MHIF FEATURED STUDY:

TAMBE

OPEN AND ENROLLING!

EPIC message: *Research MHIF Patient Referral*

CONDITION:
Para/Juxarenal AAA disease

PI:
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RESEARCH CONTACT:
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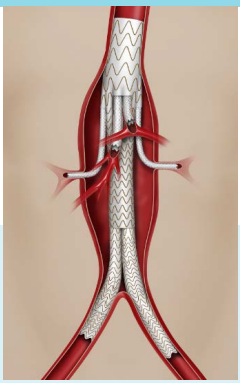
SPONSOR:
W.L. Gore

DESCRIPTION:

Evaluation of the **GORE® EXCLUDER® Thoracoabdominal Branch Endoprosthesis** in the Treatment of Thoracoabdominal and Pararenal Aortic Aneurysms. This study will look at treating thoracoabdominal or pararenal aneurysm disease with a new stent-graft design.



CRITERIA LIST/ QUALIFICATIONS:

Inclusion:

1. Aortic aneurysm involving the visceral vessel(s) requiring treatment defined as at least one of the following:
   - Fusiform aneurysm diameter ≥ 5 cm
   - Saccular aneurysm (no diameter requirement)
   - Rapid aneurysm growth (≥ 5 mm in one year)
2. Aortic aneurysm that involves the abdominal aorta, with:
   - Involvement of at least one visceral vessel and aneurysmal extension as far as 65 mm proximal to the celiac artery, and/or
   - No normal aorta between the upper extent of aneurysm and renal artery(s)

Exclusion:

1. Prior open, aortic surgery of the ascending aorta or aortic arch
2. Ruptured or leaking aortic aneurysm
3. Aneurysmal dilatation due to chronic aortic dissection
4. Infected aorta
5. Mycotic aneurysm
6. Life expectancy <2 years

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Minneapolis Heart Institute
Allina Health
Abbott Northwestern Hospital

ECMO Management of Amniotic Fluid Embolism

12/14/2020

Jonathan Urbach MD, Cardiology Fellow
Minneapolis Heart Institute

HOPE DISCOVERED HERE
Minneapolis Heart Institute Foundation®
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Disclosure

- None

Case

29-year-old healthy G1P1 presented at 39+0 for elective IOL

- Given misoprostol and went into active labor
- At 748 started feeling presyncopal and fetal bradycardia noted
- Arrive in OR at 754 for emergent Caesarean section
- During c-section, she had hemodynamic deterioration and ultimately PEA arrest
- No significant bleeding noted at this time, though the tissues were described as dusky in the op report
- CODE BLUE called at 0812

Code

- LUCAS, ACLS
- 0829 VT
  - DCCV x3 0831, 0832, 0835
- Completion of the emergent c-section
  - Noted that she was seeping through the sterile dressing and from all line sites
  - Massive transfusion protocol

POCUS

ECMO Activation

- ECMO activated in setting of refractory arrest
  - Working diagnosis was amniotic fluid embolism
- Cannulated for peripheral VA-ECMO via RFA and RFV and was on flow at 0900
- Continued to have uterine bleeding, but improving with blood product resuscitation
- Taken to cath lab for confirmation of cannula position as well as placement of a PA catheter and arterial line

Outline

- Indications / Contraindications for ECMO
- ECMO Complications
  - Thrombotic and hemorrhagic
- Anticoagulation in ECMO
  - AC of choice, monitoring strategies, institutional variation
  - ROTEM
- Amniotic fluid embolism
  - Pathophysiology, diagnosis, management
  - Role of ECMO

ECMO

- **Indications**
  - Inadequate perfusion (hypotension, low CO) despite adequate intravascular volume
  - Shock that persists despite volume, vasoactive meds, and IABP (if appropriate)
  - As a bridge
    - Recovery
    - Transplant
    - Durable MCS

- **Contraindications**
  - ***Absolute***: unrecoverable condition / not a candidate for VAD or transplant, advanced age, chronic organ dysfunction (emphysema, cirrhosis, renal failure), compliance (financial, cognitive, psychiatric, or social limitations), or prolonged CPR without adequate tissue perfusion
  - ***Relative***: unable to receive anticoagulation, advanced age, obesity

ECMO Stats

- Survival to hospital discharge for adults requiring ECMO 57% (respiratory illness) and 42% (cardiac disease)

- Bleeding / thrombotic complications are common with ECMO
  - In review of ELSO data from 2016:
    - Bleeding from surgical or cannula insertion sites 10-30%
    - CNS hemorrhage 2.2%-6%
    - Oxygentor thrombosis 7-13%
    - CNS infarction 2-4.4%

ASAIO J. 2017;63(1):60–7.

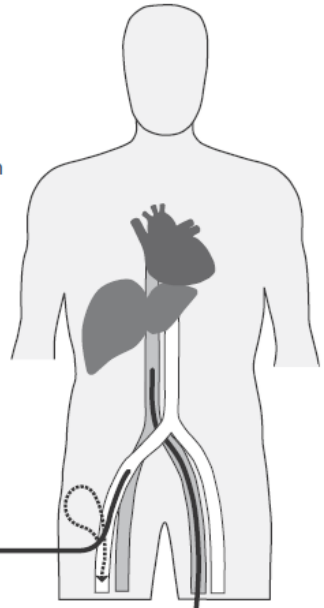
Circuit

Whole Circuit

- foreign surface → adhesion & activation
- haemodilution on commencement

Oxygenator

- consumption of platelets & plasma proteins



Pump

- altered shear
  - VWF dysfunction
  - platelet activation
  - reduced ADAMTS13

negative pressure

- *haemolysis → reduced NO*
- *cavitation*

Low Flow Zones and Connectors

(e.g. cannula to circuit connectors, back perfusion cannula ——·)

- turbulence & increased shear
- platelet activation

Systemic

Underlying Disease

- intracardiac clot due to stasis
- infection/sepsis
- post resuscitation
- trauma

Drugs

- heparin → bleeding / HIT
- antiplatelet agents

Liver

- synthetic function -procoagulant and natural anticoagulants
- fibrinolytic pathway

Systemic Inflammatory Response

- microparticle release
- leucocyte activation and NETs
- DIC
- platelet/endothelial activation

Murphy DA, Hockings LE, Andrews RK, et al. Extracorporeal membrane oxygenation-hemostatic complications. Transfusion Medicine Reviews. 2015 Apr;29(2):90-101.

