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Anaesthesia

Emergency management of maternal collapse and arrest

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Summary

- The cause of maternal collapse and cardiorespiratory arrest is not always immediately apparent
- A generic approach based on Basic and Advanced Adult Life Support is recommended
- Key modifications to these algorithms are required in pregnancy. These include early intubation and the use of lateral tilt or uterine displacement
- If circulation is not restored during cardiopulmonary resuscitation, delivery of the baby by perimortem caesarean section should be accomplished within 5 minutes of arrest
- Senior multidisciplinary help should be summoned immediately by defined emergency pathways.

INTRODUCTION

Maternal collapse is a spectrum of clinical presentations from an uncomplicated faint to sudden unexpected cardiac arrest in a term mother.

Around two-thirds of pregnancy-related deaths occur during childbirth or in the immediate postpartum period.[1] The commonest causes of world-wide maternal mortality are shown in Table 1, although it should be noted that there is widespread regional variation.

Indirect causes may be due to cardiac disease, non-pregnancy related sepsis (e.g. influenza), neurological conditions, psychiatric illness and malignancy.[2] Less common causes include pulmonary or amniotic fluid embolism, cardiovascular disease, trauma and complications from anaesthesia.

Fundamentally, the reason for the collapse may not initially be obvious. Therefore, a generic approach to resuscitation may be helpful, and can be augmented by specific treatments as the diagnosis become apparent.

Resuscitation during pregnancy

Prior to 22-24 weeks gestation, resuscitation of a collapsed pregnant woman follows the European Resuscitation Council Basic and Advanced Life Support algorithms (BLS and ALS). After this point, resuscitation is complicated by the progressively significant maternal anatomical and physiological changes discussed in this article.

Whilst the algorithms and the ABC (airway, breathing, circulation) approach remain the basis of cardiopulmonary resuscitation, modifications are required in this group. Sample obstetric arrest algorithms are shown in Figure 2 and 3. Senior multidisciplinary help should be summoned immediately by defined and rehearsed emergency pathways.

Factors affecting airway management

Difficult intubation

- High reported difficult intubation rate 1:250[3]
- Worsened by obesity and oedema (including larynx)
- Increased aspiration risk
- Increased intragastric pressure, reduced oesophageal tone and gastric motility delayed[4]

Prompt and effective airway management is critical to successful resuscitation. Efforts are directed at early intubation of the trachea, as it protects from aspiration of stomach contents and facilitates effective ventilation of the mother. It should be considered early in resuscitation, although attempts must not be at the expense of oxygen delivery. In the face of respiratory arrest, simple airway manoeuvres and positive pressure mask ventilation with or without cricoid pressure may be necessary until such time as intubation can be achieved. Repetitive attempts at intubation may lead to trauma and hypoxia, worsening an already disastrous situation.

The increased rate of difficult or failed intubation in obstetric patients is multi-factorial. Proposed factors

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Table 1: Global causes of maternal death 2003-2012[1]

	Abortion	Embolism	Haemorrhage	Hypertension	Sepsis	Other	Indirect
Worldwide	7.9%	3.2%	2.7%	14%	10.7%	9.6%	27.5%
Developed	7.5%	13.8%	16.3%	12.9%	4.7%	20%	24.7%
Developing	7.9%	3.1%	27.1%	14%	10.7%	9.6%	27.5%

include a reduction in training and expertise due to the increasing use of regional techniques, situational stress, and is worsened in the presence of large breasts, distortion of anatomy by cricoid pressure, obesity and oedema of the soft tissues and airway.

Difficult airway equipment in a well-organised trolley should be available in clinical areas, and staff practised in using it. Gum elastic bougies, alternative laryngoscopes may improve success, but should not delay ventilation by other means.

Since 2009, when the first edition of this article was published, conceptual advances have been made in respect to emergency obstetric airway management. In part, this reflects the increasingly cheaper availability of newer equipment such as optical laryngoscopes (see Figure 1), but importantly represents a much greater focus on oxygenation rather than achieving a definitive airway. Recent obstetric guidelines from the UK Difficult Airway Society (DAS) suggest only two attempts at intubation (or three if an experienced colleague is available) before moving onto a supraglottic airway device or facemask ventilation.

