Ballistic Trauma in Pregnancy

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24.1 Introduction

It has been reported that trauma will complicate approximately 1 in 12 pregnancies [1]. Within the UK the latest triennial report on maternal deaths 2012–2014 reported that 41/241 women died as a result of 'coincidental' deaths (deaths from unrelated causes which happen to occur in pregnancy or the puerperium) [2]. Of those 9 were the result of homicide and 32 by 'other causes' which include trauma. No suicides were caused by gunshot in this triennium. Morbidity data is not routinely collected nationally. In a large retrospective study 9% of the admissions involved penetrating trauma to the abdomen and 77% were gun related (22/321) [3]. Worldwide there is a paucity of good quality data evaluating ballistic trauma in pregnancy with mainly case reports and retrospective studies looking at penetrating trauma. A systematic review reported estimates of incidence/prevalence of penetrating trauma of 3.27/100,000 live births which are the same as those reported outside of pregnancy (using data from 2009 Centers for Disease Control and Prevention) [4]. The maternal mortality rate from penetrating trauma is less than in the non-pregnant population possibly due to the protective effect of the gravid uterus to the internal organs [5]. Trauma is pregnancy is mostly associated with intermittent partner violence (IPV) and road traffic accidents [4].

All forms of trauma in pregnancy can result in injury or death to the pregnant woman and the fetus. There is increased incidence of preterm labour, miscarriage, preterm premature rupture of membranes, uterine rupture, caesarean delivery, placental abruption and stillbirth [4]. In major trauma in pregnancy, abruption occurs in 70% of cases with fetal loss in 35% of cases whilst uterine rupture is less common (less than 1%) but with a 10% maternal mortality rate. Fetal death occurs in up to 40% of major and 2% of minor injuries [6].

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24.2 Changes in Pregnancy

Pregnant women undergo unique physiological and anatomical changes and knowledge of these can aid the team in management of the pregnant trauma patient. The possibility of pregnancy should be considered in all female trauma patients of reproductive age. A co-ordinated multi-professional approach to the care of pregnant women will improve the standard of care they receive and the latest MBRRACE-UK report highlighted that doctors should be appropriately trained in and engaged with the care of pregnant women [2].

24.2.1 Physiology

Significant physiological changes occur in pregnancy even within the first trimester and awareness of these can help in the management of pregnant women with trauma, Table 24.1.

Changes within the cardiovascular system are the most marked and occur even within the first few weeks of pregnancy. Cardiac output increases by 20% within the first trimester probably to compensate for the peripheral vasodilation which causes a 25–30% fall in systematic vascular resistance. By 20–28 weeks cardiac output has increased by up to 40% through an increase in stroke volume and to a lesser degree by increases in heart rate. Blood pressure falls within the 1st and 2nd trimesters and rises to non-pregnant levels in the 3rd trimester.

Plasma volume increases throughout pregnancy to approximately 150% of normal by 34 weeks' gestation (from 5 to 6–7.5L). This increase is greater than that of the red blood cell mass resulting in a dilutional anaemia (normal Hb > 105 g/dl). The platelet count falls progressively but usually remains within the normal range and women are not thought to thrombocytopenic unless the level is $<100 \times 10^9$ cells/l. Further changes within the coagulation cascade induce a pregnancy-induced hypercoagulability which is protective, preventing bleeding in labour and the post partum period. Pregnant and postnatal women are at increased risk of venothromboembolism.

The gravid uterus compresses the vena cava and aorta in the supine position and at term the inferior vena cava is occluded in 90% of supine pregnant women. This decreases venous return and cardiac stroke volume (up to 70%). During assessment and resuscitation of a pregnant woman, aortocaval compression should be kept to a minimum. This can be achieved by manual uterine displacement to the left when supine or by tilting the firm surface she is on, e.g. the operating table, 15–30 degrees to the left; Fig. 24.1. Once the baby is delivered then the vena cava flow returns and both venous return and cardiac output return to normal.

The physiological changes mean that a woman can tolerate haemorrhage of up to 1500 ml with almost no noticeable changes in her vital signs. Uterine artery vasoconstriction occurs to maintain the mother at the expense of the fetus and there is no autoregulation of uterine blood flow. Assessment of the pregnant woman should include assessment of the fetus as the fetus can show signs of poor uteroplacental blood flow before the mother shows changes in her vital signs (5th vital sign).

