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The pregnant trauma patient

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Introduction

The pregnant trauma patient poses some unique challenges. The well-being of two patients is at stake and even minor injury can lead to pregnancy losses. Physiological and anatomical differences have to be considered as well as the influence of imaging modalities and treatment on the developing foetus. Any woman of childbearing age who presents with trauma should be considered pregnant till pregnancy is ruled out by a definitive blood test or ultrasound.[1]

Epidemiology of trauma in pregnancy

Trauma in pregnancy is not an uncommon occurrence. Rates of around 6–7% are reported internationally and in some countries trauma is the leading non-obstetric cause of maternal mortality.[2,3] In a study done in South Africa, 4% of female trauma patients were found to be pregnant.[4] The spectrum of injuries in pregnant trauma patients ranges from minimal trauma associated with falls to severe polytrauma. The study in Pietermaritzburg showed 57% of cases to be due to blunt trauma with 21% due to penetrating trauma and 12% due to burns. In 52% of the cases, the trauma was intentional. The women knew their perpetrators in 81% of cases and in 55% of cases, the assailant was their intimate partner.[4] Almost 5% had self-inflicted injuries. Road traffic accidents accounted for 26% of the trauma. Forty percent of these pregnant trauma victims sustained polytrauma, 17% sustained isolated abdominal injuries and 9.5% sustained head injuries.

Surgery was needed in 12% of the cases and 80% of patients that had surgery ended up with foetal losses. Overall, more than a third of all the trauma cases were associated with foetal demise and the majority of these cases were associated with high injury severity scores. In two of the cases, however, spontaneous abortion occurred in the absence of significant trauma.

The exact maternal mortality rate as a result of trauma in South Africa is not known. In the Pietermaritzburg series, only one out of the forty-two patients died.

Physiological and anatomical considerations

Airway

The airway in a pregnant patient is eight times more likely to be difficult compared to their non-pregnant counterparts.[5] There is an increase in the Mallampati score[6,7] with progression of pregnancy as well as oedema of the mucosal surfaces. The mucosa is prone to bleeding as a result of this engorgement.[7] The addition of cervical spine injuries in the pregnant trauma patient will add to the difficulty of the airway.[2]

Respiratory

The gravid uterus pushes on the diaphragm and results in a decreased functional residual capacity. At the same time, oxygen consumption increases between 20–60%. This increased demand coupled with decreased reserves of oxygen, make the pregnant patient less tolerant of periods of apnoea or hypoventilation. Supplemental oxygen treatment should be considered for all pregnant trauma patients to maintain arterial oxygenation above 95%.[1,2]

Due to the upward displacement of the diaphragm, the position of placement of intercostal drains should also be changed. They should ideally be placed under ultrasound guidance. In the absence of ultrasound, the insertion point should be in the 4th or 5th intercostal spaces rather than the 5th or 6th intercostal spaces.[1,2]

Cardiovascular

The cardiac output gradually increases during pregnancy with both an increase in heart rate and stroke volume. This is however coupled with a decrease in systemic vascular resistance so that the blood pressure is slightly lower than the non-pregnant counterpart. The changes are not dramatic with an average decrease in blood pressure of 5–15 mmHg and increase in heart rate of about 10–15 beats per minute. When a pregnant trauma patient presents with significant tachycardia or hypotension, a cause should be sought and it should not be attributed to normal pregnancy changes.[8]

The plasma volume increases by up to 50% coupled with a 20–30% increase in red cell volume. Due to this increase in circulating blood volume, a significant volume of blood can be lost before the haemodynamic parameters start to decompensate. Vital signs are thus inaccurate indicators of shock in the pregnant trauma patient.

After 20 weeks' gestation, the gravid uterus can cause aortocaval compression in the supine patient.[9] This will result in decreased preload and cardiac output. Patients should be in a left-lateral tilt. This may however not be feasible in a patient with suspected spinal injuries. If the patient has to be in the supine position, the uterus should be manually displaced by lifting the uterus and pulling it to the left.[1]

The placental circulation does not have auto-regulation. Perfusion of the foetus is directly proportional to the maternal mean arterial blood pressure. Hypotension is not tolerated well by the foetus and needs to be corrected as a matter of urgency. Foetal distress is often an earlier marker of hypovolaemic shock than maternal vital signs.[8] Uterine blood flow is up to 700 ml/min near term. Trauma to the uterus with uncontrolled bleeding will rapidly lead to exsanguination.

