CEMACH 2003–5 Saving Mothers’ Lives: lessons for anaesthetists

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Key points
Systolic hypertension ≥160 mm Hg should be urgently and effectively treated.
Placenta percreta is an increasing cause of major obstetric haemorrhage. Women who have had a previous Caesarean section must have placental localization.
Widespread adoption of modified early obstetric warning scoring charts may help earlier recognition of critical illness.
Regular training is required in management of maternal collapse.
Obese parturients require expert management and monitoring—fatal airway complications can occur even with regional techniques.

The Confidential Enquiry into Maternal and Child Health (CEMACH) reviews every death in the UK occurring during pregnancy and up to 42 days post-partum. Originally titled Confidential Enquiries into Maternal Deaths (CEMD), this series of Reports is the longest running audit in the world. It covers every triennium since 1952, with sequential Reports having established the leading causes of maternal mortality and recommended change where appropriate. Up to 1985, only deaths in England and Wales were considered; thereafter, the whole UK was included.

The maternal mortality rate (MMR) is defined as the number of maternal deaths per 100,000 maternities. This has markedly reduced over the last 50 yr. In 1952–4, there were 1094 maternal deaths (MMR 53.29), whereas the latest Report 2003–5 records 295 deaths (MMR 13.95) of which 132 were direct and 163 were indirect. However, most of this dramatic improvement in MMR occurred early and was mainly attributable to advances in public health and medicine (Fig. 1).

Unfortunately, if we compare total deaths (223) and MMR (9.83) for the 1985–7 Report with those in the current Report 2003–5, we see that over the last 20 yr, there has been an increase in both total deaths and MMR.

Suggested explanations for the failure of MMR to decline since the last (2000–2) CEMACH Report include increasing maternal age at delivery, obesity, poor overall health status, difficulty in accessing maternity care, and the increase in immigrant mothers. One in four mothers now delivering in the UK has been born outside the UK. Whether these factors can explain the increase in MMR since 1985 is not known. In addition, the Scottish morbidity data indicate that for every maternal death, there are 60 ‘near-misses’ (rate of severe morbidity 5.3/1000 maternities).

CEMACH historically divides maternal deaths into direct deaths from conditions directly related to pregnancy and indirect deaths from conditions unrelated to pregnancy but exacerbated by it. Deaths occurring during pregnancy or within 6 weeks of birth, which were not due to or affected by pregnancy are called coincidental deaths. Deaths from any cause that occurred between 6 weeks and 1 yr after delivery are termed late deaths. Most late deaths are unrelated to pregnancy and therefore termed late coincidental deaths. This complex structure sometimes obscures causality. A ‘late’ death beyond the arbitrary 42-day post-natal period is often not counted in the quoted figures, even though the death is clearly attributable to the initial event after the patient has survived for a protracted period on the intensive therapy unit (ITU). Figure 2 therefore shows the less familiar—but more informative—leading causes of maternal deaths as direct/indirect plus relevant late deaths, with the proportion receiving major substandard care (defined as treatment—or lack of—which contributed significantly to the death of the mother, and where different treatment may have altered the outcome).

Anaesthesia as a continuing cause of maternal death

Anaesthesia was the seventh most common direct cause of maternal death in this Report and the ninth most common overall (Fig. 2). One hundred and fifty of the 295 patients who died received an anaesthetic and six of these deaths were directly caused by fatally substandard care in the management of the anaesthetic (MMR 0.28). In a further 31 cases, the anaesthetic care was considered to be poor. The Report highlights problems of obesity,
inappropriate postoperative respiratory monitoring, and drug administration errors.

The six anaesthetic deaths included four obese patients, one drug error (i.v. bupivacaine), and one haemothorax secondary to central venous pressure (CVP) line insertion. There were no deaths caused by unrecognized oesophageal intubation.

The causes of death in the above patients were:

(i) Failure of reintubation for severe bronchospasm post-extubation after laparoscopic surgery for ectopic pregnancy in an asthmatic patient.
(ii) Cardiac arrest secondary to ventilatory depression after a large dose of fentanyl before extubation. There was a delay in the arrival of the anaesthetist who had left the patient with the recovery staff after extubation.
(iii) Postoperative respiratory failure secondary to severe bronchospasm in a patient who underwent a Caesarean section (CS) using spinal anaesthesia. The patient was later returned to the ward with inadequate monitoring and treatment.

