New Approaches to Emergency Trauma Care

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Disclosures

• Prytime Medical                       Chief Medical Officer
  Founder and BoD
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• Thermal Logistics                    Consultant
• Terumo BCT                           MAB
• Arsenal Medical                       Royalty from UT
• Co-Inventor of the JETT

January 7-12, 2019
Austin, TX
- 150,000 trauma deaths every year
- Approximately 20% of civilian trauma deaths are preventable
- Real rate is 36%
  - or 54,000 a year
  - 21% or 11,300 from hemorrhage

Establishing a Regional Trauma Preventable/Potentially Preventable Death Rate

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2014, all 1843 trauma deaths in Harris County Tx

<table>
<thead>
<tr>
<th>Death location</th>
<th>All Groups n (%)</th>
<th>Preventable /Potentially Preventable n (%)</th>
<th>Nonpreventable n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prehospital§</td>
<td>847 (46.0)</td>
<td>89 (13.3)</td>
<td>758 (64.5)</td>
</tr>
<tr>
<td>Initial acute care setting**</td>
<td>657 (35.6)</td>
<td>202 (43.7)</td>
<td>365 (31.1)</td>
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<tr>
<td>After initial Hospitalization</td>
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<tr>
<td></td>
<td>339 (18.4)</td>
<td>287 (43.0)</td>
<td>52 (4.4)</td>
</tr>
</tbody>
</table>

PP deaths TBI = 16%, Hem = 21%, Sepsis = 28%
Potentially Preventable Truncal Hemorrhage Deaths

19% of all potentially preventable deaths in 2014

All Cases (n=129)

Prehospital and Hospital Deaths vs Time
2003-2005  n = 55,537
Champion H, et al, J Trauma 2016

The Fast and Consistent Curve of Death
What’s the New Approach?

• Don Quixote tilting at windmills
  – Hemostatic dressings, Tourniquets, DP, WB
  – and now
  – Truncal hemorrhage control, DP + WB transfusion at scene, en route or ED
    • It just might work

Bleeding Control Bundle of Care
Oyeniyi B et al. Injury 2016

2005-06 2012-13

Mortality decreased 30%
- 6.6% to 4.7%
- p < 0.05

Hemorrhage deaths decreased from 36% to 25%
(p<0.01).
Incredibly important paper
- NTDB data
- 2.5 million patients retrospective study (2012-14)
- AIS 4 chest and abd, significant TBI excluded
- Prehospital time and mortality

“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.”
• 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
Prehospital ... What should we do?

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

For my > 30 years its been scoop and run

Lets talk about two recent successful interventions

PreHospital Tourniquets
Balanced Resuscitation
232 patients
  - 220 males
  - ages: 4–70
    - median 28
  - 309 limbs
  - 428 tourniquets

The trauma center is too late: Major limb trauma without a pre-hospital tourniquet has increased death from hemorrhagic shock

J Trauma 2018

PH = 252
  - 3% died of hemorrhage

TC = 29
  - 14% died of hemorrhage
All the military and civilian, single and multicenter retrospective studies

**PROMMII**
Prospective Observational Multicenter Massive Transfusion Study

Whole Blood vs Components Study
Frozen Blood vs Stored Blood

Funded by DoD and NIH

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Lots of work over a long time by lots of people

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**PROP:PR**
Prospective Randomized Optimum Platelet and Plasma Ratios

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**Prehospital Plasma during Air Medical Transport in Trauma Patients at Risk for Hemorrhagic Shock**


NEJM 2018

N = 564
9 sites
23% vs 33% 30 day survival
p = 0.02
Diff at 3 hours
Including TBI
The resuscitation fluids of choice for casualties in hemorrhagic shock are (in priority order):

1. **whole blood**
2. plasma, RBCs and platelets in 1:1:1 ratio
3. plasma and RBCs in 1:1 ratio
4. plasma alone
5. RBCs alone
6. Hextend
7. crystalloid (lactated Ringer’s or Plasma-Lyte)

Very logical conclusion
Two very successful interventions

• Early hemorrhage control
  – Tourniquets
• Early balanced blood products
  – Plasma
  – Balanced Resuscitation

• Both moved from hospital to prehospital

Let's talk about Abdominal Hemorrhage
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.

