexandre Dyer [13], Jaime Friel Blanck [14], Stacey Uhl [13], Mark D Grant [15], Karen B Domino [16]

Affiliations + expand

PMID: 39655991 DOI: 10.1097/ALN.0000000000005172

Expanded preop eval vs standard eval

- Strength of evidence –low and conditional recommendation
- 6 RCT–lower risk of POD
- Parameters- frailty/cognitive impairment, physical function, psychosocial issue, comprehensive geriatric assessment
- Interventions – deprescribing meds, nutritional supplements, geriatric visits, occupational therapy visits

Prehabilitation

- Not included in advisory for lack of evidence
- Process of enhancing capacity and reserve before an acute stressor to improve tolerance of upcoming injury
- Physical exercise
- Nutritional supplements
- Cognitive training interventions

Type of Anesthesia

- Neuraxial vs General
- Strength of evidence- strong and moderate recommendation
- TIVA vs Inhaled anesthetics
- 8 RCTs did not favor TIVA or inhaled anesthesia
- Strength of evidence –low and conditional recommendation
- Effect of blood transfusion

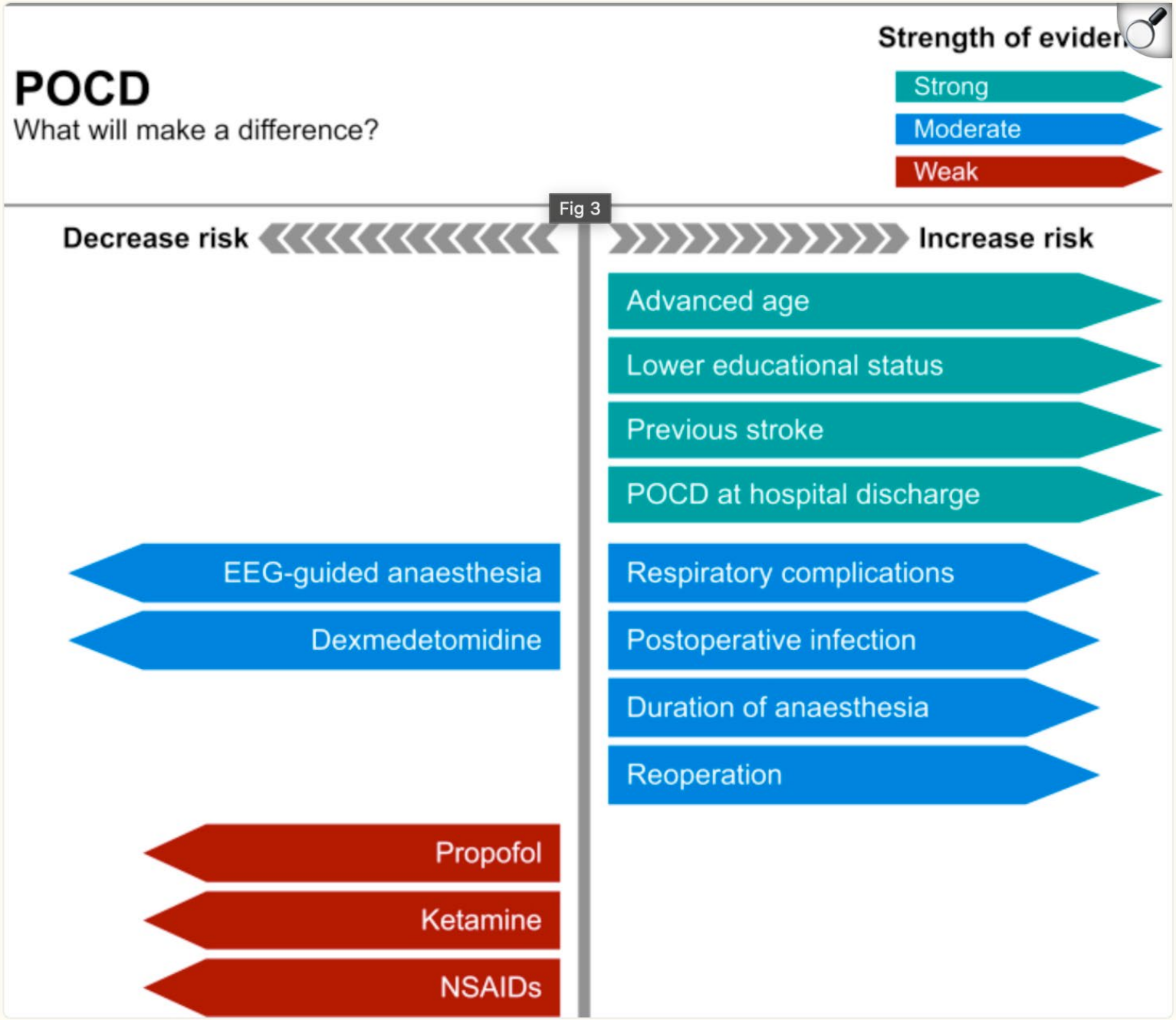
Pharmacologic Delirium Prevention

- Dexmedetomidine
- Melatonin

Perioperative use of medication with potential CNS effects

- Benzodiazepines- longer acting vs short acting
- Antipsychotics- lower delirium- inconclusive
- Ketamine - no difference
- Anticholinergics- no difference
- Corticosteroids inconclusive –lower
- NSAIDs- lower
- Gabapentin- no difference and increase

Polypharmacy


Strength of evider
POCD
What will make a difference?
Strong
Moderate
Weak
Fig 3
Decrease risk
Increase risk
Advanced age
Lower educational status
Previous stroke
POCD at hospital discharge
EEG-guided anaesthesia
Dexmedetomidine
Respiratory complications
Postoperative infection
Duration of anaesthesia
Reoperation
Propofol
Ketamine
NSAIDs

JAMA. Author manuscript; available in PMC: 2013 Mar 21.

Published in final edited form as: JAMA. 2012 Jul 4;308(1):73–81. doi: 10.1001/jama.2012.6857

Postoperative Delirium

A 76-Year-Old Woman With Delirium Following Surgery

Edward R Marcantonio [1]

Author information Copyright and License information

PMCID: PMC3604975 NIHMSID: NIHMS444707 PMID: 22669559

Case

- 73-year-old female with past medical history of depression, paroxysmal Atrial fibrillation, irritable bowel syndrome complained of GI bleeding and diverticulosis
- Hb-11g/dl, normal electrolytes
- h/o Hip arthroplasty
- She was found to polyp- underwent anterior colectomy
- Recovered well with no delirium or confusion

Case-contd

- POD 3- acute confusion- followed my fever, hypotension
- Found to have anastomotic leak- underwent diverting loop ileostomy
- Transferred to ICU
- Afib needed cardioversion
- Confused for 4 days in ICU
- Discharged to skilled nursing facility and then home

Case cont.

- 3 months later- closed ileostomy – uneventful surgery
- Immediate post op delirium
- Needed hospital admission for major depression
- Towards the end of hospital stay- fell and sacral fracture
- Discharge to skilled nursing facility
- 4 months after going home – normal- back to job as therapist and living independently and driving

Thoughts???

Re fe re n c e

- Brodier EA, Cibelli M. Postoperative cognitive dysfunction in clinical practice. BJA Educ. 2021 Feb;21(2):75-82. doi: 10.1016/j.bjae.2020.10.004. Epub 2020 Dec 24. PMID: 33889433; PMCID: PMC7810820.
- Steinmetz J., Christensen K.B., Lund T., Lohse N., Rasmussen L.S. Long-term consequences of postoperative cognitive dysfunction. Anesthesiology. 2009;110:548–555. doi: 10.1097/ALN.0b013e318195b569.
- Travica N, Lotfaliany M, Marriott A, Safavynia SA, Lane MM, Gray L, Veronese N, Berk M, Skvarc D, Aslam H, Gamage E, Formica M, Bishop K, Marx W. Peri-Operative Risk Factors Associated with Post-Operative Cognitive Dysfunction (POCD): An Umbrella Review of Meta-Analyses of Observational Studies. J Clin Med. 2023 Feb 17;12(4):1610. doi: 10.3390/jcm12041610. PMID: 36836145; PMCID: PMC9965885.
- Sieber F, McIsaac DI, Deiner S, Azefor T, Berger M, Hughes C, Leung JM, Maldon J, McSwain JR, Neuman MD, Russell MM, Tang V, Whitlock E, Whittington R, Marbella AM, Agarkar M, Ramirez S, Dyer A, Friel Blanck J, Uhl S, Grant MD, Domino KB. 2025 American Society of Anesthesiologists Practice Advisory for Perioperative Care of Older Adults Scheduled for Inpatient Surgery. Anesthesiology. 2025 Jan 1;142(1):22-51. doi: 10.1097/ALN.0000000000005172. PMID: 39655991.
- Gracie TJ, Caufield-Noll C, Wang NY, Sieber FE. The Association of Preoperative Frailty and Postoperative Delirium: A Meta-analysis. Anesth Analg. 2021 Aug 1;133(2):314-323. doi: 10.1213/ANE.0000000000005609. PMID: 34257192; PMCID: PMC8289124.
- Deiner SG, Marcantonio ER, Trivedi S, Inouye SK, Travison TG, Schmitt EM, Hshieh T, Fong TG, Ngo LH, Vasunilashorn SM. Comparison of the frailty index and frailty phenotype and their associations with postoperative delirium incidence and severity. J Am Geriatr Soc. 2024 Jun;72(6):1781-1792. doi: 10.1111/jgs.18677. Epub 2023 Nov 14. PMID: 37964474; PMCID: PMC11090994.


QUESTIONS

Thank you

Anesthesia and the Breastfeeding Patients

JOANNA SCHINDLER, MD, FASA

DIRECTOR OF MEDICAL STUDENT EDUCATION

EMORY UNIVERSITY SCHOOL OF MEDICINE DEPT OF ANESTHESIOLOGY

MEDICAL DIRECTOR PREADMISSIONS ASSESSMENT CLINIC

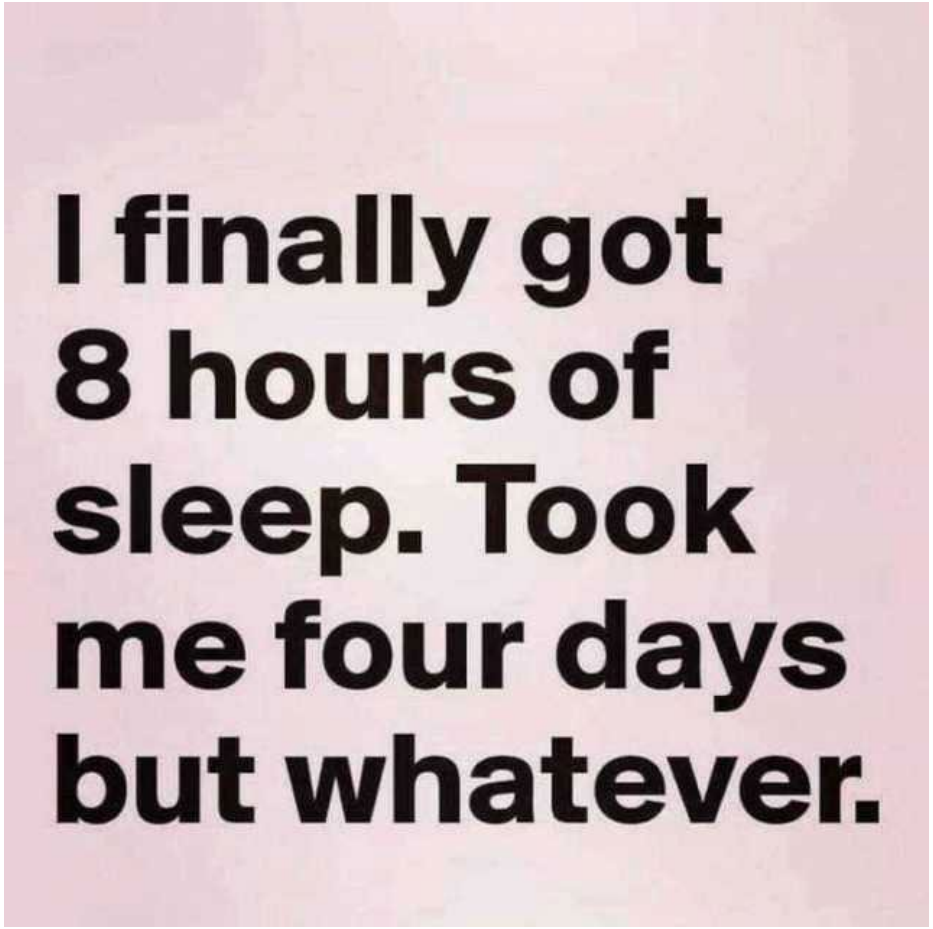
GRADY HEALTH SYSTEM

Disclosures

I am a paid consultant for Elsevier Publishing. This talk is unrelated to those topics.

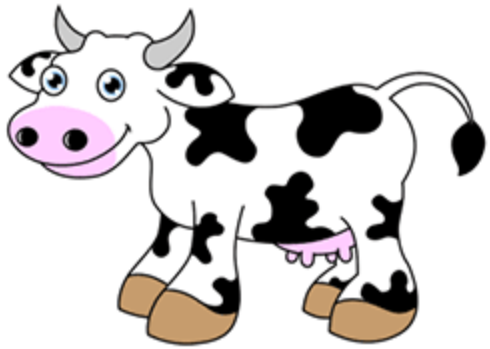
Disclosure?

I breastfed three children.

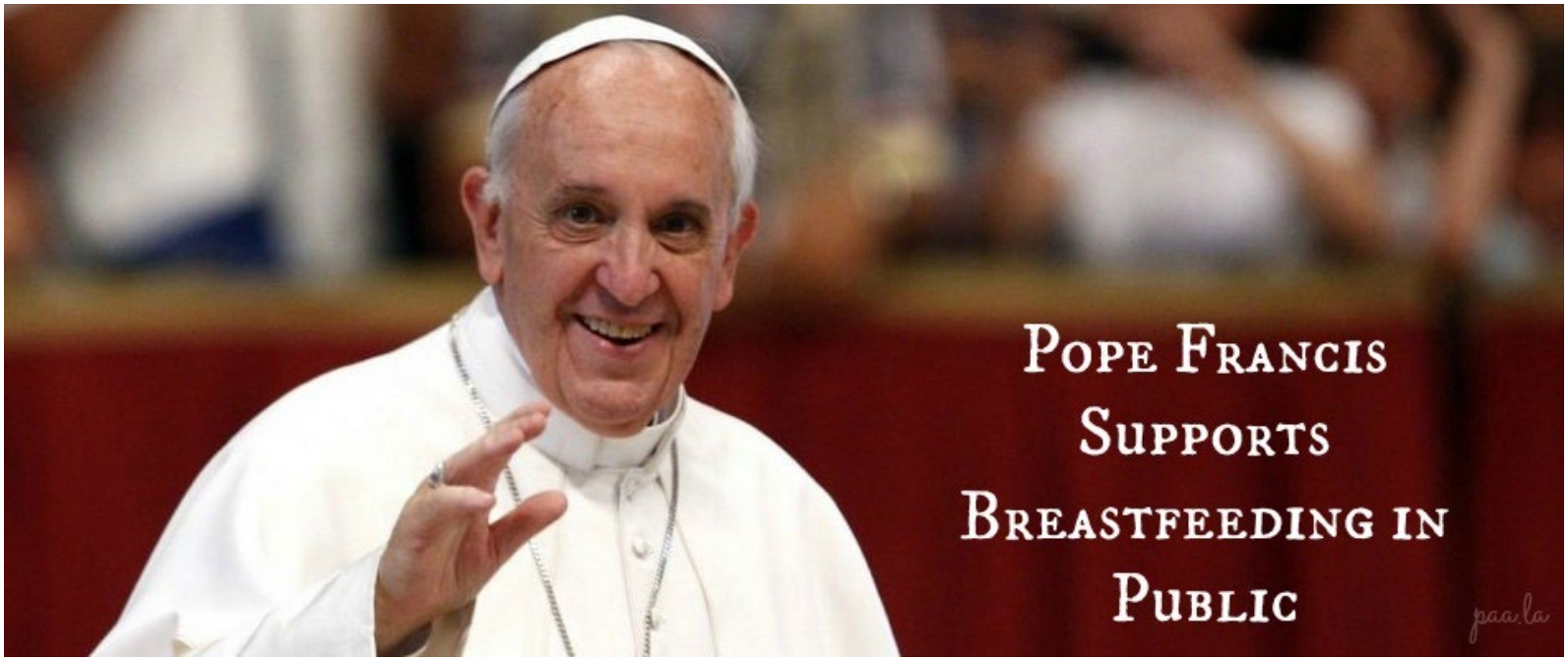


Objectives

- Maternal and pediatric benefits of breastfeeding
- Regulatory agencies, statistics, and public health
- Anesthesia and the peripartum period
- Beyond the peripartum period: presenting for surgery
- Anesthesia and the breastfeeding infant



But first some cultural context



Penman 2018

From the Jewish Perspective

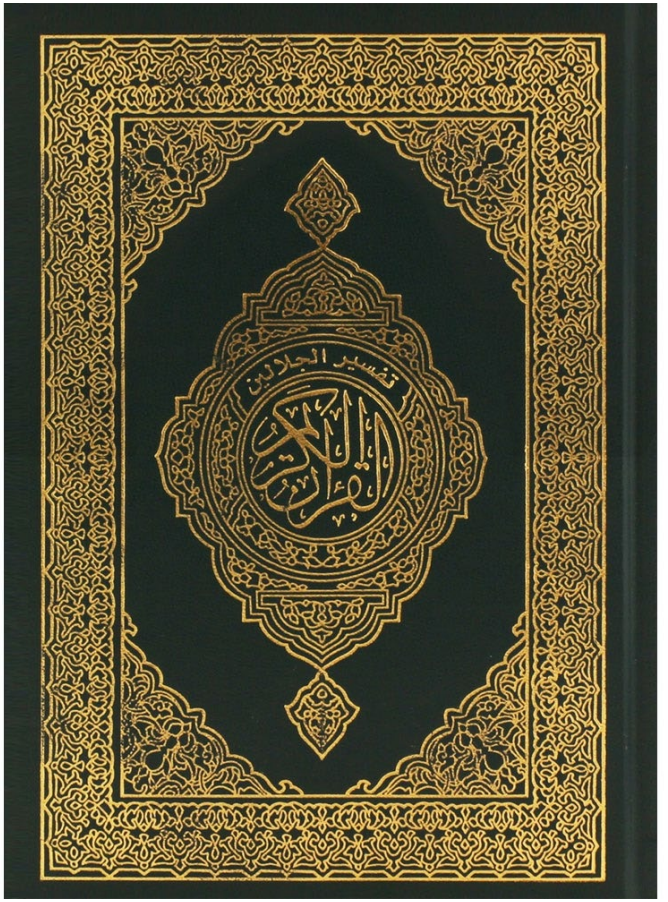
- *Gemara Ketubot, p. 60b*
- Breastfeeding is fundamental for bonding and nourishment, and nursing women should be held in high esteem.
- Breastfeeding should continue at least 24 months and no more than 4 years for a healthy child or 5 years for sickly child.

Candelaria 2019

The Islamic Perspective

- Breastfeeding is a basic right for every newborn and infant with high recommendations for breastfeeding two years (Qur'an, 2:233)
- "High spiritual esteem of breastfeeding is also demonstrated in Islamic legal rulings on breastfeeding such as the establishment of lineage, marriage illegibility and the forging of blood-like kinships."

Bensaid 2019



The Hindu Perspective

- The Sushruta Samhita—a collection of works of Sushruta, a surgeon in the Gupta period, 400 BC
  - Food should not be introduced before six months
  - Early weaning may lead to a protuberant abdomen
  - Children weaned too early will be lean for life
  - A baby's sight, sound, and touch are necessary for lactation

Laroia 2006

Why should we care?

- Your patient cares.
- Your patient's baby cares.
  - Hungry babies are cranky babies.
  - And potentially dehydrated and hypoglycemic
- The ASA, AAP, ACOG, CDC, and WHO care.
- Even JCAHO cares!
  - Rate of exclusive breastmilk feeding is part of Joint Commission's Perinatal Care Certification

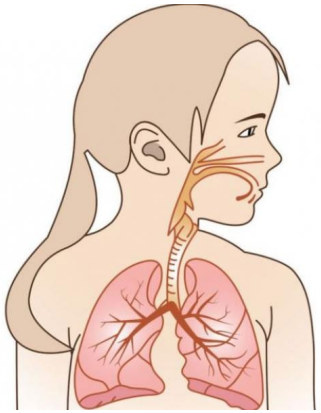
American Academy of Pediatrics

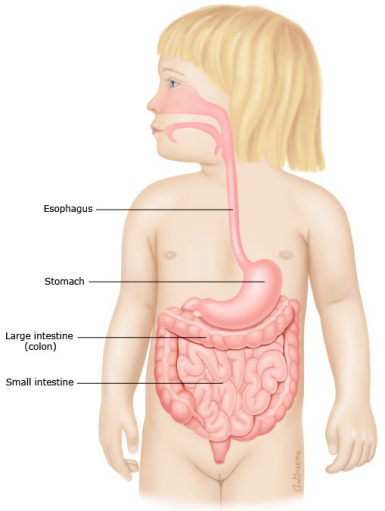
DEDICATED TO THE HEALTH OF ALL CHILDREN®

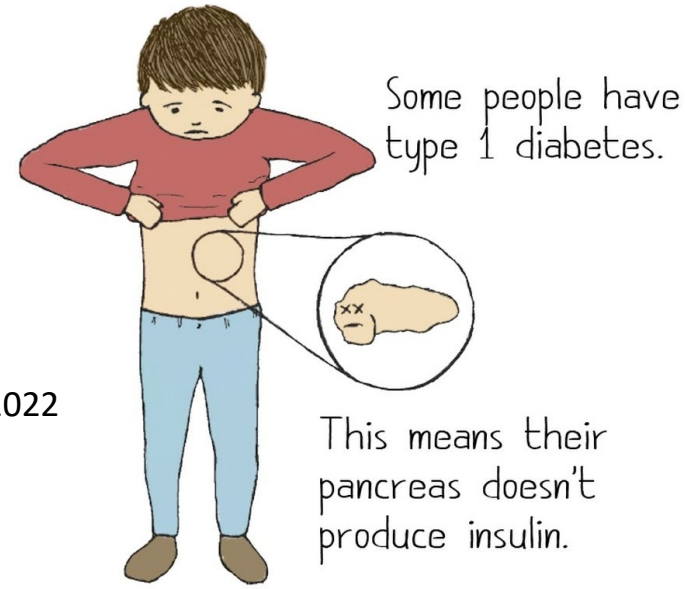
"Breastfeeding and human milk are the reference normative standards for infant feeding and nutrition."

AAP 2022

Pediatric Benefits







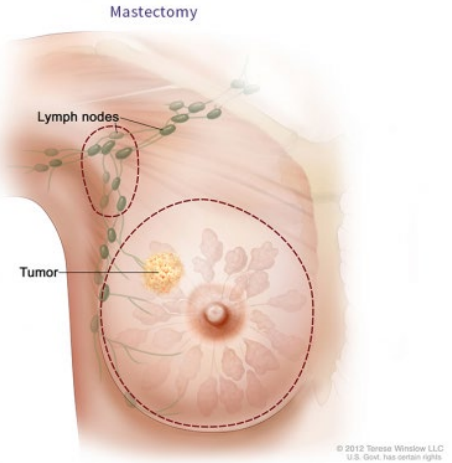
AAP 2022

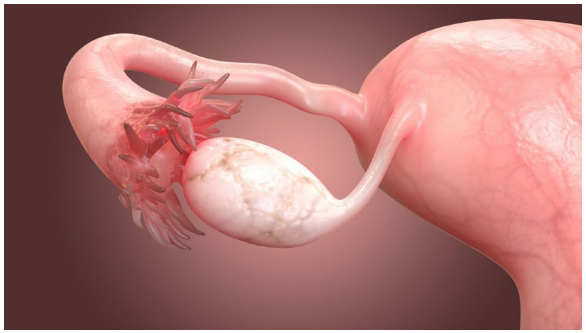
Preterm Infants

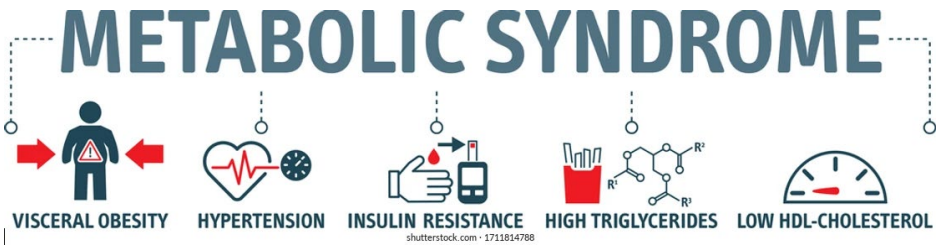
- Significantly lower rates of necrotizing enterocolitis
  - NNT to prevent 1 case of NEC = 10
  - NNT to prevent 1 case of NEC requiring surgery or resulting in death = 8
  - "No other intervention has been shown to have such a marked effect on the incidence of NEC." Sullivan 2010
- Lower rates of severe retinopathy of prematurity
- Fewer hospital readmissions in the first year of life
- Improved neurodevelopmental outcomes at 18 and 30 months

AAP 2022

Maternal Benefits







AAP 2022

AAP Guidelines

- Preterm infants
  - All preterm infants should receive human milk.
  - Pasteurized donor human milk, appropriately fortified (if infant < 1500gm) should be used if mother's own milk is unavailable or contraindicated.
- All infants
  - Six months of exclusive breastmilk feeding

AAP News™

Updated AAP guidance recommends longer breastfeeding due to benefits

June 27, 2022

Alyson Sulaski Wyckoff, Associate Editor

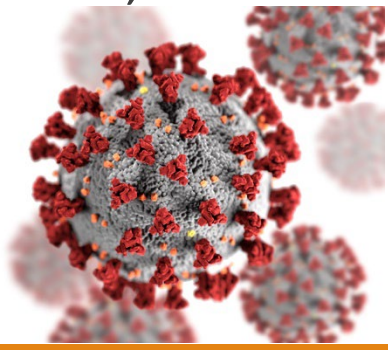
Absolute Contraindications

- Galactosemia in the infant
- Maternal HIV infection**
- Maternal HTLV-I or II infection
- Maternal illicit drug use
- Certain medications
  - Chemotherapy
  - Radioactive isotopes
  - Amphetamines
  - Ergotamines
  - Statins

AAP 2012
CDC 2020
WHO 2019

NOT Contraindicated

- Maternal smoking
- Opioid replacement therapy
- Occasional alcohol intake
- Metabolic diseases other than galactosemia
- Hepatitis B and C
- Active maternal tuberculosis, cytomegalovirus, influenza, varicella, or herpes simplex infection, COVID-19
- Mastitis and breast abscess



AAP 2022
CDC 2020

Table 1. Breastfeeding Rates Among Infants Born in 2019[a,b]

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

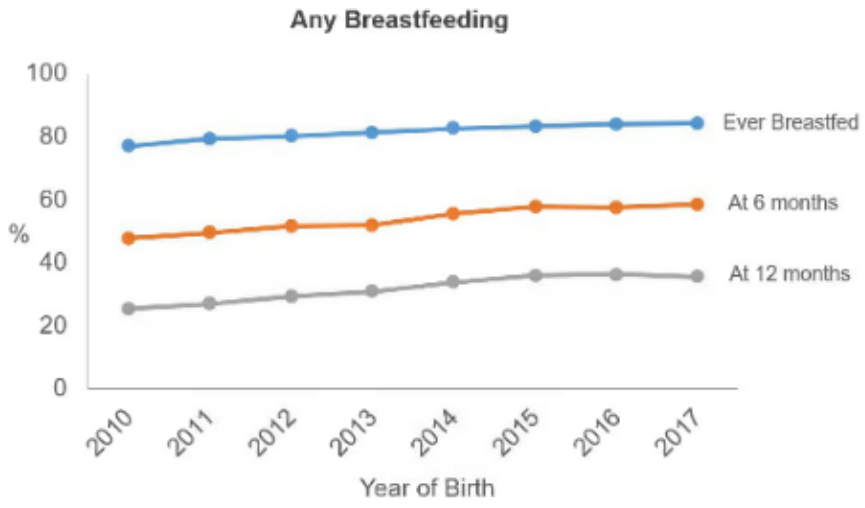
State/Territory	Ever breastfed	Breastfeeding at 6 months	Breastfeeding at 12 months	Exclusive breastfeeding through 3 months	Exclusive breastfeeding through 6 months
US National[b]	83.2	55.8	35.9	45.3	24.9
Georgia	82.6	53.1	33.7	39.9	18.7

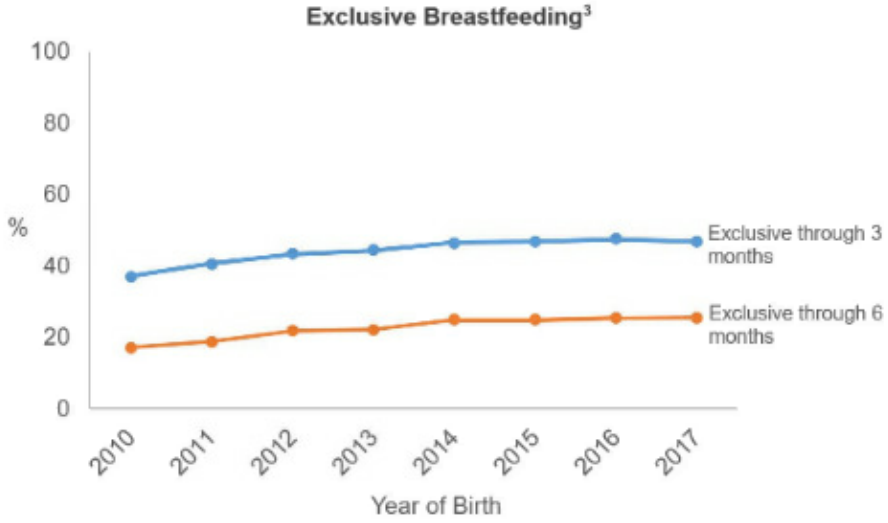
Breastfeeding Report Card

United States, 2020

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

Percentage of U.S. Children Who Were Breastfed, by Birth Year[1,2,3]





Rates of Any and Exclusive Breastfeeding by Sociodemographics among Children Born in 2018

				Race/Ethnicity
Hispanic	4336	85.0±1.9	52.8±2.8	32.3±2.6
Non-Hispanic White	12032	85.3±1.2	60.0±1.5	37.6±1.5
Non-Hispanic Black	1996	75.5±3.0	49.3±3.5	27.9±3.2
Non-Hispanic Asian	951	92.4±2.4	75.6±4.2	51.2±4.9
Non-Hispanic Hawaiian/Pacific Islander	113	NA	NA	NA
Non-Hispanic American Indian/Alaska Native	279	NA	NA	NA
2 or more races	1721	82.4±3.3	52.9±4.0	32.8±3.5
				Maternal Education
Less than high school	1662	74.9±3.3	45.0±4.0	27.5±3.4
High school graduate	3723	75.8±2.3	43.4±2.7	25.4±2.4
Some college or technical school	5377	84.5±1.7	53.5±2.4	30.6±2.2
College graduate	10666	92.1±0.9	71.7±1.5	46.9±1.7
				Poverty Income Ratio3
Less than 100	4237	76.8±2.1	44.6±2.6	26.3±2.2
100 – 199	4169	81.2±2.1	49.8±2.7	30.6±2.4
200 – 399	5563	87.2±1.6	62.8±2.3	39.7±2.3
400 – 599	3703	89.0±2.1	67.2±2.8	42.1±2.9
600 or greater	3756	90.9±1.9	69.6±2.9	43.5±2.9

