Update in
Anaesthesia



# Guideline for management of massive blood loss in trauma

Srikantha Rao* and Fiona Martin
*Correspondence Email: srao1@psu.edu

## INTRODUCTION

This article is about massive blood loss. Most published guidance focuses on trauma but the advice is also relevant to other causes such as obstetric haemorrhage. Further description of the management of maternal haemorrhage is also available in a recent *Update* article.[1] As described in the article on trauma management, 'ABCDE' can be used to guide orderly assessment and treatment of any patient with major blood loss. This is increasingly expanded to <C>ABCDE, where <C> refers to catastrophic haemorrhage control. Haemorrhage is the leading cause of preventable deaths following trauma. Early recognition of major blood loss and effective action prevents shock and its consequences.

Massive blood loss is defined as the loss of one blood volume within 24 hours.

Normal blood volume is 70ml.kg$^{-1}$ in adults (ideal body weight), 60ml.kg$^{-1}$ in the elderly and 80-90ml.kg$^{-1}$ in children. An alternative definition of massive blood loss is loss of 50% of the blood volume within 3 hours, or a rate of loss of greater than 150ml per minute. The basic management principle is to stop the bleeding and replace the volume loss.

## COMMENTARY ON ALGORITHM

The guideline presented in this article is based on template guidelines published by the British Committee for Standards in Haematology, the Adult Trauma Life Support (ATLS) group and, most recently, the Association of Anaesthetists of Great Britain and Ireland.[2,3,4] However, most of the recommendations contained in these guidelines are based only on uncontrolled observational studies and a consensus of expert opinion.

This guideline should be modified by individual institutions based on local circumstances, including personnel, equipment and blood product availability and the time required to transport specimens and blood products. Each hospital's Transfusion Committee has a vital role in ensuring the optimum and safe use of blood components. The accompanying commentary provides key references on which the guidelines are based, but does not constitute an exhaustive review of the topic.

**Box 1** - *Activate the trauma team*

External haemorrhage is easily identified during the primary survey but occult blood loss may have occurred into the chest, abdomen, pelvis, retroperitoneum or long bones. Hypotension following injury must be attributed to blood loss until proven otherwise.

Simple clinical observation of the patient's level of consciousness, skin colour, respiratory rate, pulse rate and pulse pressure gives immediate information about organ perfusion (Table 1). However, the elderly, children, athletes and individuals with chronic medical conditions do not respond to blood loss in a uniform manner. The initial physiological response to blood loss in a young fit patient is vasoconstriction followed by tachycardia. Such a patient may have lost up to 30% of their blood volume with minimal or no other clinical signs of shock. Beware the patient with a normal systolic blood pressure and a raised diastolic blood pressure (therefore a low pulse pressure).

Take blood samples at the earliest opportunity as results may be affected by colloid infusion. One team member should ensure that the identity of the patient is correctly recorded on the sample and request form, and hand them to the laboratory staff in person in order to avoid unnecessary delays.

When assessing a patient with shock remember:

- There may be more than one cause for shock.
- Young healthy patients will compensate for a long period of time and then collapse quickly.
- Isolated intracranial injuries do not cause shock.
- Always be on the alert for tension pneumothorax.

**Summary**

- Early recognition of major blood loss and effective action is necessary to prevent shock and its consequences.
- Massive transfusion may challenge local resources.
- Effective management relies upon good communication between specialties and local guidelines.
- Successful outcome requires treatment of surgical sources of bleeding, restoration of blood volume to maintain tissue perfusion and oxygenation, and correction of coagulopathy.

