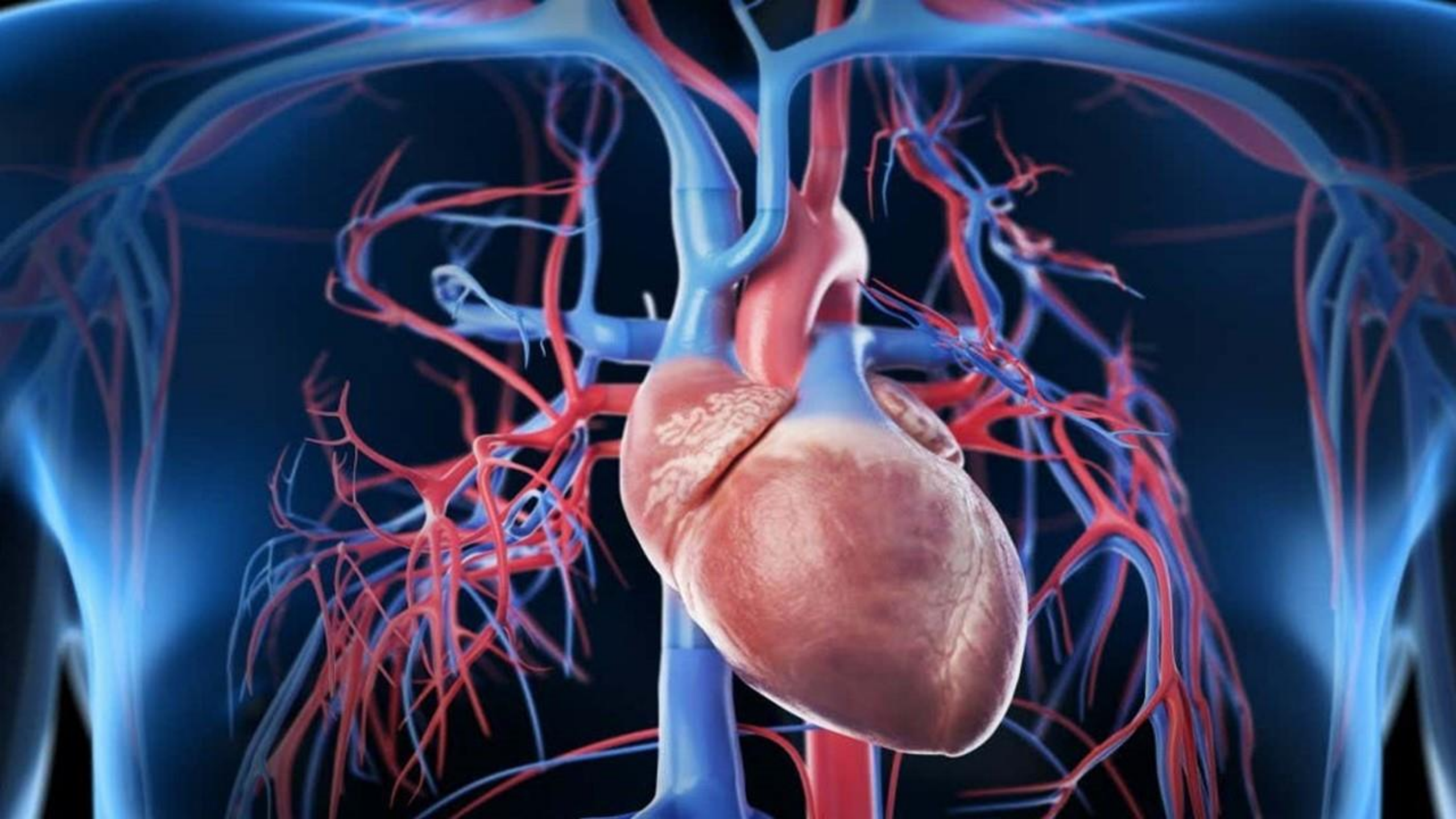


Treatment of Hemorrhagic Shock in the Elderly



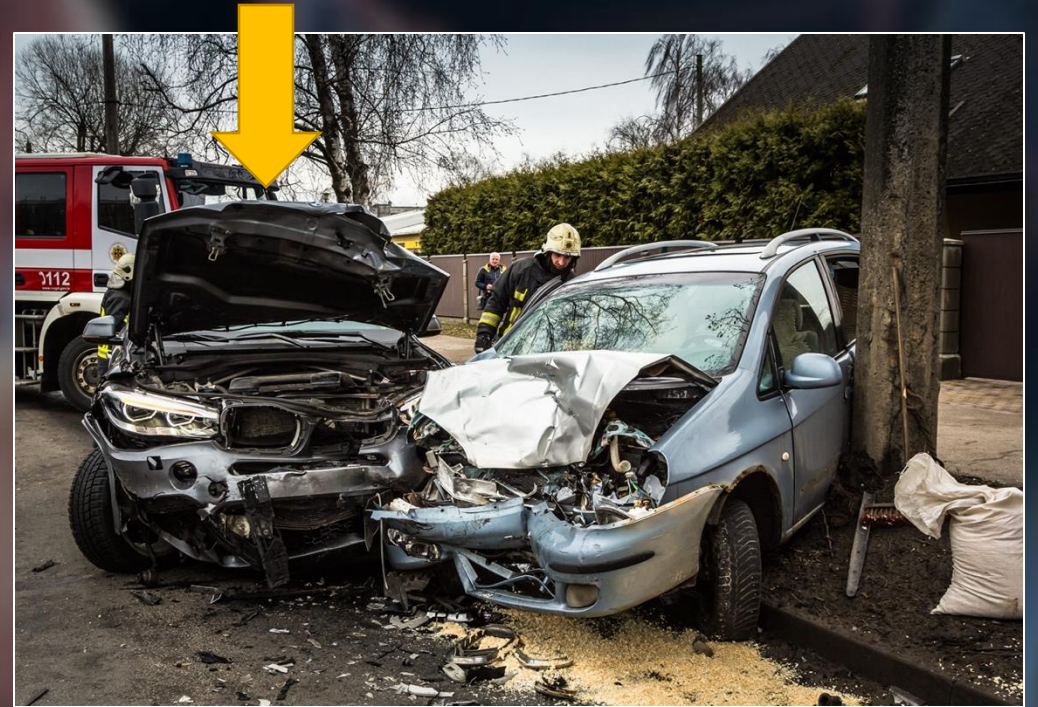
Bellal Joseph, MD, FACS
Professor & Chief of Trauma and Acute Care Surgery
The University of Arizona, Tucson, AZ





Case Scenario

- **20 y/o**
- **MVC**
- **Vitals: BP – 70/40 mm Hg**
Pulse – 110 beats/min
- **ABC score = 2**
- **Abnormal TEG**



Perspective on Resuscitation

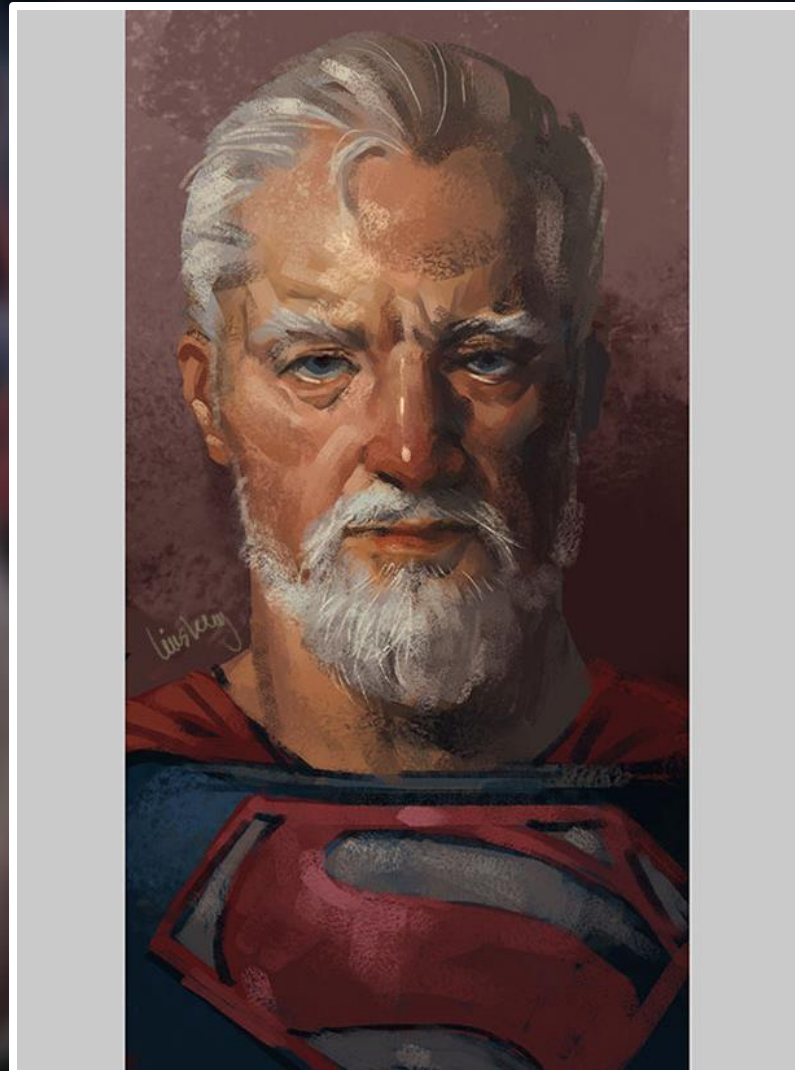
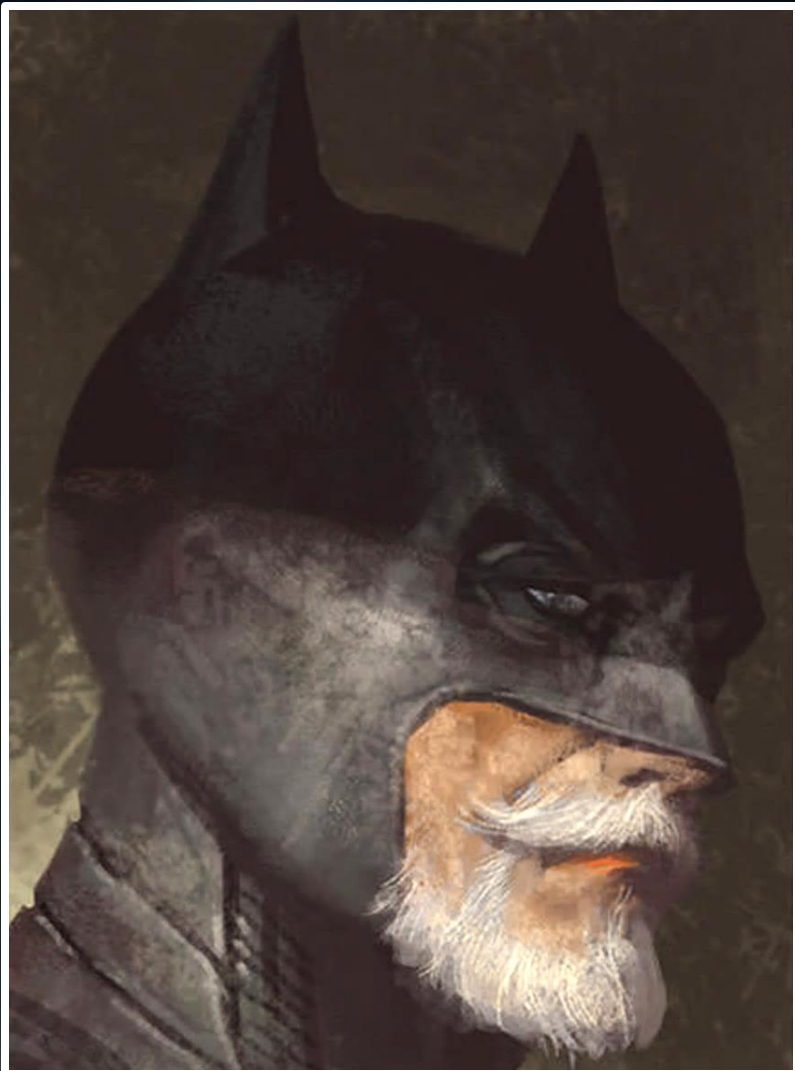


Case Scenario

- ~~70~~ **70** y/o
- MVC rollover
- Vitals: BP – **70/40** mm Hg
Pulse – **110** beats/min
- ABC score = **2**
- **Abnormal** TEG



Is There A Difference?



*“There are no secrets, no formulas.
It’s just a matter of **looking carefully**”*





The Dark Reality of Trauma

HEMORRHAGE

“The leading cause of **early** mortality in **adult** trauma patients”

The Dark Reality of Trauma



HEMORRHAGE



“The leading cause of **early** mortality in **adult** trauma patients”

Young Adults? / **Older** Adults?

Physiologic Response in Older Adults?

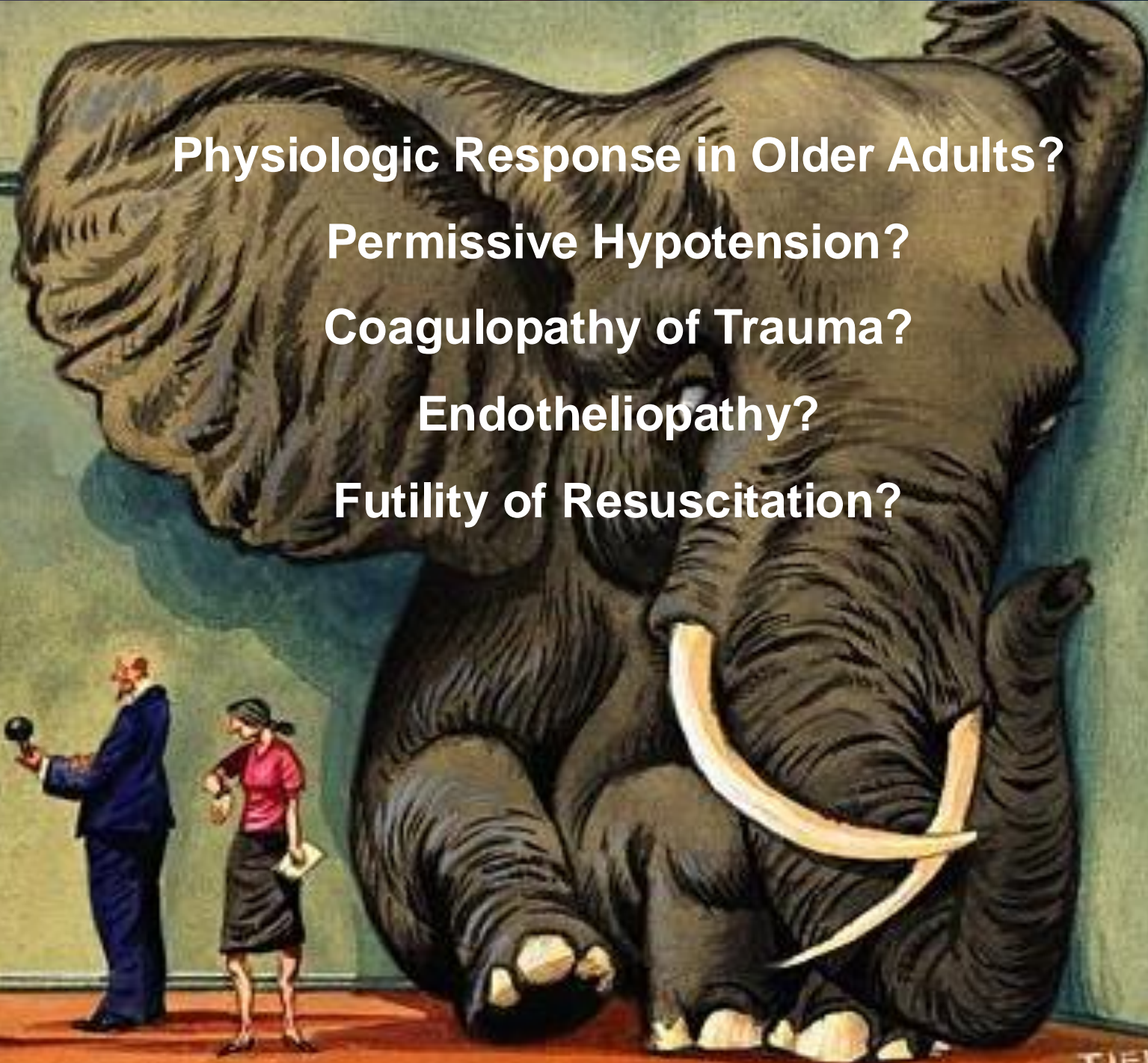
Permissive Hypotension?

Coagulopathy of Trauma?

Endotheliopathy?

Futility of Resuscitation?

