Obstetric emergencies

Brynmor A Summers
Graeme G Flett

Abstract

For more than 60 years the Confidential Enquires into Maternal Deaths triennial reports and later reports from Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK (MBRRACE-UK) have helped build a picture of maternity care within the United Kingdom (UK), highlighting not only our successes but failures in caring for women within the puerperal period. Despite most obstetric emergencies being well described and having clear management strategies and guidance, there continues to be substandard management with poor outcomes recorded. This article describes some common obstetric emergencies with which the anaesthetist will become involved. It emphasizes management related to some deficiencies identified in the MBRRACE-UK report as well as highlighting a multidisciplinary approach throughout. Good communication between team members is paramount in all aspects of medical care, but this approach should be fostered routinely to ensure that rapid and appropriate decisions are made in a safe and timely manner.

Keywords Amniotic fluid embolus; emergency caesarian section; local anaesthetic toxicity; magnesium toxicity; maternal collapse; maternal resuscitation; MBRRACE; multidisciplinary obstetric emergency simulation; sepsis

Royal College of Anaesthetists CPD Matrix: 1B03, 1B04, 2B05, 2B06

Learning objectives

After reading this article, you should:

- understand common causes of obstetric emergencies and their management
- be aware of the need for early detection and management of the critically unwell parturient
- understand the differences in resuscitation of the pregnant patient
- understand the role of simulation in the reinforcement of teaching and retention emergency skills

Introduction

The Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK (MBRRACE-UK) report published in November 2018, looking at reports from the period of 2014–2016, showed a slight increase in overall maternal mortality to 9.8 per 100,000 maternities returning to the rates seen in 2010–2012.[1] Deaths from direct causes in particular have increased and now match those seen in 2008–2010. Although this was not statistically significant, it highlights the both ongoing potential and need for improvement in maternal care.

Indirect causes continue to represent the greater proportion of deaths with cardiac disease accounting for more than double any other cause. The 2019 report will aim to address the lack of any improvement in mortality rates secondary to cardiac disease.[1]

Brynmor A Summers *BSc MBChB MSc FRCA DipIMC is a Year 6 Specialist Trainee in Anaesthesia in the North West, UK. Conflict of interest: none.*

Graeme G Flett *BSc (Hons) MB ChB MRCP (UK) FRCA AFHEA is a Consultant in Obstetric and General Anaesthesia at St Mary's Hospital, Central Manchester Hospitals Foundation Trust, UK. Conflicts of interest: none declared.*

Direct causes of maternal death remain unchanged, with thrombosis and thromboembolism in the majority, followed by haemorrhage, psychiatric causes and then sepsis.

An increase in mortality rates was seen in sepsis (both direct and indirect), pre-eclampsia, thrombosis and thromboembolism, and amniotic fluid embolus (AFE). Deaths directly related to anaesthesia remain extremely low, with only one death recorded in the reporting period.[1]

This article identifies some causes of common emergencies in obstetrics seen (Table 1) and highlights key treatment points in their management to help improve outcome. Major haemorrhage, pre-eclampsia and eclampsia are mentioned in detail within other articles in this series, as are emergencies related specifically to anaesthetic practice.

Maternal sepsis

Sepsis was the focus of the report in 2015, and remains a significant aetiology behind maternal death being responsible for 2.04 deaths per 100,000 maternities in 2009–2012.[1] Sepsis in an obstetric population can be divided into obstetric causes (further divided into genital tract, and non-genital causes) and non-obstetric causes (e.g. community acquired pneumonia, cellulitis etc.). A decrease in mortality attributed to genital tract sepsis specifically has been seen between 2006 and 2008 and

Obstetric emergencies which may present challenges to the anaesthetist

Haemorrhage – antepartum	Fetal distress of any cause
– postpartum	Emergency caesarean
Sepsis	section – for any cause
Pre-eclampsia and eclampsia	Uterine rupture
Thromboembolism	Uterine inversion
Amniotic fluid embolism	Shoulder dystocia
Maternal cardiorespiratory arrest	Cord prolapse
Anaphylaxis	Emergency cervical cerclage
Anaesthetic related	
Total/high spinal	
Failed/difficult intubation	
Local anaesthetic toxicity	

Anaesthetic related emergencies mentioned for completeness.