Any seriously injured pregnant patient should have two large bore intravenous cannulas placed above the level of the diaphragm.[1] Vasopressors have a negative impact on placental circulation and should only be used if intravenous volume resuscitation fails to correct hypotension.[1] If an anti-shock pneumatic or non-pneumatic anti-shock garment is used, the abdominal part should not be used as this will compromise placental blood flow.[1]

Gastro-intestinal

The pregnant patient is at increased risk of aspiration of gastric contents. The lower oesophageal sphincter tone decreases under the influence of progesterone. Intragastric pressure increases secondary to increased intra-abdominal pressure. All patients should be considered an aspiration risk after 16 weeks' gestation or a symphysis-pubis height of more than 16 cm. Antacid prophylaxis should be administered before surgery even when the planned anaesthetic is not a general anaesthetic. Thirty millilitres of sodium citrate should be given within 30 minutes of the procedure. A nasogastric tube should be placed in patients who are semi-conscious or unconscious to decrease the risk of aspiration.[1] Early airway protection with a cuffed endotracheal tube should be considered in such cases.

Haematological system

The plasma volume and red cell mass is increased in pregnancy. However, the plasma volume increases proportionally more than the red cell volume and this gives rise to a dilutional anaemia. There is also an increase in the white cell count and an increase in clotting factors leading to a hypercoagulable state. This predisposes the pregnant patient to thrombo-embolic complications.[10]

Comorbidities associated with pregnancy

The pregnant patient may have comorbidities related to pregnancy that need special consideration. Both the pathophysiology and the management of such comorbidities need to be considered. Examples include pre-eclampsia and eclampsia, HELLP syndrome and amniotic fluid embolism.[10]

Imaging in the pregnant patient

Radiographical investigations should not be deferred or delayed if they are indicated for maternal evaluation.[1] X-rays and CT scans expose the mother and foetus to ionising radiation. The period of biggest risk to the foetus is during the time when major organs are formed i.e. between the 2nd and 7th week of gestation. After this time period, radiation is more likely to cause growth retardation than teratogenesis.[8] The cumulative dose that is likely to induce teratogenesis is fairly high in the region of 5–10 rads or 50–100 mGy. A plain pelvic x-ray exposes the foetus to less than 0.2 mGy of radiation. Fluoroscopy and computer tomography are associated with higher doses of radiation with a pelvic CT scan being associated with up to 50 mGy.

Ultrasound is usually freely available and can be used to evaluate the foetus and to do a focused abdominal scan (FAST) to look for maternal bleeding.

The safety of MRI has not yet been established in the pregnant patient. So far, no known risks to pregnancy have been identified, making it an attractive alternative to CT scans. However, MRI studies typically take longer to complete, and it is more difficult to monitor the patient. As such, it may not be feasible in an unstable patient.

Monitoring of the foetus

There is controversy regarding the length of time that a foetus should be monitored after maternal injury. It is recommended that **all** patients who present with trauma and a viable foetus should be monitored with cardio-tocography for a minimum time of 4–6 hours. Monitoring should be continued for longer if the mother develops contractions or the uterus becomes irritable and tender, if there is vaginal bleeding or rupture of membranes, if there is a non-reassuring pattern on the non-stress test or if the mother suffered significant trauma.[11] Speculum and digital examination should be deferred in active vaginal bleeding until placenta praevia can be ruled out.[1]

Foeto-maternal haemorrhage

Traumatic interruption of the foeto-placental interphase as a result of blunt abdominal trauma can lead to foeto-maternal haemorrhage. This can lead to allo-immunisation with resultant haemolytic disease of the foetus or newborn or severe anaemia in the foetus as a result of blood loss. The clinical features of foeto-maternal haemorrhage are usually most evident in the foetus with the mother usually being asymptomatic. Foetal signs include decreased foetal movements and abnormalities in foetal heart rate such as late decelerations, a sinusoidal pattern or foetal tachycardia. If the mother is symptomatic, the features are similar to a transfusion reaction.[12]