Remember the paper that showed peak time to truncal death was 15-30 minutes?

And that patients arrive at the hospital between 37-76 minutes after injury?

Now the Bad News
• 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

Summary of Time

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

Total of 128 + minutes to stop bleeding after injury

But, peak time to death = 15-30 minutes
Hard Truth

Our trauma systems (by design) deliver seriously injured patients to the hospital well after the peak time to death.

Anatomy and Physiology

- Same in civilians and military
- Wounding agents are different
- Cause of death is the same
- Treatment is the same

- Lessons learned can be transferred back and forth
Now…..Intra-abdominal vascular anatomy is important

Current and Potential Abdominal ED and PH Hemorrhage Control Devices and Procedures

72-90% of abdominal bleeding sites above the aortic bifurcation

- ED Laparotomy
- Resus Thoracotomy
- REBOA
- AAJT
- ResQFoam

- Disgarded
- Traditional
- FDA cleared
- FDA cleared

• FDA regulated study starting in 2019
• Recognized the issue of potentially preventable truncal hemorrhagic deaths
  – 51 consecutive ED laparotomies 100% hospital death

• “Although all patients in this series died, investigation of innovative concepts to extend the art of resuscitation must continue.”
• “…additional aggressive innovative resuscitative skills, including extracorporeal support devices, will be used more frequently, including intracaval and intra-aortic tamponading balloons…..”

• Patients who did not require CPR had a survival beyond the ED of 70%
  – RT 48%, REBOA 93%; p < 0.01
• Survival to discharge of 13%
  – RT = 3%, REBOA = 22%, p< 0.05
• REBOA can confer a survival benefit over RT, in patients not requiring CPR
ResQFoam

In multiple animal studies, controls liver, spleen and iliac artery injuries above and below aortic bifurcation
3 hour treatment duration safe in animals
Potentially avoid use in patients with significant diaphragm or abdominal wall holes
Avoid use with significant hemorrhage above diaphragm
Cleared to start multicenter FDA regulated human trial (2018)

Dr David King  PI


AAJT

-FDA cleared device
-Effectively occludes aorta at the bifurcation
-DoD animal study supports 1 hour inflation
-Avoid use in patients with significant hemorrhage above aortic bifurcation

• 9,608 patients were admitted during the 2 year study period.
• 402 (4.1%) who lived long enough to receive an emergent trauma laparotomy.
  – ISS =24, 58% blunt, 75% male, age = 38
  – Evaluated if bleeding site above or below the aortic bifurcation
  – what vessel/organ was bleeding
• The external surface location of signs of injury did not correlate with the location of internal bleeding site identified during laparotomy.
• New methods Potentially beneficial
  – Zone 1 control in 96% of patients
  – ResQFoam in 87%
  – Zone 3 or AAJT in 9%

Bring all this together

• Epidemiology
• Cause of death
• Time to death and hemostasis
• Bleeding Location
• Potential solutions
• ARC = Prehospital WB + REBOA
  – Stopping truncal bleeding…. Pre-OR…. 
Conclusion

• Hypotensive patients have a very high mortality

• Time to hemorrhagic death happens at a consistent rate

• Death after trauma laparotomy hasn’t changed in 20 yrs

• 72 - 90% of abdominal bleeding sites are above the aortic bifurcation

• Earlier Hemorrhage control + balanced resuscitation should improve outcomes
  – ED and PH

• Must consider triage, personnel expertise, risks and benefits of proposed interventions

Goal

Earlier and More Effective Interventions

The time is now to set an audacious goal:

Push interventions out of the OR into the ED and Prehospital space and

Stop truncal bleeding