Innovations in Prehospital Care

University of Houston Medical School

HCA Houston Healthcare

Disclosures

- None

TIME IS IMPORTANT

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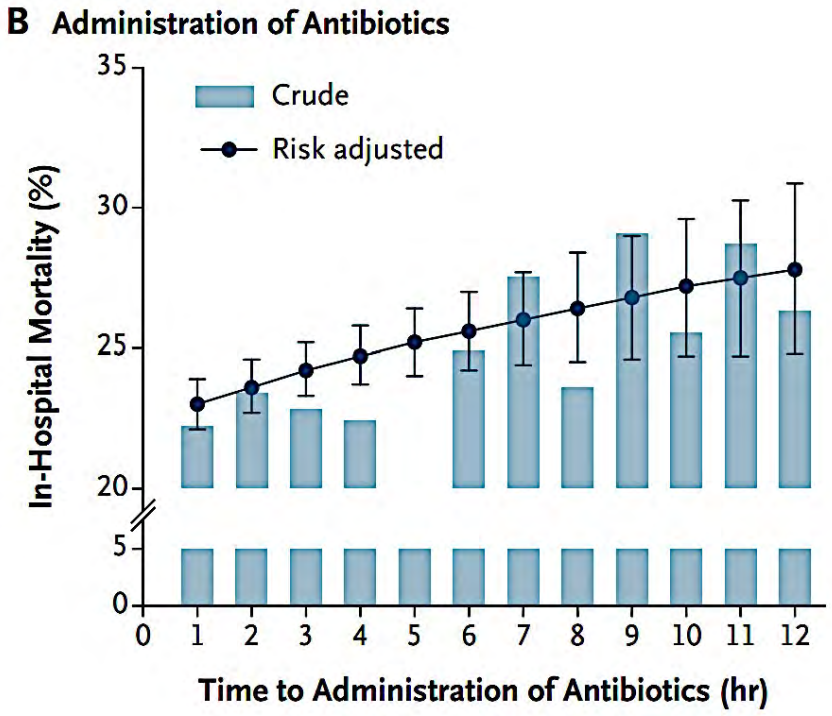
Time to Treatment and Mortality during Mandated Emergency Care for Sepsis

Christopher W. Seymour, M.D., Foster Gesten, M.D., Hallie C. Prescott, M.D., Marcus E. Friedrich, M.D., Theodore J. Iwashyna, M.D., Ph.D., Gary S. Phillips, M.A.S., Stanley Lemeshow, Ph.D., Tiffany Osborn, M.D., M.P.H., Kathleen M. Terry, Ph.D., and Mitchell M. Levy, M.D.

NEJM 2017

- 49,331 Patients - 9 hospitals
- Rapid completion of a 3-hour bundle of sepsis care
  - rapid administration of antibiotics
  - not rapid completion of an initial bolus of intravenous fluids
  - Lower risk-adjusted in-hospital mortality.



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Passage of Time is Important

- Abdominal bleeding and time to laparotomy
- Extremity bleeding and time to tourniquets
- Time to transfusion in bleeding patients
- Time to resuscitation in septic patients
- Time to IR in pelvic hemorrhage
- Time to craniotomy
- Time to laboratory dx
- Time to antibiotics in sepsis
- Time to culture results and focused antibiotics
- Duration of Antibiotics
- Time to accurate diagnosis and treatment (eg, lysis for stroke and MI)
- Rapid radiology reports.... Sent around the world, why not AI

- Who enjoys waiting for anything in the healthcare space?
  - Why should we?
  - Faster is almost always better?
  - Transparency of information
  - Process engineering to reduce delays in actionable information and improve quality of care

- Lots of Facts and Opinions

Death on the battlefield (2001–2011): Implications for the future of combat casualty care

J Trauma 2012

Brian J. Eastridge, MD, Robert L. Mabry, MD, Peter Seguin, MD, Joyce Cantrell, MD, Terrill Tops, MD, Paul Uribe, MD, Olga Mallett, Tamara Zubko, Lynne Oetjen-Gerdes, Todd E. Rasmussen, MD, Frank K. Butler, MD, Russell S. Kotwal, MD, John B. Holcomb, MD, Charles Wade, PhD, Howard Champion, MD, Mimi Lawnick, Leon Moores, MD, *and* Lorne H. Blackbourne, MD

2001 - 2011, 4,596 battlefield fatalities were reviewed

87% (n = 4012) of all injury mortality occurred pre-MTF

24% (n = 976) were deemed potentially survivable (PS)

91% (n = 888) died from hemorrhage

67% (n = 598) died from truncal hemorrhage

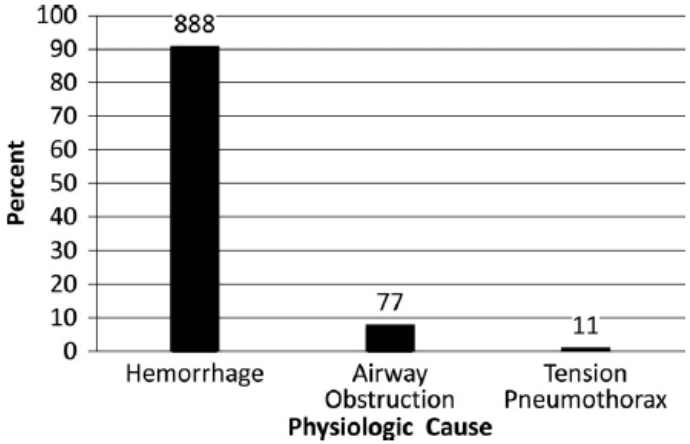


Figure 4. Injury/physiologic focus PS acute mortality (n = 976).

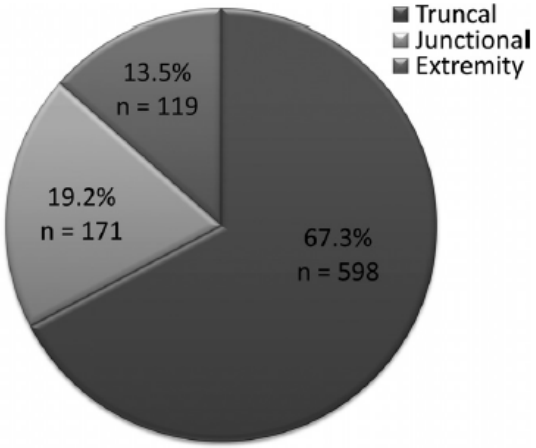
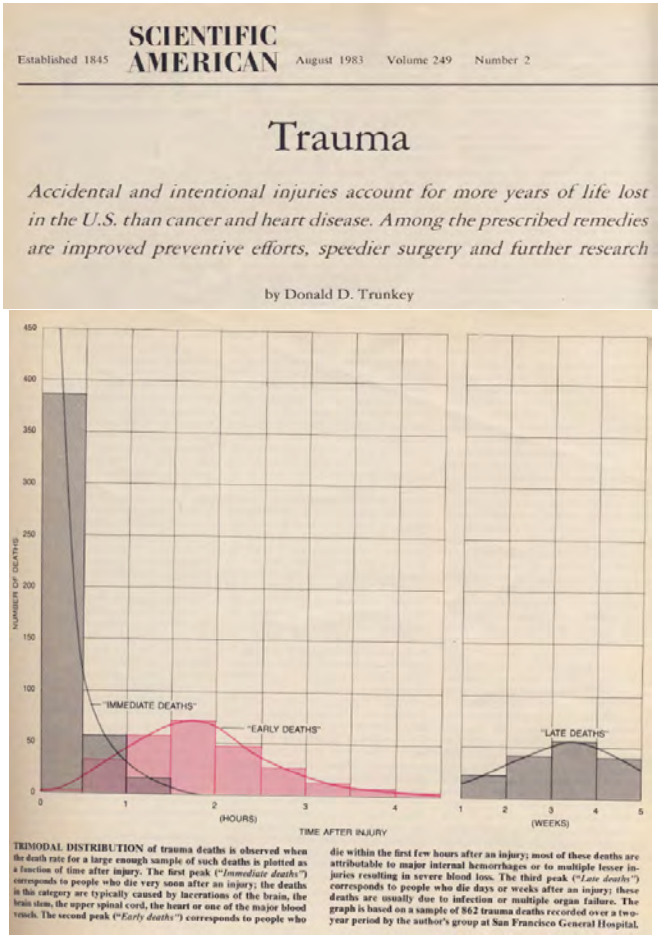


Figure 5. Anatomic focus of lethal PS hemorrhage.