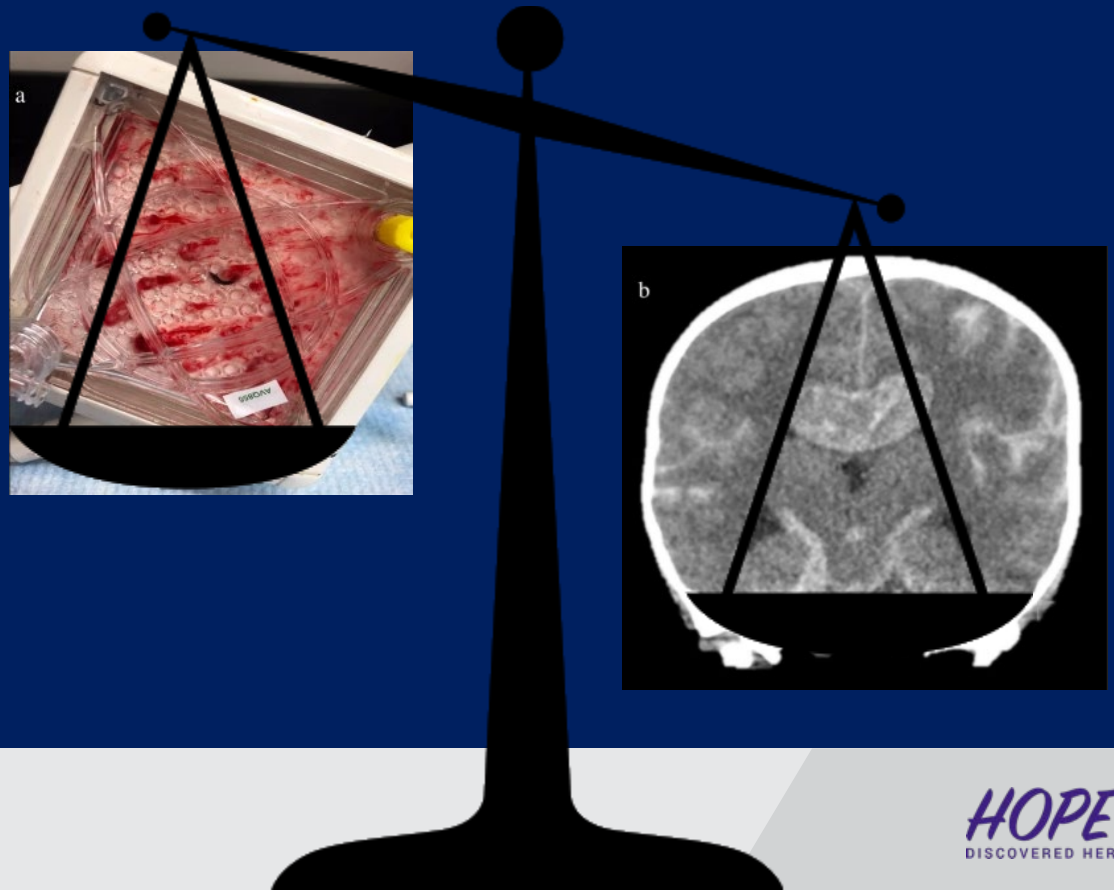
Anticoagulation in ECMO

- Strategies for Anticoagulation
  - Counterbalance exposure to non-endothelial surface of ECMO circuit
    - Bioactive coatings on surfaces limit coagulation response to circuit
  - Unfractionated heparin is the current international standard
  - Optimal anticoagulation (prevent thrombosis / limit bleeding risk) remains unknown

- Monitoring Anticoagulation
  - aPTT, ACT, anti-Xa, thromboelastography, absolute heparin dose
    - All used alone or in combination; no ideal strategy / consensus guidelines for monitoring

Chlebowski, M.M., Baltagi, S., Carlson, M. et al. Clinical controversies in anticoagulation monitoring and antithrombin supplementation for ECMO. Crit Care 24, 19 (2020).

In the balance...



HELP-ECMO Pilot

- Randomized, controlled, un-blinded pilot study at 2 ICUs in Australia
  - VA and VV ECMO pts randomized to either “standard” (aPTT target 50-70s) or low-intensity heparin protocol (aPTT target <45 seconds)
    - 31 pts; 9/31 (29%) VA, 22/31 (71%) VV
    - 16 randomized to low-intensity protocol, 15 to therapeutic dose heparin
  - Primary endpoint:
    - Difference between mean heparin dose and aPTT, anti-Xa levels
  - Secondary endpoints:
    - Thromboembolic events, ECMO circuit thrombosis, bleeding events

Blood (2016) 128 (22): 3822.

	Low-intensity (n=16)	Standard (n=15)	
mean aPTT	48.1	56.2	p=0.03
mean anti-Xa	0.11	0.3	p=0.003
mean heparin dose	11784	22050	p=0.004
DVT	2	3	p=0.57
PE	1	0	p=0.33
CVA	0	0	--
intracardiac thrombus	1	2	p=0.51
distal perfusion cannula thrombosis	2	0	p=0.16
acute pump thrombosis	1	1	p=0.96
ICH	0	1	p=0.29
RPH	1	1	p=0.96
GI	0	2	p=0.13
haemoptysis	1	1	p=0.96

Blood (2016) 128 (22): 3822.

ECMO without AC

- Retrospective, single-center analysis
  - 203 adult patients treated with VA-ECMO
  - Primary endpoint:
    - Composite of hemorrhagic and thrombotic complications
  - Secondary outcomes:
    - Transfusion needs, HIT, hospital LOS, in-hospital mortality

  - 35% (n = 75) were not anticoagulated
    - Lower complication rates in this group (57% vs 76%; p=0.007)
      - No difference in mortality, pump failure, or thrombotic complications

Venoarterial-Extracorporeal Membrane Oxygenation Without Routine Systemic Anticoagulation Decreases Adverse Events

Presented at the Fifty-fifth Annual Meeting of The Society of Thoracic Surgeons, San Diego, CA, Jan 26-29, 2019. Winner of the Thoracic Surgery Directors Association Benson R. Wilcox Award.

Katherine L. Wood MD, Brian Ayers MBA, Igor Gosev MD, Neil Kumar MD, Amber L. Melvin MD, Bryan Barrus MD, Sunil Prasad MD

Meta-analysis of ECMO without AC

- 6 case series included (n=70)
  - 84% VA-ECMO

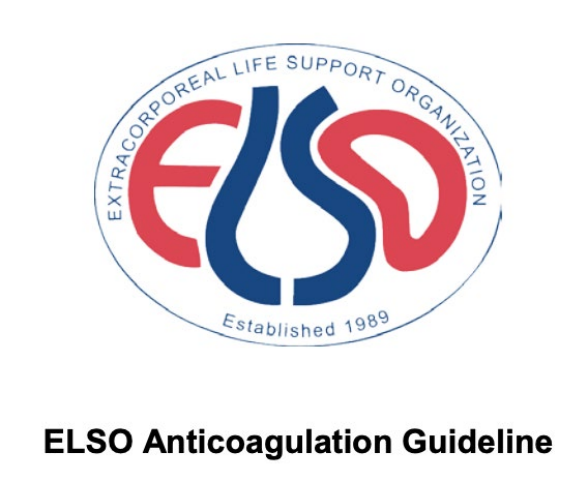
- Reason for no AC
  - High risk of bleeding after CV surgery (64%)
  - Active major bleeding (23%)
  - Severe traumatic injury (9%)

- Successful ECMO wean in 74% and survival to hospital dc 58%
  - There was significant variation in rates of circuit thrombosis
  - Patient complications inconsistently reported; small numbers

The International Journal of Artificial Organs. 2020, Vol. 43(9) 570–578

ELSO Guidelines

- Current ELSO guidelines recommend initial heparin infusion rate of 7.5-20.0 u/kg/h
  - No standardized method to achieve and monitor AC during ECMO
  - AC management / monitoring varies by institution

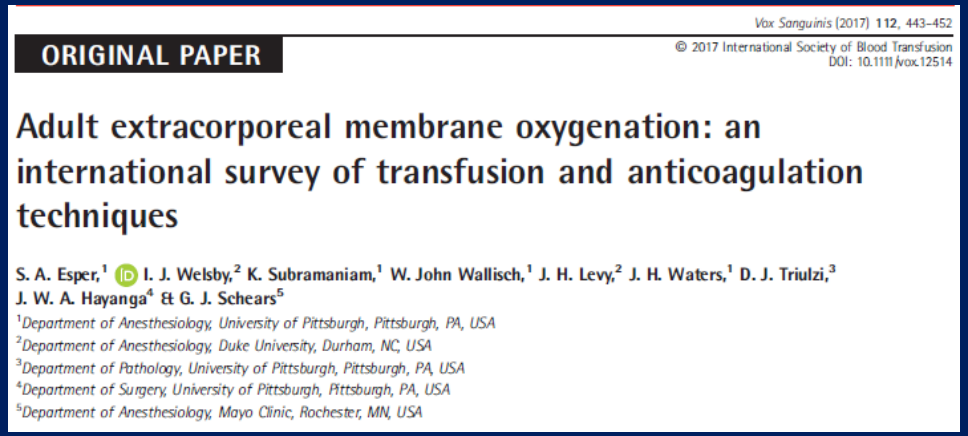


Institutional Variation

- Anticoagulant used
- Monitoring strategy

Institutional Variation

- Survey of transfusion and anticoagulation practices in adults at ECMO centers (54/166 surveyed)
  - 45/47 use heparin as primary AC
  - 1/47 uses heparin and bivalirudin equally
  - 1/47 uses bivalirudin only



Vox Sanguinis (2017) **112**, 443–452

ORIGINAL PAPER

DOI: 10.1111/vox.12514

Adult extracorporeal membrane oxygenation: an international survey of transfusion and anticoagulation techniques

S. A. Esper,[1] I. J. Welsby,[2] K. Subramaniam,[1] W. John Wallisch,[1] J. H. Levy,[2] J. H. Waters,[1] D. J. Triulzi,[3] J. W. A. Hayanga[4] & G. J. Schears[5]

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Table 1. Anticoagulants used in ECMO

Drug	Advantages	Disadvantages
Unfractionated heparin	Well known Mechanism known Easy to antagonise (protamine) Easy to monitor (aPTT/ACT)	Non-linear, variable effect Possible HIT induction
Low-molecular-weight heparin	Easy to administer Lower risk of HIT induction	Accumulation in renal impairment Can only be partially antagonised Not easy to monitor (aXa levels)
Direct thrombin inhibitors - Bivalirudin - Argatroban	Independent of AT levels Good dose response No HIT induction Mainly renal clearance Mainly hepatic clearance	No antagonist Lesser coagulation inhibition in areas of stasis Ceiling effect in aPTT Could interfere with INR measurement
Antiplatelet drugs	Inhibit coagulation at starting point Might reduce platelet consumption	No sufficient anti-coagulation No sufficient evidence

ACT = activated clotting time; aPTT = activated partial thromboplastin time; AT = antithrombin; HIT = heparin-induced thrombocytopenia; INR = international normalised ratio; VET = viscoelastic test.