***Srikantha L Rao***
Associate Professor of Anesthesiology
Medical Director of Perfusion
Penn State Hershey Medical Center
Hershey PA
USA

***Fiona Martin***
Consultant in Anaesthesia
Royal Devon and Exeter Hospital
Devon
UK

**Table 1.** *Grading shock - estimated blood loss based on patient's clinical signs at presentation. Reproduced by kind permission of the American College of Surgeons Committee on Trauma. Modified from Table 3-1 of Advanced Trauma Life Support for Doctors, Student Manual, 8th Edition, page 61.*

| | Grade of shock | | | |
|---|---|---|---|---|
| **Clinical variable** | **Class I** | **Class II** | **Class III** | **Class IV** |
| Blood loss (ml)* | Up to 750 | 750-1500 | 1500-2000 | >2000 |
| Blood loss (% of blood volume) | Up to 15% | 15%-30% | 30%-40% | >40% |
| Pulse rate (beats.min$^{-1}$) | <100 | 100-120 | 120-140 | >140 |
| Blood pressure | Normal | Normal | Decreased | Decreased |
| Pulse pressure | Normal | Decreased | Decreased | Decreased |
| Respiratory rate (min$^{-1}$) | 14-20 | 20-30 | 30-40 | >35 |
| Mental status | Slightly anxious | Mildly anxious | Anxious, confused | Confused, lethargic |
| Urine output (ml.hr$^{-1}$) | >30 | 20-30 | 5-15 | Negligible |
| Fluid replacement | Crystalloid | Crystalloid | Crystalloid and blood | Crystalloid and blood |

- * For a 70-kg man.
- The guidelines in this table are based on the 3:1 rule. Most patients in hemorrhagic shock require as much as 300 ml of electrolyte solution for each 100 ml of blood loss.
- A patient with a crush injury to an extremity may have hypotension that is out of proportion to his blood loss and may require fluids in excess of the 3:1 guideline.
- A patient whose on-going blood loss is being replaced by blood transfusion requires less than 3:1.
- The use of bolus therapy with careful monitoring of the patient's response may moderate these extremes.

Another member of the clinical team should be nominated to act as the co-ordinator for overall communication between clinical specialties, diagnostic laboratories and blood bank staff. If some blood components are kept in a regional centre then the transportation delay must be taken into account. The Hospital Transfusion Committee should periodically review massive transfusion episodes.

**Box 2** - *Stop the bleeding*

Intravenous replacement of intravascular volume cannot succeed without definitive control of bleeding. Obvious catastrophic bleeding is addressed in Box 1 (<C>). Examples include use of compression bandages, use of limb tourniquets and application of a pelvic binder for fractured pelvis.

**Box 3** - *Restore circulating volume*

Prolonged hypovolaemic shock carries a high mortality rate because of progression to organ failure and disseminated intravascular coagulation (DIC). The first priority in the treatment of major blood loss is the restoration of blood volume to maintain tissue perfusion and oxygenation. Fluid resuscitation must be started when early signs and symptoms of blood loss are suspected, not when blood pressure is falling or absent.

All transfused fluids should be warmed because hypothermia increases the risk of DIC and infection.

Initial fluid resuscitation should be by rapid infusion of warmed isotonic crystalloid (Hartmann's/Ringer's lactate or 0.9% saline) via large bore cannulae. The initial dose is 1 to 2 litres for adults and 20ml.kg$^{-1}$ for children. Volume replacement should be guided by the patient's response to initial therapy by repeated re-evaluation of ABC (see Table 2).

The goal of resuscitation is to restore organ perfusion. In some patients, if blood pressure is raised rapidly before the hemorrhage has been definitely controlled, increased bleeding may occur. Balancing the goal of organ perfusion with the risks of re-bleeding, by accepting a lower than normal blood pressure, has been called 'controlled resuscitation' or 'balanced resuscitation'. A useful concept is that of 'talking hypovolaemia', where hypotension is tolerated so long as the patient is achieving sufficient cerebral perfusion to hold a conversation. Such a strategy may buy time until surgical control of bleeding has been achieved.

**Box 4** - *Red cell transfusion*

The loss of over 40% of blood volume is immediately life threatening. Red cell transfusion is usually required when 30-40% of the blood volume is lost (Table 1). Transfusion is rarely indicated when the haemoglobin concentration is greater than 10g.dl$^{-1}$ but is almost always indicated when it is less than 6g.dl$^{-1}$. However, after equilibration and redistribution of crystalloid, the haemoglobin measured may actually be higher or lower than that during the resuscitation period. In the