Trunkey - 1983

Classic Tri-Modal
Distribution of Death



SCIENTIFIC AMERICAN

Established 1845 August 1983 Volume 249 Number 2

Trauma

Accidental and intentional injuries account for more years of life lost in the U.S. than cancer and heart disease. Among the prescribed remedies are improved preventive efforts, speedier surgery and further research

by Donald D. Trunkey

TRIMODAL DISTRIBUTION of trauma deaths is observed when the death rate for a large enough sample of such deaths is plotted as a function of time after injury. The first peak (*"Immediate deaths"*) corresponds to people who die very soon after an injury; the deaths in this category are typically caused by lacerations of the brain, the brain stem, the upper spinal cord, the heart or one of the major blood vessels. The second peak (*"Early deaths"*) corresponds to people who die within the first few hours after an injury; most of these deaths are attributable to major internal hemorrhages or to multiple lesser injuries resulting in severe blood loss. The third peak (*"Late deaths"*) corresponds to people who die days or weeks after an injury; these deaths are usually due to infection or multiple organ failure. The graph is based on a sample of 862 trauma deaths recorded over a two-year period by the author's group at San Francisco General Hospital.

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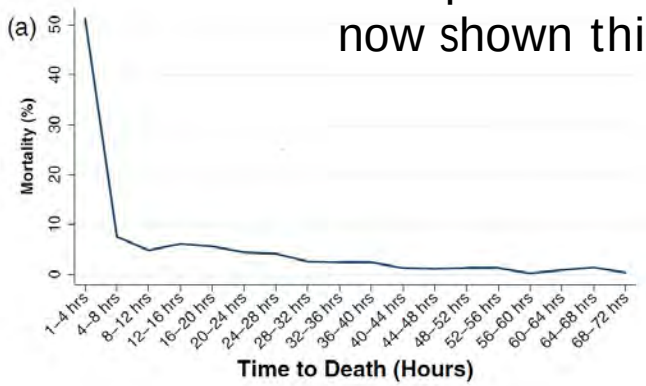
Trends in 1029 trauma deaths at a level 1 trauma center: Impact of a bleeding control bundle of care

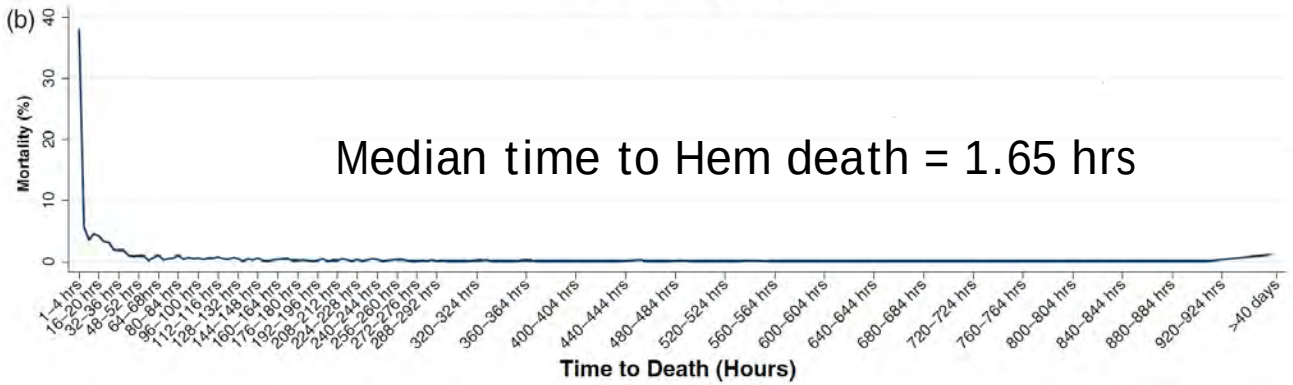
Blessing T. Oyeniyi, Erin E. Fox, Michelle Scerbo, Jeffrey S. Tomasek, Charles E. Wade, John B. Holcomb*

Center for Translational Injury Research, Division of Acute Care Surgery, Department of Surgery, Medical School, The University of Texas Health Science Center at Houston, Houston, TX, USA

Injury 2016

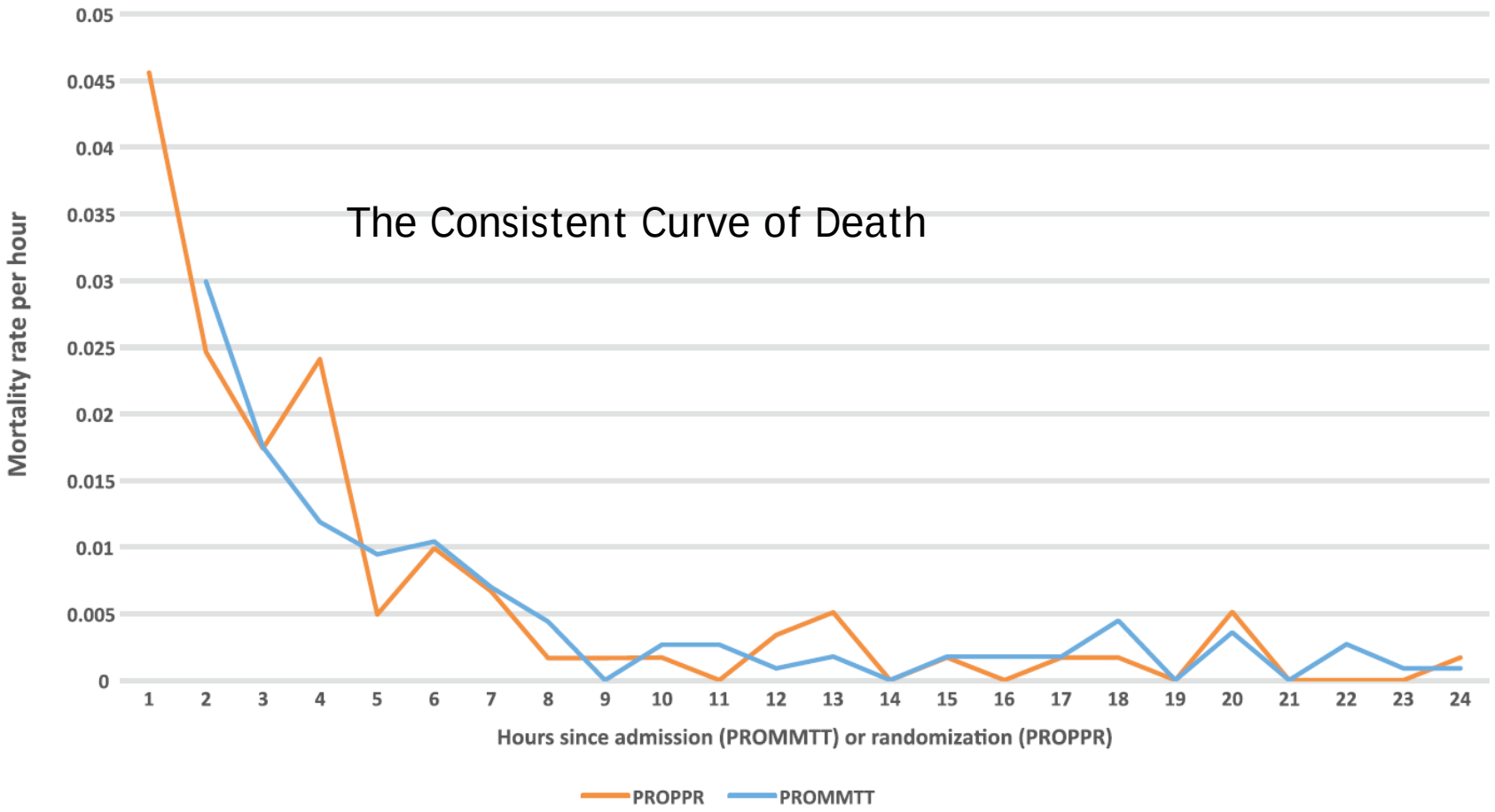
Multiple authors have now shown this pattern





Median time to Hem death = 1.65 hrs

Hourly Mortality Rates in PROMMTT and PROPPR



Trauma deaths from hemorrhage occur rapidly and in a consistent pattern over time.

- What does this say about timely intervention?

The Golden Hour: Scientific Fact or Medical "Urban Legend"?

