EDITORIAL

FORWARD SURGERY

JC Clasper, MJ Midwinter

Academic Department of Military Surgery & Trauma, Royal Centre for Defence Medicine, Birmingham

'It seems somewhat paradoxical to me that in the 21st Century, the greatest power the world has ever seen chooses to force its surgeons to practice in environments that would have been called austere 50 years ago-with very little equipment, communication and resources-and then tell them they are there to handle only the most critically injured' (1).

Introduction

During conflict the aim of effective medical care must be to save the maximum number of casualties who would otherwise die of wounds, and also to minimise disability in survivors. In addition, due to the limited assets available, it must aim to minimise resources spent on those who cannot survive at the expense of those who could recover (2).

Civilian experience has demonstrated that by establishing a Trauma System and allowing the evacuation of major trauma patients to a Trauma Centre, bypassing geographically and temporally closer non-trauma centre hospitals led to improved outcome in both developed and developing countries (3-6). Is this experience applicable to the provision of military surgery in the battlespace? Or does the nature of providing trauma surgical services during conflict with the unique tactical considerations mandate the use of Forward Surgery as part of a Military Trauma System?

Morrison highlights the dilemma of providing the optimum deployment of surgical assets in the battlefield. Forward deployment of surgical teams may allow more rapid access to surgery but these are required to be light and manoeuvrable and are therefore limited in resources compared to more fixed facilities. Rapid evacuation from the battlefield to a more capable, well resourced fixed facility (the equivalent of the civilian Trauma Centre) may be preferable but this could lead to delay in initial treatment of critically injured patients due to either tactical difficulty in evacuating the casualty, or time and distances of the battle front from the larger more static facility.

Delays in evacuation

When evacuation times are very long, or when evacuation is difficult, particularly the forward deployment of special forces (7), surgery may be required at a forward location. In this context the aim of the surgery will be to reduce the death from haemorrhage and also to reduce the infection risk particularly the infective complications associated with the delay in the treatment of limb injuries (8).

Military doctrines state that forward surgery to control haemorrhage should be available within 2 hours, and all wounds operated on within 4-6 hours. However, there is little if any evidence to support these timelines.

Providing advanced resuscitation and early surgery is based on the premise, that there is a military equivalent of the golden hour, when a significant number of casualties will die of compressible haemorrhage. Doubts have been expressed by a number of authors whether there is a golden hour, as available evidence suggests that the majority of deaths occur before any advanced care can be provided (9-12). In addition it must be appreciated that many of the later deaths are related to massive brain injury, ultimately, but not immediately fatal (9,10); these are not amenable to forward surgery.

Although it has been estimated that 10-20% of military patients may die of compressible haemorrhage it is not clear how many of these can truly be saved in the battlefield environment. Regardless of the resources deployed, if no medical care or even if buddy aid can reach a casualty within the 'platinum' 5 minutes, many will die of preventable causes. In addition it has been acknowledged that some of the 'preventable deaths' could have only survived with advanced techniques, for example cardiopulmonary bypass, that will not be available on any battlefield (13).

The majority of war wounds are now to the limbs and haemorrhage control may be required for these. This consists of ligation and packing, however, the bleeding may be from anatomically inaccessible (junctional) areas in the groin, axilla and neck. The surgeon must be experienced in gaining the required access to gain control of haemorrhage from these areas. Haemorrhage from penetrating torso injuries may also require surgical access to establish control of the bleeding. This may require entering more than one body cavity. Significant experience and resources are required to deal with these injuries, and it may be impossible, both to provide these, and remain light and manoeuvrable.

Early surgery will be required for arterial injuries that may require shunts as a temporising measure to maintain limb vascularity, and this has been reported in military surgical setting (14). In this study 28 shunts were placed in a Level II facility and then the patient evacuated to a Level III unit where definitive vascular reconstruction was performed. Patency rates of 86% for proximal shunts (both arterial and venous) but only 12% for distal shunts were reported. Most were in place for less than 2 hours although patent shunts were found at up to 18 hours after placement. Forward surgery to place a stent could therefore maintain viability of a limb until definitive surgery can be performed. However, if rapid evacuation to a base hospital with better facilities could be guaranteed within 2-4 hours, the need for this surgery in a forward location may be obviated.

