A left lateral tilt of the woman from head to toe at an angle of 15–30° on a firm surface will relieve aortocaval compression in the majority of pregnant women and still allow effective chest compressions to be performed in the event of cardiac arrest. C

In cases of major trauma, the spine should be protected with a spinal board before any tilt is applied. In the absence of a spinal board, manual displacement of the uterus should be used. ✓

There are essential adaptations to the management of a collapsed pregnant woman because of the physiological and anatomical changes of pregnancy.

After 20 weeks' gestation or when the uterus is palpable at or above the level of the umbilicus, manual uterine displacement is the preferred method to reduce compression of the inferior vena cava and aorta by the gravid uterus if performed correctly. The technique should be performed using an 'up, off and over' method.[63,64] This is achieved by placing a hand below the uterus on the maternal right and pushing the uterus slightly upwards and to the left. This maintains the woman in a supine position, allowing for continuous effective cardiac compressions if necessary.[65] Evidence level 2+

A left lateral tilt of the woman from head to toe at an angle of 15–30° to relieve aortocaval compression[66,67] can be achieved on a tilting operating table, with a solid wedge (of an appropriate size)[68] and spinal board, and allow for effective chest compressions to be performed[67]. In the absence of these, manual displacement of the uterus is preferable. Using soft surfaces, such as a bed, or objects, such as pillows or blankets, are not nearly as effective, compromise effective chest compressions, and should not be used (a video of the procedure can be found at https://www.youtube.com/watch?v=2VyqGqDNlLc). Evidence level 2+

4.4.3. Airway

Intubation in an unconscious woman with a cuffed endotracheal tube should be performed immediately by an experienced anaesthetist. ✓

The airway in pregnancy is more vulnerable because of the increased risk of regurgitation and aspiration.[63,69] For this reason, it is important to clear and protect the airway as early as possible. Intubation with a cuffed endotracheal tube should then be performed. This will protect the airway, ensure good oxygen delivery and facilitate more efficient ventilation. Intubation can be more difficult in pregnancy, so this should be undertaken by someone with appropriate skills. Failed intubation is more common in the pregnant than nonpregnant patient and a plan for failed intubation should always be considered. A full description of the failed intubation drill is available from the Difficult Airway Society.[70] In brief: Maintain oxygenation; Call for help; Supraglottic airway device; Front of Neck access. During cardiac arrest in a nonpregnant woman it is acceptable to use a supraglottic device, such as a laryngeal mask airway as an alternative to the endotracheal tube.[71] In pregnant women, physiological changes in the airway, such as hyperaemia, hypersecretion and oedema lead to increased friability of the airway mucosa causing bleeding and difficulties in visualisation for intubation.[69] Pregnant women are also more likely to regurgitate and aspirate in the absence of a secured airway (endotracheal tube) than a nonpregnant woman, and thus, the early involvement of an appropriately skilled anaesthetist remains best practice.[69] Evidence level 4

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Waveform capnography must be used to confirm and continually monitor tracheal tube placement, and may be used to monitor the quality of CPR and to provide an early indication of return of spontaneous circulation.[24]

Appendix 5 of this guideline presents suggested equipment that should be available for cases where airway management may be difficult.

4.4.4. Breathing

Supplemental high flow oxygen should be administered as soon as possible to counteract rapid deoxygenation. ✓

Bag and mask ventilation or insertion of a simple supraglottic airway should be undertaken until intubation can be achieved. ✓

Maternal physiological changes lead to increased oxygen requirements. Furthermore, in maternal collapse, reduced oxygen reserve and a reduced functional residual capacity leads to deoxygenation occurring more rapidly than in nonpregnant women. Therefore, supplemental oxygen should be added with a gas flow of 10–15 l per minute to whatever method of ventilation is being employed.[62] Evidence level 2++

Ventilation, using a face mask, or a supraglottic airway device and self-inflating bag, or via a cuffed endotracheal tube, may be more difficult because of the physiological changes of pregnancy as previously described. It can also be difficult to see the chest rise.