1:1:1



TIEDEMANN

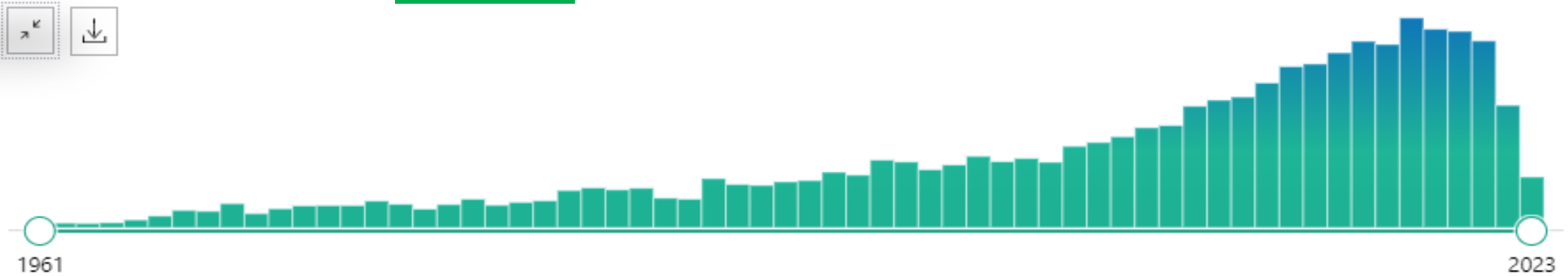
Resuscitation in Geriatric Trauma Patients Remains Unexplored



A Lot of Effort

PubMed.gov

Adult Trauma Resuscitation



Year	1974	1982	1992	2002	2008	2012	2017	2022
Count	136	155	281	500	698	975	1,211	685

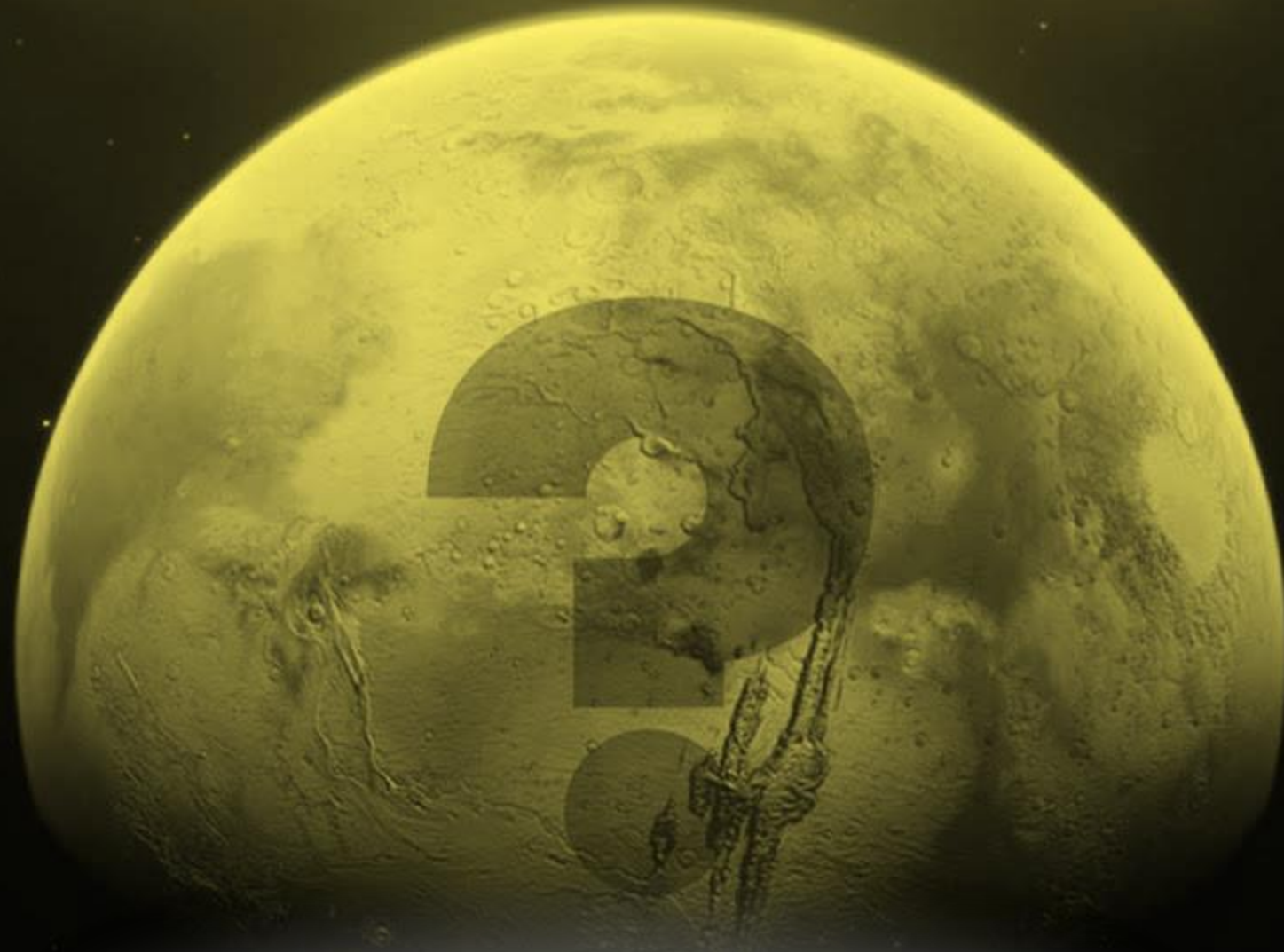
But **Not** Distributed Fairly



Older Adult Trauma Resuscitation



Year	1974	2000	2010	2015	2019	2020	2021	2022
Count	0	1	2	12	15	16	15	23



Why Is It Important?

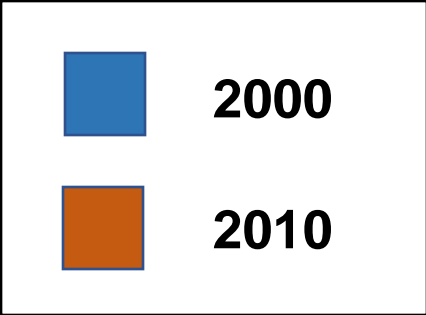
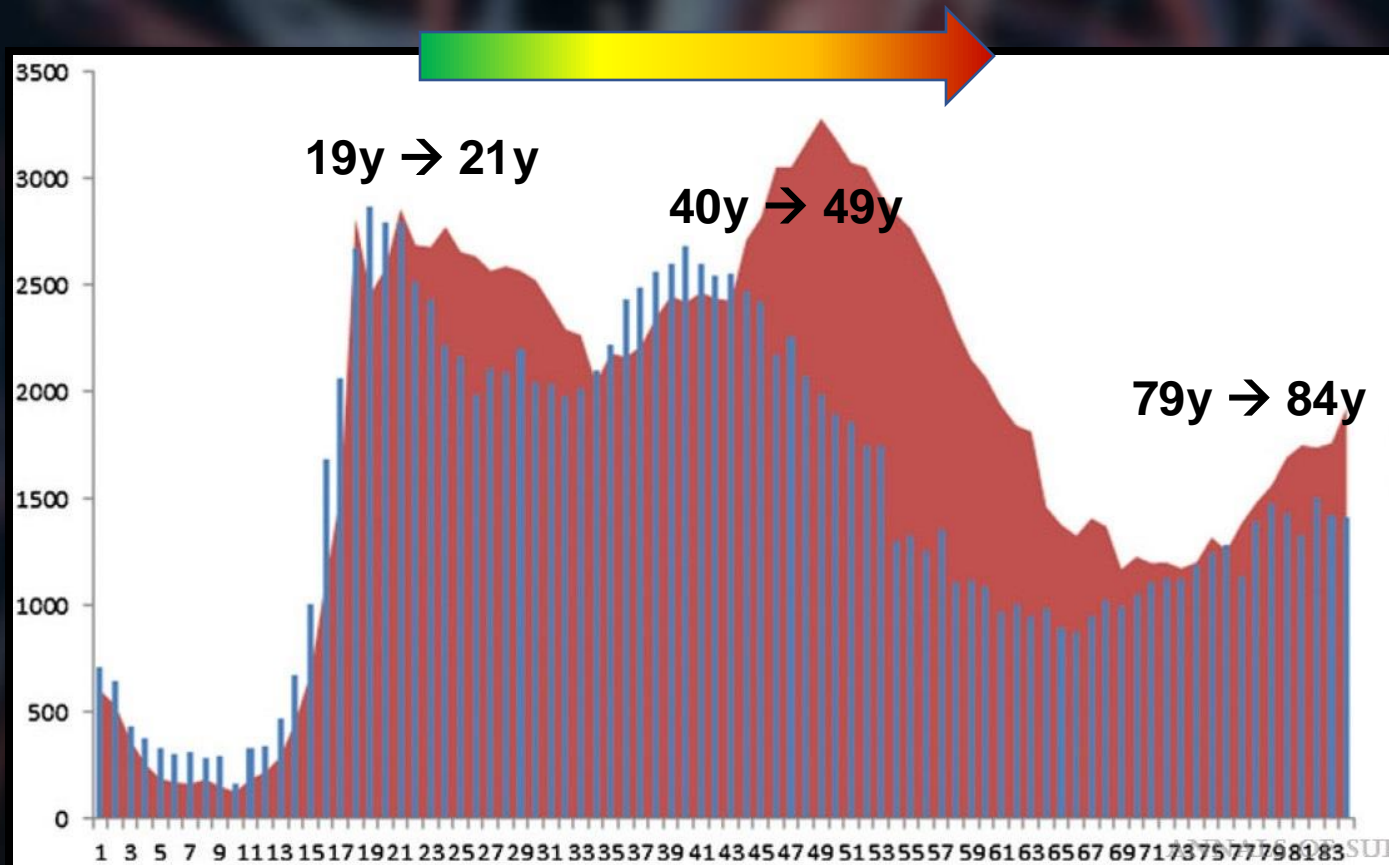
Aging Population Among Trauma Fatalities

Increasing Trauma Deaths in the United States

Rhee, Peter MD, MPH; Joseph, Bellal MD; Pandit, Viraj MD; Aziz, Hassan MD; Vercruyssen, Gary MD; Kulvatunyou, Narong MD; Friese, Randall S. MD



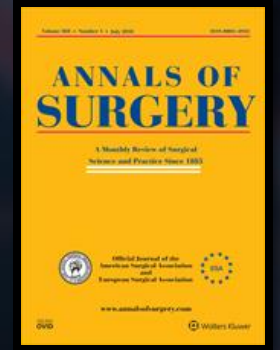
2014



Aging Population Among Trauma Fatalities

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Rhee, Peter MD, MPH; Joseph, Bellal MD; Pandit, Viraj MD; Aziz, Hassan MD; Vercruyssen, Gary MD; Kulvatunyou, Narong MD; Friese, Randall S. MD



2014

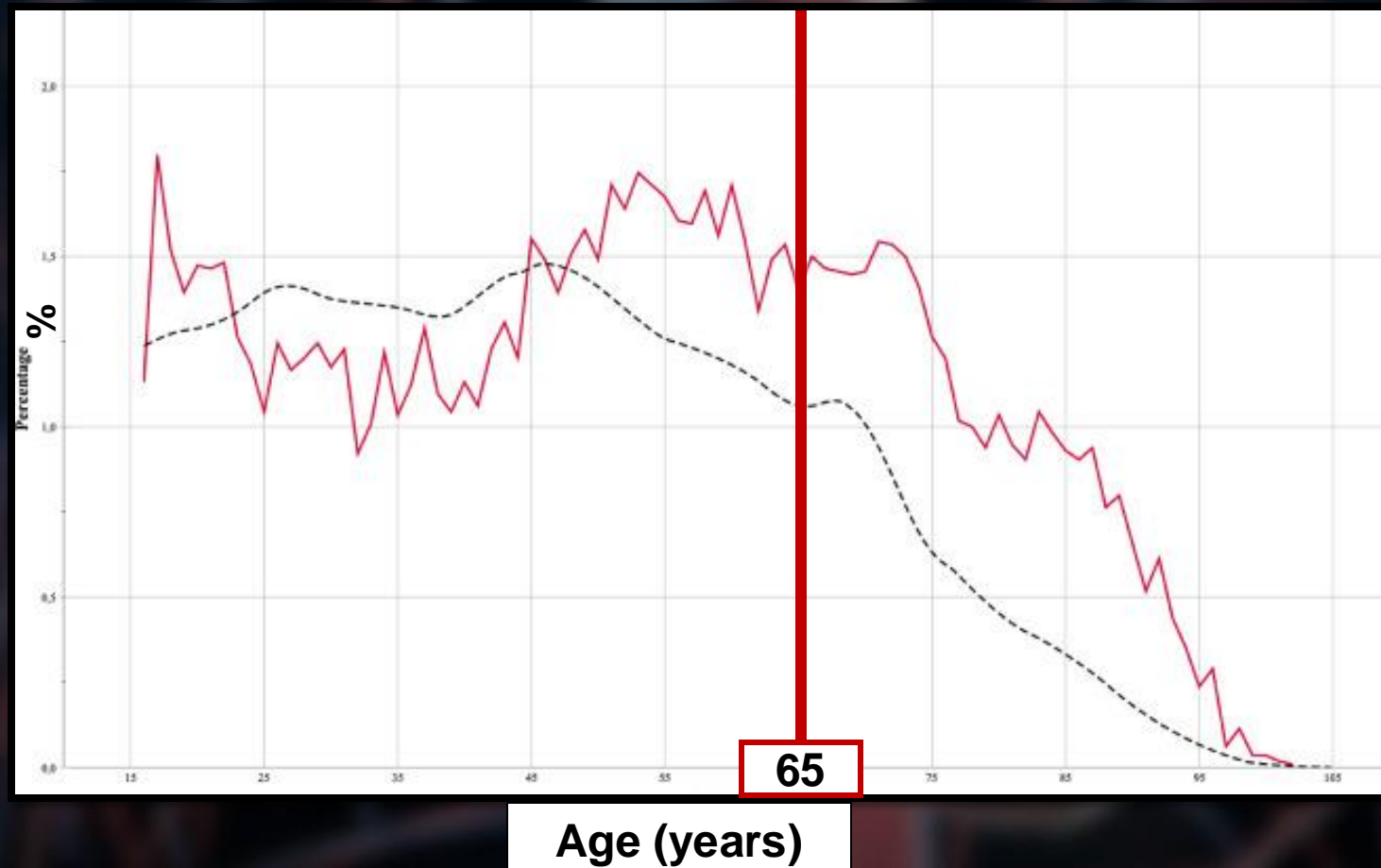
➤ Trauma was the leading cause of death in:

The **largest increases in trauma deaths** were in individuals in their **fifth and sixth decades of life**



2015 - 2018

Patients ≥ 65 constituted **33%** of the **trauma cohort**
but only **16.5%** of the **Norwegian population**



— Study Cohort
- - - Norwegian Population Age



Bleeding Control Bundle of Care

Trends in 1029 trauma deaths at a level 1 trauma center:

Impact of a bleeding control bundle of care

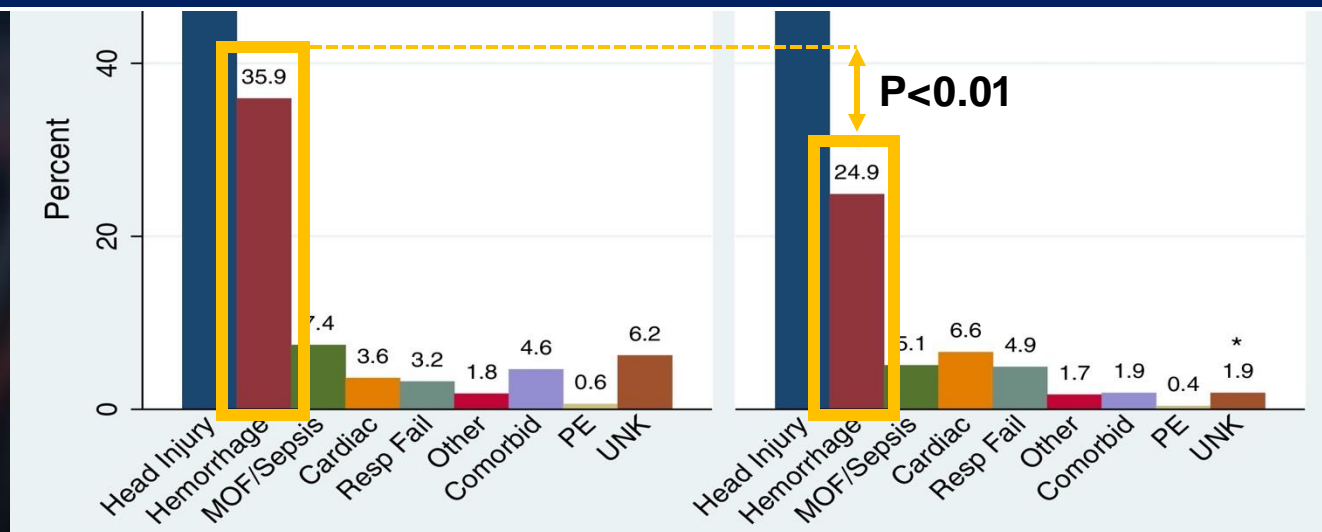
Blessing T. Oyeniyi, Erin E. Fox, Michelle Scerbo, Jeffrey S. Tomasek, Charles E. Wade, John B. Holcomb