CDC National Immunization Survey 2020

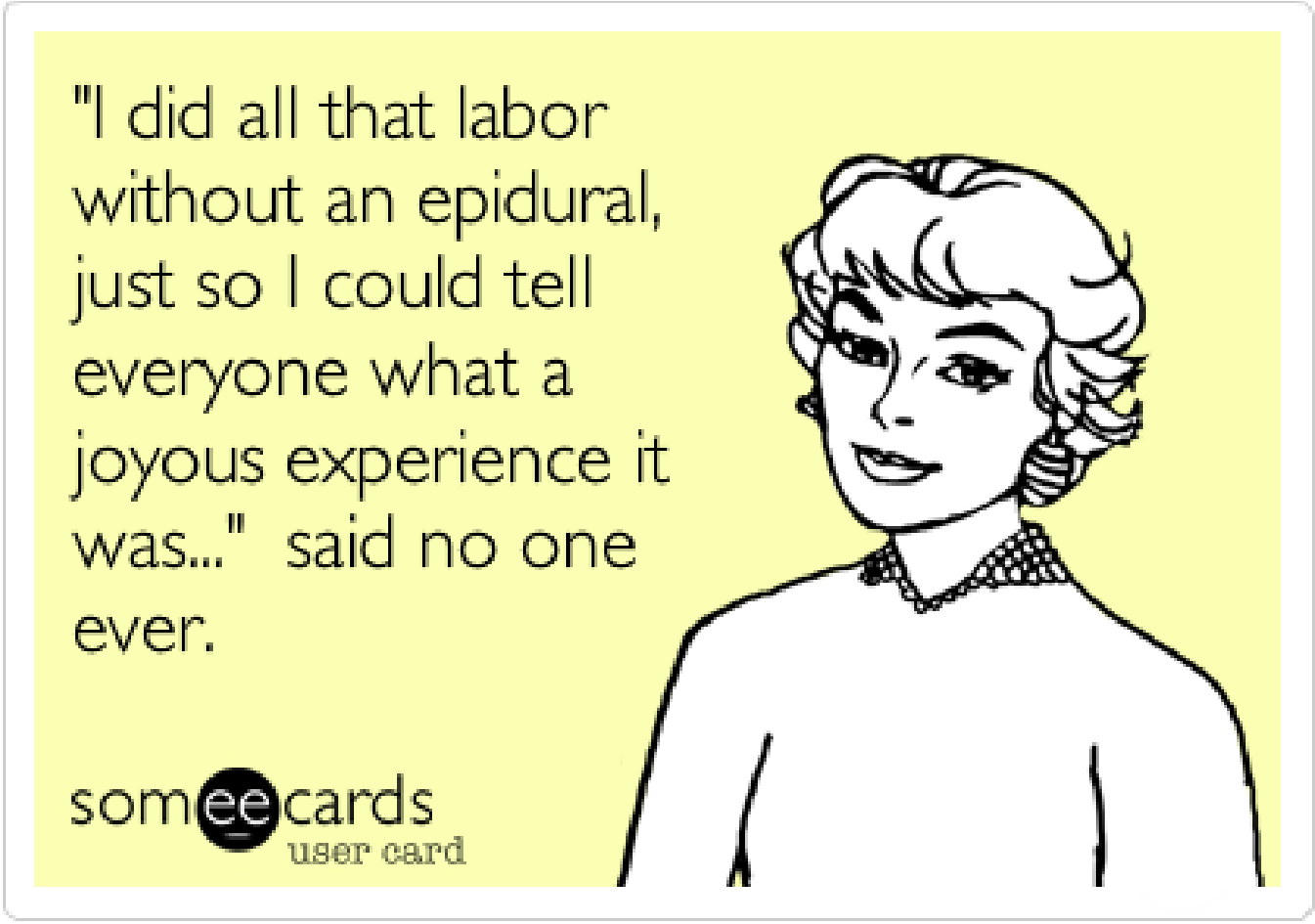
Outcome Differences

Table X. Relative and absolute differences of excess disease attributable to suboptimal breastfeeding per 100 000 women, compared with NHWs (95% CI)

	Relative differences		Absolute Differences	
	Ratio of NHBs to NHWs	Ratio of Hispanics to NHWs	Difference of NHBs minus NHWs	Difference of Hispanic minus NHWs
Child diseases				
Acute otitis media	1.68 (1.66-1.71)	1.43 (1.41-1.45)	17 312 (16 890-17 769)	10 879 (10 445-11 291)
Gastrointestinal infection	1.32 (1.31-1.33)	1.38 (1.37-1.38)	37 142 (36 283-38 039	43 398 (42 534-44 298)
LRTI requiring hospitalization	1.32 (1.25-1.39)	1.38 (1.31-1.45)	303 (245-362)	355 (291-418)
NEC	3.30 (2.92-3.69)	2.01 (1.84-2.19)	121 (110-132)	53 (45-63)
SIDS	1.95 (1.42-2.61)	1.40 (0.97-1.89)	19 (13-27)	8 (1-16)
Child deaths total	2.23 (1.63-2.84)	1.53 (1.17-1.90)	36 (23-50)	16 (7-25)

Bartick MC, Jegier BJ, Green BD, Schwarz EB, Reinhold AG, Stuebe AM. Disparities in Breastfeeding: Impact on Maternal and Child Health Outcomes and Costs. *J Pediatr*. 2017;181:49-55.e6. doi:10.1016/j.jpeds.2016.10.028

The Peripartum Period



Disclaimers

- Paucity of high quality research
- Bad quality research predominates (i.e. retrospective, observational, high crossover rates, and non-randomized)
  - Many of these studies associate epidurals with negative breastfeeding outcomes.
  - Are negative outcomes caused by the epidural?
  - Or does dysfunctional labor worsen breastfeeding outcomes and independently make women more likely to request epidural analgesia?

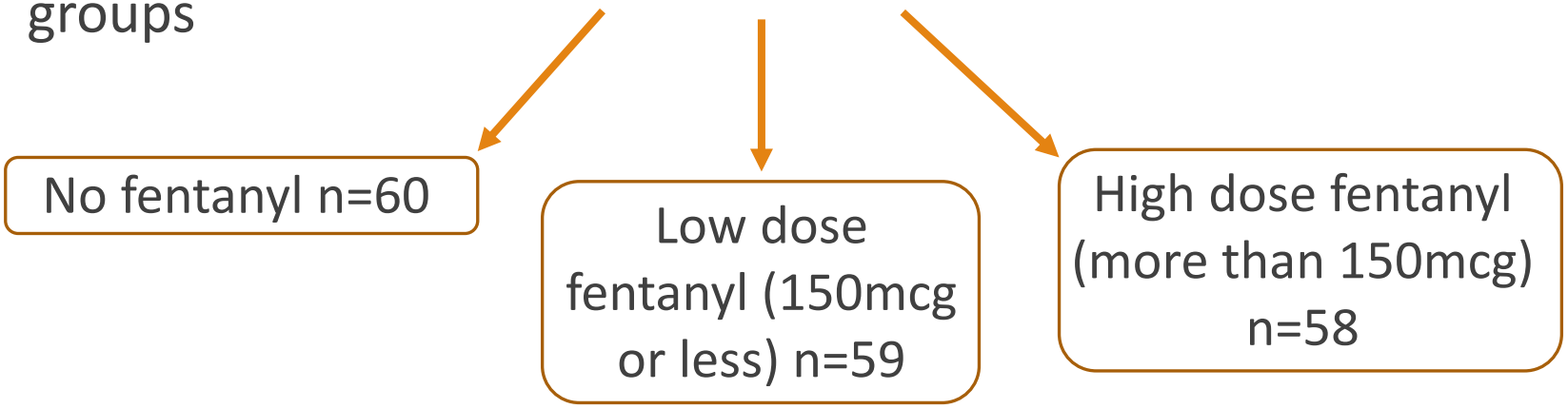
Anesthesiology 2005; 103:1211–7

Effect of Labor Epidural Analgesia with and without Fentanyl on Infant Breast-feeding

A Prospective, Randomized, Double-blind Study

Yaakov Beilin, M.D., Carol A. Bodian, Dr.P.H.† Jane Weiser, Ed.D. R.N., I.B.C.I.C.,‡ Sabera Hossain, M.S.,§ Ittamar Arnold, B.A.,‖ Dennis E. Feierman, Ph.D., M.D.,* Gregory Martin, M.D.,# Ian Holzman, M.D.***

- Random allocation of 177 multiparous women who had previously successfully breastfed an infant to three epidural groups



- Exclusion criteria
  - Any intravenous analgesic during labor
  - Cesarean delivery

Anesthesiology 2005; 103:1211–7

Effect of Labor Epidural Analgesia with and without Fentanyl on Infant Breast-feeding

A Prospective, Randomized, Double-blind Study

Yaakov Beilin, M.D., Carol A. Bodian, Dr.P.H.† Jane Weiser, Ed.D. R.N., I.B.C.I.C.,‡ Sabera Hossain, M.S.,§ Ittamar Arnold, B.A.,‖ Dennis E. Feierman, Ph.D., M.D.,* Gregory Martin, M.D.,# Ian Holzman, M.D.***

Table 4. Outcomes*

	No Fentanyl Group (n = 60)	Intermediate-dose Fentanyl Group (n = 59)	High-dose Fentanyl Group (n = 58)	*P* Value
Apgar score—1 min	9 (7–9)	9 (8–10)	9 (8–9)	0.51
Apgar score—5 min	9 (8–10)	9 (8–10)	9 (8–10)	0.61
Supplemental bottle feed	71%	75%	67%	0.63
5 mg oxycodone with 325 mg acetaminophen	62%	49%	64%	0.26
Duration of epidural analgesia, min	304 (39–868)	306 (30–1091)	268 (38–775)	0.11
Total fentanyl in labor, μg	0 (0–100)	70 (20–350)	200 (75–395)	<0.0001
Fentanyl cord, pg/ml	0 (0–82)	54 (0–323)	122 (0–533)	<0.0001
Total bupivacaine in labor, mg	77.5 (39–175)	57.5 (24.5–352.5)	45 (17–86)	<0.0001
Bupivacaine cord, ng/ml	11.4 (0.1–60.7)	8.7 (0.1–58.7)	9.8 (0.1–87)	0.55
NACS score	35 (24–40)	34 (19–40)	32 (20–40)	0.03
BF difficulty 24 h postpartum—mother†	6 (10%)	6 (10%)	12 (21%)	0.09
BF difficulty 24 h postpartum—nurse	20 (40%)	20 (40%)	19 (40%)	1.0
Not BF at 6 weeks‡	1 (2%)	3 (6%)	10 (19%)	0.002

* Data are presented as per the patients' original group assignment and are recorded as median and range or percent. † Numbers of responders are 50, 50, and 47 in the no fentanyl, intermediate-dose fentanyl, and high-dose fentanyl groups, respectively. ‡ Numbers of responders are 51, 54, and 52 in the no fentanyl, intermediate-dose fentanyl, and high-dose fentanyl groups, respectively.

BF = breast-feeding; NACS = Neurologic and Adaptive Capacity Scoring System.

Anesthesiology 2005; 103:1211–7

Effect of Labor Epidural Analgesia with and without Fentanyl on Infant Breast-feeding

A Prospective, Randomized, Double-blind Study

Yaakov Beilin, M.D., Carol A. Bodian, Dr.P.H.† Jane Weiser, Ed.D. R.N., I.B.C.I.C.,‡ Sabera Hossain, M.S.,§ Ittamar Arnold, B.A.,‖ Dennis E. Feierman, Ph.D., M.D.,* Gregory Martin, M.D.,# Ian Holzman, M.D.***

- Small but significant difference in the infants Neurologic and Adaptive Capacity Scores at 24 hrs (35, 34, and 32, p=0.03)
- At 6 weeks postpartum, mothers in the high dose group more likely to report not breastfeeding (2%, 6%, and 19%, p=0.003)
- Does total dose or dose as a function of time matter more?

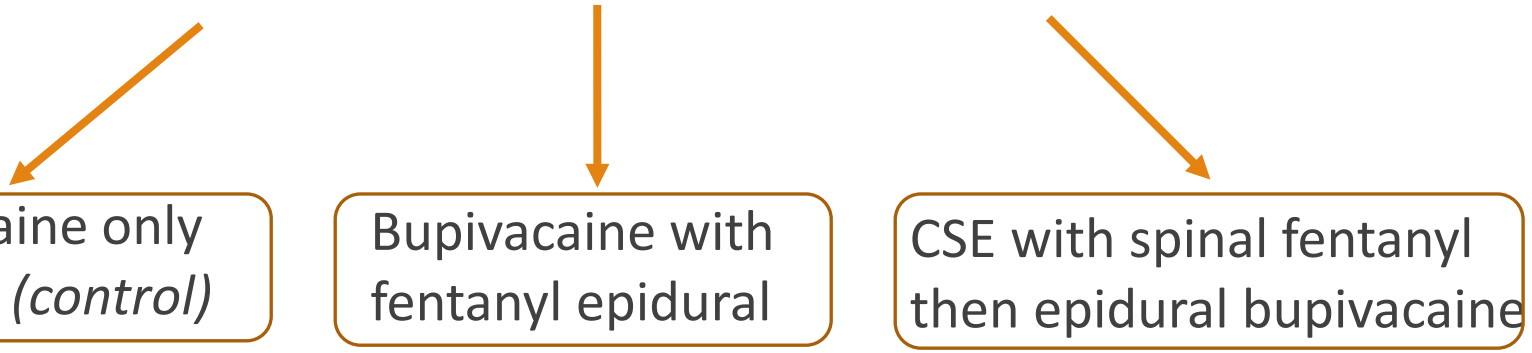
Anaesthesia
Journal of the Association of Anaesthetists of Great Britain and Ireland
Anaesthesia, 2010, **65**, pages 145–153 doi:10.1111/j.1365-2044.2009.06136.x

ORIGINAL ARTICLE

Epidural analgesia and breastfeeding: a randomised controlled trial of epidural techniques with and without fentanyl and a non-epidural comparison group

M. J. A. Wilson,[1] C. MacArthur,[2] G. M. Cooper,[3] D. Bick,[4] P. A. S. Moore[5] and A. Shennan[6] on behalf of the COMET Study Group UK

- Randomization of 1054 healthy nulliparous women to three groups



- Compared with 351 matched women who did not receive neuraxial analgesia
  - 151 of 351 received intravenous meperidine (43%)

Anaesthesia
Journal of the Association of Anaesthetists of Great Britain and Ireland
Anaesthesia, 2010, **65**, pages 145–153 doi:10.1111/j.1365-2044.2009.06136.x

ORIGINAL ARTICLE

Epidural analgesia and breastfeeding: a randomised controlled trial of epidural techniques with and without fentanyl and a non-epidural comparison group

M. J. A. Wilson,[1] C. MacArthur,[2] G. M. Cooper,[3] D. Bick,[4] P. A. S. Moore[5] and A. Shennan[6] on behalf of the COMET Study Group UK

Table 2. Infant feeding by study group (post-delivery interview).

	Control *n* = 353	CSE *n* = 351	LDI *n* = 350	Non-epidural comparison *n* = 351	
Followed up	349	348	344	351	
				No pethidine	Pethidine
				200	151
Initiated breastfeeding *n* (%)					
	231 (66.2)	230 (66.1)	217 (63.1)	132 (66.0)	84 (55.6)*†

*Significance p = 0.002 vs Control.

†Significance p = 0.035 vs Non-epidural comparison (no pethidine).

Anaesthesia
Journal of the Association of Anaesthetists of Great Britain and Ireland
Anaesthesia, 2010, 65, pages 145–153 doi:10.1111/j.1365-2044.2009.06136.x

ORIGINAL ARTICLE

Epidural analgesia and breastfeeding: a randomised controlled trial of epidural techniques with and without fentanyl and a non-epidural comparison group

M. J. A. Wilson,[1] C. MacArthur,[2] G. M. Cooper,[3] D. Bick,[4] P. A. S. Moore[5] and A. Shennan[6] on behalf of the COMET Study Group UK

- No correlation between the total dose of neuraxial fentanyl and the breastfeeding initiation rate (although average total dose was 150 mcg or less in all groups)

Table 3. Logistic regression analysis of variables associated with breastfeeding initiation.

Variable	Total	Odds ratio	95% CI	p Value
Fentanyl dose; μg				
0	648	1.0*	Reference	
1–100	316	0.77	(0.47–1.39)	0.386
101–200	288	0.56	(0.28–1.13)	0.106
201–300	112	0.54	(0.24–1.21)	0.135
301–400	31	1.36	(0.35–5.25)	0.655
> 401	10	0.52	(0.11–2.38)	0.395

Anaesthesia
Journal of the Association of Anaesthetists of Great Britain and Ireland
Anaesthesia, 2010, **65**, pages 145–153 doi:10.1111/j.1365-2044.2009.06136.x

ORIGINAL ARTICLE

Epidural analgesia and breastfeeding: a randomised controlled trial of epidural techniques with and without fentanyl and a non-epidural comparison group

M. J. A. Wilson,[1] C. MacArthur,[2] G. M. Cooper,[3] D. Bick,[4] P. A. S. Moore[5] and A. Shennan[6] on behalf of the COMET Study Group UK

	Control *n* = 353	CSE *n* = 351	LDI *n* = 350	Non-epidural *n* = 351	
Followed up	262	267	263	251	
				No pethidine 150	Pethidine 101
Breastfeeding duration; weeks					
Estimated mean	13.34	15.51	14.98	18.01	13.93
95% CI	11.41–15.27	13.47–17.54	12.90–17.06	14.93–21.10	10.82–17.03
Standard error	0.98	1.04	1.06	1.56	1.58
Still breastfeeding at 12 months n (%)	17 (6.5)	21 (7.9)	10 (3.8)	10 (6.7)	4 (4.0)

Table 5 Breastfeeding duration after birth by study group (12 month post-partum questionnaire).

Epidural Labor Analgesia—Fentanyl Dose and Breastfeeding Success

A Randomized Clinical Trial

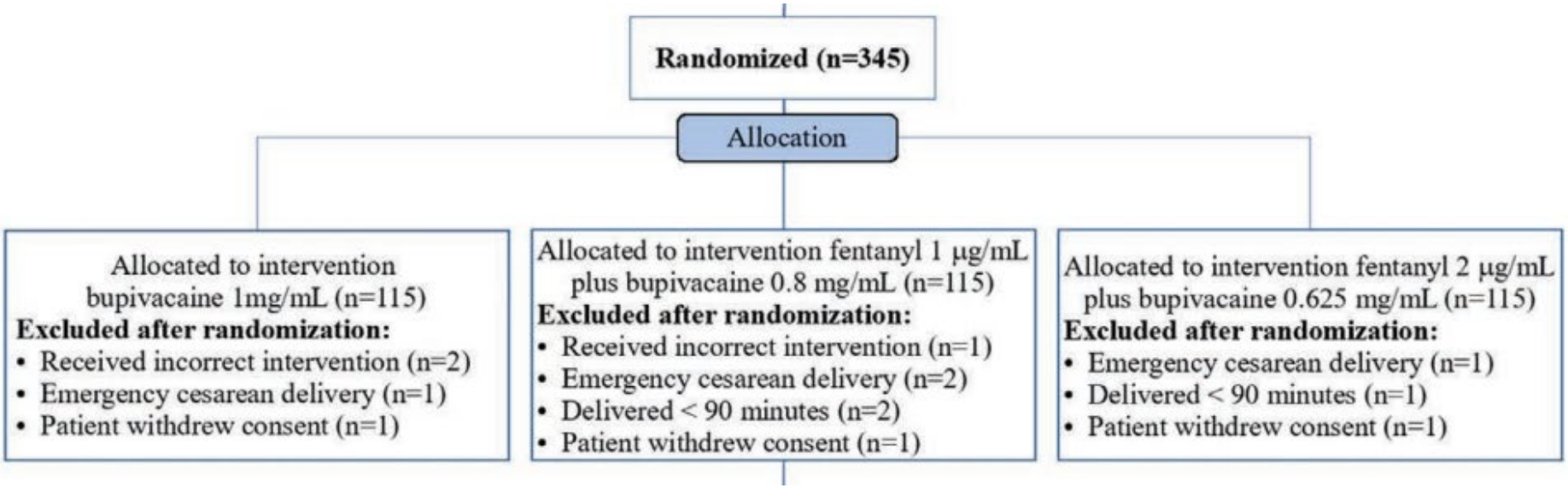
Amy I. Lee, M.D., Robert J. McCarthy, Pharm.D., Paloma Toledo, M.D., M.P.H., Mary Jane Jones, R.N., Nancy White, R.N., I.B.C.L.C., Cynthia A. Wong, M.D. (Anesthesiology 2017; 127:614-24)

- Evaluate impact of epidural fentanyl on breastfeeding success in the initial postpartum period, 6 weeks, and 3 months
- Inclusion criteria
  - English speaking
  - Greater than 38 weeks gestation
  - Hx successful breastfeeding for at least 6 weeks and desire to breastfeed at least 3 months
- Exclusion criteria
  - Intravenous opioid use
  - Expected delivery within 90 minutes of epidural request

Epidural Labor Analgesia—Fentanyl Dose and Breastfeeding Success

A Randomized Clinical Trial

Amy I. Lee, M.D., Robert J. McCarthy, Pharm.D., Paloma Toledo, M.D., M.P.H., Mary Jane Jones, R.N., Nancy White, R.N., I.B.C.L.C., Cynthia A. Wong, M.D. (ANESTHESIOLOGY 2017; 127:614-24)



Epidural Labor Analgesia—Fentanyl Dose and Breastfeeding Success

A Randomized Clinical Trial

Amy I. Lee, M.D., Robert J. McCarthy, Pharm.D., Paloma Toledo, M.D., M.P.H., Mary Jane Jones, R.N., Nancy White, R.N., I.B.C.L.C., Cynthia A. Wong, M.D. (ANESTHESIOLOGY 2017; 127:614-24)

Table 2. Infant and Breastfeeding Outcomes at Follow-up Assessments

	Patient-controlled Epidural Analgesia Solution			
	Bupivacaine 1 mg/ml + fentanyl 0 μg/ml (n = 111)	Bupivacaine 0.8 mg/ml + fentanyl 1 μg/ml (n = 109)	Bupivacaine 0.625 mg/ml + 2 μg/ml fentanyl (n = 112)	*P* Value
6-week follow-up				
Delivery follow-up interval (d)	42 (41 to 44)	42 (41 to 45)	42 (41 to 47)	[illegible]
Breastfeeding*				0.34†
Yes	100 (97)	99 (98)	102 (94)	
No	3 (3)	2 (2)	6 (6)	
Lost to follow-up	8	8	4	
3-month follow-up				
Delivery follow-up interval (d)	91 (89 to 93)	91 (90 to 95)	91 (90 to 95)	[illegible]
Breastfeeding*				0.10†
Yes	94 (94)	96 (96)	93 (88)	
No	6 (6)	4 (4)	12 (12)	
Lost to follow-up	11	9	7	
Reason stated for discontinuation				0.72
Maternal†	4 (67)	3 (75)	10 (83)	
Infant‡	2 (33)	1 (25)	2 (17)	

Data presented as median (interquartile range) or n (%) of group.

*Rate of breastfeeding and *P* value for comparison based on participants with complete follow-up. †Maternal reasons: return to work (n = 7), breast pain/mastitis (n = 4), perceived low supply (n = 4), overactive letdown (n = 1), maternal cerebral vascular accident (n = 1). ‡Infant reasons: infant did not latch well (n = 2), infant did not tolerate milk/colicky (n = 2), newborn had infection and physician instructed mother to stop (n = 1).

Epidural Labor Analgesia—Fentanyl Dose and Breastfeeding Success

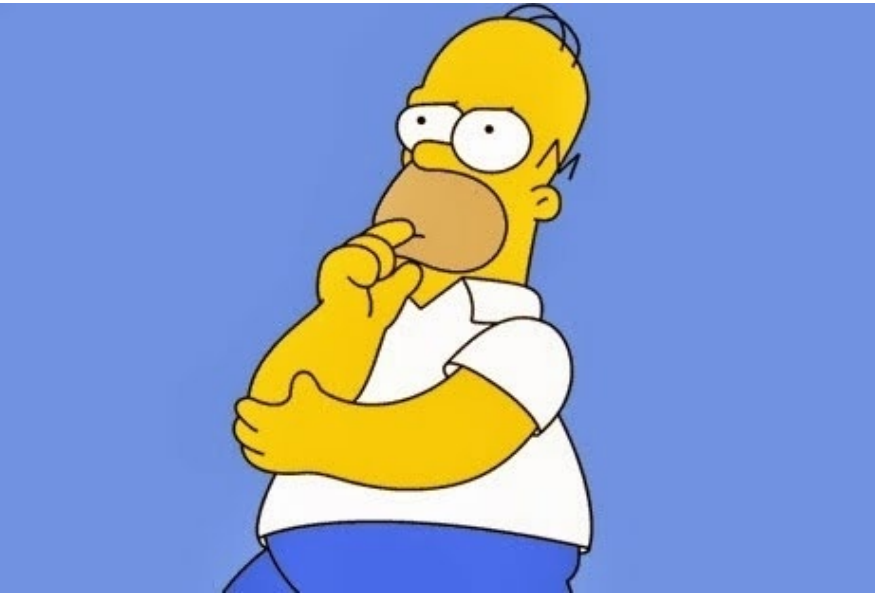
A Randomized Clinical Trial

Amy I. Lee, M.D., Robert J. McCarthy, Pharm.D., Paloma Toledo, M.D., M.P.H., Mary Jane Jones, R.N., Nancy White, R.N., I.B.C.L.C., Cynthia A. Wong, M.D.

Table 1. Maternal Characteristics, Breastfeeding History and Plan, and Motivational Assessment

	Patient-controlled Epidural Analgesia Solution*			
	Bupivacaine 1 mg/ml + fentanyl 0 µg/ml (n = 111)	Bupivacaine 0.8 mg/ml + fentanyl 1 µg/ml (n = 109)	Bupivacaine 0.625 mg/ml + 2 µg/ml fentanyl (n = 112)	*P* Value
Verbal rating score for analgesia satisfaction (0 to 100)	91 (76 to 97)	91 (76 to 99)	86 (74 to 96)	0.38
Mode of delivery, n (%)				
Vaginal	111 (100)	107 (98)	110 (98)	
Assisted vaginal	0	1 (1)	2 (2)	0.73
Cesarean	0	1 (1)	0	
Cumulative fentanyl dose (µg)	15 (15 to 15)	78 (60 to 109)	139 (97 to 210)	< 0.001

Peripartum Deep Thoughts



- If there's no analgesic or breastfeeding difference between groups, why does it matter? Lee 2017
- Hawthorne effect: the alteration of behavior by the subjects of a study due to their awareness of being observed Chestnut 2017
- Excessive fluid administration
- Early skin-to-skin contact
- Minimizing separation Martin 2018

Beyond the Peripartum Period: Anesthesia for the Breastfeeding Mother

Barash Clinical Anesthesia, 8th ed, 2017

"Human breast milk predisposes to an increased severity of aspiration pneumonitis when compared with other types of milk. Soy-based formula causes a less severe form of acute lung injury than human milk or dairy formula."

Chin C, Lerman J, Endo J: Acute lung injury after tracheal installation of acidified soy-based of Enfalac formula or human breast milk in *RABBITS.* Can J Anaesth 1999; 46:282.

Miller's Anesthesia, 9th ed. 2020—one paragraph, no references

Studies of milk levels and pharmacological properties of medications guide recommendations for the safety of anesthetics and medications in babies of breastfeeding mothers who receive these agents. For elective surgery, women may be advised to pump and store milk preoperatively to prepare for any missed feedings that occur in the postoperative period. With very few exceptions (e.g., codeine, tramadol, diazepam), most perioperative medications are likely compatible with lactation. Thus, when the mother is alert and able to breastfeed, she may do so. Recommending that lactating patients pump and discard milk after general anesthesia is no longer considered best practice. Mothers of very young or premature babies, especially those susceptible to apnea, may be advised to discuss the safety of breastfeeding while taking perioperative medications with their child's pediatrician.

Pump and Dump

Practical Challenges

- Lack of knowledge and awareness among medical personnel
- Infants who cannot take from a bottle or take formula
- NPO times and maternal dehydration
- Infrequent pumping perioperatively
  - Engorgement, clogged ducts, mastitis, breast abscesses
  - Failure to remove *feedback inhibitor of lactation* (FIL)

Infant and Young Child Feeding 2009

Is this drug safe?

1. Does the drug pass into the milk?
2. Is the drug orally bioavailable to the child?
3. What is the age and health of the child and thus likelihood of adverse events?

Reece-Stremtan 2018

4. Can the drug be timed to decrease exposure?

AAP 2001

Drug Factors

- Lipid solubility
  - Lipid soluble drugs (high Vd) are mostly outside the plasma leaving small proportion to transfer into milk
  - Lipid soluble drugs can concentrate in lipid portion of milk
- Protein binding
  - Only free, unbound drug is available to diffuse into milk

Lee 1993

Maternal Factors

- Milk (pH 7.09) is relatively acidic compared to plasma
  - Acidic drugs (low pKa) will achieve lower concentration in milk than basic drugs (high pKa)
  - Weak basic drugs may be unionized in plasma and readily transfer to milk but then ionize in more acidic milk—ion trapping

Lee 1993

Just a reminder…

≠

Neonatal Pharmacokinetics

- Increased bioavailability (especially in preterm infants)
  - Higher gastric pH
  - Different gut flora
  - Delayed gastric emptying
  - Reduced amounts of bile salts and pancreatic enzymes
  - Decreased plasma protein binding
- Impaired renal and hepatic metabolism
- Poorly developed blood brain barrier

Lee 1993

Academy of Breastfeeding Medicine: BRIEF interruption of breastfeeding (6-12 hours) after maternal general anesthesia *for infants at risk for apnea, hypotension, or hypotonia*

Reece-Stremtan 2017

"Mothers with healthy term or older infants can generally resume breastfeeding as soon as they are awake, stable, and alert. Resumption of normal mentation is a hallmark that medications have redistributed from the plasma compartment (and thus generally the milk compartment)…"

Reece-Stremtan 2017

Case Presentation

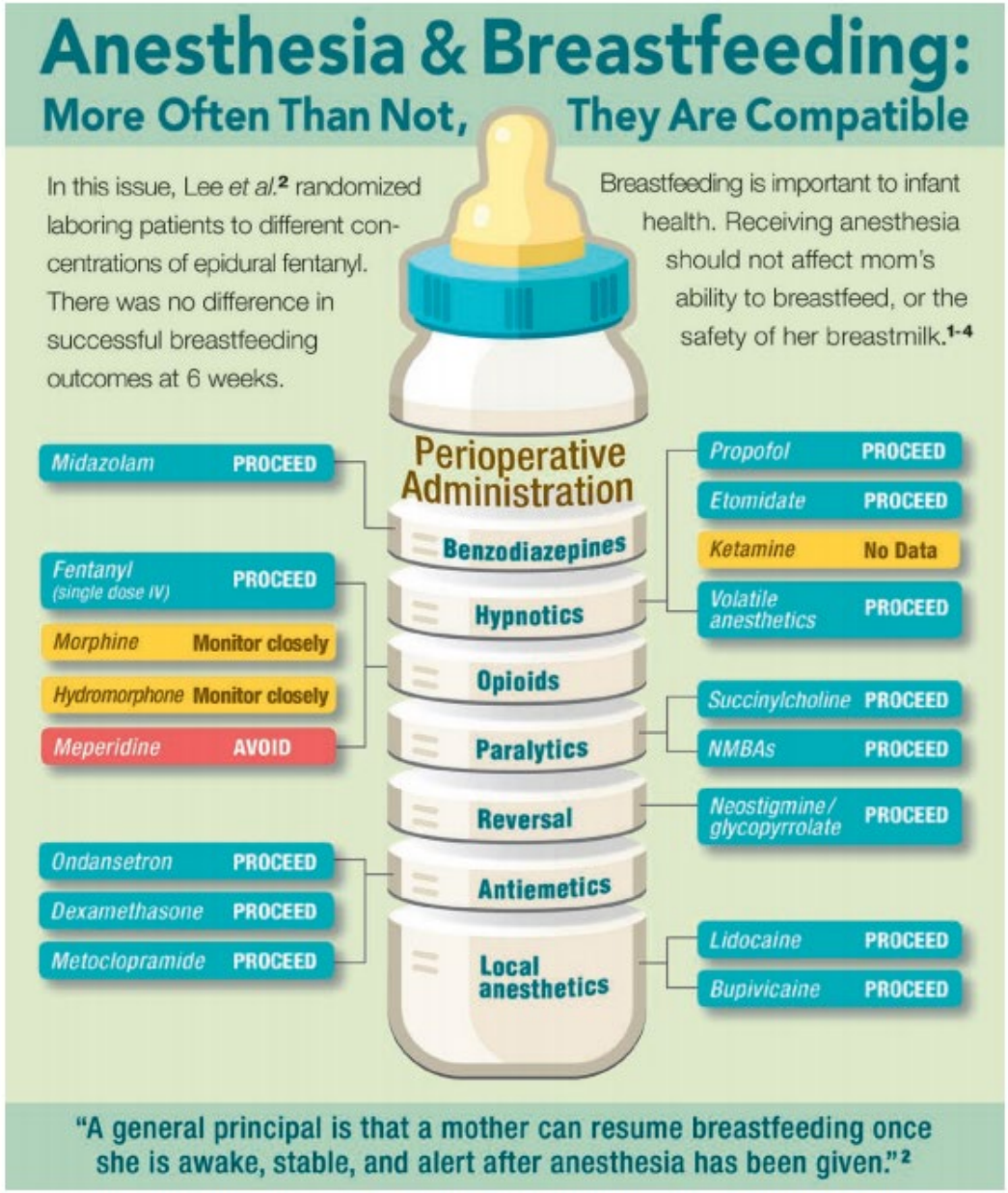
- Surgeon: Our next patient is a nice, young healthy lady who had a baby 6 months ago coming in for vein stripping.
- Me: Oh, is she breastfeeding?
- Surgeon: I don't know. *I didn't think to ask.*

If you don't ask, you won't know. Patients do not always volunteer information.

