Update on Pediatric Anesthesia
CRASH 2018

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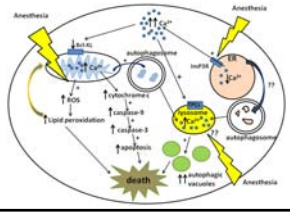
Director of Education, Children's Hospital Colorado
Program Director, CRASH

Disclosure

Objectives

Participants will be able to:

- Discuss the latest clinical research on the effects of general anesthesia on the neurocognition and its implication for the anesthetic management of children.
- Understand the American College of Surgeons children's surgery verification program and its impact on the delivery of anesthesia to children.
- Evaluate the role of the anesthesiologist for MRI procedural safety
- Examine management options of the pediatric airway and difficult airways, including advances in technology
- Understand the implication of coagulopathy in pediatric severe trauma, and discuss the role of thromboelastography in its management



Animal Studies
- Multiple species
- Almost all anesthetics
- GABA agonists, NMDA antagonists
- Mechanism
  - Neuronal apoptosis
  - Synaptogenesis
  - Oligodendrocytes

"Heathcare professionals should balance the benefits…against the potential risks, especially for procedures longer than 3 hours or if multiple procedures are required in children under 3 years. Discuss…appropriate timing of surgery or procedures requiring anesthetic and sedation drugs" **-FDA; December 12, 2016**

Caveats were made for the need for anesthesia with surgery, and that life-saving procedures should not be delayed.

FDA DRUG WARNING

"…surgeries or procedures in children younger than 3 years should not be delayed or avoided when medically necessary."

" Consideration should be given to delaying potentially elective surgery in young children where medically appropriate."

"Health care professionals should continue to follow their usual practices of patient counseling including discussing the benefits And risks of surgeries or procedures that require general anesthesia and sedation drugs."

-FDA, April 27, 2017

What about real children?

- Mostly retrospective, exception GAS
- Various sample sizes
- Mixed results
  - Mostly no changes, small differences in academic achievement, some increased risk of behavior or learning disorder
- Confounding factors
  - Heterogenous population
  - Different outcome measurements (testing methodology)
  - Clinical relevancy?
  - Other factors that effect neurodevelopment and achievement

Davidson & Sun, Anesthesiology, 2017

Short, one time exposures

- GAS
  - Prospective, randomized trial
  - GA vs awake, spinal for IHR in children < 60 days
  - Found no evidence that less that 1 hour of sevoflurane anesthesia in infancy increases the risk of adverse ND outcomes at 2 years of age compared with awake-regional anesthesia
  - 5 year data pending

Davidson, Lancet, 2016

- PANDA
  - Sibling pairs within 36 months of age
  - One sibling received anesthesia for IHR < age 3 years
  - 20 to 240 mins (median 80 mins)
  - Measured IQ, neurocognitive function/behavior
  - No difference between the groups

Su, JAMA, 2016

Age at Exposure to Surgery and Anesthesia in Children and Association With Mental Disorder Diagnosis

Anesth & Analg

Association between Exposure of Young Children to Procedures Requiring General Anesthesia and Learning and Behavioral Outcomes in a Population-based Birth Cohort

Anesthesiology

PAEDIATRIC ANAESTHESIA

Duration of general anaesthetic exposure in early childhood and long-term language and cognitive ability

BJA

Are Anesthesia and Surgery during Infancy Associated with Decreased White Matter Integrity and Volume during Childhood?

Anesthesiology

JAMA Pediatrics | Original Investigation

Association of Anesthesia and Surgery During Childhood With Long-term Academic Performance

0.41% lower grades at 16 years
0.97% lower IQ at 18 years

What does it all mean?

Responsibility Jevtovic-Todorovic, JAMA Peds, 2017

- Large body of animal studies, including growing nonhuman primates
- Mechanisms are more clear
- Primate neurodevelopment is similar – Can we ignore this data?
- There is clinical data showing association.
- Continue research and innovation

Relevancy Hansen, JAMA Peds, 2017

- Why hasn't clinical impact been noticed before?
- Outcomes testing with limitations
- Does testing outcomes → adult outcome and functioning?
- GAS, PANDA, Sweden
- Other more important factors require more attention:
  - Environmental, medical, individual

"Good news.
Your cholesterol has stayed the same,
but the research findings have changed."