These three patients died from fatal airway complications related to their obesity and inadequate postoperative monitoring. It is important to note that this can occur even when regional anaesthesia is used. The incidence of failed tracheal intubation in the obstetric population is much greater than in the general population (one in 280 compared with one in 2230). This incidence increases dramatically in the morbidly obese parturient and figures as high as 33% have been quoted in the literature. Tracheal extubation is also an important skill to acquire and is currently part of the initial test of competence in the CCT syllabus.

(iv) Cardiac arrest in a septic patient who underwent a general anaesthetic a few weeks post-partum for removal of a septic focus from the kidney. The cause of death was unknown and one possibility was arrhythmia secondary to electrolyte disturbances.

(v) The maternal death due to drug error was caused by 150 ml of 0.1% bupivacaine being accidentally administered via an i.v. line instead of the epidural catheter, resulting in a ventricular fibrillation arrest from which the patient could not be resuscitated. The NPSA has published guidelines in order to reduce the risk of such errors. Treatment with intralipid is now recommended for the treatment of local anaesthetic toxicity; it should be immediately available in all obstetric units. An initial i.v. bolus of intralipid 20% of 1.5 ml kg\(^{-1}\) (100 ml bolus for a 70 kg patient) can be repeated twice every 5 min, followed by an i.v. infusion of 0.25–0.5 ml kg\(^{-1}\) min\(^{-1}\) (400 ml over 10–20 min).

(vi) The sixth anaesthetic death was caused by a haemothorax secondary to repeated attempts at CVP line insertion in a patient with pectus excavatum and fulminant pre-eclampsia. This is the third death from a CVP line complication since the introduction of CEMACH. The current Report encourages CVP monitoring when there is clear benefit, and CVP insertion should take due account of the potential risks. It is safer to avoid central line insertion in patients with a higher risk of complications, for example, abnormal anatomy, obesity, and coagulopathy. Where technical difficulty is not anticipated and CVP monitoring is thought to be justified, the risk of complications may be reduced by the use of ultrasound guidance.

The top 10 recommendations: lessons for anaesthetists

For the first time, the current Report identifies 10 priority recommendations for improving care and encourages their introduction and implementation with audit (Table 1). Several of these recommendations are public health and educational issues (recommendations 1–4) and are not within the control of
160 mm Hg should be treated. This represents a new and important guideline, as previous recommendations have focused on mean AP of 125 mm Hg as the threshold for treatment. This change will need to be rapidly incorporated into local protocols and should be clearly identified as an action threshold on a modified early obstetric warning scoring chart (MEOWS, see below). Treatment should be instituted at lower levels of SAP if there are signs of rapid deterioration. Treatment of hypertension in pre-eclampsia includes oral treatment with labetalol or nifedipine in divided doses. If this fails to achieve an AP <160 mm Hg systolic, then a slow i.v. bolus followed by a labetalol infusion. If β-block is ineffective or contraindicated, then hydralazine can be utilized for maintenance. The advice to obtund the pressor response to intubation and extubation is re-iterated, with a welcome statement that anaesthetists should ‘be allowed’ time to achieve this, even in the face of a grade 1 CS. If the patient has laboured with an epidural, this can be topped up if time allows, otherwise spinal anaesthesia remains the technique of choice in pre-eclampsia (unless the patient has abnormal coagulation, e.g. platelet count <80–100 x 10^9 depending on locally agreed protocols), and general anaesthesia should only be used if regional block is contraindicated. The risk of producing a spinal haemorrhage in a coagulopathic patient must be balanced against the risk of intracerebral haemorrhage secondary to pressor response to laryngoscopy.

Care should be taken with the use of oxytocics in pre-eclampsia. Syntocinon should be diluted and given by slow i.v. bolus injection. Both ergometrine and syntometrine are contraindicated in hypertensive patients. However, the clinical balance between preventing bleeding from an atonic uterus and exacerbating hypertension with uterotonics can be a difficult decision and should be made by a senior anaesthetist (see 6b below).

**CEMACH recommendation 6a: ‘indications for CS should be appropriate’**

The Report states: ‘Whilst recognising that for some mothers and/ or their babies, CS may be the safest mode of delivery, mothers must be advised that caesarean section is not a risk-free procedure and can cause problems in current and future pregnancies’. Patients should have the opportunity to discuss labour analgesia with an anaesthetist antenataly, either in classes or an anaesthetic clinic, so that fear of pain in labour does not inappropriately influence the patient’s decision for Caesarean.