Allo-immunisation

As little as 0.1 ml of foetal blood in the maternal circulation can lead to allo-immunisation.[13,14] Allo-immunisation happens when an Rh(D)-negative person is exposed to red blood cells that have the Rh(D) antigen. This leads to the formation of IgG antibodies against this Rh(D) antigen.[14] Once these anti-D antibodies are present in the maternal circulation, they can cross the placenta and opsonise foetal red blood cells that have the Rh(D) antigen on their surface. The red blood cells are then destroyed in the foetal spleen leading to haemolytic disease of the foetus and newborn (HDFN) and is associated with severe foetal anaemia, hydrops foetalis and foetal demise.[13] It is recommended that all Rh-negative patients be given anti-D immunoglobulin within 72 hours of abdominal trauma.[1,14] The Kleihauer-Betke test can be used to quantify the volume of blood that entered the maternal circulation. The dose of Rh-immune globulin is based on this estimation. A dose of 300 µg (1 vial) will neutralise 30 ml of foetal blood in the maternal circulation.[15] Additional doses up to a maximum of eight vials may be needed if massive amounts of foetal blood are demonstrated in the maternal circulation.[14]

Foetal anaemia

Massive foeto-maternal haemorrhage can also lead to foetal anaemia. The definition of massive foeto-maternal haemorrhage is not universal. It is more useful to look at the volume of foetal blood lost into the maternal circulation as a percentage of the estimated foetal blood volume. The estimated blood volume of a foetus before 32 weeks' gestation is approximately 120 ml/kg and 100 ml/kg after 32 weeks' gestation.[12] A volume of 20 ml/kg foetal blood loss is a haemodynamically significant insult. There may be a role for foetal blood transfusion in cases of massive foeto-maternal haemorrhage.

There is no consensus as to which patients should be evaluated for foeto-maternal haemorrhage. Some practice guidelines[11] recommend that all pregnant trauma patients with gestational age more than 12 weeks should have a Kleihauer-Betke test, whilst others recommend only symptomatic patients after 20 weeks' gestation be tested.[12]

Specific injuries

Abruptio placentae

The quoted incidence of abruptio placenta in pregnant trauma patients varies between 6–60%.[8] This complication can occur even when the mechanism of injury is deemed to be minor or the trauma suffered seems insignificant. There have been case reports of placental abruptio happening up to 48 hours after the incident raising controversy as to the length of monitoring of the foetus after an incident. Foetal morbidity in cases of abruptio may be as high as 60%. Maternal symptoms of abruptio placentae include abdominal pain associated with vaginal bleeding and uterine contractions. Minor abruptio may also be asymptomatic. Abruptio placentae may be complicated by the onset of disseminated intravascular coagulation (DIC). This is as a result of the high concentration of tissue factor (TF) and tissue factor pathway inhibitor (TFPI) that is present in the amnion fluid, membranes and placenta that can enter the maternal circulation at the site of placental abruptio.[16,17] If abruptio is expected, management should not be delayed for ultrasound investigation as it is not a sensitive test for the diagnosis of abruptio.[1]

Blood transfusion

Use of cell-salvaged blood at Caesarean delivery

The usage of blood that is potentially contaminated with amniotic fluid and foetal cell components raised a theoretical concern for iatrogenic amniotic fluid embolism and subsequent DIC. The DIC that ensues due to the presence of amniotic fluid in the maternal circulation is as a result of the high concentration of TF and TFPI in amniotic fluid. The filters used in modern cell salvage technology are able to reduce the amount of TF by 89% and to completely eliminate the active portion of TF.[18] Precautions should still be taken to minimise the amount of amniotic fluid in the salvaged portion by discarding the blood collected before the delivery of the baby. A leucocyte depletion filter should also be used for re-infusion of the salvaged blood products.[19]

Other considerations

Transfusion should be kept to a minimum to avoid the risk of allo-immunisation with subsequent haemolytic disease of the foetus and newborn in subsequent pregnancies. If blood transfusion is necessary, O-negative blood should be transfused if cross-matched blood is not available yet.[1]