Acd Em Med 2001

E. BROOKE LERNER, MS, EMT-P, RONALD M. MOSCATI, MD

- Their search into the background of this term yielded little supporting scientific evidence
- 1975, Cowley RA. "the first hour after injury will largely determine a critically-injured person's chances for survival''
- 1979, Foster JT. "the mortality rate triples for every 30-minute increase from time of injury to definitive care"

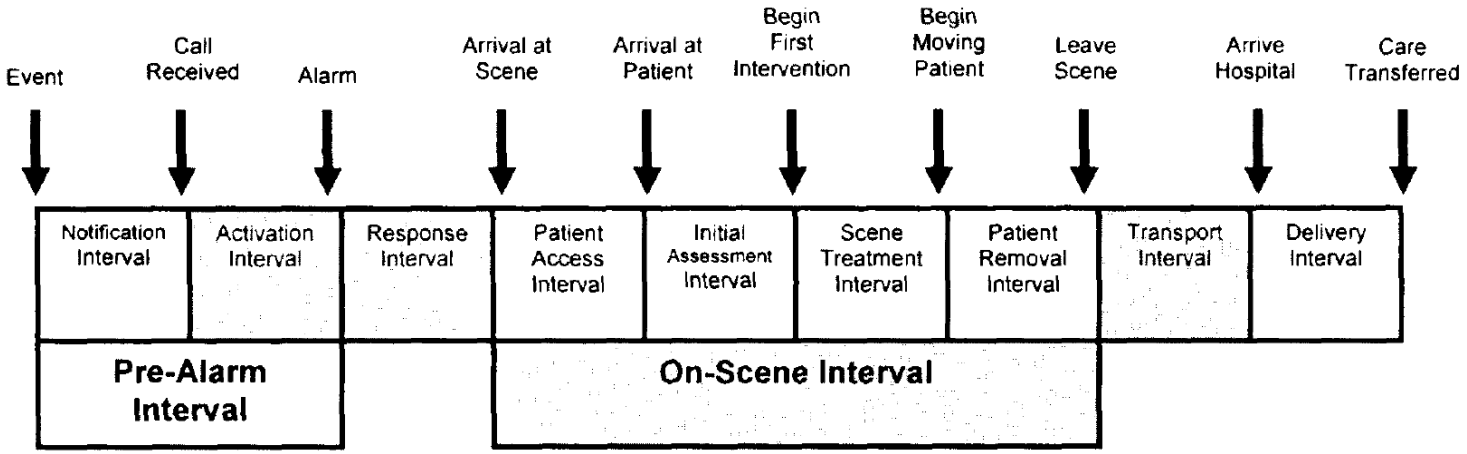
A Meta-Analysis of Prehospital Care Times for Trauma

Brendan G. Carr, MD, MA, Joel M. Caplan, MA, EMT,
John P. Pryor, MD, Charles C. Branas, Ph.D.

PEM 2006

9 discrete Intervals to consider n = 309,949

Optimize interventions and time in each interval



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Impact of prehospital mode of transport after severe injury: A multicenter evaluation from the Resuscitation Outcomes Consortium

J Trauma 2012

Eileen M. Bulger, MD, Danielle Guffey, BS, Francis X. Guyette, MD, MPH, Russell D. MacDonald, MD, MPH, Karen Brasel, MD, MPH, Jeffery D. Kerby, MD, PhD, Joseph P. Minei, MD, Craig Warden, MD, MPH, Sandro Rizoli, MD, PhD, Laurie J. Morrison, MD, and Graham Nichol, MD the Resuscitation Outcomes Consortium Investigators

- Transport time across 112 EMS agencies in North America, (n= 2,049) with 34% transported by air.
- Ground patients took 43.5 minutes to arrive at trauma centers while more severely injured helicopter patients required 76 minutes.
- The “10 min prehospital time” is hard to find documented

Carr B, et al. PEM 2006

TABLE 2. Weighted Means and Standard Deviations for Prehospital Care Intervals of Helicopter and Ground Ambulance Transport of Trauma Patients

	Helicopter Ambulance	Urban Ground Ambulance	Suburban Ground Ambulance	Rural Ground Ambulance
Activation interval (mins)				
Overall	3.53 ± 3.81	1.40 ± 1.41	1.40 ± 1.41	2.89 ± 1.64
1975–1989	4.15 ± 2.53	na	na	na
1990–2005	3.26 ± 5.15	1.40 ± 1.41	1.40 ± 1.41	2.89 ± 1.64
Response interval (mins)				
Overall	22.27 ± 29.01	5.28 ± 7.46	5.23 ± 20.04	7.86 ± 7.35
1975–1989	18.39 ± 20.17	6.48 ± 4.88	7.20 ± 7.48	9.02 ± 8.97
1990–2005	23.25*	5.25 ± 8.98	5.21 ± 28.32	7.72 ± 7.82
On-Scene interval (mins)				
Overall	21.60 ± 18.90	13.50 ± 3.71	13.45 ± 21.80	15.06 ± 16.80
1975–1989	23.03 ± 21.45	18.10 ± 6.65	21.08 ± 25.49	28.57 ± 33.67
1990–2005	20.43 ± 20.98	13.40 ± 3.56	13.39 ± 22.02	14.59 ± 16.16
Transport interval (mins)				
Overall	25.50 ± 30.29	10.78 ± 4.29	10.89 ± 17.89	17.37 ± 19.40
1975–1989	14.16 ± 12.63	11.19 ± 3.34	14.24 ± 15.64	19.81 ± 22.21
1990–2005	29.80 ± 57.48	10.77 ± 4.44	10.86 ± 18.20	17.28 ± 19.70
Totals (mins)				
Overall	72.91	30.96	30.97	43.17
1975–1989	59.73	35.76	42.51	57.40
1990–2005	76.74	30.81	30.86	42.48

Shortest time is 30 minutes

En-Route Care Capability From Point of Injury Impacts Mortality After Severe Wartime Injury

Jonathan J. Morrison, MRCS,† John Oh, MD,‡ Joseph J. DuBose, MD,§ David J. O'Reilly, MRCS,† Robert J. Russell, FCEM,¶ Lorne H. Blackbourne, MD,* Mark J. Midwinter, MD, FRCS,† and Todd E. Rasmussen, MD*||***

Ann Surg 2013

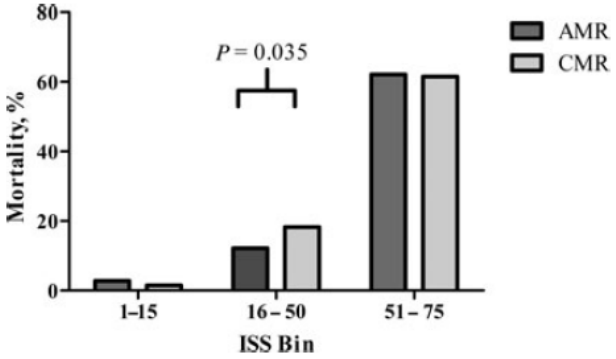

FIGURE 1. Mortality analysis of all patients retrieved by AMR or CMR platform, per ISS bins.

TABLE 4. Interventions Performed on the AMR Platform

		ISS		
	Overall	**1–15**	**16–50**	**51–75**
Number, n	1093	650	385	58
Advanced airway intervention	222 (20.3%)	36 (5.5%)	156 (40.5%)	30 (51.7%)
Chest decompression	134 (12.3%)	19 (2.9%)	96 (24.9%)	19 (32.8%)
Intraosseous access	255 (23.3%)	39 (6.0%)	177 (46.0%)	39 (67.2%)
Intravenous access	662 (60.6%)	408 (62.8%)	229 (59.5%)	25 (43.1%)
Prehospital blood	162 (14.8%)	21 (3.2%)	124 (32.2%)	17 (29.3%)

Alarhayem AQ et al. 2016

Contents lists available at ScienceDirect

The American Journal of Surgery 2016

journal homepage: www.ajconline.org

Southwestern Surgical Congress

Time is the enemy: Mortality in trauma patients with hemorrhage from torso injury occurs long before the "golden hour"

A.Q. Alarhayem [a], J.G. Myers [a], D. Dent [a], L. Liao [a], M. Muir [a], D. Mueller [a], S. Nicholson [a], R. Cestero [a], M.C. Johnson [a], R. Stewart [a], Grant O'Keefe [b], B.J. Eastridge [a, *]

[a] The University of Texas Health Science Center at San Antonio, Department of Surgery, Division of Trauma, Critical Care, and Acute Care Surgery, United States

[b] University of Washington, Department of Surgery, Division of Trauma and Acute Care Surgery, United States

NTDB data

2.5 million patients retrospective study (2012-14)