Mulder, M.M.G. & Hassan, Ibrahim & Lancé, Marcus. (2018). ECMO and anticoagulation: A comprehensive review. Netherlands Journal of Critical Care. 26. 6-13.

Institutional Variation

- Anticoagulant used
- Monitoring strategy

Table 2. Monitoring coagulation

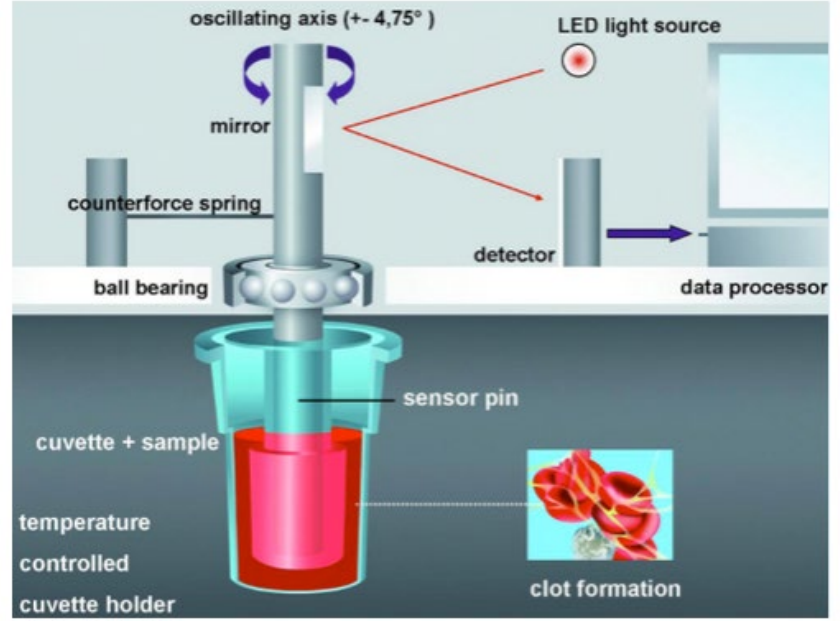
	Advantages	Disadvantages
Standard coagulation tests		
aPTT (sec)	Well known Monitoring UFH Easy to interpret	Inter-laboratory variance (could be excluded by using ratio) Time consuming
ACT (sec)	Bedside method Easy to use Immediate results	Relatively insensitive to low doses of UFH Different devices with different reference ranges
Anti Xa assay (IU/ml)	Sensitive to UFH	Time consuming Needs calibration Free haemoglobin & bilirubin could be underestimated
VETs (ROTEM/TEG)	Inhibit coagulation at starting point Might reduce platelet consumption	Poor specificity and sensitivity regarding therapy adjustment
Fibrinogen mg/l	Consumption marker	Increased in inflammatory situations Time consuming
D-dimer (mg/l)	Prognostic value for oxygenator failure	Time consuming Expensive
AT (%)	Heparin resistance (partial) Pro-coagulatory marker	Heparin resistance not completely relying on AT
Haemoglobin (g/dl)	Easy and fast	Not very relevant for coagulation
Platelet count 10^9/l	Easy and fast	No proven threshold Platelet count does not reflect platelet function

ACT = activated clotting time; aPTT = activated partial thromboplastin time; AT = antithrombin; ROTEM = rotational thromboelastometry; UFH = unfractionated heparin; TEG = thromboelastography; VET = viscoelastic test.

Mulder, M.M.G. & Hassan, Ibrahim & Lancé, Marcus. (2018). ECMO and anticoagulation: A comprehensive review. Netherlands Journal of Critical Care. 26. 6-13.

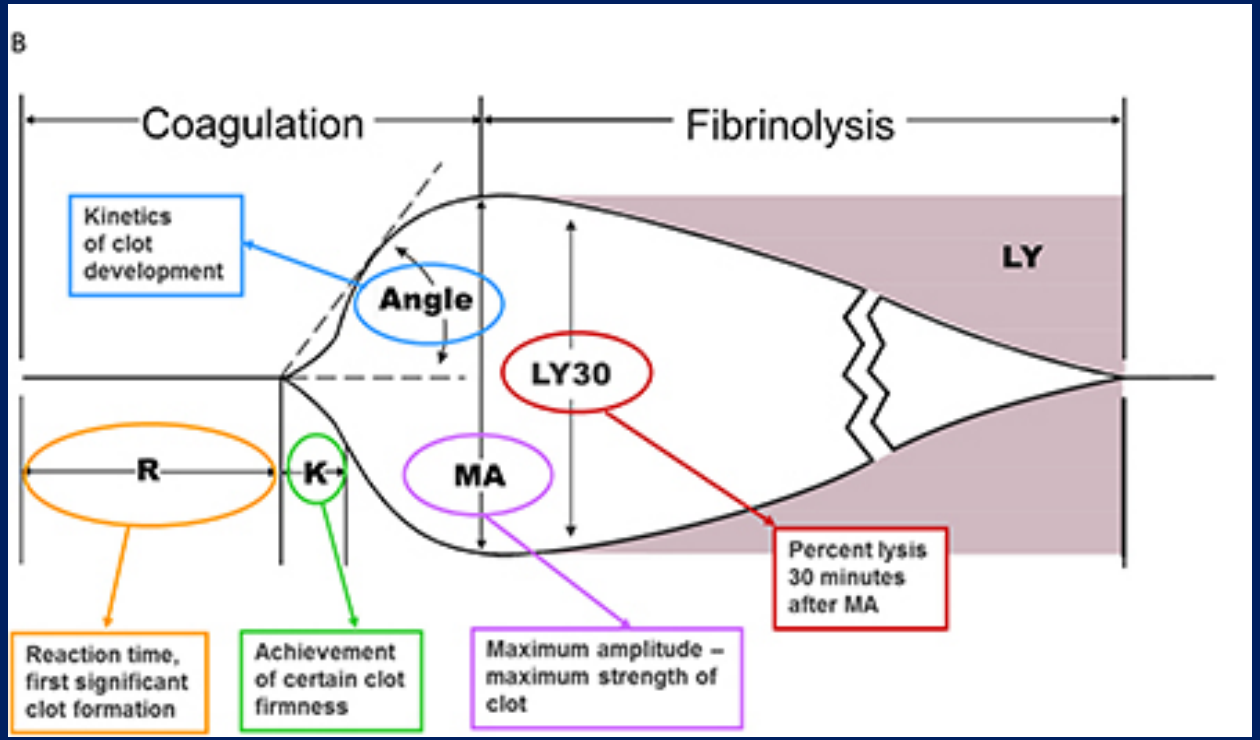
Rotational Thrombelastometry

- ROTEM is a method for measuring the quality of hemostasis
  - Uses viscoeslastic properties of a blood clot
  - Measures clot formation, clot integrity, and the presence of fibrinolysis