In the emergency 'cannot intubate, cannot oxygenate' situation, emergency cricothyroidotomy should be considered early.

The large NAP4 audit project suggested a surgical technique may be more successful than a cannula cricothyroidotomy[6].

Although this is a less comfortable technique for many anaesthetists unused to wielding a scalpel, it should be practised as part of the emergency drill and the appropriate equipment should be standardised on the difficult airway trolley as part of 'plan D'.

In short, the Resuscitation Council ALS guidance to 'intubate early' in maternal collapse must not take primacy over establishment of oxygenation by any means. Supraglottic airways (and particularly second-generation laryngeal mask airways, if available) represent a reasonable compromise, and careful consideration of continued resuscitation and maintenance of anaesthesia with such devices should be made. This point is elucidated well in the DAS 'Proceed with Surgery?' risk-balance criteria.[7] Ultimately, the final decision regarding airway management will depend on a practitioner's clinical judgement.

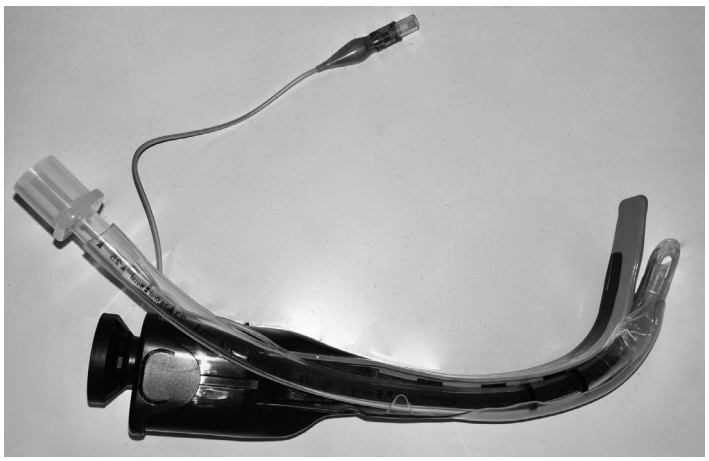

Figure 1: AirTraq battery-powered optical laryngoscope

Factors affecting breathing (ventilatory) management

Higher ventilatory requirements

- Decreased functional residual capacity (FRC) by 10-15%
- Increase in basal oxygen requirements by 20-30%
- Decreased chest compliance due to abdominal pressure

A combination of increased oxygen requirements and reduced ventilatory capacity results in rapid hypoxia once normal breathing ceases. The diaphragm is displaced upwards by the gravid uterus and exacerbates the difficulties in achieving effective positive pressure ventilation. Whilst an endotracheal tube allows high positive pressures to be employed, this may have a further deleterious effect on the cardiac output from chest compressions. This is improved following perimortem caesarean section (see section below).

Ventilation should follow usual Adult Life Support guidelines, with 100% oxygen if available. Initially two ventilations after every 30 chest compressions then asynchronous (uninterrupted) following intubation, at a rate of about 10 breaths min^{-1}.

Factors affecting circulatory management

Anatomical

- Mediastinum displaced upwards in chest
- Aortocaval compression by gravid uterus when supine

Physiological

- Increased cardiac output at rest (around 40- 50%)
- Increased blood volume (up to 60%)

Both blood volume and basal cardiac output increase dramatically from the first trimester, with around 25% of cardiac output supplying the utero-placental circulation at term. During cardiac arrest in non-pregnant subjects, closed chest compressions provide up to 30% of normal cardiac output.[9] In pregnancy, the effect of aorto-caval compression by the bulky uterus in the supine position is likely to worsen this considerably. For this reason, it is imperative to mechanically displace the uterus leftwards from the midline to reduce this effect. The ideal full left lateral position is not compatible with cardiopulmonary resuscitation, and so a compromise must be reached. A left lateral tilt of 15-30° can be achieved using a hard board but soft pillows or wedges should be avoided as chest compressions are unlikely effective[9]. Alternatively, manual leftwards displacement of the uterus using external pressure can be employed.