AIS 4 chest and abd, significant TBI excluded

Prehospital time and mortality

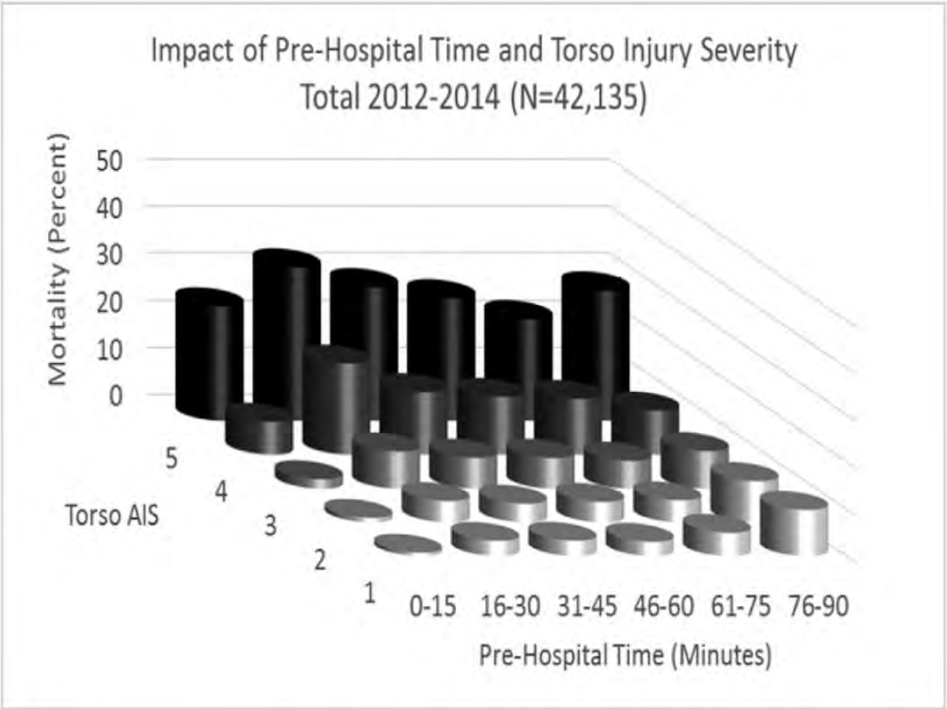

Fig. 1. Mortality Impact of prehospital time and torso injury severity for composite population 2012–2014 (N = 42,135).

Median
Prehospital
Time = 37 minutes

"We noted a precipitous incremental rise in patient mortality in patients with high-grade injuries at prehospital times 0-15 and 16-30 min, irrespective of mechanism."

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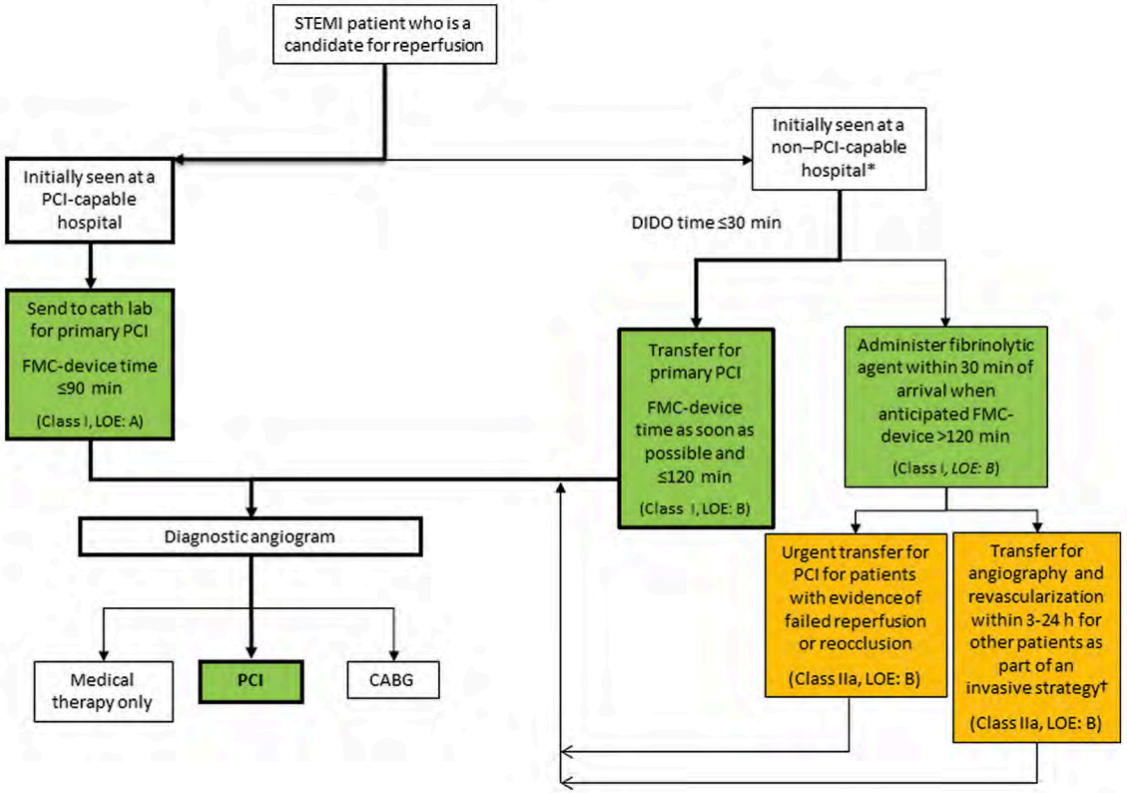
Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association®

2013 ACCF/AHA Guideline for the Management of ST-Elevation Myocardial Infarction : A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines

Patrick T. O'Gara, Frederick G. Kushner, Deborah D. Ascheim, Donald E. Casey, Jr, Mina K. Chung, James A. de Lemos, Steven M. Ettinger, James C. Fang, Francis M. Fesmire, Barry A. Franklin, Christopher B. Granger, Harlan M. Krumholz, Jane A. Linderbaum, David A. Morrow, L. Kristin Newby, Joseph P. Ornato, Narith Ou, Martha J. Radford, Jacqueline E. Tamis-Holland, Carl L. Tommaso, Cynthia M. Tracy, Y. Joseph Woo and David X. Zhao



NTCA epidemiology

- 33% working age (median age 57)*
- Improving survival over time
- ~1/2 have no or one comorbidities (CCI)**
- Most favorable reversible etiologies: MI, PE, hyperkalemia and tox overdose.***

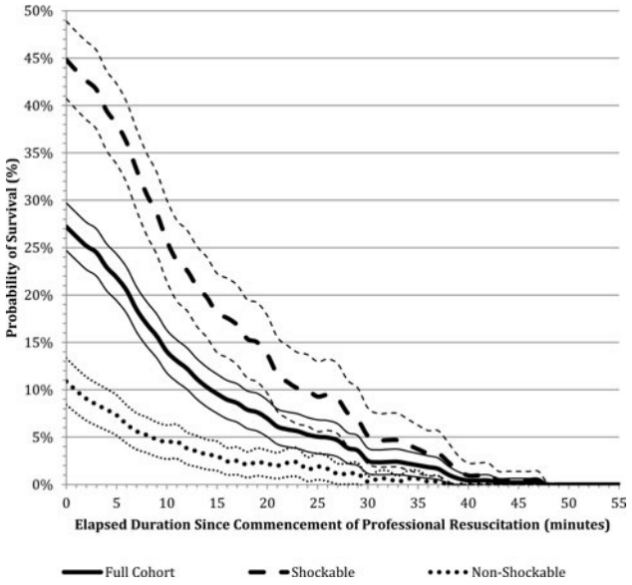
*Wissenberg, B et al. Circulation 2015
** Moriwaki et al. Shock 2013
*** Guru et al. CMAJ 1999

Relationship between Time-to-ROSC and Survival in Out-of-hospital Cardiac Arrest ECPR Candidates: When is the Best Time to Consider Transport to Hospital?

