Improving survivability from blast injury: ‘shifting the goalposts’ and the need for interdisciplinary research

A Phill Pearce,1,2 Jon Clasper1,3

Blast injury is not a new phenomenon, but the nature of warfare has changed; explosive weapons are now the most common mode of battlefield trauma.1 In this issue, McGuire et al demonstrate the incidence of explosive injury in both recent UK operations and those from decades before.2 The need for further understanding of these injuries is apparent and this issue highlights the breadth and depth of blast injury research.

Advances have been led from the front by the Defence Medical Services. Improvements in prehospital care logistics (such as the Medical Emergency Response Team), advanced resuscitation techniques and hard fought expertise led to hitherto unseen levels of survival of severely injured personnel.3,4

Improved medical care is perhaps best evidenced by the cohort of ‘unexpected survivors’.5 These personnel sustained injuries which would not have been survivable in previous conflicts. Likelihood of survival due to any injury pattern can be predicted by a variety of scoring tools. Survival of casualties despite them sustaining a mathematically unsurvivable injury burden, while illustrating the performance of our deployed trauma system should also provoke important discussion as to the relevance of our scoring systems. Should our goalposts be shifted so that the unexpected survivor now falls within the expected category? It could be argued that scoring systems will always have to change, until we reach the point where no further medical advances are possible and the goalposts are fixed.

The UK Defence Medical Services acknowledge the limitations of injury scoring systems and, as a result, have combined them with expert opinion to highlight both paradigms and deficits in clinical care or systems. Existing scoring systems were used to stratify casualties before an expert panel determined the survivability of both ‘unexpected survivors’ and deaths.3,6 Review of combat-related deaths focused on those deemed to have sustained at least potentially survivable injuries. Of all deaths in this group (UK deployed forces 2002–2013), only 8% were deemed to be at least potentially salvageable.

If we do shift the score goalposts and unexpected survivors cross the threshold into the expected category, how do we continue to push for excellence? How do we determine what the next level of unexpected survivors might be when our current scoring systems are already ‘maxed out’? Discussion of those factors which may influence unexpected death and unexpected survivors is important but those expected deaths, those thought to be unsalvageable, should also be explored. Our commonly used scoring systems predict probability of death but do not discriminate or stratify level of injury beyond that which is likely to be fatal.

Such is the high performance of our deployed medical teams, it is possible that future improved survival from blast trauma can only be achieved by mitigation and prevention. This issue highlights the importance of interdisciplinary collaboration in driving forward high-quality research and translating this to clinically affect both on and off the battlefield.

Steps to further define the injury burden of potentially ‘unexpected survivors’ have been taken by examination of fatalities within particular blast scenarios.7–8 Two such papers are part of this issue. Webster et al compares pelvic injury mechanisms from the mounted and dismounted environment with suggestion of different mitigation for each.9 The paper by Stewart et al illustrates the process with pragmatic analysis of fatal head and neck injuries following under-body blast and suggests the future focus of preventative research (protection from direct head impact rather than cervical spine injury).10

Mitigation of injury requires, first, a detailed understanding of the mechanism by which each injury occurs and, second, quantification of the likelihood of injury in response to a specified ‘dose’ of the injurious stimulus. Mitigating and preventative measures can be designed and optimised to best dampen the relationship between dose and response. This approach is applied by the injury biomechanics community to causes of intentional and accidental trauma with the majority of expertise and experience gained in the automotive industry.

The application of these principles to battlefield injury is discussed in this issue. First, detailed analysis of the injury patterns allows development of a biomechanical hypothesis. The relevance of such epidemiological papers must be maintained by ensuring sound methodology, as discussed in this issue by Gupta et al.11 Although analysis of clinical data may suggest the attributable mechanism, some form of experimental validation is invariably required.

Explosions are inherently chaotic and the recreation of blast conditions in a laboratory setting requires a degree of ingenuity and the controlled separation of the blast effects. Experiments should be reproducible, consistent and comparable. Guidelines for the recreation of these conditions (as described by Josey et al for primary blast exposure in this issue) are essential so that the dose of blast (be it overpressure, fragmentation or high rate blunt loading) be relevant and readily replicated.12

Measurement of the injurious response requires the use of an appropriate model. While postmortem human surrogates provide the greatest biomechanical fidelity for human injury, they have significant limitations for the replication of injuries to soft tissues, internal organs and for the measurement of physiological and cellular responses. Instead, an integrated research strategy must include in vitro, in vivo, in silico and ex vivo models. Similar guidelines should be applied across each of research domains. The article by Watts et al in this issue suggests appropriate guidelines for the use of animals in order align blast research with the ‘3 Rs’ of animal work: replacement, reduction and refinement.13 Application of advanced technologies allow the translation of basic science and in vivo models into high fidelity computational simulations which reduce the need for expensive and logistically difficult physical experiments. The development of a computational model from in vivo data is demonstrated by Haque et al in this issue.14

1The Royal British Legion Centre for Blast Injury Studies, Department of Bioengineering, Imperial College London, London, UK
2Academic Department of Military Surgery and Trauma, Royal Centre for Defence Medicine, Birmingham, UK
3Defence Medical Group South East, Frimley Park, Frimley, UK
Correspondence to: Sqn Ldr A Phill Pearce, The Royal British Legion Centre for Blast Injury Studies, Imperial College London, London SW7 2AZ, UK; a.pearce15@imperial.ac.uk