Table 2

Indications for perimortem caesarean section
• Estimated gestational age > 20 weeks
• Person able to perform procedure*
• Resources to allow post-operative care of mother (and ideally child, although of secondary importance)
• Peri-mortem caesarean section should be considered at the earliest stage unless there is return of spontaneous circulation
*This does not need to be an obstetrician

Table 3

Services involved in effective obstetric emergency plan
• Obstetricians
• Midwives
• Anaesthetist
• Critical Care
• Haematology
• Ancillary (theatre staff, porters etc.)

Circulatory life support should generally follow standard guidelines, with large-bore IV access, use of epinephrine, amiodarone and defibrillation as appropriate, and identification and treatment of the underlying cause. Chest compressions should be performed at a rate of 100-120min^{-1} to a depth of 5-6cm, with 30 chest compressions followed by a pause for 2 ventilations.

Once an airway is inserted chest compressions should become continuous. Exclusion of the 4 'H's and 4 'T's in the ALS algorithm to determine the cause of arrest may help. Briefly these are: hypoxia, hypothermia, hypovolaemia (include haemorrhage) and hyperkalaemia (including other biochemical abnormalities including hypokalaemia, hypocalcaemia, acidaemia and other metabolic disorders) followed by thrombosis (consider acute coronary syndrome or pulmonary embolus), toxins, tamponade (cardiac tamponade usually only seen after penetrating chest trauma), and tension pneumothorax.

It has become clear that cardio-pulmonary resuscitation remains significantly impaired by the gravid uterus after around 22-24 weeks gestation, despite the above management. Accordingly, surgical evacuation of the uterus has preceded many successful resuscitation attempts. Therefore if cardiopulmonary resuscitation is unsuccessful, delivery of the baby by perimortem section ('resuscitative hysterotomy') should be accomplished within 5 minutes. The indications for this are shown in Table 2. The logistics of this are challenging, and the need to avoid delay is likely to preclude transfer of the mother to an operating theatre.

A simple kit of gloves, scalpel and swabs is potentially life saving and should form part of a readily accessible emergency obstetric trolley.

If unknown, estimation of gestational age should be made clinically by observation and palpation. Intervention should not be delayed for formal uterine or foetal assessment.

Whilst primarily a life saving procedure for the mother, infants appear to have the best chance of survival when delivered within 5 minutes of maternal arrest (although some reports show survival up to 30 minutes[10]) and peri-mortem caesarean section should be considered at the earliest stage. The recommendation for performing peri-mortem caesarean section within 4 minutes of arrest was made by the American Heart Association in 1986. Following this, a review of cases[11] over the next two decades suggested that early delivery of the infant in cardiac arrest was associated with much improved outcomes for both mother and child (including neurologically), and certainly did not worsen the situation. The intervention should be completed within 5 minutes. A suitably specialised doctor may not always be readily available, so the skill set and experience of the operator needs to be balanced with the dire circumstances. A midline laparotomy may suit non-obstetricians as it is more familiar and avoids a possibly full bladder. A midline laparotomy will also allow better exposure to intra-abdominal organs, which may be relevant in the context of cardiovascular collapse without obvious cause.

Multidisciplinary team involvement

Effective management of obstetric emergencies relies heavily on the skills and support of several individuals and services (Table 3).

Adequate planning, preparation and rehearsal of emergency drills are crucial to this process. Many hospitals will have protocols and activation pathways to ensure that these services are rapidly engaged in the event of an emergency. Daily tasks involve checking of equipment, drugs and communication systems. Longer term tasks involve training, audit, service development, case review and risk management.

If unsuccessful, the decision to terminate CPR should be agreed by the entire resuscitation team. It is unlikely to be appropriate to stop if the patient is in VT or VF, however prolonged asystole without the identification of a reversible cause should prompt discussions about stopping resuscitation attempts.

Thorough records should be kept throughout and following the resuscitation, noting times of drugs, decisions, interventions and transfers.

Post resuscitation care

Following successful resuscitation, meticulous attention must be paid to on-going support and treatment of the mother, ideally in a high dependency or intensive care environment. Less immediate complications of obstetric emergencies, such as myocardial damage from post-partum haemorrhage[12], renal failure and pulmonary thrombo-embolic disease[13], may be underestimated contributors to mortality and morbidity.

It is good practice that senior staff members take responsibility for informing the family of key progress and outcomes throughout. Additionally, a team debrief should be carried out whether the resuscitation is successful or not.