Brian Grunau, Joshua Reynolds, Frank Scheuermeyer, Robert Stenstom, Dion Stub, Sarah Pennington, Sheldon Cheskes, Krishnan Ramanathan, Jim Christenson

PEC , 2016

-1206 "ECPR Eligible"
- After 8 min survival drops quickly
- 90% ROSC by 24 min
- Between 8-24 min consider transition to ECPR



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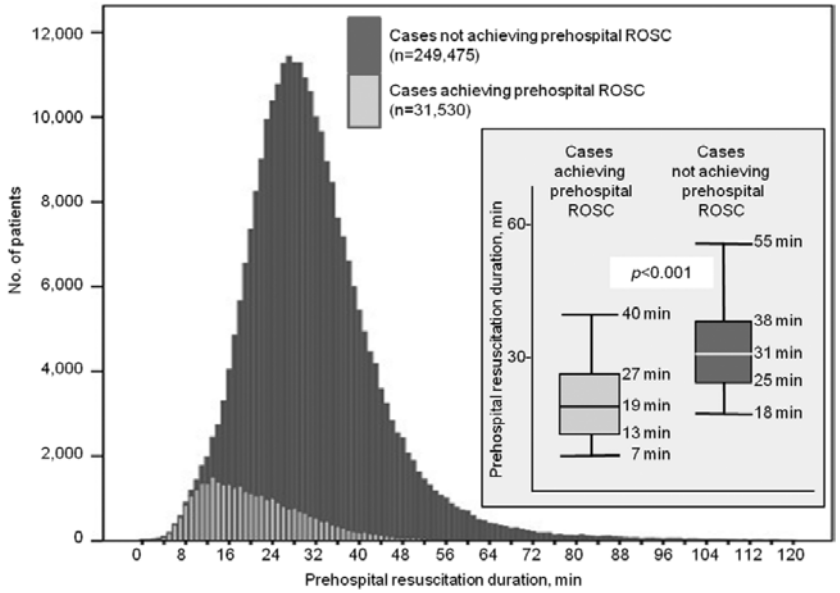
Duration of Prehospital Resuscitation Efforts After Out-of-Hospital Cardiac Arrest

Ken Nagao, MD, PhD; Hiroshi Nonogi, MD, PhD; Naohiro Yonemoto, DrPH; David F. Gaieski, MD; Noritoshi Ito, MD; Morimasa Takayama, MD, PhD; Shinichi Shirai, MD, PhD; Singo Furuya, MD, PhD; Sigemasa Tani, MD, PhD; Takeshi Kimura, MD, PhD; Keijiro Saku, MD, PhD;

282,183 OHCA patients

90% of pre-hospital ROSC did so 24 min
After 16-21 min of conventional ACLS without ROSC neurologic survival drops off
Recommended 40 of total ACLS from call and 33 of EMS
<1% without PH ROSC survived with favorable neurologic outcome.



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Prehospital ... What should we do?

- Stay and Play?
- Or
- Scoop and Run?

- After scoop and run
- Minimize time in the ED
- Run to the OR / IR / Cath lab
- Stop bleeding/open vessels

- Lets consider some more observations...

Damage control resuscitation in patients with severe traumatic hemorrhage: A practice management guideline from the Eastern Association for the Surgery of Trauma

J Trauma 2017

Jeremy W. Cannon, MD, SM, Mansoor A. Khan, MBBS (Lond), PhD, Ali S. Raja, MD, Mitchell J. Cohen, MD, John J. Como, MD, MPH, Bryan A. Cotton, MD, Joseph J. Dubose, MD, Erin E. Fox, PhD, Kenji Inaba, MD, Carlos J. Rodriguez, DO, John B. Holcomb, MD, *and* **Juan C. Duchesne, MD**, *Philadelphia, Pennsylvania*

- DCR significantly improve outcomes in severely injured bleeding patients.
- After a review of the best available evidence, we recommend the use of a MT/DCR protocol in hospitals that manage such patients and recommend that the protocol target a high ratio of PLAS and PLT to RBC.
- This is best achieved by transfusing equal amounts of RBC, PLAS, and PLT during the early, empiric phase of resuscitation.

Time to Laparotomy for Intra-abdominal Bleeding from Trauma Does Affect Survival for Delays Up to 90 Minutes

John R. Clarke, MD, Stanley Z. Trooskin, MD, Prashant J. Doshi, MS, Lloyd Greenwald, PhD, and Charles J. Mode, PhD

J Trauma 2002

- Pennsylvania Trauma Registry, n = 243, hypotensive trauma lap patients
- Time in the ED ranged from 7 to 915 minutes.
- Logistic regression on the 165 patients spending 90 minutes or less in the ED showed that the probability of death increased with time in the ED.

- Overall, 98 patients died (40%).
- The probability of death increased approximately 1% for each 3 minutes in the ED.

Mortality after emergent trauma laparotomy: A multicenter, retrospective study

J Trauma 2017

John A. Harvin, MD, Tom Maxim, Kenji Inaba, MD, Myriam A. Martinez-Aguilar, MD, David R. King, MD, Asad J. Choudhry, MD, Martin D. Zielinski, MD, Sam Akinyeye, MD, S. Rob Todd, MD, Russell L. Griffin, PhD, Jeffrey D. Kerby, MD, PhD, Joanelle A. Bailey, MD, David H. Livingston, MD, Kyle Cunningham, MD, Deborah M. Stein, MD, Lindsay Cattin, MPH, Eileen M. Bulger, MD, Alison Wilson, MD, Vicente J. Undurraga Perl, MD, Martin A. Schreiber, MD, Jill R. Cherry-Bukowiec, MD, Hasan B. Alam, MD, *and* John B. Holcomb, MD, *Houston, Texas*

- 74,048 patients admitted over 2 years at 12 centers
  - 3,117 (4%) underwent trauma laparotomy during their hospitalization
  - 1,706 (2.3%) underwent emergent trauma laparotomy
- Age was 31, male (84%), blunt trauma (67%) and ISS of 19.
- Mortality for the entire cohort was 21% with 60% of deaths due to hemorrhage.
- Mortality in the hypotensive group was 46%, with 65% of deaths due to hemorrhage.

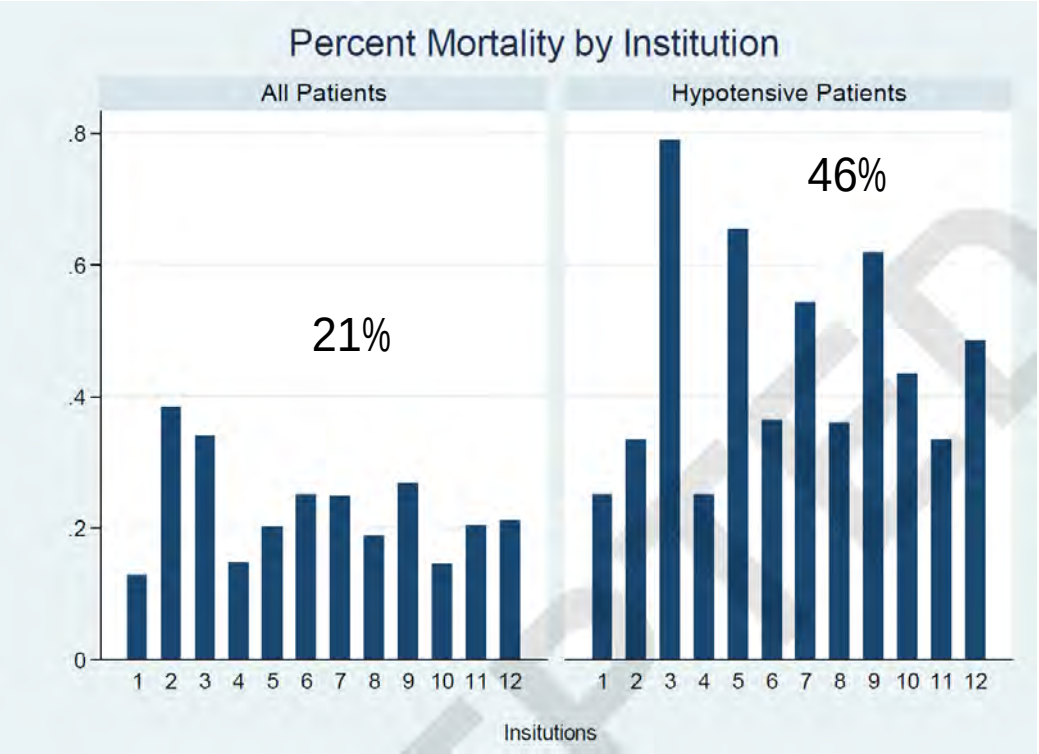
- The mortality rate for hypotensive patients (46%) requiring a laparotomy is unchanged over the last two decades.
  - Clarke JR, J Trauma 2002

Total Time in Hypotensive Laparotomy Patients (n = 394)

Prehospital time was 51 mins
ED time was 22 mins
Time in OR before operation started was 14 mins

Total time from injury until laparotomy started was 87 mins

Doesn't include actual operating time to stop bleeding



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Summary of Time

- Prehospital — 37-76 minutes
- ED — 24 mins
- OR prep — 14 mins
- Time to OR hem control — 53 mins