How do we talk to the parents?

- Legal obligations?
- Ethical obligations?
- Still no consensus on how to handle the information
- At CHCO it is not part of the standard pre-anesthesia meeting.
- But some places are formally addressing it….


Department of Anesthesiology, Perioperative and Pain Medicine

Anesthesia and Brain Development in Your Child

Future endeavors

- More data
- Changes in practice?
  - Timing of surgery
  - Necessity of diagnostic procedures
- Changing anesthetics, safer options?
  - Neuroprotective agents?
    - Dexmedetomidine
    - Xenon
  - TREX study

ACS CSV - goals

- Create the first national "multispecialty standards for children's surgical care"
- Improve pediatric surgical outcomes at the institutional level and population level

ACS CSV – Guiding Principles for continuous QI

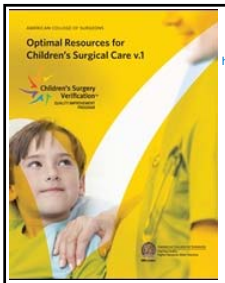
- Standards
  - Individualized by patient need, backed by research
- Proper infrastructure
  - Staffing levels, specialists, equipment, checklists
- Rigorous Data collection
  - Medical charts, research, post-discharge tracking, updated
- Verification
  - External peer-reviewed, create public assurances

ACS CSV – Why?

- Data over decades examining outcomes and complications in both the surgical and anesthesia literature.
- Worse outcomes associated with:
  - Younger age
  - Complex patients (cardiac, neonates)
  - Volume/experience
  - Training
  - Complex and simple operations

Previous Track Record

- Specialized care improves outcomes
  - Congenital Heart Disease
  - Neonatal ICU
  - Multidisciplinary Pediatric ICU
- Quality Improvement Programs by ACS
  - Breast cancer surgery
  - Cancer surgery
  - Bariatric surgery
  - Trauma
    - ACS Verification Process has improved survival by 20-25% (MacKenzie, NEJM, 2006)



https://www.facs.org/quality-programs/childrens-surgery/childrens-surgery-verification

Review articles with Anesthesia implications:
Houck CS, Current Opinion – Anesthesiology, Vol 30:3, June 2017
Peterson MB, Anesthesia & Analgesia, Dec 2017, Epub ahead of print

Children's Surgical Center Scope of Practice

	Level 1	Level 2	Level 3
Age	Any	Any	>6 months
ASA	I-V	I-III	I-II
Multidisciplinary management	Multiple med/surg specialties; peds anesthesia	Single surg specialties; neonatology; peds anesthesia	None
Operations	Major congenital anomalies; complex disease	Common anomalies and diseases	Common, low risk procedures
Ambulatory	Peds anesth written guidelines	Peds anesth written guidelines	Healthy ASA I-II; Age > 6 months

Anesthesiology service requirements

- Level I
  - 2 or more pediatric anesthesiologists on staff
  - Immediate availability 24/7
  - Pediatric anesthesiologist must be primary on children < 2 years
  - Pediatric anesthesiologist should be primary on children < 5 years, or ASA 3+
  - On site pediatric service present 24/7/365
- Level II
  - 1 or more pediatric anesthesiologists on staff
  - Must be able to serve as primary on children < 2 years
  - Pediatric anesthesiologist should be primary on children < 5 years, or ASA 3+
  - On site pediatric airway skills 24 hours/day
- Level III
  - An anesthesiologist with pediatric experience available 24/7

- Available = 60 minutes to the bedside

Classification of Pediatric Anesthesiologist in CSV Program

Type of Anesthesiologist	Board Certification/ Licensing	Peds Cases /Yr.	Other Requirements
Pediatric Anesthesiologist	BC/BE Pediatric Anesthesiologist		
Anesthesiologist with pediatric expertise	ABA BC/BE	25 patients < 24 months old	Ongoing care of pts. < 18 yrs.; ≥10 peds CME/year
Alternative pathway for pediatric anesthesiologist designation	Complete residency with documentation of pediatric component; License and credentialing to care for pts. < 2yrs	≥30% of practice / 5 yr. devoted to peds (including neonates, children < 2yr, high-risk)	PALS 48 hrs. CME/3 yrs. Peds anesth meeting/societies Case list of pts. < 2 yrs.