Table 24.1 Physiological changes in pregnancy

Cardiovascular		
• Cardiac output	Increases by 20–30% (by 10 weeks) and 40% at term	
• Heart rate	Increases by 10–15 bpm (16%)	
• Blood pressure	Decreases by 10–15 mmHg systolic and diastolic in 1st and 2nd trimesters	
• Peripheral vascular resistance	Decreases	
• Plasma volume	Increases by 50%	Dilutional anaemia
• Aortocaval compression	In supine position the gravid uterus compresses the inferior vena cava, reducing venous return to the heart	
Respiratory		
• Diaphragm	Splinting and elevation by 4 cm	Susceptible to hypoxia sooner—Smaller reserve to withstand apnoea. More difficult to ventilate.
• Minute ventilation	Increases by 40–50%	
• Tidal volume	Increases by 30–40%	
• Oxygen requirement	Increases by 20%	
• Functional residual capacity	Reduces by 20%	
• pH changes	Fully compensated respiratory alkalosis pH 7.40–7.46	
Gastrointestinal		
• Gastric emptying	Delayed	Vomiting and passive regurgitation more common
• Oesophageal sphincter	Relaxes	
Other		
• Coagulation cascade	Reduced platelet count Increase in fibrinogen (up to 50%) Resulting in a hypercoagulative state	Protective to prevent bleeding in labour and postpartum
• Musculoskeletal	Increased ligament laxity	

There is a 20% increase in the oxygen requirement (fetus and mother) through an increase in the metabolic rate and increased consumption of oxygen. There is a 40–50% increase in minute ventilation mostly due to an increase in tidal volume with no real change in the respiratory rate and a consequent maternal hyperventilation. A mild compensated respiratory alkalosis is normal in pregnancy (7.40–7.46) compared to the non-pregnant state (7.34–7.44). The gravid uterus causes upward displacement of the abdominal organs, diaphragmatic elevation, subsequent decreased lung compliance and a resultant reduced functional residual capacity by up to 20%. This means that pregnant women become hypoxic quicker (smaller reserve to withstand apnoea). There is significant need to protect the airway and provide adequate ventilation, which is also hindered by oropharyngeal oedema, weight gain and larger breasts. Women can also experience a subjective feeling of breathlessness without hypoxia.

Fig. 24.1 Manual uterine displacement to the *left*

24.2.2 Gastrointestinal Changes

Nausea and vomiting are very common complaints in normal pregnancy (50–90%). Delayed stomach emptying and oesophageal sphincter relaxation are increased in pregnancy increasing the chance of pulmonary aspiration of stomach contents. Use of H_2 antagonists e.g. Ranitidine can reduce the risk. At the start of the 2nd trimester the gravid uterus begins to rise out of the pelvis pushing the bowel upwards. The peritoneum is less sensitive and the omentum is less able to contain local inflammation.

All the physiological changes result in:

- The woman being able to sustain significant blood loss before showing changes in her vital signs
- The fetus potentially showing signs of maternal compromise before the mother
- The woman not being able to tolerate apnoea for even short periods becoming hypoxic quickly
- Aortocaval compression in the supine position from the gravid uterus requiring manual displacement to the left or lateral tilting
- Apparently minor maternal trauma causing major morbidity or mortality in the fetus

24.2.3 Anatomy

Anatomical changes also take place, the most important in the abdomen and chest. The gravid uterus slowly rises out of the pelvis from 12 weeks gestation displacing the abdominal organs upwards. By 20 weeks gestation the fundus is at the level of the umbilicus and to just at the level of the lowest ribs at 32 weeks; Fig. 24.2. As the pregnancy advances the uterus changes from a thick walled structure protecting the small fetus with a relatively large amount of amniotic fluid to a thinner walled structure with a large fetus and proportionately less amniotic fluid. Thus the fetus presents a larger target for traumatic injury. The gravid uterus affords some protection to

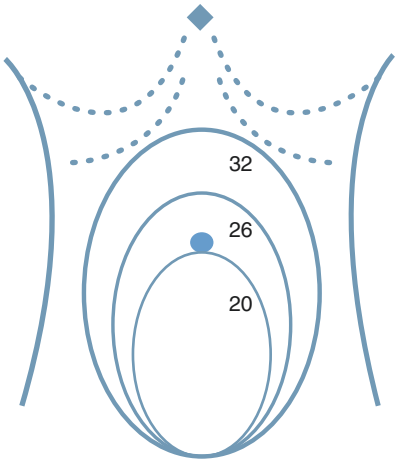

Fig. 24.2 Fundal height and gestation

retroperitoneal structures and in late pregnancy the liver and spleen, but also makes the assessment of likely injury more challenging. The peritoneum is less sensitive and the omentum is less able to contain local inflammation. The diaphragm is elevated and splinted. Smooth muscle relaxation occurs causing oesophageal sphincter relaxation with a higher risk of gastric aspiration. There is dilatation of the renal pelvis and ureters. The symphysis pubis and sacroiliac joints widen. There is generalised oedema which can involve the oropharynx. Women tend to gain weight and have larger, heavier breasts.

