How Battle Field Experience Leads to Improvement in Orthopaedic Care

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Outline

• Winners from War
  – Medical and Munitions Technology
• Insurgency Warfare
• Medical Challenges and Solutions
• Case Studies
• Medical Advances
# Lethality of War Wounds among US Soldiers

<table>
<thead>
<tr>
<th>War</th>
<th>No Wounded or KIA</th>
<th>No KIA</th>
<th>Lethality of war wounds %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revolutionary War 1775-1783</td>
<td>10623</td>
<td>4,435</td>
<td>42</td>
</tr>
<tr>
<td>War of 1812 1812-1815</td>
<td>6,765</td>
<td>2,280</td>
<td>31</td>
</tr>
<tr>
<td>Mexican War 1846-48</td>
<td>5,885</td>
<td>1,733</td>
<td>29</td>
</tr>
<tr>
<td>Civil War (Union Force)1861-1865</td>
<td>422,295</td>
<td>140,414</td>
<td>33</td>
</tr>
<tr>
<td>Spanish-American War 1898</td>
<td>2.047</td>
<td>385</td>
<td>19</td>
</tr>
<tr>
<td>World War 1 1917-1918</td>
<td>257,404</td>
<td>53,402</td>
<td>21</td>
</tr>
<tr>
<td>World War 2 1941-45</td>
<td>963,403</td>
<td>291,557</td>
<td>30</td>
</tr>
<tr>
<td>Korean War 1950-1953</td>
<td>137,025</td>
<td>33,741</td>
<td>25</td>
</tr>
<tr>
<td>Persian Gulf War 1990-1991</td>
<td>614</td>
<td>147</td>
<td>24</td>
</tr>
<tr>
<td>War in Iraq and Afghanistan, 2001-Present</td>
<td>50000</td>
<td>4875</td>
<td>10</td>
</tr>
</tbody>
</table>
Medicine: War and History

• Battle and Non Battle injuries
  – Generally outnumber battle injuries
  – Disease

• Sudan
  – Formal Medical Corps – NSW Corps

• Boer War
  – Medics as combatants
  – Nurses in the field
  – Early surgery and delayed closure
20th Century

- **World War I**
  - Orthopaedic Splintage compound Femur
    - Mortality from 80% to 15%
  - Blood Transfusions
    - 1917 could only be kept 12 hours

- **World War II**
  - Antibiotics
  - Safe Transfusion

- **Korea & Vietnam**
  - Golden Hour
    - Early aggressive resuscitation
Florence Nightingale
Biography

• Born Florence 1820 very wealthy family
• 3 months training Kaiserwerth Germany 1851
• Returned to run small private hospital
  – Harley Street London
  – Cholera very common
• 1854 with 38 nurses invites to Turkey to assist in British Hosp Military Hosp Crimean War
• Dreadful conditions
Achievements

• Cleaned up the hospital
• Improved everything
• Dramatically decreased mortality
• Known as the “Lady with the Lamp”
• Result of evening rounds
• Returned to UK as a legend
• Queen Victoria supporter and improved all areas but primarily nursing training
The very first requirement in a hospital is that it should do the sick no harm.

Women have no sympathy and my experience of women is almost as large as Europe.
Lethality of Modern Warfare

• Type of Warfare
• Personal Protection
• Blasts aimed to Kill a lot and injure many more
• Medical advances Battle and Non Battle injuries
## Injuries of Survivors

