Quick Hits in Obstetric Anesthesia

Roshan Fernando
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To my mother and father who asked me to take up a career in medicine all those years ago. To Anelia and Nia for being in my life during the time it has taken to write and publish the book and for all the fun and encouragement along the way.

Roshan Fernando

I dedicate this book to my father Dr. Mohammad Sultan and my mother Maleka Sultan. Thank you for teaching me dedication, hard work, self-belief and perseverance. I also dedicate this book to the 3 special girls in my life. My wife, Ellile, who has provided me with limitless encouragement, strength and support. And finally, to my 2 daughters, Sofia and Aarya. Thank you for every moment of joy, I cherish every second we spend together.

Pervez Sultan

I would like to thank Toc for his support and advice whilst completing this project.
I dedicate this book to Araz Pourkashanian, my friend and colleague who was loved by all on labour ward, you are missed.

Sioned Phillips

Foreword

The demand on obstetric anaesthetists is ever increasing, with the majority of women being cared for within hospital delivery areas, requiring their services. Caring for obstetric patients is very different compared to caring for patients in other surgical settings. Obstetric anaesthetists will frequently administer neuraxial anaesthesia for surgical procedures while women are awake for their operation. They must also take into consideration the effects of anaesthesia on the fetus. The types of obstetric surgical interventions are distinct compared to the routine case-load encountered by junior anaesthetists in the main operating areas of hospital facilities. As well as these differences, the majority of surgery that occurs within the delivery area is emergent in nature and requires prompt anaesthetic input. All of these factors can lead to uncertainty for novice obstetric anaesthetists, and covering delivery wards can be a daunting prospect for many anaesthetic trainees.

Quick Hits in Obstetric Anesthesia is not only aimed at novice obstetric anaesthetists but is also intended for use as a quick reference guide by all grades of anaesthetist. Information is clearly presented and summarises the management of emergency situations and common problems which are encountered while working with pregnant patients. Different anaesthetic 'recipes' and management strategies are presented for common obstetric procedures in addition to trouble-shooting chapters and 'what to do lists' for frequently encountered dilemmas. Quick Hits in Obstetric Anaesthesia includes chapters which are written by leading international experts in the field of obstetric anaesthesia, covering a spectrum of antenatal and postpartum situations when the input of obstetric anaesthetists to multidisciplinary team working is key to ensuring excellent patient outcomes.

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Contents

Epidurals for Labour Analgesia

1

Thierry Girard

Indications

- Maternal request
- High risk pregnancies, e.g. obesity, twin gestations, breech delivery
- Pre-eclampsia
- Cardiac or pulmonary maternal disease.

Although frequently discussed, a minimal cervical dilation is not a requirement for epidural labour analgesia. Early epidural analgesia is associated with a slightly shortened second stage of labour with no difference in instrumental or caesarean delivery as compared to epidurals sited in a later stage of labour.

Contra-Indications

- Patient refusal
- Coagulopathy, such as:
  - prophylactic dosage of low molecular weight heparin (LMWH) < 12 h ago
  - therapeutic dosage of LMWH < 24 h ago
  - HELLP (Haemolysis, Elevated Liver Enzymes and Low Platelets) with severe thrombocytopenia
- Infection at the site of insertion

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Consent

To seek consent during delivery is internationally accepted (Chapter 16). The procedure should be explained. The risks to be mentioned include the following:

- Failed analgesia and need for a repeat epidural (1 in 10)
- Headache (1 in 100)
- Permanent nerve injury (1 in 100,000–200,000)
- Infection and haematoma are very rare (<1 in 200,000)
- There might be an increased rate of instrumental (ventouse or forceps) deliveries [1]

There is an increase in temperature in parturients with epidural labour analgesia (Chapter 53). This is non-infectious and the impact on the neonate is unclear.

Position

Identification of the midline is easier in the sitting position, while the lateral position might be preferable for the parturient with painful contractions. In obese parturients the sitting position is preferable.

Equipment

The most basic equipment consists of an epidural needle, an epidural catheter and an epidural (particulate) filter, the latter of which is connected to the epidural catheter using a dedicated connection (Fig. 1.1). A sterile drape is also used around the site of epidural insertion to create a sterile field. The most common epidural needle, which is used worldwide, is called a Tuohy needle and is available in 18G and 16G sizes; epidural catheters are available as single or multi orifice and naturally are of a smaller gauge than the epidural needle. A flexible (soft) epidural catheter tip may be advantageous, as there can potentially be less damage to the blood vessels (accidental venous puncture) or the dura (accidental dural puncture). A facemask, a theatre cap and sterile surgical gloves are mandatory, many countries also require a sterile gown, while some do not. Chlorhexidine is the best skin antiseptic, but it is extremely neurotoxic and therefore maximal care has to be taken ***not*** to contaminate the epidural needle or catheter with chlorhexidine.

Procedure

- Careful positioning of the patient in the sitting or lateral position.
- Identification of a lumbar level of L3 or below is best performed with ultrasound. If not available, then a level below the intercristal line (Tuffier's line) should be chosen [2].
- Disinfection with 0.5% chlorhexidine in alcohol is recommended and usually applied with a commercial spray or pre-prepared cleaning sticks.
- Identification of the epidural space with a loss of resistance to saline (or to air) technique usually using a special (plastic) loss of resistance syringe. Abstain from advancing the epidural needle during uterine contractions since the risk of complications such as an accidental dural puncture (ADP) may be increased.
- Do ***not*** rotate the epidural needle after identification of the epidural space for the same reasons (increased ADP risk)
- Insert the epidural catheter through the needle and advance it maximally 7 cm into the epidural space.
- Remove the needle, withdraw the epidural catheter so as to leave the catheter 5 cm within the epidural space.
- Always aspirate without the bacterial filter (otherwise there is a risk of false negative aspiration)
- Fix the epidural catheter at the level of the skin using a sterile dressing or a commercial epidural fixation device.

Drugs

Initiation and maintenance of epidural labour analgesia is with low concentrations of amide local anaesthetics combined with lipophilic opioids [3]. The addition of a lipophilic opioid allows a reduction in the concentration of the local anaesthetic and further decreases the incidence of hypotension and lower limb motor block. Commonly used drugs are:

- (Levo)bupivacaine 0.0625–0.125%
- Ropivacaine 0.1–0.15%
- Fentanyl 1–2 μg/ml
- Sufentanil 0.5–1 μg/ml

Test Dose

The aim of a test dose is to exclude an intrathecal or intravascular position of the epidural catheter. Test doses using 2% lidocaine are not particularly sensitive or specific, and the same is true for the addition of epinephrine [4]. Therefore a dedicated test dose is not recommended. Each epidural injection is to be considered a test dose: an unexpectedly high sensory block with or without motor block is suspicious of an intrathecal injection; a lack of an analgesic effect should raise the suspicion of an inadvertent intravascular injection.

Regimens

There are several regimens to maintain epidural labour analgesia [3]:

- Intermittent manual injection
- Continuous epidural infusion (CEI)
- Patient controlled epidural bolus (PCEA)
- PCEA with a background continuous infusion
- Programmed intermittent epidural bolus (PIEB)

Intermittent manual injections, for example administered by a labour nurse or a midwife, have the disadvantage of not being automated and therefore more prone to errors.

CEI is rarely used these days within modern delivery units and has the disadvantage of causing more lower limb motor block together with breakthrough pain which necessitates physician boluses.

PCEA increases patient satisfaction and reduces motor block. The addition of a background infusion further increases patient satisfaction and reduces the need for clinician interventions.

PIEB is a modification of PCEA with a background infusion. The background infusion is converted into an automated bolus, usually given at an interval of 45–60 min. PIEB has the potential to decrease motor block and increase the spontaneous delivery rate [5]. But it is quite a new technique and further research is needed in order to confirm its advantages.

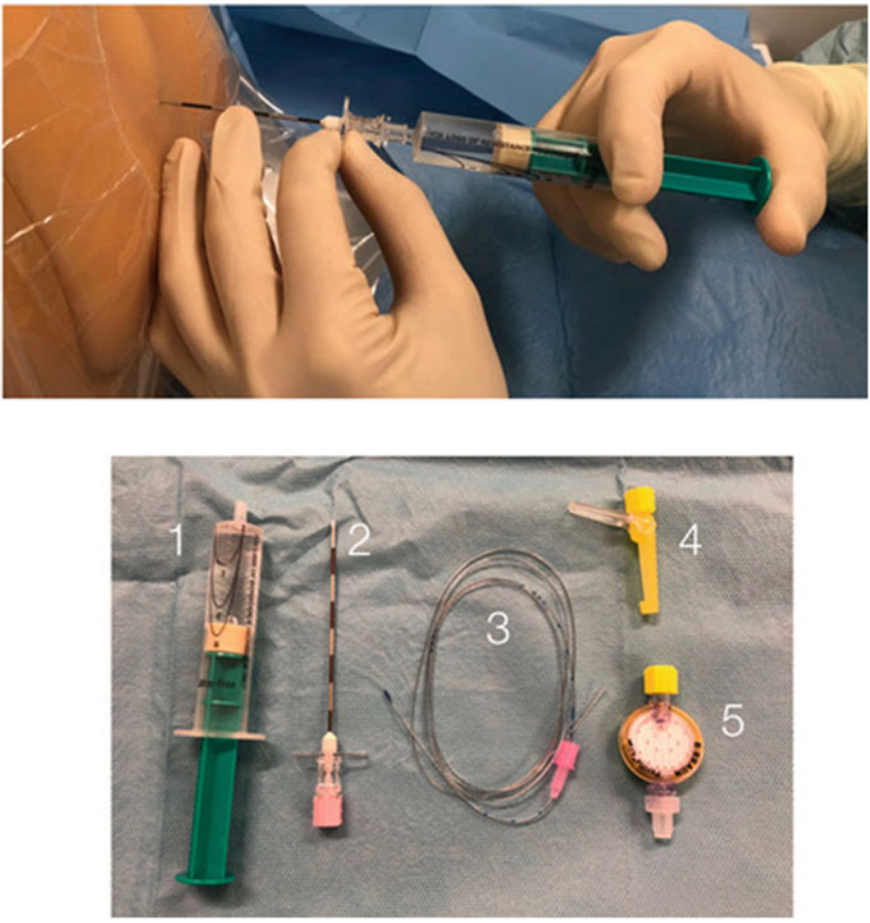

Fig. 1.1 Top panel: Training of epidural neuraxial procedure on a simulator. Bottom panel: Epidural insertion set with: 1: Loss of resistance syringe. 2: 18G epidural needle (Tuohy) with length markings every 1 cm. 3: 20G epidural catheter. 4: Epidural catheter connector. 5: Epidural bacterial filter (0.2 μm)

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Combined Spinal-Epidural Analgesia for Labour

2

Marc Van de Velde

Labour pain is effectively relieved by neuraxial analgesic techniques. Initiation of labour analgesia is either done by conventional epidural analgesia or by combined spinal epidural analgesia (CSE). CSE is commonly used worldwide but its usage varies between institutions. In some hospitals, it is the technique of choice; in other hospitals, it is only used for specific indications (including late labour, very early labour, intense painful labour, multiparous patients, twins) [1–5].

CSE Technique

Most commonly, it is a single interspace, (spinal) needle through (epidural) needle technique that is used [1]. The double interspace, double puncture technique consists of a spinal performed at a different level followed by an epidural at another level. In Fig. 2.1 the difference between a single interspace CSE and a conventional epidural is depicted.

Advantages of the CSE Technique

1. Rapid onset of analgesia. Typically, within 5 min of initiation, pain relief is established with little variation between patients (conventional epidural analgesia may take up to 30 min to work) [1–12].
2. Reduced VAS pain scores when compared to epidural analgesia (0–10 mm versus 10–30 mm VAS scores) [1–12].

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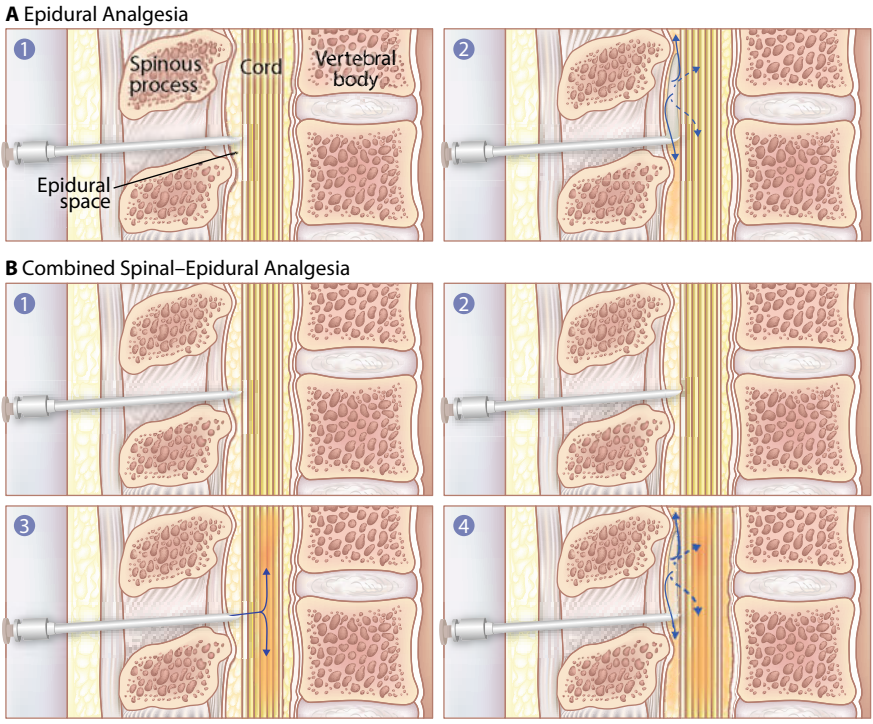

Fig. 2.1 Epidural analgesia technique (**a**) versus combined spinal-epidural technique (**b**). In epidural analgesia, the epidural space is located using an epidural needle, by a loss-of-resistance technique. A 19- to 20-gauge epidural catheter is threaded into the space and used to dose medications. In combined spinal-epidural analgesia, the epidural space is located in the same fashion, and prior to threading the epidural catheter, a small 25- to 27-gauge spinal needle is introduced through the epidural needle to puncture the dura and to bolus a single dose of local anesthetic with or without opioid. The spinal needle is removed and a 19- to 20-gauge epidural catheter is threaded for subsequent dosing. Figure reprinted with permission from Eltzschig HK, Lieberman ES, Camann WR: Regional anesthesia and analgesia for labor and delivery. N Engl J Med 2003; 348:319–32.6

3. Less breakthrough pain and fewer interventions by the attending anesthetist [13, 14].
4. Many studies have shown a reduced need for epidural catheter replacement when CSEs are used for labour analgesia. A possible explanation for these findings is confirmation of correct placement of the tip of the epidural needle in the epidural space by virtue of cerebrospinal fluid visualization through the spinal needle [13, 14].
5. Reduced local anesthetic consumption (20–30% less) with potentially less need for instrumental vaginal delivery [10].

6. Reduced motor block, or at least later onset of motor block, when compared with other low concentration epidural strategies for labour pain relief [9].

