20

RESUSCITATION

M. J. Cowen

INTRODUCTION

The key feature of all resuscitation efforts is the early recognition and management of hypovolemic shock with an overall objective of restoring the circulating blood volume to maintain normal tissue perfusion and oxygenation.

The reason for the high mortality associated with obstetric hemorrhage is simple, i.e. the delayed recognition of hypovolemia and failure to provide adequate volume resuscitation. Common problems include the failure to recognize risk factors, frequent under-estimation of the degree of blood loss, and failure to involve key personnel early enough. These problems can be operational even in developed nations, such as the UK and the US[1–3].

GENERAL CONSIDERATIONS

All resuscitation strategies include two principal objectives:

(1) Achievement of hemostasis by arresting the source of bleeding by whatever means necessary, including surgical intervention with or without anesthesia;

(2) Restoration of an adequate circulating blood volume by maintaining a normal blood pressure and urine output (> 30 ml/h in adults) (0.5 ml/kg/h).

The early recognition of problems followed by an immediate response is of paramount importance, as mobilization of the key personnel and equipment takes time. It is not possible for one individual to do all the necessary work and there is no place for acting solo in isolation. Key players must include senior obstetricians, midwives, anesthetists, hematologists and laboratory staff in the blood bank, all of whom must be alerted at an early stage, as any undue delay or failures of communication at the initial stage will invariably result in a poor outcome. In particular, the prompt involvement of experienced senior anesthetists is mandatory along with intensive care back-up facilities (see Chapters 13 and 22).

The most important first step is to secure good venous access whilst veins are still available and before shut-down occurs, preferably by two large-bore cannulae, i.e. 14 gauge (flow rate 315 ml/min) or 16 gauge (210 ml/min). The importance of cannula size and flow rate cannot be overstated, and all too often very small cannulae are inserted with poor flow rates (e.g. 20 gauge cannula flow rate = 65 ml/min) with disastrous results. In those circumstances where veins are collapsed, however, a small cannula is better than nothing.

The use of a cannula and fluid infusion are the mainstay of treatment. Most of the other activities required, including monitoring and laboratory sampling, whilst important are not actually treatment. It is easy in the busyness of the emergency scene to be distracted by these peripheral activities at the expense of treatment, i.e. intravenous fluid therapy, and it is important for the team leader to keep a sense of perspective if there is to be a good outcome.

The second most important step is to send an urgent blood sample to the laboratory for baseline readings of full blood count, including hemoglobin, hematocrit and platelet count, plus clotting tests, including prothrombin time (PT), activated partial thromboplastin time (APTT) and fibrinogen levels as a baseline. A biochemical profile and blood gas analysis are also useful, especially to measure the level of acidosis and base deficit. Because of the often rapid changes occurring, it is essential throughout the episode to keep close liaison with hematologists and the blood transfusion laboratory.

Observations, monitoring and readings must be kept continuously, preferably by a team member or midwife solely dedicated to this activity. The most useful parameter of all is the trend recorded on the basic TPR observation chart, with particular attention to pulse rate, blood pressure and urine output, because these will provide the overall picture at a glance.

In severe cases, a central line, preferably multi-lumen, inserted in the neck, subclavian or femoral zones is invaluable, not only for monitoring of central venous pressure as a guide to hypovolemia and as an assist in determining infusion requirements, but also as a good venous access for rapid infusion especially when peripheral veins are not available or collapse. In most instances, this is not a first priority, especially considering that routine labor ward personnel may not have the skill to perform this safely.

Insertion of an arterial line is useful to monitor blood gases, acidosis, and base deficit, and also to serve as a direct dynamic blood pressure monitor in the intensive care situation. This too is not, however, a priority in the immediate management, although it will be useful later, especially in severe cases. Not all patients require blood and, in deciding which fluid to use, the hazards and risks of blood transfusion warrant an initial attempt to correct hypovolemia using crystalloid or colloid solutions.

