War surgery and transfusion in makeshift hospitals in beleaguered cities

In 1714, the satirist Jonathan Swift stated that the "blessing of liberty" must be paid for in "blood and treasure".[1] As we look to events in Ukraine, the terrible price of freedom again becomes apparent. Yet war has also been the impetus for improvements in medical care, from Jean-Louis Petit's screw tourniquet and Dominique Larrey's *ambulance volante* to the modern concept of damage control resuscitation (DCR). Contemporary DCR is characterised by haemostatic resuscitation, permissive hypotension, and damage control surgery,[2] which originated on the battlefield and is now entrenched in civilian practice. It is predicated on the ability to provide massive transfusion, and protocols ensure high volumes of universal donor blood products (eg, packed red cells, plasma, platelets, and cryoprecipitate) are transfused in prespecified ratios, along with pharmaceutical adjuncts such as calcium and tranexamic acid plus point of care viscoelastic testing for trauma-induced coagulopathy.[3] Delay in initiating massive transfusion has been shown to worsen survival,[4] and more recently, fresh whole blood has been used for trauma resuscitation of combat casualties.[5] The United States Defense Committee on Trauma, Armed Services Blood Program, and Joint Trauma System have reached consensus that whole blood is the product of choice for resuscitation following traumatic haemorrhagic shock.[6]

Modern conflicts might not be as well resourced as previous settings where massive transfusion could be facilitated.[7] Transfusion supplies (and clinicians able to administrate and deliver these) might be severely limited. A trend towards loss of respect for the neutrality of medical facilities is also concerning. In the Syrian civil war (2011 to the present), beleaguered populations endured regular targeting of hospitals and health workers.[8] David Nott travelled to Syria with other Médecins Sans Frontières staff from all over the world. In 2013, in western Aleppo, regime attacks had targeted hospitals and health-care workers with snipers, shelling, and mortar fire. Makeshift hospitals were created in covert safehouses. From point of injury, patients were transported to these safehouses in unmarked vehicles, and the time from point of injury to arrival was typically 5–10 min.

Under these most austere circumstances in Aleppo, Nott recorded the patient outcomes in a personal series of 57 consecutive war-injured patients undergoing surgery. 55 (96%) patients were acutely injured, with two having been transferred for further surgery from other makeshift hospitals after primary laparotomy for war injury undertaken by other surgeons, complicated by intra-abdominal sepsis. Of the 55 patients, 17 (31%) were children. The median age of the whole cohort was 25 years (IQR 16–35), and the oldest patient was 52 years. Mechanism of injury was not recorded in one patient, 32 (59%) of 54 patients had been injured by blast, and 22 (41%) patients were injured by gunshot wound. Gender was not recorded in four patients, and of the remainder, 42 (82%) were men. Female patients were more likely to be injured by blast when compared to male patients (eight of nine *vs* 22 [43%] of 51; two-sided Fisher's exact test p=0.025; odds ratio 6.91, 95% CI 1.12–134.2), reflecting that generally, men were actively fighting, and women were injured in a domestic setting. 40 (73%) of 55 patients had extremity injury, and 20 amputations were undertaken in 14 (25%) patients. 12 (22%) of 55 patients had laparotomy, and of those 12 patients, seven (58%) had staged surgery with a primary so-called damage control laparotomy utilising abdominal packing and closure of skin only, with planned re-laparotomy after 24 h. A policy of mandatory stoma was instituted for colonic injury, and two of 55 patients had thoracotomy (one for control of pulmonary haemorrhage and one for a cardiac fragmentation wound).

All patients were brought in by civilian vehicles with no formal prehospital treatment, and without any physiological observations. Selection of patients for surgery was by classical surgical triage (ie, screening for the most critically ill in order to prioritise patients for treatment). Decisions had to be made based on status of the patient and availability of resources (rather than using formal algorithms); if considered unsalvageable, patients were palliated or simply comforted until death.[9,10] No patient with a penetrating cranial injury was selected for surgery. All patients received fresh whole blood after surgical control of bleeding had been achieved, with most receiving one unit, several receiving two, and some patients receiving three units. No patient received more than three units of fresh whole blood. The principles of care were triage followed by immediate, expert surgical control of haemorrhage, with no intensive care or postoperative artificial ventilation available. All patients selected for surgery survived and had haemoglobin levels drawn at 72 h after surgery. The median haemoglobin concentration was 62 g/L (range 45–98 g/L), and 36 (65%) of 55 patients had haemoglobin concentration below 70 g/L.

Humanitarian war surgery is characterised by austere conditions, resource and logistic chain constraints, and isolation. To these traditional challenges should now be added active targeting of medical facilities and health workers by malign actors. In such settings, the humanitarian surgical team must accomplish the greatest good for the maximum number of patients under enormous pressure and without access to accepted standards of transfusion support and critical care.

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The hallmark of war injury is high and early lethality. In a review of nearly 500 British Service Personnel who were killed in action, 68% were dead within 10 min of wounding, and 99% had died within 2 h.[11] If potentially salvageable patients are to be saved, surgical expertise must be available as soon as possible. We propose that this case series generates the following hypothesis: that for young adult and paediatric patients who have sustained blast and penetrating war trauma, short prehospital times, decisive judgement, and early surgical control of haemorrhage are the key principles to achieve success. For these patients, minimising all infusions (including blood) and tolerating (very) low post-operative haemoglobin appeared to be safe, preserved scarce blood stocks, and might have even be clinically beneficial.[12] Since the patients were relatively young, it is unknown whether this hypothesis can be extended to older patients or those with significant comorbidities, and we are unable to determine the extent of survivorship bias in the patient cohort.

What might these experiences mean for humanitarian and military providers of surgery for the war-wounded? The approach in Syria was borne from necessity in the presence of unavoidable resource and logistic constraints; yet all patients selected for operation survived, despite what might be considered under-resuscitation within modern DCR doctrine. Furthermore, no framework was established in which prehospital treatment, permissive hypotension, or formal timelines (such as the golden hour) could be achieved. Instead, a scoop and run approach was used by local civilians, with ad hoc modes of transport, followed by expedited surgery on arrival.

Although we acknowledge that humanitarian operations vary considerably, and there is always going to be some uncertainty about the translatability of experiences, circumstances such as these are likely to be encountered again by humanitarian clinicians. Russia's invasion of Ukraine is forcing hospitals underground, and resources will soon become extremely scarce.[13] The observation in Syria of the primacy of good judgement, earliest possible surgical intervention, and minimal transfusion of whole blood leading to better than expected outcomes should be acknowledged by those brave Ukrainian health workers treating patients under terrible conditions; they also should be acknowledged and further tested in safer conditions in hospitals that are not resource-deprived.[14]

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