Disadvantages Associated with a CSE

1. When spinal puncture is performed above the L2–L3 interspace: risk of damage to the conus medullaris with permanent neurologic injury [15, 16].
2. More hypotension (which can be prevented by keeping the patient, following the CSE, always in the full lateral position) [17–19].
3. An increased incidence of early fetal heart rate changes (within 10–30 min) after the spinal component has been administered. The pathophysiological mechanism is a combination of *rapid analgesia* with imbalance between the (tocolytic) stress hormone epinephrine and the uterostimulant norepinephrine, resulting in uterine hyperactivity and *mild hypotension*. High dose lipophilic opioids have been implicated to increase uterine activity. The therapy is to give a bolus of IV fluids and 5–10 mg ephedrine. This increases blood pressure and reduces uterine hyperactivity, by the indirect release of epinephrine by ephedrine which therefore may have a minor tocolytic effect, beneficial in this situation. If this fails, active tocolysis (using atosiban for example) can be considered [17, 18].
4. The epidural catheter is potentially untested if an urgent cesarean delivery needs to be performed after the initial spinal injection but before the epidural catheter has been used. However recent evidence has clearly demonstrated that epidural catheters placed as part of a CSE technique are more reliable and carry no increased risk associated with untested epidural catheters [20].
5. The technique is **not** associated with a higher incidence of Post Dural Puncture Headache (PDPH) or infection. Complications such as nausea and vomiting can occur but are not more frequent then with epidurals.

Drugs Used for the Intrathecal Component

A local anesthetic is usually combined with a lipophilic opioid such as sufentanil (1.5–2.5 mcg) or fentanyl (5–15 mcg). The local anesthetic of choice is ropivacaine (3–4.7 mg) or (levo) bupivacaine (2.5–4.0 mg).

Many institutions use small volumes of epidural low dose mixture (routinely used for epidural labour analgesia) given as the spinal injection [21]. For example, 3 ml of a low dose epidural mixture containing 0.1% bupivacaine with 0.0002% fentanyl would result in an intrathecal dose of 3 mg bupivacaine with 6mcg fentanyl.

Neostigmine and clonidine have been tested but intrathecal use of clonidine results in significant hypotension and spinal neostigmine causes nausea and vomiting. These two drugs are should **not** be added to the spinal mixture.

Maintenance of subsequent analgesia is similar to conventional epidural analgesia using a continuous epidural infusion (CEI), patient controlled epidural analgesia (PCEA) or programmed intermittent epidural boluses (PIEB).

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Non-neuraxial Options for Labour Analgesia

3

Ryan Howle and Tauqeer Husain

Labour analgesia can be broadly categorised as those where an anaesthetist is involved in the delivery of pain relief, and those which can be administered by Midwives or Nurses, without the input of an anaesthetist [1]:

Nurse / Midwife Administered Analgesia

- Paracetamol
- Entonox ®
- Parenteral opioids (usually IM)
- Transcutaneous Electrical Nerve Stimulation (TENS)
- Complementary therapies

Anaesthetist Administered Analgesia

- Neuraxial analgesia
  - Epidural (see Chap. 1)
  - Combined Spinal and Epidural (CSE) (see Chap. 2)
- Intravenous Patient Controlled Analgesia (PCA)
  - Remifentanil

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- Fentanyl
- Morphine

Entonox ®

- Entonox is an inhaled gas mixture of 50% oxygen and 50% nitrous oxide that is commonly used worldwide to provide analgesia for labouring women [2].
- Entonox only provides a modest reduction of pain scores when compared to placebo but its dissociative effect also contributes to increased maternal satisfaction.
- In delivery rooms, Entonox ® is usually administered as a gas mixture either from a gas cylinder or from a piped wall outlet through a breathing system which uses a "demand" valve. This allows non-continuous usage, reflecting the intermittent nature of labour pain, while minimising environmental impact.
- The parturient is advised on the method of use, as well as the expected side effects, such as nausea and light-headedness. Entonox ® is most effective when inhalation commences 30 s before the start of a contraction.
- Where contractions are irregular, parturients should start inhalation as soon as the contraction is felt. Inhalation should stop as soon as the contraction declines. Between contractions, the parturient should be encouraged to remove the mouthpiece and breath normally.
- In the operating theatres, Entonox ® can be given continuously by administering an equal mixture (flow) of oxygen and nitrous oxide on the anaesthetic machine and allowing the woman to inhale the gas mixture through a facemask.

Advantages

- Inexpensive
- Non-invasive
- Readily available
- Patient controlled
- No requirement for urinary catheterisation, continuous monitoring or specialist input
- Rapid onset and offset
- No effect on the term fetus or neonate

Disadvantages

- Environmental pollutant
- Occupational exposure can lead to early pregnancy losses
- Light-headedness and drowsiness
- Nausea and vomiting
- Inhibits methionine synthase—risk of haemopoietic complications with prolonged exposure (>24 h)

Transcutaneous Electrical Nerve Stimulation (TENS)

- TENS machines are non-invasive non-pharmacological devices that produce low intensity electrical currents and are thought to exert their effect via the gate-control theory of pain [3].
- Electrical stimulation of peripheral Aβ neurones inhibits ongoing nociceptive input at the level of the spinal cord. Therefore, electrodes should be placed at the dermatomal level corresponding to the pain or using acupuncture points (Fig. 3.1).
- The evidence of their effectiveness in labour shows no difference in severe pain when compared to placebo or standard care. However, there may be greater maternal satisfaction with no associated adverse events.

Fig. 3.1 A wireless dual-channel TENS machine suitable to be used for labour analgesia. Published with the permission of Med-Fit UK LTD, Stockport, UK

Complementary Therapies

- Many women would prefer to avoid pharmacological intervention during childbirth and may turn to other strategies to help them manage their pain. These include listening to music, massage, aromatherapy, acupuncture, acupressure, reflexology, yoga and hypnosis.
- Self-taught hypnosis is a popular strategy that is commonly referred to as hypnobirthing.
- Evidence from Cochrane database reviews have identified some evidence that hypnobirthing and acupuncture reduce the requirements for conventional pain relief, but not that it alleviates the pain per se. No other complementary therapies have proven to be effective [4].

Intramuscular Opioids

- Meperidine / Pethidine (half-life: 120–240 min) IM
  - E.g. 50-150 mg, maximum of two doses two hours apart.
  - Can be administered intra-muscularly and does not need a clinician prescription in the UK.
  - May exert a sedative effect as well as analgesic, which has been associated with low levels of satisfactory labour pain relief.
  - Accumulation of a normeperidine metabolite occurs with multiple doses. This may cause seizures and respiratory depression that is not reversed by naloxone.

- Morphine (half-life: 60 min)
  - E.g. 10–15 mg IM
  - Compared to meperidine, has similar analgesic action but less nausea and fewer neonatal side effects.
  - Due to the relative sedative effect and effect duration of 3–4 h, IM morphine is probably best reserved for early labour

- Diamorphine (half-life: 60 min) IM
  - E.g. 7.5 mg, maximum of two doses two hours apart.
  - Experimental data suggests superior analgesic effects, compared to meperidine. However, the clinical significance of the visual analogue pain scale reduction of 0.7–1.0 (out of 10) is questionable.
  - Diamorphine has been associated with a mean prolongation of labour of 82 min, compared to meperidine. This has led to the suggestion that diamorphine administration may lead to greater “degree” of pain by virtue of the longer length of labour [5].

- Side effects
  - Maternal—nausea, vomiting, dysphoria
  - Fetal—reduced baseline fetal heart rate, reduced heart rate variability, fewer accelerations
  - Neonatal—respiratory depression, impaired feeding [6].

Intravenous PCA

Remifentanil [7–11]

Remifentanil is a synthetic opioid with a pharmacokinetic profile that makes it favourable for the severe intermittent pain experienced in labour. It is a superior analgesic to other parenteral opioids but remains inferior to neuraxial blockade. Due to the potential side-effects, difficulty in optimal dosing, requirement for extra training and continuous midwife supervision, it's uptake across maternity units can vary significantly. Some centres offer it alongside epidural analgesia, others only in specified circumstances (such as where epidural analgesia is contra-indicated) and some do not offer it at all.

It is worth noting that the use of remifentanil PCA for labour analgesia is an off-label indication, and the manufacturers state, "the safety of remifentanil during labour or delivery has not been demonstrated".

Indications

- Contra-indication to epidural—coagulopathy, sepsis, spinal surgery
- Epidural refusal
- Severe labour pain uncontrolled by other forms of analgesia

Contra-indications

- History of sensitivity to remifentanil or other fentanyl derivatives
- Severe respiratory disease
- Long-term opioid therapy
- Recreational drug abuse
- Systemic opioid within the last four hours

Regimens

- Remifentanil prepared at a concentration of 40 mcg/ml (2 mg in 50 ml 0.9% Saline).
- 20–40 mcg bolus, 2 min lockout (varies from 1–5 min).
- There is conflicting evidence regarding the value of an additional background infusion.

- studies have reported no benefit in quality of pain relief, but increased maternal side effects, when a background infusion of remifentanil is used.
- a stepwise increase in the bolus dose with a constant infusion rate is associated with significantly higher maternal side effects than a stepwise increase in infusion rate with a constant bolus dose.
- if used at all, the recommended background infusion rate is 0.025–0.1 mcg/kg/min.
- Significant inter-patient variability in effective dose and the potential for acute opioid tolerance questions the appropriateness of a single fixed dose remifentanil PCA regimen for all parturients.

Pharmacokinetics

- Onset time—1.2–1.4 min
- Time to peak effect—2.5 min
- Context sensitive half-life—3.5 min

Side-effects

- Maternal
  - respiratory depression (see below)
  - bradycardia
  - sedation
  - nausea and vomiting
- Fetal
  - Reduced heart rate variability (less than other parental opioids)
  - Increase umbilical artery acidosis compared to epidural

Respiratory Depression

- Approximately 70% of parturients experience periods of apnea.
- Early warning signs include hypoxaemia, hypocapnea and bradypnea. However, these are not sensitive enough or provide enough warning to act as useful pre-emptive alerts.
- Cases of respiratory arrest have been reported, some progressing to maternal cardiac arrest requiring peri-mortem caesarean delivery.
- No documented case of direct maternal or fetal death.

Guidance for use

- Follow local protocol.
- Dedicated intravenous cannula for the remifentanil PCA—remove post-delivery.

- Maternal education on use—aim to pre-empt or press button at the very start of contraction.
- Use a pump with a rapid bolus delivery rate.
- Patient only to press the PCA button.
- No additional opioid use in the 4 h prior to commencing remifentanil PCA.
- No additional Entonox ® use.
- Continuous, uninterrupted one-to-one midwifery care and surveillance.
- Continuous oxygen saturation monitoring throughout, with a baseline of greater than 94% before first administration. Some studies suggest that dedicated respiratory monitoring is better at detecting apneic events than oxygen saturation monitoring.
- Sedation scores every 30 min.

Indications for an immediate anaesthetic review

- Refractory desaturation (less than 90% despite 4L/min nasal oxygen)
- Respiratory rate less than 8 breaths per min
- Sedation (eyes closed or not rousable by voice alone)

Alternative PCA Regimens

Fentanyl

Fentanyl is a short-acting opioid, with no active metabolites. Like remifentanil, it can be administered as a PCA when epidural analgesia is contra-indicated or refused [12].

Regimens

- Fentanyl prepared at a concentration of 20mcg/ml (1000mcg made up to 50 ml with 0.9% Saline).
- Bolus dose of 20mcg, lock out period 3 min, 4 h maximum 1600mcg

Pharmacokinetics

- Onset time—3–5 min
- Time to peak effect—5–15 min

Guidance for use

- Similar to the use of remifentanil PCA, there should be continuous one-to-one midwifery care, with regular respiratory rate and sedation monitoring.

Morphine

Less commonly used as analgesia in viable labour due to a prolonged neonatal half-life of 6 h.

Regimens

- Bolus dose of 2 mg, lock out period 6 min, 4 h maximum 40 mg

Guidance for use

- Morphine PCA is associated with higher rates of nausea and vomiting as well as pruritus, compared to fentanyl PCA

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Management of the Woman with an Intrauterine Fetal Death (IUFD)

4

Dinesh Das and Nisa Patel

Definitions

Late intrauterine fetal death (IUFD) is defined as fetal death in utero after 24 completed weeks of pregnancy of a singleton fetus. Stillbirth is defined as a baby delivered with no signs of life known to have died after 24 completed weeks of pregnancy [1]. Fetal loss before this period is called a spontaneous abortion or miscarriage.

Incidence

More than 3000 IUFDs occur every year in the UK, an overall rate of 4.4 per 1000 total births. Stillbirth is more common with an incidence of 1 in 200 babies [1].

Causes

- Maternal: Diabetes, SLE (Systemic Lupus Erythematosus), preeclampsia, antiphospholipid syndrome, advanced maternal age, obesity, Rhesus disease, uterine rupture, trauma, infection.

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- Fetal: Intrauterine growth restriction, congenital abnormalities, infection, placental abruption, premature rupture of membranes, cord prolapse, chorioamnionitis, placenta praevia, vasa praevia.
- No specific cause is found in almost half of stillbirths [2].

Complications

- Risk of maternal disseminated intravascular coagulation (DIC) in 10% of cases after 4 weeks of late IUFDs, rising to 30% thereafter [1]
- Sepsis.
- Emotional, psychological and social effects on parents & their family due to the loss of the fetus.

Investigations

- Identify causes of IUFD, assess maternal wellbeing and ensure prompt management of any life-threatening maternal disease.
- Haematology, biochemistry, C-reactive protein (CRP): Low platelet count may suggest occult DIC [1].
- Coagulation screen and fibrinogen: sepsis, abruption and preeclampsia increase risk of DIC [3, 4]. Fibrinogen levels < 3.0 g/L may indicate DIC developing. Coagulopathy may develop without an obvious cause in up to 4% of IUFDs [3, 4].
- Kleihauer test: To detect lethal feto-maternal haemorrhage (a "silent" cause of IUFD) [1].
- Sepsis screen: Blood cultures, swabs and urine tests.
- Depending on the patient's medical history and clinical picture other maternal tests may be indicated [1].

Obstetric Management

- Urgent delivery of the fetus if there is sepsis, preeclampsia, abruption or membrane rupture.
- Otherwise expectant (conservative) management is acceptable for several days. 85% of mothers will deliver within 3 weeks of an IUFD.
- Repeat the coagulation screen twice weekly in those with expectant management [1].

- Other blood tests such as CRP may also need to be repeated more frequently.
- Aim to manage in a quiet room separate from the other labour ward activities to reduce stress and anxiety as well as allowing the family access to support the mother.
- Vaginal birth is achieved in most cases but instrumental or caesarean delivery may be needed for specific obstetric indications.
- Mifepristone and misoprostol are usually used in combination for induction.
- Augmentation with oxytocin may be required.