**Table 2.** *Interpretation of response to initial fluid resuscitation. Reproduced by kind permission of the American College of Surgeons Committee on Trauma. Modified from Table 3-2 of Advanced Trauma Life Support for Doctors, Student Manual, 8th Edition, page 65.*

| Clinical variable | Rapid response | Transient response | Minimal or no response |
|---|---|---|---|
| Vital Signs | Return to normal | Transient improvement, recurrence of decreased blood pressure and increased heart rate | Remain abnormal |
| Estimated blood loss | Minimal (10%-20%) | Moderate and ongoing (20%-40%) | Severe (>40%) |
| Need for more crystalloid | Low | High | High |
| Need for blood | Low | Moderate to high | High |
| Blood preparation | Type and crossmatch | Type-specific | Emergency blood release (Group O -ve) |
| Need for operative intervention | Possibly | Likely | Highly likely |
| • 2000ml of isotonic solution in adults; 20ml.kg$^{-1}$ bolus of Ringer's lactate/Hartmann's in children. | | | |

setting of ongoing blood loss, the decision to transfuse must be based on estimation of loss and guided by bedside testing (e.g. Hemocue®) where available. In a well-compensated patient without heart disease, 6g.dl$^{-1}$ may be an appropriate transfusion trigger. In patients with stable heart disease and with an expected blood loss of 300ml, a haemoglobin of 8g.dl$^{-1}$ may be a more appropriate trigger. Older patients and those with co-morbidities, which limit the ability to raise cardiac output, should be transfused at a haemoglobin of 10g.dl$^{-1}$. These decisions are also influenced by the availability of blood and what may be considered to be a normal haemoglobin level in a population with endemic disease such as malaria.

Intraoperative blood salvage can be of great value in reducing the requirement for donated blood. It is contraindicated where there is wound contamination with bowel contents, urine, bone fragments or fat. This technique is dependent on having appropriate equipment and staff available, however techniques that require no specialist equipment have been described.[6]

In most blood banks completion of a full blood cross-match requires between 40 minutes to one hour. If it is urgent, **type-specific** (i.e. grouped but not cross-matched) blood can generally be provided within 10 to 15 minutes. Laboratory staff then complete the cross-match during the time taken to transport the blood and alert clinicians if there is incompatibility.

In an extreme situation it may be necessary to use group O red cells. Pre-menopausal women should receive group O Rhesus D negative red cells to avoid sensitisation and the risk of haemolytic disease of the newborn in subsequent pregnancies. However, in order to avoid severe depletion of stocks, it is acceptable to give O Rhesus D positive cells to men and post-menopausal women.

Most transfusion related morbidity is due to incorrect blood being transfused. Ensure that all staff members are familiar and up to date with local standards for checking and administering blood. Note that after replacement of one blood volume (8-10 units of red cells) further crossmatching is <u>not</u> required.

Remember to use a blood warmer, where available.

**Remember:**

- Haemoglobin values do not decrease for several hours after acute hemorrhage, when compensatory mechanisms are in place.
- Blood loss is usually underestimated or hidden.

**Box 5** - *Component therapy and investigations*

In addition to blood grouping, where available, send samples to the laboratory as soon as possible for baseline haematology, coagulation screening, fibrinogen and serum biochemistry.

*Fresh frozen plasma (FFP) and cryoprecipitate*

After massive blood loss and transfusion, coagulation factor deficiency is common, because packed red cells contain no clotting factors. After blood loss of 1.5 times the patient's total blood volume, the level of fibrinogen is likely to be below 1.0g.L$^{-1}$ (normal range 1.8-4.0g.L$^{-1}$). Fibrinogen is the precursor to fibrin and therefore a key component in the cloagulation cascade. A fibrinogen level of <0.5g.L$^{-1}$ is strongly associated with microvascular bleeding (diffuse bleeding from numerous small blood vessels which are too small for surgical methods of treatment). A decrease in other coagulation factors occurs after blood loss of twice the blood volume. Prolongation of activated partial thromboplastin time (APTT) and prothrombin time (PT) to 1.5 times the mean normal value correlates with increased bleeding and this should be corrected.