2017

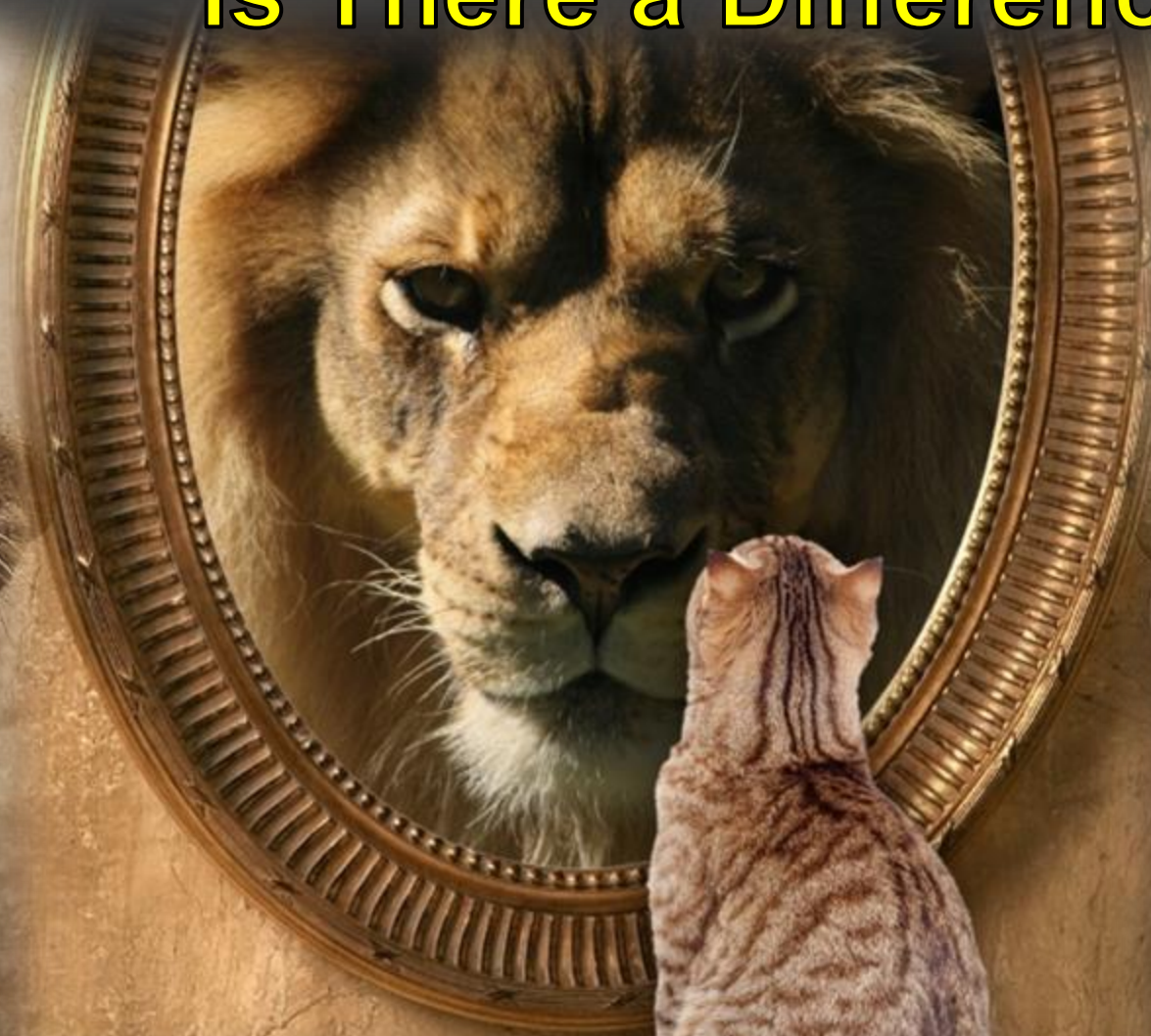
Overall Cause of Mortality

They observed an **aging population** among **all trauma pts** and among **trauma deaths** **over 9 years (2005- 2013)**



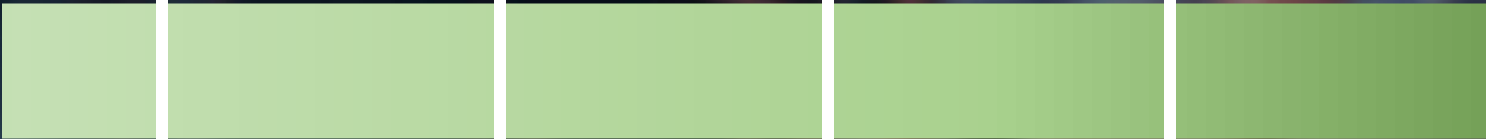

Hemorrhage-Related Mortality
(36% to 25%, $p < 0.01$)

Old vs Young Is There a Difference?



What is the Definition of the Old Age?

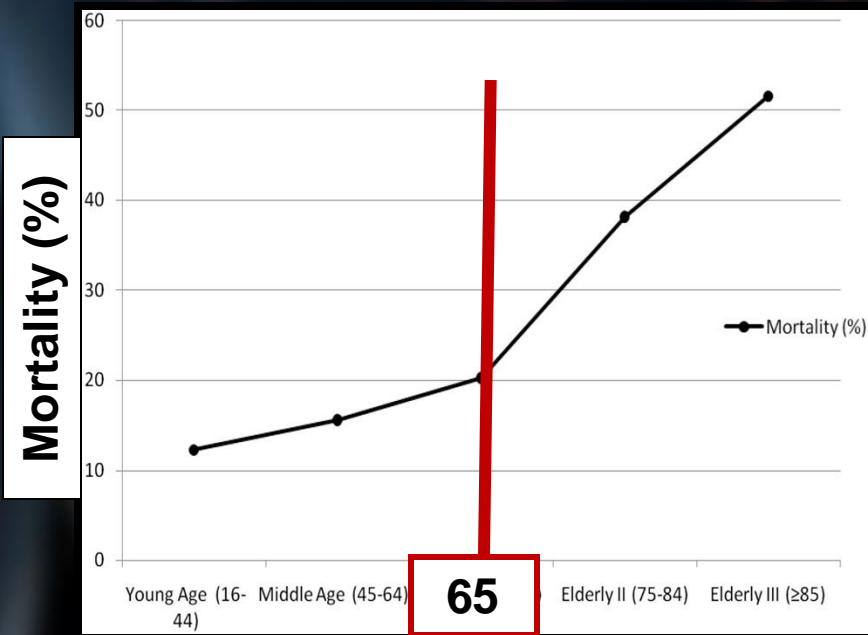
55 years 65 years 75 years 80 years



Inconsistent Definitions of Age

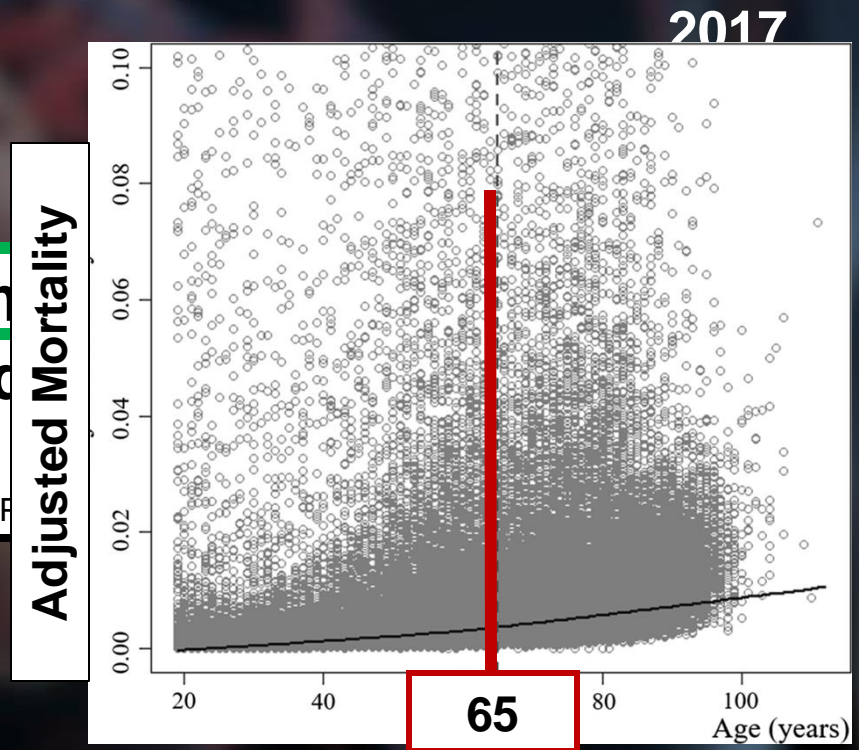
What is the Definition of the Old Age?

Mortality parallels **increasing age**, with the **inflection point at 65 years**



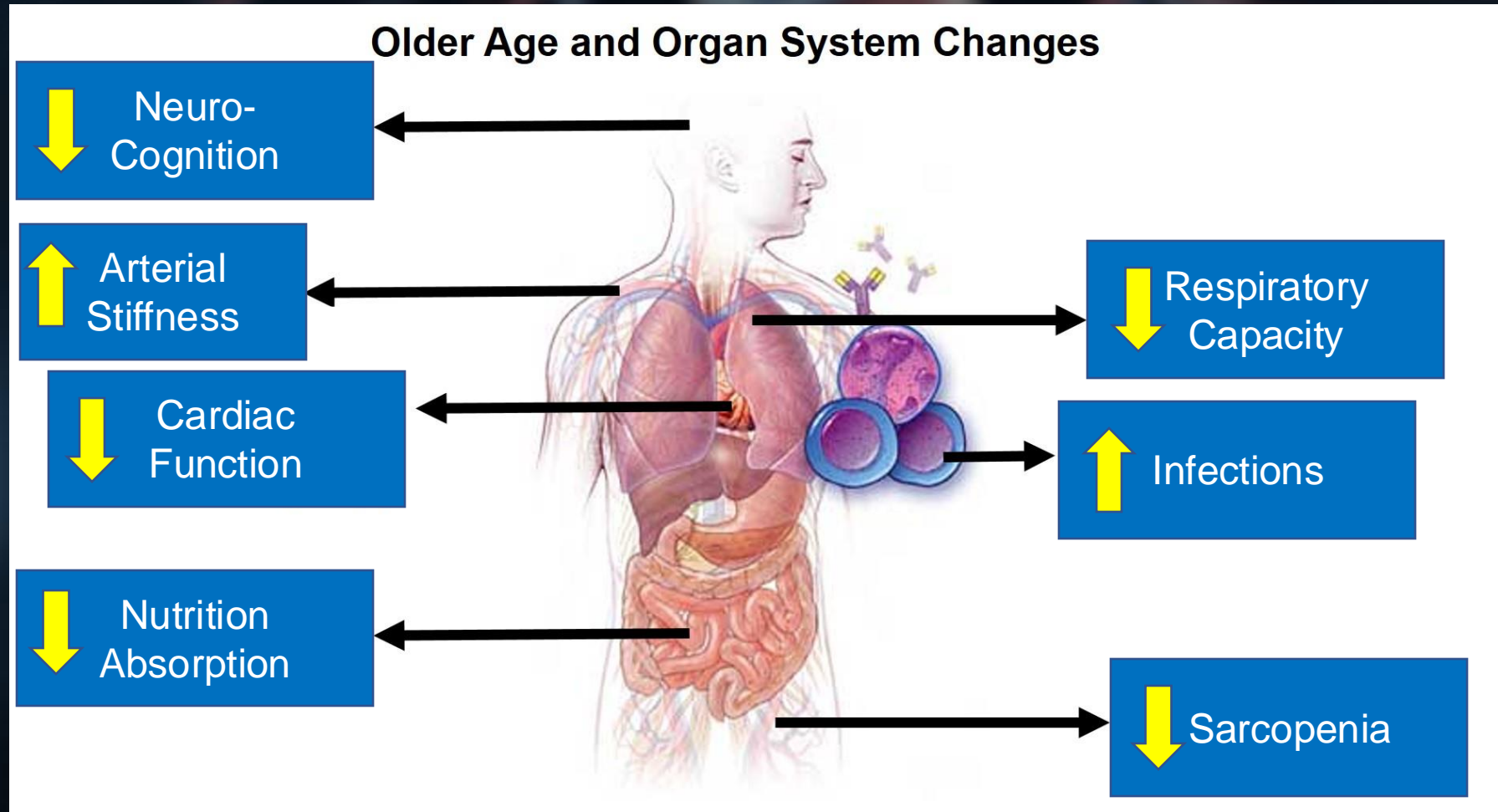
increased in-hospital mortality in a retrospective cohort study

Young Hong, Jinwoo Myung, Yun Ho Roh & Sung P



Aging

Illness leads to **devastating outcomes** in older adults



Aging vs. Frailty

Extensive Comorbidities

Cognitive Impairment

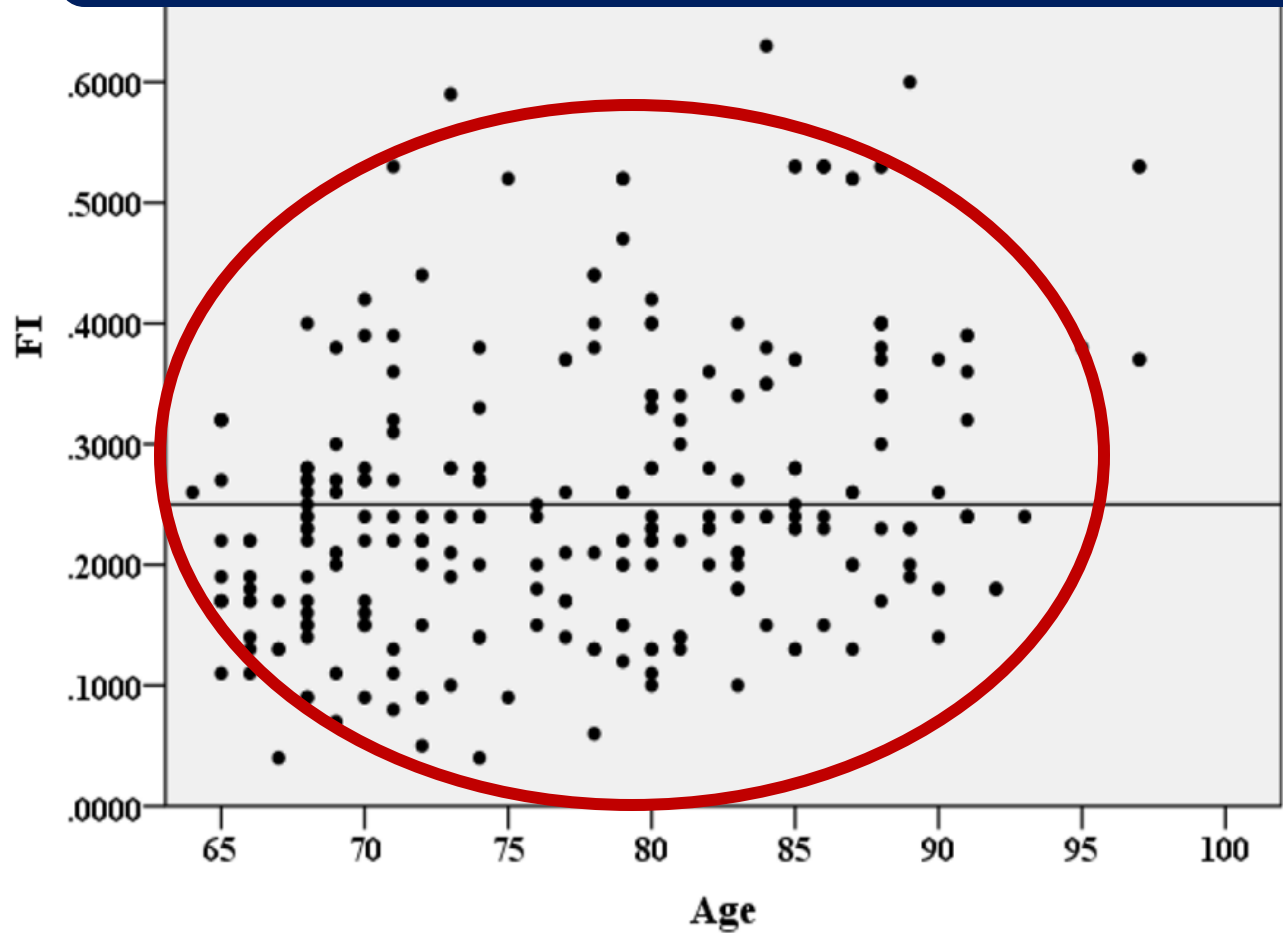
Social Isolation

Physical Function Impairment

Sedentary Behavior

Weight Loss

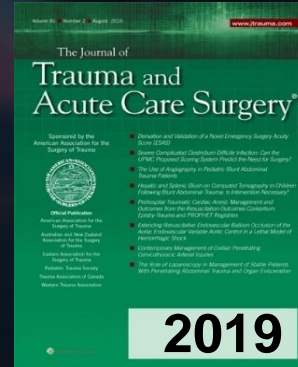
Frailty is Independent of Numeric Age!



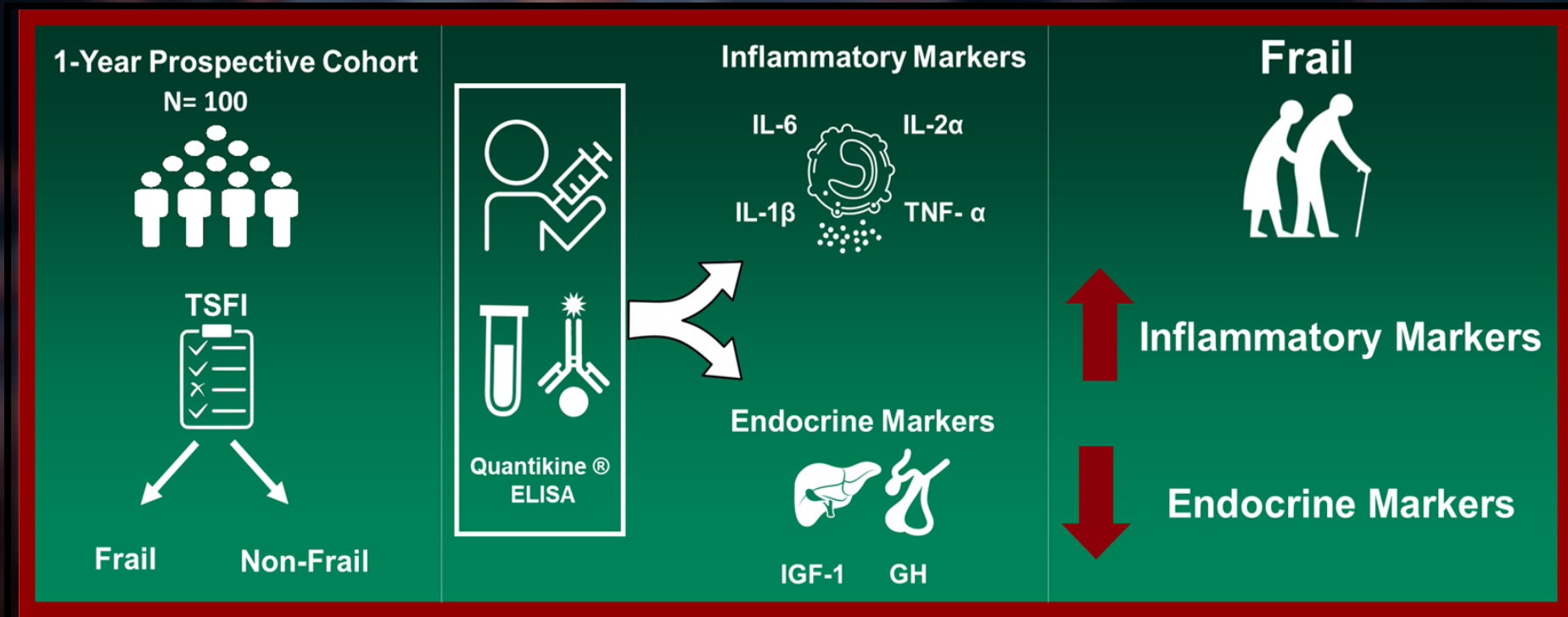
Frailty vs. Serum Biomarkers

The Acute Inflammatory Response after Trauma is heightened by Frailty: A Prospective Evaluation of Inflammatory and Endocrine System Alterations in Frailty

James Palmer, MS, Viraj Pandit, MD, Muhammad Zeeshan, MD, Narong Kulvatunyou, MD, Mohammad Hamidi, MD, Kamil Hanna, MD, Mindy Fain, MD, Janko Nikolich-Zugich, PhD, El-Rasheid Zakaria, PhD, and Bellal Joseph, MD.