These changes result in:

- Pattern of injury more difficult to predict
- Risk of gastric aspiration increased
- Risk of difficult intubation
- Ventilation more difficult
- Assessment of injury more difficult
- Resuscitation in the supine position more challenging
- Placement of thoracostomy tubes should be 1–2 intercostal spaces above the usual site of insertion

Ballistic trauma associated with blast cause varying degrees of injury with the primary blast injury and then secondary blast (fragment) injuries. The main concern is of placental abruption with massive haemorrhage and fetal death. Placental abruption is the commonest cause of fetal death [4]. Placental abruption is generally associated with abdominal pain, uterine tenderness, uterine rigidity (woody) and vaginal bleeding but none of these can be present and massive haemorrhage can be concealed within the uterus. Another risk is preterm labour or miscarriage following trauma even if the injury was assessed as minor.

These changes can result in it being more difficult to recognise the deteriorating patient as identified in MBRRACE 2016 [2]. Indeed MOET (Managing Obstetric Emergencies and Trauma, Advanced Life Support Group), the Maternity Foundation (Practical Obstetric Multi-Professional Training) and the RCOG have all put together teaching packages to help with this [6, 7]. Presentation may be atypical or insidious. Signs and symptoms can be attributed to normal pregnancy changes and those not trained in pregnancy specific changes may misinterpret findings.

Modified Early Obstetric Warning Score (MEOWS) charts are very helpful in identifying the 'abnormal.' Regular monitoring of observations will aid in the recognition of changes in condition and can improve detection of life threatening illnesses; Fig. 24.3. All women who enter an acute hospital setting should have their observations recorded on a MEOWS chart [8, 9]. Changes in the scores allow prompt escalation to a specialist and reduce likelihood of delay in recognising deterioration.

24.3 Initial Assessment of the Pregnant Woman with Ballistic Trauma

Initial management follows the usual systematic approach employed by ATLS but with reference to MOET and PROMPT both of which guide management in pregnant women [6, 7, 10]. A multidisciplinary trauma team approach including an obstetrician, obstetric anaesthetist, midwife and neonatal team improves outcome [6]. The obstetrician can assess gestation, optimise uteroplacental perfusion and assess fetal wellbeing.

24.3.1 Primary Survey

If the woman is able to communicate, then directed questions concerning pregnancy, the gestation and presence of fetal movements should be asked. Women are not always aware that they are pregnant and women should be assumed to be pregnant until proven otherwise. A urinary pregnancy test should be taken if possible. Pregnancy causes profound physiological changes even in the 1st trimester and management decisions will be affected. Immediate life threatening problems must be managed as soon as they are identified systematica lly in the primary survey in the standard approach of A, B, C. Resuscitation of the mother is the priority and in doing so will optimise the outcome for the fetus. The team should ensure they avoid the lethal triad of hypothermia, acidosis and coagulopathy.

A quick assessment of gestational age should be made to ensure manual uterine displacement of the uterus to the left or left lateral tilt 15–30 degrees if being nursed in the supine position and over 20 weeks gestation (uterine fundus at the umbilicus), Fig. 24.1.