Having said this, many patients will require rapid infusion. Proper equipment must be readily available and include a rapid infuser pump and/or pressure infusion bags, and preferably an individual team member dedicated to this activity. It is also important for all fluids to be warmed since the rapid infusion of cold fluids will create hypothermia and increase the chances of disseminated intravascular coagulation and clotting failure.

THE RECOGNITION OF HYPOVOLEMIA

The loss of circulating blood volume results in the signs of tachycardia, hypotension and oliguria. The most dangerous feature of postpartum hemorrhage is that there may be little apparent fall in blood pressure until a very late stage. This is because most patients are often young and previously fit and their cardiovascular system will compensate until a very late stage when it suddenly crashes and decompensates.

Table 1 shows a useful staging of schemes to assess the degree of obstetric hemorrhage.

In cases of severe shock, blood transfusion will normally be required if 30–40% of blood volume is lost, whilst, if over 40% blood volume is lost, the situation is immediately life-threatening[4].

TRANSFUSION CONSIDERATIONS

Blood transfusions are not without risk and it is essential that they are restricted to those in real need. Because of the known risks, which include incompatibility reactions, and infectious disease transmission, an initial attempt to correct hypovolemia should be made by using crystalloid solutions (e.g. normal saline, Ringers lactate) or colloids (gelatins, starches).

No absolute parameters can help one to decide when to start transfusing blood but clinical commonsense indicates that blood should be strongly considered after 2 liters of crystalloid and 1 liter colloid have been given if the cardiovascular system remains unstable with continued bleeding.

Blood will invariably be required if > 40% blood volume is lost, which correlates in a 70 kg adult to approximately 2.5 liters measured blood loss.

More precise arbiters are the measurement of hemoglobin and hematocrit decrease, results of which can be available almost immediately using rapid I-stat analyzers. The long-standing practice tradition that suggested that ideally the hemoglobin should be maintained at a level of 10 g/dl has changed, with rising awareness of infection risks from donated blood products, and this has led to a re-evaluation of requirements[5–7]. Recent work shows that healthy patients can tolerate a hemoglobin concentration as low as 7 g/dl[8]. Oxygen delivery will still be maintained as long as the patient is normovolemic. More recently, the American Society of Anesthesiologists Taskforce on Blood

Table 1 Staging scheme for assessment of obstetric hemorrhage

Severity of shock	*Findings*	*% blood loss*
None	None	< 15–20%
Mild	Tachycardia (< 100 bpm) Mild hypotension Peripheral vasoconstriction	20–25%
Moderate	Tachycardia (100–120 bpm) Hypotension (systolic blood pressure 80–100 mmHg) Restlessness Oliguria	25–35%
Severe	Tachycardia (> 120 bpm) Hypotension (systolic blood pressure < 60 mmHg) Altered consciousness Anuria	> 35%

From Gonik B. Intensive care monitoring of the critically ill patient. In Creasy RK, Resnik R, eds. *Maternal-Fetal Medicine*, 3rd edn. Philadelphia: WB Saunders, 1994:865–90

Component Therapy concluded that transfusion is rarely indicated when the hemoglobin level is > 10 g/dl, but almost always indicated when it is < 6 g/dl[9]. It therefore seems reasonable to conclude that transfusion should be commenced in most obstetric patients after a postpartum hemorrhage if the hemoglobin level falls below 7 g/dl[10], but that may be difficult to assess in real time under emergency situations.

In these circumstances, it is useful to have an agreed Action Plan posted in the labor and delivery ward, as published guidelines on transfusion practice are not easily referred to in the emergency situation[11–13]. As an example, Table 2 is an example of current practice which is in use at the author's hospital (taken from a national guideline[14] with local modifications[15]).

ADDITIONAL CONSIDERATIONS FOR BLOOD PRODUCTS

Additional discussion is provided in Chapter 25.