- 100 Geriatric pts
- Frail vs Non-frail
- TSFI



Decreased Glycocalyx Shedding in Hemorrhaging Geriatric Trauma Patients

Tanya Anand, Zain G. Hashmi, Robert P. Richter, Bellal Joseph, Jillian R. Richter



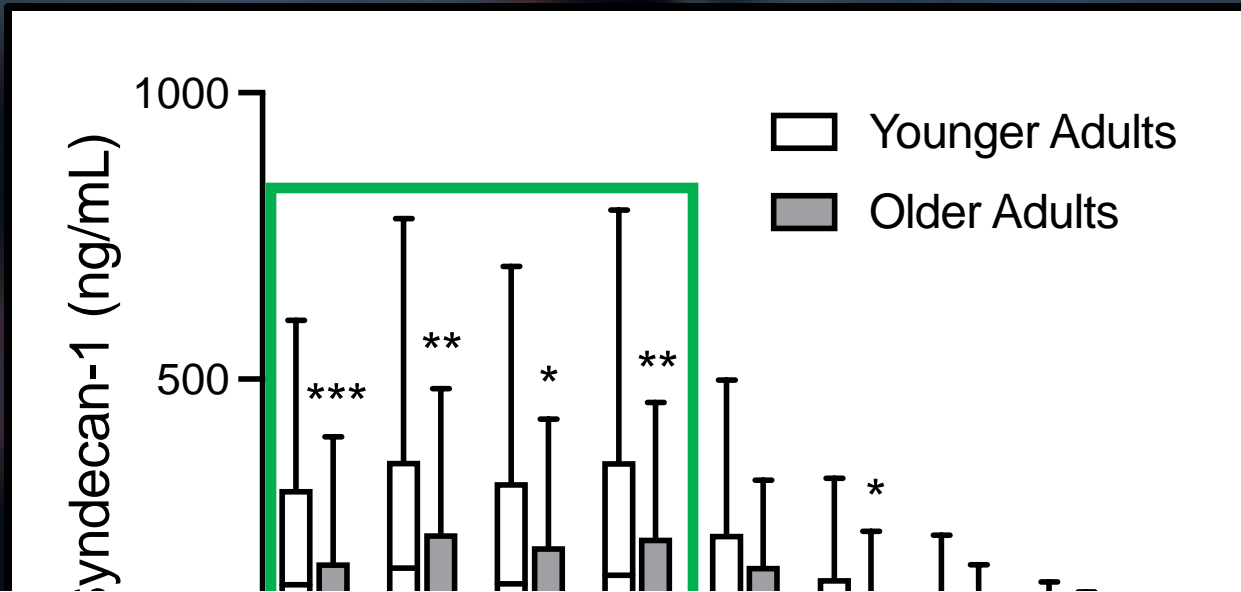
2023

- Secondary analysis of **PROPPR** trial
- **350** patients sustaining a **blunt** injury
- To compare glycocalyx shedding (**Syndecan-1 Level**) in **old** vs. **young**

Young
n=258

Vs.

Old
N=92



Age is independently associated with **Sdc-1 levels** among pts with **blunt** injuries

Multivariable Linear Regression

	B (95% CI)	P value
Age	-2.06 (-3.6 – -0.54)	0.008 *
Comorbidity	3.5 (-78.6 – 85.6)	0.933
Shock Index	76.3 (17.7 – 135)	0.011 *

Geriatric Hemorrhage



The Perfect Storm

Multiple
Comorbidities

Drugs

Low Physiological
Reserve

Frailty

REBOA

Decline

Orthopedic Triad

Blood Thinners

Renal Function

Civilian Hemorrhage-related Preventable Trauma Death

Median [IQR] Age

(Potentially) Preventable group
68 [46-84] yrs



Non-Preventable group
39 [26-57] yrs

- **55%** hemorrhage
 - In hospital: 44.3%
- **28%** hemorrhage



n=276 (41.9%)	n=271 (80.0%)
Non-Preventable: n=365 (55.4%)	Non-Preventable: n=52 (15.3%)
Unknown: n=2 (0.3%)	Unknown: n=0 (0.0%)

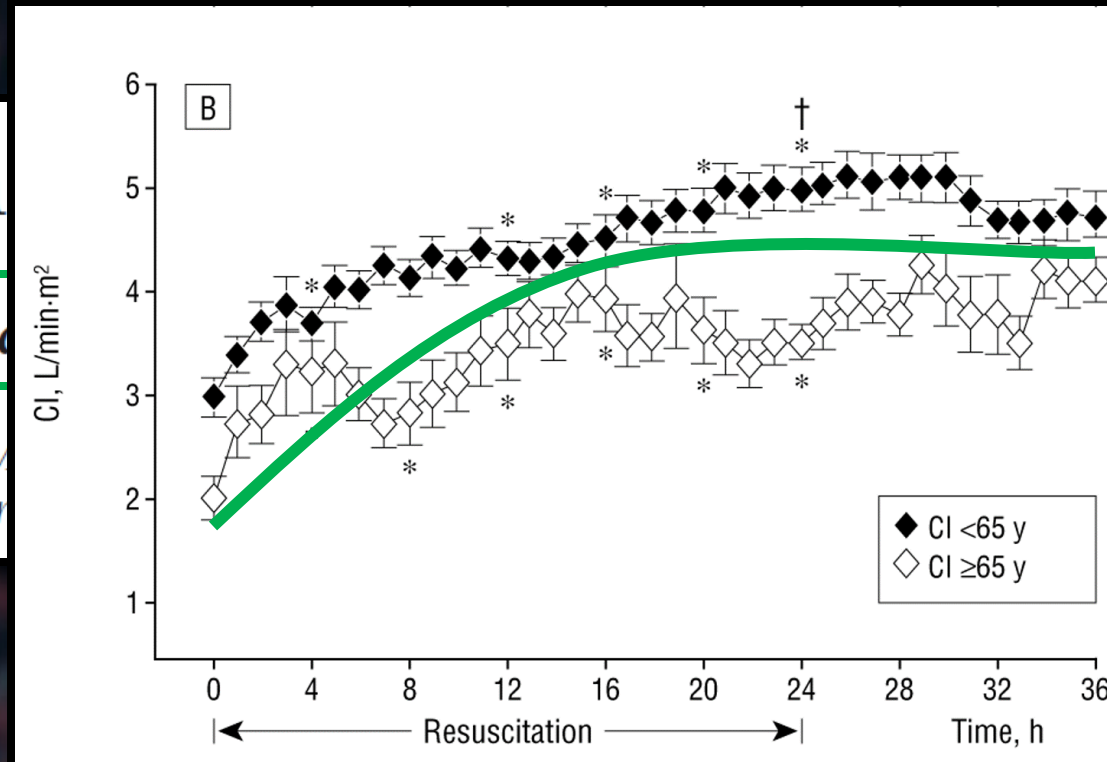
INSPIRE



Blum

The Old

Bruce A. M.
Alicia M.



hour, MD;



- Elderly pts have **initially depressed cardiac index** but generate a **hyperdynamic response**
- Although **ultimate outcome is poorer** than in the younger cohort, **resuscitation is not futile**

Successful Resuscitation Requires A Bundle of Care



**Blood
Products**

Triage

PreHospital



TEG

Time

Optimal Triage Prehospital Care



Trauma Team Activation

Geriatric Trauma Triage: Does it matter and when do you do it?

Moderator: Jody Digiacomo, MD

Speakers: Joseph Poslunzny, MD; Sasha Adams, MD; Jennifer Knight Davis, MD



2022

- **Age alone** is not a good indicator of trauma activation
- Geriatric trauma pts have a **blunted physiologic response to injury**
- Existing triage criteria for geriatric patients are **outdated**

OUTDATED

Shock index predicts mortality in geriatric trauma patients

An analysis of the National Trauma Data Bank

Pandit, Viraj MD; Rhee, Peter MD; Hashmi, Ammar MD; Kulvatunyou, Narong MD; Tang, Andrew MD; Khalil, Mazhar MD; O’Keeffe, Terence MbChB; Green, Donald MD; Friese, Randall S. MD; Joseph, Bellal MD



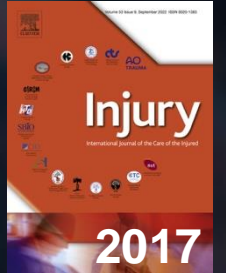
- **SI** is superior to **HR** & **SBP** for predicting **mortality** in **geriatric** trauma pts
 - How can we **predict** the need for **massive transfusion**?

	Age 65–74 y		Age 75–84 y		Age > 85 y	
	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
SI > 1	3.6 (1.8–5.4)	0.001	3.2 (2.1–4.6)	0.001	2.1 (1.4–3.9)	0.01
Male	1.1 (0.7–1.8)	0.4	1.3 (0.9–2.3)	0.2	1.15 (0.9–2.5)	0.7
SBP	1.4 (0.9–2.9)	0.09	1.6 (0.6–3.1)	0.1	1.2 (0.7–1.8)	0.4
HR	1.1 (0.9–1.9)	0.6	1.1 (0.8–2.1)	0.5	1.4 (0.8–3.2)	0.2

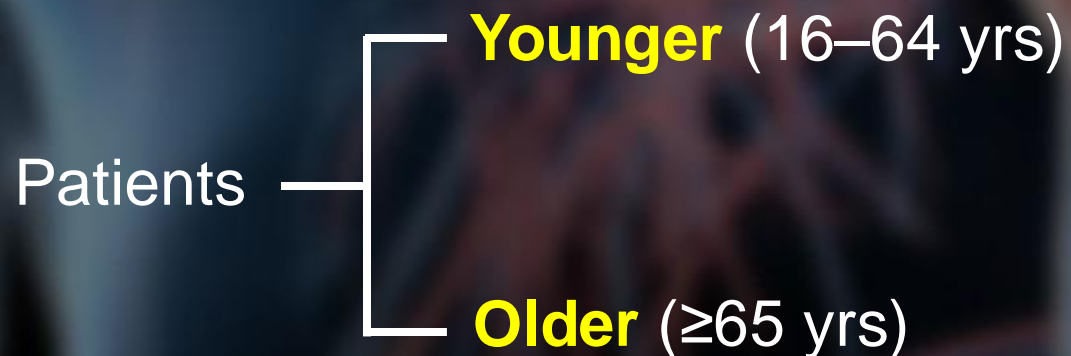
Scoring Systems

Early predictors for massive transfusion in older adult severe trauma patients

Takao Ohmori, Taisuke Kitamura, Junko Ishihara, Hirokazu Onishi, Tsuyoshi Nojima, Kotaro Yamamoto, Ryu Tamura, Kentaro Muranishi, Toshiyuki Matsumoto, Takamitsu Tokioka



- Severely injured trauma patients (**ISS ≥ 16**), admitted from 2007 to 2015
- Aim: To compare the effectiveness of **different scoring systems** in GTPs



Scoring Systems

TASH score

(Trauma **A**ssociated **S**evere **H**emorrhage)

ABC score

(**A**ssessment of **B**lood **C**onsumption)
A? **Bryan Cotton**

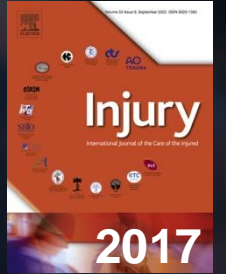
PWH score

(Prince of **W**ales **H**ospital)

Scoring Systems

Early predictors for massive transfusion in older adult severe trauma patients

Takao Ohmori , Taisuke Kitamura, Junko Ishihara, Hirokazu Onishi, Tsuyoshi Nojima, Kotaro Yamamoto, Ryu Tamura, Kentaro Muranishi, Toshiyuki Matsumoto, Takamitsu Tokioka




The **AUC** was significantly **smaller** for **older** group than for **younger** group for **all three scoring systems** ($p < 0.05$)

RABT Score

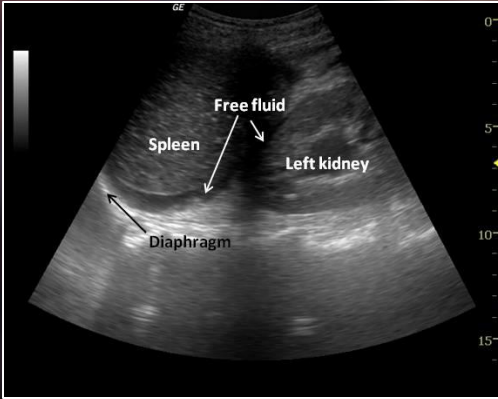
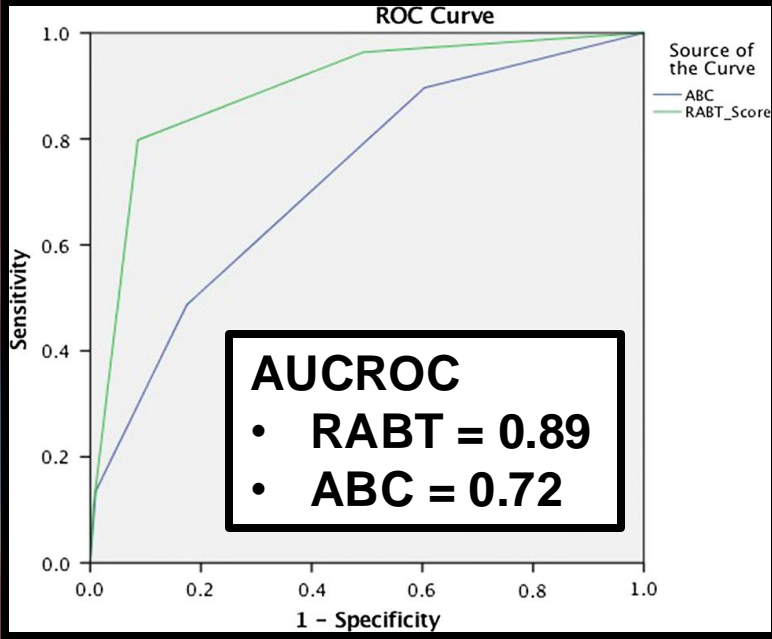
RABT: Revised Assessment of Bleeding & Transfusion Score

1. **Penetrating** injury
2. **Positive** FAST
3. **SI > 1.0**
4. **Pelvic Fracture**

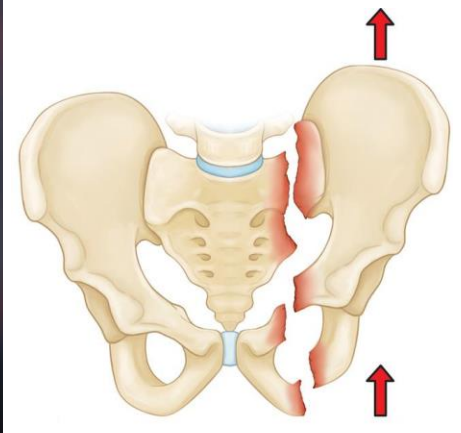
≥ 2 predicts MT



Joseph et al. World J Surg 2018



$$\frac{\text{Heart Rate}}{\text{Systolic BP}} = \text{Shock Index}$$

Predicting MT in Older Adults

The **RABT Score** Outperforms the ABC Score in Predicting Massive Transfusion for **Older Adult Trauma Patients**:
Secondary Analysis of a Multi-Institutional Trial



- Secondary analysis of RABT score MIT(2015-2017)
- **242** severely injured (median ISS, 27) geriatric trauma pts
- To compare **RABT** & **ABC** score in **predicting MT** in **older adults**