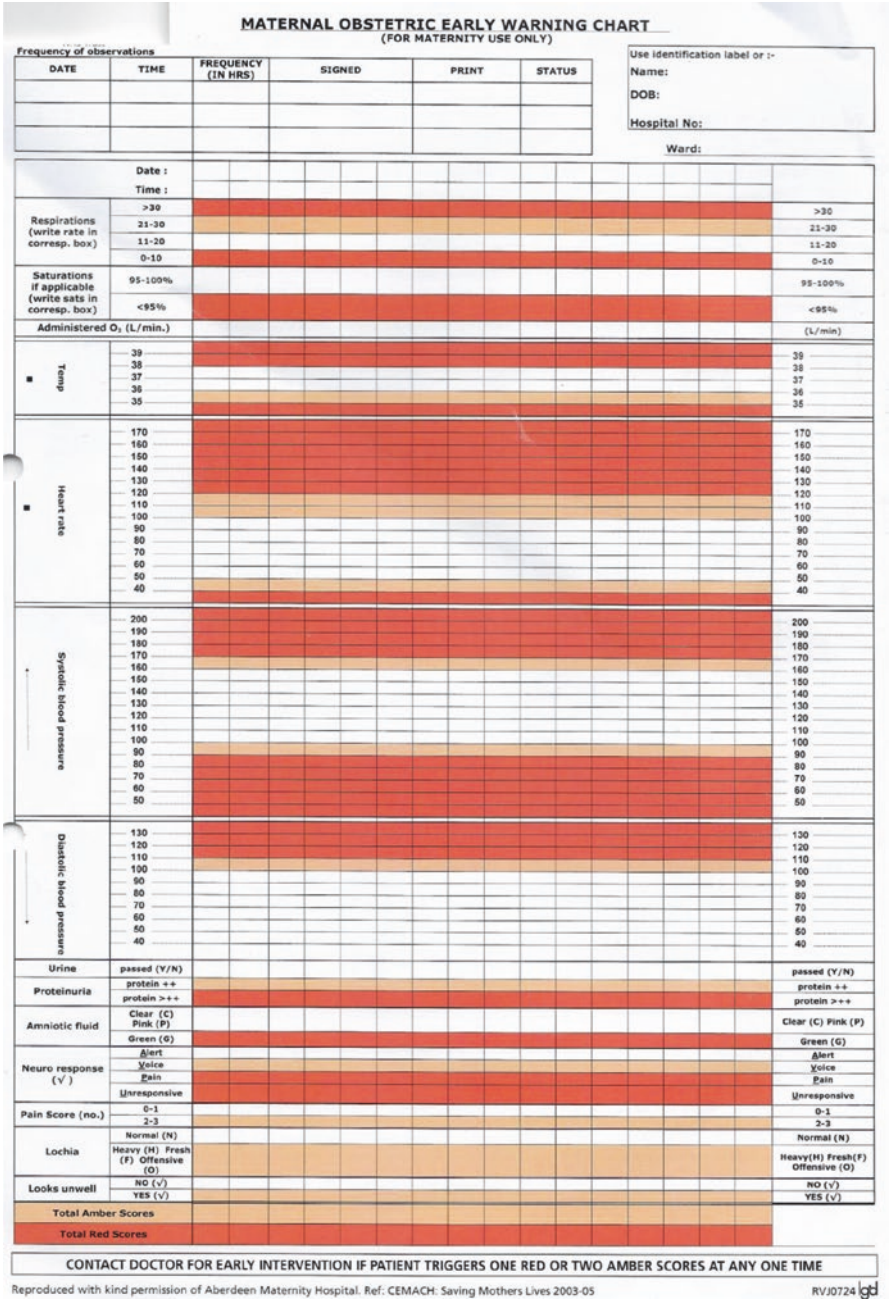

Fig. 24.3 An example of a Modified Early Warning Score (MEOWS) chart (reproduced with the kind permission of the PROMPT Foundation)

24.3.1.1 Airway

Pregnant women have a greater risk to their airway and difficult intubation compared to non-pregnant women. If airway problems are anticipated given the injury sustained then early intubation should be considered. To avoid gastric aspiration a woman with reduced consciousness should have a naso-gastric tube inserted insert two large-bore intravenous cannulae whilst taking baseline full blood count, coagulation, group and save and renal function.

24.3.1.2 Breathing

High flow oxygen via a rebreathe mask should be given to maintain maternal oxygen saturation above 95%. If a thoracostomy tube is needed then it should be inserted 1–2 intercostal spaces above the usual site of placement [6].

24.3.1.3 Circulation

Two large-bore intravenous cannulae should be inserted to allow rapid infusion of warmed crystalloid fluid or blood products. Bloods can be taken for full blood count, clotting, cross-match, renal function and a Kleihuaer test (fetal-maternal haemorrhage). Fluid resuscitation should be initiated early in pregnant women to maintain normal plasma volume but the team should be mindful of dilutional coagulopathy. Hypotensive resuscitation is not recommended in pregnant women [4, 6]. Early activation of the 'massive haemorrhage protocol' should be considered. If fully cross-matched blood is not available after 2–3.5 l of intravenous fluids have been given or if bleeding is ongoing then O-negative or type specific blood should be given without delay [11]. Clearly, this approach to the use of crystalloid fluid is a distinct feature of trauma management in obstetric patients. Vasopressors should not be used routinely in pregnant women with hypotension, rather, they should have judicial fluid resuscitation. Vasopressors have adverse effects on uteroplacental perfusion. Usual transfusion protocols should be followed with a ratio of 4 units of FFP to 6 units of red blood cells being recommended [7], and replacement of other products e.g. cryoprecipitate to keep fibrinogen greater than 2 g/l and platelets should be given when the platelet count is less than 75×10^9/l [12]. If the woman is Rhesus negative then Anti-D should be given within 72 h unless the injury is remote from the placental site [13].