**CEMACH recommendation 6b: ‘any patient with a previous CS should have placental localization’**

In the management of haemorrhage, the Report states that ‘In particular, there were questions concerning the most appropriate management of women with placenta percreta, a problem likely to become more prevalent due to its emerging relationship with previous caesarean section scars. There were also apparent failures in recognising the signs and symptoms of intra-abdominal bleeding especially after caesarean section. Lastly, ergometrine often seems to have been forgotten as a useful oxytocic drug’.

**Haemorrhage**

Seventeen women died from haemorrhage including genital tract trauma (MMR 0.8), compared with 16 in the 1985–7 Report (MMR 0.7). There has been no improvement in the past 20 yr. Ten of those who died in this triennium received substandard care (59%), mainly...
due to failure to identify and manage intra-abdominal bleeding, uterine atony, and placenta percreta. In contrast, the Scottish morbidly data show that major haemorrhage accounted for 69% of the total cases of serious morbidity, with a rate of major obstetric haemorrhage of 3.66 per 1000 maternities. Major suboptimal care was identified in only 3%, and most of the cases were well managed on the ward or high dependency unit (HDU). The critical care chapter emphasizes that recognition of critical physiological compromise such as that caused by major intra-abdominal bleeding can be assisted by the use of early warning charts (see below), and that resuscitation skills can be improved by training on appropriate courses [Management of Obstetric Emergencies and Trauma (MOET) and Advanced Life Support in Obstetrics (ALSO), see below] and the use of simulation scenarios. The importance of preventing dilutional coagulopathy in massive transfusion is highlighted, with a suggestion that there may be a role for ‘whole blood’, or for the use of 1 U of fresh frozen plasma for each pack of red cells transfused. Bedside estimation of haemoglobin (Hb) concentration using the Haemocue device is valuable, and there may be a role for near-patient coagulation testing.

Anterior placenta praevia with a previous CS scar requires multidisciplinary consultant care, and the placental site must be determined with ultrasound or magnetic resonance imaging well in advance of planned delivery. Atonic uterus is common and can often be anticipated. Syntocinon 5 U (repeated if indicated) and ergometrine 500 μg given slowly i.v. should be the first choices to prevent and treat atony of the uterus. Additionally, a syntocinon infusion should be started immediately after delivery of the baby, with 40 U of syntocinon in 500 ml of saline to run i.v. over 4 h. Both CEMACH and the UK Obstetric Surveillance System emphasize that both ergometrine and syntocinon are being withheld inappropriately in obstetric haemorrhage. Since a previous CEMACH Report where a rapid i.v. 10 U bolus of syntocinon was associated with the death of a hypotensive patient, this drug is now given by slow i.v. 5 U bolus. Any decision to withhold uterotonic in obstetric haemorrhage due to uterine atony (e.g. if the patient is also pre-eclamptic/hypertensive) must therefore be very carefully considered and made at senior level. Second-line drugs to control haemorrhage unresponsive to oxytocin and ergometrine include synthetic prostaglandin analogues carboprost (15-methyl PGF2alpha) 250 μg i.m. repeated every 15 min to a maximum dose of 2 mg, and misoprostol (PGE1) 600–1000 μg p.r. Patients who refuse blood transfusion, such as Jehovah’s Witnesses, should be actively treated with haematinics to optimize their Hb and should be offered cell salvage where appropriate.

**CEMACH recommendation 8: ‘ensuring regular training (obstetric skills and drills)’**

The management of many of the patients who died was considered suboptimal due to poor communication skills, poor resuscitation skills, and care being provided by unsupervised and inexperienced trainees. The latter factor may be exacerbated by the introduction of shorter training programmes. Lack of experience can be mitigated by attendance at resuscitation courses such as ALSO and MOET. The Report states that all staff involved in the care of acute obstetric admissions should have current ALS or ILS certification. Regular ‘skills and drills’ practice sessions on the use of major haemorrhage protocols and simulation-based teamwork training are also useful. Simulation can provide practical training for rare conditions that are rarely encountered clinically and it has been shown to improve knowledge and clinical team performance. For example, in amniotic fluid embolism (AFE; incidence 1.8/100 000 maternities), survival largely depends on adequate and effective resuscitation. In this triennium, there were 19 (17 direct and two late) deaths (MMR 0.89), with seven patients receiving substandard care, mainly relating to inadequate resuscitation efforts from first responders.

