

Multiple Extremity Amputations



Joint Trauma System Battlefield Trauma Educational Program



EWS Multiple Amputations Disclaimer



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My official disclosure is located on the AAOS database. I have no potential conflicts with this presentation.

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Photos courtesy of Christiaan Mamczak, DO Afghanistan



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Case Scenario



- A 24 year old male special operations marine was on an advise and assist mission in Jolo, Philippines, when he inadvertently stepped on an IED placed by Abu Sayyaf. His sustained traumatic bilateral above knee amputations, a near amputation of his right hand, and pelvic and abdominal injuries.
 1. What are the priorities for care?
 2. What are ways to control hemorrhage from high above knee amputations?
 3. There is questionably viable tissue on the second look surgery. How should this be treated downrange?

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Objectives



1. Describe the four components which comprise the blast injury mechanism: Primary, Secondary, Tertiary and Quarternary.
2. Describe the physiological requirements and stress of the blast trauma patient.
3. Describe the term Dismounted Complex Blast Injury (DCBI). Summarize and distinguish between acute treatment goals, initial resuscitation goals and index operative goals for this injury.
4. Summarize operative approach guidelines as they relate to surgical hemostasis, volume control, and decontamination with DCBI. Discuss posterior blast wounds and genitourinary blast injury considerations.
5. Summarize postoperative guidelines with DCBI.

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Introduction

- Devastating injuries
- Mortality risk from early exsanguination or late sepsis
- Truly life changing daily morbidity for survivors
- Encompasses the most challenging medical treatment scenarios imaginable



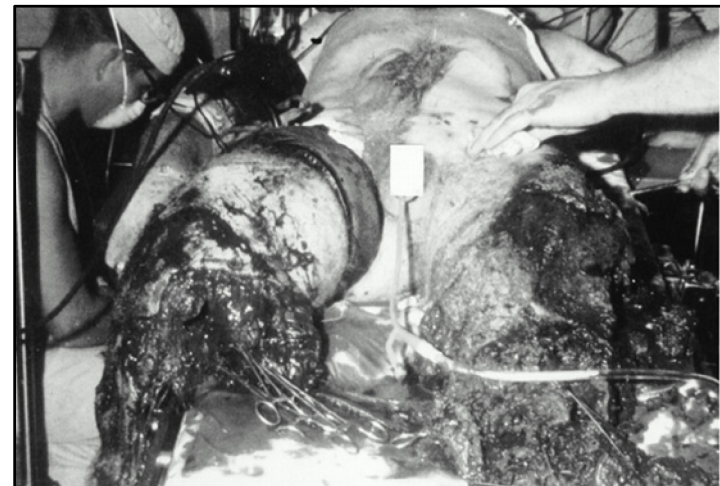
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Historical Perspective

Multiple limb amputations are NOT new or unique to Operation Iraqi Freedom or Operation Enduring Freedom (OIF/OEF).

Dougherty (JBJS 1999):

- 484 Vietnam amputees
- 33 b/l above knee amputations (6%)
- 87% secondary to blasting injuries
- 88% amputated 2° to trauma
- 12% amputated for infection
- 88 amputated 2° to trauma
- 12% amputated for infection



Dougherty (JBJS 1999;81:1384-90)

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OIF/OEF Numbers



- Historically, combat tactics dictate injury patterns.
 - ❑ Vietnam ≠ OIF ≠ OEF
 - ❑ OIF: projectile based Improvised Explosive Devices (IEDs), less 1° blast
(Ramasamy J Trauma 2008)
 - ❑ **OEF: higher 1° blast explosive IEDs with greater contamination**
(CMAJ 2010;182:1159-60, AAOS ICL Vol 57, 2008)

- Actual OIF/OEF amputation numbers are unknown:
 - ❑ Number of surviving BI vs. number of non-survivor BIs??
 - ❑ **Numbers are changing as we speak because of the evolution of downrange medical support.**

EWS Multiple Amputations Comparative Data



- It's been projected that the overall OIF/OEF amputation rates \geq Vietnam (*Lin J Orthop Trauma 2004, Stansbury J Orthop Trauma 2008*)
- **Multiple traumatic limb loss: A comparison of Vietnam veterans to OIF/OEF service members** (*Dougherty et al. J Rehab Res Dev 2010;47:333-48*)

73 Vietnam Vets

68% b/l LE amps

31.5% b/l AKA

17.8% BKA-AKA

6.9% b/l BKA

8% b/l UE amps

10% triple amps

vs.

vs.

vs.

vs.

vs.

vs.

61 OIF/OEF

69% b/l LE amps

16.4%

18%

13.1%

11% b/l UE

11% triple amps

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OIF/OEF Stats



The true numbers are not yet known ...