Table 1

2010–2012.[2] Rates reached a peak of 1.13 per 100,000 maternities in 2006–2008, falling to 0.48 in 2014–2016.[1] Improvements in the recognition and management of sepsis based on such campaigns as Surviving Sepsis in addition to the UK Royal College of Obstetricians and Gynaecologist (RCOG) Green Top Guidance on 'Sepsis in Pregnancy' may be responsible, though cyclical changes in disease prevalence have been seen.[3]

The largest risk factor for developing sepsis is surgery or trauma to the uterus or genital tract, while patient factors such as obesity, anaemia, impaired-glucose-tolerance and sickle-cell disease or trait may also increase risk. Genital tract infection with group A strepococcus was the risk factor most associated with progression to severe sepsis and septic shock and most commonly occurs in early pregnancy and peripartum.[2] The most common causative organism associated with genital tract infection in the second trimester was *Escherichia coli*.[3] Infection from a non-genital tract or 'indirect' source, represent the most common cause of maternal mortality in the 2014 MBRRACE report, after cardiac disease. The majority of these deaths were due to the Influenza pandemic within the 2009–2012 period.[2]

Sepsis is defined as life-threatening organ dysfunction caused by dysregulated host response to infection.[4] Different scoring systems have been used to try and aid early detection of sepsis such as qSOFA, but the most commonly used system is the systemic inflammatory response syndrome (SIRS) criteria. This breaks sepsis into different categories: SIRS, sepsis, severe sepsis and septic shock.

SIRS

In adults, this is defined as the presence of ≥2 of:[3]

- temperature >38.3°C or <36°C
- heart rate >90 min^{-1}
- respiratory rate >20 min^{-1}
- white blood cell count >12 × 10^9 cells $litre^{-1}$ or <4 × 10^9 cells $litre^{-1}$

Sepsis

SIRS with confirmed or suspected source of infection.

Severe sepsis

Sepsis-induced tissue hypoperfusion or organ dysfunction.

Septic shock

Sepsis with hypotension despite adequate fluid resuscitation.[5]

The physiological changes of pregnancy and labour may mask or confuse these criteria; signs of critical illness are often attributed to pregnancy, labour and pain. Temperature rises in labour are common; the heart rate increases by 25%; the respiratory rate may increase to 15 min^{-1} during pregnancy and further to 22–70 in labour; there is a leucocytosis of up to 15 × 10^9 cells $litre^{-1}$ in labour and immediately after. However there is evidence that a Modified Early Obstetric Warning Score System (MEOWS) is effective at recognizing unwell patients, with sensitivity and specificity of 89% and 79%, respectively.[6] These values should return towards normal post-delivery, therefore perseverance or recrudescence of abnormal values post-delivery should cause concern.

Research has focused on the use of biomarkers to diagnose sepsis and track response to treatment, such as procalcitonin (a pro-peptide of calcitonin, un-recordable in health and raised in bacterial infection).

Management

Clinicians are encouraged to 'Think Sepsis' at an early stage and employ key actions in its diagnosis and management:[2]

- Timely recognition including measurement of a complete set of observations.
- Fast administration of IV antibiotics within 1 hour.
- Quick involvement of experts-review by senior medical staff.
- Early involvement of a microbiologist or an infectious disease expert.

Management of sepsis should be focused and organized with a multidisciplinary approach. Resuscitation following an ABCDE approach, investigation and treatment including organ support, IV fluids and antibiotics should occur concurrently.

Investigations should include:

- Generic blood tests: FBC, U + E, Lactate, CRP, LFTs, clotting studies, ABG.
- Microbiology: Swabs of everything including breast milk, urine and blood cultures (ideally before, but not delaying, antibiotics). A nasopharyngeal aspirate or throat swab in those with respiratory tract signs or symptoms.
- Imaging as appropriate (CXR, pelvic/abdominal US or CT).