The management of maternal cardiac arrest includes perimortem CS. This should be started within 4 min of the diagnosis of cardiac arrest and completed within 5 min using minimal equipment and the most appropriate technique. The number of perimortem CSs has almost doubled compared with the last Report. There has been previous misunderstanding about the role of perimortem CS—emptying the uterus relieves aorta-caval compression and increases venous return and thereby helps to restore cardiac output. It makes ventilation easier and permits cardiopulmonary resuscitation (CPR) in the supine position. It is part of the maternal resuscitation algorithm and is not performed to save the baby, the survival of which is a welcome bonus. In this Report, there were 52 perimortem CS and 20 babies survived. These findings indicate that with improved resuscitation techniques, more babies are surviving perimortem CSs, particularly where the women collapsed in an already well-staffed and equipped delivery room or operating theatre. However, they also highlight the very poor outcome for babies delivered in Emergency Departments, especially for women who arrive after having undergone CPR for a considerable length of time. The babies who survived were born to mothers who were near or at term, and who suffered a cardiac arrest while already undergoing active treatment in the Emergency Department.

Trainees must know their limitations and should not hesitate to call for help, which should be readily available. The management of patients should be multidisciplinary and teamwork should be encouraged.

**Recommendation 9: ‘Implementation of an early warning scoring system specific for obstetrics (MEOWS)’**

The Report states: ‘In many cases, the early warning signs of impending maternal collapse went unrecognised’. The Report strongly recommends the introduction of an MEOWS system to aid the early detection of life-threatening illness such as haemorrhage, pre-eclampsia/eclampsia, AFE, and sepsis. In pregnancy, the increase in physiological reserve may mask the signs of critical
illness, resulting in a delay in diagnosis and appropriate management.

The obstetric modifications to the usual early warning chart parameters (ventilatory frequency, temperature, heart rate, SAP, mental response, urine output, and oxygen saturation) add specific obstetric indicators such as proteinuria, diastolic AP, and amniotic fluid or lochia consistency. Figure 3 shows an example used by Stirling Royal Infirmary, which was published in the current Report and can be adopted by Trusts. Such a chart should be introduced in all areas dealing with pregnant patients. It should be noted that while a carefully completed MEOWS chart can indicate deterioration requiring action, a robust mechanism to ensure that the appropriate and prompt action actually occurs is also required to alter the outcome. The rate of obstetric admission to ITU is less than 1 per 1000 obstetric admission, but fortunately, these patients have a high survival rate (96%).1

**CEMACH recommendation 10: ‘urgent guidelines are required for obesity, sepsis, and pain/bleeding in early pregnancy’**

**Obesity**

Obesity in pregnancy is defined as BMI ≥30 at booking,1 with more than 50% of women who died in this Report being either overweight or obese (see anaesthetic deaths above). Obesity in pregnancy carries major risks such as pre-eclampsia, thromboembolism, post-partum haemorrhage, gestational diabetes, cardiac disease, recurrent miscarriage, wound infection, congenital abnormality, prematurity, and stillbirth. Mothers with BMI ≥35 should have consultant led care, and all morbidly obese patients (BMI >40) should be seen in a pre-assessment clinic.

The CEMACH Report specifically recommends that ‘morbidly obese women should not be anaesthetised by trainees without direct supervision’ and that ‘management by consultant anaesthetists is essential and difficulties with airway management and intubation should be anticipated’.1

This recommendation has serious implications for staffing of labour wards and is therefore controversial. Guidelines for the management of morbidly obese patients should be readily available in all obstetric units and should include details of the availability of equipment such as wider maternity beds, operating tables with width extensions, larger thromboembolic deterrent stockings, long regional block needles, and large AP cuffs.1,3 Direct AP monitoring is very helpful and involves minimal morbidity. Manpower and electrically operated equipment for positioning should be available and staff should be encouraged to attend a manual handling course with special attention to manual handling of the obese patient. New guidelines on the management of the obese parturient were published jointly by CMACE/RCOG in March 2010 and are available from the CMACE website www.cmace.org.uk.

**Thrombosis/thromboembolism**

This is the third most common cause of maternal death, with a total of 45 deaths (41 direct and four late, MMR 2.12), with substandard care identified in 23 cases. Again, this is an increase compared with the 32 cases in 1985–7 (MMR 1.14), with predisposing factors such as obesity and increasing maternal age. The dose of low molecular weight heparin should be increased in the morbidly obese parturient, and current RCOG Clinical Green Top Guideline No. 3713 gives weight-specific dosage advice shown in Table 2.