RABT Score ≥ 2

Sensitivity: 72.5%

Specificity: 90%

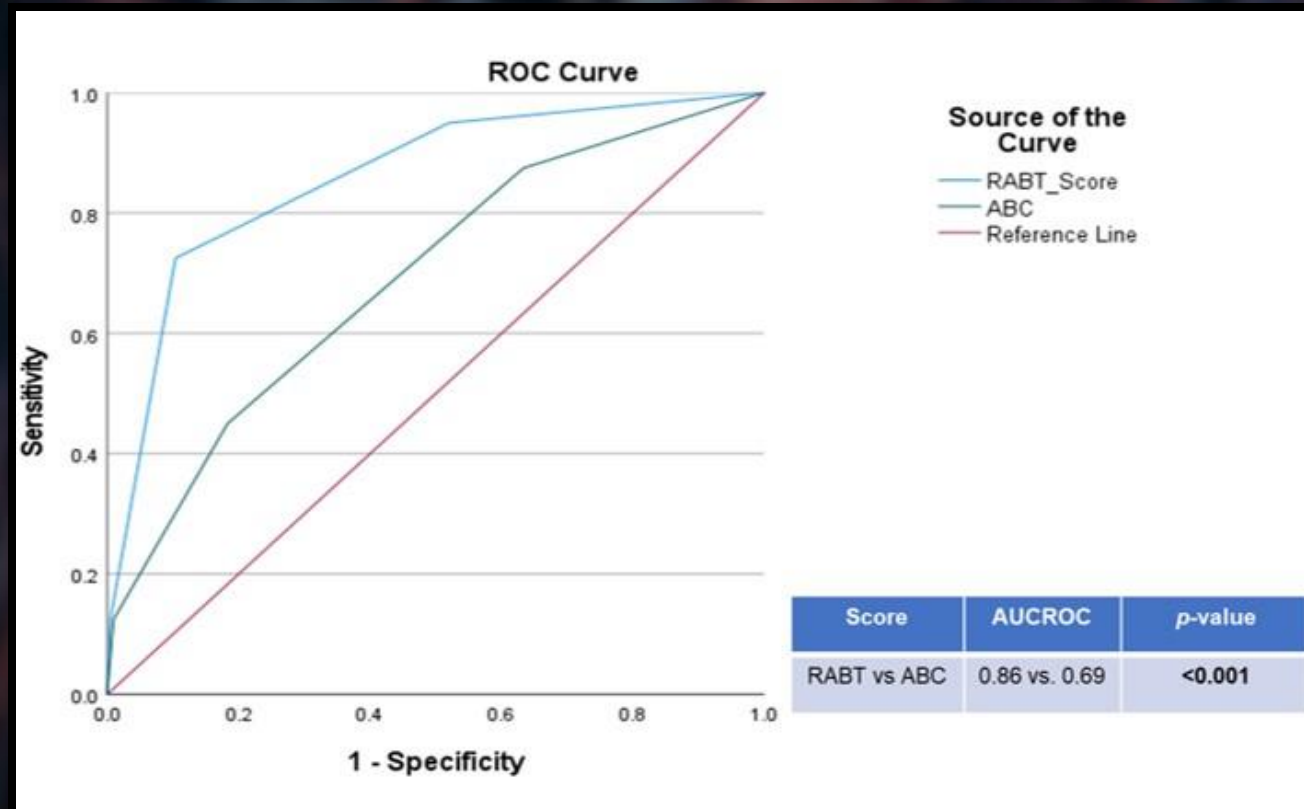
AUC curve: **0.859**

ABC Score ≥ 2

Sensitivity: 45%

Specificity: 82%

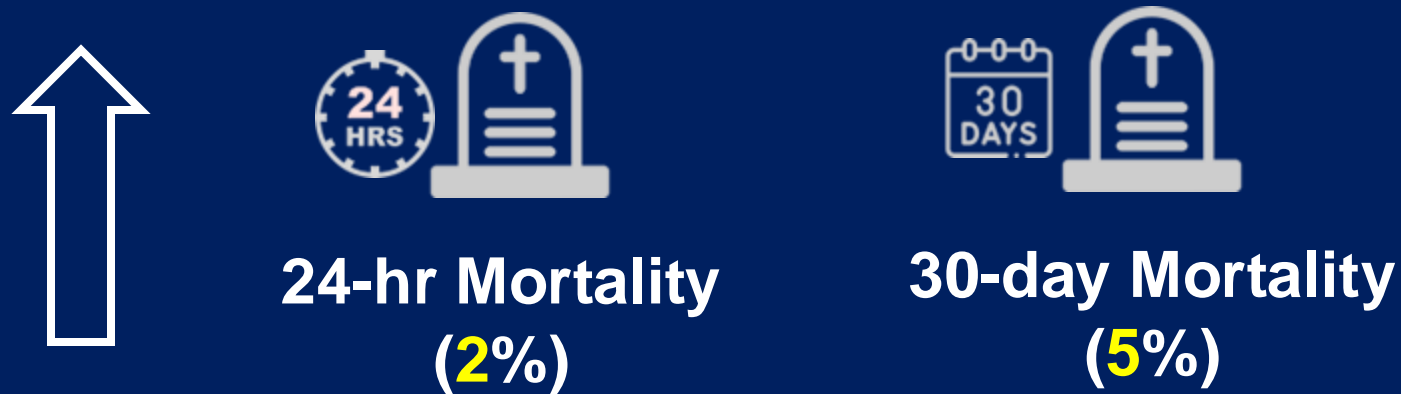
AUC curve: **0.692**



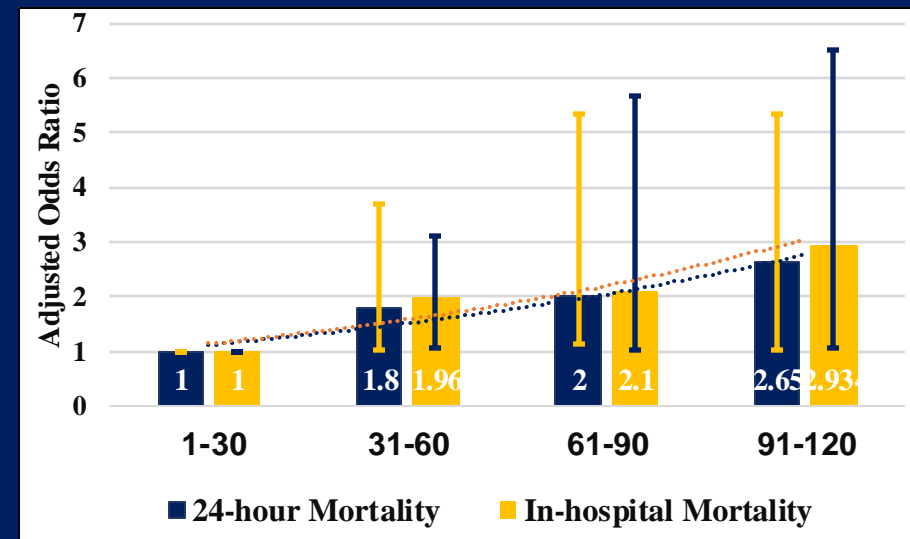
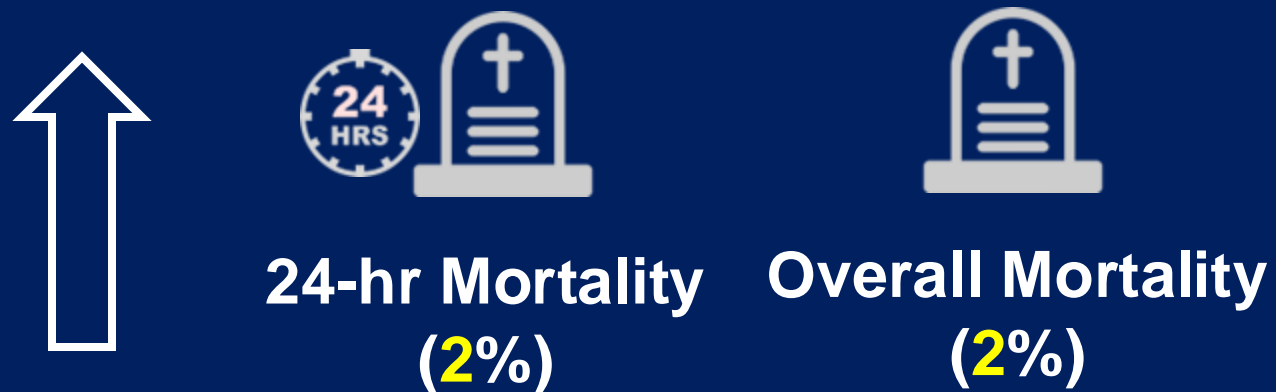
An hourglass is shown with glowing, starry sand falling from the top bulb to the bottom bulb. The sand is composed of numerous small, bright white and yellow particles, creating a trail of light. The hourglass is set against a dark blue background with a subtle gradient. A semi-transparent dark blue horizontal band is positioned across the middle of the image, containing the text.

Time Matters

- Every **minute delay** in arrival of first cooler:



- Every **minute delay** in WB transfusion:



Time-critical Interventions

Differences in time-critical interventions and radiological examinations between adult and older trauma patients

Cuevas-Østrem, Mathias MD; Wisborg, Torben MD, PhD; Røise, Olav MD, PhD; Jeppesen, Elisabeth MPH, PhD



- Analysis of the **2015-2018** Norwegian Trauma Registry
- **9,543** trauma patients, of which **28%** were **≥ 65 years**

Older Patients vs. Adult Patients



Attended by **prehospital doctor/paramedic team**

(aOR 0.64)



Transfer by **air ambulance**

(aOR 0.65)



Transfer directly to a **Trauma center**

(aOR 0.86)

Activation of Massive Transfusion for Elderly Trauma Patients

Jason S. Murry, M.D., Andrea A. Zaw, M.D., David M. Hoang, M.D., Devorah Mehrzadi, B.A., Danielle Tran, B.S., Miriam Nuno, Ph.D., Matthew Bloom, M.D., Nicolas Melo, M.D., Daniel R. Margulies, M.D., Eric J. Ley, M.D.



Mortality rates were **similar** in **old** and the **young adults**
(**50%** vs **53%**, $P = 0.80$)

Resource Utilization?

Activation of MTP should be considered in the **elderly** as this population may be
responsive to early aggressive blood transfusion

In summary



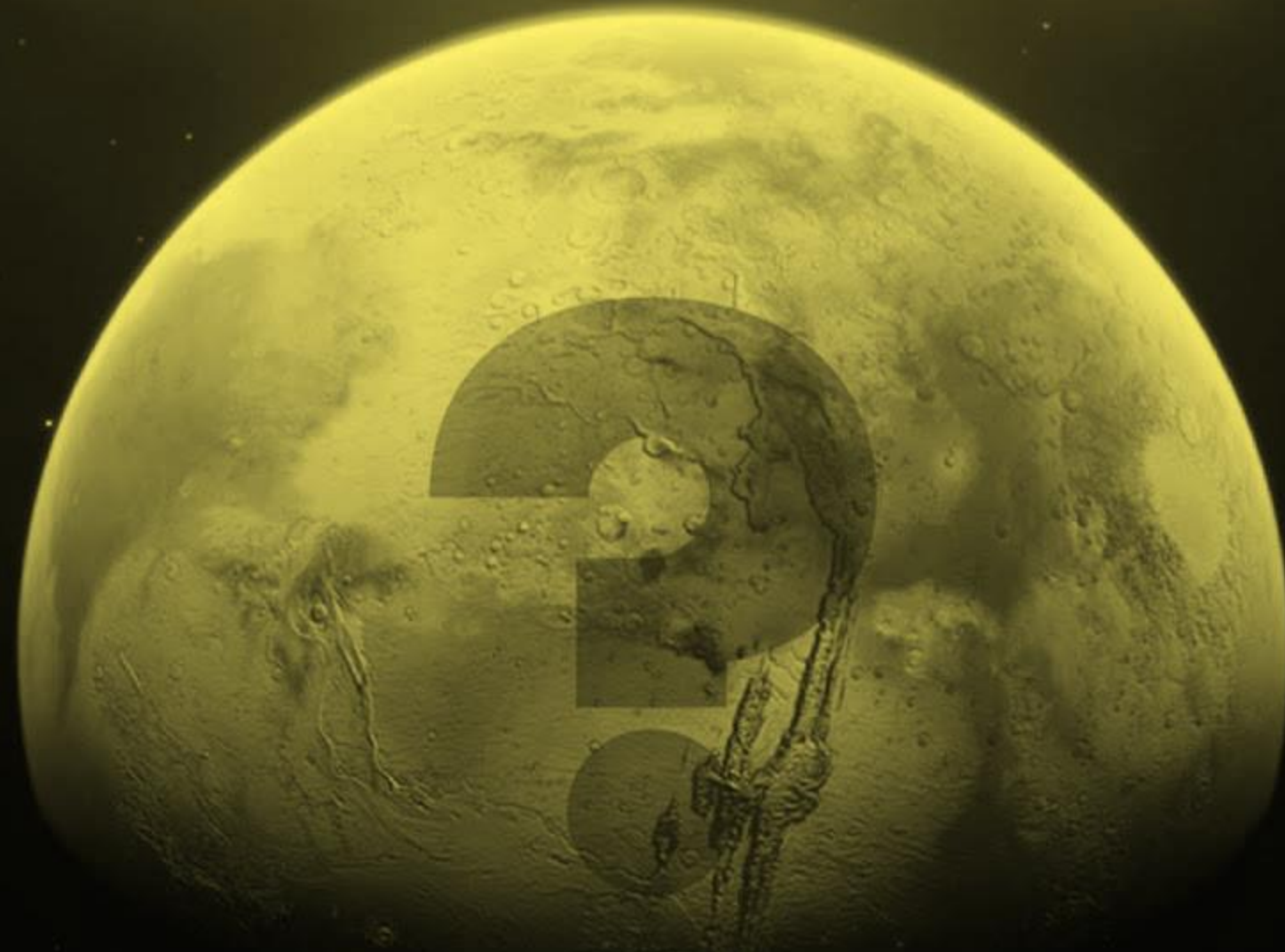
Predicting the
Need for MT



Timely
MTP Activation



Successful
Resuscitation
of Older Adults



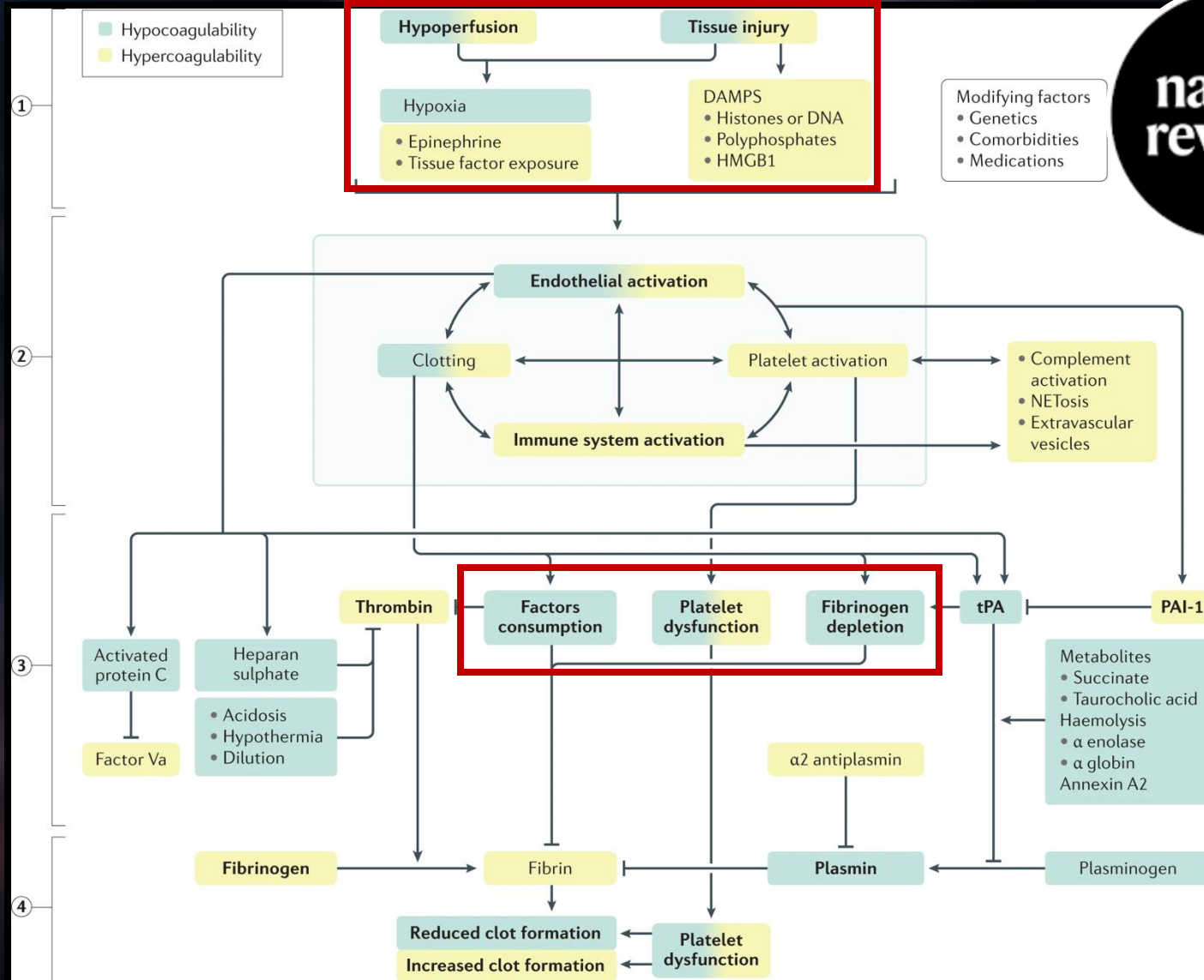
Coagulopathy of Trauma

CoT in Older Adults



Acquired
TIC

Induced
Medications



A microscopic view of a blood vessel showing red blood cells. The vessel lumen is on the left, and the vessel wall is on the right. The red blood cells are biconcave discs, some appearing in profile and others as small circles. The vessel wall is composed of a single layer of endothelial cells, with a prominent nucleus visible in one cell. The overall color is a deep blue, and the lighting creates a sense of depth and texture.

How Does the **CoT** Differ in **Older** vs. **Young** Adults?

What We Should Know

Who is **More vulnerable** to CoT?



Blood transfusion and **coagulopathy in geriatric** trauma patients

Brett Mador, Bartolomeu Nascimento, Simon Hollands & Sandro Rizoli



2017



- **Prospective** observation of **628** pts with major trauma activation
- To identify the **coagulopathy of trauma** in the **old** vs. **young** trauma pts
- After performing **propensity score matching**:

Sub-analysis with an **age cut-off of 65 years** showed:

-  in terms of **abnormal TEG**
-  mortality in the **elderly** population (**36%** vs. **16%**, $p < 0.05$)

Abnormal TEG
(**36%** vs. **48%**, $p=0.20$)

PRBC Transfusion
(**89%** vs. **90%**, $p=0.77$)

Mortality
(**28%** vs. **37%**, $p=0.33$)

Who is **More Vulnerable** to TIC?