Table 2 highlights the tasks that the medical team should aim to perform in the initial hours from presentation with severe sepsis.[3] This requires a collaborative approach from those involved in management and may ultimately require admission to the intensive care unit. Recommendations state that all consultant-led delivery suites should have a level 2 high dependency care area managed by the multidisciplinary team.[2]

Definitive treatment involves delivering the right antibiotic early while supporting the patient's organ systems. Every hour delay in administering antibiotic therapy is thought to increase mortality by 8%.[7] Intravenous antibiotics should be started empirically and changed to a definitive antibiotic with culture results. Blood cultures can show preliminary results after only 24 hours but usually require 48 hours before bacteria can be positively identified and antibiotic sensitivities are known at which point antibiotics can be reviewed.

The choice of the initial antibiotic should be guided by local antibiotic protocols, but should include a broad-spectrum of activity including anaerobe cover. Early advice from microbiology colleagues is considered essential if a patient fails to improve on the chosen antimicrobial therapy. Table 3 shows some antibiotic choices and their limitations.[3]

The 2014 MBRRACE report highlighted that fluid resuscitation was often late and inadequate, with effects of fluid boluses rarely monitored.[1] There are physiological, pathological (e.g. pre-eclampsia) and pharmacological (e.g. syntocinon) factors complicating the distribution of fluids within compartments during the pre-, intra- and post-partum. Therefore fluid management in obstetric patients is difficult, with a greater propensity for overload and pulmonary oedema, and patients should be monitored closely.

Tasks to be completed within the first 3 hours of time of presentation with severe sepsis

Obtain blood cultures prior to antibiotic administration (but do not delay antibiotics)
Administer broad-spectrum antibiotic within one hour of recognition of severe sepsis
Measure serum lactate
In the event of hypotension and/or a serum lactate >4mmol/l deliver an initial minimum 20ml/kg of crystalloid or an equivalent.
To be completed within 6 hours of time of presentation
Apply vasopressors for hypotension that is not responding to initial fluid resuscitation to maintain mean arterial pressure (MAP) >65 mmHg
In the event of persistent hypotension despite fluid resuscitation (septic shock) and/if lactate >4mmol/l, re-assess volume status and tissue perfusion
Re-measure lactate if initial lactate elevated
NB: The SSC committee has revised the bundle excluding use of CVC line & $ScvO_2$

Modified from the Surviving Sepsis Campaign Resuscitation 'Bundle' (group of therapies).[5]

Table 2

Maternal collapse and resuscitation

Cardiac arrest in pregnancy affects approximately 1 in 34,000 women.[8] Figures are rising, and are thought to be due to increasing maternal age and morbidity. The rarity of cardiac arrest in pregnancy results in maternity staff being unfamiliar with cardiopulmonary resuscitation (CPR). Maternal CPR also presents some unique problems and variations from standard adult resuscitation guidelines.

Antimicrobial choices and limitations of antimicrobials[5]

Co-amoxiclav	Does not cover MRSA or *Pseudomonas*, and there is concern about an increase in the risk of necrotizing enterocolitis in neonates exposed to co-amoxiclav in utero
Metronidazole	Only covers anaerobes
Clindamycin	Covers most streptococci and staphylococci, including many MRSA, and switches off exotoxin production with significantly decreased mortality. Not renally excreted or nephrotoxic
Piperacillin–tazobactam (Tazocin) and carbapenems	Covers all except MRSA and are renal sparing (in contrast to aminoglycosides)
Gentamicin (as a single dose of 3–5 mg/kg)	Poses no problem in normal renal function but if doses are to be given regularly serum levels must be monitored