Red cells

If blood is required instantly, it may be necessary to use the emergency supply of Group O Rh(D)-negative uncross-matched stock, but preferable to wait 5–10 min for type-specific blood, or in appropriate cases for 20–30 min for fully cross-matched blood. In general, one unit of red cells increases the hemoglobin by approximately 1.5 g/dl and the hematocrit by 5% in a 70 kg woman. In the dynamic bleeding situation, however, it is appropriate to calculate transfusion requirements so as to restore the hemoglobin to approximately 10 g/dl, albeit using blood conservatively.

Platelets

Platelets should be transfused only to prevent or correct bleeding associated with a decrease in platelet count or abnormality of platelet function as they are difficult to store and in short supply[16].

Fresh frozen plasma

Fresh frozen plasma (FFP) maintains the viability of all clotting factors. The only clear indication for FFP is the replacement of coagulation factors in clotting disorders[17]. FFP should be given if the PT and APTT exceed 1.5 times the control level in the presence of continuous bleeding. In situations with massive bleeding, however, it may be necessary to give FFP even before clotting results are available. The dose required is 12–15 ml/kg or normally 4 units for

Table 2 Acute massive blood loss: a template guideline

Immediate actions	*Key points*	*Other considerations*
• Arrest bleeding	• Early surgical or obstetric intervention • Upper G/I tract procedures • Interventional radiology	
• Contact key personnel	• Most appropriate surgical team • Duty anesthetist • Blood bank	
• Restore circulating volume N.B. In patients with major vessel or cardiac injury, it may be appropriate to restrict volume replacement after discussion with surgical team	• Insert wide-bore peripheral cannulae • Give adequate volumes of crystalloid/blood • Aim to maintain normal blood pressure and urine output > 30 ml/h in adults (or 0.5 ml/kg/h)	• Blood loss is often underestimated • Refer to local guidelines for the resuscitation of trauma patients and for red cell transfusion • Monitor CVP if hemodynamically unstable
• Request laboratory investigations	• FBC, PT, APTT, fibrinogen; blood bank sample, biochemical profile, blood gases • Repeat FBC, PT, APTT, fibrinogen every 4 h, or after one-third blood volume replacement, or after infusion of FFP	• Take samples at earliest opportunity as results may be affected by colloid infusion • Misidentification is most common transfusion risk • May need to give FFP & platelets before the FBC and coagulation results available
• Request suitable red cells N.B. All red cells are now leukocyte-depleted. The volume is provided on each pack, and is in the range of 190–360 ml	• *Blood needed immediately* – use 'Emergency stock' group O Rh (D)-negative • *Blood needed in 5–10 min* – type-specific will be made available to maintain O Rh (D)-negative stocks • *Blood needed in 30 min or longer* – fully cross-matched blood will be provided	• Contact blood transfusion laboratory or oncall BMS and provide relevant details • Collect sample for group and cross-match before using emergency stock • Blood warmer indicated if large volumes are transfused rapidly
• Consider the use of platelets	• Anticipate platelet count $< 50 \times 10^9$/l after > 2 liters blood loss with continued bleeding • Dose: 10 ml/kg body weight for a neonate or small child, otherwise one 'adult therapeutic dose' (one pack)	• Target platelet count:- $> 100 \times 10^9$/l for multiple/CNS trauma $> 50 \times 10^9$/l for other situations • Consider early use of platelets if clinical situation indicates continued excessive blood loss despite the count
• Consider the use of FFP	• Anticipate coagulation factor deficiency after > 2 liters blood loss with continued bleeding • Aim for PT & APTT $< 1.5 \times$ mean control • Allow for 20-min thawing time • Dose: 12–15 ml/kg body wt = 1 liter or 4 units for an adult	• PT/APTT $> 1.5 \times$ mean control correlates with increased surgical bleeding • May need to use FFP before laboratory results available: take sample for PT, APTT, fibrinogen before FFP transfused

continued

Table 2 *Continued*

Immediate actions	*Key points*	*Other considerations*
• Consider the use of cryoprecipitate	• To replace fibrinogen & FVIII • Aim for fibrinogen > 1.0 g/l • Allow for 20-min thawing time • Dose: 10 packs or 1 pack/10 kg in children	• Fibrinogen < 0.5 strongly associated with microvascular bleeding
• Suspect DIC	• Treat underlying cause if possible	• Shock, hypothermia, acidosis, risk of DIC • Mortality if DIC is high

