The Burden of Battlefield Medicine

4:1 ratio?
We must do better!

Non-Endorsement
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No Conflicts of Interest; I've only received Government funding for research.

Why am I here?
Operational Intensivist
Lessons learned through telemedicine
Simple Explanations
Special Operations Medical Sergeant caring for a simulated critically ill trauma patient during the Mountain Path prolonged field care training exercise. Using the Virtual Critical Care Consultation (VC3) call guide, the medic first sends images of the casualty, care documentation flow sheets, and available equipment via e-mail to the VC3 distribution list and then calls the VC3 phone number which forwards to the on-call VC3 intensivist who provides consultation.

Lessons Learned by an “Operational Intensivist”

-了解面对危机时的处境“under a bush”—— Geir Strandness
-“Why we improvise not because we want to, but because we have to” – Mike Hoffman
-Successful training is a TEAM sport!

What shouldn’t be done
- Use tech to solve people problems, don’t use tech that makes problems for people!
HOW TO TALK ABOUT TECHNOLOGY TO SCEPTICS?

Setting better expectations

Building better partnerships

EXPECTATIONS

- Technology development is a journey that requires many iterative, interim solutions that begin
  - Too Heavy
  - Too Big
  - Not field ready – too much power, difficult to use, fragile
  - But solve a problem (single use)

PARTNERSHIPS

The collaboration between the research and development team needs you as partners

- Provide problems that need solving
- To see past the problems of a prototype
- Understand its purpose
- Provide data...
Casualty Care is Resource Intensive

Current state

The Golden Hour Improves Outcomes

“Golden Hour” Evacuation

Transport

1. Tactical Combat Casualty Care
2. Tourniquets, Binders, & Hemostatic Dressings
3. Transport time < 60 minutes to surgery
4. Advanced Medical Retrieval
5. Burn Flow Sheet
6. High Intensity Blood Transfusion
7. Surgical Center Transfer
8. Damage Control Surgery
9. Decompressive Craniectomy
10. Critical Care Air Transport
11. Extracorporeal Membrane Oxygenation
12. Process Improvement
This is still Plan A...

**The Tyranny of Distance and Air/Area Denial**

<table>
<thead>
<tr>
<th>Key</th>
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<tbody>
<tr>
<td>Time without Critical Care &lt; 1 hr</td>
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<tr>
<td>Time without Critical Care 1-3 Days</td>
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**Future Problem**

<table>
<thead>
<tr>
<th>Branch</th>
<th>Killed</th>
<th>Wounded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Army and AD Force</td>
<td>318,274</td>
<td>565,861</td>
</tr>
<tr>
<td>Navy</td>
<td>62,614</td>
<td>37,778</td>
</tr>
<tr>
<td>Marines</td>
<td>24,511</td>
<td>68,207</td>
</tr>
<tr>
<td>Coast Guard</td>
<td>1,917</td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>407,316</strong></td>
<td><strong>671,278</strong></td>
</tr>
</tbody>
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**Operation Overlord**

- 209,000 Allied casualties
- 125,847 US ground forces
- Approximate Deaths:
  - Ground: 37,000
  - Air: 16,714
  - Avg. 2,459 casualties/day

**Battle of Iwo Jima**

- 19,217 Wounded
- 6,822 Dead/Missing
- Avg. 813/day

Are we ready?
Prolonged Field Care (SOMA WG)

- Field medical care, applied beyond doctrinal planning time-lines, by a Special Operations Combat Medic or higher, in order to decrease patient mortality and morbidity. Utilizes limited resources, and is sustained until the patient arrives at an appropriate level of care.

“Treating a patient that you know should be somewhere else, for longer than you want.”
- MAJ Doug Powell, MD
  USAASOC Intensivist

Austere Medicine

Defined by limited resources of
- Equipment
- Medicine(s)
- Diagnostics
- Personnel
- Knowledge, skills, abilities & expertise

Caused by:
- Location
- Time
- Distance
- Casualty numbers
So, what could we do to solve these problems?

Autonomous Casualty Care...

*Automating* Casualty Care to enhance caregiver capability and capacity...
How do we do this?

Must have a deep understanding about patient care:
- The what, why, and when will not change (much)
- The how is a target of opportunity

What do caregivers do?