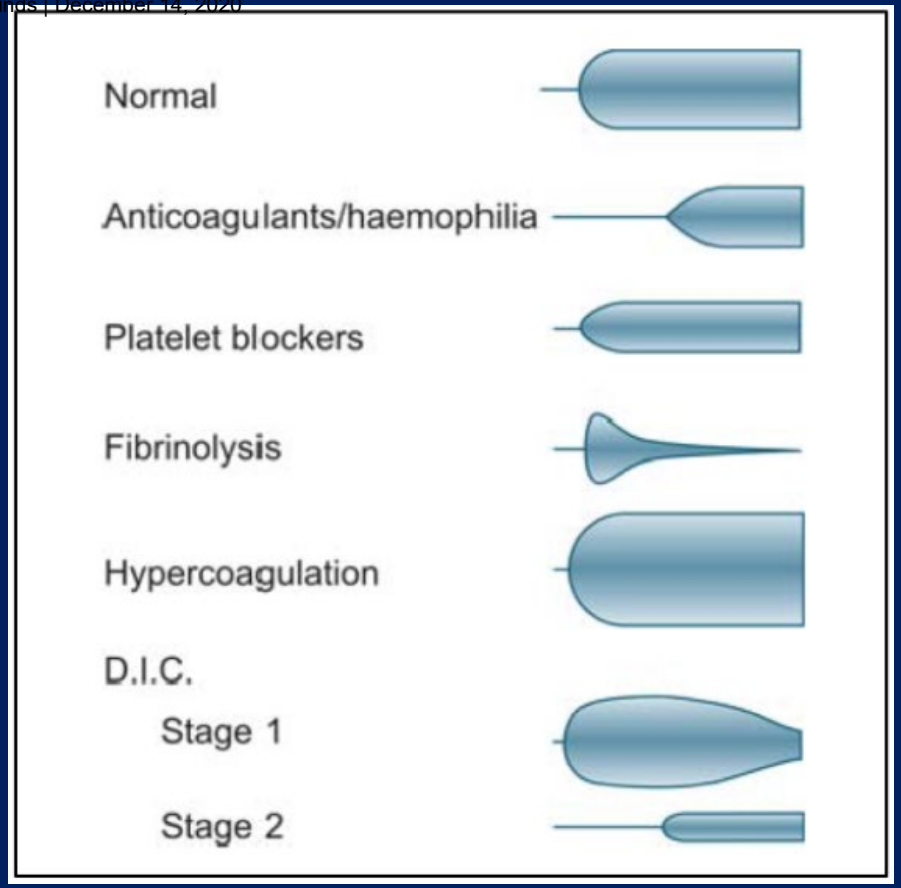


Journal of Cardiothoracic and Vascular Anesthesia. 2012; 26,1083-1093.

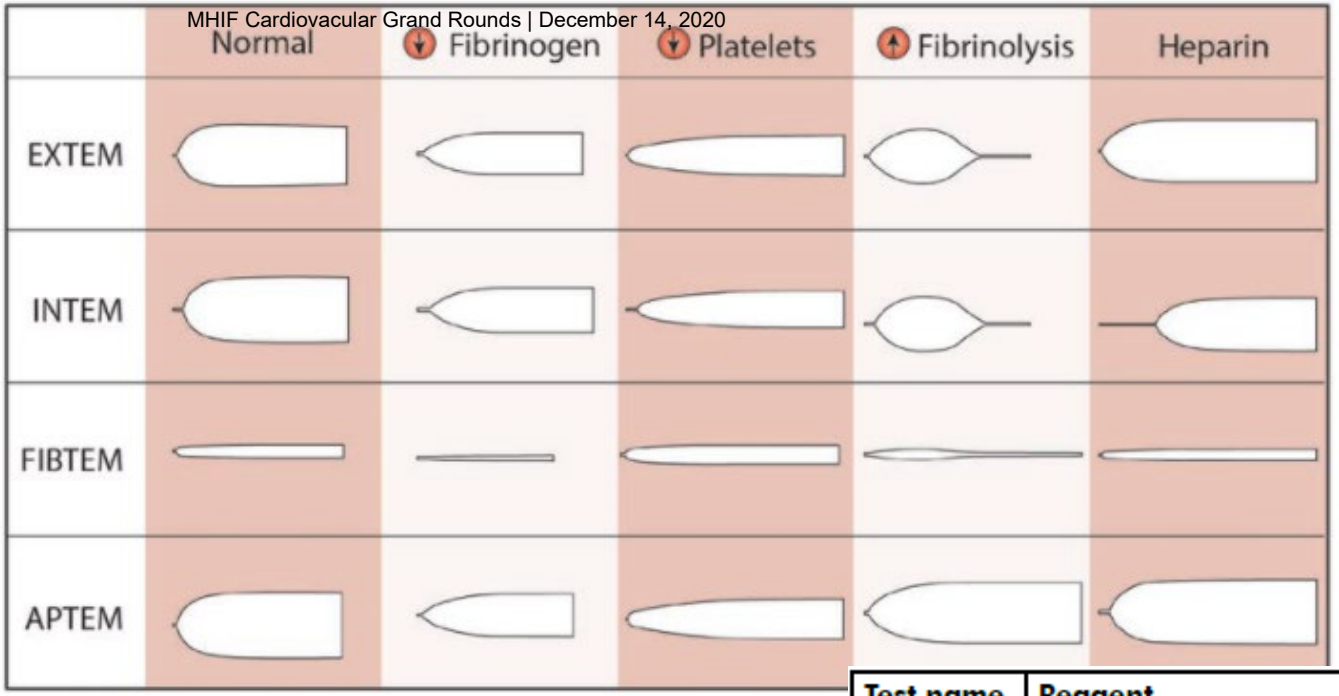
Image from Haemoview Diagnostics



J Cardiothorac Vasc Anesth. 2014;28(6):1550-1557.



Int J periop Ultrasound Apply Technol. 2012; 1(1):25-29.

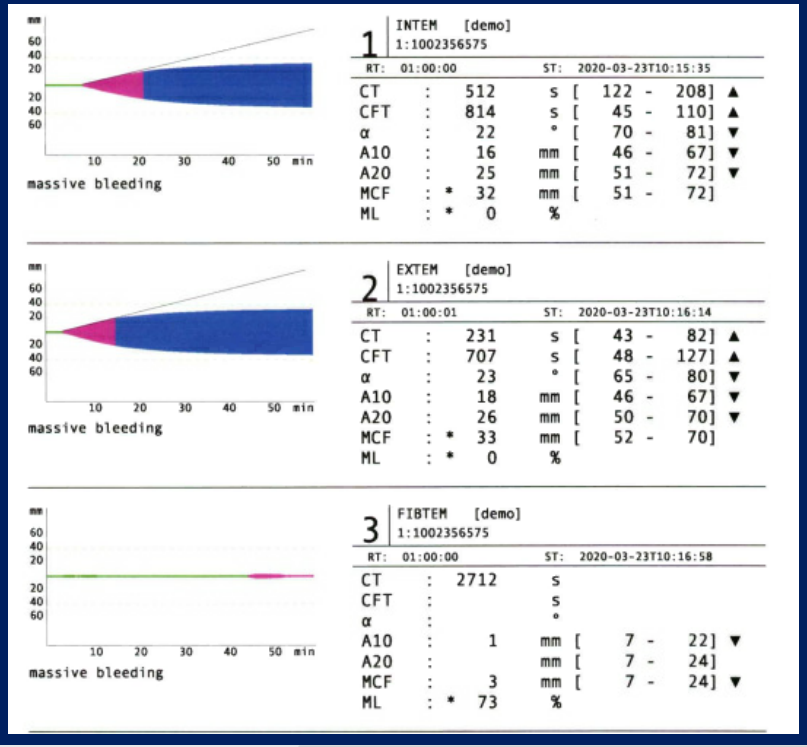


Test name	Reagent	Use
INTEM	Ellagic acid	Intrinsic pathway defects of coagulation activation
EXTEM	Recombinant tissue factor	Extrinsic pathway defects of coagulation activation
FIBTEM	Recombinant tissue factor and Cytochalasin D (platelet inhibitor)	Assesses for fibrinogen deficiency by blocking platelet contribution to clot formation
APTEM	Recombinant tissue factor and Aprotinin (fibrinolysis inhibitor)	Assesses for hyperfibrinolysis

Anesthesia and Analgesia. 2017; 126(1):46-61

Back to our case...

