

advanced life support were quickly delivered. Women who collapsed at home were more likely to die. PMCS was performed on 49 women (11 of these performed in the emergency department). Time intervals between collapse and PMCS was significantly shorter in women who survived compared with those who died (median interval, 3 minutes versus 12 minutes; $P = 0.001$).

The latest systematic review to study the efficacy of PMCS was published in 2012 by Einav et al.⁸⁷ This review identified a total of 80 relevant publications that reported the outcome of 94 women. In 31.7% of identified cases of PMCS, the procedure was found to be of benefit for maternal or fetal survival. No harm was found in any of the 94 women who underwent PMCS. When analysing maternal outcome, 54.3% of women survived until hospital discharge and 42.6% of women survived with good to moderately impaired neurological outcome. Although the study was unable to validate the need to deliver by 5 minutes duration, it was able to demonstrate that maternal outcomes were more favourable if performed within 10 minutes of maternal cardiac arrest (OR 7.42; $P < 0.05$). Neonatal survival was also associated with a shorter mean cardiac arrest to delivery time (14[\pm 11] minutes versus 22[\pm 13] minutes). Neonatal survival was only found in women who suffered cardiac arrest in hospital and there were reports of neonatal survival where delivery was performed 30 minutes after maternal cardiac arrest.

The MBRRACE-UK report 2016 described the neonatal outcomes of the 32 babies born by PMCS.³ Of these babies, 19 were delivered by caesarean section after 32 weeks of gestation; nine of the 19 babies survived. Of the 13 babies born by PMCS at 32 weeks of gestation or less, only three survived. Therefore, the overall neonatal survival of babies delivered by PMCS was 38%. Survival was directly associated with advanced gestation and delivery within a suitable birthing or critical care setting.

Evidence
level 2+

There have been successful cases of somatic support after maternal brain death to facilitate neonatal outcome.¹⁰⁷ The longest being from 15 weeks of gestation to birth at 32 weeks of gestation.¹⁰⁸ This process is not without difficulties, both in medical terms and ethically,¹⁰⁹ and what is not known is how many such cases have not been successful. In view of the complex nature of such cases, a multidisciplinary discussion including the family should be conducted in each case.

Evidence
level 2–

4.8. Who should be on the team?

In addition to the general arrest team, there should also be a senior midwife, an obstetrician and an obstetric anaesthetist included in the team in cases of maternal collapse.



The most senior obstetrician and senior anaesthetist should be called at the time of a cardiopulmonary arrest call.



The neonatal team should be called early if delivery is likely (antepartum collapse over 22⁺⁰ weeks of gestation).



Where the woman survives, a consultant intensivist should be involved as soon as possible.



If the maternity unit is an integral part of a general hospital, the maternal CPR team should be the hospital cardiopulmonary arrest team with the addition of:

- senior midwife
- most senior resident obstetrician (usually ST 3–7)
- resident anaesthetist who has recognised skills in obstetric anaesthesia (usually ST 3–7).

This will mean that the request needs to be specific with common terminology, so that the switchboard operators know exactly who to call. While managing the arrest, there must be dialogue between the team leader, the obstetrician and the obstetric anaesthetist as to how best to manage the pregnant woman.

In stand-alone consultant-led maternity units or those that are geographically distant from the main general hospital, the entire arrest team is often made up of staff from within the maternity unit. In this case, the team is usually made up of senior midwifery staff, operating department practitioners, resident obstetric staff and the resident obstetric anaesthetist.

If a maternal collapse occurs in a stand-alone midwifery unit or homebirth environment, the midwifery staff should provide life support and call a 999 ambulance to transfer the woman to the nearest appropriate environment. Maternity services that include a stand-alone midwifery unit should ensure that there is a written agreement with the ambulance service confirming the emergency status of a 999 call from the midwifery unit.

5. Clinical governance

5.1. Documentation

Accurate documentation is essential in all cases of maternal collapse, whether or not resuscitation is successful.