What delay is acceptable to minimise the risk of infection? Traditional teaching is based on the 6 hour rule implying that surgery must be carried out before 6 hours or infection is inevitable. A recent review, however, have suggested that the

Corresponding Author: Lt Col JC Clasper DPhil DM FRCSEd(Orth) FIMC DMCC RAMC, 20 Hilder Gardens, Farnborough, Hampshire, GU14 7BQ
Email: jonclasper@aol.com

time interval between injury and surgery is not a significant factor in the infection risk (15). This would back up the experience of the International Committee of the Red Cross, who report good results even when delays of days occur prior to treating open fractures (16). It would appear that forward surgery may not be required to reduce the risk of infection, even if there are delays in evacuation.

Damage control surgery (DCS).

One of the main drivers for the development of civilian damage control surgery was the management of exsanguinating abdominal haemorrhage (17), and this concept has been adopted by some without a full understanding of its aim, structure or required resources. DCS is for a compromised patient with optimal resources available, not a compromised patient with compromised resources.

It is often assumed that Damage Control Surgery and forward surgery are synonymous. While a DCS approach may be adopted in the forward setting, the surgery is only one aspect of DCS and the whole DCS philosophy requires to be understood for it to deliver improved outcomes.

DCS as a technique evolved but was first coined as a 3 phased approach in 1993 (17). This was applied to abdominal trauma and consisted of: phase 1, the control of haemorrhage and contamination with abbreviated wound closure; phase 2, the resuscitative phase to correct the lethal triad of hypothermia, acidosis and coagulopathy with physiological and biochemical stabilization in a Critical Care Unit and phase 3, re-exploration and definitive repair of injuries.

Is this the forward surgery we anticipate in the military? There is no doubt that penetrating abdominal wounds will cause life-threatening bleeding during conflict and that 20% of casualties with abdominal wounds may not survive evacuation (18). But even with DCS the majority will still die (17) and the casualties will consume vast resources. Burch reported that during the first 24 hours on the Critical Care Unit the average blood use was 9.8 units red blood cells, 8.8 units fresh frozen plasma and 10.7 units of platelets per patient (19). This is in addition to that given during the initial resuscitation. Clearly the resources to provide the continuum of DCS is going to require considerable support.

The US military believe that the best that can be provided in the field (although not at a forward location) is the equivalent of a level 3 trauma centre (20). Severe Pelvic injuries (Figures 1 and 2) for instance are complex injuries that require multidisciplinary management including interventional radiology. They require significant blood product support often far beyond that planned for a military T1 casualty far forward. Despite resources outwith those of a forward surgical facility, the outcome of such injuries remains bleak.

Recent advances in the most severe pelvic fractures have also included the use of pelvic packing, introduced in Europe, but now accepted in American trauma centres (21,22). As well as the resource constraints, there will also be training issues as these techniques are not currently taught in the United Kingdom.

Forward Surgery would also require the most experienced surgeons and anaesthetists to be forward as the decisions not to operate are the most important and also the hardest. It is also necessary to recognise when treatment is going to be futile. This use of the most surgically experienced may not deliver their experience to the largest group of patients who would benefit.

Since the original description the approach has been applied to non-abdominal injuries. DCS is a philosophy where the minimal required surgery is performed to achieve haemorrhage and contamination control and then correcting the physiology prior to performing definitive repair (23). This is not synonymous with forward surgery although may be started at this location. It is a technique applicable as much in Level 1 Trauma unit as in the field. The central place of Critical Care in DCS mandates the availability of this immediately following surgery.

Damage Control Resuscitation (DCR)

DCR has taken the principle of DCS in addressing the triad of hypothermia, acidosis and coagulopathy into the pre-operative phase (24). It continues into the operating theatre and to Critical Care. Thus DCS is a part of DCR although they may not necessarily be physically co-located if initial DCR care is occurring during transit to the surgical facility without delay.