- Estimated 1100 major limb amputations in OIF/OEF
(Tintle et al. JSOA 2010)
- 816 estimated OIF/OEF major limb amputation by 9/2010
(Fischer, Congressional Research Service; Sept 28, 2010)

Stansbury et al. (JOT 2008):

OIF/OEF 2001-2006

423 amputees

67 b/l LE, 6 b/l UE, 4 triples

18% multi-amputees

87% blast injuries

Potter et al. (JAAOS 2006):

US Army Amputee Program

381 amputees by 2005

46 b/l LE, 7 b/l UE, 20 UE/LE

19% multi-amputees

EWS Multiple Amputations OIF/OEF Numbers

Are the OIF/OEF numbers increasing?

■ OEF- AFG: Oct 2001- Present (*defense.gov*)

Total Deaths 1,757 vs . 4,408 (OIF)

KIA 1,473 vs. 3,480 (OIF)

WIA 15,204 vs. 31,921 (OIF)

■ Kelly et al. (*J Trauma 2008*)

❑ Reviewed autopsies of 2003-04 OIF/OEF casualties vs. 2006

❑ Deaths per month doubled (35 vs. 71)

❑ Increase seen in ISS (27 vs. 37) and number of wounds per casualty

❑ Morbidity and mortality attributed to prevalence and potency of IEDs



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Amputation Numbers



Amputee severity is getting worse!

June 2011 US Army Surgeon General Report: Dismounted
Complex Blast Injury Task Force

- 1. Number of triple amps doubled in 2010*** relative to the sum of the previous 8 years of combat
2. OEF BI scores and amputation rate > OIF
3. Increasing number of pelvic and GU injuries in OEF amputees

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Amputation Numbers

Why the increase?

- Change in combat tactics
 - ❑ Counter Insurgency (COIN)
 - ❑ Win the “Hearts and Minds.”
- Greater exposure for troops
 - ❑ Mounted IED and Dismounted IED encounters rising.
 - ❑ Explosive Mechanism of Injury (MOI) remain the most common cause of combat casualties (up to 88%) with greater prevalence for extremity injuries.
(Owens JOT 2007, Belmont JSOA 2009)

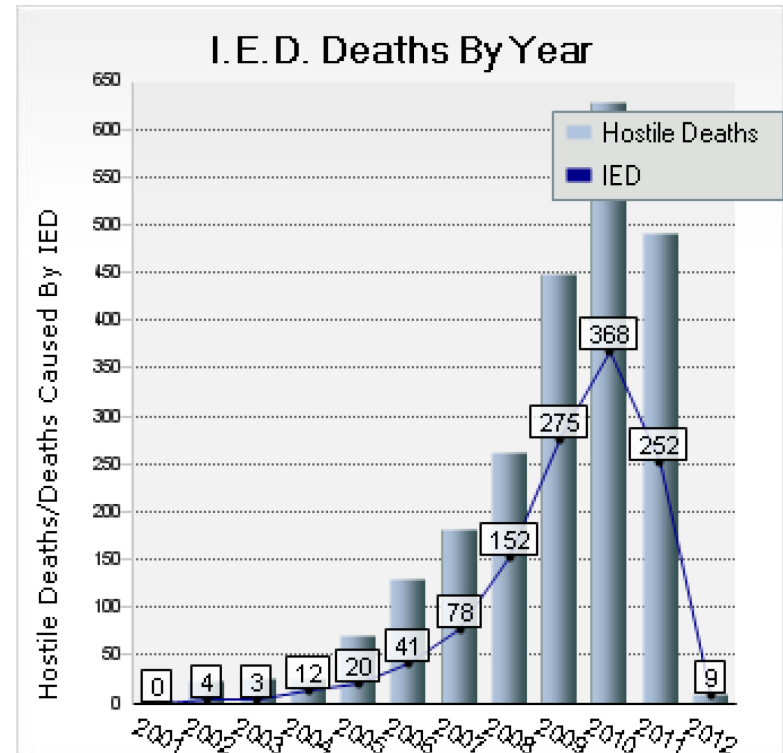


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Rise in Destructive IEDs

- Trend towards greater number of yearly IED deaths in OEF
- Associated trends of:
 - ↑ in Combat ISS
 - ↓ in Combat mortality rates ^{1,2}

1. Stansbury LG, Lalliss SJ, Branstetter JG, Bagg MR, Holcomb JB. Amputations in U.S. military personnel in the current conflicts in Afghanistan and Iraq. *J Orthop Trauma*. 2008;22:43-46.
2. Carvalho J et al. Report of the Army dismounted complex blast injury task force. Fort Sam Houston, TX. Released 18 June 2011



Source: <http://www.icasualties.org/OEF/index.aspx>

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Advances in Medicine



- Advances in combat medicine have lead to:
 - ↓ KIA rate and ↑ Orthopaedic burden
 - Body armor ↓ thoracic and abdominal KIA from 33% to 4.6%
 - Musculoskeletal Extremity Injuries ~ 50+% all combat wounds
 - IED blast mechanisms account for ~ 80% vs. GSW <20%
 - Increased survival attributed to:
 - body armor → efficient medevac system
 - tourniquets → surgeons in theater
 - CPGs/training → haemostatic resuscitation

Belmont et al. J Surg Orthop Adv 2010; Holcomb et al. Ann Surg 2007; Ritenour et al. Ann Surg 2010

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Dismounted Complex Blast Injury

All factors lead to rise in Dismounted Complex Blast Injuries.