4.4.5. Circulation

If the airway is clear and there is no breathing, chest compressions should be commenced immediately. B

Two wide-bore cannulae (minimum 16 gauge) should be inserted as soon as possible. If peripheral venous access is not possible, early consideration of central venous access, intraosseous access or venous cutdown should be considered. ✓

There should be an aggressive approach to volume replacement, although caution should be exercised in the context of pre-eclampsia or eclampsia. ✓

Abdominal ultrasound by a skilled operator can assist in the diagnosis of concealed haemorrhage. C

The same defibrillation energy levels should be used as in a nonpregnant woman. B

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Chest compressions should be commenced immediately in the absence of a cardiac output.[72] Compressions may be made difficult because of obesity and if the woman is in the tilted position. Hand position should be over the centre of the chest and it is important to ensure that the direction of compression is perpendicular to the chest wall. If a left lateral tilt is employed then the angle of tilt must be taken into account when performing chest compressions. Immediate and competent chest compressions have been found to have a direct impact on maternal outcome.[72]

Evidence level 2++

In total, 30 chest compressions (at a rate of 100–120 per minute) should be performed for every two ventilation breaths initially. If there are two rescuers, one should be responsible for chest compressions and ventilation breaths, whilst the other should ensure aortocaval decompression with manual uterine displacement. Once intubation is performed, the ratio of chest compressions to ventilation breaths should be desynchronised. Ventilation should be at a rate of 10 breaths per minute with continuous chest compressions at 100–120 per minute. Because chest compressions are not as effective after 20 weeks of gestation, there should be early recourse to delivery of the fetus and placenta if CPR is not effective.[24] In woman with a very high BMI chest compressions can be performed over the head of the woman if there is sub-optimal rescuer positioning.[73]

Evidence level 2++

Ideally, early vascular access will be obtained with wide-bore intravenous cannulae inserted above the level of the diaphragm. This allows the administration of fluids to not be affected by aortocaval compression. If peripheral venous access is difficult, there should be early consideration of central venous access, intraosseous access[74] or venous cutdown to aid volume replacement.

Haemorrhage is the most common cause of maternal collapse, and is a consequence of other causes of collapse. There must be a high index of suspicion for bleeding and awareness of the limitations of maternal clinical signs. Caution must be exercised in the clinical context of severe pre-eclampsia and eclampsia, where fluid overload can contribute to poor outcome. In the case where significant haemorrhage, and pre-eclampsia or eclampsia exist, careful fluid management is essential.

Very occasionally, ultrasound by a skilled operator can assist in the diagnosis of free fluid associated with intra-abdominal bleeding, although laparotomy should not be delayed if the findings are negative and/or the index of suspicion is high.[75–78] This, however, should not interfere with the resuscitation process.

Evidence level 2+

If defibrillation is required, the same settings should be used as in the nonpregnant adult, as there is no change in thoracic impedance.[79] Adhesive defibrillator pads are preferable to defibrillator paddles, and the left defibrillation pad should be applied lateral to the left breast. If the woman's breasts are large or engorged, defibrillator pads may need to be placed on the anterior and posterior precordium to optimise defibrillation energy transfer.[72] The energy from the defibrillation shock is directed across the heart and there is no evidence that shocks from a direct current defibrillator have an adverse effect on the fetus. Uterine monitors should be removed before shock delivery.

Evidence level 2++

4.4.6. Drugs

There should be no alteration in algorithm drugs or doses used in the Resuscitation Council (UK) protocols. ✓

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4.4.7. Other considerations

Common, reversible causes of maternal cardiopulmonary arrest should be considered throughout the resuscitation process. D

Resuscitation efforts should be continued until a decision is taken by the consultant obstetrician and consultant anaesthetist to discontinue resuscitation efforts. This decision should be made in consensus with the cardiac arrest team. ✓

Throughout the resuscitation process, consideration should be given to the cause of the collapse, so that ongoing therapy can be directed towards the specific cause to optimise outcome.[24] Evidence level 4

4.5. When, where and how should perimortem caesarean section (PMCS) be performed?

In women over 20 weeks of gestation, if there is no response to correctly performed CPR within 4 minutes of maternal collapse or if resuscitation is continued beyond this, then PMCS should be undertaken to assist maternal resuscitation. Ideally, this should be achieved within 5 minutes of the collapse. D

PMCS should not be delayed by moving the woman. It should be performed where maternal collapse has occurred and resuscitation is taking place. ✓