Given this then Forward Surgery must not be considered as an isolated surgical event, but as part of a surgical spectrum that starts with life saving surgery and continues back until recovery has been maximised.

In addition there is a risk that forward surgery, with limited resources, may be harmful, placing the casualties at risk by

Figure 1 – Severe pelvic fracture/abdominal injury. To save this patient, pelvic external fixation, laparotomy, splenectomy, massive transfusion and arterial embolisation was required. The patient remained too unstable to move from ITU for 48 hours.

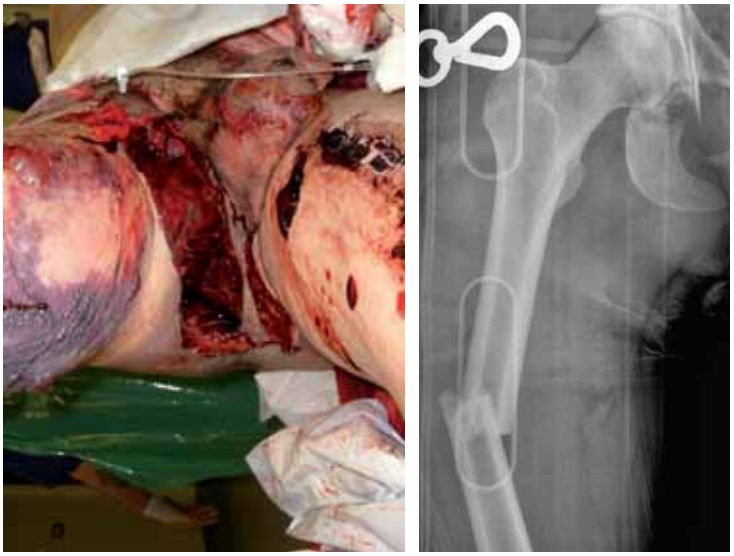

Figure 2a and b – Open pelvic/femoral fractures with severe soft tissue trauma and air in the hip joint. Despite pelvic packing, external fixation, aortic cross-clamping, internal iliac embolisation and massive transfusion (60 units), the patient died within 10 hours of injury.

doing too much, too far forward, and then evacuating an unstable patient. The need to avoid the early evacuation of unstable post-operative patients is not a recent concern, but was reported in the desert conflicts of the Second World War (25).

Summary

Deployment of Forward Surgery is a balance of risk and benefit. The resources will clearly be less than at a more major facility and so care may be compromised. Equally the tactical situation may be non-permissive and limb and life saving intervention required before the movement is possible. However, in order to provide satisfactory care at a forward location sufficient resources to deliver the full requirements of DCR & DCS must be met, which would limit manoeuvrability. This would include large volumes of blood and blood products, critical care and experienced personnel. The later will need to be some of the most senior medical staff as the decision to not operate, if intervention is unnecessary as the patient could wait or intervention would be futile, is one that requires experience. The deployment of these personnel would need to be balanced with the depletion of the experience from the major facility. Forward surgery may be appropriate in the build up phase, establishing a first surgical foot print to develop into a more capable facility (26) or wind down as the major facility is dismantled to be relocated at an alternative location. Ultimately the deployment of forward surgery hinges on the tactical assessment and the ability to evacuate casualties in a timely fashion to the best equipped and resourced facility possible. This decision must be informed by the limitations this may impose on the management of the majority casualties who do not require forward surgery. Forward surgery should only be deployed as part of an overall trauma system with continuous assessment of outcomes. The goal remains "the right patient, right place at the right time" (26).