	15 3/23/2020 0955	
COAGULATION		
D-DIMER,QUANTITATI...	>4.00 *	▲
PROTIME	26.6 *	▲
INR	2.5 *	▲
APTT	95 *	▲
FIBRINOGEN,QUANTIT...	100	▼

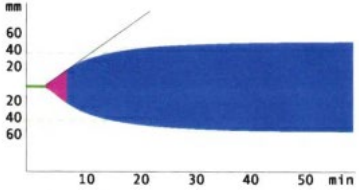


Correction of Coagulopathy

- Massive transfusion protocol
  - RBC - 8u
  - PLT - 5u
  - FFP - 5u
  - Cryo - 5u

	15 3/23/2020 0955	14 3/23/2020 1048	13 3/23/2020 1341	12 3/23/2020 2158	11 3/24/2020 0354	10 3/24/2020 1051	9 3/24/2020 1529	8 3/24/2020 2139	7 3/25/2020 0429
COAGULATION									
D-DIMER,QUANTITATI...	>4.00 * ▲								
PROTIME	26.6 * ▲		16.9 * ▲		14.5 * ▲			14.8 * ▲	14.0 *
INR	2.5 * ▲		1.4 * ▲		1.2 *			1.2 *	1.1 *
APTT	95 * ▲	55 * ▲	35 *	30 *	29 *	29 *	28 *	35 *	35 *
FIBRINOGEN,QUANTIT...	100 ▼		218		317			444	475 ▲

ROTEM 1341

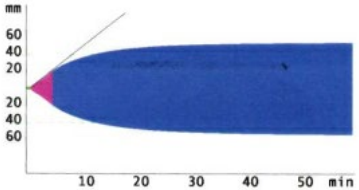


massive bleeding

1 INTEM [demo]
1:1002356575

RT: 01:00:00 ST: 2020-03-23T14:01:46

CT	:	217	s	[	122	- 208]	▲
CFT	:	230	s	[	45	- 110]	▲
α	:	50	°	[	70	- 81]	▼
A10	:	37	mm	[	46	- 67]	▼
A20	:	47	mm	[	51	- 72]	▼
MCF	:	53	mm	[	51	- 72]	
ML	: *	0	%				

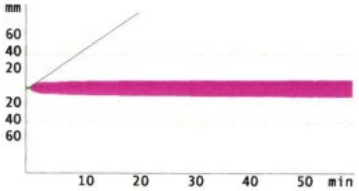


massive bleeding

2 EXTEM [demo]
1:1002356575

RT: 01:00:01 ST: 2020-03-23T14:02:25

CT	:	59	s	[	43	- 82]	
CFT	:	232	s	[	48	- 127]	▲
α	:	53	°	[	65	- 80]	▼
A10	:	38	mm	[	46	- 67]	▼
A20	:	48	mm	[	50	- 70]	▼
MCF	:	54	mm	[	52	- 70]	
ML	: *	0	%				



massive bleeding

3 FIBTEM [demo]
1:1002356575

RT: 01:00:00 ST: 2020-03-23T14:04:20

CT	:	57	s				
CFT	:		s				
α	:	48	°				
A10	:	8	mm	[	7	- 22]	
A20	:	9	mm	[	7	- 24]	
MCF	:	9	mm	[	7	- 24]	
ML	: *	0	%				

Amniotic Fluid Embolism

https://www.jsonline.com/story/news/local/wisconsin/2019/06/03/wisconsin-shaped-lightning-bolt-captured-amateur-photographer/1333371001/

Amniotic Fluid Embolism

- Catastrophic complication of pregnancy
  - Cardiovascular collapse
  - Respiratory failure
  - Coagulopathy

- Incidence estimated to be 1/8000 - 1/80,000 deliveries
  - Inaccurate diagnosis/inconsistent reporting of cases

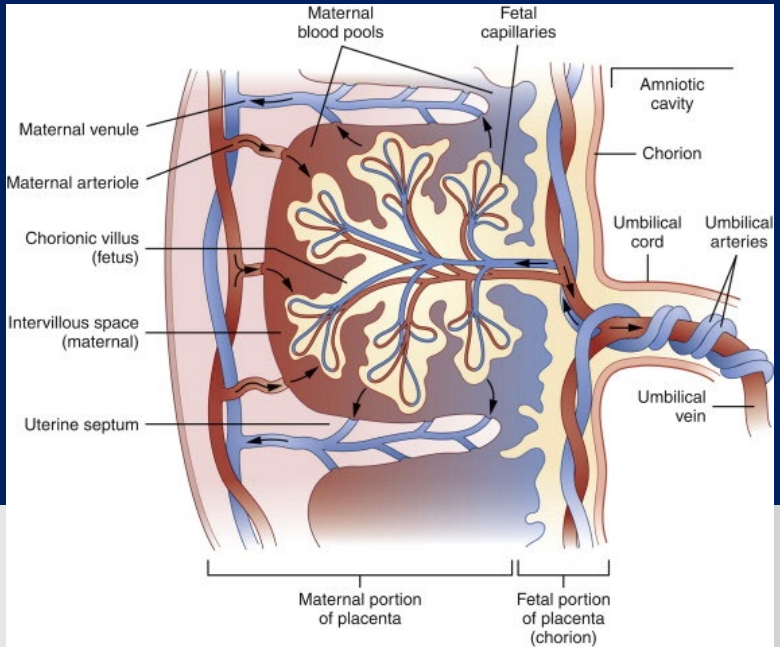
- Mortality rate
  - Prior estimates with mortality rate as high as 86%
  - More recent estimates 13-26%
    - Neurologically intact survival remains low, 15% of women

J Anaesthesiol Clin Pharmacol. 2016 Apr-Jun;
32(2): 153–159.

Pathophysiology AFE

Disruption of the maternal-fetal interface

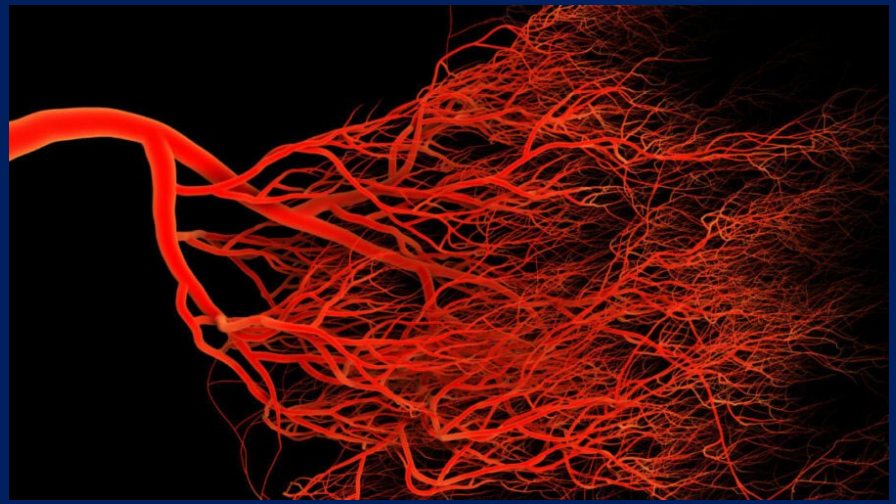
- Amniotic fluid enters maternal circulation
- Accompanied by procoagulants and fibrinolytic activators

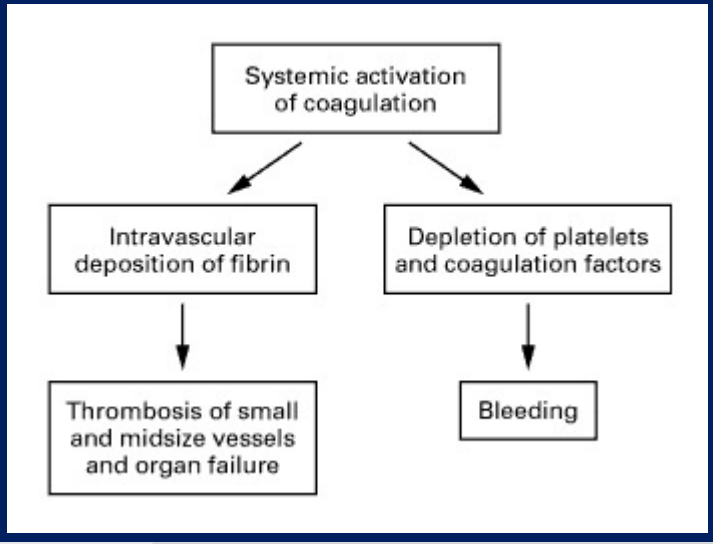


Anthony W. Norman Ph.D., Helen L. Henry Ph.D., in Hormones (Third Edition), 2015

Maternal hematologic effects

- Mediated by fetal prothrombotic substances, plasminogen activator, and plasminogen activator inhibitors
- Ultimately leads to DIC