### Anatomical Distribution of Penetrating Wounds (%)

<table>
<thead>
<tr>
<th>Conflict</th>
<th>Head and Neck</th>
<th>Thorax</th>
<th>Abdomen</th>
<th>Limbs</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>World War I</td>
<td>17</td>
<td>4</td>
<td>2</td>
<td>70</td>
<td>7</td>
</tr>
<tr>
<td>World War II</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>75</td>
<td>9</td>
</tr>
<tr>
<td>Korean War</td>
<td>17</td>
<td>7</td>
<td>7</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>Vietnam War</td>
<td>14</td>
<td>7</td>
<td>5</td>
<td>74</td>
<td>—</td>
</tr>
<tr>
<td>Northern Ireland</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>50</td>
<td>—</td>
</tr>
<tr>
<td>Falkland Islands</td>
<td>16</td>
<td>15</td>
<td>10</td>
<td>59</td>
<td>—</td>
</tr>
<tr>
<td>Gulf War (UK) **</td>
<td>6</td>
<td>12</td>
<td>11</td>
<td>71</td>
<td>(32)*</td>
</tr>
<tr>
<td>Gulf War (US)</td>
<td>11</td>
<td>8</td>
<td>7</td>
<td>56</td>
<td>18+</td>
</tr>
<tr>
<td>Afghanistan (US)</td>
<td>16</td>
<td>12</td>
<td>11</td>
<td>61</td>
<td>—</td>
</tr>
<tr>
<td>Chechnya (Russia)</td>
<td>24</td>
<td>9</td>
<td>4</td>
<td>63</td>
<td>—</td>
</tr>
<tr>
<td>Somalia</td>
<td>20</td>
<td>8</td>
<td>5</td>
<td>65</td>
<td>2</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>15</strong></td>
<td><strong>9.5</strong></td>
<td><strong>7.4</strong></td>
<td><strong>64.6</strong></td>
<td><strong>3.5</strong></td>
</tr>
</tbody>
</table>
Body Armour

St Vincents Clinic
Loads carried by Soldiers

- Greek Hoplites
- Roman Legions
- Byzantine Infantry
- Anglo Saxon Freemen
- English Pikemen
- Napoleonic Wars
- US Civil War
- British Crimean War
- British on Somme WWI
- Wingate's Chindits WWII
- US Marines Korea
- US Vietnam
- JRTC
- US Inf Desert Shield
- OEF

Estimated load masses carried on the march
Estimated total mass of all equipment soldiers took

Bar chart showing the load mass carried by different historical military forces.
Modern Warfare

- Non Conventional – asymmetric warfare
  - Tactical and Strategic differences
- Unpredictable
- Exhaustion Resources
  - Terrorism
  - Insurgency
  - Subversion
  - Information operations
“Tools” of the Trade

• Improvised Explosive Devices (IED’s)
  – Fixed position – Roadside Bombs
  – Mobile
    • People borne – suicide bombers
    • Vehicle borne

• Indirect Fire - Rockets and RPG’s

• Direct Fire - GSW
Mechanism Blast Injuries

- Primary Injury
  - Movement of air pressure
- Secondary Injury
  - Movement of Projectiles
- Tertiary Injury
  - Movement of people
- Quaternary Injury
  - Miscellaneous Injuries
- Dead to Injured – 1:4.35
Primary Injury

- Rapidly expanding blast wave
- Air filled organs most affected
  - Middle Ear
  - Lungs
  - Colon
- IED
  - 60 psi
- Hellfire Missile
  - 5,000,000 psi
Secondary Injuries

- Multiple projectiles
- Body Armour, Ballistic helmets, Ballistic Eyewear are effective
- Projectiles 1800 metres per sec
- Unprotected areas most vulnerable
- Secondary missiles energized
  - Rocks, dirt, bone fragments & clothing including additional projectiles in clothing (5mm ball bearings in the hundreds!)
Helmets & Eye Protection
Canadian SGT
Tertiary Injuries

- Victims projected into stationary objects
- Passengers in vehicles
- Head injuries and fractures
Quaternary Injuries

- Inhaled Pollutants
- Airway burns
- Thermal burns
- Crush injuries
Surgical Considerations

• Multiple patients at a time
• Multiple penetrating injuries
  – Abdominal and Chest injuries
• Peripheral Injuries
  – Which wounds to explore
• ATLS Principles
Australian Military Experience

- Sudan in 1885 March - June
  - Infantry Battalion from NSW 700 troops
  - Generally regarded as too late to be effective.
  - NSW Medical Corps
    - Volunteer Doctors and Orderlies
    - CO MAJ William Williams
      - Surgeon St Vincents Hospital
MAJ Williams Contributions

• NSW Medical Corps in Sudan
  – five ambulances, two stores carts, a water cart
  – 26 horses, tentage, hospital equipment, and field kitchen
  – In total 34 officers and ORs

• Established “Resus Team” MO, NO and 2 stretcher bearers – basis still today

• Trained stretcher bearers to be at the edge of the battle as it raged to extract casualties as quickly as possible and get them to doctors working close behind the action.