For abbreviations, see text

an adult, and the objective should be to aim for a PT and APTT less than 1.5 control level. FFP requires a thawing time of 20 min, and hence early anticipation of a potential requirement is helpful.

Cryoprecipitate

It is appropriate to administer cryoprecipitate which contains fibrinogen and factor VIII when there is evidence of a consumptive coagulopathy with a fibrinogen level less than 0.5 g/l. The normal dose is 10 units. As with FFP, cryoprecipitate needs thawing time. The aim is to restore the fibrinogen level to > 1.0 g/l.

Coagulopathy

Coagulopathy can develop rapidly in an obstetric patient. Confirmatory laboratory tests are required for precise diagnosis, but in the clinical setting of postpartum hemorrhage the presence of microvascular bleeding is a good clinical indicator[18,19]. Absence of clotting with continued bleeding strongly suggest a coagulopathy. Hemostasis is normally adequate when clotting factors are greater than 30% of normal[18–21]. If bleeding continues in the presence of clotting factors > 30% normal and a PT and APTT less than 1.5 times control level, it is unlikely that low coagulation levels are responsible[18,19].

Disseminated intravascular coagulopathy

Disseminated intravascular coagulopathy (DIC) represents the most deadly form of coagulopathy wherein a vicious cycle consumes clotting factors and platelets rapidly. DIC can develop dramatically in obstetric patients, especially in association with placental abruption and amniotic fluid embolism. It also occurs suddenly after massive bleeding with shock, acidosis and hypothermia. This latter risk emphasizes the importance of warming all infused fluids whenever possible. DIC carries a high mortality and, once established, can be difficult to reverse. Patients with prolonged hypovolemia are particularly at risk. The diagnosis can be made by frequent estimation of platelets, fibrinogen, PT and APTT. Treatment consists of administering platelets, FFP and cryoprecipitate sooner rather than later.

Complications of blood transfusion

Increasing awareness of the risks of transfusion has led to diminished use of blood and blood products in recent years. Complications can occur because of incompatibility, storage problems, and transmission of infection.

The most common cause of a transfusion-related death is incompatibility leading to a hemolytic reaction[22]. Most of such deaths are due to misidentification and are entirely preventable, emphasizing the importance of safe systems for cross-checking all blood products.

Storage problems include hyperkalemia, as potassium levels rise in stored blood which, if given rapidly and repeatedly, can give rise to hyperkalemia, especially in an acidotic, hypothermic patient. Similarly, hypothermia can increase if large volumes of cold stored blood are given rapidly without a blood warmer.

The transmission of infection is arguably the most feared complication especially in terms of HIV, hepatitis B and C and cytomegalovirus (CMV). Estimated HIV transmission risks vary widely from 1 in 200 000 to 1 in 2 000 000 transfusions[23]. But the most common transmission is of viral hepatitis, although this is decreasing with improved screening. Currently, the incidence is 1 per 103 000 units of blood transfused[23]. CMV is carried in asymptomatic donors in the neutrophil. CMV infection can be prevented by using CMV-negative blood or by eliminating neutrophils from donor blood[24].

Alternatives to transfusion

Three alternative methods of autologous transfusion are presently available: preoperative donation antepartum, perioperative cell salvage, and hemodilution. Rarely, if ever, are these feasible in the unexpected massive postpartum hemorrhage, but they nevertheless merit consideration especially when treating patients who are adherent to the Jehovan Witness belief.

