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EDITORIAL

Advances made in resuscitation: current status

P. V. Giannoudis[1,2]

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The management of polytrauma patients has been revolutionised during the past 30 years. Major advances made in accident prevention, new car designs, rescue conditions, advanced trauma life support protocols, diagnostics, surgical approaches, intensive care support, implantology, antibiotics and pharmacotherapy in general have contributed to the overall reduction of mortality rate seen in this cohort of patients [1–3]. Moreover, the philosophy of damage control surgery, a process to assist resuscitation by performing surgical maneuvers of short duration in the operating theatre with a minimal invasive approach, has been successful in reducing the additional physiological burden exerted by the second hit phenomena and thus protecting the patient of developing an exaggerated immune-inflammatory response leading to early development of multiple organ dysfunction syndrome (MODS) [4–6].

Yet, during this period of time, the three distinct peaks of mortality being at the scene of the accident (severe head injuries), first 24–48 h (uncontrolled bleeding) and days or weeks later, as a result of the multiple organ dysfunction syndrome (MODS) has not really changed substantially. The second peak of death related to heamorrhage and coagulopathy has been an area of great interest to clinicians. Restoration of the lost blood volume, correction of acidosis and coagulopathy and what should be the optimal patterns for fluid management and administration of blood products dominate the discussion [7].

✉ P. V. Giannoudis
pgiannoudi@aol.com

[1] Academic Department of Trauma and Orthopaedics, School of Medicine, Clarendon Wing, LGI, University of Leeds, Floor A, Leeds, UK

[2] NIHR Leeds Biomedical Research Unit, Chapel Allerton Hospital, Leeds, UK

To start with, coagulopathy has been shown to relate directly to the amount of fluid administered supporting the view that dilution plays a crucial role. Dysfunction of specific components and activation of protein C is connected with the exhaustion of many clotting factors [8]. Changes in pH adversely influence enzymatic function throughout the body. The degree of acidosis in the bleeding patient has been noted to correlate to the exhaustion of coagulation factors. For instance, a drop in pH from 7.4 to 7.0 decreases the activity of Factor VIIa by more than 80 % [9].

It is not a surprise, therefore, that Friscknecht et al. reported that lactate >4 mmol/L odds ratio 8.70 (1.81–41.67) and pack red blood cells (PRBC) >10 units odds ratio 7.14 (1.40–40.00) were independent risk factors at ICU admission for early mortality in patients undergoing damage control management [10].

For the early diagnosis of coagulopathy and the outcome of treatment, viscoelastic haemostatic assays (VHA), thromboelastography (TEG) and rotation thromboelastometry (ROTEM) representing base model assessing viscoelastic properties of coagulation in whole blood under low shear conditions have had great acceptance [11]. A graphic presentation of clot formation and subsequent lysis is obtainable following incubation of blood at 37 °C. Advantages to these diagnostic assays include assessment of combined influence of circulating plasmatic and cellular elements on clot formation and the short time that takes to make the results being available [12]. More and more trauma centers are currently using this approach of assessment and treatment of coagulation disturbances.

Lately, the concept of damage control resuscitation (DCR) was introduced to optimise the resuscitation process in the multiple injured patients. The hallmark of this approach is a more focussed correction of coagulopathy and metabolic imbalances. It includes such constituents as restrictive fluid

balance, permissive hypotension, haemostatic resuscitation, prompt correction of acidosis and of hypothermia and application of appropriate surgical procedures to stop bleeding. Early replacement of all the constituents of whole blood by prompt administration of blood and blood products is advocated as it has been shown that early blood transfusion can lessen the whole blood product consumption [13].

Haemostatic resuscitation is based on the administration of a mixture of red blood cells (RBCs), fresh frozen plasma (FFP) and platelets in approximately a 1:1:1 ratio. Such a strategy known as a 'balanced transfusion' would minimise the risk of dilution of coagulation factors leading to a reduction in the overall mortality rate in patients requiring massive transfusions [14].

Overall, however, the exact amount of products and the exact ratio of blood products to be administered of this volume restoration approach are yet to reach a universal consensus. Studies are ongoing with regard to this important question. It may be that different patient populations would benefit from different treatment regimes.

Another important advancement that has been made to control bleeding, reduce blood transfusion requirements and minimise complications secondary to massive transfusion is the development of unique pharmacological agents. In particular, tranexamic acid (TXA) is nowadays the most commonly used antifibrinolytic agent. In the largest randomised controlled trial to date (CRASH-2), 20,211 patients were randomised to receive TXA (1 gm of TXA infused over 10 min, followed by an intravenous infusion of 1 gm over 8 h) or Placebo (0.9 % Normal Saline) [15]. The authors reported that TXA lowered mortality (relative risk 0·91, 95 % CI 0·85–0·97) and risk of death as a result of bleeding (relative risk: 0.85, 95 % CI 0.76–0.96). In another study, it was found that the odds of death from bleeding was reduced by about 30 %, whereas, the odds of thrombotic events was also reduced by about 30 %. Consequently, it was recommended that TXA may be safely used to a wide range of patients with bleeding secondary to trauma [16].

So, have we made progress in terms of utilising effectively the 'golden hour' of trauma by achieving the end points of resuscitation successfully with the application of new strategies? What have we learned out of the military conflicts, are we applying them successfully in the civilian trauma population? Are we reducing the number of deaths secondary to bleeding and shock? There is no doubt that significant improvements have been made in all aspects of trauma care. The challenge remains now to see whether we have reached a plateau or we can still continue to reduce mortality rates.

Compliance with ethical standards

Conflict of interest Peter V Giannoudis declares that he has no conflict of interest.

Ethical standard This article does not contain any studies with human participants or animals performed by any of the authors.

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