- Evaluate
- Diagnose
- Treat
- Discuss
- “Manage”
- Synchronize

Evaluate
Diagnose
Treat
Discuss
“Manage”
Synchronize

Assess
Decide
Treat
Communicate,
Coordinate,
Synchronize

Empire Probability Combat Death

Source: James, J. Trauma. 1994

LTC (P) Jeremy Pamplin, Title, Email
**Man vs. Machine**

- **Human**
  - Speed: Slower
  - Power: Weaker
  - Consistency: Unreliable
  - Capacity: Single channel
  - Memory: Versatile and innovative, principles and strategies
  - Reasoning: Inductive, learns quickly, corrects erroneous data
  - Sensing: Multifunctional, has judgement
  - Perceiving: Copes with variance

- **Computers**
  - Speed: Superior
  - Power: Superior
  - Consistency: Superior
  - Capacity: Multichannel
  - Memory: Literal, restricted, formal
  - Reasoning: Deductive, tedious programming, fast & accurate, limited by data quality
  - Sensing: Quantitative, poor pattern recognition
  - Perceiving: Susceptible to noise

**Model for technology development**

<table>
<thead>
<tr>
<th>Core element</th>
<th>Capability</th>
<th>Technology Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment</td>
<td>Automated VS tracking</td>
<td>Monitors that document</td>
</tr>
<tr>
<td>Injury Identification</td>
<td>Machine Vision</td>
<td></td>
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</tbody>
</table>

**Artificial Intelligence**

**2016 Camelyon Grand Challenge**

- 7.5% error rate for AI-based cancer detection
- 3.5% pathologist reviewed
- Combined: 5% error rate
- Example demonstrates how "fundamental research in AI can drive development of high performing computational systems"

- NTSC OSTP National AI R&D Strategic Plan. (2016)

*Slide Courtesy of CCC Research Portfolio*
Technology Requirements

- Small
- Light weight
- Low power consumption or easily recharged or same battery as other kit
- Ideally Multi-purpose or mission essential
- Cheap/easily replaced (not a high-value item)
- Others?

Mobile Platforms!

WE NEED DATA!

Battlefield Documentation...
... is always delayed....
Data sources in austere medicine

Real-time patient data
- Physiology
- Environment
- Outcomes

Real-time caregiver data (Audio/video)
- Decisions
- Tasks/interventions

Stored long term for comparative analysis
Is this possible? How?

How to learn best practices and care synchronization

Battlefield Emergent Stabilization Skills Training

Problem: "Medic PFC" lacks knowledge, skill, ability, and/or experience with life-saving procedures


Remote
Non-Surgeon Structured Data Sensors
(Physiologic/Environmental/etc.)

Communications

Medical Treatment Facility

Surgical Specialist
Support
Monitoring

LOCAL SIDE

REMOTE SIDE

PROCEDURALIST'S VIEW

Unstructured Data Sensors
(Audio/Visual/etc.)

Summary

• We need ways to increase caregiver capability and capacity
  • Else casualties will die more

• A possible model for automating casualty care:

• We need to partner with austere caregivers to define problems, to get data and test solutions
  • Or we can’t understand how to affect change at the point of need
Future Problem

Austere Medicine (Prolonged Field Care)

- Resource Limited
  - Knowledge, skills, abilities, experience
  - People
  - "Stuff"

- Casualty Care at PON is outside the close area
- How to manage dispersed care & evacuation?
- How to Re-supply?

Multi-Domain Operations

Resource Limited

- Knowledge, skills, abilities, experience
- People
- "Stuff"

Many:1 Caregiver:Casualty Ratio

1:1 or 1:Many
Levels of Automation

1. Offers no assistance
2. Offers complete set of decision/action alternatives
3. Narrows selection down to a few
4. Suggests one option
5. Executes suggestion if human approves
6. Allows human a restricted time to veto before execution
7. Executes automatically and informs human
8. Executes human only if asked
9. Executes human only if it (the computer) "decides to"
10. Fully autonomous, ignores the human

Man versus Machine or Man + Machine?
Mary (Missy) Cummings, Duke University and MIT

Automating Casualty Care

Questions?
PFC Capabilities

- **Capabilities** combines basic diagnostic and patient treatment skills with medical equipment to define a framework for education and training

- 10 Capabilities:
  - Monitor the patient
  - Resuscitate the patient
  - Ventilate/oxygenate
  - Maintain an airway
  - Sedation/pain control
  - Physical Exam/diagnostic measures
  - Provide nursing/hygiene/comfort measures
  - Perform advanced surgical interventions
  - Telemedicine
  - Prepare the patient for flight