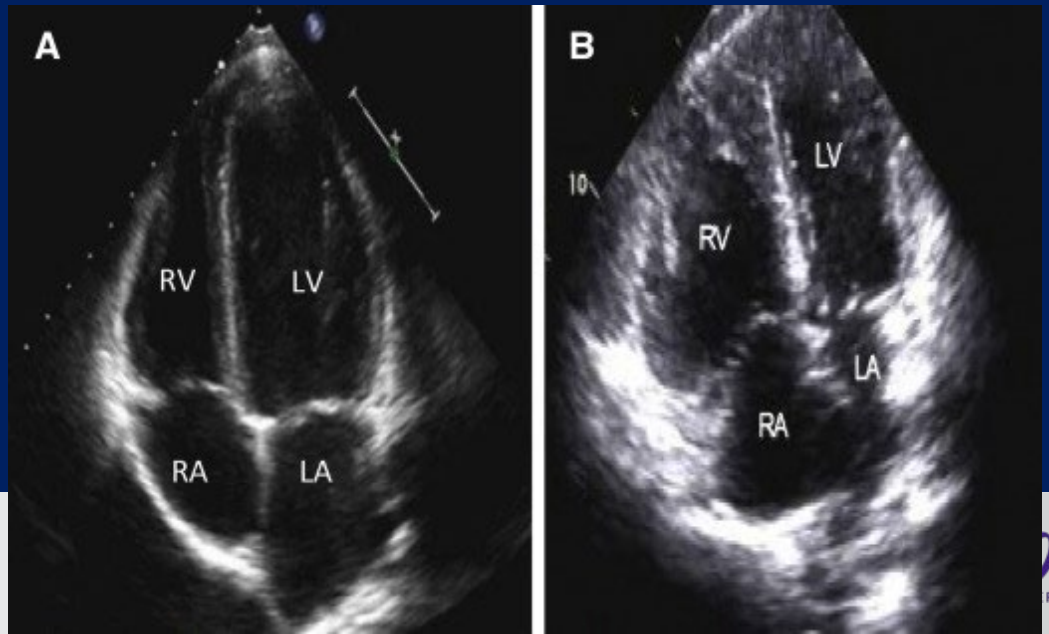




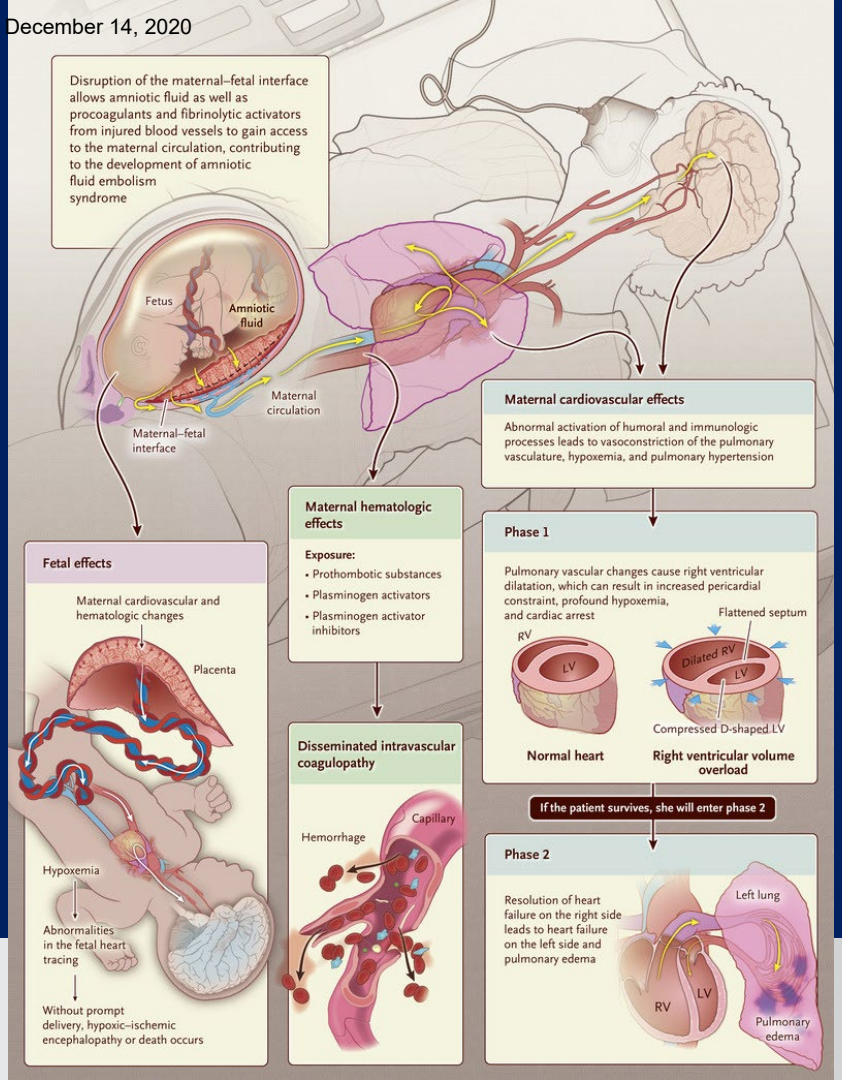
Left: Stock Media from Inok / Pond5
Right: N Engl J Med 1999; 341:586-592

Maternal Cardiovascular Effects

- Unbalanced activation of vasoactive substances
  - → vasoconstriction of pulmonary vasculature with resultant hypoxemia and PH
  - → Cor pulmonale, cardiac arrest



Pacheco. Immediate management of amniotic fluid embolism. Am J Obstet Gynecol 2020.



N Engl J Med 2019; 381:1664-1673

Clinical Presentation

- Symptoms often sudden
  - Prodrome typically involves acute dyspnea or cough, AMS, sudden hypoxia
    - Up to ⅓ of patients describe an aura of impending doom, chills, nausea/vomiting
  - Hypotension quickly follows
    - Postulated to be related to obstructive shock vs anaphylactoid reaction
  - Sudden cardiorespiratory failure
    - Typically related to sustained VT or VF, occasionally bradyarrhythmia

- If patient survives the initial cardiovascular collapse
  - DIC -> hemorrhage seen in >80% of pts with AFE
  - Seizures and/or stroke
    - Rarely reported as initial manifestations or complications of AFE
    - Case reports suggest related to presence of PFO

J Anaesthesiol Clin Pharmacol. 2016 Apr-Jun; 32(2): 153–159.
J Clin Neurosci. 2015;22(4):767. Epub 2015 Feb 21.

AFE Diagnosis

- Society for Maternal-Fetal Medicine and the AFE Foundation proposed the following diagnostic criteria (all must be present)
  - Sudden cardiac arrest or hypotension (SBP<90) with evidence of respiratory compromise (e.g. dyspnea, hypoxia, cyanosis)
  - Documentation of DIC (using modified ISTH criteria)
    - PLT > 100,000 = 0; < 100,000 = 1; < 50,000 = 2
    - Prolonged PT or INR (<25% increase = 0, 25-50% = 1, >50% = 2)
    - Fibrinogen >200 mg/L = 0; < 200 = 1
      - Score of ≥ 3 compatible with overt DIC
  - Onset during labor or within 30 min of placental delivery
  - Absence of fever during labor

Am J Obstet Gynecol 2016 Oct;215(4):408-12.

AFE Risk Factors

- Large, population-based studies evaluating multiple risk factors
  - Several identified, some discordance between studies
  - Most commonly cited risk factors
    - Cesarean delivery
    - Instrumented vaginal delivery
    - Placental abnormalities (previa, abruption, accreta)
    - Preeclampsia/eclampsia
  - No clinical or demographic risk factors consistently identified

Am J Obstet Gynecol. 2008;199(1):49.e1.
Lancet. 2006;368(9545):1444.
Obstet Gynecol. 2014;123(2 Pt 1):337.