Haemorrhage control should also follow the same principles as in non-pregnant patients. Compressible haemorrhage should be controlled but haemorrhage from injury to the uterus is not compressible whilst the fetus is in-utero. Specific techniques are discussed later.

Observations should be documented onto a MEOWS chart to allow easy recognition of parameters outside 'normal' for pregnancy. It should be remembered that the usual signs of hypovolaemic shock are not always easily seen in the pregnant woman.

If the woman collapses or develops cardiac arrest then the usual Advanced Life Support guidance should be followed [14]. (See Maternal Collapse).

24.3.2 Secondary Survey

Again, this should follow the standard approach but should include assessment of fetal wellbeing and abdominal pain. Maternal haemorrhage results in maternal hypovolaemia and hypoxia but can show as signs of fetal hypoxia before signs are seen in the mother. Early siting of a nasogastric tube should be considered to reduce risk of aspiration of stomach contents. Catheterisation of the bladder is helpful for monitoring but also to aid investigation of injuries sustained e.g. blood stained urine could indicate uterine trauma. Abdominal examination may reveal palpation of fetal parts ex-utero indicating uterine rupture. Continuous CTG monitoring should be considered. Assessment of fluid loss per vagina could reveal bleeding or ruptured membranes.

The woman can have all the usual diagnostic investigations to assess her injuries and these should not be delayed because of concern about radiation risk for the fetus. The majority of imaging techniques required for the management of a pregnant trauma patient deliver acceptably small doses of radiation to the fetus [6]. Cases should be discussed with a radiologist but never denied on the basis of risk to the fetus if the mother is seriously injured.

24.3.2.1 X-ray

Standard chest x-ray with shielding of the gravid uterus should be performed with the same threshold as in non-pregnant trauma.

24.3.2.2 FAST Scan

Good results have been noted in pregnancy for Focussed Assessment by Sonography in Trauma (FAST), it being a bed-side, non-invasive, repeatable test. The limitations to its use however include difficult evaluation of the Pouch of Douglas, unless in the early part of pregnancy, and it may not identify small intraperitoneal bleeds, injuries to the bowel, pancreas and diaphragm or placental abruption (misses up to 75%) for which clinical suspicion is a much better test than ultrasound [13]. Advantages of its use are for fetal heart visualisation and placental location [6].

24.3.2.3 CT

CT imaging is a highly sensitive and specific examination, superior to FAST, in detecting retroperitoneal injuries with a high negative predictive rate. It should only be performed in stable patients when there is as yet no clear indication for laparotomy [6, 10]. Although concern is often raised over the effect on the fetus of the dose of ionising radiation the majority of imaging techniques required for seriously ill patients deliver acceptably small doses of radiation to the fetus (chest, abdomen and pelvis CT scan mean 0.06–25 mGy). Imaging of pregnant woman should always be discussed with the radiology team but should rarely be denied on the basis of risk to the fetus in a seriously ill pregnant woman [6, 15].

24.3.2.4 Diagnostic Peritoneal Lavage

Although rarely used in modern trauma management, diagnostic peritoneal lavage should be done as an open supraumbilical procedure [6].

24.4 Structured Trauma Laparotomy

When a woman has sustained ballistic trauma to her abdomen the site of entry is important in deciding whether a trauma laparotomy is needed. If the entry wound is in the upper abdomen with penetration of the peritoneum there should be a low threshold to perform a laparotomy particularly if liver or spleen injuries are suspected. If the entry wound is below the level of the uterine fundus, the woman stable and the fetus dead or less than 23 weeks gestation selective non-operative management with close observations and a vaginal birth may be considered [5]. The uterus offers some protection to other structures. At laparotomy, the uterus should be carefully inspected without twisting or excessive traction and the surgeon should exclude it as a source of concealed haemorrhage. A trauma laparotomy is not an absolute indication for a caesarean section. The risk of precipitating labour after exploratory laparotomy is negligible, if proper care is taken [6]. A routine caesarean section can add a further 1000 ml of blood loss and as such significantly increase the blood loss and operative time.

24.4.1 Intraoperative Cell Salvage

This is now used routinely in obstetric practice where women are at risk of massive haemorrhage or where women refuse blood/blood products [13]. Previous concerns about amniotic fluid contamination returning into the maternal circulation causing AFE appear to be unfounded. Its use could be considered in trauma cases, although not where there is injury to the bowel or other contamination.