Table 3

Management

Once cardiac arrest has been confirmed, whatever the cause, CPR should proceed in line with adult advanced life support (ALS) algorithms[9] published by The Resuscitation Council (UK) (www.resus.org.uk). It should be emphasized, however, that difficulties and differences do exist from a standard adult population (Table 4). Firstly, maternal patients are at an increased risk of both aspiration and difficult intubation. Obtaining a secure airway can thus be more challenging for the anaesthetist and access to difficult airway adjuncts and techniques is therefore of benefit. This is compounded by the increase in oxygen consumption at term of up to 25%, making time from apnoea to desaturation significantly shorter. Aortocaval compression by the gravid uterus occurs as it moves out of the pelvis to become an abdominal organ as early as the 20th week, and this is increased with multiple pregnancies and polyhydramnios. Up to 50% of the cardiac output (CO) returns via the inferior vena cava, therefore aortocaval compression will significantly reduce CO and decrease the likelihood of a return of spontaneous circulation (ROSC). This may be compounded by any coexistent regional sympathetic block. Manual lateral displacement of the uterus is preferred, as effective chest compressions are performed poorly when a wedged lateral tilt is utilized, unless the patient is already on a tilting table, bearing in mind that even 30 degrees of tilt can still leave significant aortic compression.

Perimortem caesarean section (PMCS) has long had a place in maternal CPR, greatly improving maternal resuscitation and possibly facilitating survival of the fetus. Guidance advocates commencement of a PMCS in women >20 weeks' gestation if there is no ROSC by 4 minutes who are in cardiac arrest, with the aim of delivery of the fetus and placenta within 1 minute.[10] Equally however, you do not have to wait, and women do continue to die with the uterine contents intact. Resuscitation trolleys should contain a scalpel blade and cord clamps in order to facilitate PMCS without transfer to theatre. The primary aim behind PMCS is to improve maternal survival, with this in mind, delay in making the decision to perform PMCS in order to confirm fetal life is not advocated.[2] PMCS requires a surgeon or emergency medicine physician to be prepared to carry out this procedure in a timely manner.

There are situations where cardiac arrest may have been caused iatrogenically and therefore will respond to specific measures and antidotes. Treatment of pre-eclampsia with Mg^{2+} can lead to Mg^{2+} overload and toxicity. Where this is suspected,

Similarities and differences between standard adult resuscitation and resuscitation in a pregnant patient[6]

Identical to ALS Guidelines	Relevant differences
Rate/rhythm/depth of compressions	Airway difficulties
Drugs used and doses	Shorter apnoea to desaturation time
Energies for defibrillation	Aortocaval compression
Time cycles	Different causes (Mg^{2+} overdose, LA toxicity)
30:2 Ratios	Perimortem caesarean section

Table 4

magnesium should be discontinued and antidote administered intravenously as 1 g of calcium, (10 ml of 10% calcium chloride or 30 ml 10% calcium gluconate). Local anaesthetic (LA) toxicity is a recognized cause of unresponsive cardiac arrest where LA has been given via the wrong route inadvertently, or where there is toxic systemic absorption. As well as discontinuing any LA infusion, this should be treated with early administration of 20% intralipid 1.5 ml kg^{-1} bolus over 1 minute (with up to two further boluses after 5 minutes) and a 15 ml kg^{-1} hr^{-1} infusion (doubled to 30 ml kg^{-1} hr^{-1} if no improvement, or condition worsens) up to a maximum cumulative dose of 12 ml/kg (Association of Anaesthetists of Great Britain and Ireland Guidelines).[11] CPR itself may be prolonged and where available cardiopulmonary bypass may be necessary.

Amniotic fluid embolus (AFE)

AFE is a rare but sometimes devastating consequence of pregnancy, with overall mortality estimates reaching 60%.[2] Its true incidence remains unknown, although it is predicted to occur in 1:50,000 deliveries[12] and sits as the 8th most common cause of direct maternal death at 0.39:100,000 maternities in the 2014 −2016 report.[1] This multisystemic disorder can occur at any point in pregnancy, though 70% occur in labour. Various risk factors have been identified although the most common are increased maternal age, multiparity, induction of labour and rapid or hyper-stimulation of the uterus.