The operator should use the incision, which will facilitate the most rapid access. This may be a midline vertical incision or a suprapubic transverse incision. ✓

A scalpel and umbilical cord clamps (or alternative ligatures) should be available on the resuscitation trolley in all areas where maternal collapse may occur, including the accident and emergency department. ✓

The concept of PMCS was introduced by Katz et al.[80] in 1986. This research group initially focused on infant survival and found that 69% of infants survived when PMCS was performed within 5 minutes. However, when Katz et al. explored maternal outcomes, they found that hypoxic brain injury only occurred if PMCS was performed after 6 minutes. Although the research basis for this recommendation is scarce, the rationale for this timescale is that pregnant women become hypoxic more quickly than nonpregnant women, and irreversible brain damage can ensue within 4–6 minutes. The term 'resuscitative hysterotomy'[81] has been introduced by non-obstetric clinicians (for example, emergency medicine clinicians and paramedics) in the trauma and emergency department environments, as the procedure is primarily used to assist maternal resuscitation rather than to save the fetus. Obstetricians should be aware of this terminology to ensure effective communication.[82] The gravid uterus impairs venous return and thus reduces cardiac output by approximately 60% secondary to aortocaval compression.[83] Delivery of the fetus and placenta reduces oxygen consumption, improves venous return and cardiac output, facilitates chest compressions and makes ventilation easier. It also allows for internal chest compressions by inserting the hand through the open abdomen up to the diaphragm and compressing the posterior aspect of the heart against the Evidence level 4

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chest wall. This improves cardiac output beyond that achieved in closed chest compressions.[84] At less than 20 weeks of gestation there is no proven benefit from delivery of the fetus and placenta. PMCS should be considered a resuscitative procedure, to be performed primarily in the interests of maternal survival.

Evidence level 4

Delivery within 5 minutes of maternal collapse improves the chances of survival for the baby. If maternal resuscitation is continuing beyond 4 minutes of the collapse, delivery of the fetus and placenta should be performed as soon as possible to aid this, even if the fetus is already dead. Case series have shown that swift delivery of the baby improves maternal outcome even after 5 minutes have elapsed from maternal collapse.[85] There is, of course, the possibility that the outcome could be that the surviving child has sustained damage in an attempt to preserve the life of the mother.

Evidence level 2+

Time should not be wasted by moving the woman to an operating theatre; a PMCS can be performed anywhere, with a scalpel being the only essential equipment required.[86,87] With no circulation, blood loss is minimal, and no anaesthetic is required. If resuscitation is successful following birth, there should be prompt transfer to an appropriate environment at that point, as well as anaesthesia and sedation, to control ensuing haemorrhage and complete the operation. The doctrine of 'best interests of the patient' would apply to conduct of this procedure being carried out without consent.

Evidence level 4

In terms of the best incision to use, a midline abdominal incision and a classical uterine incision will give the most rapid access. However, many will be unfamiliar with this approach and as delivery can be achieved rapidly with a transverse approach, the operator should use the approach they are most comfortable with.[86] Manual uterine displacement can be stopped immediately prior to incision. If resuscitation is successful, the uterus and abdomen should be closed in the usual way to control blood loss and minimise the risk of infection. Where the resuscitation is not successful, the case should be discussed with the coroner or procurator fiscal to determine whether a postmortem is required before any medical devices, such as lines and endotracheal tube are removed, as per the Royal College of Pathologists recommendations.[88]

Evidence level 2++

To ensure there are no delays in executing a PMCS when indicated, the equipment necessary should be immediately available on the resuscitation trolley. All that is required is a fixed blade scalpel and two clamps for the umbilical cord. In the absence of a specific tray, a scalpel alone will enable delivery of the fetus and placenta, and cutting of the umbilical cord, which can then be manually compressed until a clamp is found if the baby is alive.

4.6. *What does the ongoing management consist of?*

Senior staff with appropriate experience should be involved at an early stage. ✓

Transfer should be supervised by an adequately skilled team with appropriate equipment. ✓

Ongoing management depends on the underlying cause of the collapse and appropriate senior staff must be involved early. It is essential the woman is transferred to an appropriate environment to ensure optimal ongoing care. This would usually mean transfer to a high dependency or critical care area with appropriate staff and monitoring facilities.[68] Please see Appendix 6 for more information on post collapse management.

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