Analgesia for Labour with IUFD

- The anaesthetist should assess the patient and discuss analgesic options. Decisions regarding analgesia should be made with the patient, midwife and obstetric team depending upon the history, risk factors, clinical observations, availability of tests, stage of labour, gestation and the patient's wishes.
- Inhalational analgesia using Entonox®, if available, can be offered initially.
- Parenteral opioids:
  - Intramuscular (IM) diamorphine offers better analgesia with fewer side effects compared to meperidine (pethidine) [5, 6]. Other IM opioids may also be used [6]. These are more helpful in the early stages of labour, since they avoid being attached to infusion pumps and sedative effects may be beneficial. IM injections should be avoided in coagulopathic patients.
  - Intravenous Patient Controlled Analgesia (PCA): Morphine or fentanyl is appropriate as there are no concerns regarding neonatal depression. A PCA may be started before a coagulopathy screen is available. Remifentanil can also be used although there is the risk of maternal sedation and respiratory depression. Conversely rapid maternal and neonatal plasma clearance is less beneficial than when used for labour analgesia with a viable fetus.

- An epidural technique is the most effective form of analgesia and can also be offered to the patient in the absence of significant sepsis or coagulopathy.
- The risk of coagulopathy should be assessed before performing neuraxial blocks. A normal coagulation profile within 6 h of a neuraxial block is considered acceptable [7]. The risk is very low within 3 weeks of an IUFD (unless associated with abruption, PET or uterine rupture). Check if any thromboprophylaxis has been given (or planned) and time the insertion of the neuraxial block accordingly [7, 8].

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Category 4/Planned Caesarean Delivery

5

Wint Mon and Roxaan Jappie

Caesarean delivery (CD) rates are on the increase worldwide. NHS Maternity Statistics for England showed that the caesarean delivery rate had increased to 31% of all deliveries in 2019–2020 [1]. There has been a rise in the number of elective caesarean deliveries from 11% during 2013–14 to 13% during 2019–2020 [1]. Table 5.1 lists the indications for category 4 caesarean delivery.

In general, planned CD should be carried out **after** 39 weeks of gestation to decrease the risk of neonatal respiratory morbidity due to prematurity. If planned CD is performed prior to 39 weeks of gestation, antenatal intramuscular corticosteroids should be administered [2]. A thorough discussion should be documented in the notes (at the antenatal clinic visit or within the delivery area) describing the perceived benefits/risks of CD with clear documentation of the indication and category of urgency for CD. For category 4 CD, if a consent form has been previously completed and signed in the antenatal clinic, it should be confirmed and signed again on the day of surgery. Large amounts of information pertaining to both surgery and anaesthesia should be supplemented by written leaflets and the patient should be given ample opportunity to discuss alternatives.

Anaesthetic Management

Neuraxial anaesthesia is the safest option for anaesthesia for both planned and unplanned CD. It has many advantages over general anaesthesia:

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Table 5.1 Indications for category 4 caesarean delivery [3]

Indication type	Indication
Obstetric indication	Breech singleton term pregnancy, where ECV is contraindicated or unsuccessful
	Transverse lie at term, where ECV is contraindicated or unsuccessful
	Multiple pregnancy (first twin is non-cephalic presentation)
	Placenta praevia—major (placenta completely covers or is within 2 cm of the internal cervical os)
	Morbidly adherent placenta—placenta accreta/percreta/increta
Maternal infection	Maternal HIV infection with a detectable viral load > 400 copies/ml, regardless of retroviral therapy
	Hepatitis C
	Primary genital herpes in the third trimester
Maternal co-morbidity	Maternal diabetes with an estimated fetal weight > 4.5 kg
Previous delivery	Previous major shoulder dystocia, baby affected due to a difficult vaginal delivery
	Previous traumatic delivery leading to pelvic floor dysfunction- after multidisciplinary input with urogynaecologist
Other	Maternal request*

ECV=external cephalic version, *after counselling on the benefits/risks of CD versus vaginal delivery, appropriate counselling by a health professional if there is a fear of childbirth (tocophobia), consent is based on informed choice

- Reduced risk of failed intubation and dental damage
- Reduced risk of gastric content aspiration.
- Superior postoperative pain relief due to use of neuraxial opioids
- Reduced risk of postoperative nausea, vomiting and ileus
- Reduced venous thromboembolism incidence
- Ability to have a birth partner present

The UK Royal College of Anaesthetists recommends that 95% of planned and 85% of unplanned CD should be carried out under neuraxial anaesthesia [4].

Anaesthesia Pre-assessment

All women undergoing CD should have a thorough pre-assessment with full history, physical examination and appropriate investigations.

Special considerations when obtaining the history include the following.

Obstetric history

- Parity and gravidum
- Gestation

Table 5.2 Summary of lower uterine caesarean delivery surgery

Surgical procedure—caesarean delivery
• Skin incision—low transverse incision above the pubic symphysis (Pfannensteil/Joel-Cohen incision)
• Abdomen is opened in layers—subcutaneous fat, rectus sheath, peritoneum
• Entry into the peritoneum- as high as possible avoiding bladder and bowel injury
• Bladder reflected after dissection of loose uterovesical fold of peritoneum
• Small incision made on lower segment and extended bilaterally
• Membranes ruptured
• Delivery of the baby by lifting the presenting part out of the uterine cavity while the assistant stabilizes the uterus and guides the baby out with gentle fundal pressure
• Sometimes if there is an impacted fetal head or floating head or unstable lie in a preterm baby, the delivery can be difficult
• Uterus may sustain prolonged contraction around the upper segment making the delivery difficult in emergency CD after a long labour—in such rare cases, a uterine relaxant (for example, GTN spray given as a 400 μg metered dose or IV salbutamol 100 μg) can be used to relax the uterus and aid delivery of the baby
• After delivery of the baby, a uterotonic such as oxytocin 3–5 units IV or carbetocin 100mcg IV is administered to aid placental separation and active management of the 3rd stage
• The placenta and membranes are removed completely
• At this stage, if a background risk of haemorrhage is present, further oxytocin can be administered as an infusion (10 units/hour)
• The uterus is closed in 2 layers
• If there is an extension in the uterine incision, exteriorization of the uterus may be performed
• The uterine incision is closed and haemostasis is ensured. Surgical swab and sharp counts should be checked with the scrub nurse before the abdomen is closed in layers
• Skin closure is secured by a sterile dressing and the vagina is examined for bleeding

- Previous deliveries/caesarean deliveries—indication and outcome
- Fetal health, size and position
- Placental location
- Multiple pregnancies
- Pregnancy related medical conditions

Maternal history

- Past anaesthetic and medical history
- Allergies and regular medications
- Ensure antacid prophylaxis has been given. (e.g. ranitidine 150 mg orally 12 h pre delivery and 2 h pre-delivery with oral metoclopramide 10 mg) Some units use a proton-pump inhibitor (PPI), such as oral lansoprazole 30 mg.
- Fasting status should be confirmed.

Physical examination

- Airway
- Lower back
- Cardiorespiratory assessment where appropriate

Investigations

- Blood tests obtained during the first antenatal visit
- Type and Screen (blood typing and antibody screening) must be available. Blood cross-match should be done if there is high risk of bleeding.

Intra-operative Management

- Maternity (specific) WHO checklist
- Monitoring recommended by the Association of Anaesthetists for the mother
- Large bore intravenous cannula (16 or 18 gauge)
- Antibiotic prophylaxis
- Fetal monitoring—Fetal heart rate monitoring in planned CD and cardiotocography (CTG) in emergency CD.
- Position for neuraxial anaesthesia or general anaesthesia
- Neuraxial anaesthesia and general anaesthesia for CD are described in detail in other chapters.
- Maintain normothermia (e.g. by using forced air warming or an in-line IV fluid warmer [5].
- Co-loading with crystalloid solution at the time of neuraxial anaesthesia or induction of general anaesthesia
- Left lateral tilt position for the delivery
- Management of spinal hypotension—a variable rate phenylephrine infusion with crystalloid co-loading is recommended to maintain normal blood pressure [6].
- Effective communication with the mother, her birth partner and the obstetricians is essential.
- A bolus of 3–5 International Units (IU) of oxytocin at the time of delivery and an infusion of oxytocin at 10 IU/hour after the delivery (standard practice in the UK) or 100 mcg carbetocin IV by slow bolus injection post delivery

- Analgesia—spinal/epidural opioid paracetamol and NSAIDS (if no contra-indication)
- Antiemetic—prophylactic intravenous ondansetron has also been shown to reduce spinal hypotension but its effect may be minimal [7].

Surgical approach

There are different types of surgical approach to performing a CD:

- Based on the type of uterine incision

1. Lower uterine segment caesarean delivery—this is the most common site of incision in modern obstetric practice as it is associated with improved healing and decreased risk of future uterine scar rupture [8].
2. Upper segment/classical CD—Incision made on the upper segment of the uterus was traditionally the preferred site of incision. However, due to thickness of upper uterine segment, the chances of poor healing and scar rupture are higher. In modern obstetrics, there are few selective indications for which classical CD will be preferred. For example, a classical CD is performed before definitive treatment for cervical cancer in pregnancy [9]. Also, if the patient undergoes classical CD, this necessitates elective CD in subsequent pregnancies due to the higher risk of uterine scar rupture in labour [10].

Post-operative Monitoring

- General anaesthesia—women should be monitored on a one-to-one basis by an appropriately trained member of staff until they have regained airway control and cardiorespiratory stability.
- For all forms of anaesthesia—standard monitoring including respiratory rate, pulse, blood pressure, pain and sedation every half an hour for 2 h, and hourly thereafter provided that the observations are stable.
- Modified early obstetric warning scores (MEOWS) can be used to support monitoring after CD.

Common Problems Occurring Intra- or Postoperatively

Neuraxial anaesthesia

- Hypotension—nausea + vomiting
- Inadequate neuraxial blockade
- High spinal (total spinal—rare)

General anaesthesia

- Difficult intubation
- Failed intubation
- Pulmonary aspiration of gastric contents
- Awareness
- Inadequate pain relief in immediate postoperative period

Obstetric

- Haemorrhage
- Ureteric or bladder injury
- Amniotic fluid embolism (rare)
- Deep vein thrombosis

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Spinal Anaesthesia for Caesarean Delivery

6

Sioned Phillips and Adrienne Stewart

Spinal anaesthesia is the gold standard for providing surgical anaesthesia for caesarean delivery (CD). It allows the mother and her partner to experience the birth of their baby and provides excellent operating conditions for the surgeon. The main concern surrounding the use of spinal anaesthesia is the incidence of spinal induced maternal hypotension, which can occur in up to 80% of parturients if untreated. Another disadvantage of spinal anaesthesia, compared with alternative neuraxial anaesthetic techniques for caesarean delivery, such as epidural or combined spinal epidural (CSE) anaesthesia, is that a fixed dose of local anaesthetic is administered and there is no capacity to administer additional local anaesthetic and extend the time of the effective block. Therefore, if it is anticipated that surgery may be prolonged, an alternative technique such as a CSE technique should be considered.

Contra-indications

- Patient refusal
- Allergy to amide local anaesthetics
- Uncorrected hypovolaemia
- Coagulopathy INR > 1.4, platelets < 70×10^9/L
- Localised sepsis around the insertion site
- Raised intracranial pressure (ICP)

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Consent

The parturient should be seen before elective or emergency caesarean delivery. A history should be taken including any relevant medical and obstetric history, drug history and allergies. A fasting history should be taken and the airway assessed in case of any complication. A brief description of the procedure should follow, including potential risks and complications of the procedure, as well as a careful explanation that they may experience sensations of pressure at times during the surgery and that this is to be expected.

Potential Risks and Side Effects

- Failure to achieve a satisfactory block and the need to convert to general anaesthesia
- Headache (1 in every 100)
- Permanent nerve injury (1 in 23,500–50,500) or paraplegia (1 in 54,500–141,500)
- Common side effects, such as nausea/vomiting, itching, shivering and hypotension

Needles

Atraumatic or Pencil point needles (e.g. Whitacre and Sprotte) are preferred over "cutting" needles (Quincke) as they are less likely to cause a post-dural puncture headache (PDPH), as they separate the dural fibres as opposed to cutting through them. PDPH is said to be due to the development of a leak of CSF through the dural hole. The larger the needle, the bigger the hole in the dura (and the greater the CSF leak) and therefore, the higher the risk of developing PDPH. Although 27G Pencilpoint needles are available and suitable for use, 25G and 26G needles are most commonly used. The incidence of a PDPH with a 25G Whitacre needle has been documented as being as high as 2.5–3% [1, 2], compared with 0–0.5% with a 27G Whitacre [1], therefore, smaller gauge needles such as a 26G Whitacre [3] or 27G Whitacre are recommended for use.

Position

It is often technically easier to insert a spinal with a patient sitting. However, in emergency cases, particularly when there is fetal distress, the lateral position may be more favourable for a number of reasons: it is easier to perform CTG

monitoring; there is improved maternal cardiac output; block height ascends more quickly, reducing the time to surgical anaesthesia; and in cases where there is fetal distress, an anaesthesia assistant can start pre-oxygenating the mother in the lateral position, saving time if there is a need to abandon spinal anaesthesia in favour of general anaesthesia.

A modified lateral position, called the Oxford position, can be used with the aim of preventing excessive cephalad spread of local anaesthetic. Here a pillow is inserted under the shoulders, to limit cephalad spread of local anaesthetic in the lateral position. This position is rarely used, but an understanding of patient position to manipulate spread of local anaesthetic is important.

Intrathecal Drugs and Doses

Local anaesthetic drugs

The gravid uterus results in an increase in intra-abdominal pressure, which is transmitted to the epidural venous plexus. This leads to a decrease in CSF volume, and therefore pregnant patients require a reduction of 25% in the dose of local anaesthetic, to achieve the same block height as a non-pregnant patient. Other factors, such as gestational age will also affect the final height of the block, such that pre-term patients will require more local anaesthetic, as there is less increase in intra-abdominal pressure and subsequent effect on CSF volume.

- Hyperbaric and plain (hypobaric) bupivacaine are the only licenced local anaesthetic drugs for spinal anaesthesia in the UK.
- Hyperbaric bupivacaine 0.5 and 0.75% are the most commonly used local anaesthetics as they have a fast onset of action and produce a reliable, adequate sensory block height. Both preparations contain glucose to increase the density of the spinal solution.
- The **ED95 of intrathecal hyperbaric bupivacaine is 11.2 mg** (when co-administered with an opioid) [4], however doses used to provide surgical anaesthesia for caesarean delivery, documented in the literature, **range from between 8 to 15 mg**. There is a risk of an inadequate block when lower doses are used, and of a high block with higher doses.
- The height of block is dependent on the mass of the drug given as opposed to the drug volume.

Opioid drugs

The addition of opioid drugs to the local anaesthetic will improve both the quality and duration of surgical anaesthesia.

- fentanyl 10–25 mcg—is fast and easy to prepare, therefore good in the emergency situation, however its effect is short acting (1–2 h of postoperative analgesia) and does not provide an adequate period of post-operative analgesia.
- morphine 100–200 mcg—has a slow onset but provides effective long-lasting post-operative analgesia for up to 24hours. Any preparation of morphine used via the intrathecal route must be preservative free. Intrathecal preservative free morphine is less commonly used (compared to intrathecal diamorphine) in the UK compared to many other countries. Intrathecal fentanyl should be co-administered with intrathecal morphine due to, morphines slower onset of action.
- diamorphine 300–400 mcg—is available as a crystalline formulation, requiring dilution for preparation, and so can be time consuming to prepare in an emergency. Its use is recommended in the UK by NICE (National Institute of Health and Care Excellence) as it provides good post-operative analgesia after caesarean delivery [5].