**Sepsis**

Twenty-two deaths (including one in early pregnancy and three late deaths) occurred from genital tract sepsis in the current triennium (MMR 1.04), compared with nine deaths in the 1985–7 Report (MMR 0.4)—this is a substantial and worrying increase. Substandard care was identified in 15 cases. Maternal tachycardia, constant severe abdominal pain and tenderness are important early features of genital tract sepsis that should prompt urgent medical review. Pyrexia and raised white cell count are not always present. Anaesthetists are familiar with the diagnosis and management of septic shock and should be proactive in leading the labour ward team where necessary. If sepsis is suspected, regular frequent observations should be made and the use of the MEOWS chart is crucial (see recommendation 9 above). The Critical Care section of the CEMACH Report highlights the use of the Sepsis Resuscitation Care bundle.14 Risk factors for sepsis include obesity, cervical cerclage, gestational diabetes, wound haematoma, retained products, and impaired immunity.

**Lessons not included in the top 10 recommendations**

**Cardiac disease: the leading cause of maternal death**

Cardiac disease is now the leading cause of maternal death, with a total of 82 deaths (MMR 3.87) of which 23 (28%) had substandard care (Fig. 1). Interestingly, the top 10 recommendations do not include any comment on cardiac disease, other than migrant women should have a full medical history and examination at

| Table 2 Current RCOG Clinical Green Top Guideline No. 3713 weight-specific dosage advice |
|------------------|------------------|
| Weight (kg)      | Daily dose       |
| 91–130           | Enoxaparin: 60 mg|
|                   | Dalteparin: 7 500 units |
|                   | Tinzaparin: 7 000 units |
| 131–170          | Enoxaparin: 80 mg |
|                   | Dalteparin: 10 000 units |
|                   | Tinzaparin: 9 000 units |
|                   | Enoxaparin: 0.6 mg kg⁻¹ |
| >170             | Dalteparin: 75 units kg⁻¹ |
|                   | Tinzaparin: 75 units kg⁻¹ |
booking—perhaps, this advice should be extended to all women at booking. Cardiac deaths include 16 myocardial infarcts (mostly associated with obesity, older age at childbirth, smoking, and poor diet), 12 peripartum cardiomyopathies (soon to be reclassified as direct maternal deaths), and nine thoracic aortic dissections.

CEMACH/CEMD Reports over the past 30 yr show that only a minority of cardiac deaths occur in women with known disease, (mainly congenital defects) and that the increase is entirely accounted for by women who either had identifiable risk factors at booking (BMI >30, diabetes, smoking, hypercholesterolaemia,
hypertension, and family history) or in which the problem arose entirely de novo during pregnancy. These latter two categories mainly include ischaemic heart disease, cardiomyopathy, aneurysm, and myocarditis.\textsuperscript{15} Patients with known disease will usually already be under the care of Grown Up Congenital Heart (GUCH) multidisciplinary teams and may require referral to a specialist centre for delivery depending on the exact lesion. Most repaired lesions, uncomplicated shunts, and mild valve disease represent a low risk (0.1–1.0\% mortality), with the highest risk group comprising pulmonary hypertension, Marfan’s with aortic involvement, and significant aortic stenosis or ventricular dysfunction (5–30\% mortality). Most cardiac patients are now managed by vaginal delivery, with CS usually reserved for appropriate obstetric indications. Labour requires effective pain relief with careful, slowly established low-dose epidural block and monitoring with ECG, pulse oximetry, and direct AP. Systemic vascular resistance should be maintained and vasodilators such as oxytocin should be avoided—diluted ergometrine may be preferable. Phenylephrine is the vasopressor of choice. Particular care should be taken to avoid bleeding, pulmonary oedema, arrhythmias, thromboembolism, air embolism with shunts, and bacterial endocarditis. Anaesthesia for CS may be regional or general, and the care with which each technique is administered is more important than the choice of technique in most cases. A clear understanding of the precise nature of the lesion, the presence or absence of pulmonary hypertension, and the degree of anticoagulation will guide the decision. Close observation on HDU/ITU should extend into the post-delivery period.

**Conflict of interest**

None declared.

**References**

4. Royal College of Anaesthetists. Initial Assessment of Competency. CCT in Anaesthesia II: Competency Based Basic Level Training and Assessment. 2007. Available from www.rcoa.ac.uk

Please see multiple choice questions 11–14