Antepartum donation may be considered for high-risk patients and for those with rare blood types, but it is recommended that, before donation, the hemoglobin should not be less than 11 g/l and the hematocrit 33%[25–27]. However, many obstetric patients may not be able to donate more than one unit of blood, whereas most patients requiring blood after postpartum hemorrhage require considerably more than one unit and thus would need homologous blood. Furthermore, such patients are difficult to predict. Accordingly, preoperative donation may not be beneficial or even cost-effective taking into account the low frequency of blood transfusion even in high-risk patients and the difficulty of predicting these in advance[27].

Perioperative blood salvage is a technique of scavenging blood lost during an operation, washing it and then transfusing the scavenged red cells[28]. Of concern is that washing may not adequately remove amniotic fluid and fetal debris which, when re-transfused, may precipitate the anaphylactoid amniotic fluid embolism response. Blood salvage may nevertheless be appropriate in cases of massive obstetric hemorrhage when blood bank resources are limited. Where the technique is available, it should also be considered for Jehovah Witness patients (see Chapter 15 for full discussion of perioperative salvage).

In the technique of hemodilution, 500–1000 ml blood may be collected and reinfused later; however, overall experience in massive postpartum hemorrhage is limited[29,30].

ANESTHETIC CONSIDERATIONS

Postpartum hemorrhage is the most frequent reason for emergency surgery and anesthesia in the postpartum period. The principal causes include uterine atony, trauma, retained placenta and uterine inversion, all of which are discussed in detail in other parts of this book. A large proportion of these will require anesthesia as part of the therapy to arrest the hemorrhage.

The choice of anesthetic will be dictated by circumstances, the degree of blood loss and the urgency of the situation. A general anaesthetic is preferable in most instances of significant postpartum hemorrhage with hypovolemia. The problem in using a regional block is that unrecognized hypovolemia in combination tends to aggravate hypotension and increase maternal morbidity and mortality. However, if a patient is already receiving a regional block (spinal or epidural), bleeding is controlled and the cardiovascular system stable, it may be appropriate to continue with a regional technique. If instability occurs in such circumstances, early conversion to a general anesthetic is indicated.

Crucial items for the safe conduct of an anaesthetic include the involvement of experienced senior/consultant anesthetists and additional helpers, pre-sited two wide-bore cannulae, knowledge of hemoglobin/hematocrit levels, rapid infusion devices and fluid warmers, immediate availability of crystalloid and colloid infusions and, as soon as possible, blood and blood products especially FFP, and, finally, available equipment for central venous access and direct arterial line monitoring.

A suitable general anesthetic technique includes pre-oxygenation and rapid sequence induction with cricoid pressure using either thiopentone in reduced dose (e.g. 4 mg/kg) or ketamine (1 mg/kg) or etomidate (0.2 mg/kg), followed by intubation after suxamethonium. Maintenance agents will include further muscle relaxants (e.g. rocuronium 0.6 mg/kg) with nitrous oxide, oxygen and either a very low concentration of volatile anesthetic (e.g. isoflorane) to combat awareness, or possibly opiates such as fentanyl, alfentanil or remifentanil.

In some circumstances, e.g. uterine inversion where intensive relaxation is required, an additional volatile agent may be helpful. Equipotent doses of all volatile halogenated agents produce similar degrees of uterine relaxation[31,32]. Other alternatives include use of nitroglycerine given intravenously[33,34].

CARDIOPULMONARY RESUSCITATION

The prognosis is poor in the event of cardiac arrest in a patient with severe hypovolemia after a postpartum hemorrhage because of hypoxemia and rapidly accelerating acidosis. Nevertheless, most patients are young and previously fit, as no attempts should be spared to resuscitate.

Cardiac arrest will present with sudden loss of consciousness, absent major pulses and absent respiration. Response needs to be immediate to have any chance of success and should follow the agreed Cardiac Arrest Procedure along conventional lines in three phases, e.g. UK Resuscitation Guidelines as in Figures 1 and 2.