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DCBI IED Blast Injury Pattern

Varying level bilateral lower extremity amputations ± vascular injuries

- ± UE open fxs or amputations
- ± pelvic ring injuries (open and closed)
- ± pelvic floor & perineal ST blast injuries
- ± GU blast injuries



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DCBI Highlights



- Initial survival based on:
 - ❑ Prevention of battlefield exsanguination
 - ❑ Rapid transport- more resources at Level 3 vs. 2
 - ❑ Haemostatic resuscitation (1:1:1 ratio)
 - ❑ Expedited but focused index surgical hemostasis
 - ❑ Transports up-range for controlled definitive care
- Long term survival based:
 - ❑ Prevention of sepsis and SIRS/ MODS
 - ❑ Long term outcomes are unknown ???

CAVEAT: Some injury patterns are NOT survivable!

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Acute Treatment Goals

Damage Control

- Rapidly assess survivability
- Immediate resuscitation
- Surgical hemostasis
- Surgical decontamination
- Completion amputations
- Major fracture stabilization
- ICU for more resuscitation
- Return to OR when stable



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Initial Resuscitation Goals



- Rapid transportation from point of injury
 - ❑ Timely and efficient MEDEVACs save lives.
 - ❑ Best resources for DCBI are at a level 3 facility.
 - ❑ Go straight to OR if no true trauma bay (level 2).
- Tourniquets - truly lifesaving!
 - ❑ Check to ensure pulse is stopped, look for rebleeding.
 - ❑ Thigh usually requires 2 tourniquets
- Trauma team approach is vital.
 - ❑ ER doc, Gen Surgeons, Ortho Surgeons, Anesthesia, Nurses, Techs, Radiologist(?), Sub-specialty surgeons (Urology, Vascular, Neurosurgery)

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■ Triad of Death – **must** respect the physiology

- Acidosis
- Hypercoagulable
- Hypothermic

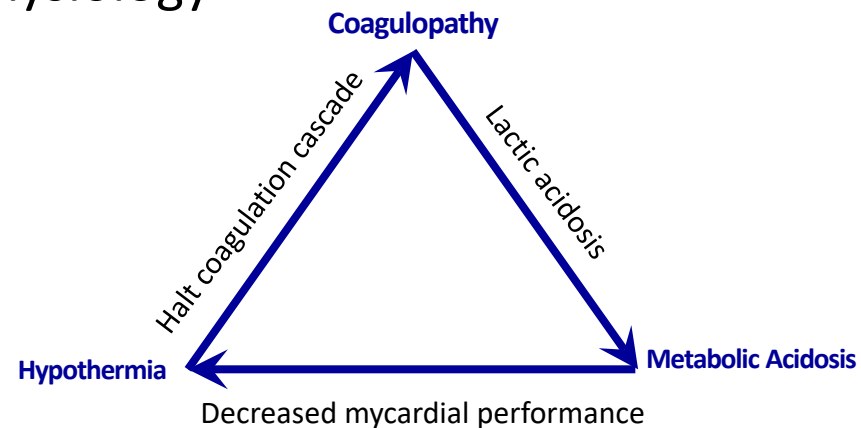
■ Damage Control Resuscitation

- Early and more aggressive correction of coagulopathy and acidosis
- Permissive hypotension (↓s intra-op blood loss)
- Favors replacement with blood products over isotonic fluids
- Hemostatic Resuscitation

(1 Packed Red Blood Cell (PRBC): 1 Fresh Frozen Plasma (FFP) : 1 Platelets)

See JTS Damage Control Resuscitation CPG at:

https://jts.amedd.army.mil/index.cfm/PI_CPGs/cpgs



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Lessons Learned



- Reverse Hypotensive Shock/Advanced Trauma Life Support (ATLS) Protocol
 - ❑ Temporarily control hemorrhage
(Combat Application Tourniquets, pressure dressings)
 - ❑ Control pelvic volume!
(Binder or Sheet)
 - ❑ Initial access with IOs sometimes needed before central access can be established (flat intravascular access)

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Lessons Learned

- Massive transfusion protocol (>10 units/24hr)
 - ❑ Anticipate further blood loss!
 - ❑ Expect 4u Packed Red Blood Cells (PRBCs) per extremity amputation.
 - ❑ 1:1:1 ratio PRBCs: FFP: Platelets
 - ❑ Recombinant Factor VII
 - ❑ Tranexamic Acid
 - ❑ Walking blood bank (level 2)