Fibrinogen may play an important part in haemostasis in the obstetric patient and one should aim to keep the fibrinogen level above 2 g/L.[20]

Maternal resuscitation and perimortem Caesarean delivery[21]

The patient should be in the supine position with manual displacement of the uterus if the fundal height is at or above the level of the umbilicus.[22] It is no longer recommended to tilt the bed to avoid aortocaval compression during resuscitation. Studies have shown that aortocaval compression can still occur even with a left lateral tilt of 30 °. At this angle, the force of chest compressions also becomes markedly ineffective. With tilt, the position of the heart in the thorax also moves.[23]

Manual left uterine displacement by a dedicated person is recommended.

Circulation

Intravenous access should be established above the level of the diaphragm so that there is no delay in drugs reaching the heart due to possible aortocaval compression. High quality compressions with a rate of 100 per minute must be administered and defibrillation should be carried out for shockable rhythms. The lateral paddle of the defibrillator should be placed under the breast tissue. The presence of foetal monitors should not deter the physician from delivering a shock when clinically indicated as the benefit far outweighs the potential risks.[23] There is no scientific evidence that the position of the hands on the sternum should be altered in the pregnant patient and the normal position as for non-pregnant patients is recommended. Ideally the efficiency of chest compressions should be monitored with

capnography and the aim should be for an $etCO_2$ of more than 10 mmHg.

Airway and breathing

Maternal hypoxaemia will ensue quickly in the absence of adequate oxygenation. Effective bag mask ventilation with 100% oxygen at 15 L/min must be performed with the avoidance of hyperventilation until someone who is skilled in airway management is available to intubate the patient. Due to the potential difficult airway in pregnant patients, it is important to have the necessary expertise and equipment for management of a difficult airway available before an attempt at an advanced airway is made. Only two attempts at intubation are allowed in the pregnant patient. After this, a failed airway should be declared, and the failed intubation algorithm should be followed.[7,23] This allows for the placement of a supraglottic airway device, again with a maximum of two attempts at placement.

Perimortem Caesarean delivery

A perimortem Caesarean delivery (PMCD) should be performed if maternal death is imminent or if high-quality cardiopulmonary resuscitation has been ongoing for four minutes without return of spontaneous circulation in the mother.[15,21] The primary aim of a PMCD is to improve resuscitation efforts to the mother. As such, the viability of the foetus should not be a determining factor in the decision to do a PMCD and it should be done in all cases where the gestational age is twenty weeks or more or where the uterus is deemed big enough to cause aortocaval compression. PMCD should be carried out in the location where the cardiac arrest took place as transport of the patient results in ineffective cardiac compressions. Minimal surgical equipment is needed and the PMCD can be started with just a scalpel and a size 20 blade. In trauma patients, a midline incision is recommended as it will allow for visualisation of other abdominal injuries that can be addressed once the uterus is evacuated.

Ethical issues

Informed consent

Pregnant trauma patients should get information about the risks associated with anaesthesia and the potential effect on the pregnancy. They should also be informed about the risks associated with radiographic investigations and blood transfusions.

Brain-dead patient with alive foetus

In a case series by Suddaby, et al. on brain-dead patients, 2.8% of cases were pregnant at the time of diagnosis.[24,25] The brain-dead pregnant patient poses an ethical dilemma as the wellbeing of the foetus is put against the resources needed to maintain the mother on life support till the foetus reaches viability. Complications associated with brain death and prolonged life support can occur. These include sepsis, electrolyte abnormalities, haemodynamic instability, the development of diabetes insipidis, problems with temperature regulation and glucose control, panhypopituitarism and disseminated intravascular coagulation.[25] Management of these patients should be multidisciplinary and should follow the same principles as the care for an organ donor. Delivery is usually via Caesarean section after foetal maturity has been reached.

Summary

Pregnancy should be considered in all female trauma patients of childbearing age. Optimal management of the mother is the best way to ensure foetal well-being. Necessary radiographic investigations and surgery should not be deferred for fear of foetal compromise. The physiological and anatomical changes that are associated with pregnancy should be considered when dealing with the pregnant trauma patient.

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