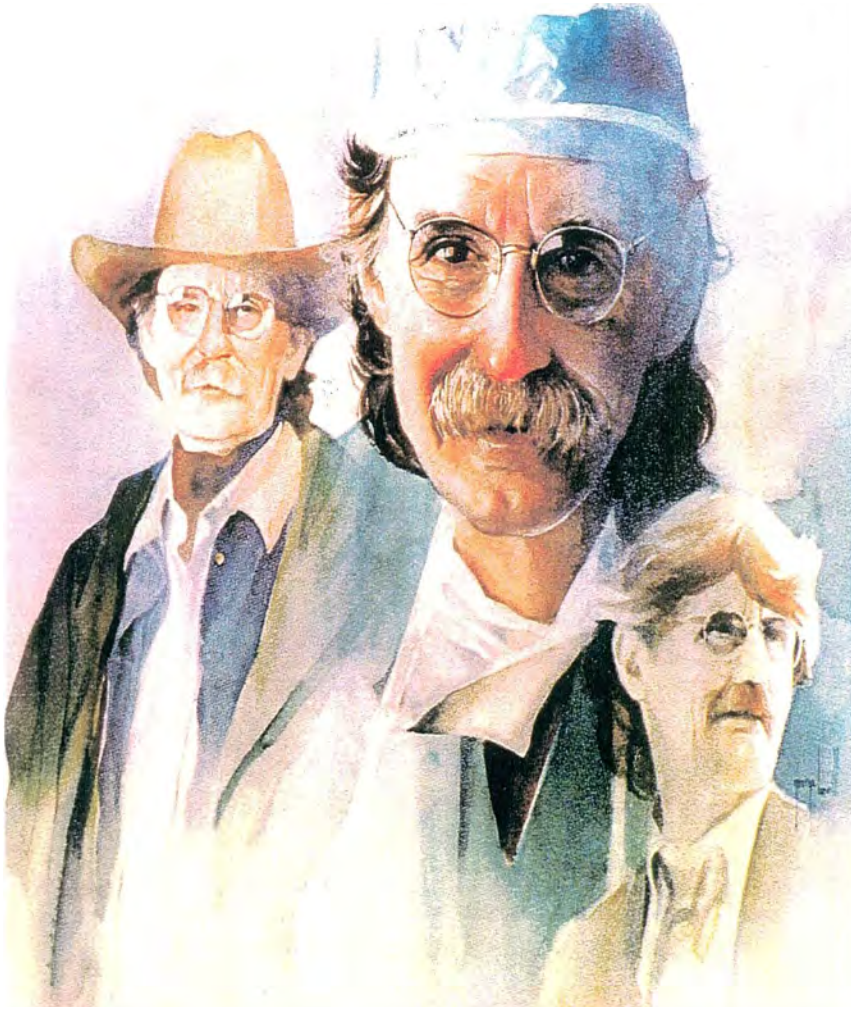
- Helicopter to OR still 104 min.

Total of 128 + minutes to stop bleeding after injury


Life Flight

Memorial Hermann Hospital

LIFE FLIGHT FOUNDED
August 19, 1976



Life Flight

- 1st Helicopter EMS program in Texas
- 2nd Helicopter EMS program in the United States
- Mission: move critically ill/injured people from scene locations and rural hospitals to definitive medical care
- 1979 – Life Flight Long-Distance Program initiated

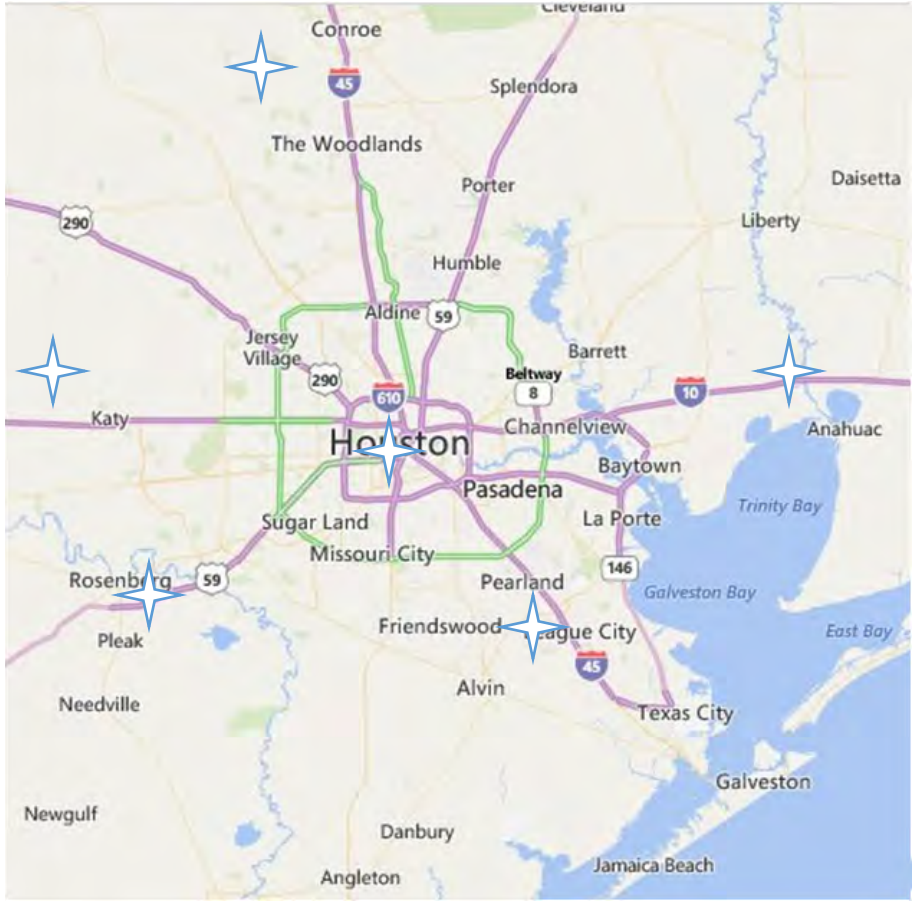
Life Flight

- Only not for profit air transport system in Southeast Texas
- One of the busiest air medical providers in the country.
  - Daily average: 10-15 Flights/Day
    - Industry Standard is 3-4 Flights/ Day
- Transported over 150,000 patients with 68% scene calls and 32% inter-facility transfers

Life Flight Operations

- 4 Community Bases
  - North at D.W. Hooks Airport (Tomball)
  - South at Pearland Regional Airport
  - East at Baytown Airport
  - West 1st-14th at MH-Sugar Land, 15th-31st at MH-Katy
- Central base at MH-TMC
  - Dedicated to heart failure devices, pediatrics and neonates

Life Flight Bases



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- Typical response area is 150 nm from Memorial Hermann-TMC
- Beyond 150 nm with refueling

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[a] The University of Texas Health Science Center at San Antonio, Department of Surgery, Division of Trauma, Critical Care, and Acute Care Surgery, United States

[b] University of Washington, Department of Surgery, Division of Trauma and Acute Care Surgery, United States

Prehospital times

37 min average

40 min blunt

30 min penetrating

Longer prehospital times associated higher mortality

Overview Time-line

- 2008 - Damage Control Resuscitation in Hospital
- 2008 - Tourniquets on Helicopters
- 2010 - Thawed Plasma and RBCs in the ED
- 2012 - Liquid Plasma, RBCs and FAST/US on Helicopters
- 2013 - 3 tourniquets on each of 600 ground ambulances
- 2014 - 2 Tourniquets and 1 Combat Gauze on all 5000 uniformed
- Houston Police Officers (IFAK)
- 2014 - Junctional Tourniquets on Helicopters
- 2014 - Liquid Plasma, RBCs in the ED in Level III centers
- 2015 - Plasma and RBCs on select ground units
- 2015 - Tactical Combat Casualty Course.
  - Additional IFAK distribution
- 2017– Whole blood on helicopters
- 2018 – Tactical response with Houston Police
  - Additional first responder training
-
- * Direct transfers to CT for stroke, cath lab and OR

Pre-hospital ultrasound

- Improve triage
- Guidance of prehospital management
- Expediting time to definitive care
  - Discern etiology of undifferentiated hypotension
  - Decision tool to initiate blood product transfusion

Training

- Training started 2011
- Focus on AEMS nurses/paramedics
- Combination of didactics, hands-on, proctored sessions, internet-based training and review sessions
- During training no intervention on findings
  - Internally validated and previously presented curriculum. 1