Planning

- Can surgery reasonably be postponed?
- Is regional anesthesia or light MAC appropriate?
- Can we schedule her early to minimize fasting?
- Does she have access to a pump in POHA *(or better yet, her child)?*
- Is general anesthesia safe?
- Can she have early access to a pump in PACU *(or even her child if appropriate)?*
- Is there a responsible adult to care for the child postoperatively besides the mother?

ANESTHESIOLOGY



Anesthesiology 2017

Anesthetic Agents

- Propofol and halogenated gases all considered safe
- Benzodiazepines
  - Midazolam and lorazepam considered safe
  - Diazepam concentrates in breastmilk and exceeds 10% of maternal plasma concentrations (long term use associated with pediatric lethargy, weight loss)

Lee 1993
Sachs 2013

Neuromuscular Blockade

- Muscle Relaxants
  - Low lipid solubility and distribute into extracellular fluid
  - Poor oral bioavailability
- Acetylcholinesterase inhibitors
  - Neostigmine not found in breastmilk
- Anticholinergics
  - Glycopyrrolate complex structure and poor bioavailability
  - Atropine found in trace amounts
  - May adversely affect milk supply if given repeatedly (i.e. scopolamine, diphenhydramine)

Reece-Stremtan 2017
Lee 1993

What about sugammadex?

Society for Obstetric Anesthesia and Perinatology

Statement on Sugammadex during pregnancy and lactation

Ad Hoc task force: Willett, Butwick, Togioka, Bensadigh, Hofer, Zakowski

April 22, 2019

PATIENTS WITH ESTABLISHED LACTATION

SAFE TO USE

After receiving sugammadex, it is likely safe to resume a normal breastfeeding routine once the patient has recovered from general anesthesia. However, the patient should be informed that the effects on lactation are unknown (see Section IIIa. Use of sugammadex in breastfeeding women: early postpartum versus established lactation).

Nonopioid Analgesics

- Acetaminophen is particularly safe
  - Younger infants have low levels of cytochrome P450

Sachs 2013

- NSAIDs (except aspirin) considered safe
  - Low lipid solubility and high protein binding
  - Avoid in mothers with infants who have ductal-dependent cardiac lesions

Reece-Stremtan 2017

- Aspirin should be avoided
  - Serum concentrations approach 40% of maternal concentration
  - Risks of Reyes syndrome, platelet dysfunction, and hyperbilirubinemia

Sachs 2013

Local Anesthetics

COCAINE IS BAD, KIDDOS

Intravenous Opioids

- Fentanyl and the other …ils all considered safe
  - Low levels in breastmilk
  - Low oral bioavailability

  Reece-Stremtan 2017
  Lee 1993
- Morphine and hydromorphone
  - Poor bioavailability
  - Short term vs. chronic use
  - Rare case reports

  Reece-Stremtan 2017
  Sachs 2013
- Meperidine—avoid use
  - Active metabolite (normeperidine) with long half life
  - Consistently associated with dose-related sedation

  Reece-Stremtan 2017
  Sanofi-Aventis 2010

Oral Opioids

- Hydrocodone and oxycodone are better choices
  - Parent drug has effects
  - Partially metabolized to more active metabolites by CYP2D6
  - Hydrocodone: limit to 30mg daily (drug label says use caution)
  - Oxycodone: new FDA labeling as of 2024—limit to 60mg daily

Genus Lifesciences 2024

- Codeine and tramadol are poor choices
  - Dependent on CYP2D6 metabolism to active metabolites
  - Ultrarapid metabolizers may have excessively high amounts of active metabolites
  - FDA advises against use in lactating women

Reece-Stremtan 2017
Sachs 2013

Resources

Drugs and Lactation Database (LactMed)

Bethesda (MD): National Library of Medicine (US); 2006-.

Copyright and Permissions

Search this book

InfantRisk for Healthcare Professionals

The InfantRisk App gives health care providers fast, convenient access to up-to-date and evidence-based information about prescription and non-prescription medications and their safety during pregnancy and breastfeeding.

Safety Ratings & Information

Reliable safety ratings and other information on more than 20,000 drugs.

Drug Recommendations by Condition

Major lists of appropriate drugs for pregnant and breastfeeding mothers for various conditions like headache, nausea, and allergies.

Medication Search

Search by product name and/or sort by category to obtain product safety information and indicate if that product is safe for use.

Download on the App Store GET IT ON Google Play

A Better View

American Society of Anesthesiologists™

Statement on Resuming Breastfeeding after Anesthesia

Committee of Origin: Obstetric Anesthesia

(Approved by the ASA House of Delegates on October 23, 2019)

Patients should resume breastfeeding as soon as possible after surgery because anesthetic drugs appear in such low levels in breastmilk. It is not recommended that patients "pump and dump."


WON'T SOMEONE PLEASE
THINK OF THE CHILDREN?!?
memegenerator.n

Not just Nutrition

"…he's wanted to nurse almost constantly over the past 6 days in the hospital. It's been the most powerful comfort, distraction, and pain medication. We've gotten through an IV stick and 2 separate blood cultures with barely a whimper, a million blood pressure checks and rectal temps, scary doctor visits, rough moments waiting for pain medication, and it's helped us sleep in an unfamiliar place. Nursing has saved us both."

A physician mother with her hospitalized child (used with permission)

Not 2…Not 6…

PRACTICE PARAMETERS

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**

Recommendations for Breast Milk

- Breast milk may be ingested for up to 4 h before elective procedures requiring general anesthesia, regional anesthesia, or procedural sedation and analgesia.

Breast Milk—Not Two Hours

Table 3. Comparison of Gastric Fluid Analysis

	Clear-liquid-fed	Breast-fed	*P* value
Number with gastric fluid recovered[a]	10/46 (22)	8/24 (33)	NS
Volume[b] (mL/kg)	0.3 ± 0.9	0.7 ± 1.1	NS
pH[b]	2.1 ± 1.4	2.6 ± 1	NS
Volume ≥0.4 mL/kg[a]	8/46 (17)	8/24 (33)	NS
Volume ≥1 mL/kg[a]	3/46 (7)	7/24 (29)	0.03
pH ≤2.5[a]	9/10 (90)	4/8 (50)	NS
Volume >0.4 mL/kg and pH ≤2.5[a]	7/46 (15)	4/24 (17)	NS

NS = not statistically significant.
[a] Numbers of patients (percentages).
[b] Values are expressed as mean ± SD.

Litman 1994

- Comparison of gastric contents in infants fed clears vs breastmilk two hours before surgery
- Study discontinued prematurely due large percentage (29%) of breastfed infants with unacceptably high residual gastric volumes (>1 mL/kg)

Breast Milk—Four Hours NPO

TABLE 4

The number of infants with residual gastric contents following preoperative fasting

	Postive gastric aspirate	> 0.4 ml/kg	Fasting time (minutes)
Breast milk	3	1	208
Infant formula	8	2	281
Total	11	3	261

Anaesthesia and Intensive Care, Vol. 18, No. 4, November, 1990

- Alternative study in breastfed infants < 3 months of age
- Only 1 in 30 with residual gastric volume > 0.4 mL/kg when breastfed between 3-4 hours before surgery

We've had something for the…

- *The generalist…*
- *The OB specialist…*
- *The pediatric anesthesiologist…*
- *What about the needs of lactating healthcare workers?*

Statement on Lactation Among Anesthesia Clinicians

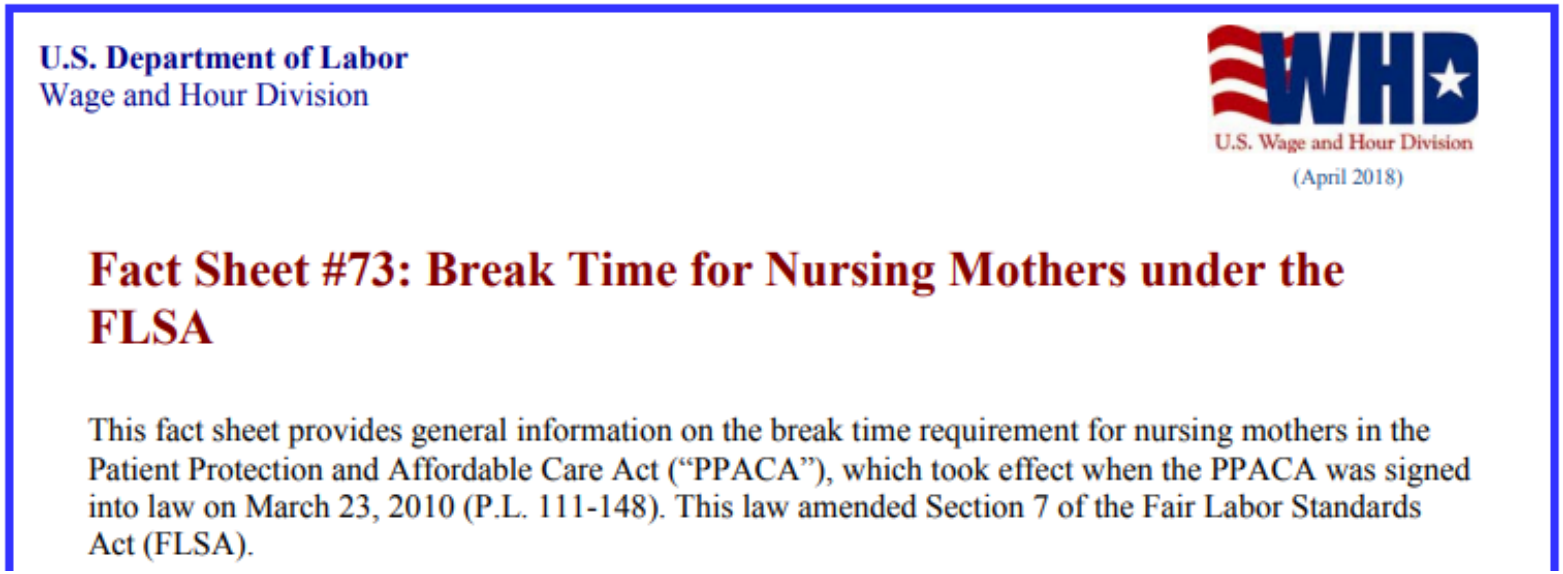
Developed by: Committee on Young Physicians
Approved by: ASA House of Delegates on October 13, 2021

Download PDF

The ASA recognizes the needs of women physician anesthesiologists, anesthesiology residents and fellows, anesthesiologist assistants, and nurse anesthetists who are breastfeeding. Breast milk is the recommended source of nutrition for infants, and breastfeeding has independent benefits for the physical and psychological health of both parent and child. To continue producing an adequate breast milk supply and to avoid complications associated with delays in expressing milk, an individual who is breastfeeding and pumping should have the same freedom in the clinical workplace to address lactation-related needs as any person has to address other medical conditions.

Employers should develop lactation policies that, at minimum, comply with applicable state, local, and federal laws. When possible, the ASA supports the following recommendations regarding lactation:

1. Physician anesthesiologists, trainees, anesthesiologist assistants or nurse anesthetists who intend to breastfeed must be allowed flexibility to support expressing breast milk while at work ("pumping"). Reasonable break time for pumping and a location (other than a bathroom) that is shielded from view and free from intrusion from coworkers and the public to express breast milk should be provided when needed.


U.S. Department of Labor
Wage and Hour Division

WHD
U.S. Wage and Hour Division
(April 2018)

Fact Sheet #73: Break Time for Nursing Mothers under the FLSA

This fact sheet provides general information on the break time requirement for nursing mothers in the Patient Protection and Affordable Care Act ("PPACA"), which took effect when the PPACA was signed into law on March 23, 2010 (P.L. 111-148). This law amended Section 7 of the Fair Labor Standards Act (FLSA).

Georgia Breastfeeding Law

ENACTED GEORGIA BREASTFEEDING LAW

Ga. Code An. § 31-1-9 The breastfeeding of a baby is an important and basic act of nurture which should be encouraged in the interests of maternal and child health. A mother m
baby are otherwise authorized to be.

Ga. Code An. § 34-1-6 Employer obligation to provide time for women to express breast milk for infant child

§ 45-1-7. Paid break time and private location for expression of breast milk, Clink link below:

Labor and industrial relations; provisions regarding employer's obligation to provide break time for an employee to express breast milk; revise

§ 43-22A-1 (2016) § 43-22A-1. Click link to: Georgia Lactation Consultant Practice Act

https://www.georgiabreastfeedingcoalition.org/breastfeeding-legislation accessed 1/10/2025

In Summary

- Breastfeeding has maternal and pediatrics benefits and is the normative infant feeding standard.
  - *Lots of agencies are tracking it.*
- Epidural opioids, at least at low doses, do not negatively impact breastfeeding.
- Anesthesia and breastfeeding are generally compatible with a few considerations.
  - *“Pumping and dumping” is rarely indicated.*
  - *“Sleeping and keeping” is better.*
- Breastfeeding is comforting for pediatric patients and requires a 4 hour fast.

References (1)

1. Penman, Maggie. “Pope Francis Once Again Encourages Mothers To Breastfeed In The Sistine Chapel.” https://www.npr.org/sections/thetwo-way/2018/01/07/576319476/pope-francis-once-again-encourages-mothers-to-breastfeed-in-the-sistine-chapel. Accessed 10 March 2021.
2. Candelaria LM, Bressler T, Spatz DL. Breastfeeding Guidance for Orthodox Jewish Families When Newborns Require Special Care and Continued Hospitalization. MCN Am J Matern Child Nurs. 2019 Mar/Apr;44(2):80-85. doi: 10.1097/NMC.0000000000000513. PMID: 30807326.
3. Bensaid B. Breastfeeding as a Fundamental Islamic Human Right. J Relig Health. 2021 Feb;60(1):362-373. doi: 10.1007/s10943-019-00835-5. PMID: 31093832.
4. Laroia N, Sharma D. The religious and cultural bases for breastfeeding practices among the Hindus. *Breastfeed Med*. 2006;1(2):94-98. doi:10.1089/bfm.2006.1.94
5. Meek JY, Noble L; Section on Breastfeeding. Policy Statement: Breastfeeding and the Use of Human Milk. *Pediatrics*. 2022;150(1):e2022057988. doi:10.1542/peds.2022-057988
6. Sullivan S, Schanler RJ, Kim JH, Patel AL, Trawöger R, Kiechl-Kohlendorfer U, Chan GM, Blanco CL, Abrams S, Cotten CM, Laroia N, Ehrenkranz RA, Dudell G, Cristofalo EA, Meier P, Lee ML, Rechtman DJ, Lucas A. An exclusively human milk-based diet is associated with a lower rate of necrotizing enterocolitis than a diet of human milk and bovine milk-based products. J Pediatr. 2010 Apr;156(4):562-7.e1. doi: 10.1016/j.jpeds.2009.10.040. Epub 2009 Dec 29. PMID: 20036378.
7. United States Breastfeeding Committee. *Implementing The Joint Commission Perinatal Care core measure on exclusive breast milk feeding.* Washington, DC: United States Breastfeeding Committee; 2010.
8. CDC Guidelines on Breastfeeding and Special Circumstances. https://www.cdc.gov/breastfeeding/breastfeeding-special-circumstances/maternal-or-infant-illnesses/hiv.html#:~:text=In%20the%20United%20States%2C%20to,pregnancy%2C%20birth%2C%20or%20breastfeeding. Last reviewed 4 Feb 2020. Accessed 19 March 2021.
9. WHO e-Library of Evidence for Nutrition Actions (eLENA). Infant feeding for the prevention of mother-to-child transmission of HIV. Last reviewed 11 Feb 2019. Accessed 10 March 2021.
10. CDC Guidelines on Breastfeeding and Special Circumstances. https://www.cdc.gov/breastfeeding/breastfeeding-special-circumstances/maternal-or-infant-illnesses/covid-19-and-breastfeeding.html. Last revised 3 Dec 2020. Accessed 20 March 2021.
11. *Breastfeeding Report Card*. https://www.cdc.gov/breastfeeding-data/media/pdfs/2024/06/CORRECTED_332395-B_2022-Breastfeeding-Report-Card_v12_508c.pdf. Accessed 6 November 2024.

References (2)

12. Ruth A. Lawrence, Robert M. Lawrence,Chapter 3 - Physiology of Lactation,Editor(s): Ruth A. Lawrence, Robert M. Lawrence. Breastfeeding (Seventh Edition), W.B. Saunders, 2011, Pages 62-97. https://doi.org/10.1016/B978-1-4377-0788-5.10003-3.
13. Beilin Y, Boidan CA, Weiser J, et al. Effect of labor epidural analgesia with and without fentanyl on infant breast-feeding; a prospective, randomized, double-blind study. *Anesthesiology* 2005; 103:1211-7.
14. Wilson MJ, MacArthur C, Cooper GM, Bick D, Moore PA, Shennan A. Epidural analgesia and breastfeeding: a randomized controlled trial of epidural techniques with and without fentanyl and a non-epidural comparison group. *Anaesthesia* 2010; 65:145-53.
15. Lee AI, McCarthy RJ, Toledo P, Jones MJ, White N, Wong CA: Epidural labor analgesia—fentanyl dose and breastfeeding success: A randomized clinical trial. *Anesthesiology* 2017; 127:614-24.
16. Chestnut D. Labor epidural analgesia and breastfeeding. *Anesthesiology* 2017; 127:593-5.
17. Martin E, Vickers B, Landau R, Reece-Stremtan S. ABM Clinical Protocol #28, Peripartum Analgesia and Anesthesia for the Breastfeeding Mother. Breastfeed Med. 2018 Apr;13(3):164-171. doi: 10.1089/bfm.2018.29087.ejm. Epub 2018 Mar 29. PMID: 29595994.
18. Barash P et al. Clinical Anesthesia, 8th ed. Wolters-Kluwer. 2017.
19. Miller, Miller's Anesthesia, 9th ed. Elsevier. 2020.
20. Infant and Young Child Feeding: Model Chapter for Textbooks for Medical Students and Allied Health Professionals. Geneva: World Health Organization; 2009. SESSION 2, The physiological basis of breastfeeding. Available from: https://www.ncbi.nlm.nih.gov/books/NBK148970/
21. Reece-Stremtan S, Campos M, Kokajko L; Academy of Breastfeeding Medicine. ABM Clinical Protocol #15: Analgesia and Anesthesia for the Breastfeeding Mother, Revised 2017. Breastfeed Med. 2017 Nov;12(9):500-506. doi: 10.1089/bfm.2017.29054.srt. Epub 2017 Aug 8. PMID: 29624435.
22. Lee JJ, Rubin AP. Breastfeeding and anaesthesia. *Anaesthesia* 1993; 48;:616-25.

References (3)

23. Infographics in Anesthesiology: Anesthesia & Breastfeeding: More often than not, they are compatible. *Anesthesiology* 2017; 127:19a.
24. American Academy of Pediatrics Committee on Drugs. Transfer of drugs and other chemicals into human milk. Pediatrics. 2001 Sep;108(3):776-89. doi: 10.1542/peds.108.3.776. PMID: 11533352.
25. Sachs HC; Committee On Drugs. The transfer of drugs and therapeutics into human breast milk: an update on selected topics. Pediatrics. 2013 Sep;132(3):e796-809. doi: 10.1542/peds.2013-1985. Epub 2013 Aug 26. PMID: 23979084.
26. Society for Obstetric Anesthesia and Perinatology Statement on Sugammadex during pregnancy and lactation. Ad hoc task force: Willett, Butwick, Togioka, Bensadigh, Hofer, Zakowski. April 22, 2019.
27. Sanofi-Aventis U.S. LLC. Demerol (meperidine) [package insert]. U.S. Food and Drug Administration website Available at: https://www.accessdata.fda.gov/drugsatfda_docs/label/2011/005010s050lbl.pdf. Rvised September 2010.
28. Genus Lifesciences Inc. Oxycodone Hydrochloride Capsules [package insert]. U.S. Food and Drug Administration website. https://www.fda.gov/media/178922/download?attachment Revised April 2024.
29. American Society of Anesthesiologists Obstetric Anesthesia Committee. Statement on Resuming Breastfeeding after Anesthesia. Oct 23, 2019.
30. 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. 2017 Mar;126(3):376-393. doi: 10.1097/ALN.0000000000001452. PMID: 28045707.
31. Litman RS, Wu CL, Quinlivan JK. Gastric volume and pH in infants fed clear liquids and breast milk prior to surgery. Anesth Analg. 1994 Sep;79(3):482-5. doi: 10.1213/00000539-199409000-00013. PMID: 8067551.
32. van der Walt JH, Foate JA, Murrell D, Jacob R, Bentley M. A study of preoperative fasting in infants aged less than three months. Anaesth Intensive Care. 1990 Nov;18(4):527-31. doi: 10.1177/0310057X9001800420. PMID: 2268020.

Questions?

EMORY UNIVERSITY SCHOOL OF MEDICINE | Department of Anesthesiology

Perioperative Gastric Ultrasound & NPO Status in the Era of GLP-1 Receptor Agonists

Ian McCullough, M.D., FASE

Assistant Professor of Anesthesiology
Director of Point-of-Care Ultrasound
Department of Anesthesiology
Emory University School of Medicine

Perioperative Gastric Ultrasound & NPO Status in the Era of GLP-1 Receptor Agonists

Gastric ultrasound Anatomy and Technique

Gastric Content Classification & Stratification of Aspiration Risk

GLP-1 RAs

Gastric Ultrasound and your Clinical Practice

Conflicts of Interest

None

Learning Objectives

1) Identify the anatomy pertinent to Gastric Ultrasound

2) Understand proper scanning technique

3) Differentiate between:
   - -An empty stomach / minimal liquid
   - -Large volume liquid gastric contents
   - -Solid gastric contents

4) Understand how and when gastric ultrasound can stratify aspiration risk.

ASA Practice Guidelines on Perioperative Fasting

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

https://pubs.asahq.org/anesthesiology/article/126/3/376/19733/Practice-Guidelines-for-Preoperative-Fasting-and

Technique

Position:

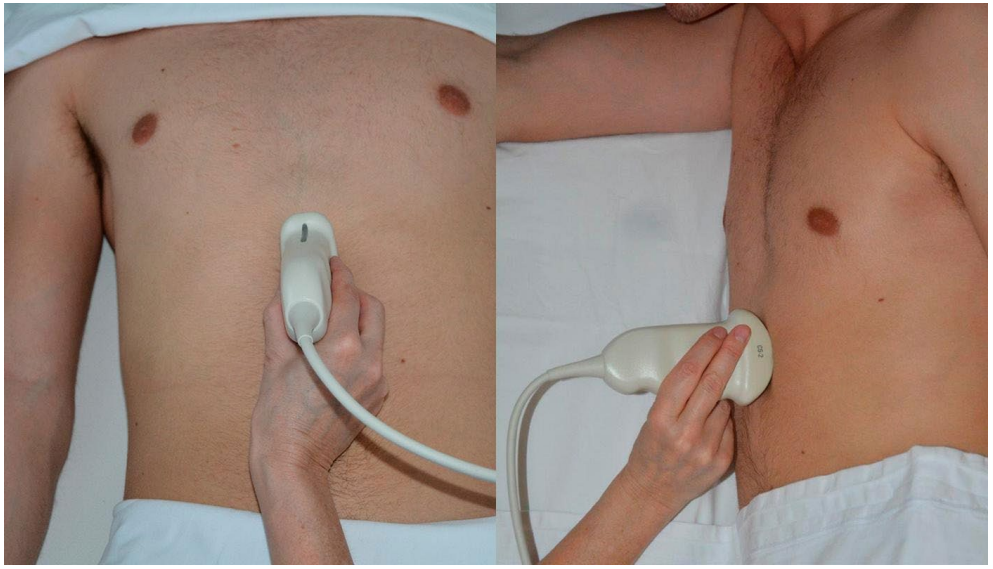
- Supine or Right Lateral Decubitus (RLD)
  - RLD: Better for identifying solids and liquids
    - Required for Quantification of Liquids

Transducer:

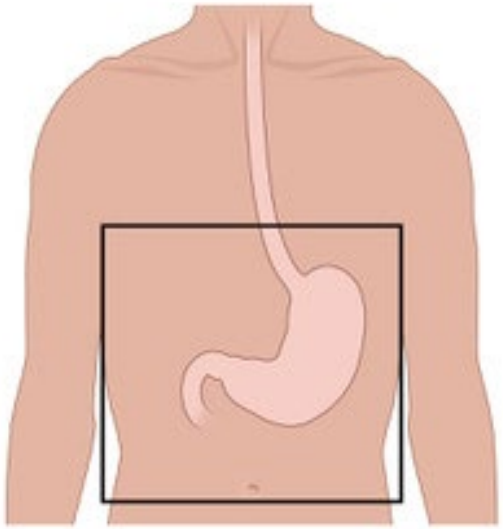
- Curvilinear
- Phased array (can be used)
- Linear (can be used in Peds)

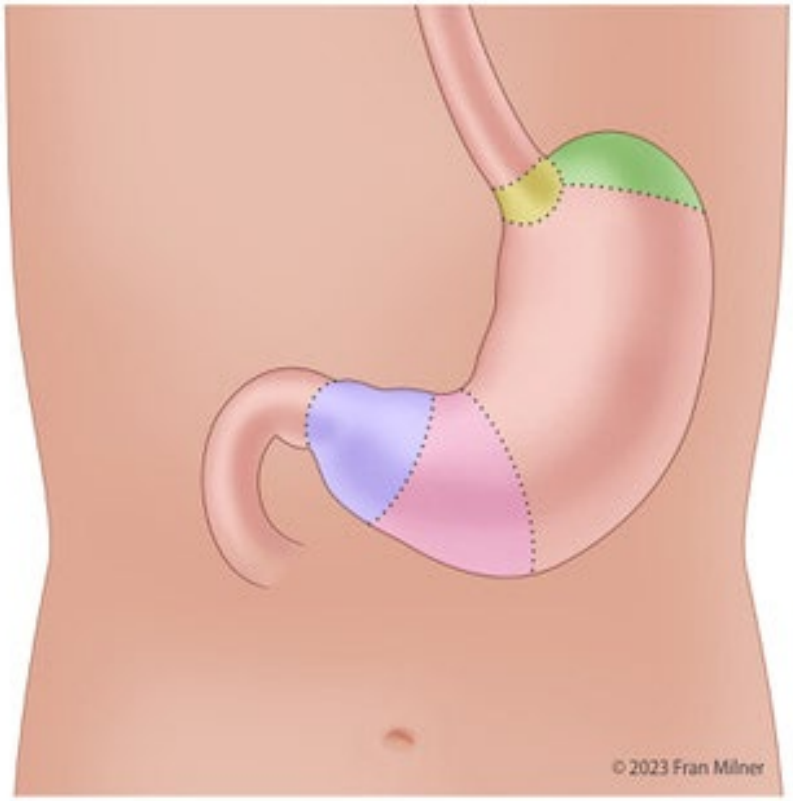
Transducer position:

- Subxiphoid
- Mid Sagittal Plane
- Indicator cephalad

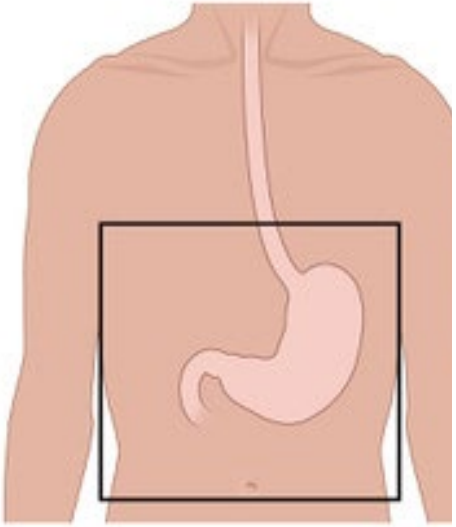


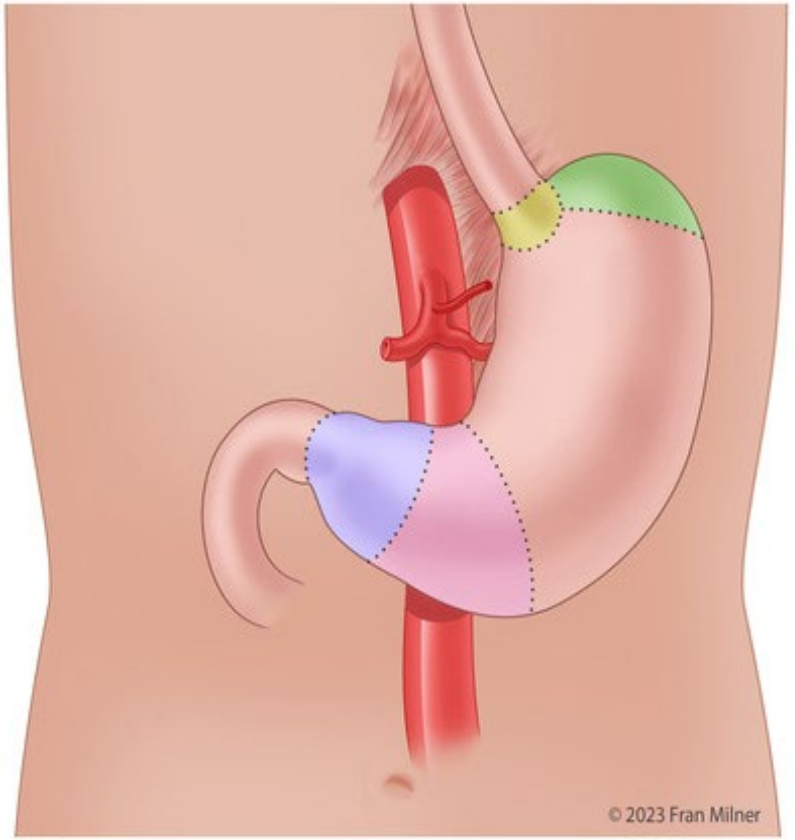
Anatomy



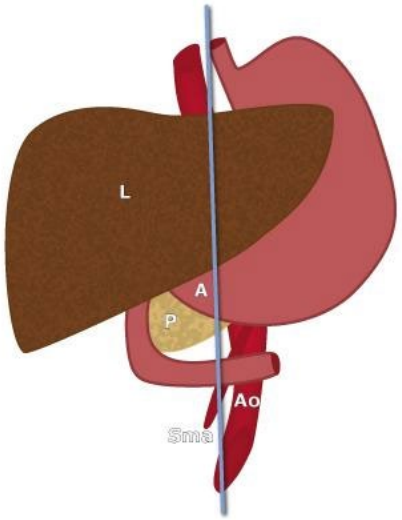


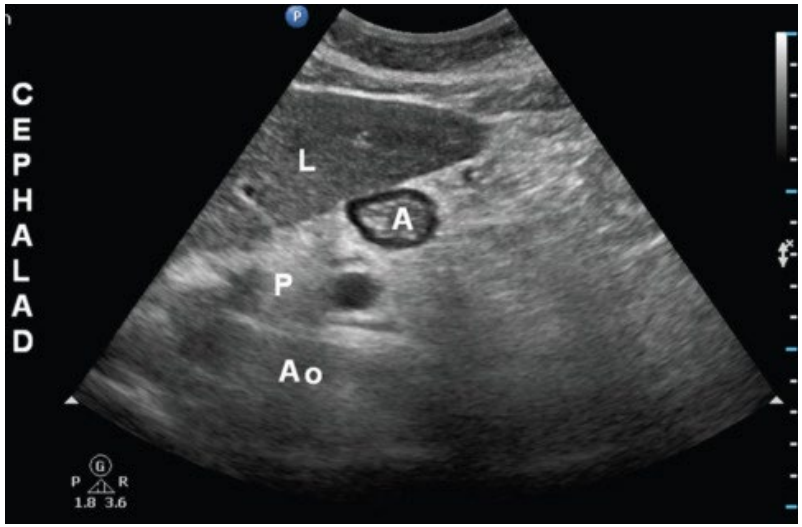
Anatomy

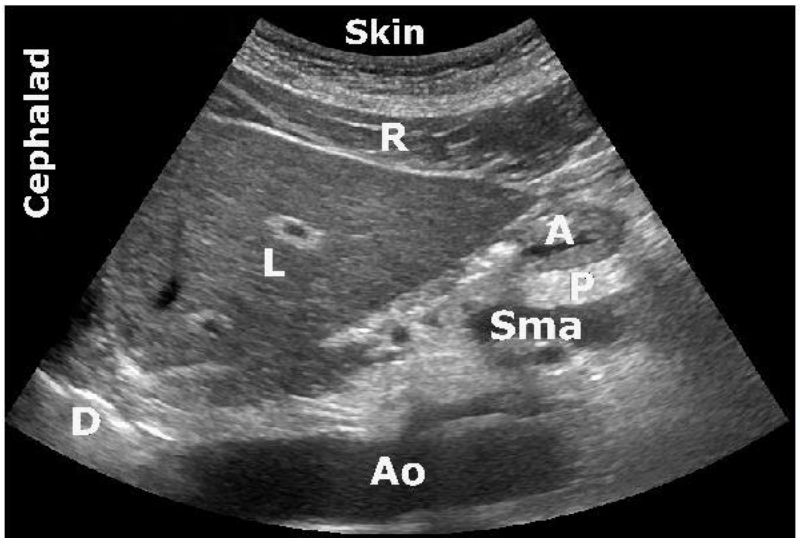


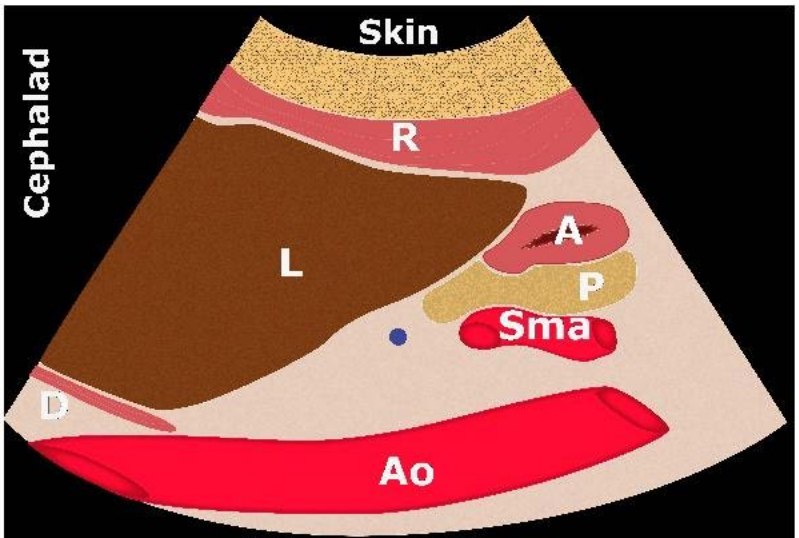


Anatomy / Technique

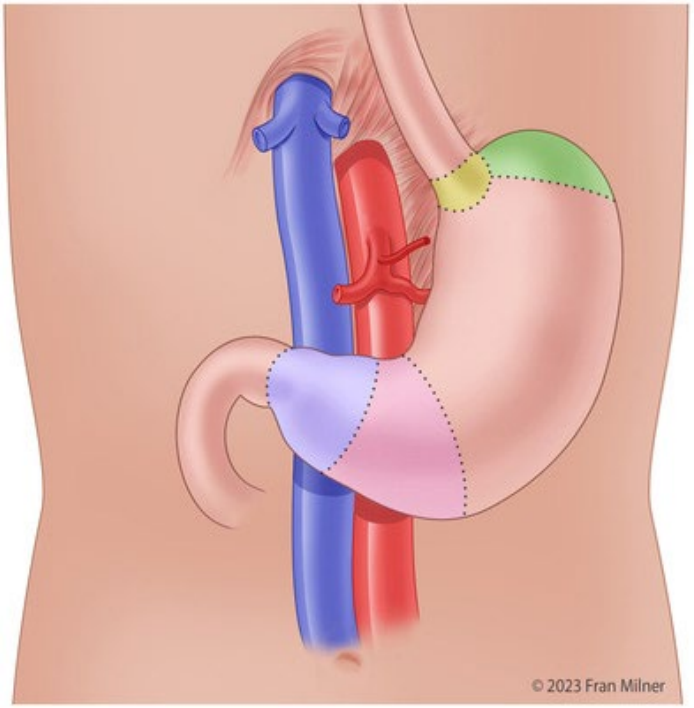


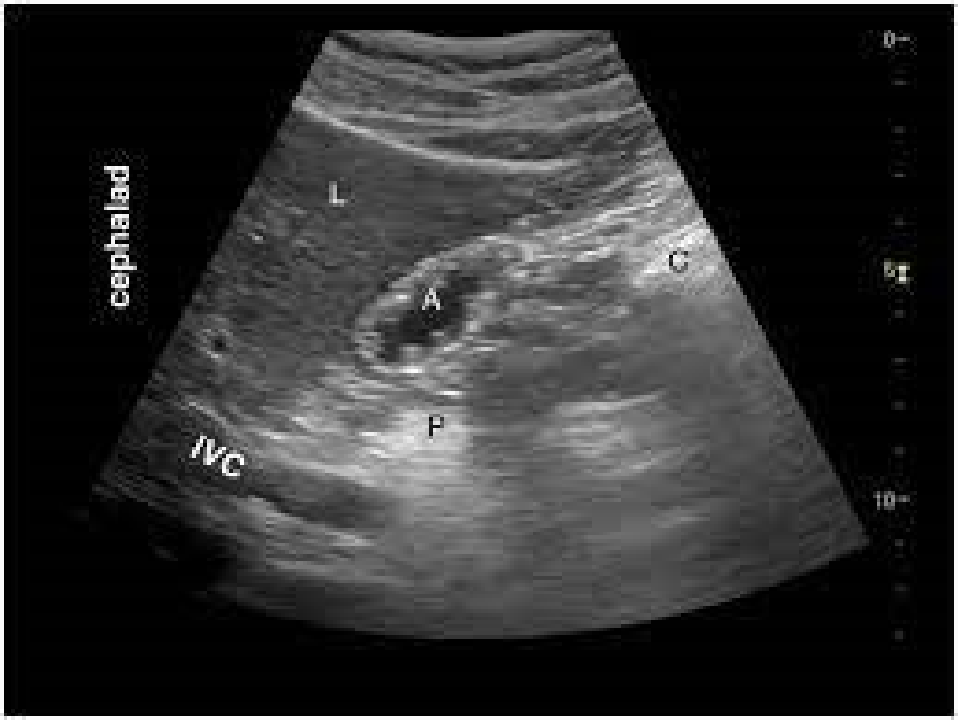




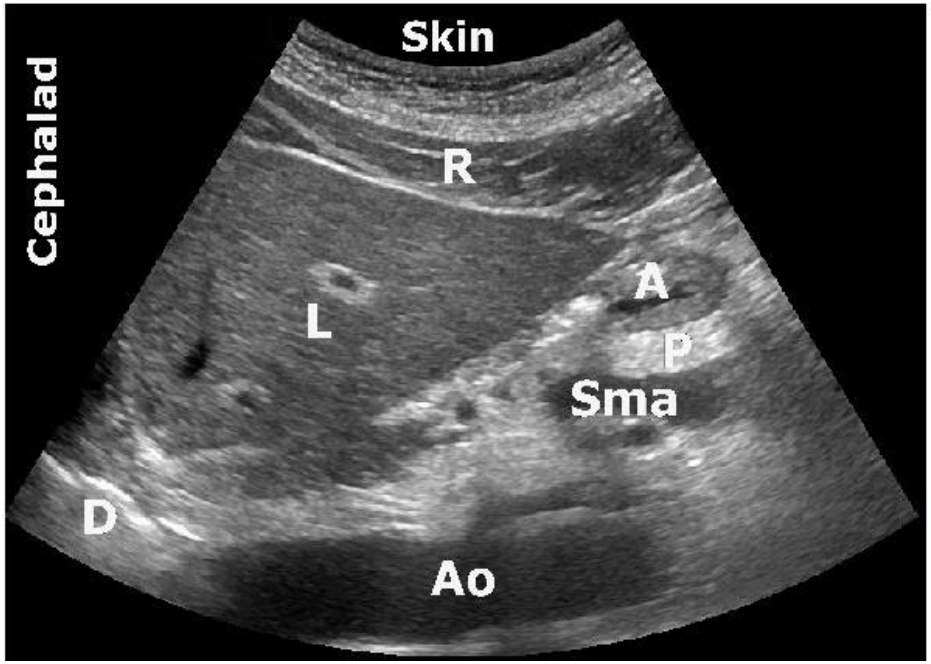


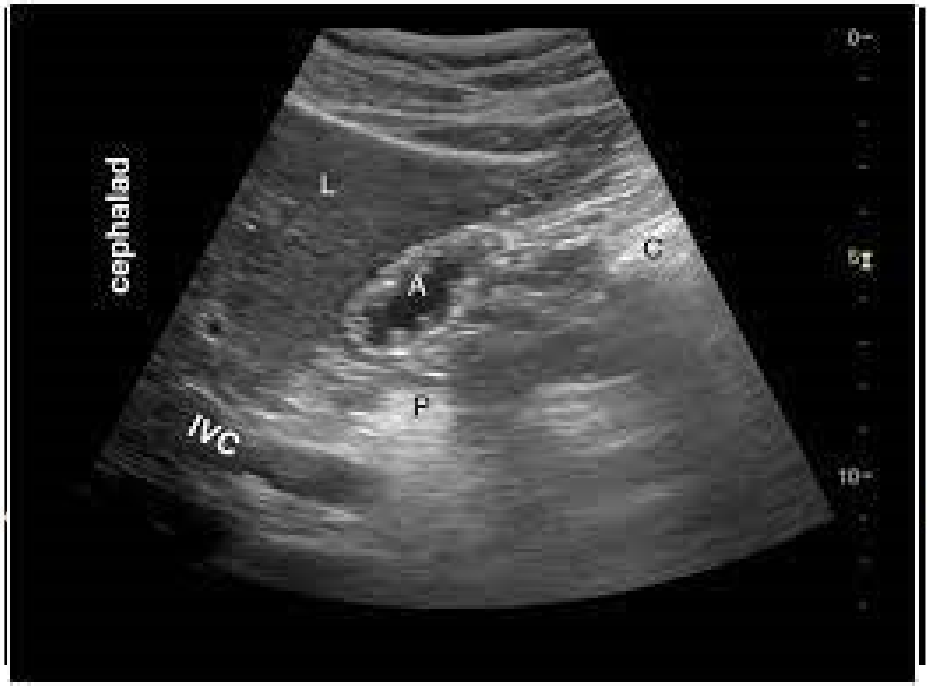
Anatomy / Technique





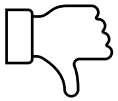
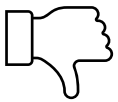
Anatomy / Technique





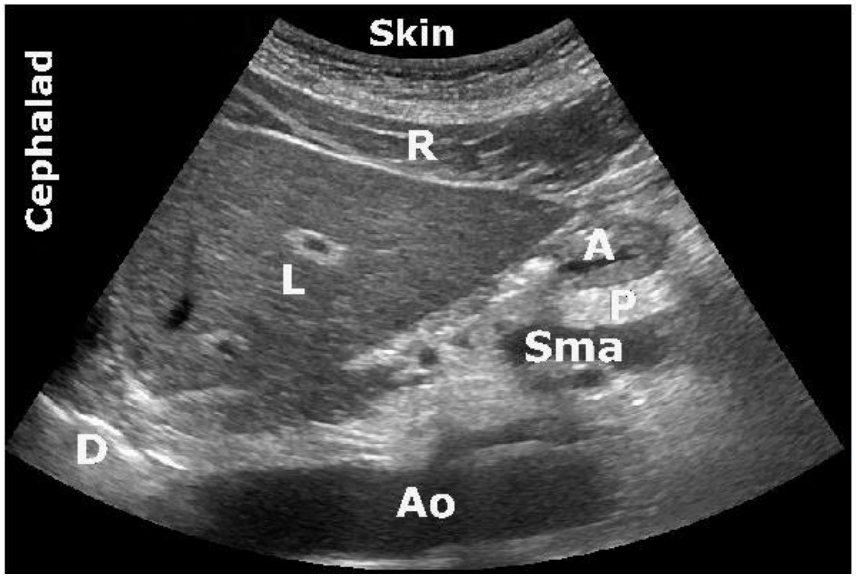
Anatomy / Technique

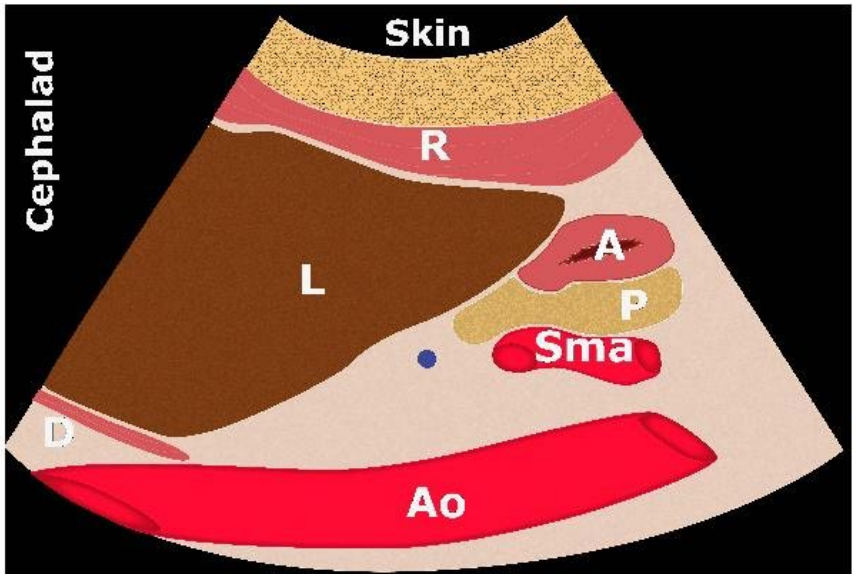
Gastric Content Classification

- Classes
  - Empty stomach / Minimal Liquids 
  - Small volume clear liquids 
  - Large volume clear Liquids 
  - Solid gastric contents 
    - Early verses late presentations
    - Mixed gastric contents

https://www.gastricultrasound.org/en/acquisition/#anatomy

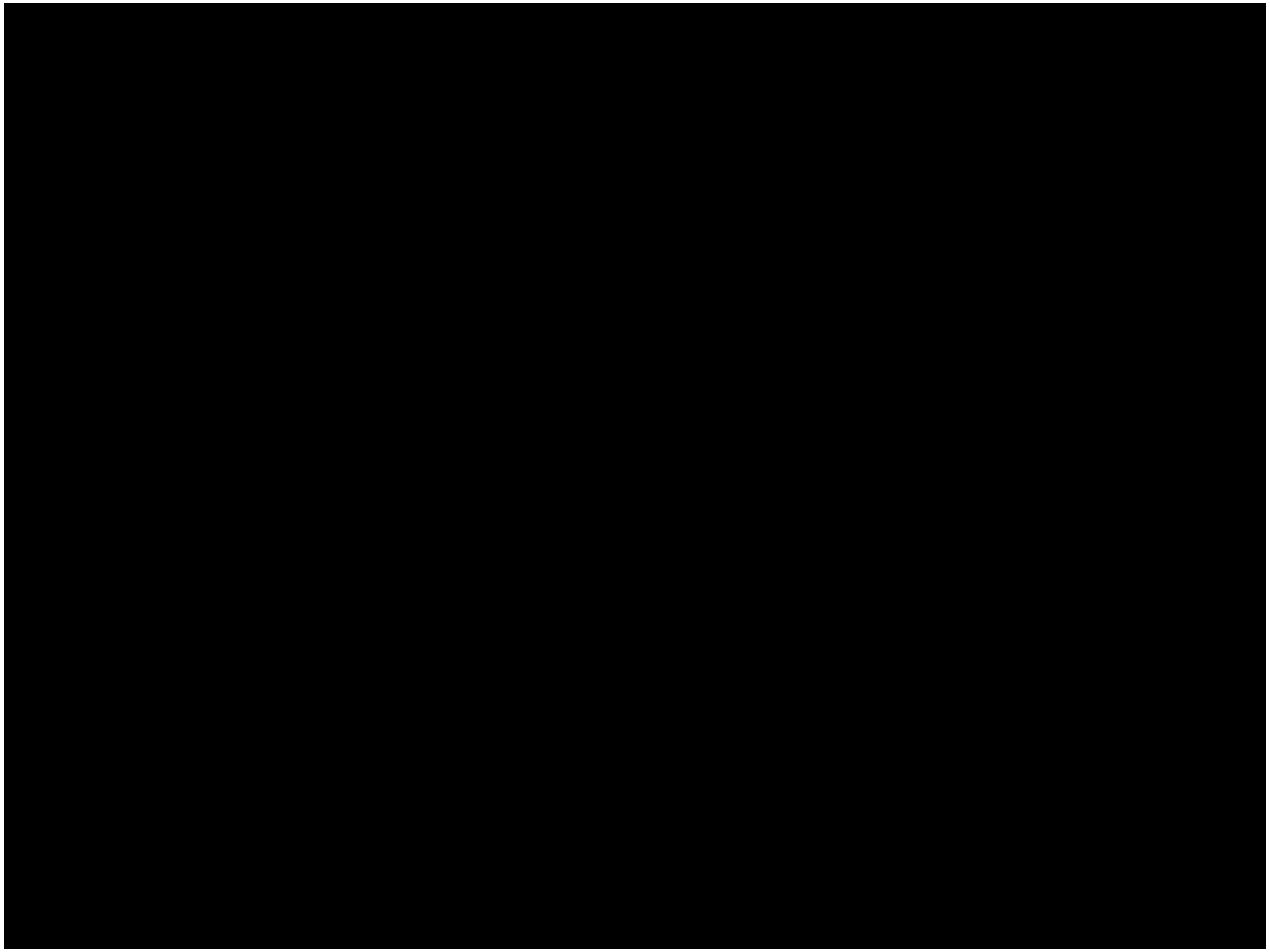
Empty Stomach / Minimal Liquid





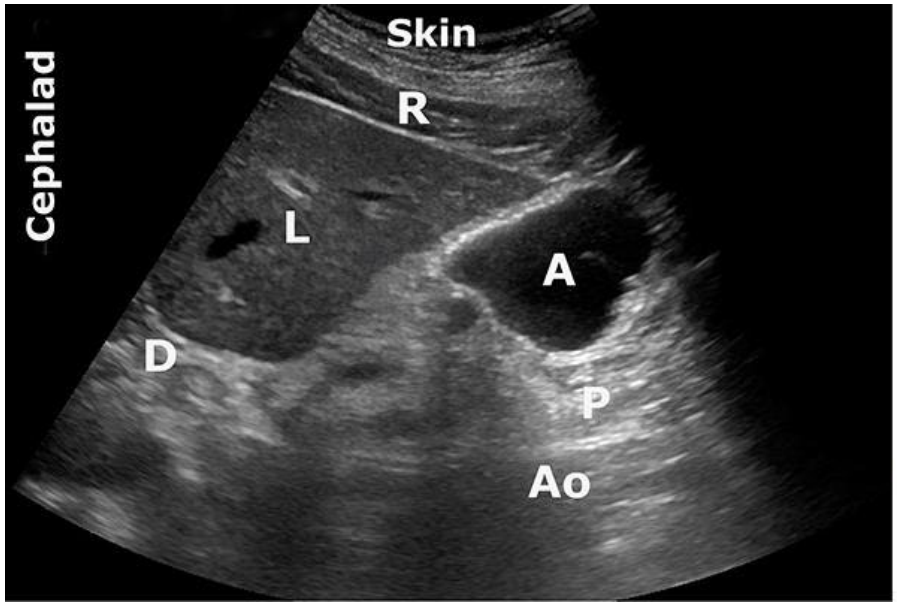
https://www.gastricultrasound.org/en/acquisition/#anatomy

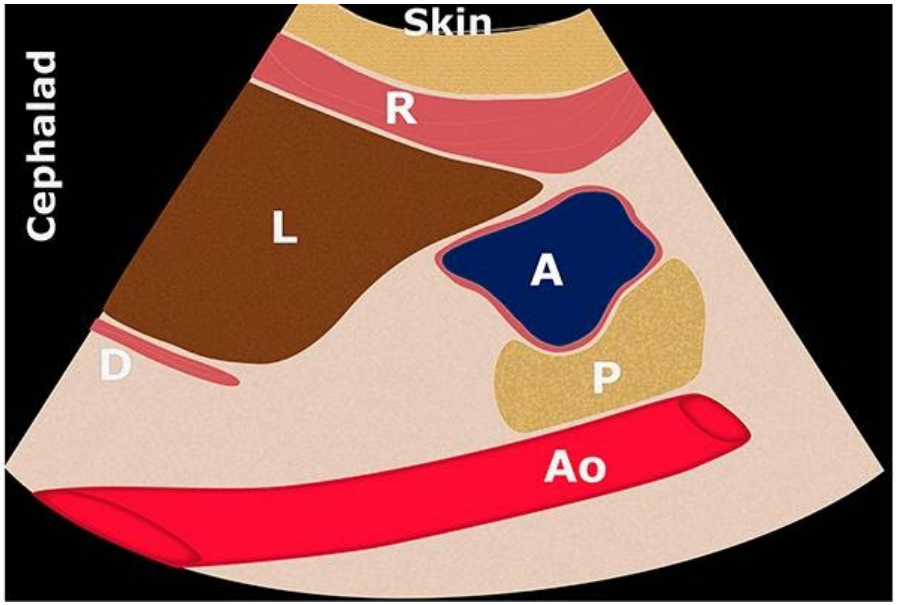
Empty Stomach / Minimal Liquid



Empty Stomach / Minimal Liquid

Large Volume Liquid



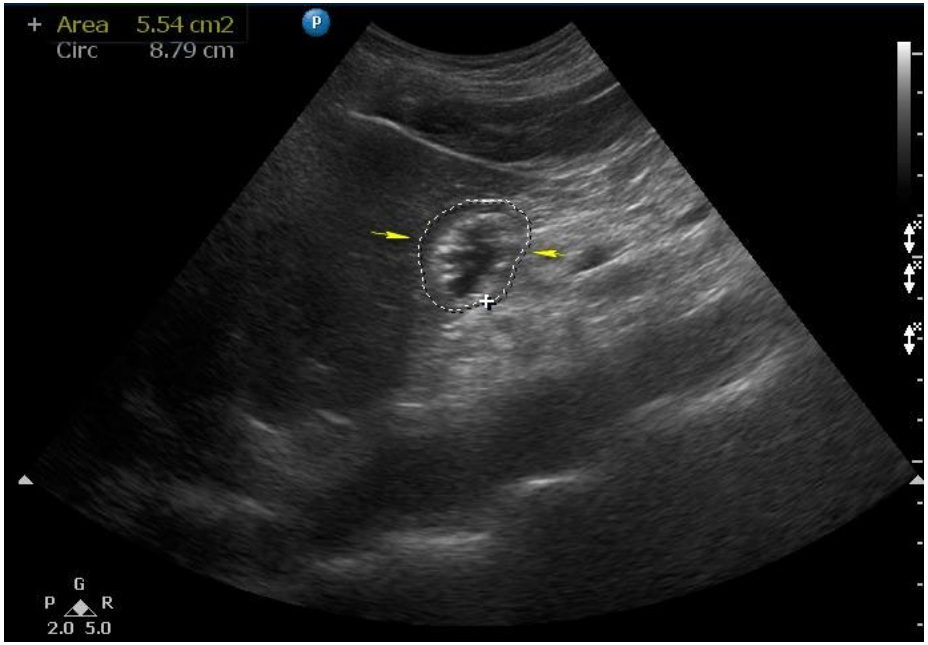


https://www.gastricultrasound.org/en/acquisition/#anatomy

Large Volume Liquid

How much is too much?

>1.5 cc/kg Total Body Weight



VOLUME (ML) = 27.0 + 14.6 X (RIGHT-LAT CSA) – 1.28 X (AGE)

www.gastricultrasound.org

Large Volume Liquid

How much is too much?