Management of AFE

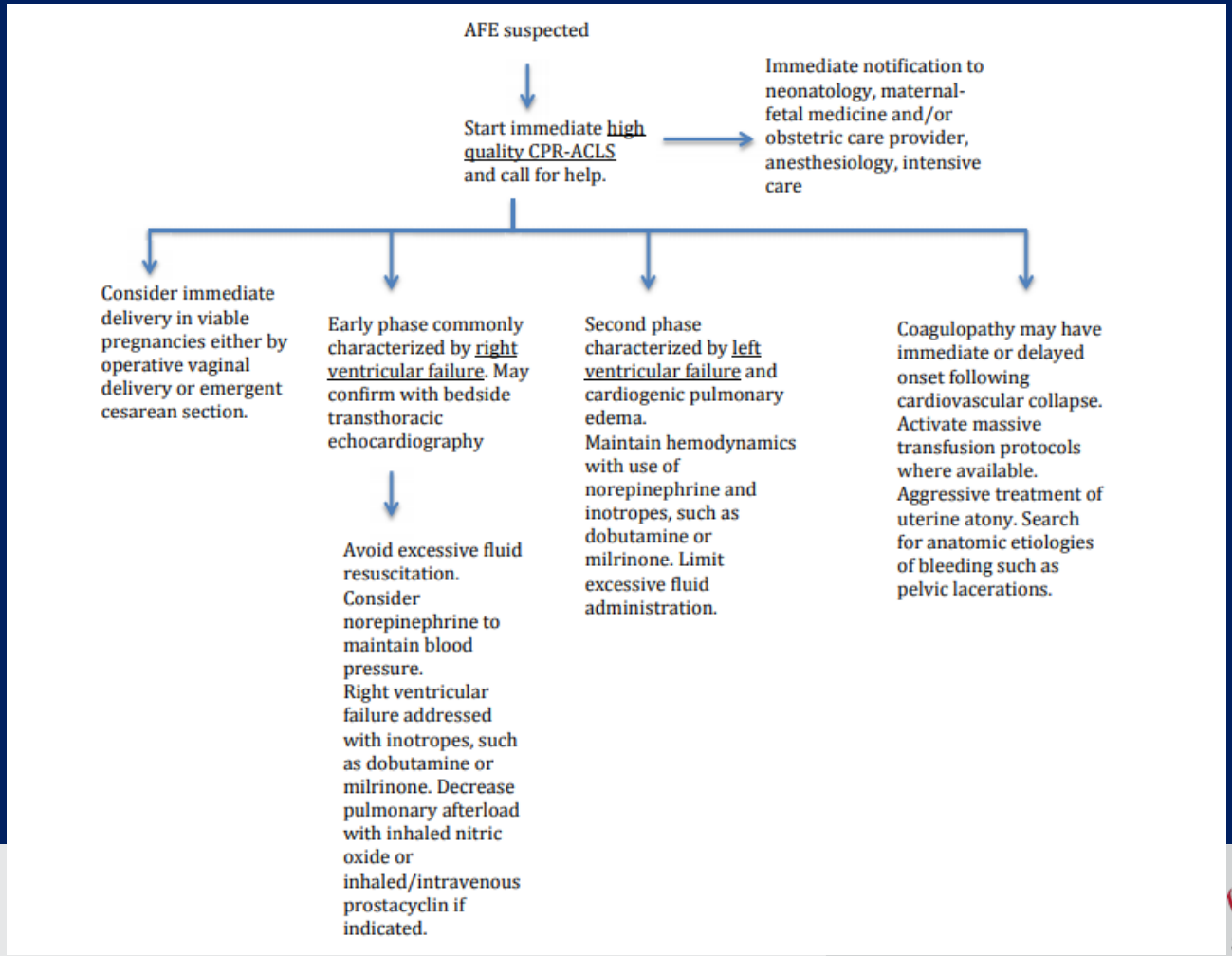
- SMFM Guidelines
  - Immediate high quality CPR (standard BCLS and ACLS) (Grade 1C)
  - Multidisciplinary team (Best Practice)
  - Vasopressors, antiarrhythmics, and defibrillation should be used with standard doses
  - Emergent perimortem cesarean performed simultaneously

TABLE 1
Components of high-quality cardiopulmonary resuscitation in pregnancy

Components
Rapid chest compressions (100 × minute)
Perform hard compressions, achieving a depth of at least 2 inches
Assure adequate chest recoil between compressions
Minimize interruptions of chest compressions
Avoid prolonged pulse checks (no more than 5—10 seconds)
Resume chest compressions immediately after defibrillating
Switch provider of compressions every 2 minutes to avoid fatigue
Lateral displacement of uterus during resuscitation

SMFM. Amniotic fluid embolism: diagnosis and management. Am J Obstet Gynecol 2016.

Am J Obstet Gynecol 2016;215:B16-24.



Am J Obstet Gynecol 2016 Oct;215(4):408-12.

Management of AFE

- Multidisciplinary, team-based approach recommended
  - CPR
  - Control hemorrhage / reverse coagulopathy
  - Deliver the fetus
  - Exclude alternative diagnoses
    - PE, sepsis, MI, OB hemorrhagic shock, air embolism, anesthetic complications, etc.

- Improved coordination of resuscitation postulated to account for improved mortality rate
  - What about ECMO?

Am J Obstet Gynecol 2016 Oct;215(4):408-12.

Current Guidelines

- “The use of VA-ECMO has been described in cases of AFE refractory to conventional resuscitation maneuvers. However, the use of AC during ECMO may worsen bleeding in the profoundly coagulopathic patient with active hemorrhage. Because of these concerns, as well as lack of adequate evidence of benefit, ECMO is controversial and not routinely recommended in the management of AFE.”


Society for Maternal-Fetal Medicine

SMFM Clinical Guidelines No. 9:

smfm.org

Amniotic fluid embolism: diagnosis and management

CrossMark

Society for Maternal-Fetal Medicine (SMFM) with the assistance of Luis D. Pacheco, MD; George Saade, MD; Gary D. V. Hankins, MD; Steven L. Clark, MD

Cases

Extracorporeal Therapies for Amniotic Fluid Embolism

Viau-Lapointe, Julien MD; Filewod, Niall MD, MSc

Use of Extracorporeal Membrane Oxyg … Fulminant Course of Amniotic Fluid Embolism Syndrome Immediate … livery

Jae Ha Lee, M.D.[1], Hang Jea Jang, M.D.[2], Jin Ha… D.[2], Sun Young Kim, M.D.[2], Hyun-kuk Kim, M.D.[2]

Case Reports

Successful application of extracorporeal … rane oxygenation and intra-aortic … n counterpulsation as lifesaving … y for a patient with amniotic fluid …

Case report

Amniotic fluid em… catastrophic pulmonary vas… diagnosis by transesophag… echocardiogram and trea… cardiopulmonary bypass ☆

Russell D Stanten MD[a], Leigh I.G Iverson MD[a], Terrance M Daugharty MD[a], Crystal Terry MD[a], Edward Blumenstock MD[a]

Temporary extracorporeal circulatory support and pulmonary embolectomy for catastrophic amniotic fluid embolism

Michael S Firstenberg [1], Erik Abel, Danielle Blais, Katja Turner, Mona Halim-Armanios, Galina Dimitrova, David Cohn, Philip Samuels

…D[a], Ping-Chun Li MD[b], Horng-Der Tsai MD[a], Chang-Hai …

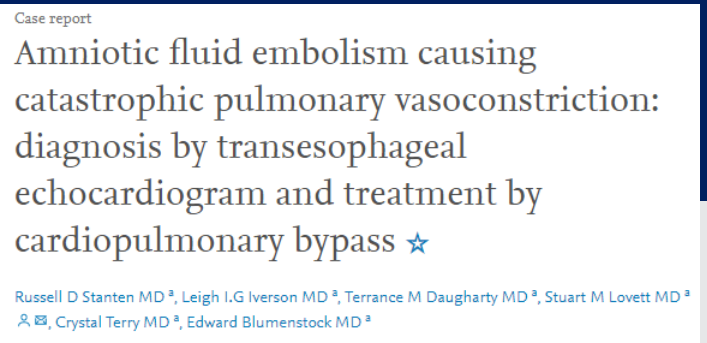
…RECORDS OF THE MASSACHUSETTS …

Ca… 2012 — A 43-Year-Old Woman with Cardiores… Cesarean Section

Jeffrey L. Ecker, M.D., Ken Solt, M.D., Michael G. Fitzsimons, M.D., and Thomas E. MacGillivray, M.D.