1. Press G, Miller S, et al. Eval of a Training curriculum for Prehospital Trauma Ultrasound. J of Em Med. 2013; 45 (6) 856–864

PROSPECTIVE EVALUATION OF PREHOSPITAL TRAUMA ULTRASOUND DURING AEROMEDICAL TRANSPORT

Gregory M. Press, MD,* Sara K. Miller, MD,* Iman A. Hassan, MD,† Kiyetta H. Alade, MD,* Elizabeth Camp, MS,‡ Deborah del Junco, PHD,‡ and John B. Holcomb, MD‡

J Em Med 2014

7 mos period – 1963 flights
293 patients received in-flight ultra-sound
All novice sonographers

Table 2. Test Characteristics for Helicopter Emergency Medical Services Extended Focused Assessment with Sonography in Trauma Interpretations for the Abdominal, Cardiac, and Lung Components with Outcomes of Presence of Injury and Required Interventions

	Sensitivity, % (95% CI), n/N	Specificity, % (95% CI), n/N	PPV, % (95% CI), n/N	NPV, % (95% CI), n/N
Abdominal				
Hemoperitoneum	46 (27.1–94.1), 12/26	94.1 (89.2–97), 161/171	54.5 (32.7–74.9), 12/22	92 (86.7–95.4), 161/175
Required intervention	64.7 (38.6–84.7), 11/17	94 (89.2–96.8), 171/182	50 (28.8–71.2), 11/22	96.6 (92.4–98.6), 171/177
Cardiac				
Pericardial fluid	0 (0–70), 0/3	99.6 (97.3–100), 236/237	0 (0–94.5), 0/1	98.7 (96.1–100), 236/239
Required intervention	—, 0/0	99.6 (97.3–100.0), 239/240	0 (0–94.5), 0/1	100 (98–100), 239/239
Lung				
Pneumothorax	18.7 (8.9–33.9), 8/43	99.5 (98.2–99.9), 444/446	80 (44.2–96.5), 8/10	92.7 (89.9–94.8), 444/479
Required intervention	50 (22.3–58.7), 9/9	99.8 (98.6–100), 469/470	90 (54.1–99.5), 9/10	98.1 (96.3–99.1), 469/478

CI = confidence interval; EFAST = extended focused assessment with sonography in trauma; HEMS = helicopter emergency medical services; NPV = negative predictive value; PPV = positive predictive value.

Pre-hospital Medication

		Mins post dose	Weight LF-kg	Shock Index	Dose	Systolic diff	Map diff	Systolic % Change	Map % change	HR % change	Pain value change	n value
VERSED	Trauma	3.85	81.91	0.94	2.71	-14.43	-10	-12.18%	-11.91%	-2.29%	-0.264	53
	Medical	3.8	82.21	0.749	2.44	-11.48	-8	-10.69%	-10.53%	-2.34%	-0.082	122
FENTANYL	Trauma	4.78	85.78	0.717	69.47	-6.21	-6	-6.61%	-10.46%	-3.94%	-1.05	95
	Medical	4.95	87.5	0.696	71	-5.644	0	-6.48%	-2.98%	-0.40%	-0.93	104
KETAMINE	Trauma	5.08	84.98	0.854	95.9	15.92	12	10.33%	8.09%	10.11%	-2.79	123
	Medical	3.98	80.24	0.875	65.8	10.71	8	4.06%	1.49%	1.72%	-0.675	42

PREHOSPITAL ABC SCORE ACCURATELY TRIAGES PATIENTS WHO WILL REQUIRE IMMEDIATE RESOURCE UTILIZATION

MICHAEL D. GOODMAN, MD, HARVEY HAWES, MD, MATTHEW J. POMMERENING, MD, GREGORY M. PRESS, MD, JEFFREY R. SKANCHY, BS, ELIZABETH CAMP, MPSH, CHARLES E. WADE, Ph.D., JOHN B. HOLCOMB, MD, BRYAN A. COTTON, MD, MPH [1,3]

ABC SCORE

Defined as positive if two or more of the following were present in flight:

- Penetrating mechanism (0= No, 1= Yes)
- ED systolic blood pressure of 90 mmHg or less (0= No, 1= Yes)
- ED heart rate of 120 bpm or greater (0= No, 1= Yes)
- Positive FAST (0= No, 1= Yes)

Prehospital - provides an acceptable over-triage rate

Tool for predicting resource utilization upon arrival.

Improve trauma team activation, early mobilization of resources from the blood bank, operating room, and intensive care unit

Implemented its use on all flights and mobilize resources based on a positive prehospital ABC score

Prehospital Transfusion of Plasma and Red Blood Cells in Trauma Patients

John B. Holcomb, MD, Daryn P. Donathan, BS, Bryan A. Cotton, MD, Deborah J. del Junco, PhD, Georgian Brown, RN, Toni von Wenckstern, RN, Jeanette M. Podbielski, RN, Elizabeth A. Camp, PhD, Rhonda Hobbs, Yu Bai, MD, PhD, Michelle Brito, BS, Elizabeth Hartwell, MD, James Red Duke, MD, Charles E. Wade, PhD

PreHosp Em Care 2014

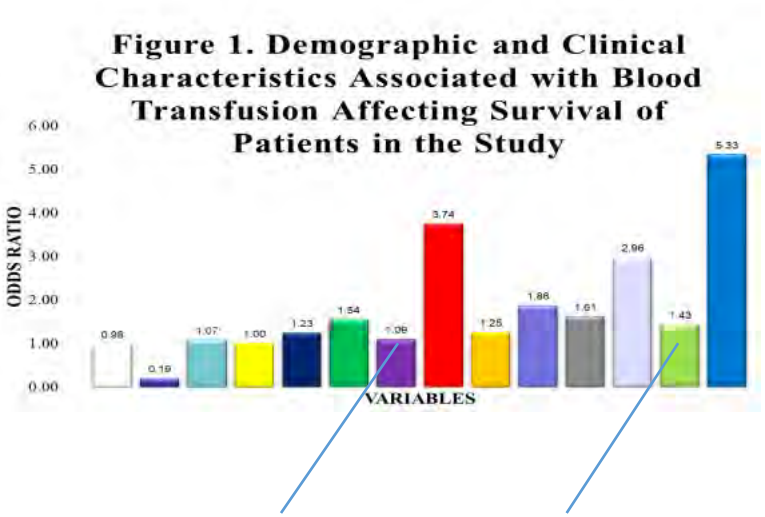
- Prehospital plasma and RBC transfusion was associated with improved early outcomes, negligible blood products wastage.
- Similar to the data published from the ongoing war, improved early outcomes are associated with placing blood products prehospital.
- Thousands of units flown, > 300 patients transfused
- 1.9% wastage

Demographic and Clinical Indicators that may Influence Survival After Blood Transfusion in Pediatric Patients at a Level 1 Trauma Center in Houston, Texas.

Alexjandro Daviano [1,2], Joeseph Love [3,4], Jeffery Tomasek [3,5], Ryan Gunter [3,4], Kyle Kalkwarf [3,4], Jennifer Horney [1,2]

Texas A&M Health Science Center[1], Texas A&M School of Public Health[2], University of Texas Health Science Center[3], Memorial Hermann Hospital Texas Medical Center[4], University of Texas Health Science Center's Center for Translational Injury Research[5]

- All pediatric trauma transports by Life Flight 2011-2016 (N=627)
- 216 (34%) received blood
  - Need for transfusion
    - Blunt injuries
    - Intubation
    - Positive fast
    - Survival associated with
    - MAP 76-97



REVIEW ARTICLE

Whole blood for hemostatic resuscitation of major bleeding

Philip C. Spinella,[1,2] Heather F. Pidcoke,[2] Geir Strandenes,[3,4] Tor Hervig,[4] Andrew Fisher,[5] Donald Jenkins,[6] Mark Yazer,[7] James Stubbs,[8] Alan Murdock,[9] Anne Sailliol,[10] Paul M. Ness,[11] and Andrew P. Cap[2]

- Logistical, economic and clinical benefits of cold stored low titer type O whole blood
- Cold stored for up to 21 days
  - Platelets OK
- Improved function compared to 1:1:1

