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Emergency red cells first: Rapid response or speed bump? The evolution of a massive transfusion protocol for trauma in a single UK centre

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ABSTRACT

Background: Death from massive haemorrhage due to traumatic injury is potentially preventable after hospital admission using haemorrhage control and improved resuscitation techniques including massive transfusion protocols. Massive transfusion protocols (MTP) are an essential element of damage control resuscitation and provide a coordinated clinical pathology response to massive haemorrhage after hospital admission. The decision to activate and de-activate a MTP is based on a number of patient and local factors. The purpose of this before-and-after study was to determine the impact of modifying a protocol to include emergency red cells. In addition, we investigated whether massive transfusion prediction models could have been used to guide on-going transfusion support.

Methods: Sequential MTP activations over three years, before and after protocol revision, were analysed. Percentage of MTP activation, component usage and outcome data were compared. Trauma associated severe haemorrhage (TASH) and assessment of blood consumption (ABC) scores were derived and receiver operating characteristic (ROC) analysis undertaken for an outcome defined as the use of >6 red cell units.

Results: 52 MTP1 and 66 MTP2 activations arose from 216 and 495 major trauma cases, respectively. Protocol change significantly reduced the MTP activation rate ($p = 0.0006$) from 24% to 13%, and the number of activations requiring >10 RCC increased from 13% to 36% ($p = 0.006$). Average emergency red cells usage in the second cohort increased to 4 units. Survival, coagulation parameters, and time to MTP pack issue were all unaffected by the protocol revision. The TASH score showed an area under ROC (AUROC) of 0.88 ongoing transfusion requirements.

Conclusion: The change in protocol increased the use of emergency red cells but reduced MTP activation and use of multiple blood components. The TASH score appears to provide a useful predictive tool for ongoing transfusion support and may be of value for the trauma clinicians.

Introduction

Rapid and efficient transfusion support is an essential component in the management of major haemorrhage (MH) [1]. This has been highlighted by the experiences gained during recent military conflicts, and has led many civilian trauma centres to adopt ratio-based major transfusion protocols (MTPs) within the framework of a massive haemorrhage protocol [2]. The introduction of protocols results in a better co-ordinated response, better outcomes and a reduction in complications [3,4]. Although the optimal ratio of blood product use is uncertain there has been a move in civilian centres to adopt RCC:FFP ratios of 3:2 or 2:1 [5]. It is probable that the early use of plasma and platelets should be even higher in the severely injured. The recently published study by Holcombe et al. showed that although that the use of a 1:1:1 ratio of RCC:FFP:Platelets did not result in a significant reduction in mortality at 24 h or 30 days, more patients achieved haemostasis and fewer experienced death by exsanguination.

Massive haemorrhage protocols including a massive transfusion protocol have increasingly become an integral part of damage control resuscitation (DCR) in order to prevent and manage posttraumatic coagulopathy in the first hour and beyond. The

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massive haemorrhage protocol should include the clinical, laboratory and logistic response [6]. Protocols should also address the immediate availability of un-crossmatched group O red cells for trauma patients with massive haemorrhage [7]. The decision to activate the local massive transfusion protocol is complex, must be made rapidly, and yet if not required may lead to unnecessary treatment, waste of resources or harm [8]. Scoring systems have been proposed to improve the prediction for massive transfusion support [9,10].

We introduced a fixed-ratio massive transfusion protocol in August 2008 based on transfusion shock packs of 1:1 red cell concentrates (RCC):fresh frozen plasma (FFP) followed by the early use of platelets and cryoprecipitate. The protocol included prompts for activation of the protocol which could be done either in the pre-hospital environment or on admission. Pre-hospital activation requires additional training and has subsequently been shown to be effective [11]. Transfusion packs were prepared when ordered with a target response time of 30 min. Ongoing monitoring established that packs were often ordered but not used [12]. In addition, there were occasional incidents where there appeared to be delay in emergency transfusion support despite reference to the use of emergency red cells within the protocol. We proposed that adding an additional step in the protocol prompting the use of emergency red cells during initial resuscitation may improve the emergency use of blood rather than crystalloids. Red cells could be given either during the pre-hospital or hospital period. Where red cells are given during the pre-hospital period then this step would be omitted. The final ratio of RCC to FFP following the introduction of the additional step of 2 RCC to the initial 4 plus 4 pack was designed to be RCC:FFP = 6:4.