(1) Basic life support – the ABC system. This includes Airway control, Breathing support and Circulatory support.

(2) Advanced life support. This includes intubation and ventilation, continued circulatory support often with epinephrine (adrenaline), defibrillation and ECG monitoring, drugs and fluids, and management of complex arrhythmias.

(3) Prolonged life support, including all intensive care systems.

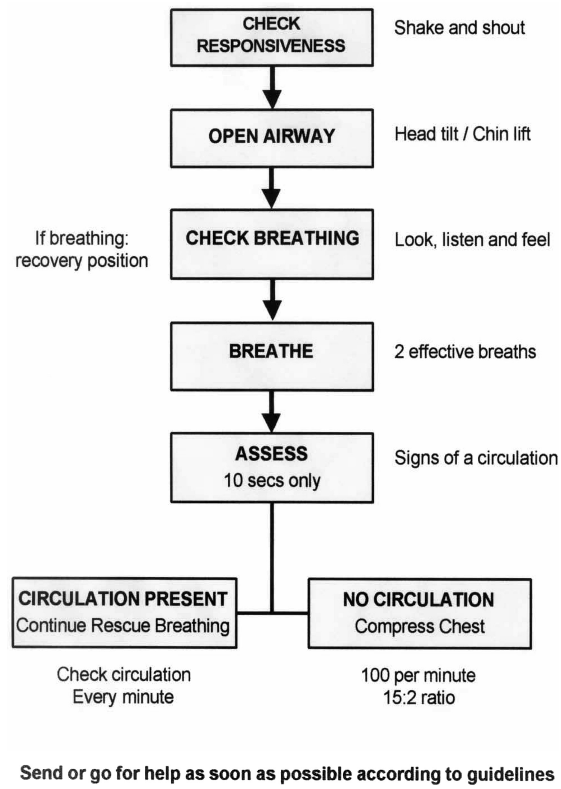

Figure 1 Adult basic life support (Resuscitation Council, UK)

Three items are of crucial importance:

(1) External cardiac massage must be commenced without delay if there are no palpable major pulses;

(2) Adrenaline 1 mg given every 3 min will frequently be required;

(3) Given that the root cause of the arrest is hypovolemia, vigorous attempts to restore a circulatory blood volume must be continued throughout the cardiopulmonary resuscitation process if there is to be any chance of success.