Sounds like a great idea, with lots of support…

- But…
- ASA has some reservations
  - Access to care, travel times
- American Academy of Emergency Medicine (JACS 2015)
  - "all of us are trained to care for kids during residency"
  - Requirements for peds specialization in EM = not sufficient evidence for improved pediatric outcomes
- Geography (Muffly M, et al, A&A, July 2016, June 2017)
  - The children and the pediatric anesthesiologist are not necessarily living in the same area
    - 10.2 million children (0-17 years) live > 50 miles from the nearest peds anesthesiologist
    - 2.7 million childrens are 0-4 years

Verified Children's Surgical Centers

- Lurie Children's Hospital
- CS Mott Children's Hospital
- Children's Hospital Wisconsin
- Duke Children's Hospital
- Penn State Children's Hospital
- Texas Children's Hospital
- UC Davis Children's Hospital

- 125 centers have expressed interest in verification.

Pediatric MRI

MRI utilization and anesthesia

- NCH examined all MRI's in an ACO – Partners for Kids (330K kids in Ohio)
- 2011 – 2014 MRI utilization increased from 11 to 12 encounters / 10,000 member-months
- Anesthesia increased from 21 to 28% of cases
- Anesthesia costs increased from 22% of MRI cost to 33%

- Univ of Iowa demonstrated MRI/CT annual growth rates 8% with anesthesia growth of 8.5%

- At CHCO we perform approximately 12,000 MRI in 2017
- 1/3 with anesthesia

Uffman JC, Am Coll Radio, 2017
Wachtel, A&A, 2009

ORIGINAL ARTICLE

Identification of quality improvement areas in pediatric MRI from analysis of patient safety reports

Examined MRI on pediatric patients 2010-2015
16,749 studies, safety reports filed on 0.52%

< 6 yrs. (0.89%) vs (0.41%) for older children
Sedated pts (0.8%) vs (0.45%) for awake pts
Inpatients (1.1%) vs (0.4%) for outpatients

Higher level of safety reports were all associated with sedation and anesthesia

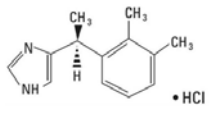
most common causes for safety reports:
service coordination (34%)
drug reactions (19%)
diagnostic test ordering errors (11%)

MINISYMPOSIUM: MINIMIZING SEDATION IN PEDIATRIC MRI

Pediatric anesthesia and neurotoxicity: what the radiologist needs to know








Alternatives to general anesthesia

Can we reduce anesthesia exposure? Neonatal brain MRI: Swaddling vs. sedation, a national survey

Benjamin J. Heller [a,*], Francine S. Yudkowitz [b], Scott Lipson [b]

[a] Department of Anesthesiology, Icahn School of Medicine at Mount Sinai, 1 Gustave L. Levy Place, New York 10029, USA
[b] Division of Pediatric Anesthesiology, Icahn School of Medicine at Mount Sinai, 1 Gustave L. Levy Place, New York, 10029, USA

96 programs surveyed, 58 responded.
64%(n = 37) used feed and swaddle
32% (n = 19) use sedation
3% (n = 2) used general anesthesia (GA).

Success rate of obtaining quality MRI images varied by technique.
Feed and swaddle group
81% reported that a failure to obtain useful images occurred < 25%
11% reported that it occurred 25–75%
5% reported that it occurred > 75%

Sedation/GA group, 100% reported failure to obtain useful images occurred rarely.

Journal of Clin Anesthesia, 2017

DOI: 10.1111/pan.13184

EDITORIAL

WILEY Pediatric Anesthesia

The radiological home: Pediatric anesthesiologist's role in risk assessment for imaging procedures

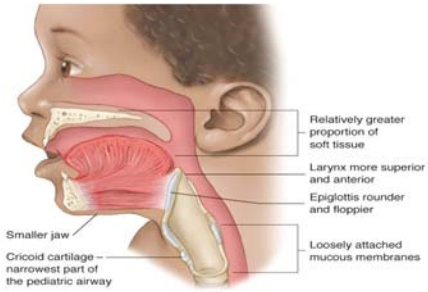
Cravero, Ped Anesth, 2017

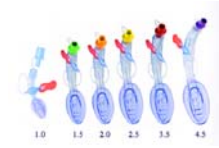
Safety : Necessity
Cardiorespiratory risks of anesthesia
The neurotoxicity ?