Higher mortality in pediatric and adult trauma patients with traumatic coagulopathy, using age-adjusted diagnostic criteria

Christopher R. Reed MD, Hannah Williamson MS, Cory Vatsaas MD, Reed Kamyszek BS, Harold J. Leraas MD, Candice Ray MD, James Otto PhD, Tamara Fitzgerald MD, PhD, Suresh Agarwal MD, Elisabeth T. Tracy MD



2017

- Retrospective analysis over 6 years (2012-2017)
- **Coagulation test results** of **1,983** Pts with **ISS \geq 9**
- To compare acute traumatic **coagulopathy-associated mortality by age**

Infant/child

N=156

Adult

N=1,524

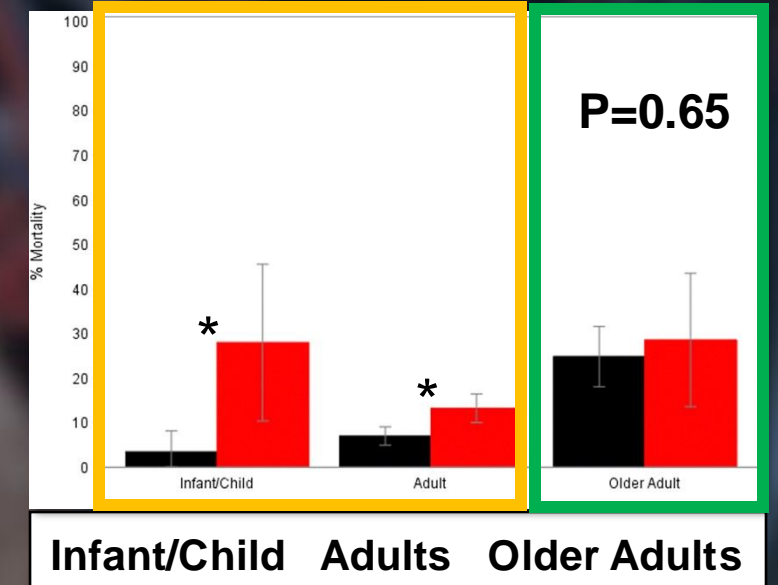
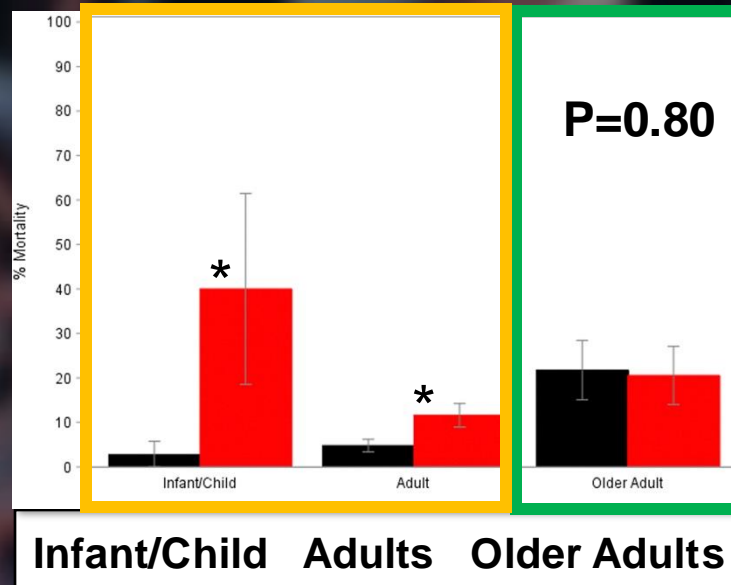
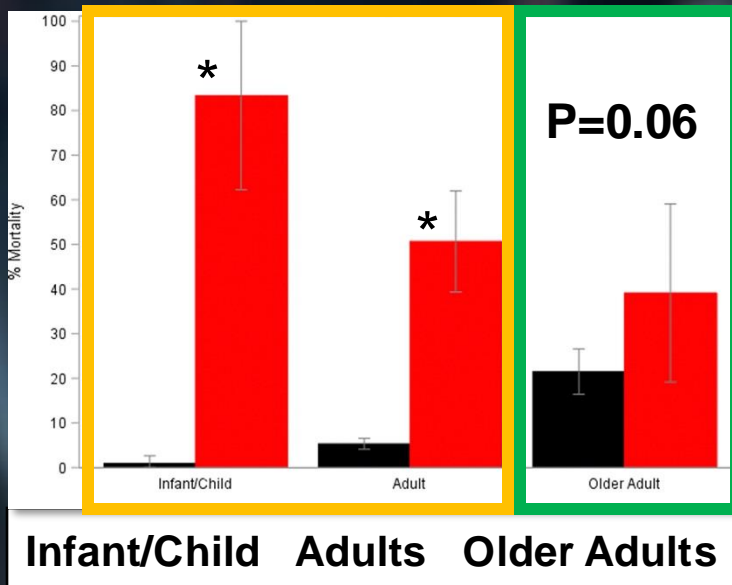
Older Adults

N=303

Implicating age-related hemostatic biologic differences

Mortality by

Coagulopathy



■ Prolonged PTT

■ Normal PTT

■ Prolonged INR

■ Normal INR

■ Low Fibrinogen

■ Normal Fibrinogen

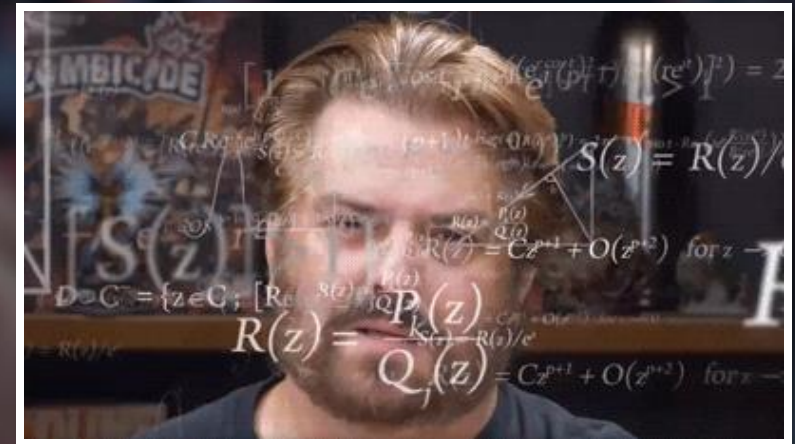
A 3D medical illustration of a blood vessel. The vessel is shown in a cross-section, with a dark red interior. A large, spherical blood clot is visible in the center, composed of a dense network of light blue fibers and red blood cells. Several individual red blood cells are scattered throughout the vessel, appearing as small, biconcave discs. The background is a blurred, reddish-pink color, suggesting a microscopic view of the blood.

Anticoagulation and Bleeding

Anticoagulation in Elderly



- **Median age** for people with **atrial fibrillation** is about **70 years**
- Studies on **older adult** trauma patients show:
 - **>10%** have an **INR >1.5**
 - **1/4** of these pts were taking **Coumadin**



How to differentiate **acquired** vs **induced** coagulopathy in this population?

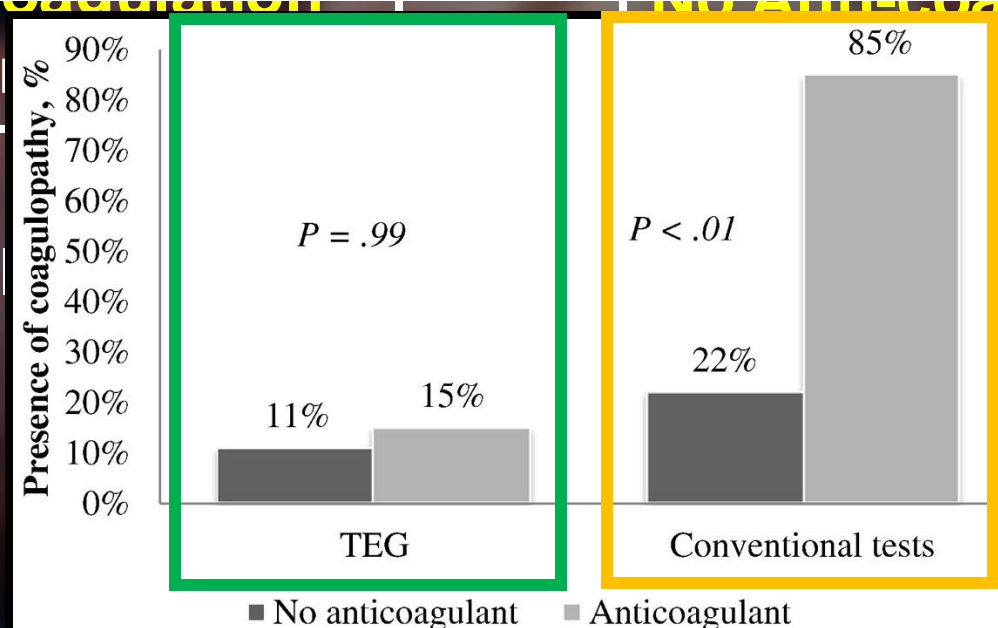
Thromboelastogram does not detect pre-injury anticoagulation in acute trauma patients

Jawad T. Ali, Mitchell J. Daley, Nina Vadiiei, Zachary Enright, Joseph Nguyen, Sadia Ali, Jayson D. Aydelotte, Pedro G. Teixeira, Thomas B. Coopwood, Carlos VR. Brown

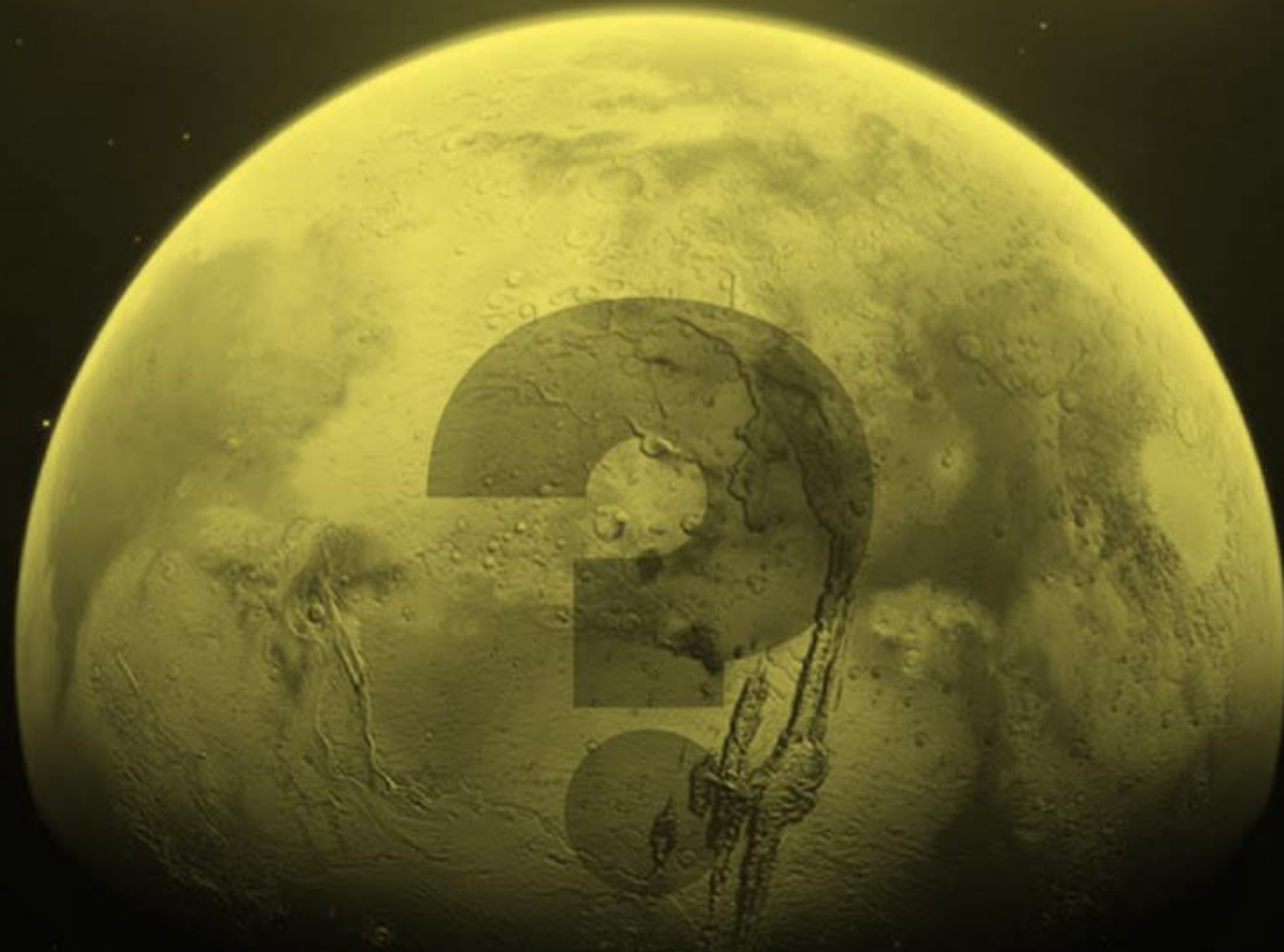


- **TEG** has **limited clinical utility** for presence of **pre-injury AC**
- **Traditional markers** of **drug-induced coagulopathy** should guide reversal decisions

- Anti-coagulants include



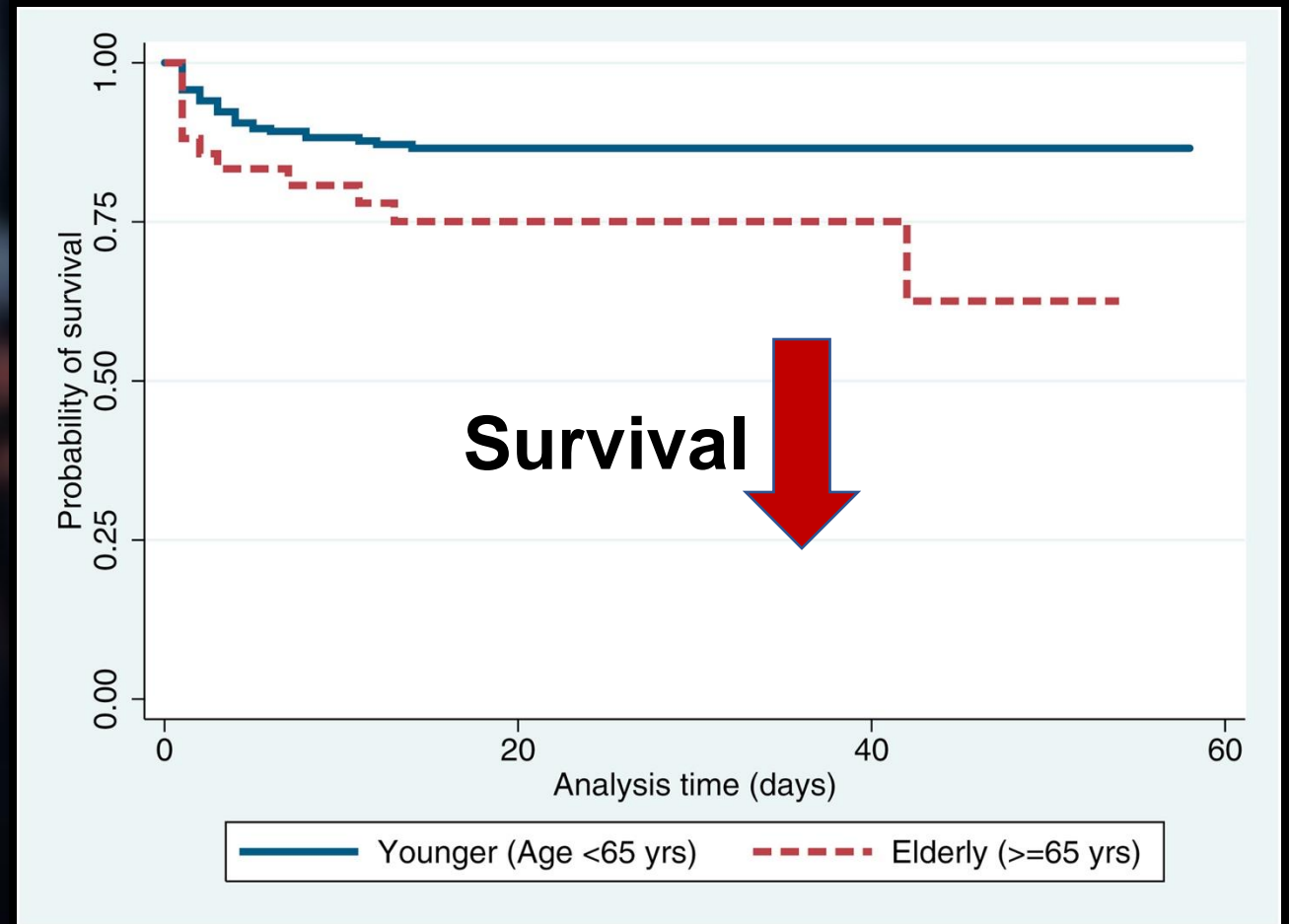
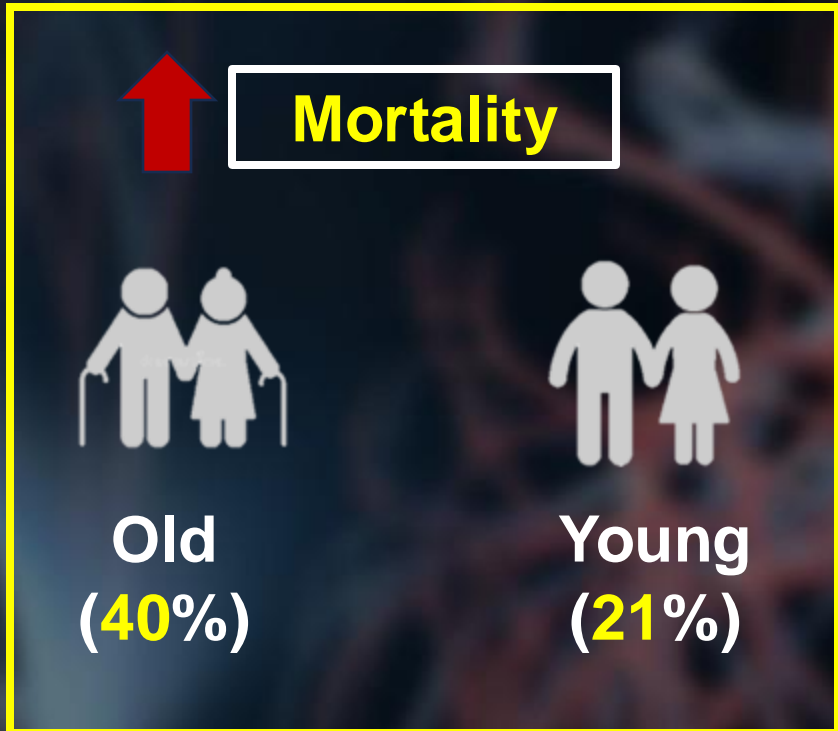
a inhibitor



Resuscitation of Older Adults

Survival Analysis of Patients Receiving Massive Transfusion

Old (≥ 65 yrs) vs. Young (< 65 yrs)



Warm Fresh WB

Cold Stored Whole Blood

4F-PCC

Cryoprecipitate

First Platelets?