Editorial

J R Army Med Corps: first published as 10.1136/jramc-2018-000968 on 16 May 2018. Downloaded from http://militaryhealth.bmj.com/ on April 12, 2021 by guest. Protected by copyright.
Each of these steps is essential for understanding of the relationship between the blast ‘dose’ and the injury ‘response’. The capability of equipment designers and engineers to protect against a specified threat (as described by Sedman et al in this issue) is dependent on this process.15

This research chain requires expertise in different areas. Engineers, biologists, physicists and computer scientists all have important roles to play in an integrated research strategy. In this issue, Nguyen et al show the diverse experimental capabilities made possible by this form of academic cooperation.16 Successful collaboration requires the forging of a shared mission and the development of ‘T-shaped’ researchers who are able to cultivate their own discipline and look beyond it.17

Medical involvement is important in the blast injury research domain. Although the research role of the clinician has classically been to determine the optimal clinical care required for patients, clinicians are among those best placed to examine injury and understand the importance of injury mitigation to eventual outcome. The ‘surgeon-scientist’ is well established in clinical and preclinical research, but injury prevention and survivability research perhaps requires the ‘surgeon-engineer’ with an in-depth understanding of injury mechanism and quantification.

This role requires a change in perspective on trauma care. Opportunities of the clinician to influence survival should not begin at the point of injury but extend across the full spectrum to consider the cause and context of injury. The ‘Left of Bang’ approach to trauma has been eloquently discussed by Eisenstein et al18 with particular regard to physiological pretrauma intervention.19 Although the translation of this concept to blast injury protection is apparent, Left of Bang should be considered by all trauma interested clinicians, military and civilian, who are well placed to identify and instigate those protective, behavioural, social and political changes which will reduce or mitigate injury.

Contributors APP wrote the initial manuscript with critique from JC. Both authors subsequently edited and revised the final manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent Not required.

Provenance and peer review Not commissioned; internally peer reviewed.

OPEN ACCESS

Open access This is an open access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) license, which permits others to distribute, remix, adapt and build upon this work, for commercial use, provided the original work is properly cited. See: http://creativecommons.org/licenses/by/4.0/

© Article author(s) (or their employer(s) unless otherwise stated in the text of the article) 2019. All rights reserved. No commercial use is permitted unless otherwise expressly granted.

To cite Pearce AP, Clasper J. J R Army Med Corps 2019;165:5–6.

Accepted 25 April 2018

Published Online First 16 May 2018

J R Army Med Corps 2019;165:5–6.

doi:10.1136/jramc-2018-000968

REFERENCES

1 Champion HR, Bellamy RE, Roberts CP, et al. A profile of combat injury. J Trauma 2003;54:513–19.

2 McGuire. From Northern Ireland to Afghanistan: Half a Century of Blast Injuries. JRAMC Blast Ed., 2019:165, 27–32.

3 Penn-Barwell JG, Roberts SAG, Midwinter MJ, et al. Improved survival in UK combat casualties from Iraq and Afghanistan. J Trauma Acute Care Surg 2015:1.

4 Wooley J, Round JA, Ingram M. Global lessons: developing military trauma care and lessons for civilian practice. Br J Anaesth 2017;119(suppl 1):i135–i142.

5 Russell RJ, Hodgetts TJ, McLeod J, et al. The role of trauma scoring in developing trauma clinical governance in the Defence Medical Services. Philos Trans R Soc Lond B Biol Sci 2011;366:171–91.

6 Russell R, Hunt N, Delaney R. The Mortality Peer Review Panel: a report on the deaths on operations of UK Service personnel 2002–2013. J R Army Med Corps 2014;165:150–4.

7 Singleton JA, Gibb IE, Hunt NC, et al. Identifying future ‘unexpected’ survivors: a retrospective cohort study of fatal injury patterns in victims of improvised explosive devices. BMJ Open 2013;3:e003130.

8 Pearce AP, Bull AMJ, Clasper J. Midiastrinal injury is the strongest predictor of mortality in mounted blast amongst UK deployed forces. Injury 2017:48:1900–5.

9 Webster. Pelvic Fractures and Environment at Injury. JRAMC Blast Ed 2019;165:15–17.

10 Stewart SK, Pearce AP, Clasper JC. Fatal head and neck injuries in military underbody blast casualties. J R Army Med Corps 2019;165:18–21.

11 Gupta et al. Guidelines for Conducting Epidemiological Studies of Blast Injury. JRAMC Blast Ed 2019:165:41–4.

12 Josey. Guidelines for Reproducing Blast Exposures in the Laboratory. JRAMC Blast Ed 2019:165:10–14.

13 Watts S, Kirkman E, Bieler D, et al. Guidelines for using animal models in blast injury research. J R Army Med Corps 2019;165:38–40.

14 Haque M, Das A, Scott TE, et al. Primary blast lung injury simulator: a new computerised model. J R Army Med Corps 2019;165:45–50.

15 Sedman. Protection of the lung from blast overpressure by stress wave decouplers, buffer plates or sandwich panels. JRAMC Blast Ed 2109;165:27–32.

16 Nguyen TT, Pearce AP, Carpanen D, et al. Experimental platforms to study blast injury. J R Army Med Corps 2019;165:33–7.

17 Brown RR, Delatic A, Wong TH. Interdisciplinarity: how to catalyse collaboration. Nature 2015;525:315–7.

18 Park E, Eisen R, Kinio A, et al. Electrophysiological white matter dysfunction and association with neurobehavioral deficits following low-level primary blast trauma. Neurobiol Dis 2013;52:150–9.

19 Eisenstein NM, Naumann DN, Bowley DM, et al. Pretrauma interventions in force health protection: introducing the “Left of Bang” Paradigm. J Spec Oper Med;16:59–63.