Block Assessment

- A sensory block height to cold sensation to T4, and light touch to T5 is widely regarded as acceptable for caesarean delivery.
- It is also important to test that the sacral roots are blocked prior to surgery, as well as ensuring a dense bilateral motor block in the lower limbs. A lack of motor block usually indicates a poorly functioning spinal.
- Block height and lower limb motor block assessment achieved before surgery should be carefully documented and recorded in the notes.

Common Problems Encountered

- Inadequate block—before surgery: depending on the urgency of surgery, consider a repeat spinal anaesthetic, adjusting and reducing the dose according to the initial block height achieved. May need to convert to general anaesthesia if insufficient time to repeat the block.
- Inadequate block—during surgery: depending on the stage of surgery, consider IV adjuncts such as IV fentanyl, however conversion to general anaesthesia may be required (See Chaps. 56, 9).
- Spinal-induced hypotension—leading to nausea and vomiting: the prophylactic use of a vasopressor infusion such as phenylephrine together with crystalloid co-loading, in addition to reactive phenylephrine bolus doses can be used to facilitate blood pressure control (See Chap. 10).

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Combined Spinal-Epidural Anaesthesia for Caesarean Delivery

7

Marc Van de Velde

Most caesarean deliveries are performed under neuraxial anaesthesia. In the vast majority of cases this is a Single Shot Spinal (SSS) technique (see Chap. 6). Unplanned operative deliveries in women who were initially planning to deliver vaginally and with a labour epidural catheter in place, usually have the epidural topped-up for surgery (see Chap. 8). However, in many institutions or for a variety of indications, combined spinal-epidural anaesthesia (CSE) is performed for caesarean delivery. In this chapter the CSE technique for operative delivery is discussed as well as potential advantages and disadvantages regarding its use.

The CSE Technique

A single interspace, (spinal) needle through (epidural) needle technique is commonly used when performing a CSE [1]. For a description of the technique see Chap. 2 on 'combined spinal-epidural analgesia for labour'.

CSEs can be performed in either the sitting or left lateral positions. Testing of the level and degree of motor and sensory blockade after CSE placement, is performed in a similar manner to block testing after a SSS (see Chap. 56).

Indications

Although a SSS is the preferred technique for most operative deliveries, CSE may have a role to play in certain situations:

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- Prolonged surgery—the availability of an epidural catheter to extend anaesthesia duration in case of prolonged surgery (e.g. obesity, complicated surgery, repeat caesarean delivery, placenta accreta spectrum). A single shot spinal injection produces a good quality block, but of a limited duration (75–120 min). A CSE should be considered for any procedure, which could potentially last beyond this duration.
- History of previous failed or inadequate spinal block.
- Anatomical abnormality (e.g. severe scoliosis), increasing the possibility of an inadequate block with the initial spinal injection.
- Following the removal of an inadequately functioning labour epidural catheter before urgent caesarean delivery. Occasionally a previously sited epidural catheter used to provide labour analgesia is used to provide anaesthesia for surgery using high concentration local anaesthetic drugs, but fails to provide an inadequate level of anaesthesia before surgery starts. In such cases, a low dose (spinal) CSE (followed by an epidural top-up) may be preferable to avoid a potentially high spinal block, which is sometimes associated with a full dose spinal (following an epidural top-up). Naturally, the clinical urgency of proceeding with an emergency caesarean delivery, will dictate which mode of anaesthesia is the most appropriate to be used.
- Hemodynamically compromised parturients—a single shot spinal technique, in which rapid vasodilation could cause haemodynamic compromise, is contraindicated in the presence of certain cardiac comorbidities (e.g. aortic stenosis). A low dose CSE (spinal) followed by an epidural top-up may provide improved cardiovascular stability in these situations compared to a SSS technique.
- Low dose spinal anesthesia can be used to avoid profound hypotension, maternal nausea and vomiting as well as reducing the use of high dose vasopressors such as phenylephrine. Whenever a lower spinal dose is used, a backup epidural catheter is advised to manage or prevent breakthrough pain in cases of prolonged surgery (>45 min). For dosing regimens see below.
- Postoperative analgesia—the epidural catheter can be used for postoperative analgesia if necessary, using a patient controlled epidural analgesia (PCEA) technique with low dose epidural mixtures of local anaesthetic and opioid.

CSE Spinal Doses

Usually, intrathecal hyperbaric/heavy bupivacaine is administered in the intrathecal component of a CSE. A standard dose of heavy bupivacaine used in a SSS (11–15 mg) is administered, although some experienced anesthesiologists may choose to use a lower dose. It is important to note that the duration of anaesthesia is significantly reduced as a result of spinal dose reductions. Clinicians that use a low dose CSE technique typically administer 6–9 mg of heavy bupivacaine, which may result in good anaesthetic conditions for only 40–50 min depending on patient factors such as weight, height and size of the gravid uterus. Therefore, when

surgery is prolonged an epidural top-up should be considered after approximately 40 min (prophylactically) if surgery is ongoing in order to prevent/manage breakthrough sensations or pain. A meta-analysis found that spinal doses of bupivacaine below 8 mg compromised anaesthetic efficacy (requiring increased anaesthesia supplementation via the epidural catheter) despite the benefit of lower side-effects such as nausea/vomiting and hypotension [2].

When the epidural catheter is used to extend the height of the spinal block (qv), prolong the duration or enhance the quality of the anaesthesia block, titrated doses of high concentration local anaesthetic can be administered (such as lidocaine 2% with 1 in 200,000 epinephrine, ropivacaine 0.75%, bupivacaine 0.5%, levobupivacaine 0.5% or chloroprocaine 3%).

A Practical Approach to Using A Low-dose CSE Technique

- Single space, needle-through-needle, CSE performed in the sitting position at the L3-L4 or L4-L5 interspace.
- Loss of Resistance (LOR) to saline.
- Injection of 6.0–7.5 mg heavy bupivacaine with 2.5 mcg sufentanil or 15 mcg fentanyl (with or without intrathecal preservative-free morphine 150 mcg or diamorphine 300 mcg).
- Insertion of an epidural catheter 3–5 cm within the epidural space.
- Supine position with a left lateral tilt, head down position until the anaesthesia block level reaches the T4 dermatome (absence of cold sensation is usually tested, since touch sensation is usually preserved during low dose spinal anesthesia).
- Once the block reaches a level to include the T4 dermatome (to cold sensation), the head down position is no longer needed, and surgery can start.
- If the sensory block does not reach the T4 dermatome, an incremental epidural top-up is given until a T4 level is reached. A suitable epidural top-up could include 5–10 ml of 0.5% levobupivacaine or the same volume of 0.75% ropivacaine.
- If the uterus is not closed within 40 min of the spinal injection, a prophylactic titrated dose of high concentration epidural top-up is administered.
- Some anesthesiologists use an Epidural Volume Extension (EVE) technique when using a low dose spinal as part of a CSE. EVE is a technique which is said to extend a spinal block whereby saline (5–10 mL) is administered via the epidural catheter (or directly through the epidural needle) after the administration of intrathecal local anaesthetic. The aim is to extend the cephalad spread of the sensory block, by a volume effect. However, the effect of EVE has been shown to be equivocal [3].

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Epidural Top-Up for Caesarean Delivery

8

Ryan Howle and Tauqeer Husain

An epidural that has been sited for labour analgesia can be converted to anaesthesia for operative delivery by "topping up" with higher concentrations of local anaesthetic. This is distinct from a de novo epidural, which takes longer to provide adequate anaesthesia when inserted at the time of surgery, and therefore may be impractical for most clinical situations.

Indications

- Operative intervention—e.g. caesarean delivery, perineal repair, manual removal of placenta, examination under anaesthesia
- Trial of instrumental delivery—e.g. forceps, ventouse, Kiwi delivery

Contra-indications

- Inadequate epidural labour analgesia—e.g. missed segments, unilateral block, need for multiple clinician epidural boluses in labour
- Surgical urgency doesn't allow for time to top-up
- Known or suspected accidental dural puncture
- Change in maternal condition that would make epidural top-up unsafe—e.g. major obstetric haemorrhage

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Factors Affecting Decision to Top-up an Existing Epidural Catheter

- Quality of epidural
  - Adequate labour analgesia is usually associated with adequate operative anaesthesia.
  - If the analgesic block has receded, the top-up may take longer to provide surgical anaesthesia.
  - Where epidural analgesia has not been established in labour, an epidural top-up can produce unpredictable operative anaesthesia.
  - If an epidural has been difficult to insert during labour, it should be utilised for operative anaesthesia where possible, as alternative neuraxial procedures are also likely to be difficult to perform.
- Time to delivery/surgical readiness
  - Epidural anaesthesia often takes longer than spinal anaesthesia to establish a clinically appropriate block level. This is also dependent on the top-up regimen used (see below).
  - When planning for time-critical emergency delivery, 10–20 min should be allowed for an epidural top up to provide adequate anaesthesia.
- Maternal well-being
  - The slower onset of action of epidural top-ups, compared to spinal anaesthesia, is often associated with less haemodynamic disturbance in cases of maternal cardiac disease, pre-eclampsia or mild blood loss. However, as the volume of blood loss increases, neuraxial anaesthesia and analgesia becomes increasingly poorly tolerated regardless of whether the spinal or epidural route of administration is used.
  - If there is increased maternal risk from general anaesthesia (e.g. predicted difficult airway), establishment and optimisation of neuraxial anaesthesia should occur as a priority during labour. This will facilitate successful epidural top up for caesarean delivery, if required.

Epidural Top-up Regimens

- Various mixtures are in use [2] and depend on institutional protocols (Table 8.1).
- The addition of fentanyl to the top-up mixture (50–75mcg) can reduce the onset time by up to 2 min.
- 'Fast-mix' solution (local anaesthetic + epinephrine + bicarbonate) can produce surgical anaesthesia within 7 min. However, this needs to be offset with the time

Table 8.1 Methods of epidural top-up (Hillyard et al. 2011) [1]

Epidural top-up mixture (15–20 ml solution)	Block onset time (min)	Intra-operative supplementation (%)
Levobupivacaine 0.5% or Bupivacaine 0.5%	10–18	15–29
Bupivacaine 0.5% (10 ml) + Lidocaine 2% (50:50 mixture)	12	34
Ropivacaine 0.75%	10	13
Lidocaine 2% + epinephrine 1:200,000 (100 mcg)	9–14	8–21

required to prepare the solution (up to 4 min) and the extra risk of drug error during preparation of the solution [3].

- These regimens utilise alkalisation, by the addition of 8.4% sodium bicarbonate, to raise the injectate pH, which in turn increases the amount of lipophilic, unionised local anaesthetic that can diffuse through the nerve cell membrane to block the nerve impulse. This translates clinically to a significantly quicker onset of action, improved pain threshold and density of motor block [4].
- Alkalinisation should be performed using preservative-free sodium bicarbonate, as alternative preparations contain Ethylenediaminetetraacetic acid (EDTA), which may be associated with neurological injury. In the UK, a lack of availability of preservative-free sodium bicarbonate recently has led to the many units using only 2% lidocaine with 1:200,000 epinephrine (or 100mcg).
- This adjusted 'fast-mix' solution is prepared as: 20 ml 2% lidocaine with 0.1 ml 1:1,000 epinephrine (100mcg) added immediately before administration.

How to Top-up

- Test dose—3–5 ml, wait two to three minutes
  - Observe for signs and symptoms of intrathecal or intravascular spread (e.g. rapid onset high block, hypotension, tachycardia, dyspnoea, lip tingling, light-headedness, seizures, arrhythmias).
- Total dose—15–20 ml
  - Delivering a large volume bolus (e.g. 10 ml) at high pressure will encourage rapid dermatomal spread [5]. However, large bolus administration in an untested epidural catheter exposes the patient to the risk of high/total spinal or intravenous spread and local anaesthetic toxicity.
  - Optimal administration would be to deliver 15–20 ml in divided doses after an adequate test dose.

Where to Top-up

- Deciding where to initiate testing and topping up of an epidural catheter requires a balance between the time required to achieve surgical anaesthesia, patient safety and the ability to identify erroneous spread.
- However, once the top-up has commenced, an anaesthetist must remain with the patient until the end of surgery.
- Top-up in the labour room—usually unmonitored and difficult to identify complications. If performed, only administer the test dose and accompany the patient to theatre and attach monitoring at the earliest opportunity.
- Top-up in the operating theatre—extended onset time but improved patient safety.

Block Assessment

The block should be assessed before or immediately after the epidural top-up to identify a baseline, then at regular intervals to determine if the patient has adequate anaesthesia appropriate for surgery. In the presence of an effective analgesic block, a multi-modal approach to block assessment is necessary to assess progression [4, 6].

- Temperature sensation can be assessed with ice or an ethyl chloride spray.
- Light touch can be assessed by the initial "blowing" or "air jet" sensation of the ethyl chloride spray or with cotton wool or tissue paper.
- Motor (Bromage score)—often preserved with an analgesic block (e.g. for labour analgesia) and can remain incomplete after an effective epidural top-up.
- Pain/pinprick—e.g. Neurotip ® (rarely used clinically), skin pinching provides a crude assessment.
- Care should be taken to differentiate completely anaesthetised levels (e.g. absolutely no appreciation of cold) from transition zones where there is some blunting of sensation (e.g. some appreciation of cold) and non-anaesthetised areas (e.g. where there is a complete appreciation/sensation of cold).
- In the anaesthetic literature, adequacy of neuraxial anaesthesia for caesarean delivery has been quoted as a block to light touch up to T5 bilaterally. However, surveys of obstetric anaesthetists in the UK suggest that in practice most favour a block to cold up to T4 bilaterally. The latter approach does not seem to be associated with greater rates of inadequate anaesthesia [7].
- Good clinical practice will be influenced by local guidelines and personal clinical experience. However, it should include assessment and documentation of the upper levels and ideally lower levels (sacral blockade) to both light touch and cold, although in practice (especially in emergency situations) this is rarely documented.

Failed Epidural Top-up

This should not be declared until at least 15 min have elapsed giving sufficient time for the block to establish. Management will depend on clinical urgency, maternal health and projected block progression (time to develop surgical anaesthesia).

- Inadequate block height but good progression—additional boluses of epidural mixture may assist in achieving the required level of anaesthesia. However, care should be taken when the total administered local anaesthetic is approaching the maximal toxic dose (e.g. in a 90 kg woman, local anaesthetic toxic dose limit will be achieved after 27 ml of 2% lidocaine with epinephrine). Administering local anaesthetic slowly when it is certain that the epidural catheter is not in a blood vessel may mitigate some of the risks of local anaesthetic toxicity and allow further small boluses to be administered.
- Poor progression or patchy/incomplete block—consider an epidural bolus or the addition of fentanyl but be prepared to abandon the top-up and to use an alternative technique.

Abandoned Top-up

In situations where an epidural top-up has been abandoned due to a lack of effectiveness, an alternate form of anaesthesia must be identified and initiated.