FFP contains predominantly factors 2 (fibrinogen), 7, 9, 10 and 11. When blood loss is rapid and red cells are infused rapidly, FFP infusion will be needed after approximately 4 units of packed red cells have been given. When the patient has lost one total blood volume, give 12-20ml.kg$^{-1}$ body weight (about 4 units of FFP in an adult). This volume of FFP will raise coagulation factor levels by about 20%. The effectiveness of FFP may be reduced due to rapid consumption in the

presence of continued bleeding. There is increasing evidence from recent military experience that supports the use of transfusion packs - i.e. giving blood and FFP and platelets in equal ratios. Balancing massive transfusion with an approximate 1:1 ratio of red blood cells to plasma, from the beginning of resuscitation, is logical in severely injured trauma patients, who develop coagulopathy as a primary event from their injury, not secondary to clotting factor dilution, hypothermia or acidosis.

Further studies of use of transfusion packs in hospital practice are needed, because patients often have comorbidities and the nature of the trauma is usually motor vehicle trauma and crush injuries, lower velocity gunshot wounds and stab wounds.

When fibrinogen levels remain low (<1.0g.$L^{-1}$), give cryoprecipitate 1-1.5 packs per 10kg body weight or about 6 packs for an adult. Cryoprecipitate contains fibrinogen, factor 8, factor 13 and von Willebrand factor (that is important for platelet function).

*Platelets*

Aim for the following platelet levels:

| | |
|---|---|
| > 75 x $10^9$.$L^{-1}$ | Critical level for all bleeding patients |
| > 100 x $10^9$.$L^{-1}$ | For patients with:<br>• multiple high-energy trauma or,<br>• central nervous system injury or,<br>• if platelet function is abnormal (patients with end stage renal disease). |

Anticipate a platelet count of <50 x $10^9$.$L^{-1}$ when about two blood volumes have been replaced by red cell transfusion.

Where platelets are available, they may not be stored locally. You may need to consider ordering them before they are needed, so that they are available when the patient's platelet level becomes critical. Where available, it is important to check these parameters frequently (at least four-hourly and after each therapeutic intervention), to monitor the need for and the efficacy of component therapy.

*Investigations*

Ideally, tests of coagulation and full blood count should be repeated every hour when bleeding is ongoing. Where available, base deficit and lactate can be useful in determining the presence and severity of shock. Serial measurement of these parameters can be used to observe trends, assess adequacy of resuscitative treatment and guide further therapy. If available, thromboelastography® (TEG®) or thromboelastometry (ROTEM®) should be performed to assist in characterising the coagulopathy and in guiding haemostatic therapy.

**Box 6** - *Shock and DIC*

Shock describes an abnormality of the circulatory system leading to inadequate organ perfusion and tissue oxygenation. In trauma, the most likely cause is blood loss, but consider other causes such as cardiogenic shock, cardiac tamponade, tension pneumothorax, neurogenic shock, and septic shock.

Most patients are at risk of dilutional coagulopathy when volume replacement is with crystalloids and red cells. In additon patients suffering massive trauma are also at risk of consumptive coagulopathy and liable to develop clotting abnormalities, even in the absence of significant dilution. These patients may have clinically apparent abnormal bleeding without abnormal coagulation tests.

Patients taking anticoagulant drugs may need specific treatment. Warfarin should be reversed with a prothrombin complex concentrate and intravenous vitamin K (5-10mg). Low molecular weight heparin can be partially reversed with protamine.

Platelet dysfunction may be present in patients with renal disease and those on antiplatelet medication, such as aspirin or clopidogrel. Patients with liver disease, associated with reduced synthesis of clotting factors, may develop clinically significant coagulopathy with blood loss of less than one blood volume.

Hypocalcaemia and hypomagnesaemia often occur in massively transfused patients and will require monitoring and correction.

If accelerated fibrinolysis is suspected (particularly in multiple trauma) or identified by laboratory assay of fibrin degradation products or by the use of thromboelastography, antifibrinolytic drugs such as intravenous tranexamic acid may be used to reverse fibrinolysis. A loading dose of 1g over 10 min followed by 1g over 8 hours is recommended.

**Box 7** - *Stabilise the patient*

When the primary injury has been addressed, the patient should be transferred to the Intensive Care Unit for further treatment. The patient should have regular clinical observations, haemoglobin levels and blood gas analysis to ensure that resuscitation is adequate and that bleeding is not continuing.