>1.5 cc/kg Total Body Weight

VOLUME (ML) = 27.0 + 14.6 X (RIGHT-LAT CSA) – 1.28 X (AGE)

Right lat CSA (cm^2)	Age(y) 20	30	40	50	60	70	80
2	**31**	**18**	**5**	**0**	**0**	**0**	**0**
3	**45**	**32**	**20**	**7**	**0**	**0**	**0**
4	**60**	**47**	**34**	**21**	**9**	**0**	**0**
5	**74**	**62**	**49**	**36**	**23**	**10**	**0**
6	**89**	**76**	**63**	**51**	**38**	**25**	**12**
7	103	**91**	**78**	**65**	**52**	**40**	**27**
8	118	105	**93**	**80**	**67**	**54**	**41**
9	133	120	107	**94**	**82**	**69**	**56**
10	147	135	122	109	**96**	**83**	**71**
11	162	149	136	123	111	**98**	**85**
12	177	164	151	138	125	113	100
13	191	178	165	153	140	127	114
14	206	193	180	167	155	142	129
15	220	207	194	182	169	156	143
16	235	222	209	200	184	171	158
17	249	236	224	211	198	185	173
18	164	251	239	226	213	200	187
19	278	266	253	240	227	214	202
20	293	281	268	255	242	229	217
21	307	295	282	269	256	244	231
22	323	310	297	284	271	259	246
23	337	324	311	298	285	273	260
24	352	339	326	313	301	288	275
25	366	353	340	327	315	302	289
26	381	368	355	343	330	317	304
27	395	382	369	357	344	331	318
28	410	397	385	372	359	346	333
29	424	411	398	386	373	360	347
30	439	427	414	401	388	375	363

https://www.gastricultrasound.org/en/acquisition/#anatomy

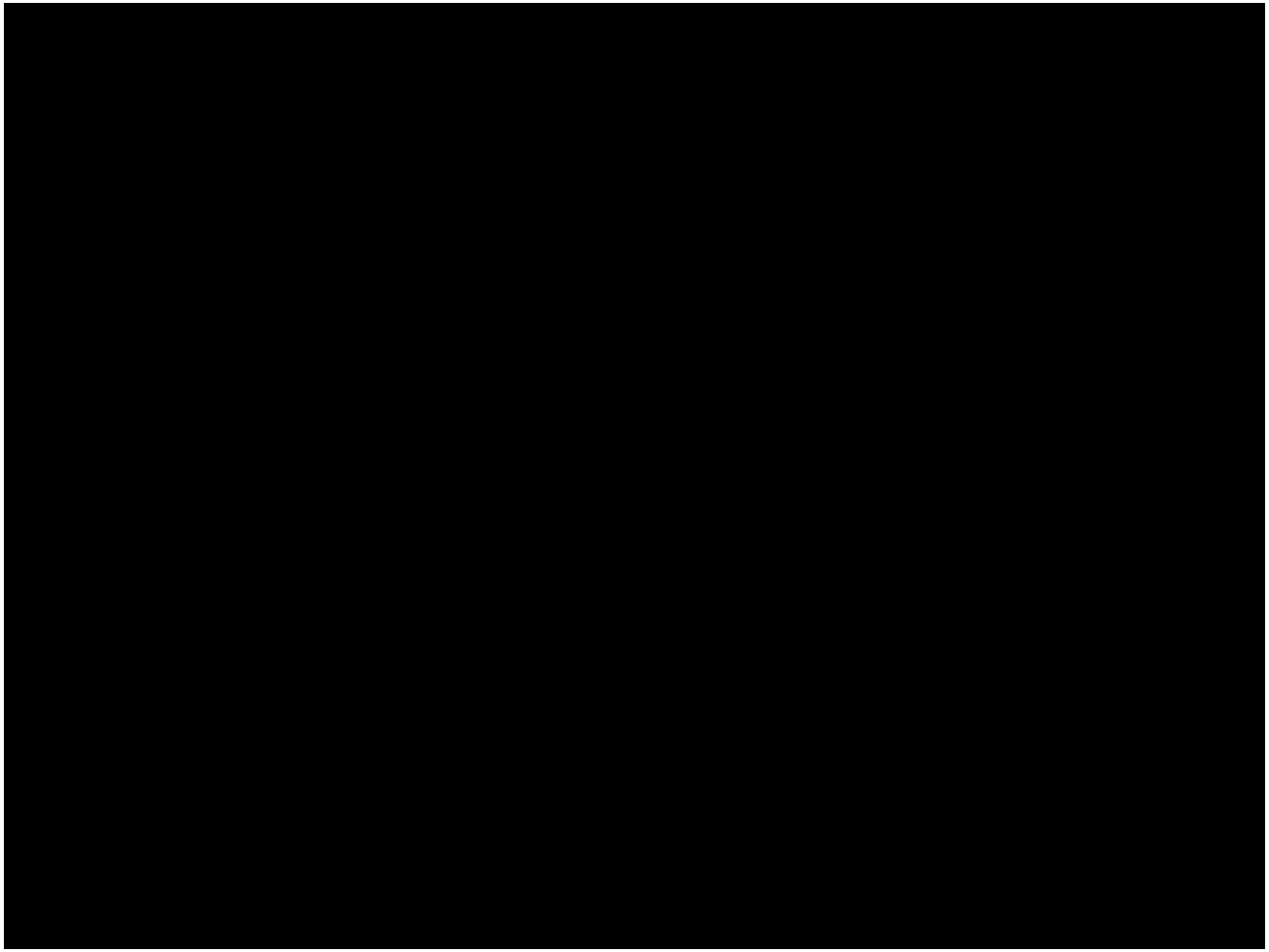
Large Volume Liquid

Caveats to volume measurement:

Only quantify if:

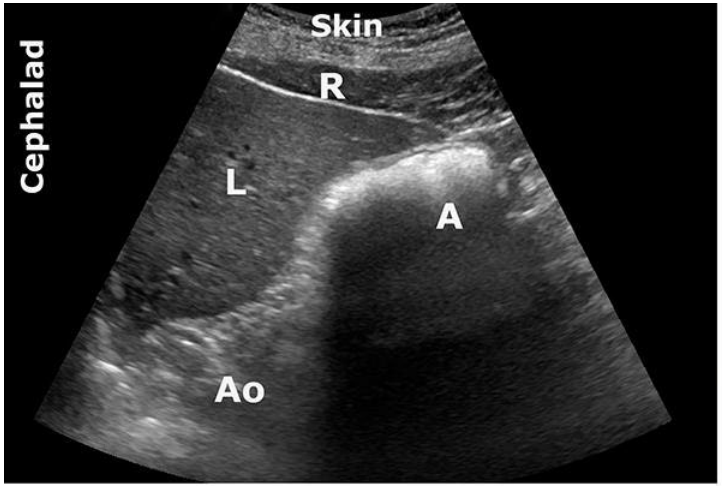
- -Only ingestion was Clear Liquids
- -BMI <40
- -No significant hiatal hernia
- -No history of gastric surgery
- -Pt must be in RLD position

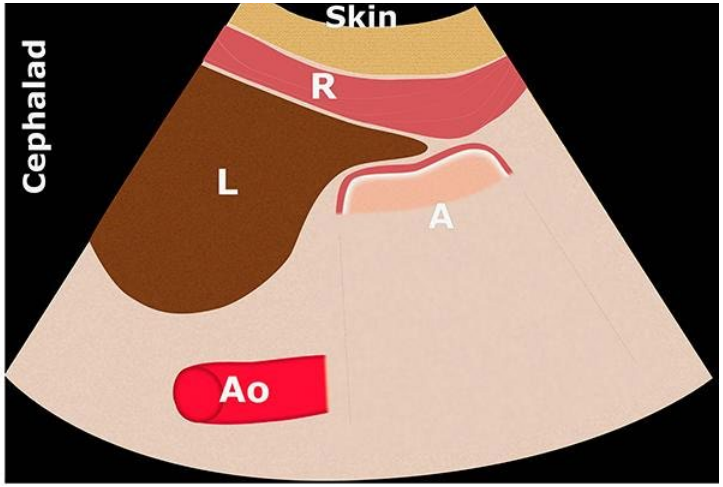
Large Volume Liquid

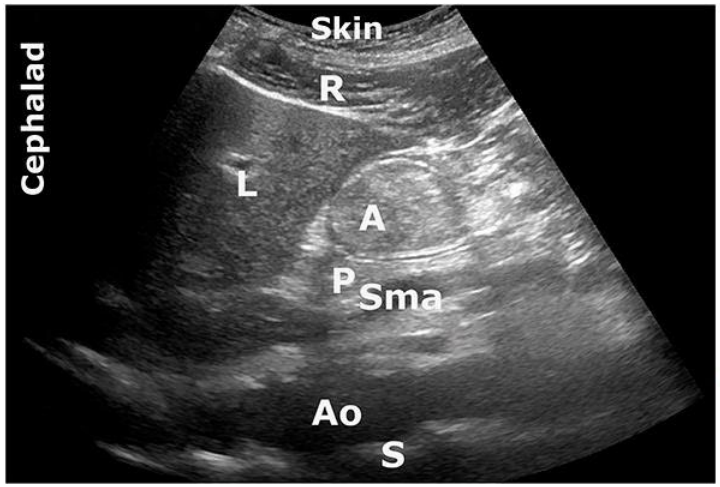


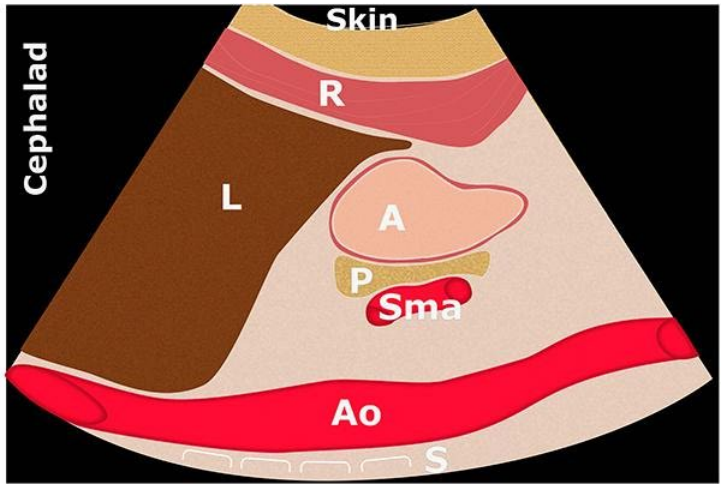
Large Volume Liquid

Solid Gastric Contents



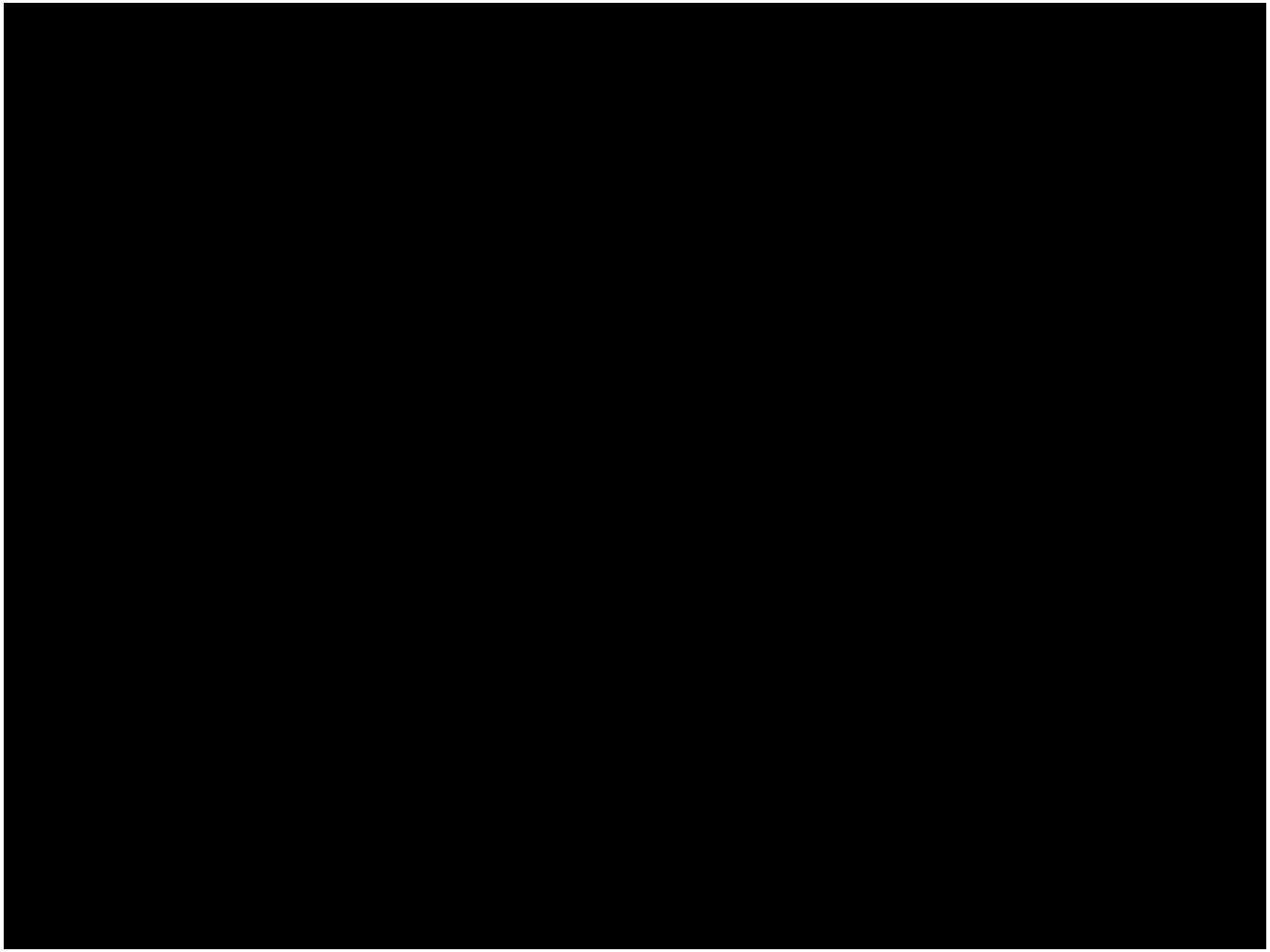




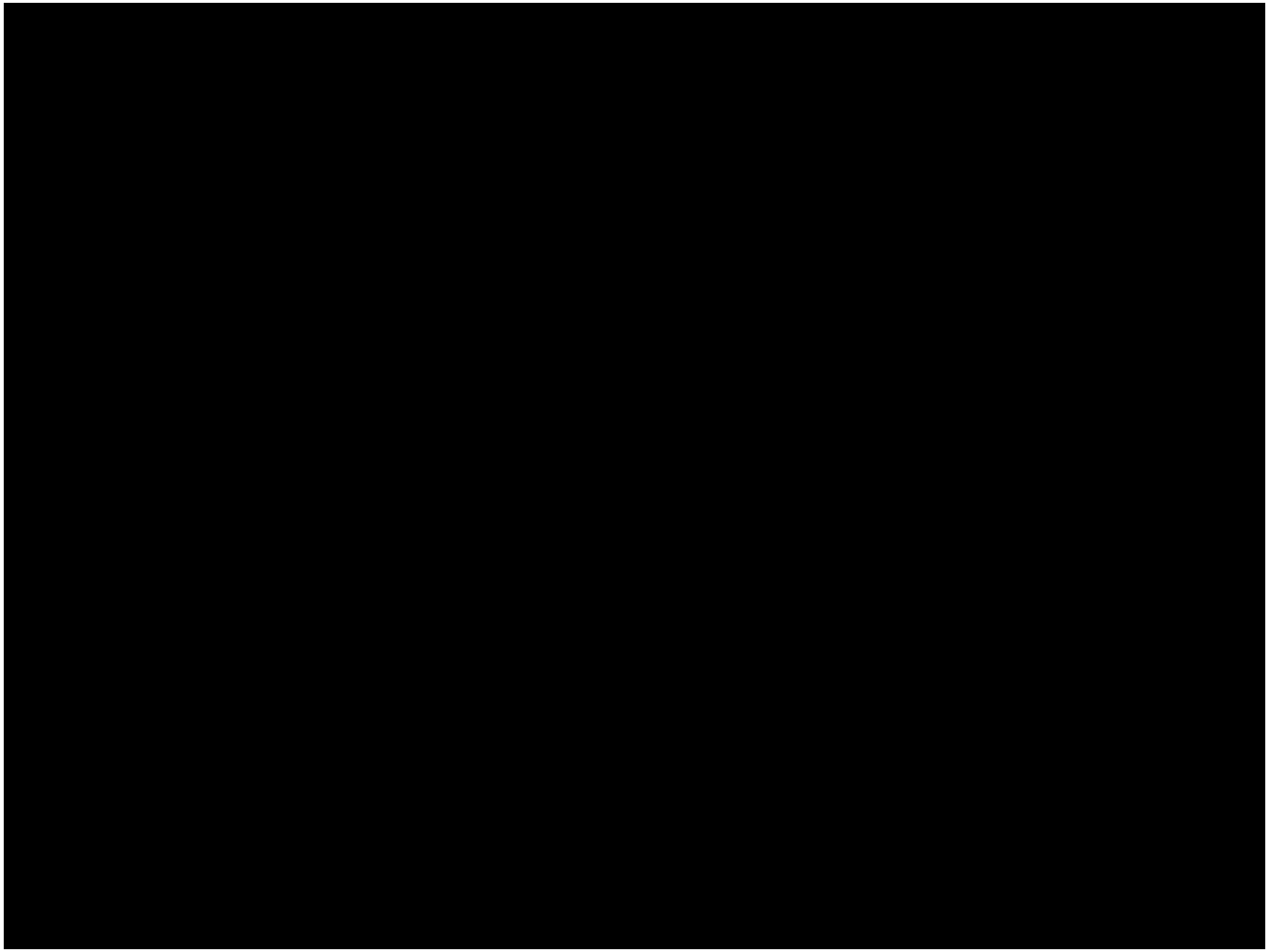


https://www.gastricultrasound.org/en/acquisition/#anatomy

Solid Gastric Contents

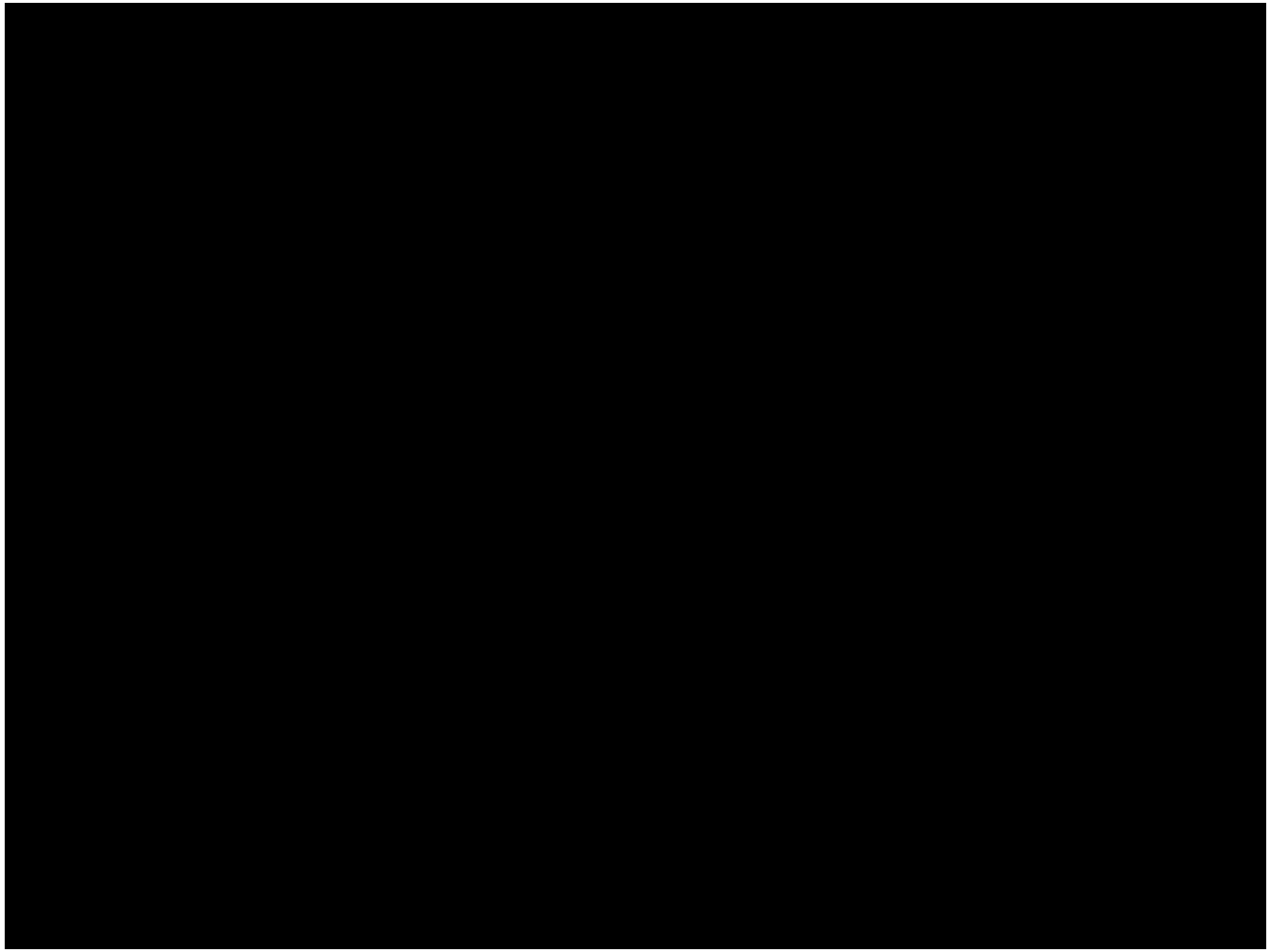


Solid Gastric Contents



Solid / Mixed Gastric Contents

Mixed Gastric Contents



GLP-1 RAs

GLP-1

- Secreted by intestines in response to food ingestion
- Slows Gastric Emptying
- Promotes Satiety

GENERIC NAME	DRUG NAME
albiglutide	Tanzeum
dulaglutide	Trulicity
exenatide	Byetta, Bydureon
liraglutide	Saxenda, Victoza
lixisenatide	Adlyxin
semaglutide	Ozempic

GLP-1 RAs

JAMA Surgery | Original Investigation

Glucagon-Like Peptide-1 Receptor Agonist Use and Residual Gastric Content Before Anesthesia

Sudipta Sen, MD; Paul P. Potnuru, MD; Nadia Hernandez, MD; Christina Goehl, MD; Caroline Praestholm, MS; Srikanth Sridhar, MD; Omonele O. Nwokolo, MD

JAMA Surg. doi:10.1001/jamasurg.2024.0111
Published online March 6, 2024.

Key Points

Question Is glucagon-like peptide-1 receptor agonist (GLP-1 RA) use associated with increased residual gastric content (RGC) in fasted patients presenting for elective procedures under anesthesia?

Findings In this cross-sectional study of 124 patients who fasted for the guideline-recommended duration, the prevalence of increased RGC on gastric ultrasonography was 56% in GLP-1 RA users compared with 19% in nonusers, a significant difference after confounder adjustment.

Meaning Patients taking a GLP-1 RA had a higher prevalence of increased RGC despite fasting for the guideline-recommended duration.

GLP-1 RAs

Results: 24 studies met eligibility criteria.
All studies, except one case report, reported patients with confounding factors for retained gastric contents and aspiration, such as a history of diabetes, cirrhosis, hypothyroidism, psychiatric disorders, gastric reflux, Barrett's esophagus,
Of the eight studies (three prospective and five retrospective) that evaluated residual contents in both GLP-1 users and non-users, seven studies (*n* = 7/8) reported a significant increase in residual gastric contents in GLP-1 users compared to non-users (19–56% vs. 5–20%).
In the three retrospective studies that evaluated for aspiration events, there was no significant difference in aspiration events, with one study reporting aspiration rates of 4.8 cases per 10,000 in GLP-1 RA users compared to 4.6 cases per 10,000 in nonusers

Conclusions: Most of these studies include confounding factors that may influence the association between GLP-1 RAs and an increased risk of aspiration and related events.
While GLP-1 RAs do increase residual gastric contents in line with their mechanism of action, the currently available data do not suggest a significant increase in aspiration and regurgitation events associated with their use

GLP-1 RAs

Included 13 studies involving a total of 84,065 patients.
Patients receiving GLP- 1RA therapy exhibited significantly higher rates of RGC (OR, 5.56; 95% CI, 3.35 to 9.23), a trend that was consistent among patients with diabetes (OR, 2.60; 95% CI, 2.23 to 3.02). Adjusted analysis, accounting for variables such as sex, age, body mass index, diabetes, and other therapies, confirmed the elevated rates of RGC in the GLP-1RA user group (adjusted OR, 4.20; 95% CI, 3.42 to 5.15).
Rates of aborted and repeated procedures were higher in the GLP-1RA user group (OR, 5.13; 95% CI, 3.01 to 8.75; and OR, 2.19; 95% CI, 1.43 to 3.35; respectively).
No significant differences were found in AE and aspiration rates be- tween the 2 groups (OR, 4.04; 95% CI, 0.63 to 26.03; and OR, 1.75; 95% CI, 0.64 to 4.77; respectively).

Use of GLP-1RAs is associated with increased retention of gastric contents and more frequent aborted procedures during upper endoscopy.
However, the adverse event and aspiration rates do not seem different.

GLP-1 RAs

GLP-1 RAs

Concerns:

- Only examined emergent surgeries
- NPO status of Control patients?
- Inclusion criteria: Prescription for GLP1-RA
- RSI?
- How were they RSI'd?
- Outcome was "Postoperative Respiratory Complications"

GLP-1 RA Literature Summary

GLP1-RAs delay gastric emptying, and result in residual contents in many patients following traditional NPO Guidelines.

Does that translate to increased aspiration risk?

TBD, not yet fully addressed
But Probably

ASA GLP1-RA Guidance

American Society of Anesthesiologists Consensus-Based Guidance on Preoperative Management of Patients (Adults and Children) on Glucagon-Like Peptide-1 (GLP-1) Receptor Agonists

Girish P. Joshi, M.B.B.S., M.D., Basem B. Abdelmalak, M.D., Wade A. Weigel, M.D., Sulpicio G. Soriano, M.D., Monica W. Harbell, M.D., Catherine I. Kuo, M.D., Paul A. Stricker, M.D., Karen B. Domino, M.D., M.P.H., American Society of Anesthesiologists (ASA) Task Force on Preoperative Fasting

ASA GLP1-RA Guidance

Most Patients Can Continue GLP-1 Drugs Before Surgery

Take into account patient specific factors for delayed gastric emptying and consider the following:

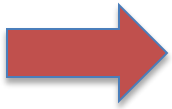
- Patients in the escalation phase of GLP-1 drugs (early in treatment) are more likely to have delayed stomach emptying. Defer elective surgery until:
  - Escalation phase has passed
  - GI side effects (nausea, vomiting, abdominal pain, shortness of breath, or constipation) have dissipated
- Patients on a higher dose should follow a liquid diet for 24 hours before the procedure.
- Patients with other medical conditions that slow stomach emptying may further modify the perioperative management plan.

Can minimize the risk of delayed gastric emptying by:

- A liquid-only diet for 24 hours before surgery.
- Adjusting the anesthesia plan to minimize aspiration risk.
- Using POCUS before the procedure to assess stomach contents in patients at highest risk.

Emory Guidance

Dulaglutide (Trulicity) (weekly)
Exenatide ER (Bydureon BCise) (weekly)
Exenatide IR (Byetta) (twice daily)
Liraglutide (Saxenda, Victoza) (daily)
Lixisenatide (Adlyxin) (daily)
Semaglutide (Ozempic, Wegovy) (weekly)
Semaglutide (Rybelsus) (daily)



Patient presents on glucagon-like peptide 1 receptor agonist (GLP-1RA)

Can case be performed with minimal sedation +/- regional?

No

Ability to perform gastic ultrasound?

No

Is the patient experiencing GI symptoms**?

No

GLP-1 RA Drug held per current ASA statement?

Yes

ASA says to proceed*
Discuss risks/benefits of proceeding with the patient and surgeon/proceduralist

Yes

Perform Pocus Exam

Yes

Gastric contents present or inconclusive exam

Yes

Consider delaying procedure but discuss with patient and surgeon/proceduralist

Anesthesia machine in procedural room

No

Yes

All parties agree to proceed

No

Yes

Delay Procedure

No

Proceed using full stomach precautions

Yes

No

Gastric Ultrasound Key Points

Technically easy to learn

Aspiration Risk Stratification:

- Empty stomach / minimal liquids
- <1.5 cc /kg Clear Liquids
- >1.5 cc / kg Clear Liquids
- Solids & Mixed

Ensure RLD Position if Quantifying

- Only clear liquids should be quantified

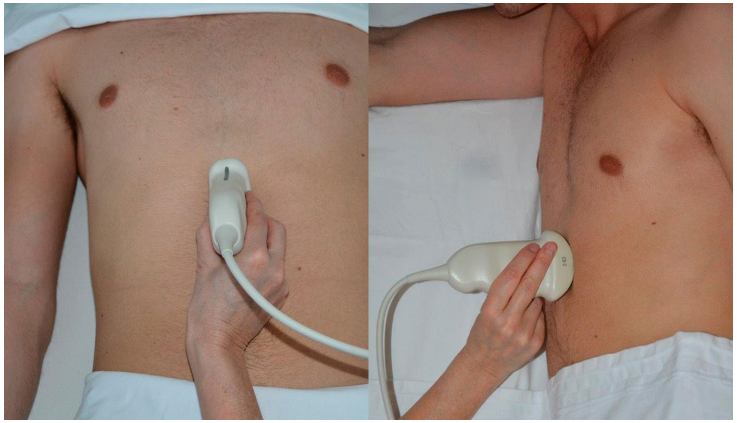
Identify Aorta to ensure you are looking at the Antrum

Clinical Practice

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



Should we think beyond NPO time?

Acknowledgements

Peter Van de Putte, MD PhD & Lionel Bouvet, MD PhD of GastricUltrasound.org

Clinical Practice

Clinical Practice

References

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 126(3):p 376-393, March 2017. | DOI: 10.1097/ALN.0000000000001452

https://www.gastricultrasound.org/en/acquisition/#anatomy

Sen S, Potnuru PP, Hernandez N, Goehl C, Praestholm C, Sridhar S, Nwokolo OO. Glucagon-Like Peptide-1 Receptor Agonist Use and Residual Gastric Content Before Anesthesia. JAMA Surg. 2024 Jun 1;159(6):660-667. doi: 10.1001/jamasurg.2024.0111. PMID: 38446466; PMCID: PMC10918573.

Chang MG, Ripoll JG, Lopez E, Krishnan K, Bittner EA. A Scoping Review of GLP-1 Receptor Agonists: Are They Associated with Increased Gastric Contents, Regurgitation, and Aspiration Events? J Clin Med. 2024 Oct 23;13(21):6336. doi: 10.3390/jcm13216336. PMID: 39518474; PMCID: PMC11546377.

Facciorusso A, Ramai D, Dhar J, Samanta J, Chandan S, Gkolfakis P, Crinò SF, Maida M, Anderloni A, Boskoski I, Triantafyllou K, Dinis-Ribeiro M, Hassan C, Fuccio L, Arvanitakis M. Effects of Glucagon-Like Peptide-1 Receptor Agonists on Upper Gastrointestinal Endoscopy: A Meta-Analysis. Clin Gastroenterol Hepatol. 2024 Aug 12:S1542-3565(24)00717-1. doi: 10.1016/j.cgh.2024.07.021. Epub ahead of print. PMID: 39142543.

Dixit AA, Bateman BT, Hawn MT, Odden MC, Sun EC. Preoperative GLP-1 Receptor Agonist Use and Risk of Postoperative Respiratory Complications. JAMA. 2024 May 21;331(19):1672-1673. doi: 10.1001/jama.2024.5003. PMID: 38648036; PMCID: PMC11036309.

https://www.asahq.org/about-asa/newsroom/news-releases/2024/10/new-multi-society-glp-1-guidance

Kindel TL, Wang AY, Wadhwa A, Schulman AR, Sharaiha RZ, Kroh M, Ghanem OM, Levy S, Joshi GP, LaMasters TL; American Gastroenterological Association; American Society for Metabolic and Bariatric Surgery; American Society of Anesthesiologists; International Society of Perioperative Care of Patients with Obesity; Society of American Gastrointestinal and Endoscopic Surgeons. Multisociety Clinical Practice Guidance for the Safe Use of Glucagon-like Peptide-1 Receptor Agonists in the Perioperative Period. Clin Gastroenterol Hepatol. 2024 Oct 29:S1542-3565(24)00910-8. doi: 10.1016/j.cgh.2024.10.003. Epub ahead of print. PMID: 39480373.

Ebb and Flow: Understanding Burn Shock

Andrew Bowman, MD
Emory University
Grady Memorial Hospital

EMORY UNIVERSITY

Grady

- No disclosures to report

Each year there is an estimated

1 person

per 10,000 people in the U.S.

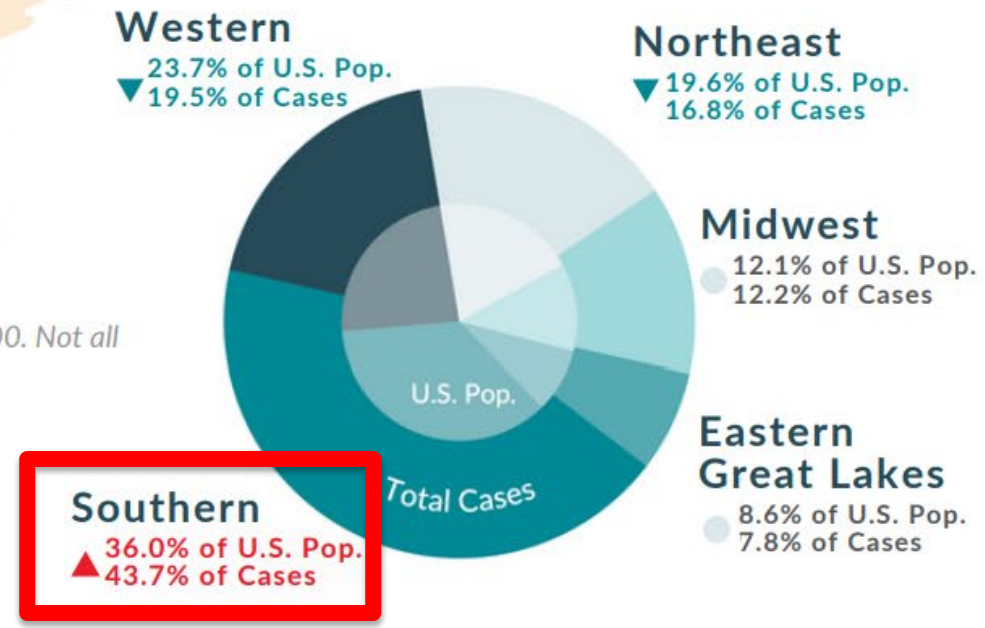
requiring inpatient hospitalization at a burn center

Cases per 10,000 in U.S. Population calculated as (Total Cases / 5 years / U.S. Population) x 10,000. Not all burn centers contribute data to this report.

QUICK FACTS

REGIONAL STATS

Percent of Cases vs. U.S. Population by Region



EMORY UNIVERSITY

American Burn Association. (2024). *Annual Burn Injury Summary Report*.