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Figure 2: Emergency management of maternal collapse and arrest (BLS). Modified Basic Life Support algorithm for in-hospital obstetric emergencies

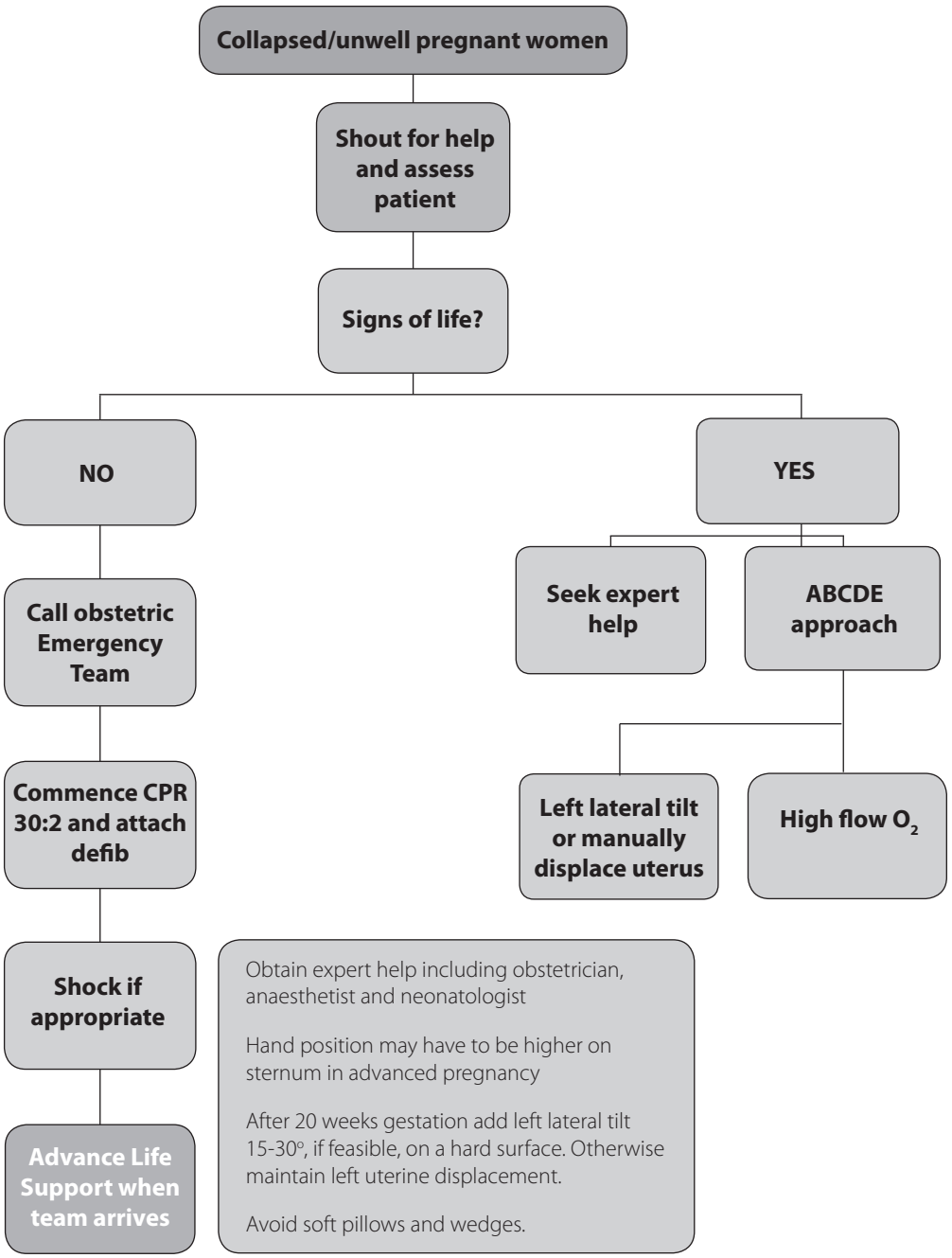

Figure 3: Emergency management of maternal collapse and arrest (ALS). Modified Advanced Life Support algorithm for in-hospital obstetric emergencies