24.5 Caesarean Delivery

Indications for urgent caesarean delivery should include suspected uterine injury or rupture and should be only performed with an uninjured uterus to allow access to extra-uterine injuries e.g. low rectal injury or need for retroperitoneal exposure, where pelvic fixation is required to control haemorrhage, maternal cardiac arrest, suspected amniotic fluid embolus and fetal distress but remembering that maternal wellbeing is the priority. In cases of fetal death it can be more appropriate to induce labour and achieve a vaginal birth later.

24.6 Specific Haemorrhage Control

24.6.1 Antepartum Haemorrhage (APH)

When the injury is thought to be associated with massive antenatal haemorrhage (direct trauma to the uterus, uterine rupture or placental abruption) then expediting delivery is the most effective way of managing the haemorrhage control [13]. In the trauma situation this is most likely to be through a caesarean section unless the woman is in labour with the cervix fully dilated. A caesarean section in association with massive antepartum haemorrhage will be technically challenging regardless of cause. Senior obstetric assistance should be sought as well as from the neonatal team, even when there is thought to be no fetal heart activity. The baby when delivered can be examined by the neonatal team who can then decide if resuscitation is futile. Assessment of the fetal wellbeing in these situations is very difficult antenatally and so it is better than the team are present at the start of the caesarean and not called urgently later [13]. Neonatal anaemia is associated with APH. Uterine rupture, once the baby is delivered, should be repaired in a 2 or 3 layer continuous closure using an absorbable suture (Vicryl 0 or 1). Preparations should be made for a hysterectomy if bleeding persists. An APH is a major risk factor for a postpartum haemorrhage (PPH). "APH weakens and PPH kills." Regardless of the gestation, resuscitation and management of the mother take precedence.

24.6.2 Postpartum Haemorrhage (PPH)

Once the baby is delivered PPH can occur. At caesarean section it is advised that oxytocin 5 iu be given iv as the anterior shoulder of the baby is being delivered. This reduces the risk of PPH [12]. Ongoing bleeding can be managed through uterine massage—"rub up a contraction, expel clot and aim for a uterus like a cricket ball" [7]. Addition of further medications is possible with Syntometrine (oxytocin 5 IU and ergometrine 500 mcg) and/or oxytocin alone 5 IU iv. Both are equally efficacious with blood loss >1000 ml and Syntometrine better at loss <1000 ml. Oxytocin is the drug of choice if maternal blood pressure is not known or she is hypertensive but caution should be used when there is maternal hypotension as it can reduce the blood pressure further. Once a contracted uterus has been achieved then an oxytocin infusion (40 IU in 500 ml normal saline and ran at 125 ml/h for 4 h) could be commenced [7, 12]. Further medical management could include carboprost 250 mcg deep im into the leg every 15 min for a maximum of eight doses. Misoprostol can be considered in low resource settings where more effective drugs (oxytocin) not available. Tranexamic acid can be used and reduces PPH [12], but further studies are needed to evaluate its use thoroughly and the WOMAN (World Maternal Antifibrinolytic) trial is due to report soon [16].

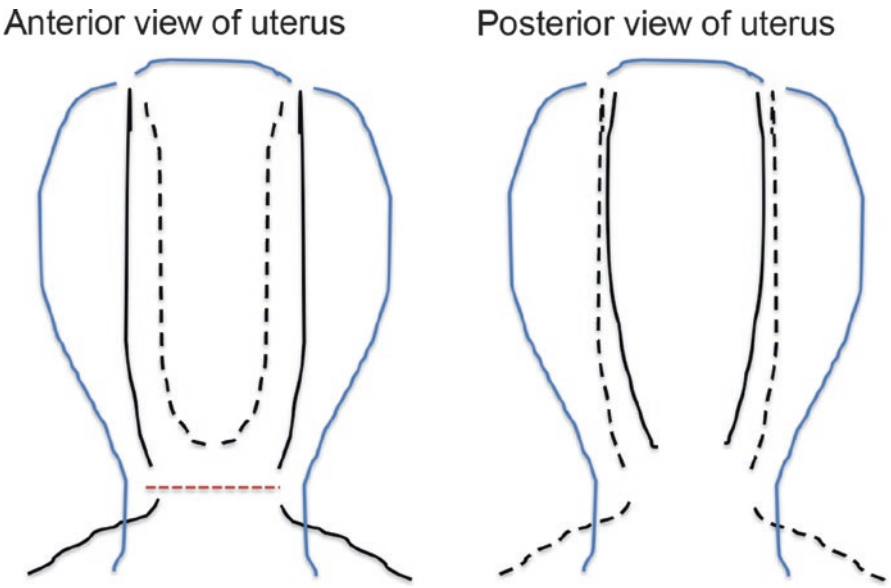

Fig. 24.4 An example of a 'Modified B Lynch suture'