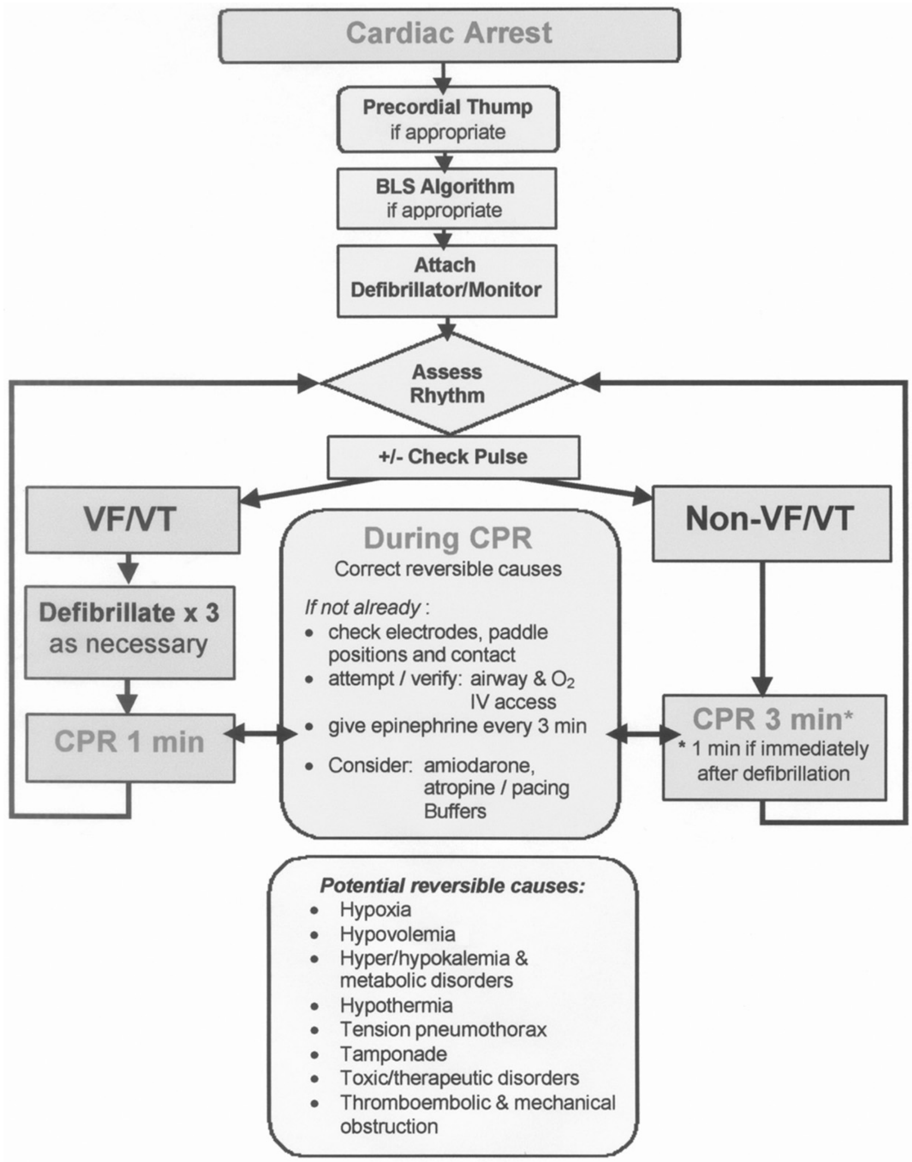

Figure 2 Advanced life support algorithm for the management of cardiac arrest in adults (Resuscitation Council UK). BLS, basic life support; VF, ventricular fibrillation; VT, ventricular tachycardia; CPR, cardiopulmonary resuscitation; ETT, endotracheal tube

References

1. Rochat RW, Koonin LM, Atrash HK, *et al.* Maternal mortality in the United States: report from the maternal mortality collaborative. *Obstet Gynecol* 1988;72:91
2. Li XF, Fortney JA, Kotelchuck M, Glover LH. The postpartum period: the key to maternal mortality. *Int J Gynaecol Obstet* 1996;54:1–10
3. Why Mothers Die 2000–2002. Confidential Enquiries into Maternal Deaths in the United Kingdom. London: Department of Health, HMSO, 2004
4. American College of Surgeons. *Advanced Trauma Life Support Course Manual.* Chicago: American College of Surgeons, 1997:103–12
5. Combs CA, Murphy EL, Laros RK. Cost-benefit analysis of autologous blood donation in obstetrics. *Obstet Gynecol* 1992;80:621–5
6. Camann WR, Datta S. Red cell use during cesarean delivery. *Transfusion* 1991;31:12–15