Giotto di Bondone
1276-1337
Italy

Children are not little adults

Anatomy of the Pediatric Airway





THE LANCET February 18, 2017

The effect of endotracheal tubes versus laryngeal mask airways on perioperative respiratory adverse events in infants: a randomised controlled trial

Thomas F E Drake-Brockman, Anoop Ramgolam, Guicheng Zhang, Graham L Hall, Britta S von Ungern-Sternberg

-Princess Margaret Hospital for Children, Perth Australia
-July 2010-May 2015
-181 infants < 1 yr; GA with/out regional or local; low dose fentanyl
-LMA n=85; ETT n=95
-Assess PRAE (major & minor)

RCT – Infant LMA vs ETT

- PRAE Overall ETT
  - 53% vs LMA 18% (RR 5.30)
- Major PRAE
  - ETT 19% vs LMA 4% (RR 2.94)

"paradigm shift ?" (Fiadjoe & Litman, Lancet, Feb 2017)

- Seems like a very high rate of PRAE
- Questions
  - What are complications?
    - Desaturation < 95%, Coughing were minor PRAE
  - No standard timing of device removal
  - ETT were typically "awake"
  - What is awake?
    - Eye opening, sustained grimace and squirming
    - Careful about stage 2
    - Typically wait until procedure is complete
  - Challenging long held beliefs – a good thing for improvement.

ORIGINAL ARTICLE

Evaluation of the C-MAC Miller Video Laryngoscope Sizes 0 and 1 During Tracheal Intubation of Infants Less Than 10 kg

Florian J. Raimann, MD,* Colleen E. Cucu, MD,* Detlev Kern, MD,* Kai Zacharowski, MD, FRCA,* Udo Rolle, MD,† Dirk Meininger, MD,*‡ Christian F. Weber, MD,* Christian Byhahn, MD,*§ and Haitham Mutlak, MD*

No difference between that 0 and 1 Miller blades

But indirect visualization gave better Cormack-Lehane grade

Pediatric Emergency Care, 2017.

Pediatric Difficult Intubation Registry (PeDI)

- Created 2012, by a 48 member special interest group of the Society for Pediatric Anesthesia
- Data repository of airway management techniques and outcome in children with difficult airways
- Complications 2016 (Fiadjoe, Lancet, January 2016)
  - 1018 difficult intubations from 2012-2125
  - 20% of difficult airways had complication
  - 3% severe – cardiac arrest most common severe complication (2%)
  - Complications associated with > 2 DL attempts, < 10 kg, short thyromental distance

Recommendation: limit DL attempts and move to indirect technique.

Videolaryngoscopy *versus* Fiber-optic Intubation through a Supraglottic Airway in Children with a Difficult Airway

An Analysis from the Multicenter Pediatric Difficult Intubation Registry

Nicholas E. Burjek, M.D., Akira Nishisaki, M.D., M.S.C.E., John E. Fiadjoe, M.D., H. Daniel Adams, B.S., Kenneth N. Peeples, M.P.H., M.S.W., Vidya T. Raman, M.D., Patrick N. Olomu, M.D., Pete G. Kovatsis, M.D., Narasimhan Jagannathan, M.D.; for the PeDI Collaborative Investigators*

Hypoxemia is the most common precursor to intubation-related adverse event is children with difficult airways
Children less than 1 year are particularly vulnerable

Videolaryngoscopy n=786; FOI-SGA n=114

First attempt success VL 51%; FOI-SGA 59% (p=0.160)
Overall success VL 79%; FOI-SGA 89% (p=0.016)

Infants < 1y:
First attempt success VL 36%; FOI-SGA 54% (p=0.041)
Overall success VL 68%; FOI-SGA 80% (p=0.170)
Number of attempts less with FOI-SGA

Anesthesiology, Sep 2017

A quality improvement initiative to increase the safety of pediatric emergency airway management

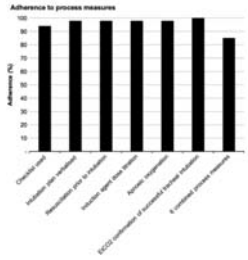
Elliot Long[1,2,3] | Domenic R. Cincotta[1,2,3] | Joanne Grindlay[1,2,3] | Stefano Sabato[2,4] | Emmanuelle Fauteux-Lamarre[1,2] | David Beckerman[1,5] | Terry Carroll[1,4,5] | Nuala Quinn[1] | On behalf of the Pediatric Research in Emergency Departments International Collaborative (PREDICT)