Poor documentation remains a problem in all aspects of medicine and can have potential clinical and medicolegal consequences.¹¹⁰ Contemporaneous note keeping is difficult in a resuscitation situation, unless someone is scribing. Those involved should then write full notes as soon as possible after the event.

Evidence
level 4

5.2. Incident reporting

All cases of maternal collapse should generate a clinical incident form and the care should be reviewed through the clinical governance process.



All cases of maternal death should be reported to MBRRACE-UK.



Maternal collapse is a rare and potentially devastating event, and substandard care continues to be highlighted.^{2–5} In all cases of maternal collapse, care should be reviewed to ensure individual and organisational learning. Staff and the family should be reassured when care has been optimal.

Evidence
level 2+

In view of the significant reduction in maternal mortality over the years, robust population-based data regarding maternal collapse through a national reporting system would render valuable information about management and outcomes.

National reporting and scrutiny of maternal deaths continue to provide valuable information and learning, as do confidential enquiries into severe morbidity.² Evidence level 2+

5.3. *Training*

All generic life support training should consider the adaptation of CPR in pregnant women. ✓

All maternity staff should have annual formal multidisciplinary training in generic life support and the management of maternal collapse. ✓

Life support training improves resuscitation skills. A

Small group multidisciplinary interactive practical training is recommended to improve the management of maternal collapse. C

All front-line staff must be aware of the adaptations for CPR in pregnancy. This includes paramedics who will deal with collapse in the community setting and accident and emergency department personnel, as well as staff within a maternity unit.

The RCOG, the Royal College of Midwives and MBRRACE-UK³ recommend that all staff undergo annual training in obstetric emergencies. Evidence level 4

Multidisciplinary team training in small groups has been shown to improve outcomes in all medical emergencies and there continues to be a wealth of data to demonstrate that this is particularly the case in obstetric emergencies.¹¹¹ Interactive training has been shown to improve teamwork, communication and the confidence of individual clinicians to manage obstetric emergencies and increase the incidence of PMCS.^{112,113} Evidence level 1+

The best method of training remains unclear, although there is evidence to support small group interactive training.¹¹¹ Various courses exist^{73,114,115} and have been evaluated well by those undertaking them with individuals reporting an improved knowledge and confidence after course attendance.¹¹⁶ The ideal frequency of training is not clear, but this should occur at least annually for all staff.¹¹⁷ Evidence level 2–

5.4. *Debriefing*

Debriefing is recommended for the woman, the family and the staff involved in the event. ✓

Maternal collapse can be associated with post-traumatic stress disorder (for the woman, her family and for staff involved), postnatal depression and tocophobia. Debriefing is an important part of holistic maternity care and should be offered by a competent professional to support the ongoing mental health of all concerned.¹¹⁵ Evidence level 4

6. Recommendations for future research

- Investigate the effectiveness of CPR with manual uterine displacement versus maternal tilt.
- Determine the effectiveness of human factors and emergency simulation training for maternal collapse clinical scenarios.
- Investigate the best diagnostic and management strategies for AFE.

7. Auditable topics

- Proportion of staff undergoing regular training in life support (100%).
- Proportion of staff undergoing regular training in maternal collapse (100%).
- Audit of the management of maternal collapse (100%).
- Compliance with incident reporting (100%).
- Achievement of PMCS within 5 minutes of collapse on hospital premises, where there is no response to resuscitation (100% in pregnancies over 20 weeks of gestation).
- Presence of a scalpel on resuscitation trolleys (100%).

8. Useful links and support groups

- UK Obstetric Surveillance System (UKOSS) [<https://www.npeu.ox.ac.uk/ukoss>].
- MBRRACE-UK: Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK [<https://www.npeu.ox.ac.uk/mbrrace-uk>].
- Advance Life Support in Obstetrics (ALSO) [<http://www.also-uk.com/>].
- Practical Obstetric Multi-Professional Training (PROMPT) [<http://www.promptmaternity.org/>].
- Managing Medical and Obstetric Emergencies and Trauma (mMOET), Advanced Life Support Group (ALSG) [<http://www.alsg.org/home/>].
- The Birth Trauma Association [<http://www.birthtraumaassociation.org.uk/>].