As with all trauma, one needs to decide whether the haemorrhage is compressible. Bimanual compression is an excellent way of stemming the bleeding along with direct pressure to the injury while the anaesthetist resuscitates the woman. Surgical repair of injuries to the vagina, perineum or cervix with an absorbable suture should be performed. In very severe cases aortic compression until the femoral pulse is absent could be employed. Uterine balloon tamponade is recommended as the first line surgical management for treating PPH secondary to uterine atony [12]. The balloon catheter is inserted into the uterine cavity and up to 500 ml of warm saline is used to inflate it. An oxytocin infusion can be started. It can be left for 24 h. B Lynch brace suture and other compression suture methods are known and are most likely to be effective if the bimanual compression technique has achieved reduction in blood loss; Fig. 24.4. Uterine vessel and internal iliac artery ligation can be attempted but both are challenging with the gravid uterus in situ and generally needs vascular surgeon assistance. Hysterectomy may be necessary to control on-going bleeding or to remove a very damaged uterus following trauma. This should be performed earlier rather than later [12]. Ideally and when feasible, a second experienced clinician should be involved in the decision for hysterectomy [12].

24.6.3 Interventional Radiology

This is difficult to arrange in an emergency setting but can be useful if the mother is stable, the baby has been delivered and there is continuous bleeding.

24.7 Specific Obstetric Problems

24.7.1 Amniotic Fluid Embolism (AFE)

This may occur following uterine trauma. It is a serious condition which can occur with an intact uterus. Although not well understood it is thought to be a syndrome of peripartum collapse with coagulopathy which is similar to anaphylaxis in response to fetal material in the maternal circulation. Different patterns of presentation have been seen: maternal loss of consciousness or seizure then delivery (35%), fetal distress and then maternal collapse (23%), maternal hypotension, breathlessness, fetal bradycardia then delivery (14%), maternal collapse after CS (14%), and loss of conciousness or seizure immediately following birth of baby [2, 6–8]. In each case this was then followed by coagulopathy (disseminated intravascular coagulation (DIC)) and significant maternal haemorrhage. Treatment is resuscitative initially with correction of the coagulopathy and management of massive maternal haemorrhage (involvement of haematology team).

24.7.2 Air Embolism

Can occur with rupture of the uterus, during administration of intravenous fluids, blood products under pressure or following manipulation of the placenta at caesarean. It is typically associated with chest pain and collapse. Classically diagnosed through the auscultation of a typical waterwheel murmur over the precordium. Initial management involves preventing further air embolism (stop the pressurised fluids, tilt the patient head-up to increase venous pressure, flood the surgical field with saline) and supportive treatment [6, 7].

24.7.3 DIC

DIC can occur after massive haemorrhage, AFE or massive abruption. This results in a consumptive coagulopathy (low platelets, fibrinogen, bleeding). Point of care coagulation testing can be helpful. Tranexamic acid should be considered [6, 7].

24.7.4 Musculoskeletal Trauma

A major pelvic disruption usually presents as a cardiovascular problem and should be managed in the same way as in the non-pregnant patient to try to manage the uncontrolled bleeding. Pelvic fracture may cause fetal head fracture and injury particularly if the fetal head is engaged. An AP x-ray of the pelvis is very helpful. Resuscitate and immobilise the pelvis if fracture is suspected to ‘turn off the tap.’ Massive retroperitoneal haemorrhage from pelvic fracture is more likely as the pelvic vessels are very engorged and major pelvic disruption tears the pelvic venous

plexus. Delivery of the fetus by caesarean section is often required to 'save' the fetus but, even if the fetus is dead, it is needed to allow access to control the haemorrhage [6, 10]. Pelvic fractures pre se are not an indication for caesarean delivery as most women can safely attempt vaginal birth following a pelvic fracture, even those that occur in the third trimester. Long bone fractures should be treated as normal but it is occasionally necessary to empty the uterus to allow access for proximal vascular control.