EWS Multiple Amputations Initial Resuscitation Guidelines

- Role of ED thoracotomy?
 - Not truly effective for non-thoracic hemodynamic instability
 - Use when vitals lost <2min b4 arrival

- Pre-operative studies
 - CXR AP Pelvis
 - FAST +/- CT Head



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Initial Resuscitation Guidelines

- Assess viability before operation

- ? Cardiac activity (EKG)
- ? Cardiac volume (FAST)
- ? Pupillary Reaction

- If absent, pronounce as expired.*

- Assess resources and triage

- May exhaust Level 2 stored blood
- May not be suitable in mass casualty



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Index Operative Goals

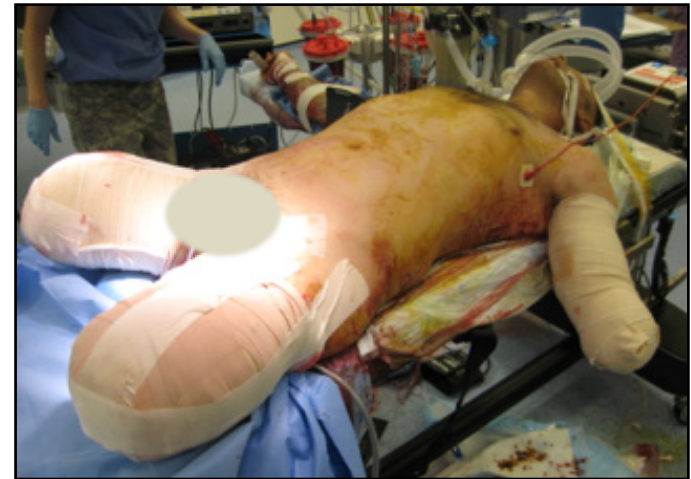
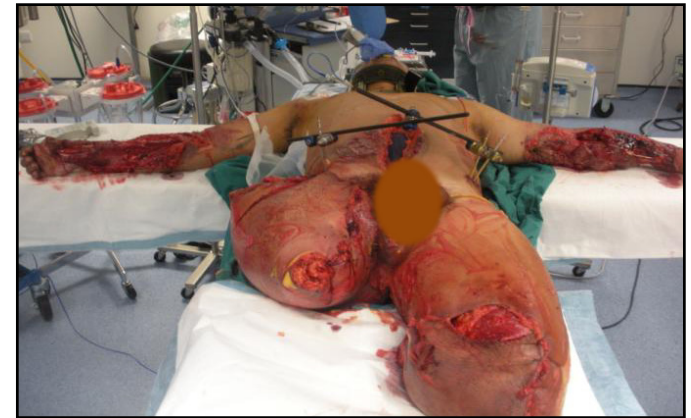


- Save life first and maybe a limb
- Hemorrhage control is paramount
- **Damage control surgery is life-saving in critically ill**
 - *Pape et al. JAAOS 2009*
 - *Pape et al. Crit Care Med 2000*
 - *Porter et al. J Trauma 1997*
 - *Rotondo et al. J Trauma 1993*
- Prevent unnecessary 2nd physiologic hit.

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Operative Approach Guidelines

- DCBI without pelvic floor/perineal disruption
 1. Tourniquets, Zone 3 REBOA, or proximal femoral artery control via retroperitoneal approach
 2. ± Pelvic External fixation
 3. Debride devitalized tissue
- *REASSESS injuries and survivability*
 - ❑ Decontamination
 - ❑ Evaluate for rectal/urologic injuries
 - ❑ Stabilize other long bones



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Surgical Hemostasis

Potential bleeding sources:

1. Traumatic amputations
2. Junctional major vessels
3. Peri-pelvic vessels
4. Abdominal organs
5. Long bone fractures



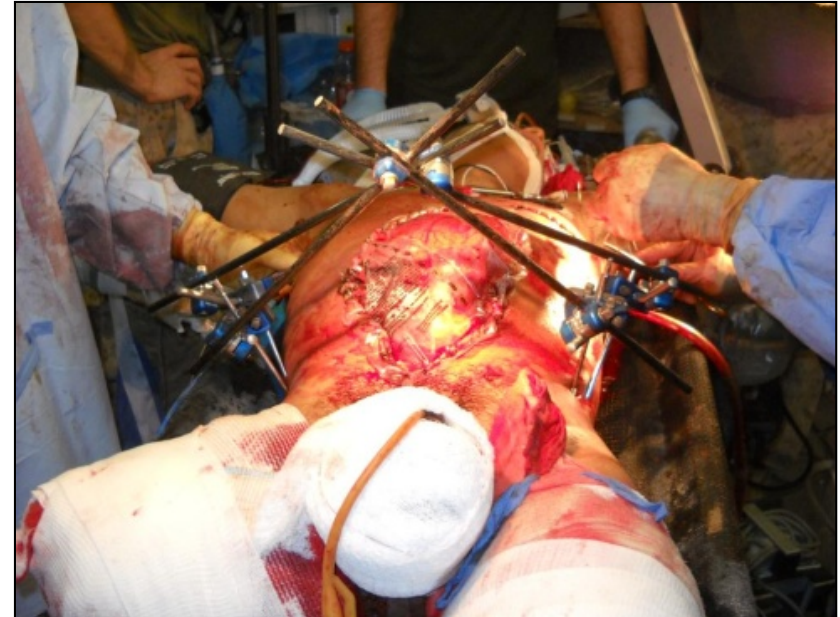
NOTE: Prolonged ischemia raises risk of extremity flap necrosis and subsequent higher amputations. Goal is to release temporary iliac control with repair, shunting or distal level ligation.

HOWEVER: Definitive iliac ligation and surgical hemipelvectomy are accepted measures with massive retroperitoneal bleeding.

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Pelvic Stabilization

- Stabilizing the motion of unstable bone fragments reduces bleeding
- Sheet < Binder < Ex-fix
- Pelvic Ex-fix allows ST access
- Iliac crest pins vs. AILS pins (flouro required)

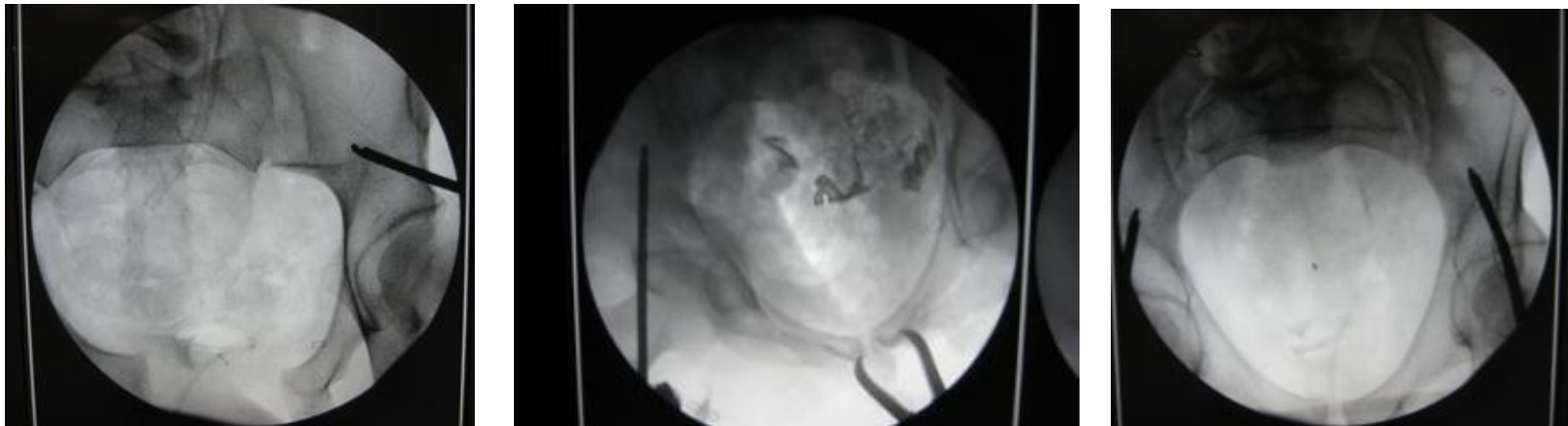


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Pelvic Stabilization

(continued)

- Reduction through celiotomy exposure (*Ghanayem et al. J Trauma 1995*)
- Stabilize before turning prone/lateral
- Plan ostomies/catheters with definitive fixation incisions



Placement of Allis external fixation pins shows surgical reduction of pubic symphysis

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Decontamination

- Revision Amputations
 - ❑ Conserve length when possible
 - ❑ Flaps rather than guillotine style
 - ❑ Account for all vessels and nerves
- Soft tissue Challenges
 - ❑ If it's alive, keep it!
 - ❑ ST injuries evolve quickly !
 - ❑ Require repeat I&Ds q24-48°
- Adequate Debridement
 - ❑ Systematic approach: skin → SQ tissue → fascia → muscle → bone