Despite continued research its cause has never been clearly elucidated. However, it is now often described as an anaphylactoid process resulting from fetal squames and amniotic fluid entering the maternal circulation stimulating a cascade of endogenous mediators, rather than a true embolic process. This results in a biphasic response with the initial insult related to the release of products into the maternal circulation resulting in the release of biochemical mediators causing pulmonary artery vasospasm and pulmonary hypertension. Followed by a second phase where disseminated intravascular coagulation (DIC) is triggered, which together with uterine atony, can result in massive haemorrhage.[13] This has encouraged a change in nomenclature to the 'anaphylactoid syndrome of pregnancy' rather than AFE. This new designation more accurately reflects the many similarities to anaphylaxis and septic shock than embolism, which is in turn reflected in the signs and symptomology. The amount of fetal debris required to cause this syndrome is variable and may involve just minute quantities. Post-mortem examination of individuals thought to have succumbed to this event can often reveal fetal squames within the pulmonary circulation; however, this is not always the case, and it is therefore neither sensitive nor specific. Broncho-alveolar lavage may support the diagnosis, but there is no pathognomonic marker for AFE.

AFE can be defined on the clinical picture. Criteria associated with AFE in the absence of any alternative cause include a range of signs and symptoms extending from subtle 'non-specific' signs such as restlessness, numbness, and agitation, to major cardiovascular collapse associated with breathlessness, cyanosis, hypotension, seizures, arrhythmias and maternal coagulopathy and haemorrhage.[12] Because of this inconsistent presentation and varied differential diagnosis, formal diagnosis can be difficult. It is therefore often a diagnosis of exclusion requiring a high index of suspicion.

Management

Signs and symptomology will dictate the overall management and urgency of the situation. Those with fulminating syndromes and cardiovascular collapse should be managed according to standard ALS protocols.[9] 100% oxygen and CPR should commence immediately and delivery of baby should be expedited to ensure its effectiveness. Where maternal resuscitation is not effective or successful, PMCS should be commenced according to ALS and RCOG guidance. Where there is maternal response or ROSC this would still necessitate delivery of baby by category one caesarean section to allow ongoing management of the mother. There is no requirement to delay delivery in order to confirm fetal viability.[2] Successful management is more likely with early recognition; however, even with successful management of the initial phase up to 83% develop some degree of DIC[13] and the 2014 MBRRACE report advocates activation of the Major Haemorrhage Protocol at the time of decision to proceed to PMCS.[2] Ongoing support is likely to involve management within a critical care environment for the provision of cardiovascular, renal and respiratory support where necessary.

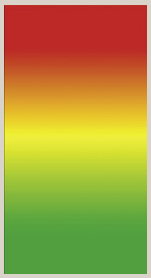
Emergency caesarean section (C/S)

Since the maternal confidential enquiry commenced in 1952 there has been a dramatic change in the numbers of caesarean sections performed both elective and emergency within the UK. These generally following an increasing trend. A large proportion of emergency C/S can be anticipated and so there should be adequate time in most instances to make plans or even the provision for expert help to be available. To facilitate this, there should be ongoing communication within the multidisciplinary team to ensure that the anaesthetist is kept aware of arising problems on the delivery unit so that action plans can be initiated. There will, of course, remain an unpredictable number of cases, which require the skill and timely management of the resident team to ensure a good outcome for mother and baby.

There is a diverse range of reasons why an emergency C/S may be requested (Table 1). Whatever the reason, the urgency should be classified according to RCOG good practice guidance (Table 5) introduced in 2010.[14] This emphasizes a continuum of urgency that may vary within any one category, but fosters universal communication between team members allowing an indication of the degree of urgency and a recommended decision to delivery time. It has to be remembered that situations can change rapidly and subsequent review once the patient has entered theatre should be performed, which may up-grade or down-grade the initial urgency. This may reveal a resolving bradycardia from measures performed to improve the CTG status (intrauterine resuscitation), which may alter the initial choice of anaesthesia and increase overall safety and maternal satisfaction in an already stressful situation.