24.7.5 Maternal Collapse

It is important that resuscitation starts as soon as possible with manual uterine displacement to the left. Classically it has been taught that at 4 min from the start of resuscitation of a mother with cardiac arrest then a perimortem caesarean should be performed with the aim of delivering the fetus (emptying the uterus), if more than 20 weeks gestation, at 5 min [14]. Increasingly, evidence is emerging that collapse to birth times of less than 3 min are associated with better maternal outcomes [7]. Therefore once resuscitation has commenced if not immediately successful the uterus should be emptied. Delivering the baby will immediately reduce any aortocaval compression, increase venous return, reduce oxygen requirement and increase the likelihood of successful resuscitation. The procedure should be 'announced' to the team. It should occur where she is being resuscitated and she should not be moved. The equipment required to start the procedure is a disposable surgical knife only. This should be taped to the outside of the 'perimortem caesarean section pack.' Entry into the abdomen should be based on operator preference. The 'classical' midline incision uses the natural diastasis of the recti abdomini that occurs later in pregnancy and is relatively bloodless. Obstetricians however are more familiar with the lower transverse abdominal incision and can deliver a baby in less than 1 min. The incision on the uterus should then be a midline incision (classical caesarean section) to avoid the need to reflect the bladder. A small vertical incision is made and once the uterine cavity is entered then scissors could be inserted to further open the uterus to avoid harm to the fetus. Once the baby is delivered the uterus and abdomen can be packed and definitive closure occur later if resuscitation is successful. The midline incision is helpful when there is trauma to the abdomen (trauma laparotomy) and it can allow the heart to be reached through the diaphragm for open cardiac massage. Cardiopulmonary resuscitation should continue throughout the delivery process. A neonatal team will need to be present if the fetus is at least 23 weeks gestation. The caesarean, although performed to aid resuscitation of the mother, has been shown to improve survival of the fetus [2, 8]. In the 2006–2008 report, when done at less than 28 weeks, there were no neonatal survivors but at more than 36 weeks there was a 47% survival and all of these were delivered soon after cardiac arrest [8].

The decision to stop should be a team approach including an obstetrician, if available. It should be noted that no doctor has been found liable for performing a peri-mortem caesarean section.

24.7.6 Maternal Collapse Outside Hospital

It is important that resuscitation starts as soon as possible with manual displacement of the uterus to the left. The aim should be to rapidly transfer the woman to hospital for a perimortem caesarean section although there are instances where this can be performed by a trained team in the community. Emergency department staff and surgical members of the trauma team should be taught how to perform this procedure in the absence of an obstetric team.

24.8 Neonates

Involvement of the neonatal team when the woman is at least 23 weeks gestation is paramount. Preterm babies born at less than 28 weeks gestation should be placed in a polythene bag (up to their neck) without drying immediately after birth. They should be nursed under a radiant heater and the bag remain in place until care is taken over by the neonatal team [7, 17]. If the pregnancy is less than 35 weeks gestation and there is a chance that she will not deliver for more than 24 h then antenatal corticosteroids can be given to the mother to aid maturity of the fetal lungs [18]. These are given at time 0 h, 24 h and the maximum benefit is thought to be seen from 48 h. These could be considered by the obstetric team. The RCOG recommend that magnesium sulphate should be given to women at risk of preterm birth (at less than 30 weeks gestation) as a neuro-protective function for the fetus and to improve long term outcomes [19]. Ideally this is given at least 2 h before delivery. This could be considered by the obstetric/neonatal team along with antenatal corticosteroids.

24.9 Summary

Box 24.1 reiterates key issues in the resuscitation of pregnant women after trauma. Although ballistic trauma is rarely seen in pregnant women an understanding of the physiological and anatomical changes that occur can aid management. There is a paucity of data surrounds the subject. Crucially, a team approach including obstetricians, neonatologists, midwives and obstetric anaesthetists should be used. Resuscitation of the woman is the priority. It must be understood

that pregnant women tend to compensate well and that signs of shock is a late and ominous sign with assessment of the fetus sometimes highlighting concerns in the mother.

Box 24.1
Five important points when resuscitating pregnant women:

1. Resuscitation of the mother is the priority and resuscitating the mother will resuscitate the fetus
2. Compression of the vena cava by the gravid uterus must be avoided and manual uterine displacement of the uterus or 15–30 degree tilt must be maintained throughout resuscitation
3. Signs of shock are a very late sign during pregnancy and indicate a significant blood loss (>25%)
4. All trauma should be considered significant
5. If maternal cardiac arrest then consideration should be made to deliver the baby by caesarean section (resuscitative hysterotomy) and started as soon as initial attempts deemed unsuccessful with no delay (within 4 min)

The management of trauma in pregnancy where the outcome is poor can be very traumatic to staff involved. The welfare of all members of the team should be considered and a debriefing session should be offered where all can contribute if they wish.

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