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.
Appendix S1. Maternal Collapse literature search strategy

References

1. Tunçalp O, Hindin MJ, Souza JP, Chou D, Say L. The prevalence of maternal near miss: a systematic review. *BJOG* 2012;119:653–61.
2. Beckett VA, Knight M, Sharpe P. The CAPS Study: incidence, management and outcomes of cardiac arrest in pregnancy in the UK: a prospective, descriptive study. *BJOG* 2017;124:1374–81.
3. Knight M, Nair M, Tuffnell D, Kenyon S, Shakespeare J, Brocklehurst P, et al. editors. *Saving Lives, Improving Mothers' Care – Surveillance of Maternal Deaths in the UK 2012–14 and Lessons Learned to Inform Maternity Care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2009–14*. Oxford: National Perinatal Epidemiology Unit, University of Oxford; 2016.
4. Knight M, Kurinczuk JJ, Tuffnell D, Brocklehurst P. The UK Obstetric Surveillance System for rare disorders of pregnancy. *BJOG* 2005;112:263–5.
5. Healthcare Improvement Scotland. Scottish Confidential Audit of Severe Maternal Morbidity: reducing avoidable harm. 10th Annual Report Edinburgh: HIS 2014.
6. Manning E, O'Farrell IB, Corcoran P, de Foubert P, Drummond L, McKernan J, et al. *Severe Maternal Morbidity in Ireland Annual Report 2015*. Cork: National Perinatal Epidemiology Centre; 2017.
7. Kayem G, Kurinczuk J, Lewis G, Golightly S, Brocklehurst P, Knight M. Risk factors for progression from severe maternal morbidity to death: a national cohort study. *PLoS ONE* 2011;6:e29077.
8. Royal College of Obstetricians and Gynaecologists. *Epilepsy in Pregnancy. Green-top Guideline No.68*. London: RCOG; 2016.
9. Confidential Enquiry into Maternal and Child Health. *Saving Mothers' Lives: Reviewing Maternal Deaths to Make Motherhood Safer – 2003–2005. The Seventh Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom*. London: CEMACH; 2007.
10. Knaus WA, Zimmerman JE, Wagner DP, Draper EA, Lawrence DE. APACHE-acute physiology and chronic health evaluation: a physiologically based classification system. *Crit Care Med* 1981;9:591–7.
11. Lee A, Bishop G, Hillman KM, Daffurn K. The medical emergency team. *Anaesth Intensive Care* 1995;23:183–6.
12. Morgan RJM, Williams F, Wright MM. An early warning scoring system for detecting developing critical illness. *Clin Int Care* 1997;8:100–1.
13. Kause J, Smith G, Prytherch D, Parr M, Flabouris A, Hillmak K; Intensive Care Society (UK); Australian and New Zealand Intensive Care Society Clinical Trials Group. A comparison of antecedents to cardiac arrests, deaths and emergency intensive care admissions in Australia and New Zealand, and the United Kingdom—the ACADEMIA study. *Resuscitation* 2004;62:275–82.
14. Watkinson PJ, Barber VS, Price JD, Hann A, Taressenko L, Young JD. A randomised controlled trial of the effect of continuous electronic physiological monitoring on the adverse event rate in high risk medical and surgical patients. *Anaesthesia* 2006;61:1031–9.
15. Jacques T, Harrison GA, McLaws ML, Kilborn G. Signs of critical conditions and emergency responses (SOCCER): a model for predicting adverse events in the inpatient setting. *Resuscitation* 2006;69:175–83.
16. Stenhouse C, Coates S, Tivey M, Allsop P, Parker T. Prospective evaluation of a modified early warning score to aid earlier detection of patients developing critical illness on a general surgical ward. *Br J Anaesth* 2000;84:663.