Once haemostasis is secured standard venous thrombo-prophylaxis should be considered as patients develop a prothrombotic state following massive blood loss.

## PRE-EVENT PLANNING

1. Chose a particular approach for your institution and rehearse it before you need to use it.
2. The Hospital Transfusion Committee should periodically review massive transfusion episodes to look for points for improvement.
3. When adapting this guideline for your hospital, bear in mind the following:

*Blood Bank*

- Time required by the blood bank for a type and screen.
- Time required by the blood bank for crossmatch of specific units.

- Amount and type of blood locally available.
- Time required for transport from the nearest blood bank.
- Time required to thaw frozen blood components (fresh frozen plasma and cryoprecipitate).

*Clinical laboratory*

- Time taken to measure PT, APTT.
- Time taken to conduct a full blood count and platelet count.
- Time taken for a blood gas analysis, biochemistry profile and serum lactate measurement.

## SUMMARY

- Find the source of bleeding and stop it.
- A named senior person must take responsibility for communication and documentation.
- Ensure correct blood sample ID when sending specimen to the laboratory.
- Ensure correct patient identification prior to transfusion of blood components
- Recognise your local limitations when dealing with laboratory and blood bank turnaround times for issue of blood and other components after crossmatch.
- Allow for about 30 minutes thawing time for FFP and cryoprecipitate.
- Allow for delivery time from blood centre if away from the hospital.
- The patient may have multiple antibodies following a massive transfusion. Make sure that this is clearly recorded in their notes, possibly by an ALERT sticker on the front.
- Practice this protocol to determine your actual response times.

## REFERENCES


1. Baldwin S, Rucklidge M. Management of obstetric haemorrhage. *Update in Anaesthesia* 2009, **25,2**: 41-8. Available at: http://update.anaesthesiologists.org/wp-content/uploads/2009/12/Management-of-obstetric-haemorrhage.pdf
2. Guidelines on the management of massive blood loss. British Committee for Standards in Haematology, Stainsby D, MacLennan S, Thomas D, Isaac J, Hamilton PJ. *Br J Haematol* 2006; **135**: 634-41.
3. Advanced Trauma Life Support for Doctors. Student Course Manual, 8th Edition. American College of Surgeons Committee on Trauma.
4. Association of Anaesthetists of Great Britain and Ireland. Blood transfusion and the anaesthetist: management of massive haemorrhage. *Anaesthesia* 2010; **65**: 1153-61. Available at: http://www.aagbi.org/sites/default/files/massive_haemorrhage_2010_0.pdf
5. Advanced trauma life support, 8th edition, the evidence for change. Kortbeek JB et al. *J Trauma* 2008; **64**: 1638-50.
6. M J Mackenzie, D Nanko, D Hilli, N B Essé. A percutaneous method for blood salvage in ruptured ectopic pregnancy: experience from a Médecins Sans Frontières hospital in Ivory Coast. *Update in Anaesthesia* 2008; **24,1**: 47-8.


## FURTHER READING


- Perkins JG, Cap AP, Weiss BM, Reid TJ, Bolan CD. Massive transfusion and nonsurgical hemostatic agents. *Crit Care Med* 2008; **36** (7 Suppl): S325-39.
- Moor P, Rew D, Midwinter MJ, Doughty H. Transfusion for trauma: civilian lessons from the battlefield *Anaesthesia* 2009; **64**: 469-72.
- Thomas D, Wee M, Clyburn P et al. Blood Transfusion and the anaesthetist: management of massive haemorrhage. *Anaesthesia* 2010; **65**: 1153-61.
- Spence RK, Carson JA, Poses R et al. Elective surgery without transfusion: Influence of preoperative hemoglobin level and blood loss on mortality. *Am J Surg* 1990; **59**: 320-4.
- Robertie PG, Gravlee GP. Safe limits of hemodilution and recommendations for erythrocyte transfusion. *Int Anesthesiol Clin* 1990; **28**: 197-204.
- Schuster KM, Davis KA, et al. The status of massive transfusion protocols in United States trauma centers: massive transfusion or massive confusion. *Transfusion* 2010; **50**: 1545-51.