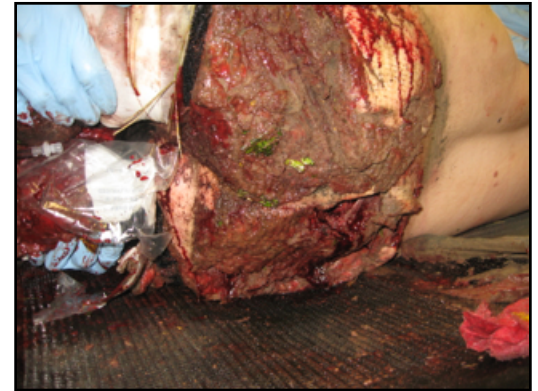


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Posterior Blast Wounds

- Unfortunately common
 - ❑ Position lateral or prone
 - ❑ Stabilize pelvis before prone position
 - ❑ Large wounds difficult to VAC
 - ❑ Usually need fecal diversion
 - ❑ May need to be done at 2° surgery

- Dressing considerations
 - ❑ Wound Vac if possible
 - ❑ Antibiotic bead pouch
 - ❑ Dakin's soaked gauze
 - ❑ Wet-to-dry Hip Spica



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Genitourinary Blast Injuries

- Also unfortunately common
 - ❑ OIF/OEF Combat Urologic Trauma ~5%
(*Serkin et al. J of Trauma 2011*)
 - ❑ Scrotal blast wounds
 - ❑ Testicle destruction
 - ❑ Penile lacerations
 - ❑ Penile destruction
- Damage control urology
 - ❑ Urologists are scarce in theater
 - ❑ Bladder repair
 - ❑ Suprapubic catheter

** Urinary output critical to assessing adequate resuscitation*



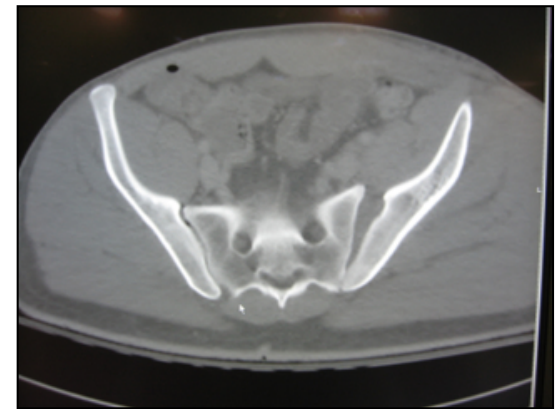
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What about other fractures?

Fracture stabilization priority

1. Pelvis
2. Long bones
3. Periarticular fxs
4. Small bones/joints

Ex-Fix all long bone fractures prior to transport



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Postoperative Guidelines

Don't do too much during the index procedure!

- Save life 1st, save a limb 2nd: They can die on the table!
- Damage control surgery <2hrs
(Pape et al. JAAOS 2009)
- Index procedure → ICU → 2° surgeries
 - ✓ ICU resuscitation
 - ✓ Completion CT scans
 - ✓ Secondary operative debridements
 - ✓ Removal of Internal Iliac Vessel Control
 - ✓ Transfer to next level of care
 - ✓ Ongoing debridement and reconstruction
 - ✓ Role of DVT/PE prophylaxis



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Non-survivable Injuries

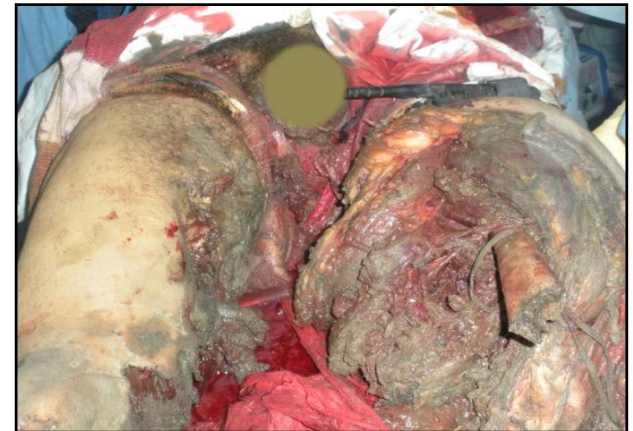
- True incidence is unknown but probably greater than we think
- Associated with:
 - ❑ Proximity to IED
 - ❑ Proximal blast injury
 - ❑ **Junctional hemorrhage**
 - ❑ Intracranial injury



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Case #1 - High b/l LE amps

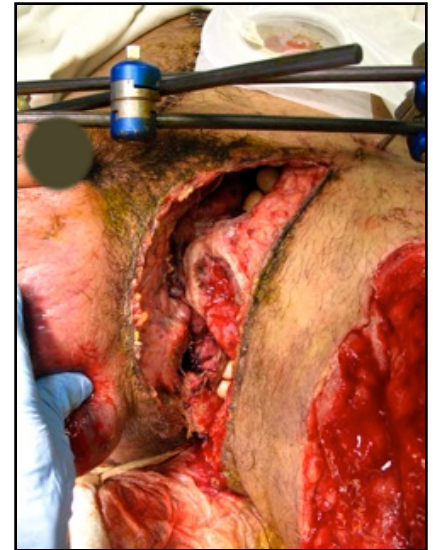
- CASE #1: High b/l LE amps, massive open pelvic ring injury
- Unsurvivable injury pattern after ED Thoracotomy, Ex-Lap and Pelvic Ex-fix:
 - Care terminated
 - Fallen hero



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Case #2 – Triple amp

- CASE #2: Triple amp, Open APC3 Pelvic Ring Injury
- Post-operative sepsis and MODS set-in at 7 days
 - ❑ Care was withdrawn.
 - ❑ Patient expired.