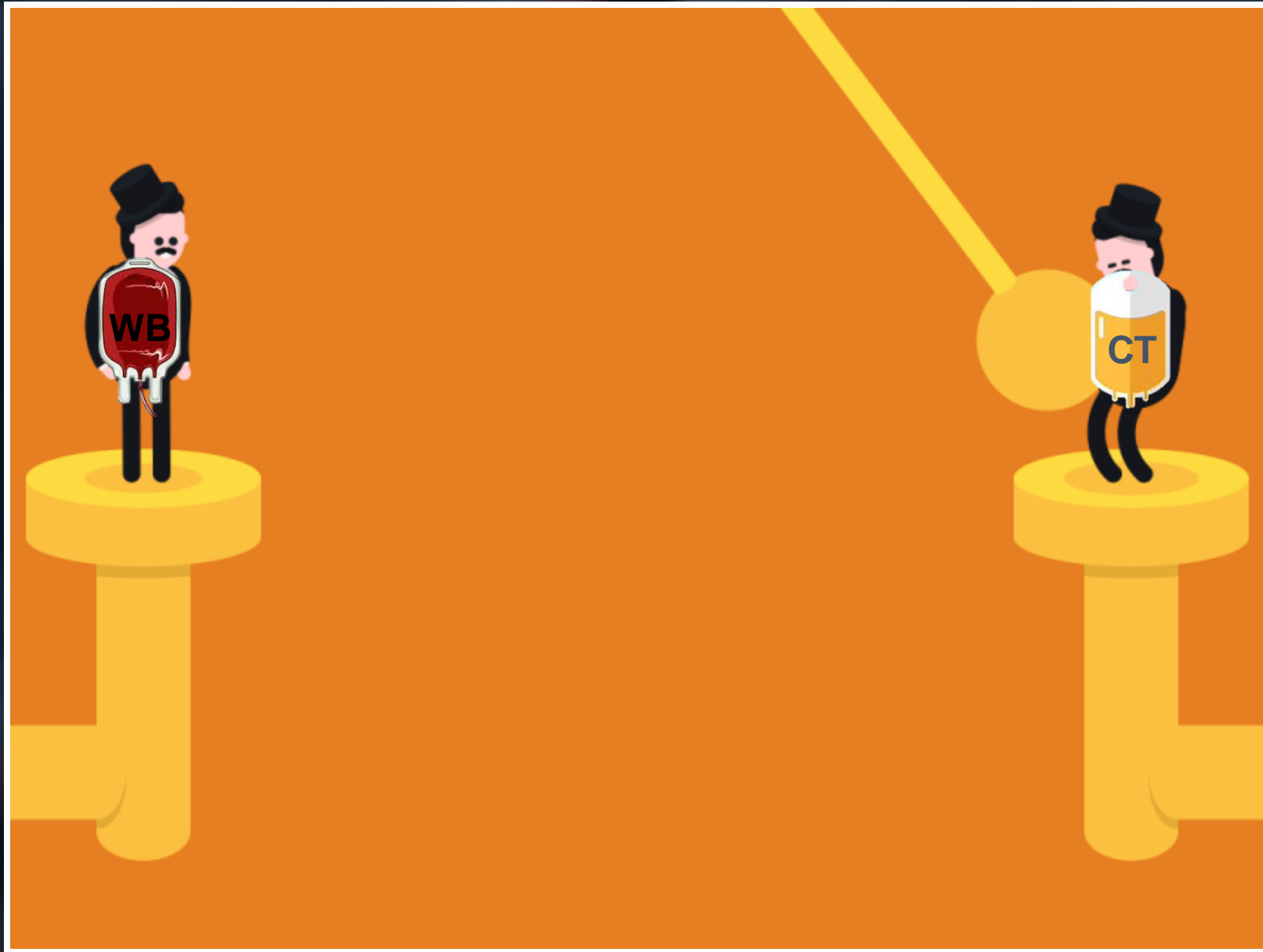
1:1:1

First Plasma?

Fibrinogen Concentration

Optimal Blood Product?



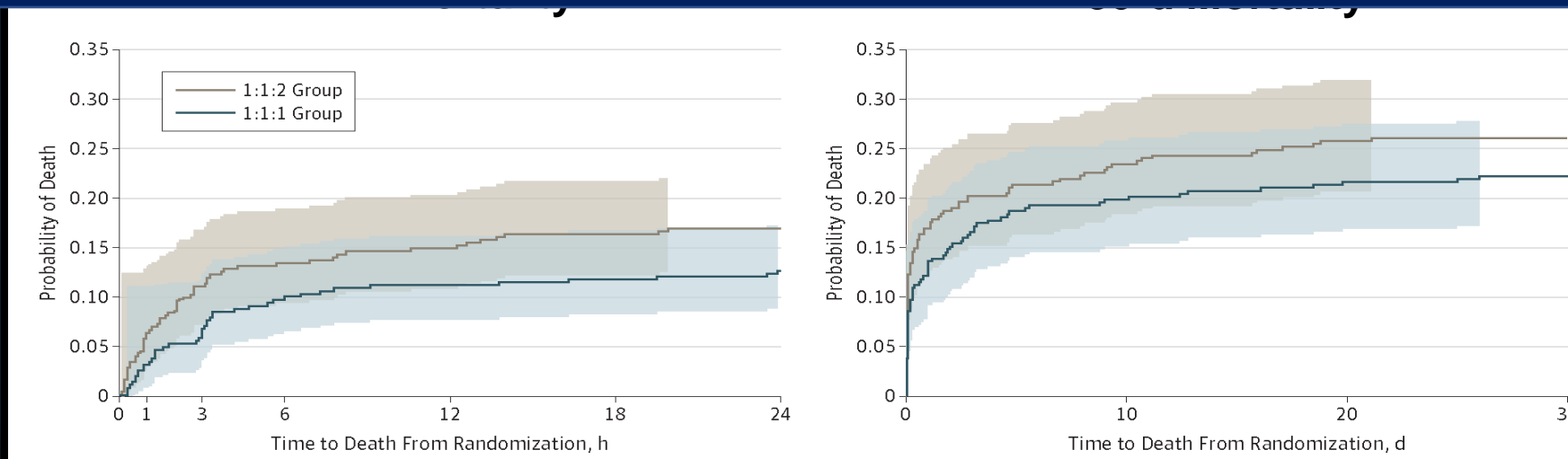


The Optimal Ratio of Component Therapy?



1:1:1 vs. 1:1:2

- **Mean age** was **35 years** with the **oldest** participant being **51 years old**
 - Is this study **generalizable** to the **older adult population**?



HR: 0.72 (95% CI, 0.49-1.07)

HR: 0.83 (95% CI, 0.61-1.12)

Massive blood transfusion following older adult trauma: The effect of **blood ratios** on mortality

Rae D. Hohle MD, Jillian K. Wothe BS, Benjamin M. Hillmann PhD, Christopher J. Tignanelli MD, MS, James V. Harmon MD, PhD,
Victor R. Vakayil MBBS, MS



2022

- Retrospective analysis of **ACS-TQIP 2013-2017**
- **3,134** patients ≥ 65 years with **Massive Blood Transfusion**
- **MBT** $\rightarrow \geq 10$ units/24hr or ≥ 5 units/4hr
- Patients were stratified based on **blood ratios (FFP:PRBC)**:

1:1
(n=963)

1:2
(n=1,253)

1:3
(n=438)

1:4
(n=165)

1:5
(n=110)

1:6+
(n=196)

Massive blood transfusion following older adult trauma: The effect of **blood ratios** on mortality

Rae D. Hohle MD, Jillian K. Wothe BS, Benjamin M. Hillmann PhD, Christopher J. Tignanelli MD, MS, James V. Harmon MD, PhD, Victor R. Vakayil MBBS, MS

Multivariable Regression Analysis

3

2.7

1:2 compared to 1:1



24-hr Mortality
(60%)



30-day Mortality
(44%)

■ 24-hr Mortality ■ 30-day Mortality



Whole Blood – A Game Changer

Are CT and WB the Same?



There is a Difference

Whole Blood in Those with Old Blood: The Use of Whole Blood in the Geriatric Trauma Population

Warner, Rachel DO; Mc Cullough, Mary Alyce MD; Painter, Matthew D. MD; Hoth, James J. MD, FACS; Meredith, Wayne J. MD, FACS; Miller, Preston R. III MD, FACS; Nunn, Andrew M. MD, FACS



2021

- Retrospective analysis of **ACS-TQIP 2016-2020**
- **183** patients ≥ 55 years with **Blood Transfusion**
- To identify the effect of **WB** on the resuscitation of **older adults**

WB compared to CT:



Mortality

(**32%** vs. **31%**, $p=0.89$)



24-h PRBC Transfusion

(**1,100ml** vs. **2,657ml**, $p<0.01$)



In-hospital PRBC Transfusion

(**1,500ml** vs. **2,915ml**, $p<0.01$)

The Role of Whole Blood Hemostatic Resuscitation in Bleeding Geriatric Trauma Patients

Hamidreza Hosseinpour MD, Michael Ditillo DO, FACS, Christina Colosimo DO, MS, Tanya Anand, MD, MPH, FACS, Sai Krishna Bhogadi, MD, Audrey Spencer, MD, Khaled El-Qawaqzeh, MD, Adam Nelson, MD, Louis Magnotti, MD, MS, FACS, Bellal Joseph, MD, FACS



2023

- Retrospective analysis of ACS-TQIP 2017-2020



The Role of **WB** in **Older adults** is yet to be defined



6-hr Mortality
(**70%**)



24-hr Mortality
(**68%**)



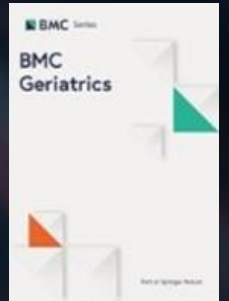
In-hospital Mortality
(**47%**)



Goal Direct Resuscitation

Implementation of new **standard operating procedures** for **geriatric trauma** patients with multiple injuries: a single level I trauma center study

Lorenz Peterer, Christian Ossendorf, Kai Oliver Jensen, Georg Osterhoff, Ladislav Mica, Burkhardt Seifert, Clément M. L. Werner, Hans-Peter Simmen, Hans-Christoph Pape & Kai Sprengel



2019

- A single center **pre** (2000-2006) & **post** (2007-2012) **SOP** cohort study
- **311** geriatric (≥ 65 yrs) patients with **ISS ≥ 9** , Pre (n=**131**), Post (n=**180**)

Standard Operating Procedures (SOPs)



Damage Control Surgery



Goal-directed Coagulation Management



Futility of Resuscitation?

What if?

Sometimes older adults are beyond our capabilities



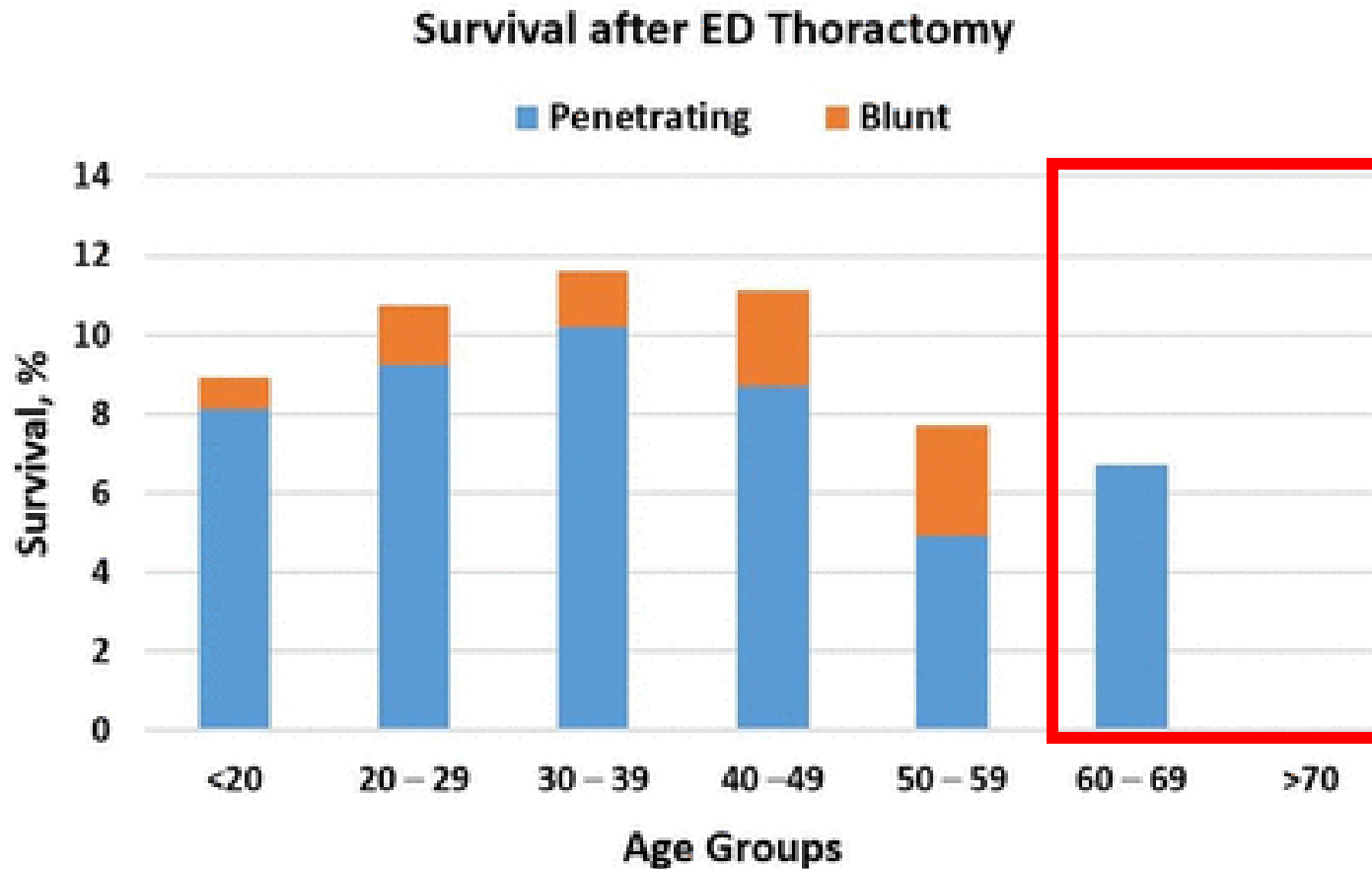
Is there a point where further efforts become
INAPPROPRIATE?