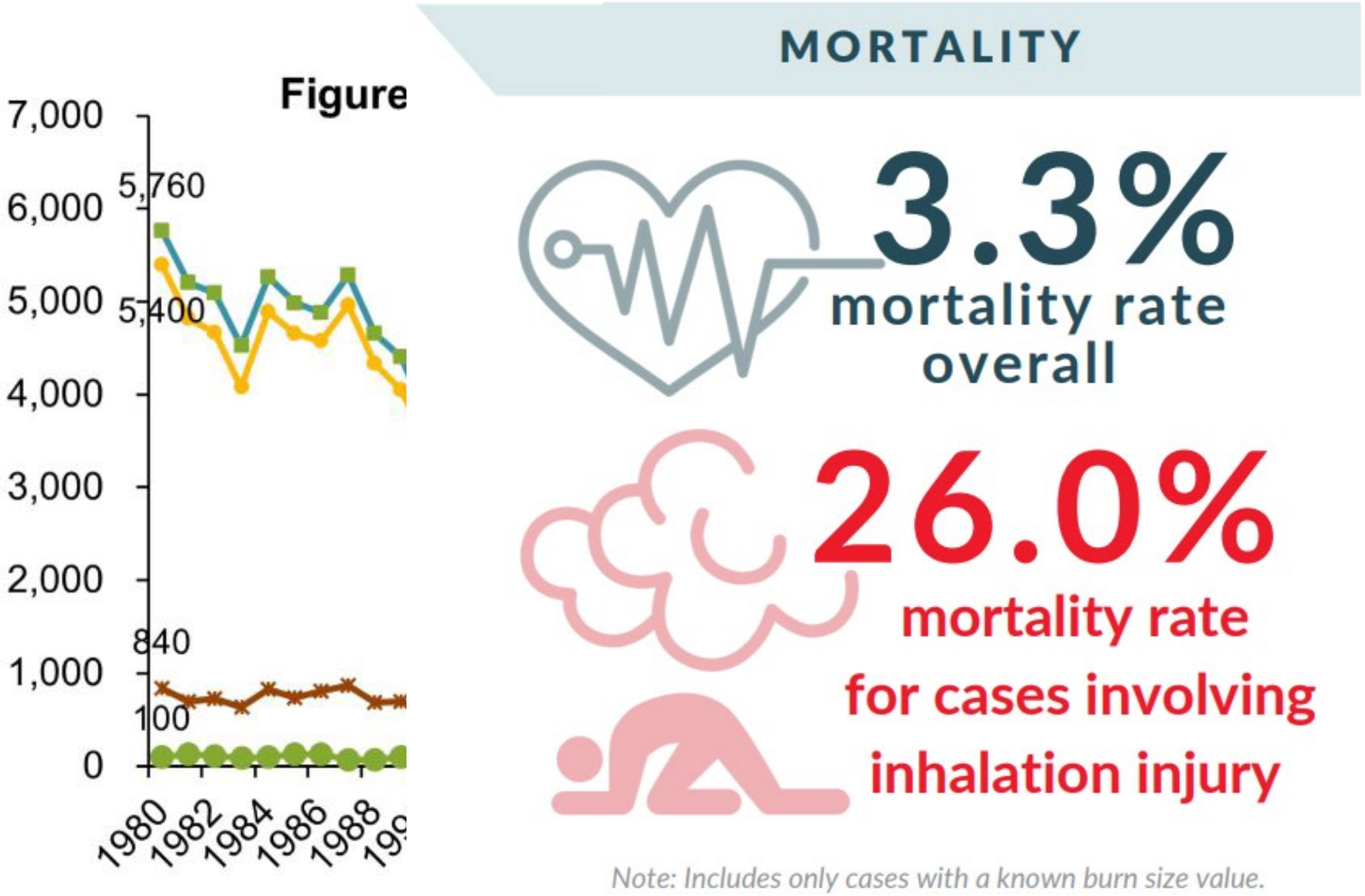
Burn Injury Epidemiology

Table 1. Sources of Burn Injury Incidence Reporting

	ABA BISR	ABA Fact Sheet	CDC NHAMCS	NIS	NEDS	CDC WISQARS	Claims data
Patient population	Admissions	ED & admissions	ED	In-patients	ED	Unintentional injuries	Claims
Burn injury estimate	30,135	486,000	359,000	118,720	438,185	287,926 non-fatal 3,529 fatal	698,555
Estimate year	2022	2011	2020	2020	2020	2020	2020

EMORY UNIVERSITY

(Ivanko, Garbuzov et al. 2024)



American Burn Association. (2024). *Annual Burn Injury Summary Report*.

Burn Types

- Acute Thermogenic Injury
  - Smoke inhalational injury
- Electrical Injury
- Radiation Burns
- Chemical Burns
- Desquamating diseases

A Burn Center Only Problem?

1 Partial thickness burns greater than 10% TBSA.

Burn Triage Criterion	% at Burn Center (n = 252)	% at Nonburn Center (n = 269)	*P*
admitted with either burns to face, hands. feet, genitalia, perineum, major joints	73.0 (184/252)	74.0 (199/269)	.796
admitted with second–degree burn >10% TBSA	38.5 (97/252)	19.7 (53/269)	<.001
admitted with third–degree burns	56.7 (143/252)	46.5 (125/269)	.020
admitted because of chemical burns	0.40 (1/252)	0.37 (1/269)	.859
admitted with either burns to face, hands, feet, genitalia, major joints and third-degree burns	43.5 (110/252)	10.8 (29/269)	<.001
admitted with second–degree burn >10% TBSA: and third–degree burns	38.5 (97/252)	9.7 (26/269)	<.001
admitted with either burns to face, hands, feet, genitalia, perineum, major joints: and % admitted with second–degree burn >10% TBSA: and third–degree burns	30.6 (77/252)	10.0 (27/269)	<.001

ABA criteria for transfer to Burn Center

EMORY UNIVERSITY

(Davis et al., 2012)

Brief History of Military and Civilian Burn Trauma

Lorenz Heister (1683-1758)
Pioneer of battlefield surgery

Heister classified burn trauma in terms of heat, pain, depth and time. He also conjectured that the burn response was an inflammatory response and described the extravasation of fluid and red cells from the vessels in burn patients.

1970s: Advent of early excision

2023 Advances in skin grafts, dressings, tissue-engineered substitutes and biomaterials-based biological dressings.

2023 Parkland and modified Brooke's formulae remain standard-of-care to determine the initial fluid administration required for burn patient.

2005-2010 Jeschke and colleagues report that secondary injury can persist for at least 5-10 years.

1989 Herndon and colleagues showed immune deficiency and mortality in severely burned patients.

1952 Evans and colleagues provide a synthesis of fluid and electrolyte requirements for severe burns patients.

1951 Wallace, Pulaski and Tennison proposed a simplified "Rules of Nine" method to assess burn TBSA. Methods have improved to include age and a prognostic value which predicted death.

1940s Cope and Moore also formulated an IV fluid solution that comprised 50% plasma and 50% saline.

World War II: saw rapid developments in fluid resuscitation for burns and antibiotics to prevent infection. Tests were developed for discriminating 2nd and 3rd degree burns. Major advances were made in plastic surgery.

1923 Frank Underhill (1877-1932) provided a better understanding of severe burn pathophysiology and showed burn shock correlated with increased hematocrit, secondary to fluid and electrolyte loss. Underhill stressed correcting plasma volume with fluids and capillary leak.

1916-24 Du Bois team and S.G.Berkow independently provided formulas/tables to estimate body surface area when height and weight are known.

Early 20th century: Burn treatment involved mechanical cleansing, surgical debridement and topical solutions to prevent the release of 'toxins from the burn wound and to dry out the wound to allow formation of hard coagulum to minimize fluid loss".

1897 Following from the early work of Gerard van Swieten (1750s) and Von Buhl (1855), saline infusions for severe burns were first advocated clinically.

1869 Swiss surgeon Jacques-Louis Reverdin (1842-1929) performed one of the first 'sterile' free skin graft procedures under anesthesia in Denmark.

1867 British surgeon Joseph Lister (1827-1912) adopted Pasteur's 'germ theory' and promoted antiseptic procedures. Lister postulated that infection came from exposure of the wound to the air in without the protection of the skin. Termed the antisepsis postulates of Lister and Pasteur.

1862 French physician H Baraduc (1850–1909) described blood thickens after a burn and observed it has difficulties passing through small vessels.

1859 Claude Bernard (1813-1878) formulated his theory of fixity of "milieu intérieur" to preserve constant the conditions of the internal environment, and role of the CNS.

1843 The first hospital for the treatment of large burns was established on the grounds of the Edinburgh Royal Infirmary.

1832 Guillaume Dupuytren reported gastric and intestinal dysfunction in burn patients, and first described "intensive cerebral congestion" in the autopsy of burn victims.

Before the 19th century: Investigators demonstrated that, after a burn, fluid is lost from the blood and the blood became thicker. Immediate cooling was controversial.

1822 German surgeon Johann Friedrich Dieffenbach 1792-1847) studied skin grafting but apparently was unsuccessful in performing a free graft in humans.

1799 Surgeon James Earl (1755-1817) advocated immediate cooling of the burn wound to halt injury progression, which is a part of the first aid recommended today.

1797 Edward Kentish's *Essay on Burns* described pressure dressing burns to relieve pain and reduce blistering.

1794 Battlefield Surgeon and scientist John Hunter (1728-1793) published his famous: *A Treatise on the Blood, Inflammation and Gunshot Wounds*. He believed burn treatment was a treatment of trauma and inflammation and cooling the burn was not protective.

1607 German surgeon William Fabry (1560-1634) wrote a burn treatise *De combustionibus* and classified a burn into three degrees and described a windlass (twisting stick).

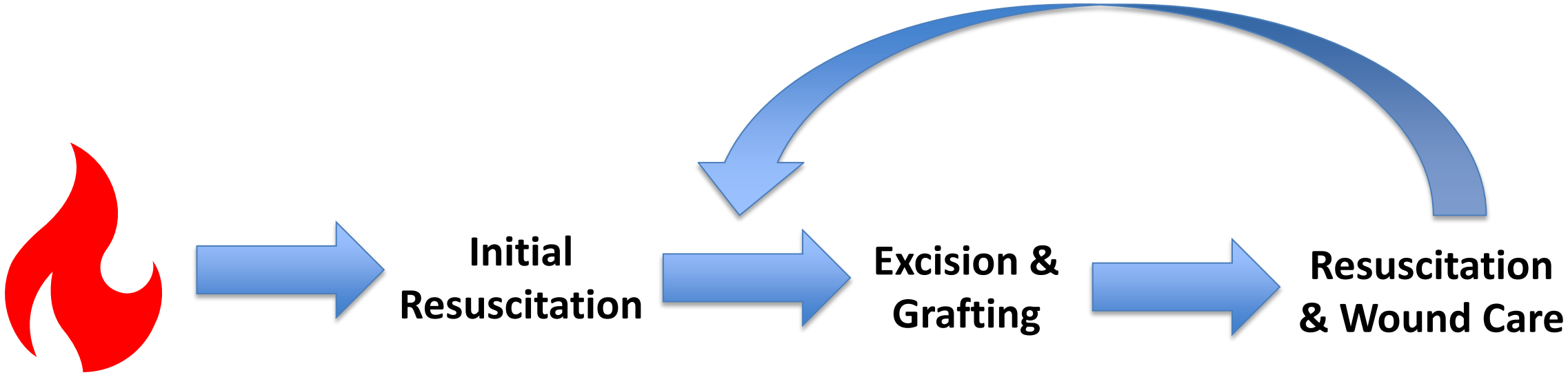
1560s English surgeon William Clowes (c.1543–1604) advocated the application of powders and ointments, e.g. onion paste, for gunpowder burns.

1537 French surgeon Ambroise Paré (c.1510- 1590) pioneered new surgical techniques for battlefield medicine, especially wound healing.
War and increased gunpowder use created major gaps in knowledge in burn trauma, and how to treat it medically and surgically on the battlefield.

2023
2000s
1900s
1800s
1700s
1600s
1500s

(Dobson, Morris and Letson 2024)

Burn Injury Timeline



Burn Injury Physiology

THE LANCET] ORIGINAL ARTICLES [APRIL 11, 1942

POST-SHOCK METABOLIC RESPONSE *

D. P. CUTHBERTSON, M.D., D.SC. GLASG.
GREIVE LECTURER IN PHYSIOLOGICAL CHEMISTRY IN THE UNIVERSITY OF GLASGOW

Ebb Phase → **Flow Phase**

12-72hr after initial injury

Days to years after initial injury

EMORY UNIVERSITY

Burn Injury Physiology

Major Burn – typically involving ≥20% TBSA

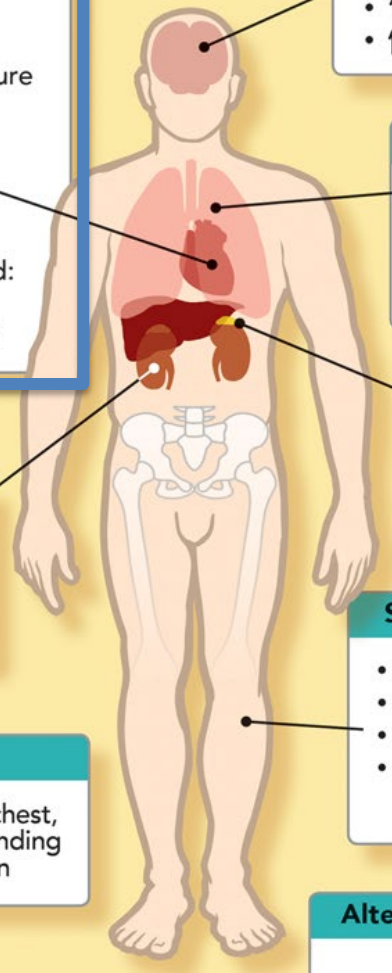
Ebb Phase

12-72hr after initial injury

Flow Phase

Days to years after initial injury

Pathophysiologic Changes in the Early Phase (24-48 hrs) of Burn Injury



Heart & Circulation

- Tachycardia
- ↓ Cardiac index
- ↓ Stroke volume
- Normal or low blood pressure
- ↓ SvO_2
- ↑ PVR and SVR
- ↑ Hematocrit
- CVP variable
- Metabolic acidosis
- Echocardiogram/ultrasound:
  - Small chambers
  - Decreased contractility

Brain

- Altered mental status
- ? Cerebral edema
- ↑ Pain response
- ↑ ADH

Lungs – Inhalation Injury

- Pulmonary edema
- Bronchospasm, bronchorrhea
- Acute respiratory distress syndrome

Adrenal gland

- ↑ Aldosterone
- ↑ Cortisol

Kidney-Bladder

- Myoglobinuria
- Oliguria
- Urine fractional Na^+ <1%

Skin

- Non-blanching burned skin
- Mottled clammy non-burned skin
- Fluid loss through burned skin
- Generalized edema in >25% body burn

Circumferential burn

- Compartment syndrome of chest, abdomen and/or limbs depending on site of circumferential burn

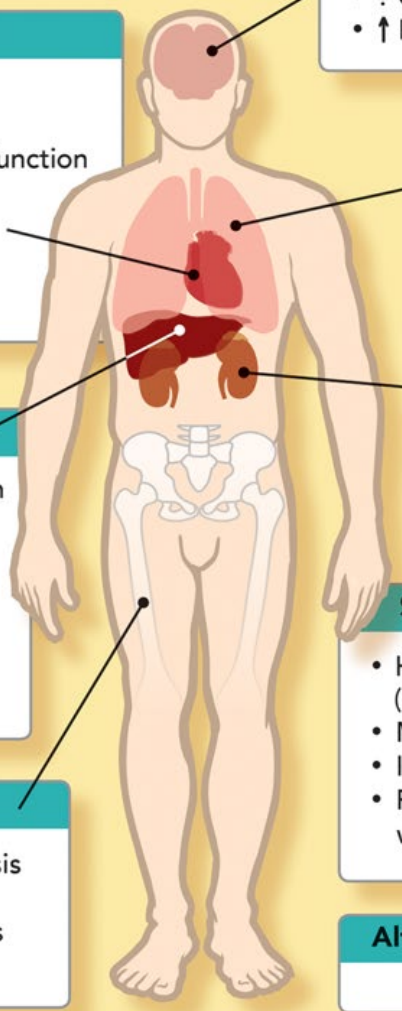
Altered pharmacological responses

EMORY UNIVERSITY

ANESTHESIOLOGY
Trusted Evidence: Discovery to Practice

From: Acute and Perioperative Care of the Burn-injured Patient
Anesthesiology. 2015;122(2):448-464. doi:10.1097/ALN.0000000000000559

Pathophysiological Changes During Hypermetabolic/hyperdynamic Phase of Burn (> 48 hrs)



Brain
- Altered mental status
- ? Cerebral edema
- ↑ Pain response

Heart & Circulation
- Tachycardia
- ↑ Cardiac index
- Subclinical myocardial dysfunction
- Echocardiogram
  - Altered contractility
- ↑ SvO_2
- ↓ SVR

Lungs – Inhalation Injury
- Pulmonary edema
- Bronchospasm, bronchorrhea
- Acute respiratory distress syndrome
- Pneumonia

Kidney
- ↑ Glomerular filtration rate
- ↓ Tubular function

Liver
- Altered metabolic function
- Altered drug clearance
- Fatty liver
- ↑ Live blood flow
- ↑ Gluconeogenesis
- ↓ Coagulation factors
- Albuminemia

Systemic inflammatory response
- High energy expenditure (↑O_2 consumption & ↑CO_2 production)
- Muscle catabolism
- Insulin resistance - hyperglycemia
- Persistence of generalized edema with >25% body burn

Bone marrow
- ↓ Hematopoiesis
- Anemia
- Immunoparesis
- Osteoporosis

Altered pharmacological responses

EMORY UNIVERSITY

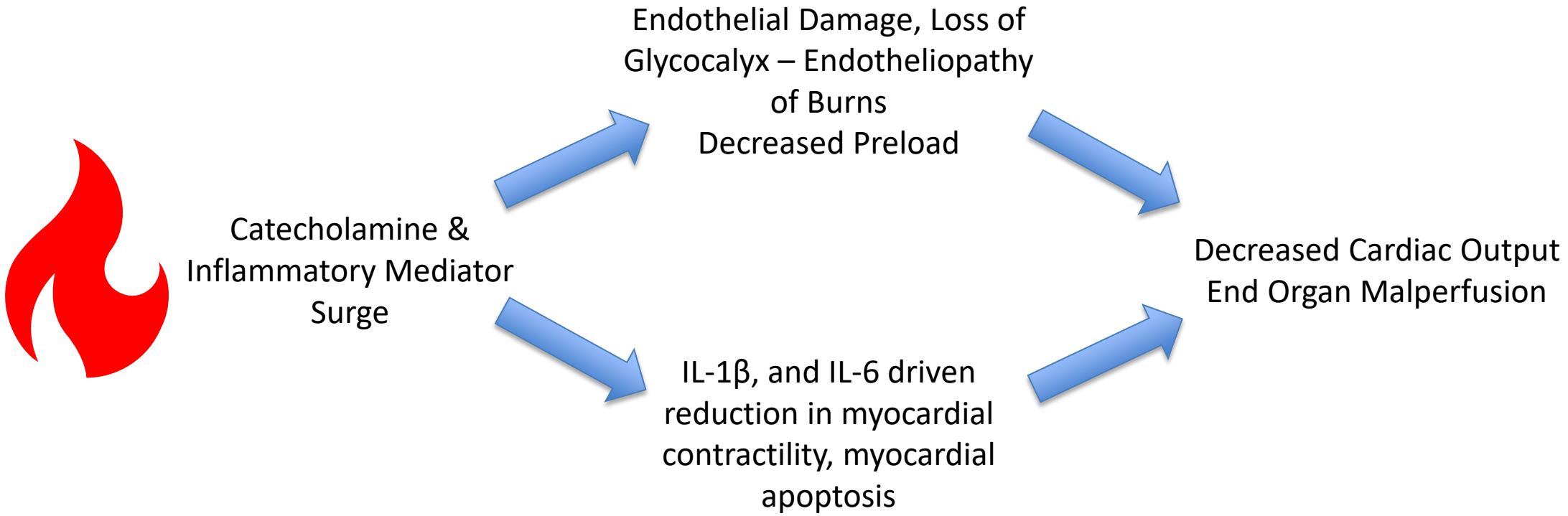
ANESTHESIOLOGY
Trusted Evidence: Discovery to Practice

From: Acute and Perioperative Care of the Burn-injured Patient
Anesthesiology. 2015;122(2):448-464. doi:10.1097/ALN.0000000000000559

Burn Shock

1. Intravascular fluid depletion
2. Increased SVR, followed by low SVR
3. Reduced myocardial contractility

Burn Shock


Endothelial Damage, Loss of Glycocalyx – Endotheliopathy of Burns
Decreased Preload
Catecholamine & Inflammatory Mediator Surge
IL-1β, and IL-6 driven reduction in myocardial contractility, myocardial apoptosis
Decreased Cardiac Output
End Organ Malperfusion

Burn Shock

- During the ebb (initial) phase, cardiac output is reduced. This results from the interplay of:
  - Hypovolemia
  - increased systemic vascular resistance
  - decreased cardiac contractility (circulating humoral factors – TNF-α/ROS/endothelin 1/interleukins)
  - decreased myocardial response to catecholamines (endogenous and exogenous due to decreased receptor affinity and a decrease in 2nd messenger production)
  - decreased coronary blood flow

Burn Resuscitation

Table 1 Burn resuscitation formulas

1942	Harkins formula	Any patient with at least a 10% burn: administer 1,000cc plasma for each 10% total surface area burn over first 24hrs.
1947	Body weight burn budget	First 24 hrs: 1-4 L LR + 1200ml 0.5NS + 7.5% body weight colloid + 1.5-5L D5W. For second 24hrs: same formulation except change colloid to 2.5% body weight
1952	Evan's formula	First 24hrs: NS at 1ml/kg/%burn + colloids at 1ml/kg/%burn + plus 2000ml glucose in water. Second 24hrs: one-half the first 24hrs crystalloid and colloid req + the same amount of glucose in water as in the first 24h.
1953	Brooke formula	First 24hrs: LR at 1.5 ml/kg/% TBSA burn + colloid at 0.5 ml/ kg/% TBSA burn. Second 24 hrs: Switch to D5W 2000 ml
1974	Parkland formula	First 24 hrs: LR at 4ml/kg/%TBSA; give half in first 8 hrs and the remaining over next 16 hrs. Second 24hrs: colloid at 20-60% of calculated plasma volume to maintain adequate urinary output.
1979	Modified brooke	First 24 hrs: LR at 2 ml/kg/% TBSA burn, one half in the first 8 hours and half in the remaining 16 hours. Second 24 hrs: colloid at 0.3 to 0.5 ml/kg/% TBSA burn + D5W to maintain urine output.
1984	Monaro formula	First 24hrs: Saline with 250 mEqNa + 150 mEqlactate + 100 mEqCl. Rate adjusted per urine output. Second 24 hours: one third of isotonic salt administered orally.

EMORY UNIVERSITY

(Bacomo & Chung, 2011)

Burn Resuscitation

SUMMARY AR

American Burn Association Practice Guidelines Burn Shock Resuscitation

Tam N. Pham, MD,* Leopoldo C. Cancio, MD,† Nicole S. Gibran, MD*

Table 2. Common estimates of volume resuscitation in the first 24 hours

	Formula Name	Solution	Volume in First
Adult	Parkland	Lactated Ringer's	4 ml/kg/%burn
	Modified Brooke	Lactated Ringer's	2 ml/kg/%burn

RECOMMENDATIONS

Standards

There are insufficient data to support a treatment standard treatment at this time.

Guidelines

- Adults and children with burns greater than 20% TBSA should undergo formal fluid resuscitation using estimates based on body size and surface area burned.
- Common formulas used to initiate of resuscitation estimate a crystalloid need for 2 to 4 ml/kg body weight/%TBSA during the first 24 hours.
- Fluid resuscitation, regardless of solution type or estimated need, should be titrated to maintain a urine output of approximately 0.5–1.0 ml/kg/hr in adults and 1.0–1.5 ml/kg/hr in children.
- Maintenance fluids should be administered to children in addition to their calculated fluid requirements caused by injury.
- Increased volume requirements can be anticipated in patients with full-thickness injuries, inhalation injury, and a delay in resuscitation.

Resuscitation Endpoints

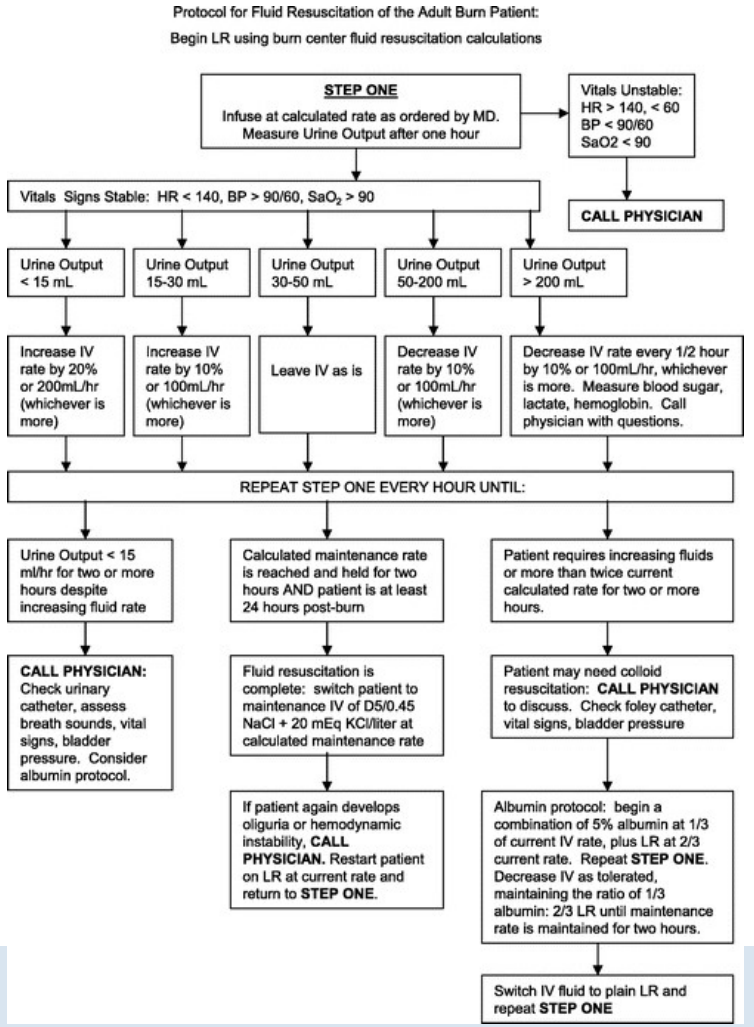
RECOMMENDATIONS

Standards

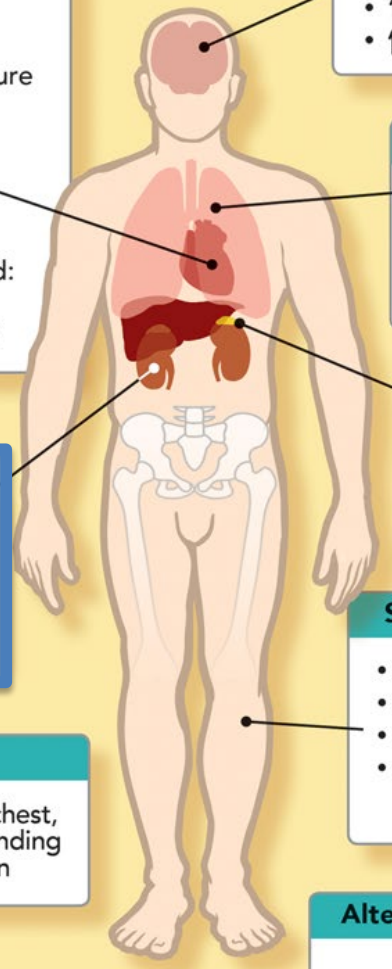
There are insufficient data to support a treatment standard treatment at this time.

Guidelines

- Adults and children with burns greater than 20% TBSA should undergo formal fluid resuscitation using estimates based on body size and surface area burned.
- Common formulas used to initiate of resuscitation estimate a crystalloid need for 2 to 4 ml/kg body weight/%TBSA during the first 24 hours.
- Fluid resuscitation, regardless of solution type or estimated need, should be titrated to maintain a urine output of approximately 0.5–1.0 ml/kg/hr in adults and 1.0–1.5 ml/kg/hr in children.
- Maintenance fluids should be administered to children in addition to their calculated fluid requirements caused by injury.
- Increased volume requirements can be anticipated in patients with full-thickness injuries, inhalation injury, and a delay in resuscitation.



Pathophysiologic Changes in the Early Phase (24-48 hrs) of Burn Injury



Heart & Circulation

- Tachycardia
- ↓ Cardiac index
- ↓ Stroke volume
- Normal or low blood pressure
- ↓ SvO_2
- ↑ PVR and SVR
- ↑ Hematocrit
- CVP variable
- Metabolic acidosis
- Echocardiogram/ultrasound:
  - Small chambers
  - Decreased contractility

Brain

- Altered mental status
- ? Cerebral edema
- ↑ Pain response
- ↑ ADH

Lungs – Inhalation Injury

- Pulmonary edema
- Bronchospasm, bronchorrhea
- Acute respiratory distress syndrome

Adrenal gland

- ↑ Aldosterone
- ↑ Cortisol

Kidney-Bladder

- Myoglobinuria
- Oliguria
- Urine fractional Na^+ <1%

Skin

- Non-blanching burned skin
- Mottled clammy non-burned skin
- Fluid loss through burned skin
- Generalized edema in >25% body burn

Circumferential burn

- Compartment syndrome of chest, abdomen and/or limbs depending on site of circumferential burn

Altered pharmacological responses

EMORY UNIVERSITY

ANESTHESIOLOGY
Trusted Evidence: Discovery to Practice

From: Acute and Perioperative Care of the Burn-injured Patient
Anesthesiology. 2015;122(2):448-464. doi:10.1097/ALN.0000000000000559

Burn Resuscitation

F. The Difficult Resuscitation

Estimates of resuscitation fluid needs are precisely that — estimates. Individual patient response to resuscitation should be used as the guide to add or withhold fluid. The following groups are likely to be challenging and may require close burn center consultation:

- Patients with associated traumatic injuries
- Patients with electrical injury
- Patients with inhalation injury
- Patients in whom resuscitation is delayed
- Patients with prior dehydration
- Patients with alcohol and/or drug dependencies (chronic or acute)
- Patients with very deep burns
- Patients burned after methamphetamine fire or explosion
- Patients with severe comorbidities (such as heart failure, or end-stage renal disease)

In patients requiring excessive fluids, resuscitative adjuncts should be considered to prevent major complications such as pulmonary edema and compartment syndromes. Typical scenarios are: the provider is unable to achieve sufficient urine output at any point, or the patient develops oliguria when crystalloid infusion is reduced. Colloids in the form of albumin (and less commonly plasma) can be utilized as a rescue therapy. Synthetic colloids in the form of starches should be avoided due to their increased risk of harm. Close consultation with the nearest burn center is advised when initiation of colloid is being considered.

EMORY UNIVERSITY

Burn Resuscitation

A primer on burn resuscitation

Ferdinand K Bacomo, Kevin K Chung

U.S. Army Institute of Surgical Research, 3400 Rawley E. Chambers Avenue, Fort Sam Houston, TX 78234, USA

Table 3: Guidelines for the difficult resuscitation

At 12–18 h post-burn, calculate the PROJECTED 24-h resuscitation if fluid rates are kept constant. If the projected 24-h resuscitation requirement exceeds 6 mL/kg/%TBSA or 250 mL/kg then the following steps are recommended

1. Initiate5%albuminatarateof25-100ml/hr.(20-30%=25ml/hr,31-44%=50ml/hr,45-60%=75ml/hr,<61%=100ml/hr)
2. Check bladder pressures every 4 h.
3. If urine output (UOP) < 30 cc/h, consider monitoring central venous pressures (CVP) from a subclavian or IJ along with central venous ($ScvO_2$) saturations. (Goal CVP 8–10, $ScvO_2$ 60–65%)
   a) If CVP not at goal then increase fluid rate.
   b) If CVP at goal then consider vasopressin 0.04 units/min to augment MAP (and thus UOP) or Dobutamine 5 mcg/kg/min (titrate until SvO_2 or $ScvO_2$ at goal). Max dose of Dobutamine is 20 mcg/kg/min.
   c) If both CVP and $ScvO_2$ at GOAL then stop increasing fluids (EVEN if UOP < 30 cc/h). The patient should be considered hemodynamically optimized and the oliguria is likely a result of established renal insult. Some degree of renal failure should be tolerated and expected Continued increases in fluid administration despite optimal hemodynamic parameters will only result in "resuscitation morbidity", that is oftentimes more detrimental than renal failure.
4. Every attempt should be made in minimize fluid administration while maintaining organ perfusion. If UOP > 50 cc/h, then decrease the fluid rate by 20%.