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DCBI Studies



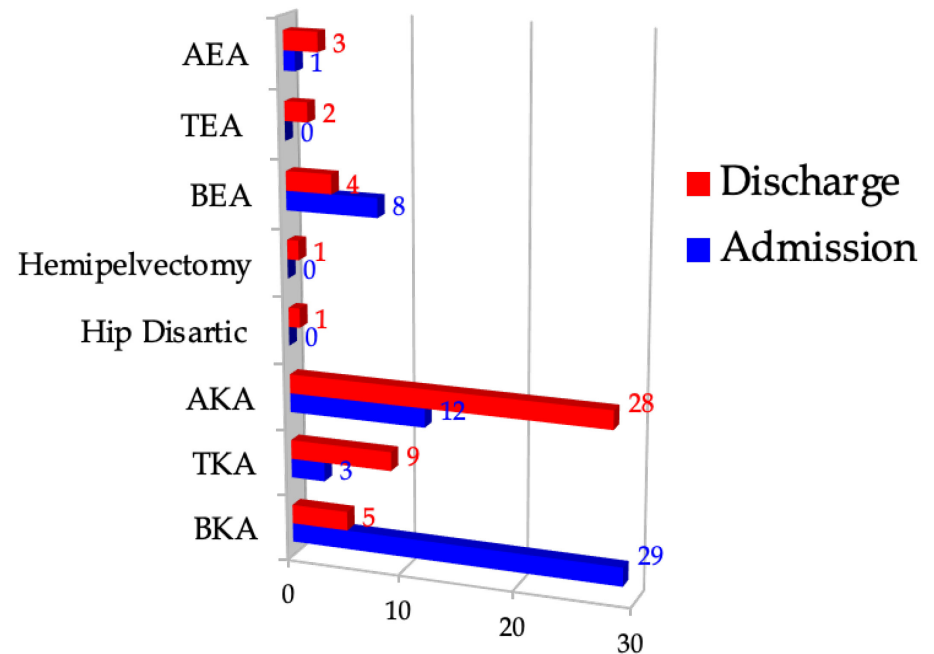
An Analysis of the Initial Treatment and Clinical Markers for an Emerging Frequency of Bilateral Lower Extremity IED Blast Amputations in Afghanistan (*Benfield R, Mamczak CN, Vo KC et al.- JBJS submission Jan 2012*)

- 1,234 Trauma Admissions at KAF Role 3 (01 Jun – 31 Dec 2010)
- 77 casualties had at least 1 IED extremity amputation
- **Study Group: 32 dismantled IED b/l LE amputations**
 - ❑ 10 excluded (8 arrived w/o vital signs, 2 received prior care)
 - ❑ Final Population: N= 22 patients
 - ❑ Avg Age: 29 y/o (range 13-44)
 - ❑ 14 US, 7 ANA or ANP, 1 Canadian
 - ❑ **13 Double Amps**
 - ❑ **9 Triple Amps (41%)**

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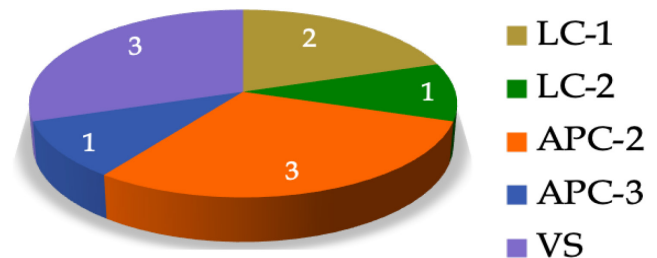
- Below knee amputation (BKA) was the most common presenting level (n=29)
- Above knee amputation (AKA) was the most common discharge level (n=28)
- 77% underwent revision amputations to a higher level
- 50% discharged with bilateral AKA or higher



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- 12 patients had pelvic injuries (55%)
- 3 acetabular fxs (2 open)
- 10 ring injuries (5 open, 7 unstable)
- 69% had perineal or buttock blast wounds (of which 68% had pelvic injuries)
- 50% had GU injuries (of which 73% had pelvic injuries)

Pelvic Ring Injuries



Open 46%

Unstable 54% (Young-Burgess)

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DCBI Studies



- Average of 54 total units of blood products (1:1:1)
 - ❑ 82% received massive transfusions (>10units/24hrs)
 - ❑ Open pelvic injury (p=0.047)
 - ❑ Perineal blast (p=0.03)
 - ❑ GI injury (p=0.017)