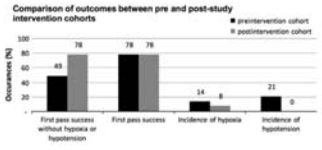
TABLE 2 Quality improvement measures undertaken to improve the safety of emergency airway management

Study interventions	Process measures	Outcome measures	Balancing measures
Airway algorithm	Checklist use	First pass success without hypoxia or hypotension	Gastric distension
Standardized equipment	Airway plan		Poor face mask seal
Checklist	Physiologic resuscitation		Aspiration of gastric contents
Template	Dose titration of induction agent		
Endtidal carbon dioxide monitor	Use of apneic oxygenation		
Team training	Endtidal carbon dioxide use		
Postevent debrief			

Pediatric Anesthesia, 2017

Outcomes





[1]Department of Emergency Medicine, The Royal Children's Hospital, Parkville, Vic., Australia

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[3]Department of Pediatrics, Faculty of Medicine, Dentistry, and Health Sciences, University of Melbourne, Parkville, Vic., Australia

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[5]Department of Nursing, Faculty of Medicine, Dentistry, and Health Sciences, University of Melbourne, Parkville, Vic., Australia

Pediatric Anesthesia

ORIGINAL ARTICLE

Evaluation of emergency pediatric tracheal intubation by pediatric anesthesiologists on inpatient units and the emergency department

Wenyu Bai, Kristine Golmirzaie, Constance Burke, Tara Van Veen, Robert Christensen, Terri Voepel-Lewis & Shobha Malviya

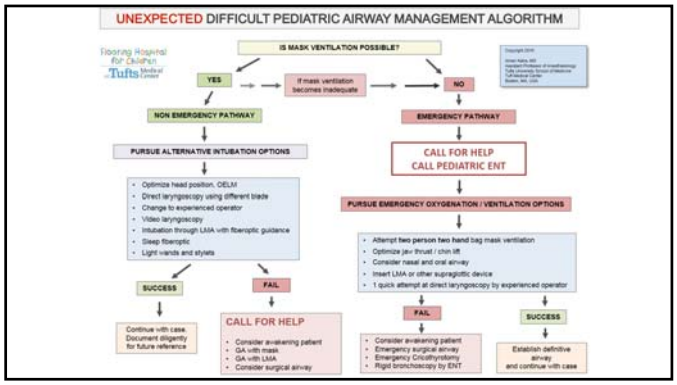
132 intubations with median age of 3.3 years

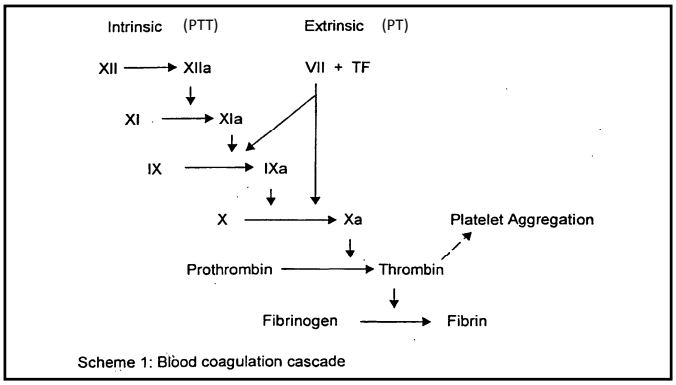
10.6% were found to be difficult airways (> 2 attempts)

78.6% of difficult airways required alternative airway technique

Major intubation-related adverse event occurred in 3.8%

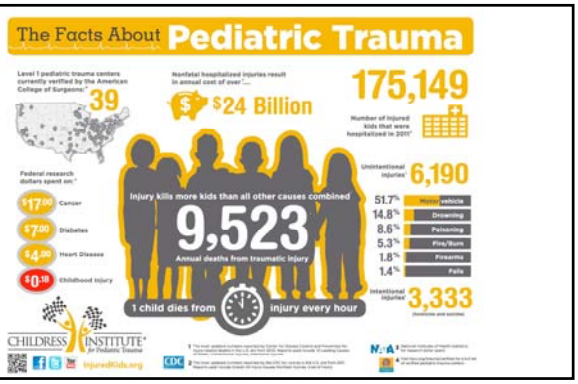
Mild-to-moderate event in 17.4%





Scheme 1: Blood coagulation cascade

Turns out it's a bit more complex



Prevalence and Impact of Admission Acute Traumatic Coagulopathy on Treatment Intensity, Resource Use, and Mortality: An Evaluation of 956 Severely Injured Children and Adolescents