- Where time critical delivery or maternal health precludes further neuraxial attempts, or when maternal consent for further neuraxial procedures is not obtained, general anaesthesia should be planned for delivery.
- In any other situation, further spinal or Combined Spinal-Epidural (CSE) anaesthesia should be performed, once the epidural catheter has been removed.
- There is some debate about the role of spinal anaesthesia following a failed epidural top-up, with some case reports of unpredictable spread of spinal anaesthesia leading to a high spinal block and the need for emergency intubation. This has led to some suggestions that spinal anaesthesia should be avoided in this situation or the total spinal dose reduced.
- However, the use of spinal anaesthesia, administered in either a full or reduced dose, is routine practice in many institutions following failed epidural top-up. Advocates of reduced doses (typically 20–30% less) argue the risk of high spinal block is due to volume expansion of the epidural space from previous epidural drug administration, which results in a higher dermatomal block level. However, this is not supported by prospective, randomised evidence. Additionally, a reduced dose spinal anaesthetic may expose the patient to another inadequate block, the risks of a second procedure and the need for subsequent general anaesthesia [4].

- A reasonable approach may be to administer a "normal" spinal dose, but take proactive steps to minimise the effects of a high block with careful positioning, intravenous fluids and vasopressors. Alternatively, if a reduced spinal dose is to be administered, it should be as part of a CSE procedure to reduce the risk of further suboptimal anaesthesia.

End of Surgery

Decisions about epidural management after surgery are also required.

- Post-operative analgesia can be provided by administration of a long-acting opioid (e.g. 3 mg diamorphine or 2–3 mg morphine) via the epidural catheter before the end of surgery.
- Most epidurals catheters are removed at the end of surgery, but caution must be employed if there is risk of coagulopathy (e.g. blood loss greater than 1500 ml, Haemolysis Elevated Liver enzymes and Low Platelets (HELLP) variant of pre-eclampsia or pre-delivery coagulopathy) or imminent return to theatre (e.g. on-going bleeding or removal of vaginal packs).
- If an epidural catheter is kept in situ; meticulous monitoring, handover, documentation and follow-up is required.

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General Anaesthesia for Caesarean Delivery

9

Atif Chaudhary and Robin Russell

Indications

- Extreme urgency (maternal or fetal compromise)
- Contraindication to neuraxial block: coagulopathy, sepsis, hypovolaemia, lack of consent
- Patient request
- Inadequate neuraxial block
- Maternal co-morbidities: significant cardiac or neurological disease, abnormal placentation

Contraindications

- Patient refusal
- Predicted difficult airway
- Allergy to general anaesthetic drugs

Pre-Assessment

The degree of pre-assessment depends on urgency of delivery. The follow issues should be addressed:

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- Past medical and anaesthetic history
- Pregnancy-related conditions
- Current medications
- Allergies
- Last food and drink intake
- Airway assessment
- Full blood count & cross-match (where indicated)
- Placental location
- Antacids: intravenous ranitidine 50 mg (unless previously given) OR intravenous omeprazole 40 mg and oral sodium citrate 30 mL
- Consent: include information on difficult intubation, aspiration of stomach contents, accidental awareness, sore throat, nausea and vomiting and postoperative analgesia

Induction of Anaesthesia

Before induction of anaesthesia:

- Patient positioned supine with left uterine displacement. A ramped position or head elevation pillow (Fig. 9.1) may be required for optimal airway management due to an increase in chest diameter and breast tissue
- Trained, dedicated anaesthetic assistant in attendance
- Large-bore intravenous access with fluids running
- Patient monitoring (ECG, non-invasive BP, oxygen saturation, end-tidal gas monitoring)
- Airway equipment checked including available difficult airway trolley. Video laryngoscopes are increasingly used for difficult intubation (Fig. 9.2). Suction readily available

Fig. 9.1 The Oxford HELP (Head Elevation Pillow) Pillow which is used to improve the view at laryngospcopy during endotracheal intubation. Published with permission from Alma Medical, UK

Fig. 9.2 The C-MAC videolaryngoscope which is used to facilitate the view at laryngoscopy during endotracheal intubation. Published with the permission of Karl Storz, Germany

- Pre-oxygenation
- Insertion of urinary catheter
- Surgeons scrubbed and the patient's abdomen cleaned and draped
- WHO checklist performed
- Prophylactic broad-spectrum antibiotics

Traditionally, pre-oxygenation has been performed with a tight-fitting facemask and oxygen flow rates >10 L/min for three minutes. Oxygen at 5 L/min may also be given via nasal cannulae to maintain bulk flow of oxygen during attempts at intubation [1]. Before induction, end-tidal oxygen levels should be >90%. There has been recent interest in the use of trans-nasal humidified rapid-insufflation ventilator exchange (THRIVE) [2]. More research is needed to establish its role in obstetric general anaesthesia.

Rapid-sequence induction is preferred to minimise the risk of aspiration of stomach contents. Cricoid pressure of 10 N force is applied by the anaesthetic assistant as the patient starts to lose consciousness and increased to 30 N when the patient is anaesthetised. If applied incorrectly, cricoid pressure can lead to difficulty with intubation. It may need to be reduced or removed where difficulty occurs although this may increase the risk of aspiration [1].

Drugs for Rapid Sequence Induction

- Thiopental (5–7 mg/kg) OR Propofol (2–2.5 mg/kg)

Thiopental has been used for many years but due to its decreasing popularity in other areas of anaesthesia, many younger anaesthetists are less familiar with its use. High-quality evidence supporting the use of one particular agent in terms of

maternal awareness and neonatal depression is lacking. There may be an increased risk of drug errors with thiopental. The use of either agent is acceptable. Etomidate and ketamine are now rarely used.

- Succinylcholine (1.5 mg/kg) OR Rocuronium (1–1.2 mg/kg)

Succinylcholine has a rapid onset, short duration and muscle fasciculation (not always seen in pregnancy) indicates its effect. However its side effects (myalgia, potassium rise, arrhythmias, trigger for malignant hyperpyrexia, raised intracranial pressure and prolonged duration in cholinesterase deficiency) have resulted in an increasing popularity in rocuronium. There are concerns about rocuronium's longer duration of action if intubation and oxygenation are not possible. Its effects may be reversed with sugammadex. If required within three minutes of administration of rocuronium 1.2 mg/kg, a dose of 16 mg/kg of sugammadex is recommended for reversal of neuromuscular blockade. Rocuronium's side effect profile is favourable when compared to succinylcholine, although cases of anaphylaxis have been reported. As an alternative to rocuronium, atracurium 0.4–0.5 mg/kg can be used although its onset of action is slower.

Obtunding the Hypertensive Response to Laryngoscopy

Laryngoscopy and intubation stimulate a profound hypertensive response which is undesirable especially in women with hypertensive, cardiac or neurological disease. This may be obtunded by:

- Opioids: remifentanil (1–1.5 μg/kg); alfentanil (10–15 μg/kg); fentanyl (1–1.5 μg/kg)
- Labetalol (5–10 mg boluses to effect)
- Esmolol (0.5–2 mg/kg)
- Magnesium (40 μg/kg): caution in patients already receiving magnesium therapy
- Lidocaine (1.5 mg/kg)

The neonatal team should be informed of maternal drug administration at induction of general anaesthesia.

Maintenance of Anaesthesia

Anaesthesia is usually maintained with a volatile agent (sevoflurane or isoflurane) with or without nitrous oxide. Overpressure techniques, in which high concentrations of volatile agents with high fresh gas flows are given initially, are

recommended to reduce the risk of awareness. A minimum alveolar concentration (MAC) value of 1.0–1.5 should be maintained until delivery. Higher inspired oxygen concentrations improve umbilical cord gas values but have not been demonstrated to improve clinical outcome. It is usual to administer 50% oxygen and to ventilate to normocapnia of pregnancy (4.0–4.5 kPa) pre delivery. Intravenous anaesthesia can be used and may be helpful in the presence of uterine atony; however, in the majority of cases no obvious advantage has been demonstrated over volatile-based techniques.

Following delivery, it is usual to administer an oxytocin bolus (3–5 IU slowly) and infusion (10 IU/h). Opioids are usually given after delivery and the concentration of volatile agent reduced. Intravenous fluids are given to replace preoperative deficit and intraoperative losses. Local anaesthetic blocks may be administered by the surgeon during wound closure or by the anaesthetist at the end of surgery. On completion of surgery, anaesthetic agents are discontinued and the patient awoken in either the left-lateral or sitting position. Extubation should occur only when the patient is awake.

Postoperative Management

All patients should receive the same standard of recovery as other surgical patients and should include:

- Supplemental oxygen
- Regular observations: heart rate, blood pressure, respiratory rate and oxygen saturation
- Multimodal analgesia: regular paracetamol, non-steroidal anti-inflammatory drugs (if not contraindicated), and opioids (intravenous patient-controlled analgesia)
- Thromboprophylaxis
- Postnatal anaesthetic review

Problems Specific to General Anaesthesia for Caesarean Delivery

- Failed intubation (see Chap. 64) at caesarean delivery occurs in approximately 1 in 400 cases in the UK [3]
- Volatile anaesthetic agents reduce uterine tone potentially increasing haemorrhage, although this effect can be minimised with oxytocin.
- Accidental awareness (see Chap. 61) is more common in the obstetric population (1 in 600 cases) [4]

- Placental transfer of anaesthetic drugs may have effects on the baby. Opioids are increasingly used at induction to blunt the stress response to laryngoscopy and to reduce the risk of accidental awareness [5]. The neonatal team should be informed of their use.

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Hypotension During Spinal Anaesthesia for Caesarean Delivery

10

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Background

Hypotension following spinal anaesthesia (SA) for caesarean delivery (CD) causes adverse effects in both mother and fetus [1, 2]. In the neonate, depressed Apgar scores and umbilical acidosis are correlated to the duration and severity of hypotension. In the mother, it causes nausea and vomiting, dizziness and decreased levels of consciousness. Maternal hypotension has been historically defined as a systolic arterial blood pressure (SBP) <80% of baseline, or 90–100 mmHg [3]. The incidence of hypotension following SA is high; therefore prevention and treatment should be principle aims for management, and are discussed in detail in an international consensus [4].

Haemodynamic Changes

SA primarily causes a decrease in systemic vascular resistance (SVR) due to arteriole vasodilation and moderate venodilation from sympathetic blockade. This leads to a compensatory baroreceptor-mediated reflex tachycardia and increase in stroke volume, causing an early rise in cardiac output (the product of stroke volume and heart rate: CO = SV x HR).

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Standards for Monitoring

An accurate baseline blood pressure should be recorded, usually non-invasively using an automatic oscillometric device. Repeated measures should be performed if in active labour, or if a higher value is obtained than expected.

- Repeat measurements every 1–2 min from the induction of SA [5].
- Uteroplacental perfusion relies on both maternal blood pressure and cardiac output. Maternal heart rate (HR) is a surrogate for cardiac output, and so bradycardia should be avoided.
- Continuous blood pressure monitoring with an intra-arterial device or non-invasive pulse contour devices such as the Clearsight® device, may be beneficial in high-risk cases especially in women with cardiac disease.

Vasopressors

The goal of management is to restore the SVR, therefore α adrenergic agonists are recommended as first-line for prevention and treatment of SA-induced hypotension. Phenylephrine, an almost pure α receptor agonist, is currently the agent of choice, with causes less neonatal acidosis and provides superior blood pressure control when compared to ephedrine, which was previously favoured in obstetric anaesthesia to treat SA-induced hypotension [6]. Vasopressors with some β agonist activity may have an even better profile (norepinephrine, metaraminol), but evidence is currently limited [7].

Administration

Prophylactic infusion is superior to reactive bolus administration in clinical practice, as boluses are likely to be delayed and result in more hypotension compared to infusion treatment [8]. A phenylephrine variable rate prophylactic infusion should be started at 25–50 $\mu g.min^{-1}$ immediately after induction of SA and titrated to maintain SBP and HR. Excessive use should be avoided to prevent dose-dependent reductions in both maternal HR and cardiac output [9].

- SBP should be maintained at $\geq 90\%$ of baseline with frequent monitoring.
- Episodes of SBP <80% should be treated promptly with additional boluses of phenylephrine 50–100 μg. Increasing the rate of infusion alone will not work as rapidly as administering a bolus.
- If SBP <90% baseline with a low HR, low dose ephedrine boluses (6 mg) may be used.
- For hypotension <80% baseline, with bradycardia, an anticholinergic (glycopyrronium, atropine) may be needed, but evidence for the routine use of glycopyrronium is lacking [10].

- Persistent hypotension should prompt a search for other causes of hypotension e.g. hypovolaemia, cardiac failure.
- After delivery of the neonate, the phenylephrine infusion may be reduced.

Computer-controlled 'smart pumps'

- More recently, closed loop automated vasopressor delivery systems have been studied that utilise computer controlled feedback algorithms [11].
- For on–off algorithms, the infusion is turned on when SBP is below the threshold.
- In future, these systems may provide better haemodynamic control than clinician-controlled pumps.

Mechanical Strategies

- Avoidance of aortocaval compression should be achieved when supine with left lateral uterine displacement ideally by using a uterine wedge or a 15° operating table tilt. Manual uterine displacement may be more effective, but is difficult to achieve during CD.
- Leg compression with bandages, inflatable boots or anti-thromboembolic stockings may be effective, but results show heterogeneity between methods. Venous compression is likely less effective than more intensive arteriolar compression [12].
- Leg elevation to 30° after SA may reduce the incidence of hypotension, but this is impractical for surgery.

Fluid Strategies

Intravenous fluid-loading techniques can improve cardiovascular stability after SA, but should be used in conjunction with vasopressor prophylaxis [13].

- Crystalloid preloading has limited efficacy in preventing SA-induced hypotension and so is not recommended.
- Crystalloid co-loading (administering a fluid bolus at the time of the spinal) may provide some additional benefit to vasopressor prophylaxis, if infused under pressure early on during the onset of SA [5]. However in routine clinical practice many anaesthetists run the fluid co-load without a pressurised system.
- Colloid preloading (e.g. with hydroxyl-ethyl starch) may be effective but confers no advantage over crystalloid co-loading. 500 ml preload of colloid appears to have a similar benefit to 1000 ml of crystalloid co-load, and so either can be utilised to facilitate the prevention of hypotension with a phenylephrine infusion [14] (Fig. 10.1).