References

1. Morrison CA. A military surgeon questions the value of a forward austere surgical team. *J Am Coll Surg* 2006; **203**: 262-3.
2. Clasper JC, Rew D. Trauma life support in conflict. *Br Med J* 2003; **327**: 1178-9.
3. Cales RH. Trauma mortality in Orange County: the effect of implementation of a regional trauma system. *Ann Emerg Med* 1984; **13**: 1-10.
4. Husum H, Gilbert M, Wisborg T, Van Heng Y, Murad M. Rural prehospital trauma systems improve trauma outcome in low-income countries: a prospective study from North Iraq and Cambodia. *J Trauma* 2003; **54**:1188-96.
5. Trunkey, DD. Trauma. Accidental and intentional injuries account for more years of life lost in the U.S. than cancer and heart disease. *Scientific American* 1983; **249**:28-35.
6. Brohi K. Trauma Specialist Centres. Ann Roy *Coll Surg Eng* 2007; **89**: 252-3.
7. Husar J, Eltz J. Mobile surgical teams in Croatian special forces units (1990-1993). *Croatian Med J* 1993; **34**:276-9.
8. Bhatnagar MK, Smith GS. Trauma in the Afghan guerrilla war: effects of lack of access to care. *Surgery* 1989; **105**:699-705.
9. Brown RF, Binns JH. Missile Injuries in Aden. *Injury* 1970; **1**:293-302.
10. Cutting PA, Agha R. Surgery in a Palestinian refugee camp. *Injury* 1992; **23**:405-9.
11. Cohen O. Second Lebanon War: The Medical Challenge 12/07 – 14/08/2006. Powerpoint presentation COMEDS, Canada, 6 June 07.
12. Scope A, Farkash U, Lynn M, Abargel A, Eldad A. Mortality epidemiology in low-intensity warfare: Israel Defense Forces' experience. *Injury* 2001; **32**: 1-3.
13. Rich N. Personal Communication (JC).
14. Rasmussen TE, Clouse WD, Jenkins DH, Peck MA, Eliason JL, Smith DL. The use of temporary vascular shunts as a damage control adjunct in the management of wartime vascular injury. *J Trauma* 2006; **61**: 8-15.
15. Zalavras CG, Marcus RE, Levin LS, Patzakis MJ. Management of open fractures and subsequent complications. *J Bone Joint Surg [Am]* 2007; **89-A:** 884-95.
16. Coupland RN, Howell PR. An experience of war surgery and wounds presenting after 3days on the border of Afghanistan. *Injury* 1988;**19**:259-62.
17. Rotondo M, Schwab CW. Damage control: an approach for improved survival in exanguinating penetrating abdominal injury. *J Trauma* 1993; **35**:373-83.
18. Rozin RR, Kleinman Y. Surgical priorities of abdominal wounded in a combat situation. *J Trauma* 1987; **27**:656-60.
19. Burch J.M, Oritz VB, Richardson RJ. Abbreviated laparotomy and planned reoperation for critically injured patients. *Ann Surg* 1992; **215**: 476-84.
20. Holcomb JB, McMullin NR, Pearse L, et al. Causes of death in U.S. special operations forces in the global war on terrorism 2001-2004. *Ann Surg* 2007; **245**: 986-91.
21. Cothren CC, Osborn PM, Moore EE, Morgan SJ, Johnson JL, Smith WR. Preperitonal pelvic packing for hemodynamically unstable pelvic fractures: a paradigm shift. *J Trauma* 2007; **62:**834-9.
22. Tötterman A, Madsen JE, Skaga NO, Røise O. Extraperitoneal pelvic packing: a salvage procedure to control massive traumatic pelvic hemorrhage. *J Trauma.* 2007; **62**:843-52.
23. Bowley, DMG, Barker P, Boffard KD. Damage control surgery - concepts and practice. *J R Army Med Corps*, 2000; **146**:176-82.
24. Holcomb JB, Jenkins D, Rhee P, et al. Damage control resuscitation: directly addressing the early coagulopathy of trauma. *J Trauma* 2007; **62**: 307-10.
25. Mitchell GA, Logie NJ, Handley RS. Observations on casualties from the western desert and Libya arriving at a base hospital. *J R Army Med Corps* 1941; **77**:561-70.
26. Eastridge BJ, Jenkins D, Flaherty S, Schiller H, Holcomb JB. Trauma systems development in a theater of war: experiences from Operation Iraqi Freedom and Operation Enduring Freedom. *J Trauma* 2006; **61**:1366-73.