No survivors aged >60 years with blunt trauma

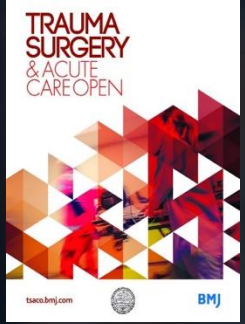
No survivors aged >70 years, regardless of injury mechanism

Improving survival
a 5-year

- A 5-year (2
- 2,229 patients



omy:
m



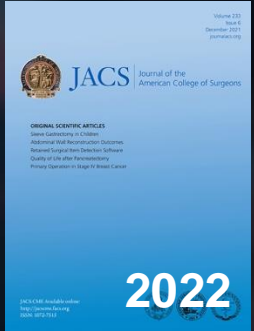
2018

Thoractomy (ERT)

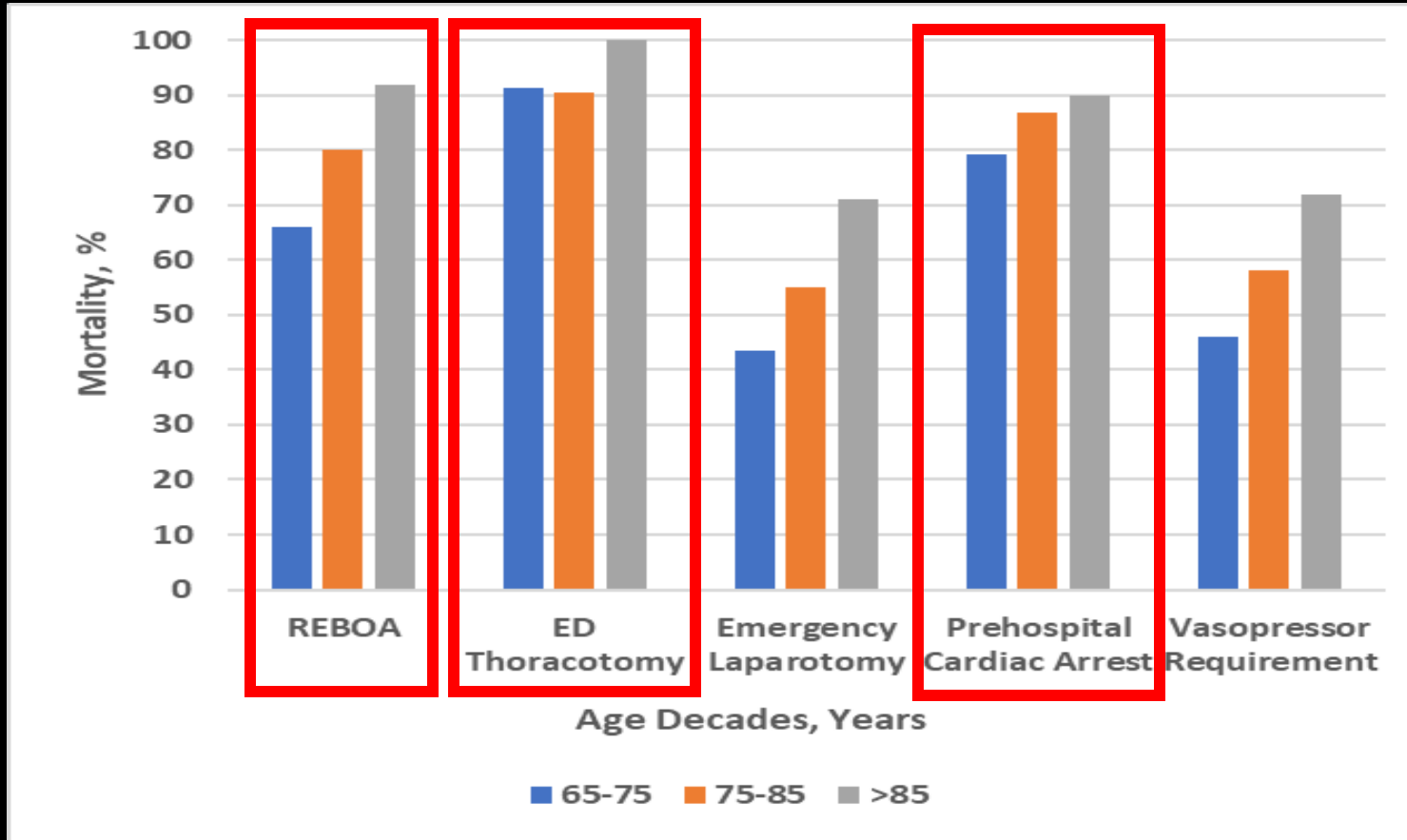
Futility of Resuscitation

Futility of Resuscitation Among Geriatric Trauma Patients: Do We Need to Define When To Withdraw Care

Anand, Tanya MD, MPH; Nelson, Adam C MD; Obaid, Omar MD; Ditillo, Michael F. DO FACS; El-Qawaqzeh, Khaled W M MD; Stewart, Collin MD; Reina Limon, Raul F A MD; Hosseinpour, Hamidreza MD; Nguyen, Lucia MD; Joseph, Bellal MD FACS



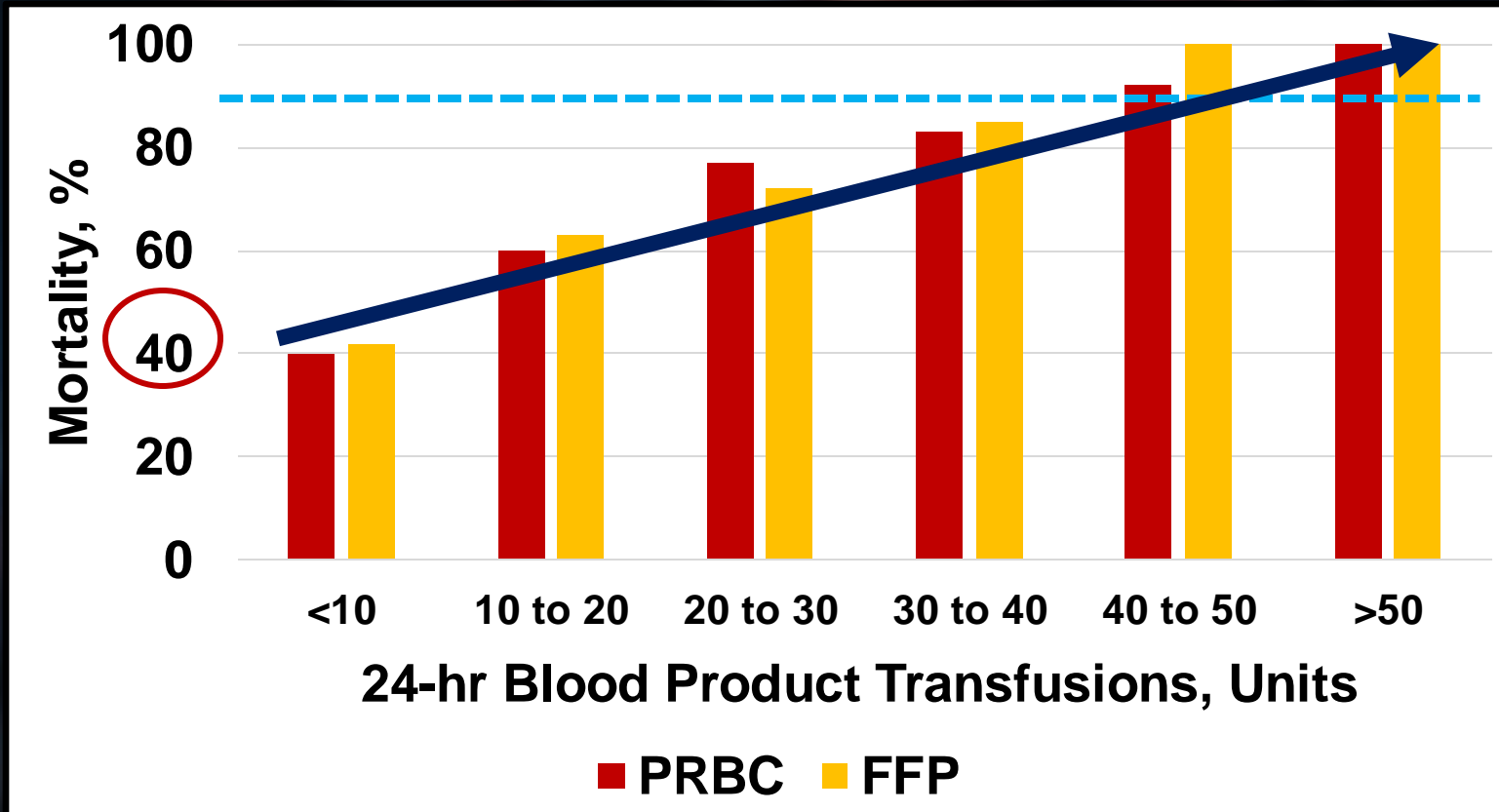
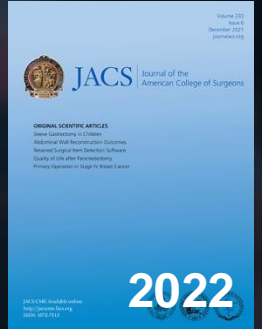
- 2018 ACS T
- All severely
- Futility of re



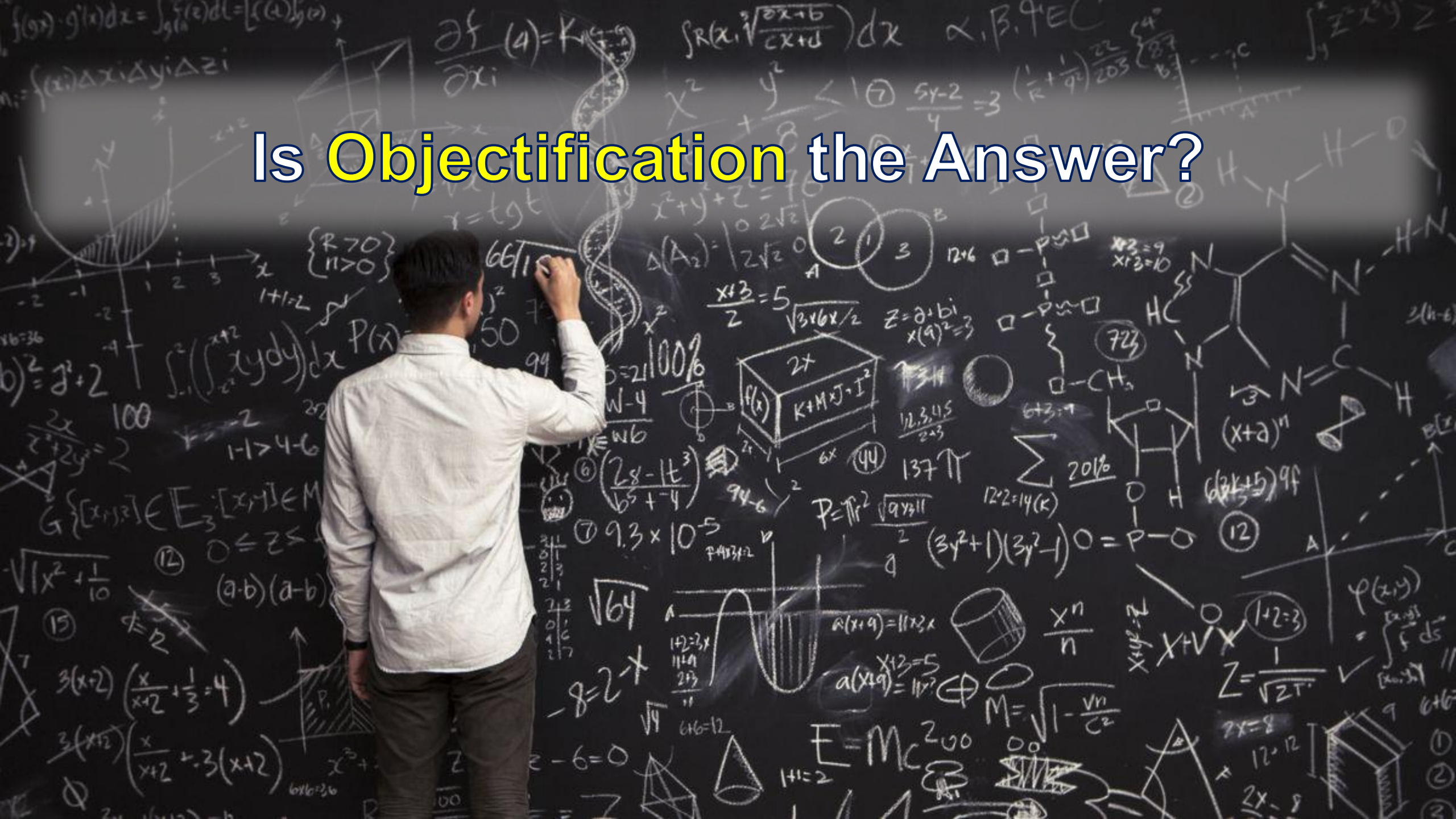
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Is Objectification the Answer?



Futility of Resuscitation Measure

Decisions, Decisions: **Futility of Resuscitation Measure** Identifies Elderly Trauma Patients Who May Not Benefit from Heroic Measures

Michael Ditillo, Hamidreza Hosseinpour, Andrew Tang, Omar Obaid, Lynn Gries, Khaled El-Qawaqzeh, Randall Friese, Raul Reina, Adam Nelson, Bellal Joseph



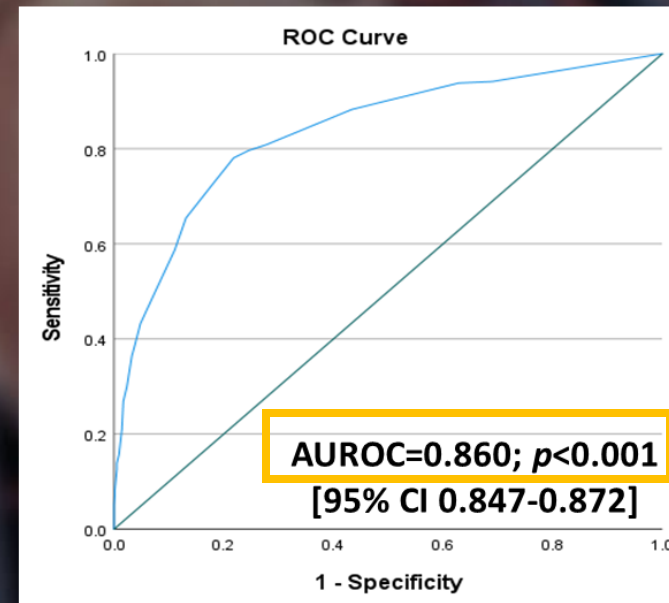
2022

- Analysis of 2017-2018 TQIP
- **5,562 severely injured geriatric trauma** patients were identified
- Randomly divided into **derivation** cohort (80%) & **validation** cohort (20%)
- 4,468 derivation; 1,094 validation

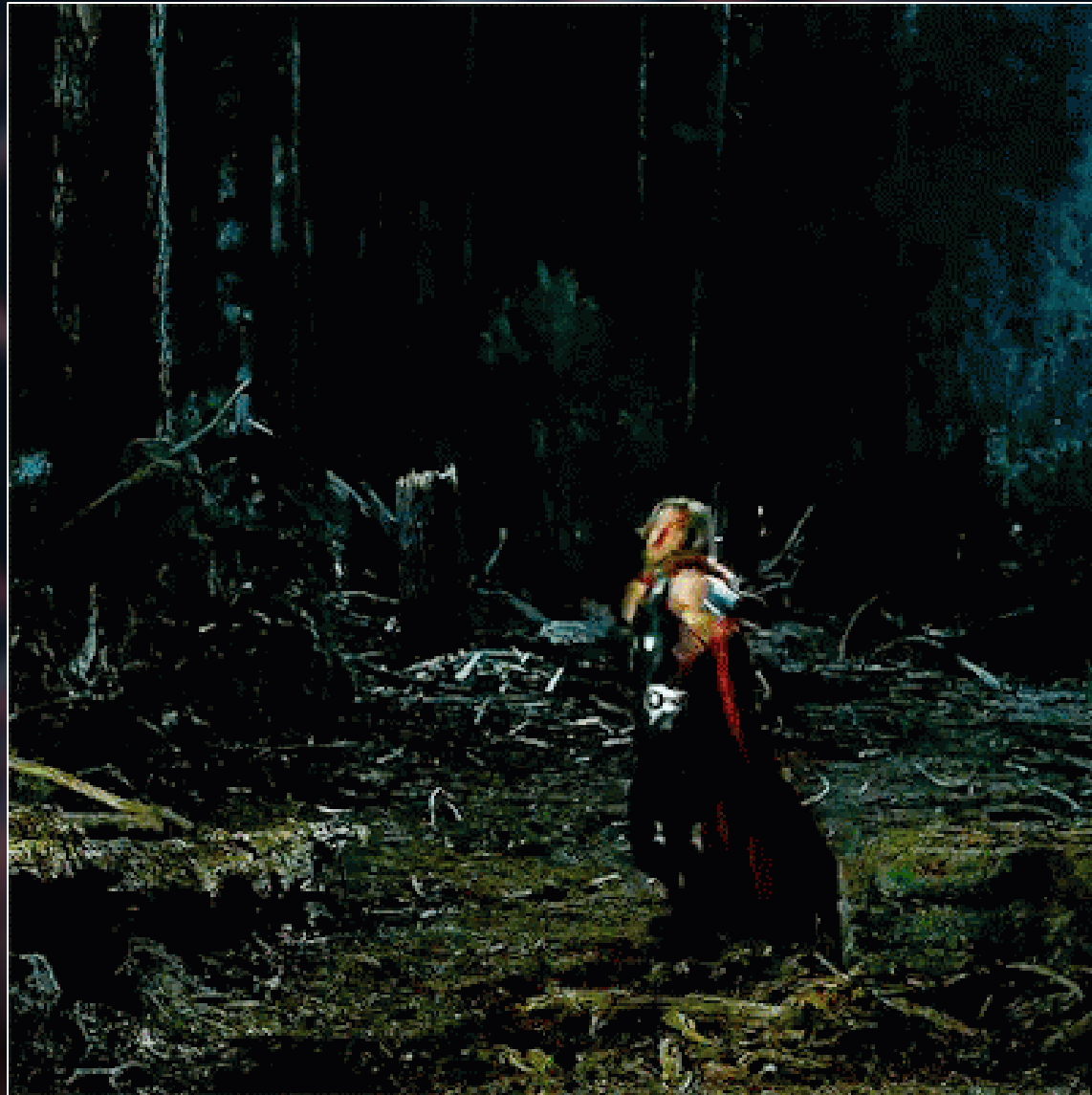
Futility of Resuscitation Measure

Futility of Resuscitation Measure	Points
Age 60-70 yrs	0
70-80 yrs	2
>80 yrs	3
Frailty	1
Prehospital Cardiac Arrest	7
≥1 Episode of SBP <50 mm Hg	6
Early Vasopressors (<6 hrs)	2
ED Thoracotomy	9
REBOA	1
PRBC Within 4 hrs ≤5 Units	0
6-10 Units	3
11-15 Units	6
16-20 Units	7
>20 Units	9
Severe TBI and GCS ≤8	7
TBI Midline Shift	1
Craniectomy	1

FoRM	Number of Patients	Mortality n (%)
<2	1,207	70 (6%)
2-5	1,482	190 (13%)
6-8	573	242 (42%)
9-12	576	327 (57%)
13-16	321	263 (82%)
17-20	162	149 (92%)
>20	147	140 (95%)



It All Comes Down to This



It All Comes Down to This

Geriatric Patients are **Different**

CoT May **Not** Impact **Geriatric** Pts as Their Younger Counterparts

It All Comes Down to This

The Role of **WB** in Older Adults is Still unclear

Futility of Resuscitation Matters

There Is A Need For **Standardized** Resuscitation
Strategies For **Older Adult** Trauma Patients





@TopKnife_B



bjoseph@arizona.edu

Thank You!