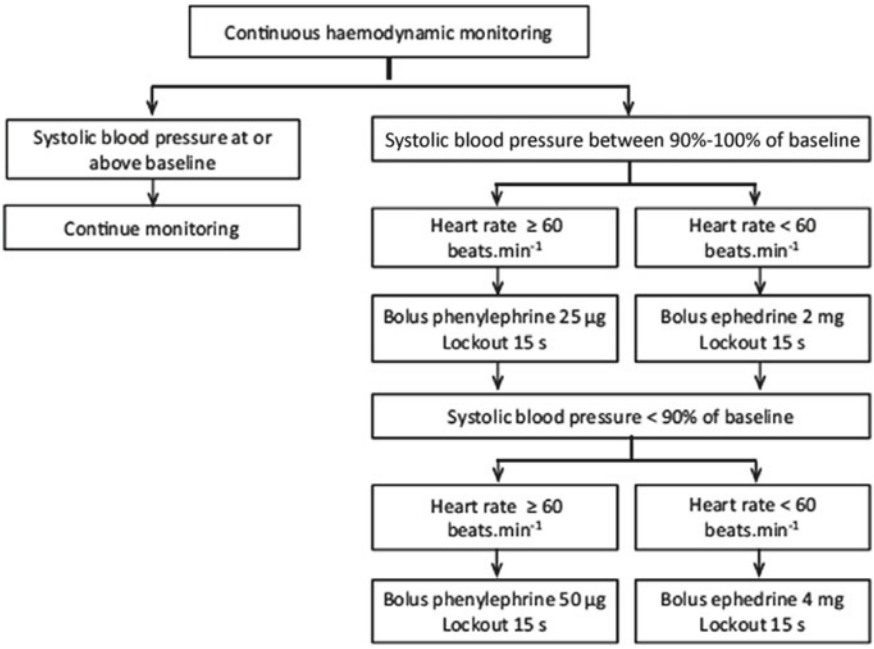

Fig. 10.1 Schematic diagram of the algorithm used in a double-intravenous vasopressor automated system for treatment of hypotension following SA for CD. Reproduced with permission from John Wiley and Sons Publications [15]

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Pain Relief After Caesarean Delivery

11

Amber Naz and Mitko Kocarev

Introduction

Caesarean delivery is associated with moderate to severe postoperative pain, comparable to the pain after abdominal hysterectomy [1]. Post caesarean pain affects the mother's functional capacity during recovery from surgery and taking care of her newborn. It is the most important concern of expectant mothers undergoing caesarean delivery and therefore effective post-operative pain management should aim for visual analogue pain (VAPS) scores of below 3 (on a scale of 0–10) both at rest and on movement [2].

High acute pain scores on VAPS are independent predictors of developing chronic post caesarean pain, which is reported in more than 18% of patients up to 3 months and 6% of patients for up to 12 months after surgery [3].

There appears to be considerable variability amongst patients regarding their pain experience, opioid use, and functional recovery after caesarean delivery [4]; therefore, a systematic approach, beginning with a targeted preoperative assessment tailored to the individual patient's need is necessary for optimum results.

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Multimodal Analgesia

Multimodal analgesia involves the use of a variety of analgesic medication and techniques that target different mechanisms of action in the peripheral and/or central nervous system, with the aim to improve analgesia using their synergistic and additive effects. Post-caesarean pain control strategy is based on various components of the multimodal approach.

Neuraxial Opioids

Neuraxial anesthesia is used as the preferential technique for the majority of caesarean deliveries and neuraxial opioids currently represent the "gold standard" for providing effective and prolonged post-caesarean analgesia. Both the epidural and intrathecal routes have been shown to produce similar pain relief.

- Morphine (preservative free formulation)
  - Hydrophilic opioid, slower onset, prolonged duration of analgesia up to 27 h after a single dose [5]
  - Recommended for postoperative analgesia.
  - Dosing regimen: 0.1–0.2 mg Intrathecal (IT) and 3 mg epidural.

- Diamorphine (a crystalline powder which needs to be reconstituted)
  - Lipophilic opioid; fast onset, a single dose may be effective up to 14 h [6]
  - Recommended for both intraoperative and postoperative analgesia.
  - Dosing regimen: 0.25–0.4 mg IT and 3 mg epidural.

- Fentanyl
  - Lipophilic with a linear molecular structure; very rapid onset; short-lived action of 2–4 h.
  - Excellent intraoperative analgesia however limited postoperative analgesia.
  - Dosing regimen: 10–25 mcg IT. 50–100 mcg epidural.

- Extended-release epidural morphine (EREM) is a unique multivesicular liposome-based delivery system (DepoFoam®), which contains aqueous morphine sulfate. This slow release formulation extends the analgesic period for up to 48 h and reduces the need for supplemental analgesics in comparison with conventional epidural morphine [7]. The recommended EREM dose is 6–8 mg after the umbilical cord is clamped.

Side Effects of Neuraxial Opioids

- Maternal
  - Respiratory depression
  - Nausea and vomiting
  - Pruritus
  - Sedation
  - Urinary retention
  - Reactivation of the oral herpes simplex virus
- Neonatal
  - Respiratory depression

Pruritus; a common side effect, especially with epidural opioids can be managed with opioid antagonists such as naloxone, at a risk of some reversal of analgesia. Prophylactic 5HT3 inhibitors, such as ondansetron, can be used for prevention of nausea, vomiting as well as pruritus [8].

Systemic Opioids

They are the mainstay of treatment in patients who have not received neuraxial opioids and can be used for rescue analgesia in those that have:

- Intravenous patient controlled analgesia (IV PCA)
  - Preferred over other parenteral routes for acute postoperative pain as it provides better analgesia, early ambulation, less sedation and better patient satisfaction [9]. The most commonly used opioids are morphine and fentanyl.
- Oral opioids

These can be included initially as part of a multimodal approach or as a "step down" oral alternative after initial IV PCA. They are an integral part of patient controlled oral analgesia (PCOA) treatments that enable patients to manage their own pain medication [10]. A Cochrane review in 2015 concluded that an ideal oral analgesic regimen has not yet been proven [11]. Some recommended drugs regimens are shown in Table 11.1.

Table 11.1 Recommended oral opioid analgesic regimens

Opioid oral analgesic	Recommended dose/interval	Side effects	Comments
Morphine immediate release tablets/oral solution	10–20 mg PO q4 h	Mu agonist class side effects[a]	Can stimulate histamine release, hypotension, bronchospasm
Codeine	30–60 mg PO q6 h	Mu agonist class side effects[a] light headedness, dizziness, shortness of breath	Active metabolite is morphine. Some individuals may metabolize codeine to morphine more rapidly. Prolonged exposure may cause higher than expected levels of morphine in breast milk leading to severe adverse events in infants [12]. Should not be used by breastfeeding mothers
Oxycodone immediate release tablets	5–10 mg PO q4–q6 h	Mu agonist class side effects[a]	Oral oxycodone-based post-operative oral regimen has been found equi-analgesic to intrathecal morphine after caesarean delivery [13]
Oxycodone extended release tablets	10–20 mg PO q12 h		
Tramadol 50 mg PO q8 h	50 mg PO q8 h	Dizziness, nausea, constipation, headache, sedation, dry mouth	Mixed mu agonist opioid and noradrenaline and serotonin (5-HT) reuptake inhibitor. Increased risk of seizures with high doses (>400 mg/day) or history of seizure disorder

[a]Common side effects of mu agonists include respiratory depression, sedation, nausea, vomiting, constipation, pruritus; less commonly euphoria and dysphoria

Non-Steroidal Anti-Inflammatory Drugs (NSAIDS)

These have been found to be very effective in post caesarean pain and decrease opioid requirements by 30–50% [14]. There are not many comparative studies between various NSAIDS and their use is directed by availability and institutional preferences.

- Diclofenac 50 mg PO q8hrly.
- Ketorolac 30–60 mg IV/IM q8hrly

- Celecoxib a selective cyclooxygenase-2 (COX-2) inhibitor, 200 mg or 400 mg PO single dose [15, 16], can be considered in patients at risk of gastrointestinal and renal side effects of other non-selective NSAIDs.

Paracetamol has additive and synergistic effects with NSAIDS and reduces opioid requirements by 10–20% [17].

- A common dosing regimen is 1 gm PO or IV Q6 h.

Adjuvants

- **Anticonvulsants**: Gabapentin and pregabalin, when used as part of a multimodal regime, have been found to increase the quality of postoperative analgesia and reduce opioid consumption [18, 19]. However, the evidence in the setting of caesarean delivery is inconclusive [20, 21]. Side effects including sedation, visual disturbances and a high maternal to fetal transfer ratio limit the routine use of these drugs, especially preemptively. Currently, there is insufficient evidence to support the use of gabapentin in standard analgesic practice, but it may still be considered for patients at higher risk of experiencing severe post-caesarean pain.
- **Ketamine**: Sub-anaesthetic intravenous doses of ketamine 0.15–0.5 mg/kg have been found to have benefit in the setting of caesarean delivery under general anaesthesia (GA) but not under spinal where neuraxial opioids have already been used [22]. This drug may again have a role as a preemptive analgesic in patients in whom pain is difficult to manage.
- **Clonidine**: This has been used as an adjunct with intrathecal local anaesthetics and shown to increase the duration and quality of post-operative analgesia. However, the side effects of sedation and maternal hypotension may limit its routine use for post caesarean delivery pain. It can be considered for persistent post caesarean pain as it may reduce the pain sensitization and perceived increase in pain intensity over time ("wind-up") [23].

Patient Controlled Epidural Analgesia (PCEA)

Although not recommended for routine use because of undesirable side effects such as delayed ambulation, increased nursing workload, cost and epidural catheter related complications, PCEA, may still be worthwhile in certain situations:

- Opioid-tolerant patient (history of chronic pain, substance abuse disorder)
- Non-availability or contraindication to opioids
- Contraindications to NSAIDS.
- Rescue analgesia where multimodal regimens are inadequate.

Transverse Abdominis Plane Block (TAP)

Evidence suggests that TAP blocks are effective in providing pain relief after caesarean delivery under general anaesthesia (GA) [24] and spinal anaesthesia without long acting opioids such as morphine [25]. Additionally, intrathecal morphine is found to be associated with superior analgesia compared with TAP block alone [25]. The spread of local anaesthetic within the fascial plane provides effective analgesia to the abdominal wall, but the visceral pain arising from the abdominal cavity remains untreated. However, it appears that more posterior block approaches may increase the duration and quality of analgesia [26] possibly by producing some degree of block along the thoracolumbar sympathetic chain.

TAP blocks can be effectively used:

- When GA has been used for caesarean delivery.
- When long acting neuraxial opioids have not been used.
- Rescue analgesics if pain is predominantly from the incision site and not visceral.

TAP blocks can be used with bilateral continuous infusion catheters and with additives such as clonidine along with local anesthetics.

Quadratus Lumborum Block (QLB)

QLB is a relatively novel fascial plane block. It has been shown to provide effective pain relief after caesarean delivery [27]. Compared to the TAP block, QLB is associated with extended spread of local anesthetic providing superior quality of analgesia with longer duration and reduced morphine consumption [28]. A recent study on cadavers showed that the injected contrast can spread cranially to the thoracic paravertebral space and intercostal spaces reaching the somatic nerves and the thoracic sympathetic trunk [29]. However, the level of sensory block achieved with QLB varies with the location of injection. Currently, anterior, posterior, lateral and intramuscular approaches have been described. The optimal approach for caesarean delivery has yet to be determined.

Summary

Post caesarean pain remains an inadequately managed entity with significant inter-patient variability that warrants identification of patients at high risk, and their management with the use of analgesic regimens tailored to individual needs (Fig. 11.1). The initial strategy includes targeted preoperative assessment followed by utilization of intraoperative interventions such as intrathecal/epidural morphine

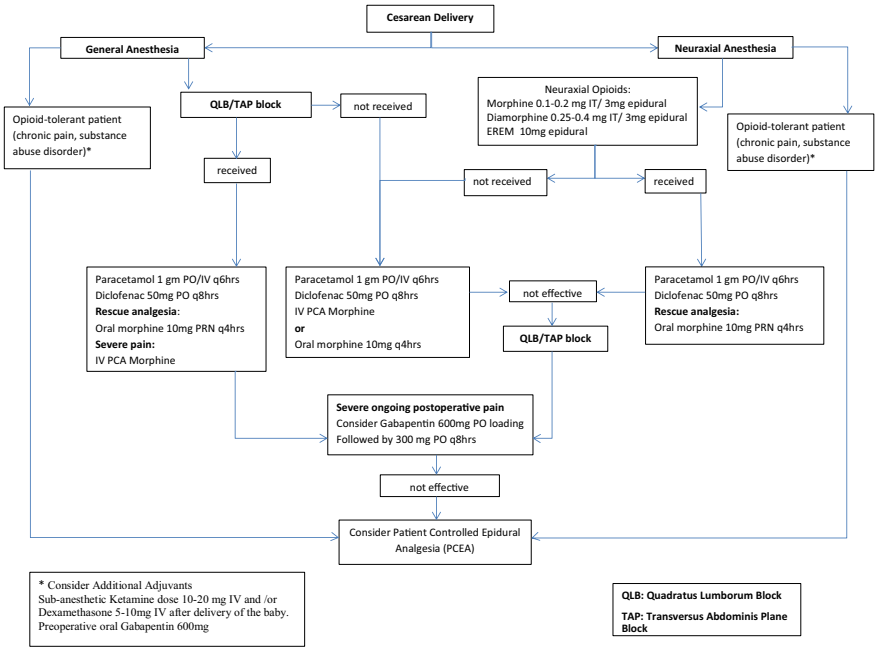

Fig. 11.1 Cesarean delivery postoperative pain management algorithm

if neuraxial anesthesia has been used, or TAP/QLB block for caesarean delivery under general anaesthesia. Subsequently, multimodal analgesia is essential in providing adequate post-operative pain control. This approach should ensure improved maternal functional capacity and facilitate her recovery after caesarean delivery.

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Manual Removal of Placenta

12

Rebecca Brinkler and John Dick

Indication

Retained placenta.

Incidence

Incidence of retained placenta is 2% of all deliveries worldwide.

Definition of Retained Placenta

- Retained placenta is defined as failure to deliver the placenta within 30 minutes of birth with active management and within 60 minutes of birth with physiological management [1].
- In an actively managed 3rd stage 98% of placentas are delivered within 30 minutes while in a conservatively managed 3rd stage it can take up to 60 minutes for 98% of placentas to deliver.

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Pathophysiology of Third Stage of Labour

- Normal expulsion of the placenta occurs due to contraction of the retroplacental myometrium leading to shear stress on the maternal surface of the placenta, which causes it to detach. Myometrial contractions then expel the placenta from the uterus.
- The placenta can be retained due to failure to detach from the myometrium (placenta adherens) or a failure to be expelled from the uterus as a result of a closing cervix (trapped placenta).
- Active management consists of administering a uterotonic, uterine massage and traction on the cord as well as emptying the bladder.
- If the placenta has not been delivered within 1 hour of active management or there is significant ongoing bleeding, manual removal of the placenta needs to be performed, usually under anaesthesia.

Risks Factors Associated with Retained Placenta

- Previous retained placenta
- Previous injury to uterus
- Abnormal placental implantation
- Preterm delivery
- Induced labour
- Multiparity
- Stillbirth
- Maternal age >30 years.

Complications of Retained Placenta

(1) Postpartum haemorrhage (PPH)
    - Primary PPH. The bleeding risk begins to increase 20–30 minutes after delivery of the neonate.
    - Secondary PPH. This may occur with unrecognised retained placental tissue.
(2) Postpartum endometritis
(3) Uterine inversion
(4) Cervical shock.
    - The placenta separates, but lies above the cervix without it being expelled as normal. Marked bradycardia and hypotension can occur due to increased vagal tone.