Trans 2016

Fluid Resuscitation for Hemorrhagic Shock in Tactical Combat Casualty Care

TCCC Guidelines Change 14-01 – 2 June 2014

JSOM 2014

Frank K. Butler, MD; John B. Holcomb, MD; Martin A. Schreiber, MD; Russ S. Kotwal, MD; Donald A. Jenkins, MD; Howard R. Champion, MD, FACS, FRCS; F. Bowling; Andrew P. Cap, MD; Joseph J. Dubose, MD; Warren C. Dorlac, MD; Gina R. Dorlac, MD; Norman E. McSwain, MD, FACS; Jeffrey W. Timby, MD; Lorne H. Blackbourne, MD; Zsolt T. Stockinger, MD; Geir Strandenes, MD; Richard B, Weiskopf, MD; Kirby R. Gross, MD; Jeffrey A. Bailey, MD

- The resuscitation fluids of choice for casualties in hemorrhagic shock are (in priority order):
  - whole blood
  - plasma, RBCs and platelets in 1:1:1 ratio
  - plasma and RBCs in 1:1 ratio
  - plasma alone
  - RBCs alone
  - Hextend
  - crystalloid (lactated Ringer's or Plasma-Lyte)

Whole blood on helicopter

- Following the evidence
- Where it leads…

- Added to aircraft
- November, 2017
- 100+ patients
- (including peds)

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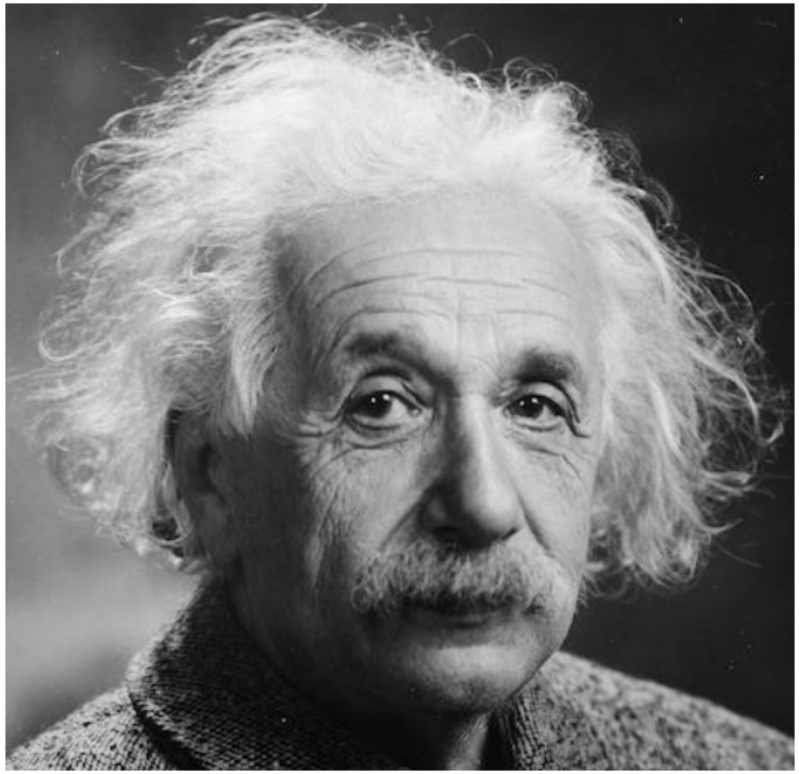
So what are we going to do?

- Prevention is best
- Drive / Fly faster to the hospital?
  - Plenty to suggest not helpful
- Create more Level 1 / 2 trauma centers?
- Increase access to angiography suites?
- Run faster to the OR / IR suite?
- Change human physiology?

  - How about earlier abdominal hemorrhage control in the ED and Prehospital?
  - Improve perfusion pre-hospital ACLS? Bridge to ECMO?

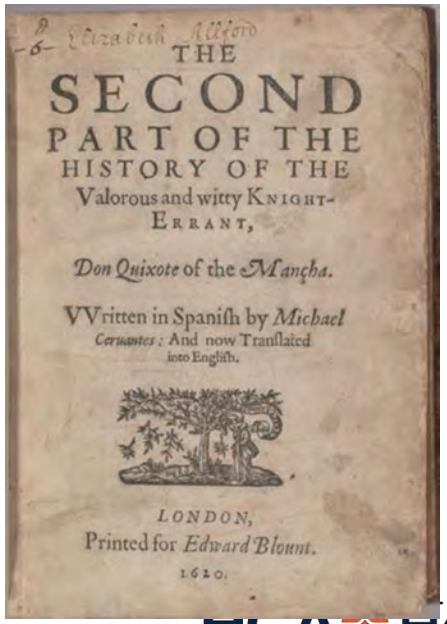


- Scoop and Run, Minimize ED time,
- Run faster to the OR, Operate quickly…….
- No change in Laparotomy mortality in 20 years

"Insanity Is Doing the Same Thing Over and Over Again and Expecting Different Results"

Heresy alert

- Don Quixote tilting at windmills
  - Prehospital ultra-sound, pre-hospital transfusion triggers, Whole blood
  - and now
  - Truncal hemorrhage control and WB transfusion at scene or en route
    - But it just might work



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Multicenter retrospective study of noncompressible torso hemorrhage: Anatomic locations of bleeding and comparison of endovascular versus open approach

J Trauma 2017

Ronald Chang, MD, Erin E. Fox, PhD, Thomas J. Greene, MPH, Brian J. Eastridge, MD, Ramyar Gilani, MD, Kevin K. Chung, MD, Stacia M. DeSantis, PhD, Joseph J. DuBose, MD, Jeffrey S. Tomasek, MD, Gerald R. Fortuna, Jr., MD, Valerie G. Sams, MD, S. Rob Todd, MD, Jeanette M. Podbielski, RN, Charles E. Wade, PhD, John B. Holcomb, MD, *and* the NCTH Study Group, *Houston, Texas*

To describe the anatomic location of truncal bleeding in patients presenting with NCTH and compare ENDO versus OPEN

Houston and San Antonio Level 1 trauma centers

(x4, n = 543, 2008-2012)

	Endo	Open	RT
• Chest (137)	30%	21%	31%
• Abdomen (225)	22%	50%	50%
• Pelvis (167)	46%	26%	15%

Anatomic bleeding locations were 25% chest

72% abdomen / pelvis.

Resuscitative endovascular balloon occlusion of the aorta (REBOA) in the pre-hospital setting: An additional resuscitation option for uncontrolled catastrophic haemorrhage☆

Samy Sadek[a,*], David J. Lockey[b], Robbie A. Lendrum[c], Zane Perkins[d], Jonathan Price[e], Gareth Edward Davies[f]

- 32 year old male in hemorrhagic shock after fall

REBOA placed on scene with ongoing resuscitation

- Vertical shear pelvic fracture
- Internal iliac injuries
- Aortic dissection

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J Spec Oper Med. Spring 2017;17(1):1-8.

A Modern Case Series of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in an Out-of-Hospital, Combat Casualty Care Setting.

Manley JD, Mitchell BJ, DuBose JJ, Rasmussen TE.

USAF – 3 patients with penetrating injuries, class IV shock
ER-REBOA placed in austere environment
Normalization of BP with whole blood transfusion allowing for general anesthesia and laparotomy (inflation time 18-65 minutes).

Undergoing training

Procedures Logged

Residency

Procedure Name	Independent Target	Review Total Passed	Review Total Not Passed	Residency Total Passed	Residency Total Not Passed	Independent
Arterial Line Placement	5	0	0	2	0	
Central Line – Int. Jugular	5	0	0	4	0	
Central Line – Subclavian	5	0	0	1	0	
Central Line Exchange Over Wire	5	0	0	2	0	
Chest Tube	5	4	0	4	0	
Swan-Ganz Catheter Insertion	5	0	0	0	0	

University of Houston Medical School

HCA Houston Healthcare℠

Undergoing training

- Cadaver lab - putting all crew through anatomic and procedural access training (5 attempts each)
- Simulation manikin – (5 successful attempts each)
- Monitored in IR – agreement with IR faculty to put each crew member through 5 actual access cases with supervision.
- Monitored on air craft – Each member will have their access attempts monitored and remediation for unsuccessful access.
- NEED BUY IN
  - Assistance with IR, Vasc, Trauma, ER

Conclusion

- Time to hemorrhagic death happens at a consistent rate
-
- Death after trauma laparotomy hasn't changed in 20 yrs
- Earlier Hemorrhage control should improve outcomes
  - ED vs PH
- Must consider triage, personnel expertise, risks and benefits of prehospital deployment
- Aortic occlusion may improve outcomes...
  - Potential bridge to ECMO?

Additional Projects:

- Collaboration with IT for linear database
- Personalized training program for airway management
- ”Opiate-lite” transport
- Pre-hospital surviving sepsis
- Advanced responder course with TEEX
- Joint Services training platform with local first responders and trauma centers