Where a decision for category 1 C/S has been made the patient should be transferred into theatre as soon as practicable. Where there is evident or continued fetal distress intrauterine resuscitation should be commenced while preparation for C/S is made, and this may ultimately down-grade the urgency of the C/S.

A classification relating the degree of urgency to the presence or absence of maternal or fetal compromise[14]



Spectrum of urgency	Definition	Category
Maternal or fetal compromise	Immediate threat to life of woman or fetus	1
	No immediate threat to life of woman or fetus	2
	Requires early delivery	3
	At a time to suit the woman and maternity services	4
No maternal or fetal compromise		

Table 5

The patient should be immediately positioned left lateral to relieve any continued aortocaval compression, 100% oxygen should be given to the mother via a tight fitting facemask or if available high-flow nasal cannulae, and where there is intravenous syntocinon running this should be discontinued and removed to prevent any accidental bolus during transfer or in theatre. Intravenous fluid resuscitation should be commenced 500–1000 ml crystalloid (if this is not contraindicated such as in pre-eclamptic patients), and where blood pressure is low this can be raised with appropriate boluses of vasopressor (50–100 μg of phenylephrine) aiming to restore blood pressure to within 10% of the patients baseline. Where there is apparent uterine hyperstimulation then tocolysis may be beneficial with the administration of either two sprays of sublingual GTN or 250 μg of terbutaline subcutaneously.

Once in theatre, the patient should be reassessed to confirm the status of the fetus and mother at which point a definite decision as to the mode of anaesthesia can be made. Where there is continuing fetal distress or ongoing bradycardia, then general anaesthetic (GA) may be the most appropriate choice. This, however, has to be balanced against the increased risk associated with GA and where there is significant concern over the patient's airway such as in morbidly obese patients, it may not be possible to provide GA without senior assistance. The Difficult Airway Society and Obstetric Anaesthetists' Association have produced a difficult airway algorithm that includes a risk assessment table to help guide the anaesthetist on whether to continue with the surgery in the event of a failed intubation.[15] A pre-intubation checklist can be used to reduce the risk of error occurring through omission as a result of the high pressure nature of a GA section. Where there is uncontrolled hypertension in pre-eclamptic patients, GA should not be commenced without adequate blood pressure control and suitable attenuation of the pressor response to intubation. If the CTG has normalized then there may be time to perform spinal anaesthesia. Rapid sequence spinal anaesthesia has been described and although effective, requires strict adherence to time limits (and good situational awareness) to ensure the avoidance of repeated attempts to the detriment of maternal or fetal wellbeing. Maternal pre-oxygenation should continue during this time. Epidural top-up may also be an option with 15–20 ml 0.75% ropivacaine allowing the development of rapid and effective block. However, it is important that the epidural has been functioning well during labour, that there has been no immediately preceding low dose top up which may prevent further top up in theatre, and that there is time available to wait for the development of an adequate block. Again, if there is time pressure it may be best to abandon an epidural in favour of spinal anaesthesia or, in extreme urgency, GA.

Multidisciplinary obstetric emergency simulation

Despite the majority of obstetric emergencies being handled with skill and expertise, sadly in the minority they still result in devastating consequences with either the loss of the mother, fetus or both. There is continued evidence that in certain circumstances obstetric emergencies are subject to mismanagement.[2] Two reports by the Institute of Medicine speculated, that team training and the implementation of 'team behaviors' could reduce medical errors and improve patient safety, and obstetrics lends itself well to this 'multidisciplinary team training'.[16] The use of simulators in medicine is spreading fast. Anaesthesia has been both at the forefront and a principal investigator of its use. A number of studies have looked at its use particularly within obstetrics, although these have varied in study design as well as methods of training (whether that be low or high fidelity), and their ultimate outcome measurements. A common theme in all, however, is that team training potentially leads to a better recognition of intrapartum problems, which together with appropriate and timely intervention, can result in better outcomes for mother and child. It may particularly improve the resultant chain of action between decision for delivery and actual birth of the child.[16] Already many courses exist both locally and nationally such as PROMPT (www.promptmaternity.org) and MOET (www.alsg.org/uk/MOET) which provide the ability for teams to come together and train in a safe environment, and to practice communication and clinical skills related to common and uncommon emergencies. Regular skills and drills can also be performed in house, although this can be difficult to organize on an already busy labour ward. Despite this, it is more accessible, allows for repeated exposure and frequent updates, and is a core requirement for local clinical negligence management. There is

currently no evidence to support an additional benefit to training in a simulation centre.[16] ◆