• Modified a cart for specific use as Ambulance.
Military Service

- Training Exercises – regular activity
- Disaster Assistance
  - Common in our Area
    - Papua New Guinea, Indonesia, Philippines, Pakistan
- Peace Keeping
  - Bouganville, Timor, Solomon Islands, Fiji
- War Like Service
  - Timor, Iraq, Afghanistan
- All in the last 20 years
Military Deployments

• Medical is critical but not the Mission
• Chain of Command
• Limited Control of what happens
• Limited resupply
• Unpredictable
• Diseases not seen in Australia
• General poor nutrition
• No facilities or services
Military Surgery

- Natural Disasters and War Like
- A large volume of work in a very short time with limited supplies and no short term resupply
- However Resus team in a FST (Role2) or Role 3 is as capable as any major ED in any major Hospital.
- Kandahar in 2009 15 to 20 CAT1 patients per day – NSW has about 250 per year.
Challenges and Solutions

• Disaster Assistance
  – Essential to do simple and effective.
  – Easy for next person to take over without notes
  – Do what fails well – rarely second chance
  – Very minimal resources and slow resupply
  – Personal risks of disease and climate
OP SLIPPER
AUS MTF4 2009

• Australia rotates with Dutch and Singaporean Teams
• Surgical Team
  – Orthopaedic and General Surgeon
  – Anaesthetist and Intensivist
  – 2 Theatre RNs
  – Theatre Technicians (Medics)
• Intensive Care Team
  – 3 ICU RNs
  – ICU Technicians (Medics)
Dutch Hospital

• Role 1 GP and general medical
• Dental services
• Physiotherapy
• Pathology
• Radiology
• Mortuary

• Pharmacy
• Wards
• Administration
• Theatre Complex
  – Operating Room
  – Intensive Care 2 beds
  – Resuscitation – 2 Cat A
  – Recovery 2 Bays
  • Second Resus
Modern Medical Advances

• Tactical Casualty Combat Care TC3
  – Control Haemorrhage
    • Tourniquets – issued to all
    • One handed application
    • Injured can apply themselves

• Control breathing
  – Pneumothorax
    • Thoracocentesis

• Hold fluids in most cases
  – Damage Control Resusciation
Lessons Learnt

• Permissive Hypotension
  – Rapid transfer to FST and OR where indicated

• Resuscitation Teams
  – Team permitted to function
  – Senior specialists kept back until invited to assist.

• Damage Control Surgery

• Provision of Transfusion Products
  – Walking Blood Bank
  – Frozen Blood – Dutch Solution
Permissive Hypotension

- Minimal fluid at scene
- Accept BP 80mm Hg if no brain injury
- Airway and bleeding control
  - All troops trained and issued with tourniquets
- Scoop and run rather than stay and play
- Transfer to FST – Resus and OR capability ASAP
- Early and aggressive blood transfusion
- Rapid transfer to surgery
- In AFG 95% survival if pulse on arrival at FST
Resus Teams

- Doctor, Nurse and 2 Medics
- 2 Teams ready with additional 2 teams
- Role 2 could manage 4 CAT 1 at a time
- Senior MO (ICU) would monitor patients
- Other Specialists kept away unless necessary
- Permitted teams to work as a team
- Role 3 facility capacity for 16 CAT 1
  - In 2009 would handle 15 to 20 CAT 1 per day
- All Sydney about 250 CAT 1 per year

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Damage Control Surgery

- “The modern operation is safe for the patient. The modern surgeon must make the patient safe for the modern operation”