7. Consensus Conference. The impact of routine HLTV-III antibody testing of blood and plasma donors on public health. *JAMA* 1986;256: 1178–80
8. Consensus Conference. Perioperative red blood cell transfusion. *JAMA* 1988;260:2700–3
9. American Society of Anaesthesiologists Task Force. Practice Guidelines for Blood Component Therapy. *Anesthesiology* 1996;84: 732–47
10. Chestnut DH, ed. Antepartum and postpartum hemorrhage. In *Obstetric Anesthesia: Principles and Practice*. Amsterdam: Elsevier Mosby, 2004: 676–7
11. British Committee for Standards in Haematology. Guidelines for transfusion for massive blood loss. *Clin Lab Haematol* 1988;10:265–73
12. British Committee for Standards in Haematology. Guidelines for the use of fresh frozen plasma. *Transfus Med* 1992;2:57–63
13. British Committee for Standards in Haematology. Guidelines for platelet transfusions. *Transfus Med* 1992;2:311–18
14. Stainsby D, MacLennan S, Hamilton PJ. Management of massive blood loss: a template guideline. *Br J Anaesth* 2000;85:487–91
15. Milton Keynes General NHS Trust. *Acute massive blood loss – a template guideline*. 2002:1–10
16. Consensus Conference. Platelet transfusion therapy. *JAMA* 1987;257:1777–80
17. Transfusion alert: Indications for the use of red blood cells, platelets, and fresh frozen plasma. US Department of Health and Human Services, Public Health Service, National Institutes of Health, 1989
18. Ciaverella D, Reed RL, Counts RB, *et al*. Clotting factor levels and the risk of diffuse microvascular bleeding in the massively transfused patient. *Br J Haematol* 1987;67:365–8
19. Murray DJ, Olson J, Strauss R, *et al*. Coagulation changes during packed red cell replacement of major blood loss. *Anesthesiology* 1988;69:839–45
20. Consensus Conference. Fresh-frozen plasma: indications and risks. *JAMA* 1985;253;551–3
21. Aggeler PM. Physiological basis for transfusion therapy in hemorrhagic disorders: a critical review. *Transfusion* 1961;1:71–85
22. Honig CL, Bove JR. Transfusion associated fatalities: Review of Bureau of Biologics report. *Transfusion* 1980;20:653–6
23. Goodnough LT, Brecher ME, Kanter MH, AuBuchon JP. Transfusion medicine. 1. Blood transfusion. *N Engl J Med* 1999;350:438–47
24. Pamphilon DH, Rider JH, Barbara JA, Williamson LM. Prevention of transfusion-transmitted cytomegalovirus infection. *Transfus Med* 1999;9: 115–23
25. Droste S, Sorensen T, Price T, *et al*. Maternal and fetal hemodynamic effects of autologous blood donation during pregnancy. *Am J Obstet Gynecol* 1992;167:89–93
26. Kruskall MS, Leonard S, Klapholz H. Autologous blood donation during pregnancy: analysis of safety and blood use. *Obstet Gynecol* 1987;70:938–40
27. Andres RL, Piacquadio KM, Resnick R. A reappraisal of the need for autologous blood donation in the obstetric patient. *Am J Obstet Gynecol* 1990;163:1551–3
28. Williamson KR, Taswell HF. Intraoperative blood salvage. A review. *Transfusion* 1991;31: 662–75
29. Estella NM, Berry DL, Baker BW, *et al*. Normovolemic hemodilution before cesarean hysterectomy for placenta percreta. *Obstet Gynecol* 1997;90:669–70
30. Grange CS, Douglas MJ, Adams TJ, Wadsworth LD. The use of acute hemodilution in parturients undergoing cesarean section. *Am J Obstet Gynecol* 1998;178:156–60
31. Munson ES, Embro WJ. Enflurane, isoflurane, and halothane and isolated human uterine muscle. *Anesthesiology* 1977;46:11–14
32. Turner RJ, Lambros M, Keyway L, Gatt SP. The in-vitro effects of sevoflurane and desflurane on the contractility of pregnant human uterine muscle. *Int J Obstet Anesth* 2002;11:246–51
33. Altabef KM, Spencer JT, Zinberg S. Intravenous nitroglycerin for uterine relaxation of an inverted uterus. *Am J Obstet Gynecol* 1992;166:1237–8
34. Bayhi DA, Sherwood CDA, Campbell CE. Intravenous nitroglycerin for uterine inversion. *J Clin Anesth* 1992;4:487–8