The primary aim of this study is to describe the impact of changing the protocol. The secondary aim was to assess if existing scoring systems for the prediction of massive transfusion, normally used at the point of activation, could have been used to guide the subsequent requirement for component support beyond the first massive transfusion pack.

Materials and methods

Setting and MTP revisions

Setting

This study was a retrospective observational review of practice in a single institution, the Queen Elizabeth University Hospital Birmingham, UK. The hospital is the receiving facility for UK military trauma patients and equivalent to a US level 1 trauma centre. It serves a population of 1.2 million UK civilians. Following the UK wide reconfiguration of major trauma networks, the institution was designated a regional Major Trauma Centre during the period of study. Pre-hospital treatment for trauma included a 24 h physician led emergency response capability with day time helicopter support. Pre-hospital transfusion was not available. Patients admitted to the trauma unit who require trauma ward admission for $\geq$3 days, critical care admission or whose injury led to their death (30 days) are recorded in the UK Regional Trauma Audit Research Network (TARN) database. The unit receives approximately 300–400 such cases *per annum*, which satisfy this classification and are herein referred to as major trauma cases.

Implementation

The hospital implemented the first massive haemorrhage protocol containing a massive transfusion protocol (MTP) in 2008 following a review of the military experience, the literature and consultation with key stake-holders. This protocol was based on the UK military transfusion algorithm and is outlined in Fig. 1A. Activation of the massive haemorrhage protocol and the MTP were concurrent and was made at the discretion of the trauma team leader, a senior clinician, with consensus from the trauma team. MTP pack one consisted of 4 units of red cell concentrates (RCC) and 4 units of fresh frozen plasma (FPP) (thawed from frozen on request). The second, and all subsequent, transfusion packs also contained an adult therapeutic dose (ATD) of platelets (PLT). Cryoprecipitate was given as clinically directed on the basis of laboratory fibrinogen and thrombo-elastography results. Thrombo-elastography was available in theatres and the critical care unit. Clinicians were informed that all MTP activations would be prospectively recorded by the transfusion laboratory and would be subsequently reviewed in multi-disciplinary meetings.

Review

The first annual review of MTP1 activations highlighted a number of concerns. Concerns included delays in transfusion, despite access to emergency red cells, and the non-use of thawed FFP when provided. The transfusion protocol was therefore modified one year after implementation (Fig. 1B). The revised (MTP2) protocol algorithm included a short initial evaluation period during which clinicians were prompted to use emergency RCC transfusion if immediate transfusion support was required. The recommended maximum number of emergency RCC units was two. This amendment was not designed to stop massive haemorrhage protocol activation i.e. be a speed bump. It was designed to provide a rapid red cell response during resuscitation and assessment before proceeding to massive transfusion i.e. multi-component transfusion support. The initial massive haemorrhage activation continued to alert the laboratory to thaw frozen plasma just in case it was needed. However, a telephone call confirming full MTP activation was required to release the massive transfusion pack.

Change management

The roll-out of both MTPs was supported by specific training in the emergency department. Copies of the algorithm were present in all clinical areas for reference. The protocol also formed part of the trust's mandatory transfusion training for medical staff during which the continued requirement for baseline blood samples was emphasised. We anticipated that there would be a learning curve associated with the introduction and change of protocol. To reduce the impact of any learning curve associated with the introduction of protocols we have not included MTP cases occurring in the first 100 days after implementation of either.

Blood components

All blood components met UK specifications including leucodepletion. The estimated age of all RCC provided for transfusion packs was 18–21 days. Emergency RCC were group O RhD and Kell negative. Fresh frozen plasma was single donor, quarantined plasma from untransfused males. Plasma was thawed and issued to order. Thawed plasma maintained within temperature control was returned to stock and stored at 4 °C for 24 h before discard. Platelets were either prepared by apheresis or derived from whole blood (4 buffy coats). The adult therapeutic dose (ATD) of platelets was $>2.4 \times 10^{11}$.

Predictive scoring systems

The trauma associated severe haemorrhage (TASH) score and assessment of blood consumption (ABC) scores were both calculated in accordance with their original publications and subsequent validation [9,10,13]. (Appendix 1 outlines the constitution and details of clinical parameters required to measure these scores).