} Indicators for
↑ transfusion
requirements

- Average index surgical time: 142.5 minutes
 - ❑ 6 unstable pelvic rings treated with AHS ex-fix, 1 w/ hemipelvectomy
 - ❑ 9 colonic diversions: 44% w/ perineal blast and 88% w/ pelvic injuries
 - ❑ 5 resuscitative thoracotomies
 - ❑ Pelvic injury (p=0.03)
 - ❑ Triple amps (p=0.01)

} Longer OR times

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DCBI Studies



■ Study: Non-survivors in KAF

Jun - Dec 2010 = 52

- ❑ 37 double amps
- ❑ 14 triple amps
- ❑ 1 quad amp

■ 30-day mortality data

- ❑ 14 alive, 3 unknown (all Afghan)

■ 5 expired

- ❑ 2 double amps vs 3 triple amps
- ❑ 3 pelvic injuries
(50% of open pelvic injuries)

■ Cause of death

- ❑ Hemodynamic shock (3)
- ❑ Sepsis (1)
- ❑ Head injury (1)

■ Correlations

- ❑ GCS <8 (p=0.001)
- ❑ Hollow viscus injury (p=0.04)
- ❑ Surgical hemipelvectomy (p=0.03)
- ❑ Resuscitative thoracotomy (p=0.02)

Associated with rise in
30-day mortality risk

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DCBI Studies



- **Study:** Early management of proximal traumatic lower extremity amputation and pelvic injury caused by IEDs.

(Jansen JO, Tai NR, Russell R et al. 10.1016/j.injury.2011.08.027)

- Retrospective study at Bastion Role 3
- Jan 2007 - Dec 2010
- Document only British injuries
- 100 IED-related LE amputees
 - ✓ Average age: 25 year old
 - ✓ Average ISS 30
 - ✓ 34 single LE amps
 - ✓ 66 double LE amps
 - ✓ 84 survived, 16 expired

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DCBI Studies



- Early Mortality Data - 16% overall
 - Average ISS of survivors =29 vs. expired =46
 - 60% of hindquarter amps died
 - 16% with at least 1 or more AKAs died
 - 10% with single or double BKAs died
 - No mention of the # of triple or quad amps
- Also used 1:1:1 ration resuscitation – but no stats
- Allowed prolonged index surgeries – Average 6 hours!
 - MERT MEDEVAC employs receiving critical care team
 - DCR begun before casualty arrives at Bastion Role 3
 - ROTEM routinely used to assess resuscitation

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Other DCBI References

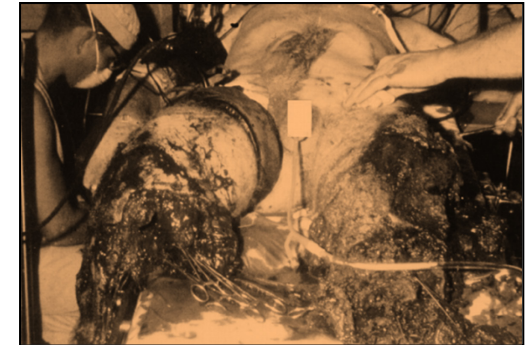


- JTS CPGs Apr 2011. Management of High Bilateral Amputations
https://jts.amedd.army.mil/index.cfm/PI_CPGs/cpgs
- JTS CPGs Mar 2011. Fresh Whole Blood Transfusion
https://jts.amedd.army.mil/index.cfm/PI_CPGs/cpgs
- Mamczak CN, Elster EA. Complex Dismounted IED Blast Injuries: The Initial Management of Bilateral LE Amputations with and without Pelvic and Perineal Involvement. J Surg Orthop Adv 2012;21:1-6

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Conclusions

- DCBI's are NOT a new injury pattern to war BUT have an unfortunate emerging frequency in OEF and should be expected.
- Training can help prepare surgeons for their care.



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Conclusions



- These devastating injury patterns are survivable (but not all).
- A common tactical resuscitative and surgical protocol is effective for initial treatment: DCS, avoid 2nd hit!
- High consumption of downrange resources is expected.
- More proximal wounding patterns with open pelvic injuries carry an increased risk of death in theater.
- Long-term outcomes are needed to determine the final morbidity and mortality of this injury pattern.



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Case Scenario



- A 24 year old male special operations marine was on an advise and assist mission in Jolo, Philippines, when he inadvertently stepped on an IED placed by Abu Sayyaf. His sustained traumatic bilateral above knee amputations, a near amputation of his right hand, and pelvic and abdominal injuries.
 1. What are the priorities for care?
 2. What are ways to control hemorrhage from high above knee amputations?
 3. There is questionably viable tissue on the second look surgery. How should this be treated downrange?