17. Goldhill DR, McNarry AF, Mandersloot G, McGinley A. A physiologically-based early warning score for ward patients: the association between score and outcome. *Anaesthesia* 2005;60:547–53.
18. Subbe CP, Slater A, Menon D, Gemmell L. ASSIST: a screening tool for critically ill patients on general medical wards. *Intensive Care Med* 2002;28:S21.
19. Gao H, McDonnell A, Harrison DA, Moore T, Adam S, Daly K, et al. Systematic review and evaluation of physiological track and trigger warning systems for identifying at-risk patients on the ward. *Intensive Care Med* 2007;33:667–79.
20. Hillman K, Chen J, Cretikos M, Bellomo R, Brown D, Doig G, et al. MERIT study investigators. Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. *Lancet* 2005;365:2091–7.
21. National Institute of Health and Care Excellence. *Acutely Ill Patients in Hospital: Recognition of and Response to Acute Illness in Adults in Hospital*. Clinical Guideline No. 50. London: NICE; 2007.
22. Gopalan PD, Muckhart DJ. The critically ill obstetric patient: what's the score? *Int J Obstet Anesth* 2004;13:144–5.
23. Royal College of Physicians. National Early Warning Score (NEWS) 2. *Standardising the Assessment of Acute-illness Severity in the NHS*. Updated report of a working party. London: RCP; 2017.
24. Resuscitation Council (UK). Adult advanced life support. [https://www.resus.org.uk/resuscitation-guidelines/adult-advanced-life-support/#reversible]. Accessed 13 January 2019.
25. Selo-Ojeme DO, Welch CC. Review: spontaneous rupture of splenic artery aneurysm in pregnancy. *Eur J Obs Gynae Reprod Biol* 2003;109:124–7.
26. Glover P. Blood losses at delivery: how accurate is your estimation? *Aust J Midwifery* 2003;16:21–4.
27. Toledo P, McCarthy RJ, Hewlett BJ, Fitzgerald PC, Wong CA. The accuracy of blood loss estimation after simulated vaginal delivery. *Anaesth Analg* 2007;105:1736–40.
28. Knight M, UKOSS. Antenatal pulmonary embolism: risk factors, management and outcomes. *BJOG* 2008;115:453–61.
29. Fitzpatrick KE, Tuffnell D, Kurinczuk JJ, Knight M. Incidence, risk factors, management and outcomes of amniotic-fluid embolism: a population-based cohort and nested case-control study. *BJOG* 2016;123:100–9.
30. Morgan M. Amniotic fluid embolism. *Anaesthesia* 1979;4:20–32.
31. Tuffnell DJ. United Kingdom amniotic fluid embolism register. *BJOG* 2005;112:1625–9.
32. Clark SL, Hankins GD, Dudley DA, Dildy GA, Porter TF. Amniotic fluid embolism: analysis of the national registry. *Am J Obstet Gynecol* 1995;172:1158–67.
33. Conde-Agudelo A, Romero R. Amniotic fluid embolism: an evidence-based review. *Am J Obstet Gynecol* 2009;201:445.e1–e13.
34. Gei AF, Vadhera RB, Hankins GD. Embolism during pregnancy: thrombus, air and amniotic fluid. *Anaesthiol Clin North Am* 2003;21:165–82.
35. Kobayashi H. Amniotic fluid embolism: anaphylactic reactions with idiosyncratic adverse response. *Obstet Gynecol Surv* 2015;70:511–7.
36. Houze d'A, Petit S, Devisme L, Deruelle P. Can the presence of amniotic emboli in the myometrial vasculature be interpreted as a sign of amniotic fluid embolism? *Am J Obstet Gynecol* 2012;206:S54.
37. Legrand M, Rossignol M, Dreux S, Luton D, Ventré C, Barranger E, et al. Diagnostic accuracy of insulin-like growth factor binding protein-I for amniotic fluid embolism. *Crit Care Med* 2012;40:2059–63.
38. Malhotra S, Yentis SM. Reports on Confidential Enquiries into Maternal Deaths: management strategies based on trends in maternal cardiac deaths over 30 years. *Int J Obstet Anesth* 2006;15:223–6.