Ioannis N Liras, BS, Henry W Caplan, MD, Jakob Stensballe, MD, PhD, Charles E Wade, PhD, Charles S Cox, MD, FACS, Bryan A Cotton, MD, MPH, FACS

Coagulopathy defined by rTEG:

ACT ≥ 128secs
α-angle ≤ 65 degrees
Maximum Amplitude (MA) ≤ 55mm
Lysis at 30 mins from 20mm amplitude (LY-30) ≥ 3%

Highest-level Trauma patients < 17 y
956 patients; 507 (57%) coagulopathic vs 449 (43%) noncoagulopathic/control

Journal of Am College of Surgeons, April 2017

Outcomes (Liras IN, JAmCollSurg, 2107)

- Coagulopathic patients were:
  - Younger
  - Received more transfusions
  - Fewer ICU-free, ventilator-free days
  - Higher mortality at 30d: 12% vs 3% (p<0.001)
- Logistic regression
  - (age, gender, mechanism, SBP, ISS)
- Mortality for hypocoagulopathy
  - OR 3.67 (95%CI 1.768-7.632) p<0.001

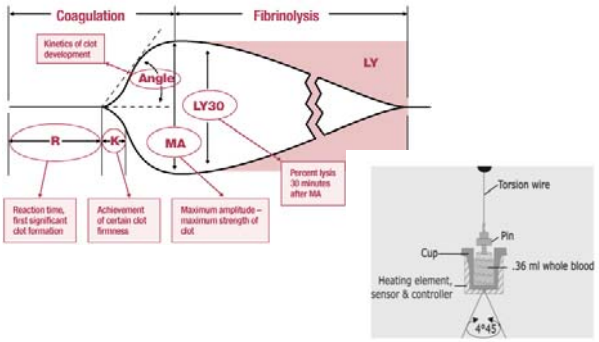


Table 2
TEG transfusion triggers and product selection.

Value	Normal	Transfusion trigger	Product	Dose
TEG-ACT	86–118 s	> 128 s	Plasma	20 mL/kg
Alpha angle	64°–80°	< 60°	Cryo	1 unit/10 kg
K value	0–2.5 min	> 2.5 min		
MA	52–71 mm	< 55 mm	Platelets	15 mL/kg
LY-30	0–8%	> 3%	TXA	≥ 12 yo (adult dosing): 1 g loading dose over 10 min followed by a 1-g infusion over 8 h < 12 yo: 15 mg/kg (max dose 1 g) loading dose over 10 min followed by a 2 mg/kg/h infusion for 8 h

Leeper CM, Seminar in Pediatric Surgery, 2017

Seminars in Pediatric Surgery 26 (2017) 8–13
Contents lists available at ScienceDirect
Seminars in Pediatric Surgery
journal homepage: www.elsevier.com/locate/sempedsurg

Viscoelastic hemostatic assays in the management of the pediatric trauma patient

Christine M. Leeper, MD, MS, Barbara A. Gaines, MD*
Department of Surgery, University of Pittsburgh School of Medicine, Children's Hospital of Pittsburgh of UPMC, 7th Floor, Faculty Pavilion, One Children's Hospital Dr. 4401 Penn Ave, Pittsburgh, Pennsylvania 15224

Abnormalities of fibrinolysis in pediatric trauma

Shutdown
LY-30 ≤ 0.8%

Hyperfibrinolysis
LY-30 ≥ 3%

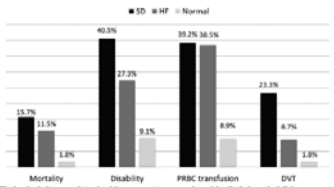


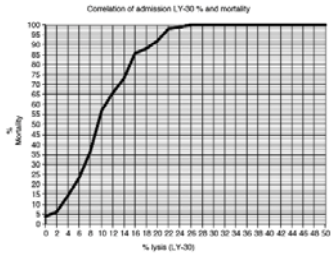
Figure 3. Derangement in fibrinolysis is associated with poor outcomes in critically injured children.