Anaesthetic Management of a Patient Undergoing Manual Removal of Placenta

- Either neuraxial or general anaesthesia
- When planning the anaesthetic technique, it is important to consider whether there has been significant blood loss leading to haemodynamic compromise or coagulopathy. In either case a neuraxial block would not be appropriate.
- Clinical assessment of the patient's haemodynamic state should take place in addition to measuring visible blood loss
- Always consider the possibility of concealed blood loss.
- Delays in going to the operating theatre due to scheduling of more urgent cases can result in ongoing bleeding and hypovolaemia.
- The patient may need resuscitation prior to induction of anaesthesia.

Surgical Procedure (Fig. 12.1) [2]

1. Full aseptic precautions are implemented, with the operator often wearing arm length gloves to insert one hand into the uterine cavity (Fig. 12.1).
2. The placental edge is identified and is steadily detached with the fingers until separated.
3. The other hand is placed on the abdomen and maintains fundal pressure, pushing downwards towards the opposite hand, which is within the uterine cavity.
4. Ultrasound guidance is often used to ensure complete removal of any retained products.
5. There is a risk of uterine perforation and inversion.
6. Occasionally a placenta remains adherent and this requires senior obstetric input for further management.

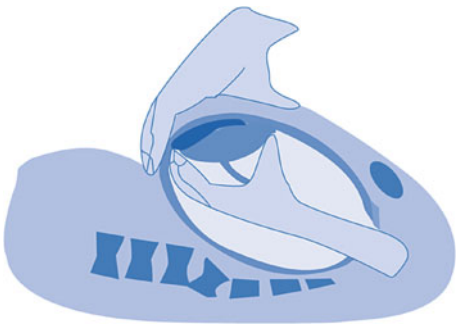

Fig. 12.1 Manual removal of the placenta (manoeuvre of Credé). Figure reproduced from: Obstetric management of labour, delivery and vaginal birth after caesarean delivery. Devlieger R, Smet M-E. In Oxford Textbook of Obstetric Anaesthesia. Eds. Clark V, Van de Velde M, Fernando R. Oxford University Press 2016. Published with permission from Oxford University Press through PLSclear

General Anaesthesia

- Airway risk in a postpartum patient must be assessed and managed in the same way as any pregnant patient.
- Antacid prophylaxis should be administered before a standard rapid sequence or modified rapid sequence induction including pre-oxygenation.
- Maintenance of anaesthesia is usually with a volatile agent such as sevoflurane.
- Volatile agents relax the uterus and may allow easier removal of the placenta; however they may also lead to increased bleeding as a result of reduced uterine tone. Therefore, a minimum alveolar concentration (MAC) of ≤ 1 is usually administered.

Neuraxial Anaesthesia

- This is the preferred method of anaesthesia.
- There are no guidelines regarding ideal block height.
  - A block to T10 was previously thought to be adequate as this covers the innervation of the uterus. However, the bimanual technique of placenta removal requires palpation of the uterus through the abdomen, which causes abdominal discomfort. It has been shown that there is significant reduction in discomfort when the spinal block height is at a T6 dermatome level or above, compared to a block height to a T9–T10 dermatome level. An increased block level has not been shown to increase the incidence of intraoperative hypotension [3].
- For spinal anaesthesia we would recommend using a dose of hyperbaric bupivacaine (e.g. 10–14 mg) adequate to achieve a sensory block level height to T4 or above. Intrathecal opioids such as fentanyl 15 mcg may improve the quality of the block.
- If there is a pre-existing labour epidural analgesia catheter in place, then this can be used to provide surgical anaesthesia using high concentration local anaesthetics such as: 2% lidocaine with epinephrine, 0.5% levobupivacaine or 0.75% ropivacaine; using a volume between 10 and 15 ml. Epidural opioids such as fentanyl 50-100 mcg added to the local anaesthetic may improve the quality of the block.

Pharmacological considerations

- Oxytocin—A bolus (5 units) may be given to assist separation followed by an infusion after removal to assist uterine contraction (e.g. 40 units in 500 mls 0.9% saline at 125 mls/h i.e. @10 units/h).
- Carboprost—250 mcg IM, maximum dose 2 mg. May also help control bleeding in addition to oxytocin.

- The use of ergometrine (500 mg intramuscularly) is controversial since it may constrict the cervix making placental removal more difficult.
- Glyceryl trinitrate (GTN)—If the cause of placental retention is due to obstruction behind a contracted cervix, GTN (2 sublingual sprays—2 × 200 mcg metered doses) will relax the uterus/cervix. Alternatively, an intravenous bolus of 50–250 mcg can be given. Hypotension and bleeding (due to uterine relaxation) are possible complications.
- Antibiotics—Manual removal of the placenta is associated with an increased risk of endometritis, therefore the World Health Organisation (WHO) recommend prophylactic intravenous antibiotics prior to commencing this procedure.

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Cervical Cerclage (Insertion and Removal)

13

David Monks, Pervez Sultan, and Methodius Tuuli

Definition

The term cervical cerclage describes the placement of a circumferential suture at various anatomical sites along the length of the cervix. The types of cervical cerclage are summarized in Table 13.1.

Indications

Cervical cerclage is performed, in women with presumed or evident cervical insufficiency, to prevent loss of the pregnancy. This is due to either an inherent or acquired (previous trauma/surgery) weakness of the cervix and cerclage provides structural support to maintain the fetal membranes within the uterus and may also prevent ascending infection through maintenance of cervical length and

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Table 13.1 Types of cervical cerclage

Procedure	Description	Typical duration of procedure (min)
Transvaginal cerclage (McDonald)	Purse-string suture placed at the *cervico-vaginal junction* (no bladder mobilzation)	20–40
High transvaginal cerclage (Shirodkar)	Purse-string suture placed *above the level of the cardinal (uterine) ligaments* following bladder mobilization	30–60
Transabdominal cerclage (TAC)	Placed at the *cervico-isthmic junction* via a laparotomy (often Pfannensteil incision) or laparoscopy	60–90
Occlusion cerclage (OC)	An attempt to retain the endocervical mucus plug by a continuous non-absorbable suture at the *external cervical os*	20–40

Table 13.2 Indications for cervical cerclage

Indication	Description
History-indicated cerclage (HIC)	The insertion of a *prophylactic cerclage* in women with a gynaecological or obstetric history that suggests that they are at higher risk of spontaneous second-trimester loss or pre-term delivery. A HIC is normally inserted at 12–14 weeks of gestation
Ultrasound-indicated cerclage (UIC)	This is performed as a *therapeutic measure* on asymptomatic women when cervical shortening is observed on transvaginal ultrasound, often between 14 and 24 weeks of gestation
Exam-indicated cerclage	This is a *salvage procedure* when premature dilatation of the cervix leads to herniation of fetal membranes into the vagina

preservation of the endocervical mucus plug. Indications for cervical cerclage are summarized in Table 13.2 [1, 2].

Contraindications

Contraindications include multiple pregnancy, chorioamnionitis, ongoing vaginal bleeding, pre-term premature rupture of membranes (PPROM) and active labor.

Anesthestic Management

Cervical cerclage is routinely performed as a day case procedure. The anesthetic used to facilitate this varies widely across the UK and globally. The most common anesthetic techniques utilized are spinal or general anesthesia (GA) and, less

commonly, epidural, combined spinal-epidural (CSE) anesthesia or pudendal nerve block. The choice is influenced by the specific procedure, indication, maternal choice and risk/benefit for mother and fetus. One large retrospective study assessed the anesthetic technique for cervical cerclage and found no differences in obstetric outcomes and only marginal differences in recovery times (shorter after GA) and post-procedural analgesic requirements (greater after GA) [3].

Regardless of anesthetic technique chosen, the following should be considered in all cases:

- Prophylaxis to avoid aspiration—fasting according to national/institutional guidelines. Consideration also should be given to the use of ranitidine and metoclopramide prior to surgery in order to reduce acidity and volume of gastric secretions.
- Precautions to avoid hypotension and placental insufficiency.
- Position using left uterine displacement when gestational age >18–20 weeks.
- Fetal heart rate monitoring (depending on institutional policy and whether pre-viable gestational age).
- Possible need for uterine relaxation.

Spinal Anesthesia with Hyperbaric Local Anesthetic

This technique works very well for *prophylactic sutures (HIC and UIC)* as it provides quick and reliable anesthesia of the vagina and perineum (S2–4) and cervix (T10–L1). Decisions regarding local anesthetic, dose and supplemental opioids are made with the usual considerations required for ambulatory care. A commonly-used regimen is hyperbaric bupivacaine (7.5–12.5 mg) ± fentanyl (10–20 mcg) but shorter acting agents such as prilocaine or chloroprocaine are used, routinely, in some centres. A block to the level of the T10 dermatome is usually desirable prior to commencing the procedure. Since the operator may request a Trendelenburg position in certain circumstances, some anesthesiologists may choose to keep the patient seated for 2–3 min following intrathecal injection in order to produce a "saddle block," and to minimize cephalad spread upon positioning.

The use of minimally effective doses, short-acting opioids, judicious intraoperative fluid therapy and emptying of the bladder at the end of the procedure, can obviate the need for urinary catheterization although vigilance for post-operative urinary retention is essential.

General Anesthesia

There are certain scenarios where GA may be preferred to a neuraxial technique. This decision should be made after consideration of the risks in individual patients and discussion with the operating team, particularly regarding the surgical technique and risk of rupture of membranes.

Disadvantages of General Anesthesia

- *Risks to the fetus of in-utero exposure to GA:* animal studies have demonstrated the neurotoxicity of most anesthestic agents as evidenced by neuronal apoptosis and long-term behavioural deficits [4]. There is some data from humans suggesting an association between exposure to GA agents during cesarean delivery and autism [5]. These findings are however limited by their observational nature and further studies are required.
- *Risk of failed intubation:* although the risk of failed intubation in parturients is known to be higher than in the non-pregnant population, the physiological changes and clinical circumstances that confer this increased risk are arguably more relevant during the latter stages of pregnancy than the early second trimester. Routine airway assessment and planning for GA however, should remain routine practice prior to cervical cerclage.
- *Risk of pulmonary aspiration:* the incidence of aspiration in fasted patients undergoing elective cervical cerclage in the second trimester is uncertain, although a large retrospective cohort of women having deep sedation in the second trimester to facilitate dilation and evacuation of products of conception demonstrated a low incidence of pulmonary aspiration (0.08%, 95% CI 0.01–0.29%) [6]. Should assessment of aspiration risk be low, second-generation supraglottic devices are considered safe by many anesthesiologists.

Advantages of General Anesthesia

- *Improved surgical access*: some operators prefer the surgical conditions provided by GA when performing abdominal cerclage.
- *Reduced risk of ruptured membranes*: in rescue cerclage, it is proposed that GA can minimize rises in intrauterine pressure by: avoiding positioning the patient

for neuraxial anesthesia; employing the tocolytic effects of inhalational agents; and facilitating the steep Trendelenburg position. These theoretical advantages, however, are not supported by conclusive evidence.

Potential Risks Associated with Cervical Cerclage

- Rupture of fetal membranes
- Pre-term labour and associated neonatal morbidity and mortality
- Bleeding
- Infection
- Cervical lacerations
- Cervical stenosis (delayed onset)
- Uterine rupture (onset of labor prior to cerclage removal)

Removal of Transvaginal Cerclage

This is often performed without anesthaesia at 37–38 weeks but transabdominal cerclages are most commonly removed at the time of cesarean delivery or may be maintained for future pregnancies.

Discharge Criteria

Standard discharge criteria for day case/ambulatory care procedures apply.

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External Cephalic Version

14

Ruth Shaylor and Carolyn F. Weiniger

Background and Indications

Breech presentation occurs in 3–4% of pregnancies [1]. Vaginal delivery for breech presentation is associated with increased neonatal morbidity and mortality [2]. There is also epidemiological evidence that children born via vaginal breech delivery do not perform as well at school in terms of exams results later in life compared to children presenting with breech presentation born by caesarean delivery or vertex presentation born by vaginal delivery [3]. Consequently, breech presentation is associated with a high incidence of caesarean delivery [4], despite caesarean delivery being a high contributing factor to maternal morbidity and mortality.

External cephalic version (ECV) is a procedure that can turn the fetus from breech to cephalic presentation whilst in-utero and allow the mother to attempt vaginal delivery. ECV should be offered to all women who are at least 37/40 weeks gestational age with a fetal breech presentation and without contraindications to the procedure or vaginal delivery [5]. It has an overall success rate of approximately 60% [4].

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Contraindications

Absolute contraindications:

- Any contraindication to vaginal delivery
- Multiple gestation (although the second twin may undergo ECV after delivery of the first)
- Placenta accreta or praevia
- Non-reassuring baseline fetal heart rate
- Patient refusal.

Relative contraindications:

- History of placental abruption
- Uterine anomalies
- Suspicion of ruptured membranes
- HELLP syndrome (hemolysis; elevated liver enzymes; low platelet count)
- Pre-eclampsia or severe pregnancy-induced hypertension
- Fetus with congenital abnormalities
- Fetal growth restriction (estimated fetal weight [EFW] <5th percentile).

Performing ECV

(1) Ultrasound to confirm fetal breech position,
(2) Obtain full informed consent,
(3) Perform baseline cardiotocography (CTG) to assess fetal wellbeing and to identify underlying uterine contractions.
(4) Consider administering a tocolytic. Protocols vary among institutions. Commonly administered agents include either terbutaline subcutaneously or nifedipine orally. Side-effects of tocolysis can include maternal tachycardia.
(5) ECV should be performed under fetal monitoring (ultrasound can be used to identify the fetal heart rate) and operating facilities should be readily available.
(6) When the uterus is relaxed the obstetrician lifts the fetal feet out of the pelvis and then places one hand on the fetal head and one on the fetal buttocks and attempts to turn the fetus in a forward roll motion.
(7) If that is unsuccessful then a backward roll may be attempted. Up to three attempts should be allowed per procedure with full assessment of fetal well being between attempts.
(8) After the procedure, fetal monitoring should continue until the trace is reassuring and has returned to baseline.

(9) If the ECV is unsuccessful then a second attempt may be offered at a later date.
(10) After ECV, the parturient may be discharged with the aim for vaginal or caesarean delivery at a later date depending on the outcome of the procedure.

Pain Management

- ECV may be uncomfortable for the parturient and abdominal guarding decreases the success rate. Neuraxial block may provide maternal comfort and abdominal wall relaxation.
- Several studies have reported that a block to neuraxial *anesthesia* density is associated with improved ECV success rates [6, 7].
- Neuraxial block to *analgesic* density is not associated with increased ECV success.
- It is important that the obstetric anesthetist working within the delivery suite is aware of such patients in case any complications occur (see below).
- In many countries/institutions (such as the within the UK), neuraxial analgesia or anaesthesia are not routinely offered for this procedure (Fig. 14.1).