REFERENCES

1 on behalf of MBRRACE-UK. In: Knight M, Bunch K, Tuffnell D, et al., eds. Saving lives, improving mothers' care – lessons learned to inform maternity care from the UK and Ireland confidential Enquiries into maternal deaths and morbidity 2014-16. Oxford: National Perinatal Epidemiology Unit, University of Oxford, 2018.

2 on behalf of MBRRACE-UK. In: Knight M, Kenyon S, Brocklehurst P, Neilson J, Shakespeare J, Kurinczuk JJ, eds. Saving lives, improving mothers' care – lessons learned to inform future maternity care from the UK and Ireland confidential Enquiries into maternal deaths and morbidity 2009-12 2014. Oxford: National Perinatal Epidemiology Unit, University of Oxford. Accessed April 2019, www.npeu.ox.ac.uk/mbrrace-uk/reports.

3 Sepsis in Pregnancy, Bacterial (Green-top 64a). https://www.rcog.org.uk/globalassets/documents/guidelines/gtg_64a.pdf (Accessed April 2019).

4 Singer M, Deutschman CS, Seymour CW, et al. The third international consensus definitions for sepsis and septic shock (Sepsis-3). *J Am Med Assoc* 2016 Feb 23; **315:** 801–10.

5 Dellinger RP, Levy MM, Rhodes A, et al. Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock. *Crit Care Med* 2013; **41:** 580–637.

6 Singh S, McGlennan A, England A, et al. A validation study of the CEMACH recommended modified early obstetric warning system (MEOWS). *Anaesthesia* 2012; **67:** 12–8.

7 Kumar A, Roberts D, Wood KE, et al. Duration of hypotension before initiation of effective antimicrobial therapy is the critical determinant of survival in human septic shock. *Crit Care Med* 2006; **34:** 1589–96.

8 O'Connor M, Smith A, Nair M, et al. UKOSS annual report 2015. Oxford: National Perinatal Epidemiology Unit, 2015.

9 Resuscitation guidelines. 2015. Accessed April 2019, https://www.resus.org.uk/resuscitation-guidelines/.

10 Royal College of Obstetricians and Gynaecologists. Green-top guideline 56. Maternal collapse in pregnancy & the Peurperium'. 2001, http://www.rcog.org.uk/womens-health/clinical-guidance/maternal-collapse-pregnancy-and-puerperium-green-top-56.

11 A4 sheet. Management of severe local anaesthetic toxicity 2. 2010. Accessed April 2019, http://www.aagbi.org/sites/default/files/la_toxicity_2010_0.pdf.

12 Knight M, Tufnell D, Brocklehurst P, Spark P, Kurinczuk JJ. Incidence and risk factors for amniotic fluid embolism. *Obstet Gynaecol* 2010; **115:** 910–7.

13 Dedhia JD, Mushambi MC. Amniotic fluid embolism. *Br J Anaesth CEPD Reviews* 2007; **7:** 152–6.

14 Classification of urgency of caesarian section – A continuum of risk. https://www.rcog.org.uk/globalassets/documents/guidelines/goodpractice11classificationofurgency.pdf (Accessed April 2019).

15 OAA DAS obstetric airway guidelines. 2015. Accessed April 2019, https://www.oaa-anaes.ac.uk/assets/_managed/cms/files/Clinical%20Guidelines/Guideline_Algorithms_2015.pdf.

16 Merién AER, Van de Ven J, Mol BW, et al. Multidisciplinary team training in a simulation setting for acute obstetric emergencies: a systematic review. *Obstet Gynecol* 2010; **115:** 1021–31.