At LY-30 3%, mortality doubles from 6% to 14%

Table V. Comparison of outcomes and complications between those children with hyperfibrinolysis (LY30 ≥3%) and those without hyperfibrinolysis (LY30 <3%)

	LY30 ≥3% (n = 197)	LY30 <3% (n = 622)	P value
Median ICU-free days (IQR)	29 (28, 30)	29 (27, 30)	.053
Median Vent-free days (IQR)	30 (29, 30)	30 (29, 30)	.788
VTE rate, %	1.0%	2.3%	.245
Pneumonia rate, %	3.1%	4.5%	.398
SIRS rate, %	2.1%	4.1%	.191
Sepsis rate, %	1.5%	2.8%	.316
Respiratory failure rate, %	15.0%	21.5%	.050
MOF rate, %	0.0%	0.3%	.539
In-hospital mortality	14%	6%	<.001
Cure, %			

ICU, Intensive care unit; IQR, interquartile range; LY30, percentage of clot lysis at 30 minutes after maximum clot strength; MOF, multiorgan failure; SIRS, systemic inflammatory response syndrome; VTE, venous thromboembolism.



multivariate logistic regression analysis

LY30 ≥3%	6.20	2.465–16.269	<.001

Liras IN, Surgery, 2015

Trending Fibrinolytic Dysregulation

Fibrinolysis Shutdown in the Days After Injury Is Associated With Poor Outcome in Severely Injured Children

Christine M. Leeper, MD, MS,*† Matthew D. Neal, MD,* Christine J. McKenna, MSN,† and Barbara A. Gaines, MD*†

Annals of Surgery • Volume 266, Number 3, September 2017

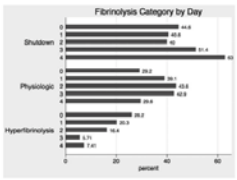


FIGURE 2. Fibrinolysis category by day, demonstrates overall increase in proportion of patients in shutdown and decrease in proportion of patients with hyperfibrinolysis.

Prospective observational study in 83 severely injured children

14.5% mortality, 43.7% disability, 9.8% deep vein thrombosis

Fibrinolysis shutdown is most common state, LY-30 < 0.8% Associated with death, disability, DVT (all with p < 0.05)

Poor outcome includes pts with HF on Day 0 → SD on Day 1-4 HF on presentation → NL, not associated with poor outcome

Easily detected with TEG

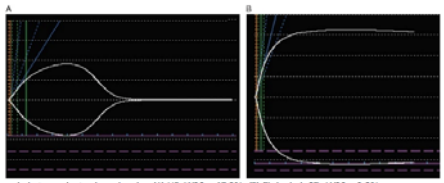
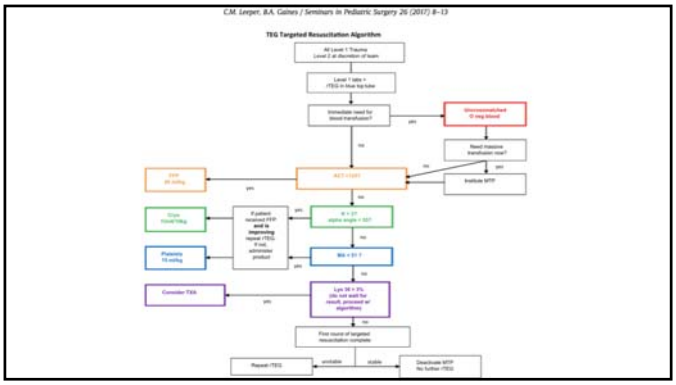


Figure 1. Thrombelastography tracings showing (A) HF, LY30 = 67.8%, (B) fibrinolysis SD, LY30 = 0.2%.



TEG-targeted resuscitation?

- Transfusion, anti-fibrinolytics?
- Cochrane review 2016 – Wikkelso, et al.
  - Bleeding adults and children (cardiac surgery patients)
  - VHA guided transfusion strategies
  - Reduced: mortality, need for blood products, morbidity
- Less data on trauma
  - Adult show promise
  - Especially with penetrating trauma
- Pediatric trauma is different
  - mostly TBI and blunt trauma
  - MVA and NAT