   After 24 h, LR infusion should be titrated down to maintenance levels and albumin continued until the 48 h mark.

EMORY UNIVERSITY

Concern

The Phenomenon of "Fluid C
Burn Resuscitation

Jeffrey R. Saffle, MD, FACS

Table 2. Review of r[illegible] reports of fluid cre

Reference	No. of Patients Who Exceeded Parkland Requirements	Resuscitation Received, ml/kg/%TBSA	Comments
Kaups et al (1998)[6]	83/83 (100%)	NA	Review of patients treated 1994–1995 to assess the relationship of base deficit to outcomes. All patients exceeded Parkland calculations; the 14 patients with base deficit >6 had larger burns, more inhalation injury, higher mortality, and greater fluid requirements (21 ± 4 vs 12 ± 3 liters, an increase of 75%).
Engrav et al (2000)[11]	29/50 (58%)	5.2 ± 2.3 (no range given)	Review from seven centers. Majority of patient exceeded Parkland requirements; this was more pronounced in patients with inhalation injury.
Ivy et al (2000)[7]	98/109 (90%)	9.36 (2.2–38.6)	Prospective evaluation of the incidence of intra-abdominal hypertension and abdominal compartment syndrome in burn patients; seven developed the former and two developed the latter. Authors recommend routine monitoring of bladder pressure in any patient who receives >250 ml/kg fluid.
Cartotto et al (2002)[10]	26/31 (84%)	6.7 ± 2.8	Retrospective evaluation of patients treated 1998–2000. Two interesting observations: first, patients arrived and began resuscitation a mean of 1.7 hours post-injury but had already received 2.5 ± 1.9 liters of lactated Ringer's solution. Second, Parkland formula was quite accurate for the first 8 hours post-burn but requirements increased after that in 15/31 patients.
Cancio et al (2004)[59]	56/89 (63%)	6.1 ± 0.22 (no range given)	Review of patients resuscitated 1987–1997 with the modified Brooke formula, which included a small amount of albumin. Burn size and body weight were associated with increased fluid requirements.
Friedrich et al (2004)[8], Sullivan et al (2004)[9]	NA	3.6 ± 1.1 (1970s) vs. 8.0 ± 2.5 (2000)	Comparison of 11 patients resuscitated during 1975–1979 with 11 patients matched for age, sex, and burn size treated during 2000. Recent patients received more than double the fluid received by patients in the 1970s despite equal urine output. In second publication, authors suggest that increased opioid use in the first 24 hours may contribute to increased fluid requirements.

NA, data not available.

Concern for Fluid Creep?

TABLE 4. Fluid Resuscitation Data

	0–24 Hours [mean (SD)]	24–48 Hours [mean (SD)]
Crystalloids (L)	17.2 (9.4)	6.2 (4.8)
Colloids (L)	0.33 (0.92)	0.39 (0.69)
Total fluids (L)	17.5 (9.7)	6.6 (5.0)
Urine (L)	2.0 (1.3)	2.0 (1.0)
Urine (mL/kg per hour)	1.1 (0.77)	1.1 (0.59)
Parkland score	1.3 (0.6)	0.5 (0.4)

TABLE 3. Baseline Patient and Injury Characteristics

Variable	Average (range) or %
Total patients	72
Age (yr)	40.6 (18–86)
Weight (kg)	80.6 (49–124)
Total body surface area (TBSA) burn	44.5 (20–90)
Total full-thickness burn	30.7 (1–90)
Inhalation injury	42%
Time to admission postinjury (hr)	3.4 (0–12)
Admitted on ventilator	57%
Apache II score	20.1 (6–36)
Initial base deficit	4.5 (−9 to 15)
Burn mechanism (%)	
Flame	76
Flash	11
Other	13
Gender (male) (%)	71

Concern for Fluid Creep?

ORIGINAL ARTICLES

The Association Between Fluid Administration and Outcome Following Major Burn

A Multicenter Study

Matthew B. Klein, MD, Douglas Hayden, MS,† Constance Elson, PhD,† Avery B. Nathens, MD, PhD, MPH,‡ Richard L. Gamelli, MD,§ Nicole S. Gibran, MD,* David N. Herndon, MD,‖ Brett Arnoldo, MD,¶ Geoff Silver, MD,‡ David Schoenfeld, PhD,† and Ronald G. Tompkins, MD, ScD#*

TABLE 5. Patient Outcomes

Outcome Variable	Mean (SD) or %
Mortality	25%
Multiorgan failure*	21%
Total nosocomial infections	3.1 (4.4)
Total no. of events	3.2 (3.1)
Bloodstream infections	11%
Pneumonia	54.9%
ARDS	35%
Abdominal compartment syndrome	4.2%

*Maximum Denver Score ≥4.

TABLE 7. Effect of Proportion of Fluid Above Volume Predicted

Outcome	OR (95% CI)*
ARDS	
0%–25% above predicted	0.52 (0.17–7.3)
>25% above predicted	1.69 (0.48–5.9)
Pneumonia	
0%–25% above predicted	0.71 (0.23–2.1)
>25% above predicted	5.67 (1.1–29.9)
Multiple organ failure	
0%–25% above predicted	0.94 (0.24–3.7)
>25% above predicted	1.6 (0.38–6.6)
Bloodstream infections	
0%–25% above predicted	1.12 (0.17–7.33)
>25% above predicted	2.91 (0.51–16.5)
Death	
0%–25% above predicted	0.42 (0.08–2.5)
>25% above predicted	5.33 (1.4–20.4)

*Reference: less than or equal to predicted volume.

Concern for Fluid Creep?

Table 1. Reported Series of Secondary Abdominal Compartment Syndrome

First author	Year	No. of patients	Cause	Severity	IAH (Threshold)	ACS*	ACS mortality (%)	Rx†
Observational								
Greenhalgh‡	1994	30	Burn	Mean 56% BSA	11/30 (30 mmHg)		54	PD+LAP
Ivy§	1999	3	Burn	> 70% BSA	3/3 (25 mmHg)	3/3	100	Escharotomy
Maxwell§	1999	6/1,216 ICU admissions	Extraabdominal trauma	Mean ISS 25		6/6	67	LAP
Ivy‡	2000	10	Burn	> 46% BSA	7/10 (25 mmHg)	2/10	50	Sedation+LAP
Corcos§	2001	3	Burn	> 40% BSA		3/3	66	PD
Biffl§	2001	14	Mixed	Mean BD 14.1		14/14	38, trauma 100, nontrauma	LAP
Latenser§	2002	9	Burn	> 40% BSA	9/13 (25 mmHg)	4/13	100	PD+LAP
Hobson§	2002	10/1,014 Burns	Burn	Mean 70% BSA		10	60	PD+LAP
Balogh‡	2002	11/1,540 TICU	Trauma	Mean ISS 28	25 mmHg	11	54	LAP
Hong‡	2002	2/706 TICU	Trauma	Mean ISS 18	2 (20 mmHg)	0	NA	NA
Balogh‡	2003	15/188 Shock	Trauma	Mean ISS 28	25 mmHg	15	53	LAP
Miglietta§	2003	2	Trauma	Severe CHI	Severe	2	0	LAP
Interventional								
O'Mara‖	2005	15 crystalloid 15 colloid	Burn	(> 40% BSA > 25%+inhalation)	90% 12% (25 mmHg)	13% 0%	100 NA	Fluid titration+ paralysis

*Rate of ACS reported per se.
†Most notable therapies used.
‡Prospective case series.
§Respective case series.
‖Prospective randomized control.
ACS, abdominal compartment syndrome; BD, based deficit; BSA, body surface area; CHI, closed head injury; IAH, intraabdominal hypertension; ISS, Injury Severity Score; LAP, laparotomy; NA, nonapplicable; PD, percutaneous drainage; TICU, trauma ICU.

Burn Resuscitation

Table 1 Burn resuscitation formulas

1942	Harkins formula	Any patient with at least a 10% burn: administer 1,000cc plasma for each 10% total surface area burn over first 24hrs.
1947	Body weight burn budget	First 24 hrs: 1-4 L LR + 1200ml 0.5NS + 7.5% body weight colloid + 1.5-5L D5W. For second 24hrs: same formulation except change colloid to 2.5% body weight
1952	Evan's formula	First 24hrs: NS at 1ml/kg/%burn + colloids at 1ml/kg/%burn + plus 2000ml glucose in water. Second 24hrs: one-half the first 24hrs crystalloid and colloid req + the same amount of glucose in water as in the first 24h.
1953	Brooke formula	First 24hrs: LR at 1.5 ml/kg/% TBSA burn + colloid at 0.5 ml/ kg/% TBSA burn. Second 24 hrs: Switch to D5W 2000 ml
1974	Parkland formula	First 24 hrs: LR at 4ml/kg/%TBSA; give half in first 8 hrs and the remaining over next 16 hrs. Second 24hrs: colloid at 20-60% of calculated plasma volume to maintain adequate urinary output.
1979	Modified brooke	First 24 hrs: LR at 2 ml/kg/% TBSA burn, one half in the first 8 hours and half in the remaining 16 hours. Second 24 hrs: colloid at 0.3 to 0.5 ml/kg/% TBSA burn + D5W to maintain urine output.
1984	Monaro formula	First 24hrs: Saline with 250 mEqNa + 150 mEqlactate + 100 mEqCl. Rate adjusted per urine output. Second 24 hours: one third of isotonic salt administered orally.

EMORY UNIVERSITY

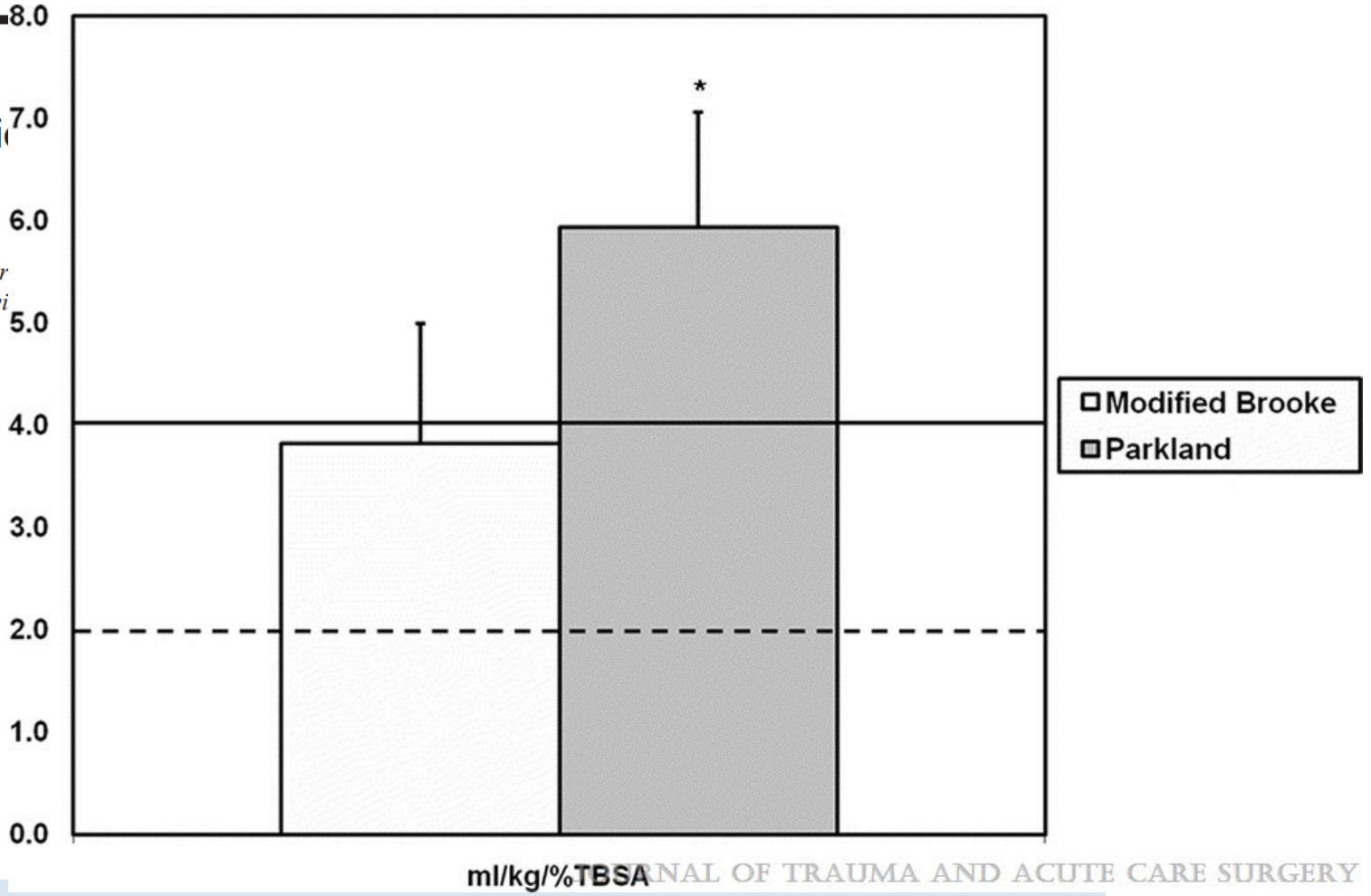
(Bacomo & Chung, 2011)

Burn Resuscitation

ORIGINAL ARTICLE

Resuscitation of Severely Burned Military Casualti
More Fluid

Kevin K. Chung, MD, Steven E. Wolf, MD, Leopoldo C. Cancio, MD, Ricar
John A. Jones, BS, BBA, Jeffery McCorcle, PA, Booker T. King, MD, Davi
Evan M. Renz, MD, and Lorne H. Blackbourne, MD



JOURNAL OF TRAUMA AND ACUTE CARE SURGERY

EMORY UNIVERSITY

Burn Resuscitation

Hold the
Patie

Ste
Richard L. C
Th

TABLE 1. Baseline Patient and Injury Characteristics as a Function of Resuscitation Strategy

		Resuscitation Strategy			
	Overall	**Restrictive (<4 cc/kg/TBSA)**	**Standard (4–6 cc/kg/TBSA)**	**Excessive (>6 cc/kg/TBSA)**	***P***
Total patients	330	109	128	93	
Center					<0.001
1	104 (31%)	26 (25%)	59 (57%)	19 (18%)	
2	81 (25%)	21(26%)	28 (35%)	32 (40%)	
3	87 (26%)	27 (31%)	27 (31%)	33 (38%)	
4	6 (2%)	1 (17%)	3 (50%)	2 (33%)	
5	52 (16%)	34 (65%)	11 (21%)	7 (13%)	
Mean age (SD)	41.3 (15.8)	40.9 (15.5)	40.8 (15.6)	42.3 (16.6)	NS
Sex (male)	247 (75%)	86 (79%)	92 (72%)	69 (74%)	NS
Mean weight, kg (SD)	83.5 (83.5)	89.9 (21.6)	83.6 (21.1)	75.7 (17.4)	<0.001*
Mean % TBSA (SD)	41.0 (18.2)	42.4 (19.1)	41.8 (18)	38.1 (17.3)	NS
Mean %total full-thickness (SD)	31.0 (19.1)	29.3 (20.1)	32.3 (17.2)	31.1 (20.3)	NS
Burn mechanism					
Flame	276 (84%)	85 (78%)	112 (88%)	79 (85%)	NS
Flash	22 (7%)	10 (9%)	5 (4%)	7 (8%)	NS
Scald	17 (5%)	8 (7%)	6 (5%)	3 (3%)	NS
Other	15 (5%)	6 (6%)	5 (4%)	4 (4%)	NS
Inhalation injury	129 (39%)	28 (26%)	61 (48%)	40 (43%)	<0.001†
Mean APACHE II score (SD)	20.8 (9.2)	16.0 (8.5)	22.3 (8.8)	24.2 (8.1)	<0.001†
Mean initial base deficit (SD)	-5.14 (4.9)	-4.59 (5.0)	-5.41 (4.8)	-5.27 (4.9)	NS
Mean 24-hour fluids, L (SD)	16.4 (10.0)	10.3 (5.6)	17.2 (8.5)	22.3 (11.9)	<0.001‡

Burn Resuscitation

Hold the Pendulum: Rates of Acute Kidney Injury are Increased in Patients Who Receive Resuscitation Volumes Less than Predicted by the Parkland Equation

Stephanie A. Mason, MD, Avery B. Nathens, MD, PhD,* Celeste C. Finnerty, PhD,†‡*
*Richard L. Gamelli, MD,§ Nicole S. Gibran, MD,¶ Brett D. Arnoldo, MD,|| Ronald G. Tompkins, MD,***
David N. Herndon, MD,‡ and Marc G. Jeschke, MD, PhD††,
The Inflammation and the Host Response to Injury Collaborative Research Program

TABLE 4. Factors Associated with AKI*

Predictor	Adjusted Odds Ratio (95% CI)	*P*
Fluid group†		
Restrictive	3.25 (1.18–8.94)	0.02
Excessive	1.03 (0.41–2.59)	0.95
Age (per year)	1.02 (1.00–1.05)	0.05
Female sex	0.35 (0.12–1.01)	0.05
APACHE II score (per 1 unit)	1.17 (1.10–1.25)	<0.001
TBSA (per % increase)	0.98 (0.96–1.01)	0.22
Inhalation injury	1.25 (0.52–2.97)	0.61
Burn mechanism‡		
Flash	6.68 (1.90–23.49)	0.003
Scald	1.82 (0.18–18.14)	0.61
Other	2.61 (0.48–14.15)	0.27
Treatment center§		
1	0.71 (0.25–1.96)	0.51
2	0.47 (0.15–1.48)	0.19
3	2.49 (0.19–32.97)	0.49
4	1.00 (0.29–3.48)	0.99

EMORY UNIVERSITY

Burn Resuscitation: The Dilemma

- Inadequate Resuscitation leads to organ failure and potential death
- Global microvascular permeability leads to edema formation in both burned and unburned tissues
- Resuscitation with IV fluids worsens edema formation and increases the risk of compartment syndromes

Burn Resuscitation: The Dilemma

- Blood Pressure is often normal within a few hours of injury. BP cuffs may be inaccurate
- Heart Rate is a poor indicator of volume status due to high sympathetic tone. HR is often 110-120s in appropriately resuscitated individuals

- Hemoconcentration is common during initial resuscitation

Advanced Burn Life Support Course

PROVIDER MANUAL
2018 UPDATE

EMORY UNIVERSITY

Burn Resuscitation: The Dilemma

American Burn Association Clinical Practice Guidelines on Burn Shock Resuscitation

Robert Cartotto, MD, FRCS(C)[*,1], Laura S. Johnson MD, FACS, FCCP, FCCM[2], Alisa Savetamal MD FACS[3], David Greenhalgh MD, FACS[4], John C Kubasiak MD[5], Tam N. Pham MD[6], Julie A. Rizzo MD[7,8], Soman Sen MD[9], Emilia Main MI[10]

5984 references imported for screening as 5984 studies
- 6 duplicates removed

5978 studies screened against title and abstract
- 5741 studies excluded

237 studies assessed for full-text eligibility
- 167 studies excluded
  - 62 Abstract not full text
  - 50 Wrong study design
  - 25 Review article
  - 6 study proposal registration
  - 5 letter to Editor
  - 3 Wrong comparator
  - 3 abstract
  - 3 survey
  - 2 Wrong patient population
  - 2 Wrong setting
  - 2 animal study
  - 2 case report
  - 1 Wrong intervention
  - 1 duplicate paper
- 0 studies ongoing
- 0 studies awaiting classification

70 studies selected for full text review
- 46 studies excluded for not meeting PICO criteria

24 studies included

American Burn Association Clinical Practice Guidelines on Burn Shock Resuscitation

Robert Cartotto, MD, FRCS(C)[*,1], Laura S. Johnson MD, FACS, FCCP, FCCM[2], Alisa Savetamal MD FACS[3], David Greenhalgh MD, FACS[4], John C Kubasiak MD[5], Tam N. Pham MD[6], Julie A. Rizzo MD[7,8], Soman Sen MD[9], Emilia Main MI[10]

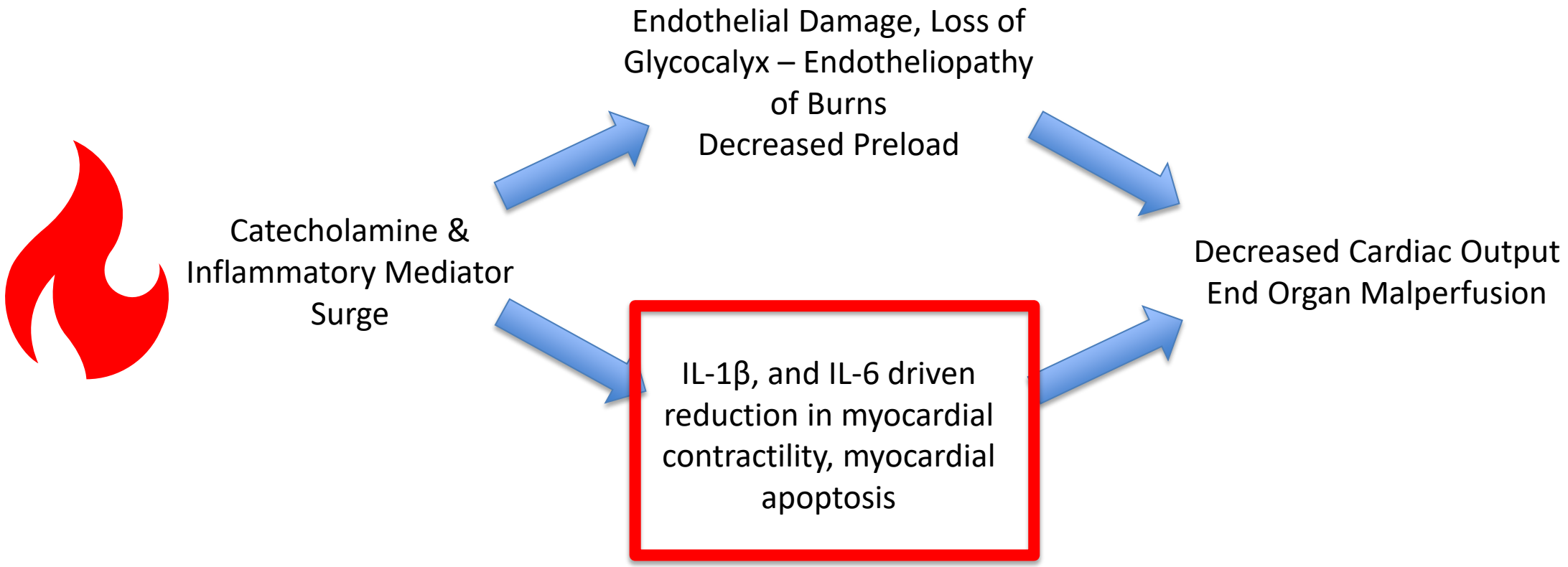
- Some questions addressed include:
  - What starting rate should be used for crystalloid resuscitation?
  - Should albumin be used during resuscitation? When?
    - Should FFP be used?
  - Are there other useful parameters to guide resuscitation?
    - Including CVP, transpulmonary thermodilution, SVV/PPV, trending lactate or base deficits

American Burn Association Clinical Practice Guidelines on Burn Shock Resuscitation

Robert Cartotto, MD, FRCS(C)[*,1], Laura S. Johnson MD, FACS, FCCP, FCCM[2], Alisa Savetamal MD FACS[3], David Greenhalgh MD, FACS[4], John C Kubasiak MD[5], Tam N. Pham MD[6], Julie A. Rizzo MD[7,8], Soman Sen MD[9], Emilia Main MI[10]

- Some questions addressed include:
  - What starting rate should be used for crystalloid resuscitation? 2mL/kg/%TBSA
  - Should albumin be used during resuscitation? Prn When? Rescue
    - Should FFP be used? Yes (in our institution)
  - Are there other useful parameters to guide resuscitation? No – SVV/PPV unknown
    - Including CVP, transpulmonary thermodilution, SVV/PPV, trending lactate or base deficits

Burn Shock


Endothelial Damage, Loss of Glycocalyx – Endotheliopathy of Burns
Decreased Preload
Catecholamine & Inflammatory Mediator Surge
IL-1β, and IL-6 driven reduction in myocardial contractility, myocardial apoptosis
Decreased Cardiac Output
End Organ Malperfusion

Cardiac Dysfunction

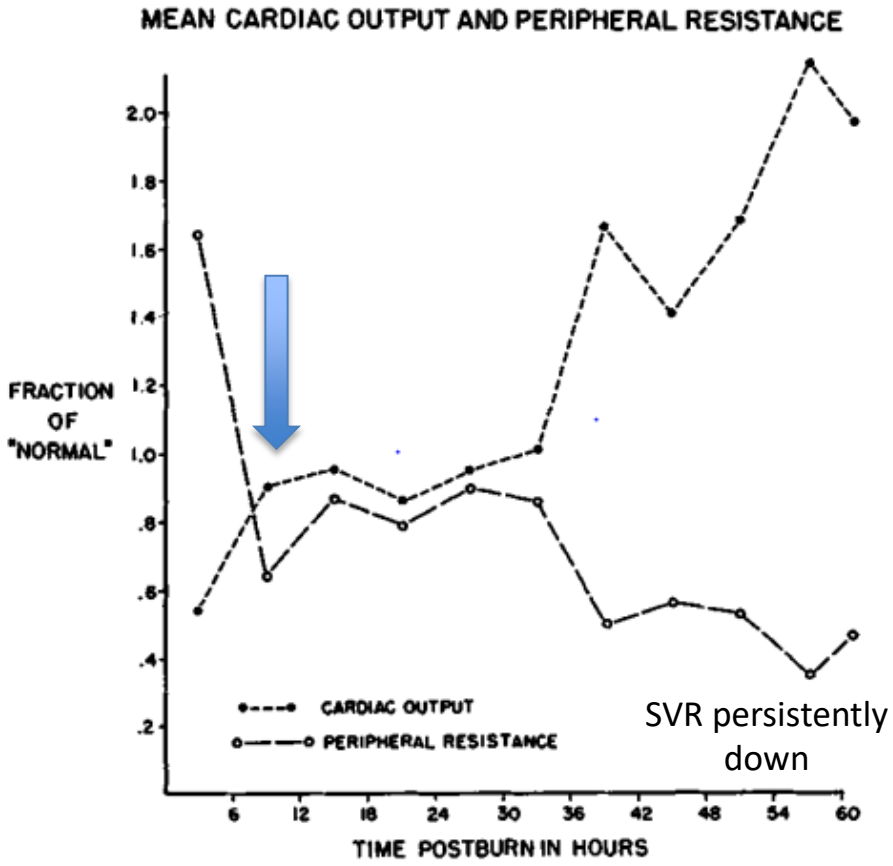
THE JOURNAL OF TRAUMA

Vol. 11, No. 1
Printed in U.S.A.

HEMODYNAMIC CHANGES IN THE EARLY POSTBURN PATIENT: THE INFLUENCE OF FLUID ADMINISTRATION AND OF A VASODILATOR (HYDRALAZINE)

BASIL A. PRUITT, JR., LTC., MC, ARTHUR D. MASON, JR., M.D., AND JOHN A. MONCRIEF, M.D.

From the United States Army Institute of Surgical Research, Brooke Army Medical Center, Fort Sam Houston, Texas



SVR persistently down

EMORY UNIVERSITY

Cardiac Dysfunction

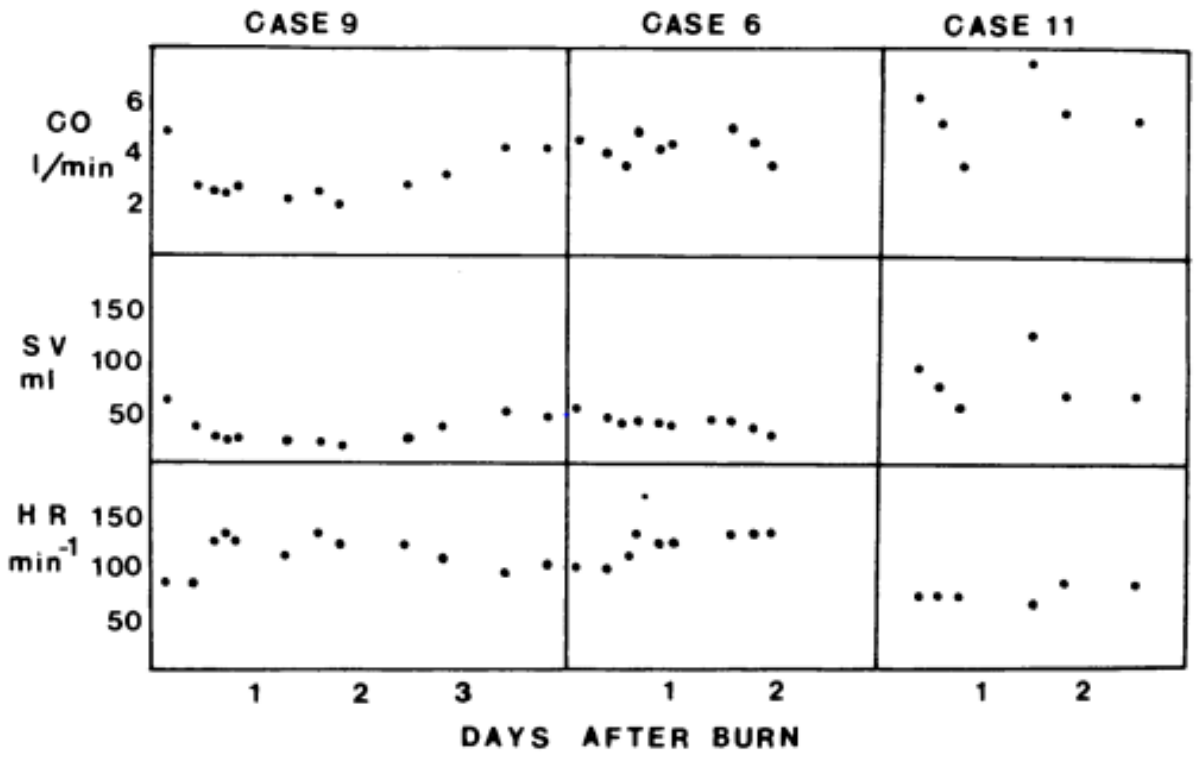


FIG. 4 Cardiac output (CO), stroke volume (SV) and heart rate (HR) values during and after resuscitation.