Lord Moynihan 1835 - 1936
Principles

• Multi Trauma Patient more likely die from intra-operative metabolic failure than from failure to complete operative repair
• Patients die from a triad of coagulopathy, hypothermia and metabolic acidosis
• Control of haemorrhage, prevention of contamination and protection from further injury
• No margin for error
• Decreased mortality CAT 1 from 65% to 19%
Parameters

- When to convert to Damage Control
- pH < 7.2
- Core Temp < 32°C
- > Blood Volume Transfusion
- Early decision gives best survival.
Three Phases

- Primary Surgery
- Intensive Care Resuscitation
- Planned reoperation
- Principles extend to all surgery
  - Particularly Limb saving
  - Do basic Limb saving and revisit
Case Study Male 20 yrs

- UD possible 3 rounds of 5.56!
  - Weapon safety problems!
- Rotary AME doors open and patient wet
  - Core temp < 32°C
- Coagulopathic on admission
  - Wound packed
- Temp in Resus on way to OT 32.8°C
- First pH 7.27 (in OT ABG from arterial line)
Resuscitation

• Fluids - from Injury to leaving OT
  – 3000ml Crystalloid
  – 600ml Colloid
  – 14 Units Red Cells
  – 12 Units FFP
  – 10 Units Platelets

• Total Time in OT 140 minutes
Findings

• Extensive bleeding from right iliac crest wound
• Extensive damage ascending colon, caecum, ileum.
• Laceration 2nd/3rd part duodenum
• Extended Right Hemicolecctiontomy
• Bowel closed with GIA stapler
• No anastomosis performed
Intensive Care

- Arrived Temp 32.8°C same as pre op
- After laparotomy left open packed and Vac
- pH on admission 7.43
- Temp restored to 37.2°C
- Blood loss dropped to 300ml per hour for 2 hours and then stopped.
- Transfer at 4 hours
- Needed to ensure Unit ready for next patient
Follow Up

• Transferred to Role 3
• Principally for CT scan for spine
• Poor Communication
• 3/7 later
  – Bowel anastomosis
  – Plan to close abdomen
  – Chest infection antibiotics
  – All else good
Blood Solutions

• Walking Blood Bank
  – Fresh blood from fellow soldiers
    • Limited or no testing
    • Huge pressure on “mates”
    • Limited supplies
    • Very noble but unsafe

• Fresh Blood from wherever
  – Very difficult shelf life 4 weeks maximum

• Dutch Solution Frozen Blood
Dutch solution

- Frozen blood bank deployed in one mission
- Resupply as needed (less logistic requirement)
- All blood fully screened
- Blood supplied as needed by 2 person
- 6 units of PRBC (O-) thawed for use, rest supplied as needed
  - All fresh RBC (frozen within 24 hours of collection)
- Wastage approaches zero regardless of operational tempo
Frozen Blood

• “Shelf Life” (stored at -80°C)
• All frozen on Day 1
  – Red Cells 10 years
  – FFP 7 years
  – Platelets 3 years
Dutch Blood Solution

- Frozen -70°C on day 1 collection
  - Kept in Holland for 1 year and donor retested
  - “Shelf Life”
    - Red Cells - 10 years
    - Plasma - 7 years
    - Platelets - 3 Years
- Transported packed in dry ice
- Stored in -80°C freezer
- Reconstituted in 20 to 30 minutes
- Once reconstituted blood good for 2 to 3 weeks.
- Never short of blood and never any delay for blood.
In Summary

• Military Deployment offers unique experience
• Radical solutions are found
• Very accurate data collected and reviewed
• Experience shows that radical approaches works
• Able to demonstrate to civilian trainees and colleagues
• Otherwise we would stay in our comfort zone and limit progress
Acknowledgements

- All of other ADF members who helped get me there and who I worked with.
- To all ADF members doing the hard work who we were able to provide a high level of care to.
- My family left at home with only limited contact – Good and regular phone calls but not able to say a lot.
- Personal and Family Burdens carried by the 18,000 Australians to Iraq and Afghanistan since 2001