Case

- 45 G2P0, h/o prior myectomy admitted 37.5 weeks for elective Cesarean
  - 1 minute after clamping cord --> acute SOB, desats, hypotension, and LOC
  - Intubation, CPR
  - TEE within 10 minutes of arrest
    - Dilated, akinetic RV
    - Underfilled, hyperdynamic LV
  - Central cardiopulmonary bypass 53 minutes following arrest
    - 30,000u heparin at start of run
    - Coagulopathy corrected with blood products
  - TEE showed normalization of RV function
    - Decannulated after 83 minutes of run time
  - Extubated POD1, DC POD7 with near complete recovery (memory loss surrounding event)

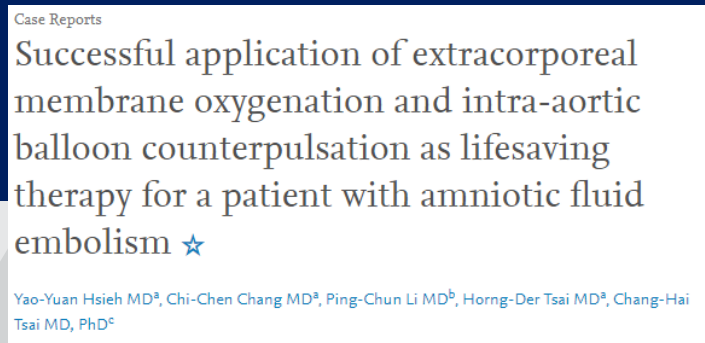

Case report

Amniotic fluid embolism causing catastrophic pulmonary vasoconstriction: diagnosis by transesophageal echocardiogram and treatment by cardiopulmonary bypass ☆

Russell D Stanten MD [a], Leigh I.G Iverson MD [a], Terrance M Daugharty MD [a], Stuart M Lovett MD [a], Crystal Terry MD [a], Edward Blumenstock MD [a]

Case

- 34 G7P3A3 admitted at term in labor
  - Cervical dilation to 3cm, reassuring FHT
  - 4 hrs after admission, sudden onset of sharp thoracic pain, dyspnea, and cyanosis
    - Followed by maternal disorientation and fetal bradycardia
  - Emergency cesarean section under local anesthesia
  - During C-section:
    - Maternal tachycardia, loss of pulse, DIC
    - CPR, massive transfusion, DCCV
    - Bedside u/s with dilated RV, underfilled/hyperdynamic LV
  - Peripherally cannulated VA-ECMO along with an IABP
    - Heparin administered
    - MCS weaned at 40 hrs post-partum
    - Discharged after 24 days without complication


Case Reports

Successful application of extracorporeal membrane oxygenation and intra-aortic balloon counterpulsation as lifesaving therapy for a patient with amniotic fluid embolism ☆

Yao-Yuan Hsieh MD[a], Chi-Chen Chang MD[a], Ping-Chun Li MD[b], Horng-Der Tsai MD[a], Chang-Hai Tsai MD, PhD[c]

Case

- 36F primigravida with twins
  - Gestational DM and HTN
  - Admitted at 30x5 with uncontrolled progression of labor → C-section under general anesthesia
  - Shortly after extubation, became cyanotic and hypotensive → PEA arrest
  - CPR and “immediate” cannulation for VA-ECMO
    - 3,000u heparin administered
    - Weaned off of ECMO at ~72 hrs
  - Labs consistent with DIC
  - CTA without PE
  - Trach placed on day 7
  - Prolonged encephalopathy, discharged to nursing home on HD 40 with cognitive impairment

Use of Extracorporeal Membrane Oxygenation in a Fulminant Course of Amniotic Fluid Embolism Syndrome Immediately after Cesarean Delivery

Jae Ha Lee, M.D.[1], Hang Jea Jang, M.D.[2], Jin Han Park, M.D.[2], Yong Kyun Kim, M.D.[2], Ho Ki Min, M.D.[2], Sun Young Kim, M.D.[2], Hyun-kuk Kim, M.D.[2]

TEE in AFE

Table 1. Transesophageal Echocardiographic Findings in Acute Amniotic-Fluid Embolism.

Year	Study	Findings	Outcome
2010	Lee et al.[15]	Severe right ventricular dysfunction Free-floating clot in the right and left atria	Cardiopulmonary bypass and survival
2009	Vellayappan et al.[19]	Enlarged right ventricle Moderate right ventricular hypokinesis Large mass in the right atrium through patent foramen ovale Dilated tricuspid valve annulus Trace-to-mild tricuspid regurgitation Normal left ventricle	Cardiopulmonary resuscitation and survival (pathology report showed squamous-cell epithelium in the mass)
2004	James et al.[13]	Normal left ventricular contractility D-shaped left ventricle Enlarged pulmonary artery and right ventricle Sluggish flow in the pulmonary arteries	Cardiopulmonary resuscitation and death
2003	Stanten et al.[10]	Massive right ventricular dilatation and akinesis Vigorous, small left ventricle	Cardiopulmonary bypass and survival
1999	Shechtman et al.[18]	Right ventricular failure Bulging of interatrial septum and interventricular septum toward the left Severe tricuspid regurgitation Small and decompressed left ventricle	Cardiopulmonary resuscitation and death

N Engl J Med 2012; 367:2528-2536

The Case for ECMO in AFE

- Cardiovascular collapse is a hallmark of AFE

- Standard of care is supportive in nature
  - Case can be made that ECMO cannulation should be considered
  - Anticoagulation used in many of these cases, though may not be needed if deemed too risky
  - The importance of multidisciplinary teams in the rapid management of presumed AFE

- Guidelines lag behind

Back to our case...

- Initial hemodynamics upon arrival to ICU
  - 3-4 LPM at 3500 RPM
  - PA 38/28 (32), RA 20, MAP 94
  - Started on dobutamine, lasix gtt, and nitroprusside

- No heparin was administered with cannulation in setting of hemorrhage
  - Decision made to forgo AC during ECMO run pending correction of coagulopathy
  - In coordination with OB/GYN, intensivists, and heart failure teams → started low-intensity fixed rate heparin (500 u/hr on 3/24, ~32.5 hrs after starting run)

- Hemodynamics remained stable
  - Limited turndown echo 3/24 AM reassuring
  - Full turndown 3/25 with therapeutic AC followed by decannulation (51.3 hrs total run time)

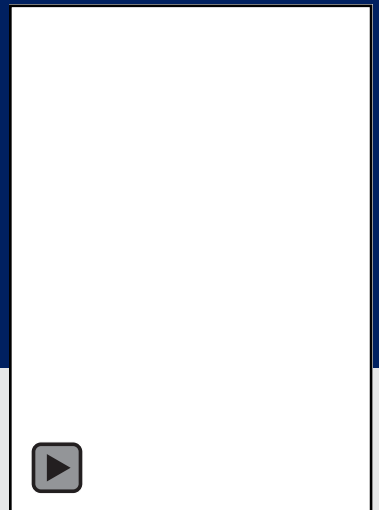
3/24 — Trouble waking with sedation reduction

- Neurology consulted
- Decreased movement R>L
- No movement of legs
- Not following commands

3/25 — CT head

- Unremarkable
- Normal gray-white definition

3/26 — MR brain



3/27 — Weaned off of vasoactive medications

4/4 — Ongoing acute encephalopathy

- Few signs of improvement
- Not following commands
- Efforts to wean sedation limited by agitation

4/6 — Family meeting

- While neurologic prognosis unclear, proceed with restorative care
- Plan for trach/PEG and eventual LTACH

4/7 — Trach placed

4/8 — PEG placed

- Gazes to left, able to track to the right
- Not following commands consistently
- Moves limbs spontaneously

4/9 — Able to wean off of sedation completely

4/12 — Continued improvement

- Now consistently following commands
- Mouths answers to questions
- Neurology notes “good prognosis” for first time

4/15 — Discharged to CKRI

- Bilateral R>L weakness
- Ambulating with walker
- Impaired cognition

4/21 — Discharged home

- Fully independent
- Return to normal cognition
- No appreciable deficits

Close to home

- A truly devastating turn of events in a moment supposed to be joyful
- An outcome worth celebrating
- Personal connection

Thank You!


VISITOR
Room #
Date:

Future Directions

- ELSO Registry
  - All cases of AFE managed with ECMO in the past 5 years
  - Will analyze clinical data and short-term outcomes
  - Collaboration with cardiology, ICU, OB/GYN
  - No prior case-series has been published