TABLE II *Details of cases studied. Cardiac output was measured as described in the text. Stroke volume values are quoted as ml/beat, cardiac output values as l/min. Figures in brackets are the time post injury at which the lowest value of cardiac output was recorded and are expressed as hours and minutes.*

Case	*Age/sex*	*% burn*	*Admission cardiac output*	*Lowest cardiac output*	*Lowest stroke volume*
1	81 F	15	1.96	1.96 (4 40)	26.8
2	33 M	44	4.61	2.84 (33 30)	18.4
3	67 M	46	4.80	2.03 (17 30)	20
4	70 F	27	2.71	2.25 (9 30)	22.9
5	32 M	38	2.36	2.16 (13 30)	19.4
6	15 M	31	4.43	3.38 (47 30)	25.3
7	20 M	24	5.40	3.40 (46 30)	36.2
8	23 M	23	7.81	4.42 (47 30)	49.3
9	24 M	36	4.72	1.81 (43 20)	15.4
10	28 M	55	5.65	2.45 (46 40)	20.4
11	49 M	36	6.00	3.61 (19 30)	51.6
12	16 M	28	3.13	1.86 (19 45)	17.6
13	49 F	49	2.68	2.40 (12 15)	20.8
14	40 M	49	3.07	2.83 (18 15)	26.4
15	37 M	40	6.70	3.02 (25 00)	26.2

Echocardiography & Burn Shock

EAST Podium Paper 2023

Burn excision within 48 hours portends better outcomes than standard management: A nationwide analysis

Walter A. Ramsey, MD, Christopher F. O'Neil, Jr, MD, Andres M. Corona, MD, Brianna L. Cohen, MD, Nicole B. Lyons, MD, Matthew S. Meece, MD, Rebecca A. Saberi, MD, MSPH, Gareth P. Gilna, MD, Shevonne S. Satahoo, MD, Joyce I. Kaufman, MD, Carl I. Schulman, MD, PhD, Nicholas Namias, MD, MBA, Kenneth G. Proctor, PhD, *and* **Louis R. Pizano, MD**, *Miami, Florida*

Burn excision within 48 hours portends better outcomes than standard management: A nationwide analysis

Walter A. Ramsey, MD, Christopher F. O'Neil, Jr, MD, Andres M. Corona, MD, Brianna L. Cohen, MD, Nicole B. Lyons, MD, Matthew S. Meece, MD, Rebecca A. Saberi, MD, MSPH, Gareth P. Gilna, MD, Shevonne S. Satahoo, MD, Joyce I. Kaufman, MD, Carl I. Schulman, MD, PhD, Nicholas Namias, MD, MBA, Kenneth G. Proctor, PhD, *and* **Louis R. Pizano, MD**, *Miami, Florida*

TABLE 1. Demographic Information

	Early Excision (Within 48 h) n = 1,135 (50%)	Control (48–120 h) n = 1,135 (50%)
Age*	36 (22–54)	38 (23–55)
Female	317 (28)	323 (29)
TBSA 10–19%	722 (64)	722 (64)
TBSA 20–29%	207 (18)	207 (18)
TBSA 30–39%	82 (7)	82 (7)
TBSA 40–89%	123 (11)	123 (11)
TBSA >89%	1 (0)	1 (0)

*Reported as median (interquartile range).

TABLE 3. Outcomes in Severe Burns (TBSA, ≥20%)

	Time From Arrival to First Excision		
	Within 48 h n = 413 (50%)	Within 48–120 h n = 413 (50%)	*p*
Demographics			
Female sex	100 (24)	113 (27)	0.301
Age*	39 (24–54)	39 (25–56)	0.472
Clinical outcomes			
Hospital LOS, d*	25 (12–48)	27 (17–45)	**0.013**
ICU LOS, d*	15 (5–23)	17 (8–35)	**0.029**
Ventilator days*	10 (4–22)	14 (4–26)	0.248
Intubation	237 (57)	240 (58)	0.833
Mortality	62 (15)	50 (12)	0.223
Complications			
Deep venous thrombosis	7 (2)	17 (4)	**0.039**
Pulmonary embolism	1 (0)	6 (2)	0.123
Any venous thromboembolism	7 (2)	20 (5)	**0.009**
Ventilator-associated pneumonia	32 (8)	47 (11)	0.080
Severe sepsis	19 (5)	31 (8)	0.083
Acute respiratory distress syndrome	11 (3)	18 (4)	0.190
Catheter-associated urinary tract infection	12 (3)	24 (6)	**0.042**

*Reported as median (interquartile range).
Findings associated with a *p*-value <0.05 are presented in bold.

EMORY UNIVERSITY

WHAT IS THE ROLE OF ANESTHESIA?

What is the Role of Anesthesia?

Hypovolemia + Systolic Dysfunction + Early Excision

= Intraop Shock

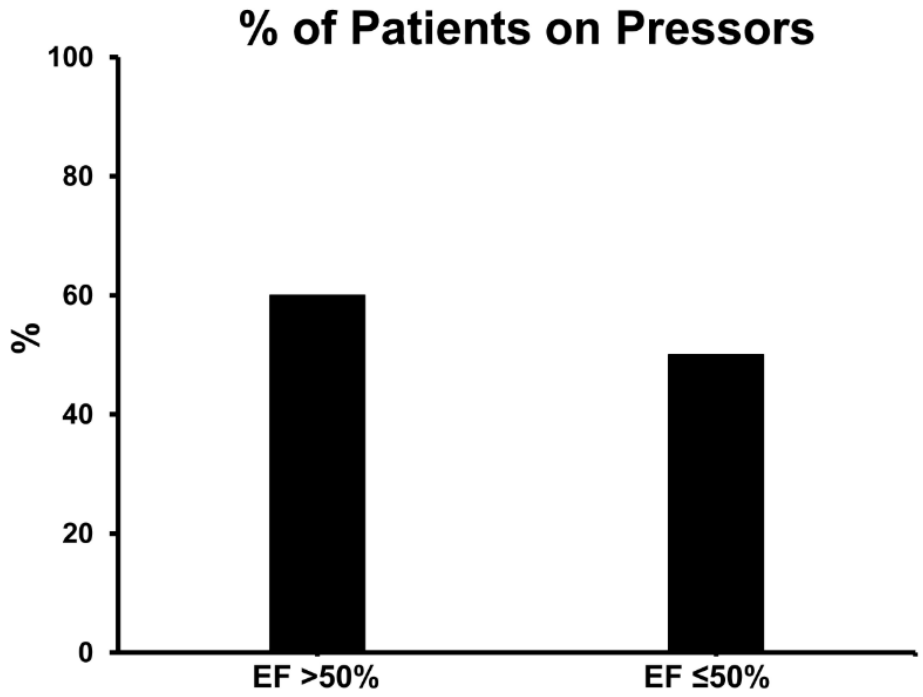
Echocardiography & Burn Shock

Burn Induced Cardiac Dysfunction Increases Length of Stay in Pediatric Burn Patients

Taylor S. Howard, B.A.[*], **Daniel G. Hermann, M.D.**[*], **Alexis L. McQuitty, M.D.**[*], **Lee C. Woodson, M.D., Ph.D.**[*,○], **George C. Kramer, Ph.D.**[*], **David N. Herndon, M.D.**[*,○], **Paul M. Ford, M.D.**, and **Michael P. Kinsky, M.D.**[*]

[*] University of Texas Medical Branch

[○]Shriners Burns Hospital Galveston, TX



EMORY UNIVERSITY

Tran
man

Marc
John F
[a] Departm
Galvestor
[b] Critical
[c] Departm
Oxford, U
[d] Klinik fi
[e] Departm

Table 1 – Grading of manuscripts included in the systematic review. The manuscripts are presented in descending grade of evidence. TEE = transesophageal echocardiography, TBSA = total body surface area burn, EF = ejection fraction, ICU = intensive care unit, N/A = not applicable.

Study Year Citation	Evidence Grade	Patients included/ (total number)	Patient-important outcomes
Howard et al. 2012 [7]	Cohort study 2b		- Systolic dysfunction in 62% of patients with initial EF ≤50% - Increased number of surgeries, ventilator days, and length of stay in the ICU - Diastolic function measurements were obtained in 65% of patients, and 88% had evidence of diastolic dysfunction
Kuwagata et al. 1992 [6]	Cohort study 2b		- LV filling and LV distensibility (M-mode) significantly decreased - Profound depression of LV diastolic function in burn patients compared to multiple trauma patients
Bak et al. 2009 [8]	Cohort study 2b	10/(10)	- Preload variables, global systolic function, and oxygen transport recorded simultaneously by three separate methods showed no need to increase the total fluid volume within 36 h of a major burn - Early (12 h) signs of central circulatory hypovolemia (supports more rapid fluid infusion at the beginning of treatment)
Bak et al. 2008 [9]	Cohort study 2b	10/(10)	- Close correlation between acute myocardial damage recorded by both echocardiography and leakage of troponin (even when global systolic function is not deteriorated) - Restrictive left ventricular diastolic function (mitral flow Doppler)

EMORY UNIVERSITY

Echocardiography & Burn Shock

- Suggested Indications:
  - Hemodynamic Monitoring
  - Diagnosis of Cardiac Infections
  - Diagnosis of Cardiomyopathies

Transesophageal echocardiography in the management of burn patients

Marc O. Maybauer [a,b,c,d,], Sven Asmussen [a], David G. Platts [b,e], John F. Fraser [b], Filippo Sanfilippo [c], Dirk M. Maybauer [d]*

[a] *Department of Anesthesiology, University of Texas Medical Branch and Shriners Burns Hospital for Children at Galveston, USA*
[b] *Critical Care Research Group, University of Queensland and the Prince Charles Hospital, Brisbane, Australia*
[c] *Department of Cardiothoracic Anaesthesia and Intensive Care, Oxford Heart Centre, Oxford University Hospitals, Oxford, UK*
[d] *Klinik für Anästhesie und Intensivtherapie, Philipps Universität Marburg, Germany*
[e] *Department of Cardiology, University of Queensland and the Prince Charles Hospital, Brisbane, Australia*

Echocardiography & Burn Shock

Myocardial function and haemodynamics in extensive burn trauma: evaluation by clinical signs, invasive monitoring, echocardiography and cytokine concentrations. A prospective clinical study

A. Papp[1], A. Uusaro[2], I. Parviainen[2], J. Hartikainen[3] and E. Ruokonen[2]
Departments of [1]Surgery, [2]Anaesthesiology and Intensive Care, and [3]Medicine, Kuopio University Hospital, Kuopio, Finland

Table 1

Description of the patients.

Patient	Sex	Age (years)	TBSA (%)	Baux index	Etiology	Inhalation injury	ICU days	DMV	Death	Cause of death
1	M	52	22	74	Hot air	No	45	43	No	
2	M	44	21	65	Flame	Yes	21	9	No	
3	F	57	28	85	Flame	No	11	9	No	
4	M	52	53	105	Flame	No	3	3	Day 3	Multi-organ failure
5	M	52	27	79	Flame	Yes	7	0	No	
6	M	50	27	77	Flame	No	23	9	No	
7	M	32	96	128	Scald	No	35	31	Day 35	Multi-organ failure
8	M	71	13	84	Flame	Yes	1	1	No	
9	M	43	22	65	Flame	No	4	0	No	
Median		52	27	79			11	9		

TBSA = total body surface area burned; Baux index = age + TBSA burned; DMV = days of mechanical ventilation.

EMORY UNIVERSITY

Echocardiography & Burn Shock

Myocardial function and haemodynamics in extensive burn trauma: evaluation by clinical signs, invasive monitoring, echocardiography and cytokine concentrations. A prospective clinical study

A. Papp[1], A. Uusaro[2], I. Parviainen[2], J. Hartikainen[3] and E. Ruokonen[2]
Departments of [1]Surgery, [2]Anaesthesiology and Intensive Care, and [3]Medicine, Kuopio University Hospital, Kuopio, Finland

Table 3

Results of echocardiographic measurements and haemodynamic data at these same time points (median, interquartile range and *P*-value) at days 1, 2 and 3.

Parameter/day	Day 1 median	iq-range	Day 2 median	iq-range	Day 3 median	iq-range	*P*-value
Echocardiography							
LVEDA (cm^2)	12.5	9.6–17.6	12.6	9.2–16.3	15	11.7–17.6	0.066
LVESA (cm^2)	6.1	4.8–7.3	5.6	4.8–6.2	6.4	5.1–8.7	NS
AFS (%)	48.5	43–51.2	48.4	38.4–70	55.4	47.8–59.2	NS
PEm ($cm\,s^{-1}$)	54	37.8–57	59.8	48–68	60.4	50.2–69.5	NS
PAm ($cm\,s^{-1}$)	55	48–75.6	58.7	52.1–82.2	58.5	56–71.9	NS
PEAm (ratio)	1	0.7–1.3	1.1	0.6–1.2	0.9	0.9–1	NS
PSpv ($cm\,s^{-1}$)	43.9	34.6–50	55.1	38.9–72.3	45.8	38.8–51.2	NS
PDpv ($cm\,s^{-1}$)	26	25.1–62.1	52	33.1–59.4	43.7	33–56	NS
PApv ($cm\,s^{-1}$)	14.5	7.4–30	12.6	11.1–19.3	15.5	9.7–21.2	NS
Haemodynamics							
CI ($l\,min^{-1}m^{-2}$)	3.7	2.7–4.6	4.3	3.7–5.8	4.3	3.7–5.0	NS
SVi ($ml\,m^{-2}$)	35.4	26.8–41.6	40.4	32.8–55.3	40	36.6–47.8	NS
HR ($b\,min^{-1}$)	111	83–120	112	100–123	116	81–128	NS
PAOP (mmHg)	3.5	2.1–4.8	3.8	3.5–4.6	5	3.5–7.4	NS
SAPm (mmHg)	64	60–79	69	60–77	68	59–72	NS

LVEDA = left ventricle end diastolic area; LVESA = left ventricle end systolic area; AFS = fractional area shortening; PEm = peak early velocity of the mitral flow; PAm = peak atrial velocity of the mitral flow; PEAm = PE/PA ratio; PSpv = peak velocity of forward flow in the pulmonary vein during systole; PDpv = peak velocity of forward flow in the pulmonary vein during diastole; PApv = peak atrial velocity of the pulmonary vein; CI = cardiac index; SVi = stroke volume index; HR = heart rate; PAOP = pulmonary artery occlusion pressure; SAPm = mean arterial pressure.

EMORY UNIVERSITY

Echocardiography

Use of Transesophageal Echocardiography in A Retrospective Review

Linsey Etherington, MD, Jeffrey Saffle, MD, Amalia Cochran, MD, FACS

Table 1. Demographic and clinical characteristics of patients undergoing TEE (N = 17)

Median age (yr)	45.4 (range, 8–71)
Male (%)	82
Median TBSA (%)	43.4 (range, 17.5–87)
Inhalation injury (%)	47

Table 2. TEE indications, findings, and therapeutic interventions

Indication for TEE	TEE Findings	Therapeutic Intervention
Bacteremia	No vegetations, small pericardial effusion	None
Bacteremia	Mitral valve vegetation	Initiation of antibiotics
Bacteremia	No vegetations, normal echo	None
Bacteremia	No vegetations, normal echo	None
Bacteremia	No vegetations, normal echo	None
Hypotension	Hypovolemia	None
Hypotension	Normal echo	None
Hypotension	Hypovolemia, hyperdynamic	None
Hypotension	Small pericardial effusion	None
Hypotension	Right heart failure	Start dobutamine
Hypotension	Hypovolemia	None
Hypotension	Normal echo	None
Hypotension	Fluid overload	None
Hypotension	Hypovolemia	None
Atrial fibrillation	No thrombus identified, hypovolemia	Proceed to cardioversion
Evaluation of prosthetic valve	St Jude Valve, normal echo	Continued anticoagulation
Fluid overload	Mild pulmonary hypertension	None

Echocardiography & Burn Shock

Time 0	24hr+	48hr+	Days to Weeks	
Burn Injury	Burn Shock	Early Excision	Repeated Excision & Grafting	
Cardiac Function	Function ↓	Function ↓ or ↔	Function ↓ or ↑	ARDS, Sepsis, DVT/PE
Volume Status	Volume ↓	Volume ↔	Volume ↓ or ↑	

Burn Shock: Sepsis as a Guide?

Echocardiography is the best cardiovascular 'monitor' in septic shock

Article *in* Critical Care and Resuscitation · October 2006

DOI: 10.1016/S1441-2772(23)02102-6 · Source: PubMed

Review

Point-of-Care Ultrasound: A Multimodal Tool for the Management of Sepsis in the Emergency Department

Effie Polyzogopoulou [1], Maria Velliou [1,*], Christos Verras [1,2], Ioannis Ventoulis [3], John Parissis [1], Joseph Osterwalder [4] and Beatrice Hoffmann [5]

EMORY UNIVERSITY

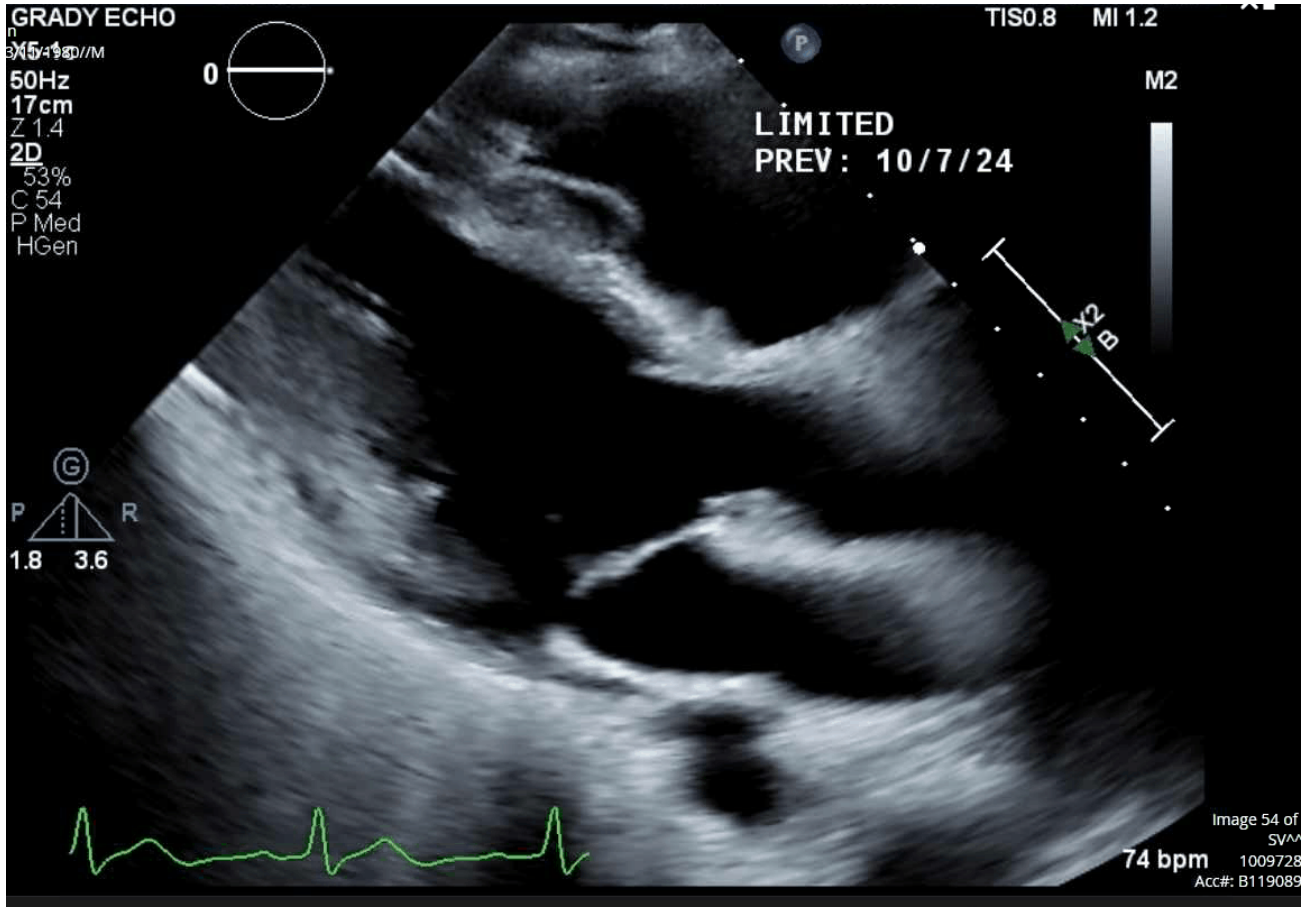
Echocardiography & Burn Shock

Table 1 Definitions of cardiac ultrasound categories

	UAPE	Cardiac POCUS	CCE	Limited echo	Comprehensive echo
Diagnostic expectations	"Routine" performance of a single imaging protocol to augment bedside examination	Focused exams with specific imaging protocols based upon suspicion of a specific disease (e.g., rule out tamponade)	Focused on a collection of specific views/findings pertinent to the care of the critically ill (e.g., cardiac output, fluid responsive)	Focused on previously delineated findings as a follow-up exam; limited imaging protocol applied to answer a specific question	Comprehensive, all findings, quantification; increasingly use advanced techniques
Application frequency	Frequent, daily, multiple physicians	Usually once, per disease, but more frequently if change in clinical status	On admission or change in clinical status, potentially frequently	As follow up to comprehensive echo; potentially multiple times over weeks to months	Once (per admission, change in clinical status)
Interpretation of findings	Presence or absence of ultrasound "signs" indicative of cardiac abnormality	Findings related to the diagnosis sought in protocol	Primary and incidental findings recorded in views	All findings, primary and incidental, recorded in limited views	All findings, primary and incidental recorded in comprehensive imaging
Quantification	Usually Absent	Optional	Typically	Typically	Mandatory
Indication	Physical exam	Clinical suspicion	Medical necessity	Medical necessity	Medical necessity
Documentation	Images not recorded (except for QA), findings reported in physical exam	Image archiving and formal reporting controversial	Images archived, formal report	Images archived on PACS, formal report	Images archived on PACS, formal report
Teaching required	Introductory and modest (weeks)	Modest (weeks to months)	Advanced (months)	Advanced (years)	Advanced (years)
Notes	Used "in the manner and intent" of cardiac physical examination	Similar to UAPE, but disease specific	Imaging protocols specific to issues in the critically ill; comparison to available prior studies as indicated	Reading all findings increases training burden. Comparison to available prior studies is standard practice. Must be able to convert to comprehensive at bedside	Completely evaluates all findings, regardless of referral question or incidental nature. Comparison to available prior studies is standard practice.

CCE, critical care echocardiography; *PACS*, Picture Archival and Communication System; *POCUS*, point of card ultrasound; *UAPE*, ultrasound assisted physical examination.
Adapted from: Kimura BJ. Point-of-care cardiac ultrasound techniques in the physical examination: better at the bedside. Heart 2017;103:987-994. https://doi.org/10.1136/heartjnl-2016-309915.

Echocardiography & Burn Shock



EMORY UNIVERSITY

Echocardiography & Burn Shock

Perioperative applications of focused cardiac ultrasound

McKenzie M. Hollon, MD[a], Caitlin Bradley, MD[a], Ian McCullough, MD[a], Emilee Borgmeier, MD[b]

Review

Perioperative Point of Care Ultrasound for Hemodynamic Assessment: A Narrative Review

Seminars in Cardiothoracic and Vascular Anesthesia
2023, Vol. 27(3) 208–223

DOI: 10.1177/10892532231165088
journals.sagepub.com/home/scv
Sage

Caitlin A. Bradley, MD[1], Chris Ma, MD[1], and McKenzie M. Hollon, MD, FASE[1]

EMORY UNIVERSITY

Echocardiography & Burn Shock

Table 5

Hemodynamic states and their associated FOCUS and echocardiographic findings.

Diagnosis	Associated FOCUS Findings	Advanced Echocardiography Findings
LV systolic failure	Decreased motion, regional or global, decreased wall thickening, dilation of LV	Low CO, low EF, decreased SV, regional wall motion abnormalities
RV failure	Enlarged RV, flattening of IVS, decreased motion of RV, underfilled LV	Reduced CO, decreased TAPSE, decreased S' on TDI
Hypovolemia	Small LV cavity size at end diastole, with normal or hyperdynamic function, no signs RV dilation, +/− small collapsing IVC	Low CO, high EF
Vasodilation	Small LV cavity at end systole with normal LV size at end diastole	High CO, high EF
Obstruction: AS	Bright, thickened, immobile aortic valve leaflets with decreased cusp separation, hypertrophic LV walls	Elevated mean and peak gradients, decreased valve area
Obstruction: MS	Bright, thickened leaflets with reduced motion, LA enlargement	Elevated mean and peak gradients, decreased valve area,
Obstruction: cardiac tamponade	Presence of pericardial fluid Large, noncollapsible IVC	Diastolic chamber collapse (RV), trans-mitral or trans-tricuspid Doppler variation
Obstruction: tension pneumothorax	Underfilled and hyperdynamic LV and RV	
Diastolic failure	Large LA, biatrial enlargement, severe LVH	Decreased annular tissue Doppler, elevated E/e', transmitral Doppler patterns, significant TR

AS indicates aortic stenosis; CO, cardiac output; EF, ejection fraction; FOCUS, focused cardiac ultrasound; IVC, inferior vena cava; IVS, interventricular septum; LA, left atrium; LV, left ventricle; LVH, left ventricular hypertrophy; MS, mitral stenosis; MV, mitral valve; RV, right ventricle; SV, stroke volume; TAPSE, tricuspid annular place systolic excursion; TDI, tissue doppler; TR, tricuspid regurgitation.

Echocardiography & Burn Shock

- Future Directions:
  - Addition of TTE/TEE to burn preoperative assessment may help guide management in the severe burn populations
  - Research tracking outcomes is needed
- Limitations:
  - Provider Inexperience/Access
  - Variable Cardiac phenotypes after burn injury
  - Inability to access windows due to dressings
  - Necessity of repeated scans to guide treatment
  - Limited established research

Questions?

Andrew Bowman, MD
Emory University
Grady Memorial Hospital

EMORY UNIVERSITY

Grady

References

- Bittner, E. A., Shank, E., Woodson, L., & Martyn, J. A. (2015). Acute and perioperative care of the burn-injured patient. *Anesthesiology, 122*(2), 448-464. doi:10.1097/aln.0000000000000559
- Cartotto, R., Johnson, L. S., Savetamal, A., Greenhalgh, D., Kubasiak, J. C., Pham, T. N., . . . Main, E. (2024). American Burn Association Clinical Practice Guidelines on Burn Shock Resuscitation. *J Burn Care Res, 45*(3), 565-589. doi:10.1093/jbcr/irad125
- Bacomo, F. K., & Chung, K. K. (2011). A primer on burn resuscitation. *J Emerg Trauma Shock, 4*(1), 109-113. doi:10.4103/0974-2700.76845
- Cartotto, R., Burmeister, D. M., & Kubasiak, J. C. (2022). Burn Shock and Resuscitation: Review and State of the Science. *Journal of Burn Care & Research, 43*(3), 567-585. doi:10.1093/jbcr/irac025
- Chung, K. K., Wolf, S. E., Cancio, L. C., Alvarado, R., Jones, J. A., McCorcle, J., . . . Blackbourne, L. H. (2009). Resuscitation of severely burned military casualties: fluid begets more fluid. *J Trauma, 67*(2), 231-237; discussion 237. doi:10.1097/TA.0b013e3181ac68cf
- Davis, J. S., Dearwater, S., Rosales, O., Varas, R., Quintana, O. D., Pizano, L., . . . Schulman, C. I. (2012). Tracking Non–Burn Center Care: What You Don't Know May Surprise You. *Journal of Burn Care & Research, 33*(6), e263-e267. doi:10.1097/BCR.0b013e3182504450
- Etherington, L., Saffle, J., & Cochran, A. (2010). Use of transesophageal echocardiography in burns:a retrospective review. *J Burn Care Res, 31*(1), 36-39. doi:10.1097/BCR.0b013e3181cb8ebc
- Howard, T. S., Hermann, D. G., McQuitty, A. L., Woodson, L. C., Kramer, G. C., Herndon, D. N., . . . Kinsky, M. P. (2013). Burn-induced cardiac dysfunction increases length of stay in pediatric burn patients. *J Burn Care Res, 34*(4), 413-419. doi:10.1097/BCR.0b013e3182685e11
- Klein, M. B., Hayden, D., Elson, C., Nathens, A. B., Gamelli, R. L., Gibran, N. S., . . . Tompkins, R. G. (2007). The association between fluid administration and outcome following major burn: a multicenter study. *Ann Surg, 245*(4), 622-628. doi:10.1097/01.sla.0000252572.50684.49
- Mason, S. A., Nathens, A. B., Finnerty, C. C., Gamelli, R. L., Gibran, N. S., Arnoldo, B. D., . . . Program., t. H. R. t. I. C. R. (2016). Hold the Pendulum: Rates of Acute Kidney Injury are Increased in Patients Who Receive Resuscitation Volumes Less than Predicted by the Parkland Equation. *Annals of Surgery, 264*(6), 1142-1147. doi:10.1097/sla.0000000000001615
- Maybauer, M. O., Asmussen, S., Platts, D. G., Fraser, J. F., Sanfilippo, F., & Maybauer, D. M. (2014). Transesophageal echocardiography in the management of burn patients. *Burns, 40*(4), 630-635. doi:10.1016/j.burns.2013.08.032
- Papp, A., Uusaro, A., Parviainen, I., Hartikainen, J., & Ruokonen, E. (2003). Myocardial function and haemodynamics in extensive burn trauma: evaluation by clinical signs, invasive monitoring, echocardiography and cytokine concentrations. A prospective clinical study. *Acta Anaesthesiol Scand, 47*(10), 1257-1263. doi:10.1046/j.1399-6576.2003.00235.x
- Porter, J. M., & Shakespeare, P. G. (1984). Cardiac output after burn injury. *Ann R Coll Surg Engl, 66*(1), 33-35.
- Ryan, C. M., Schoenfeld, D. A., Thorpe, W. P., Sheridan, R. L., Cassem, E. H., & Tompkins, R. G. (1998). Objective estimates of the probability of death from burn injuries. *N Engl J Med, 338*(6), 362-366. doi:10.1056/nejm199802053380604
- Saffle, J. I. (2007). The phenomenon of "fluid creep" in acute burn resuscitation. *J Burn Care Res, 28*(3), 382-395. doi:10.1097/bcr.0b013e318053d3a1
- Tapking, C., Popp, D., Herndon, D. N., Branski, L. K., Hundeshagen, G., Armenta, A. M., . . . Kinsky, M. P. (2020). Cardiac Dysfunction in Severely Burned Patients: Current Understanding of Etiology, Pathophysiology, and Treatment. *Shock, 53*(6), 669-678. doi:10.1097/shk.0000000000001465
- Bradley, C. A., Ma, C., & Hollon, M. M. (2023). Perioperative Point of Care Ultrasound for Hemodynamic Assessment: A Narrative Review. *Seminars in Cardiothoracic and Vascular Anesthesia, 27*(3), 208-223. doi:10.1177/10892532231165088
- Hollon, M. M., Bradley, C., McCullough, I., & Borgmeier, E. (2022). Perioperative applications of focused cardiac ultrasound. *International Anesthesiology Clinics, 60*(3), 24-33. doi:10.1097/aia.0000000000000371

EMORY UNIVERSITY

CME Claiming

Please follow the directions below to complete the meeting evaluation and claim credits. Once you are enrolled for the activity an email is sent to the email address that is listed on your ASA account. **Don't try and claim until you receive an email from the ASA**. If you experience difficulties logging in or no longer have access to that email, don't hesitate to contact jpmeetings@asahq.org, and we will be happy to assist you.

Please do not create a duplicate account, your credit will not track to duplicate account.

NO ASA ACCOUNT
If you do not have an account with ASA, an email will be sent to you to create a free account.

ACCESSING THE WEBPAGE
Click the link below and log in using the email on your ASA account and password.

https://education.asahq.org/course/view.php?id=4179

RETRIEVING YOUR PASSWORD
You can retrieve or set a new password by entering your email address at: https://www.asahq.org/member-center/forgot-password

CLAIMING CREDIT
Please complete the steps below to evaluate the activity and claim CME.

1. Complete the evaluation.
2. Click on the certificate, enter the credit you are claiming.
3. Print your certificate or save it as a PDF for your files.

Please note you must claim your credits for this course by December 31, 2025. You will NOT be able to claim credits after this date.

Jointly Provided by... American Society of Anesthesiologists™