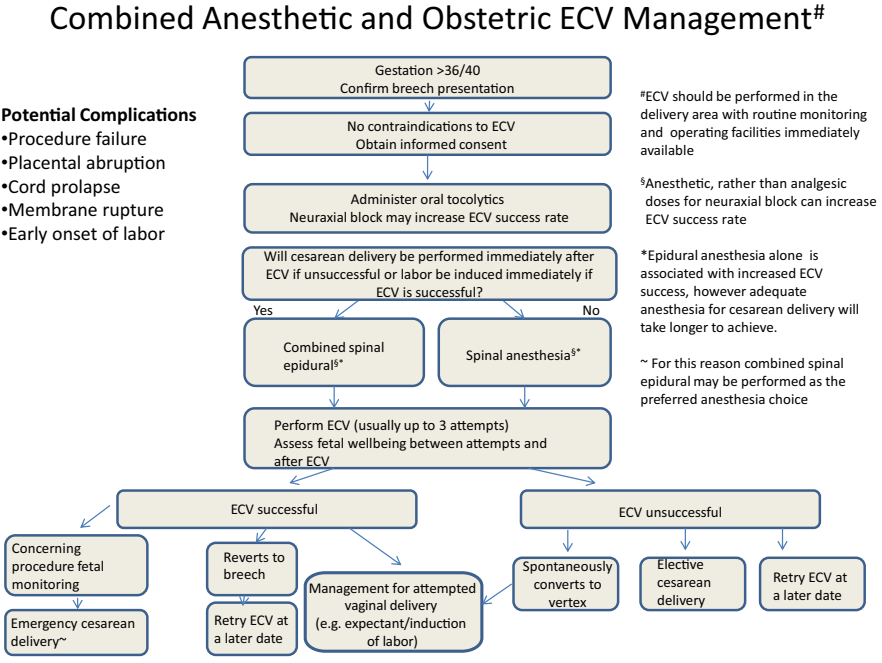

Fig. 14.1 Combined anesthetic and obstetric management of external cephalic version

Anaesthesia for ECV

- A specific anesthesia assessment and consent should be obtained for neuraxial anesthesia (see Chaps. 6 and 8).
- The patient should be fasted and receive antacid prophylaxis.
- The procedure should be performed in the operating room to facilitate speedy conversion to caesarean delivery if required. If this is not practical then it should be performed in an area with full anesthetic monitoring and an obstetric team with full operating facilities readily available if there is a need for urgent operative delivery.

Spinal versus CSE anaesthesia technique?

- If the likelihood for requirement of emergency caesarean delivery is deemed to be low and there are no plans to perform an elective caesarean delivery if the procedure is successful, then spinal anesthesia alone can be suitable, however a combined-spinal epidural (CSE) technique enables more flexibility in the decision process.
- If planned conversion to elective cesarean delivery in the event of unsuccessful ECV is likely, a CSE technique should be considered with a suitable local anesthetic dose.
- Consider administering a short-acting intrathecal opioid such as fentanyl in addition to the local anesthetic dose (for recommended doses see below), and a long-acting opioid via the epidural catheter if cesarean delivery is performed.
- Following the ECV, maternal monitoring is required in an appropriate setting such as the recovery room or a monitored labor ward bed until the return of motor and sensory function.

Spinal and CSE dosing strategies

Practice varies widely among institutions regarding neuraxial block technique, drug and doses, sensory and motor block target of the drug administered. Local ECV logistics such as the setting where ECV is performed also vary.

- Aim for a sensory dermatome block height to T6
- A typical spinal regimen for an ECV can consist of 7.5–10 mg hyperbaric bupivacaine with 15 mcg fentanyl.
- There may be a role for shorter acting agents such as intrathecal prilocaine providing quicker recovery and hospital discharge following ECV procedure.
- The epidural catheter can be used to achieve the desired block height with lower intrathecal bupivacaine doses.
- The epidural catheter can also be used to:

(1) provide analgesia for labour
(2) to provide anaesthesia for caesarean delivery
(3) administer epidural long-acting opioids such as morphine for postoperative analgesia if a caesarean delivery is performed.

Complications [4]

- Procedure failure
- Placental abruption
- Cord prolapse
- Membrane rupture
- Early onset of labor

Changes in fetal heart rate are not uncommon during ECV but usually settle after the procedure is completed. If the ECV is performed under single shot spinal anesthesia, the duration of anaesthesia may be inadequate to cover emergency caesarean delivery. The conversion rate to emergency caesarean delivery is 0.45–1.6% at the time of ECV procedure in experienced centers [8]. ECV at term is safe, decreasing the rate of cesarean delivery from 95% without ECV to 20% with ECV, reducing the likelihood of maternal morbidity [9], and is associated with a decreased likelihood of cesarean delivery in subsequent pregnancies [10].

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Artificial Rupture of the Membranes

15

Priyanka Sara and Pat O'Brien

Artificial rupture of the membranes (ARM), also known as amniotomy, is a procedure in which the membranes containing the amniotic fluid (liquor) around the fetus are accessed through the cervix and broken or ruptured deliberately. In order to perform ARM, the membranes must be physically accessible through the cervix, i.e. the cervix needs to be at least 1 cm dilated.

Indications

- To initiate labour (induction of labour/IOL)—not used alone, usually followed by oxytocin augmentation [1, 2]. (see Chap. 32 Augmentation of Labour)
- To augment/accelerate the process of labour
- To allow application of a fetal scalp electrode or fetal scalp blood sampling (for measurement of pH/lactate).

Contraindications

- Placenta praevia
- Vasa praevia
- Umbilical cord presentation
- Malpresentation—breech/transverse lie

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- High fetal head within the pelvis (relative contraindication—see below)
- Preterm labour (relative contraindication, normally allowed to progress spontaneously)
- Caesarean delivery required for another reason
- Previous classical caesarean delivery/>2 caesarean deliveries
- Maternal/fetal anatomical abnormality that contraindicates vaginal birth
- Active primary genital herpes/maternal HIV with a high viral load.

Procedure

See Fig. 15.1.

Setting and Preparation

- Preferably performed within the delivery area or birth centre and not on the antenatal ward, as ARM can sometimes lead to unexpected complications such as umbilical cord prolapse or placental abruption.
- Confirm that the fetal presenting part is cephalic and engaging/entering the pelvis.
- There is a significant risk of umbilical cord prolapse if:
  - The head is "floating" free above the pelvis
  - There is an unstable lie of the fetus
  - Polyhydramnios (large amniotic fluid volume) is diagnosed.
- If the risk of cord prolapse is considered to be high, ARM may be performed in the operating theatre in case emergency caesarean delivery is required.
- In rare situations during induction of labour following the initial first step of administering prostaglandins, if the cervix has not adequately opened and

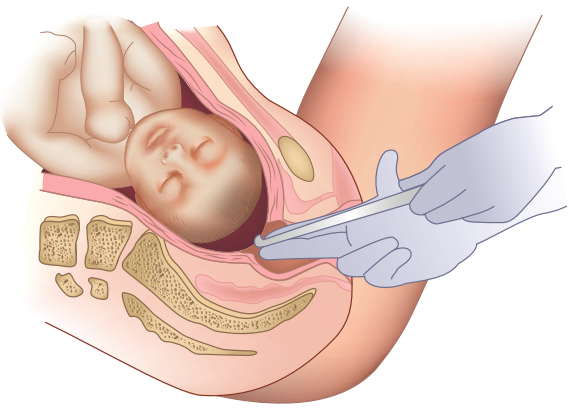

Fig. 15.1 Rupture of the membranes using an amnihook

ripened (<1 cm and long), vaginal examinations and ARM can be uncomfortable and painful due to both prostaglandin effects and technical difficulties of performing an ARM. In such instances, epidural analgesia should be considered prior to an ARM attempt.

- If ARM is not possible, this can be described as "failed IOL" and can be converted to a category 2 emergency caesarean delivery.
  - In high risk cases performed in the operating theatre (high risk for cord prolapse and difficult ARM), women should be adequately fasted and antacid prophylaxis administered since there is a possibility that caesarean delivery will be required.
  - In situations where the presenting fetal head is high and not within the pelvis, a 'controlled' ARM should be performed, allowing the amniotic fluid to drain slowly, perhaps with some pressure on the fundus of the uterus to push the fetal head further into the pelvis.

Procedure (for a Right-Handed Examiner)

- Counsel and explain the procedure to the woman as it can cause discomfort; ask her to empty her bladder and position her for an ARM.
- 2-finger vaginal examination with the right hand to assess the cervix and feel the membranes. The left hand holds and guides the amnihook to break the membranes as shown in the figure.
- Check the colour of liquor (meconium/blood tinged/clear) and amount (no/minimal/copious).
- Check the fetal heart rate, as transient fetal heart decelerations can occasionally be triggered by umbilical cord compression after ARM.

Anaesthetic Considerations

Pain Management

ARM can usually be performed with no analgesia or simple analgesia such as paracetamol/intramuscular opioids such as morphine/diamorphine, or inhaled Entonox®. However, in a minority of cases when the woman finds it too painful (for example, when the cervix is very posterior in the vagina and only 1 cm dilated), there is a role for epidural analgesia using analgesic doses (similar to initiation of labour epidural rather than anaesthetic doses for caesarean delivery) to facilitate the ARM procedure. ARM alone may be enough to trigger labour; if not, further augmentation with oxytocin may be required.

Managing the Risks

Complications after ARM are uncommon, but umbilical cord prolapse, revelation of frank blood-stained liquor and fetal bradycardia with placental abruption have been reported. Even though ARM in certain cases carries a risk of cord prolapse [3, 4], a Cochrane review of amniotomy for augmenting spontaneous labour demonstrated no difference between ARM versus no ARM, in the incidence of cord prolapse (RR 1.00, 95% CI 0.14–7.10). This would suggest that artificial membrane rupture carries a low risk of cord prolapse provided clinical judgement is made as to its safety in individual women [5]. Depending on the maternal and fetal condition, emergency caesarean delivery may occasionally be necessary. This would most likely necessitate a general anaesthetic if neuraxial anaesthesia had not already been administered.

- The obstetric anaesthetist within the delivery area should be aware of any woman at high risk of cord prolapse after a proposed ARM, who does not have an epidural in situ.
- This would allow an assessment regarding any potential difficulties in administering a GA in an emergency (for example obesity or difficult airway) and a management plan between the obstetrician and anaesthetist to be made prior to the procedure.

Efficacy

Although amniotomy appears to be effective for inducing labour when the cervix is favourable, when compared with vaginal prostaglandins, it is associated with more frequent need for oxytocin augmentation. The UK National Institute for Health and Care Excellence (NICE) guidance advises that amniotomy alone should not be used as a primary method of induction of labour unless there are specific clinical reasons for avoiding vaginal prostaglandins (PGE_2), in particular the risk of uterine hyperstimulation [1]. This makes ARM the preferred mode of induction in multiparous women with an open cervix. It is an inexpensive intervention and is a good method for women who wish to minimise drug intervention. However, women should be aware of the need for augmentation with an oxytocin infusion if contractions do not start 2–4 hours after ARM or there is insufficient progress of labour.

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Consent

16

Kate McCombe

Adult patients with capacity have absolute autonomy over their bodies and so we must seek valid consent before any medical intervention. Failing to gain consent risks criminal prosecution for battery (harmful or offensive contact with another person), a civil claim in medical negligence for financial compensation, and disciplinary action from the professional regulators e.g. the General Medical Council (GMC) in the UK.

Seeking consent is a process, not an event, and the process should facilitate an exchange of information to allow a mutually acceptable management plan to be reached. Consent must not be reduced to simply, 'getting the patient to sign a form' to protect us from litigation.

Capacity

To give **consent** a patient must have **capacity**. A capable patient can:

1. **Understand** information about the treatment.
2. **Retain** this information for long enough to
3. **Weigh** it in the balance and come to a decision.
4. **Communicate** this decision (this does not have to be verbally).

The legal age of majority is the age where minors cease to be considered children and are assumed to have legal control over their decisions and actions. It varies between countries, for example, in the UK patients over the age of 16 are assumed to have capacity unless serious doubt exists to the contrary [1], whilst in the USA

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and Australia the age of majority is 18. In the eyes of the law, pregnant or laboring women retain their capacity except in the rarest of circumstances [2]. The Association of Anaestheists which publishes nationally accepted guidance for the profession across many areas of clinical practice, confirms in their guidance pertaining to obstetric consent, "*Drugs, fatigue, pain or anxiety may compromise the capacity of the adult parturient, but do not necessarily lead to incapacity unless the degree of compromise is severe.*" [3].

Standards of Information Disclosure

For consent to be valid, the patient must be informed of all **material risks** inherent in the procedure, no matter how unlikely they are to occur. A risk is material if, "*a reasonable person in the patient's position would be likely to attach significance to the risk.*" [4].

Consent for neuraxial anaesthesia should include [5]:

Risk	Epidural	Spinal
Significant drop in blood pressure	1: 50 (occasional)	1: 8 (common)
Pruritus	1: 3–10 (dose dependent) (common)	1: 5 (dose dependent) (common)
Ineffective block necessitating additional pain relief in labour or delivery	1: 8 (common)	1: 20 (occasional)
Failure to provide surgical anaesthesia necessitating general anaesthesia	1: 20 (occasional)	1: 50 (occasional)
Post dural puncture headache (PDPH)	1: 100 (uncommon)	1: 500 (uncommon)
Nerve damage (numb patch on a leg or foot or weakness)	1: 1000 temporary (quite rare) 1: 13,000 duration >6 months (rare)	1: 1000 temporary (quite rare) 1: 13,000 duration >6 months (rare)
Paralysis	1: 250,000 (extremely rare)	1: 250,000 (extremely rare)
Infection	1: 50,000 epidural abscess (very rare) 1: 100,000 meningitis (very rare)	1: 50,000 epidural abscess (very rare) 1: 100,000 meningitis (very rare)
Accidental loss of consciousness ('high spinal')	1: 100,000 (very rare)	1: 100,000 (very rare)

Types of Consent

The law in the UK and USA does not require separate **written** consent for anaesthesia. The Association of Anaestheists guidance states, "*a signed form does nothing to validate or invalidate the consent. The anaesthetic can be considered a component of another treatment or part of a larger and interrelated process (e.g. epidural pain relief for childbirth), rather than a treatment in itself.*" [3]. The GMC advises that we take written consent for any intervention which is *'complex or high risk'*, or has *'significant consequences for the patient's employment, social or personal life'* [6]. Although, *written* consent is not a legal requirement prior to insertion of neuraxial anaesthesia, the patient must still be informed of the risks and benefits of the intervention and give their consent and this conversation must be documented in the medical notes. Regardless of the law, many hospitals insist on written consent before any anaesthetic intervention is undertaken and doctors should follow local protocols and guidance.

In reality, it can be very difficult to have a meaningful discussion of risk with a woman in advanced labour and women may retain little of the information given at this time. Therefore, early provision of information about pain relief is essential, ideally in the antenatal period, but certainly early in labour so that women have the opportunity for due consideration of their options. Most delivery areas within the UK use the UK Obstetric Anaesthetists' Association (OAA) Epidural Information Card to aid this process during labour [5].

If a woman requests an epidural but is too distressed to engage in the consent process, then it is reasonable to proceed and to document that the epidural was performed with the patient's implied consent (i.e. she allowed the procedure to be performed) and in her best interests to relieve her pain.

Birth Plans

A woman who has expressed a wish not to have an epidural on her antenatal birth plan retains the capacity, and the right, to change her mind during labour and the anaesthetist should proceed in the usual manner without fear of reprimand. In the rare case of loss of capacity during labour, the Association of Anaestheists advises that the birth plan be respected as a documented refusal of therapy [3].

Emergency Delivery

The consent process must be tailored to facilitate urgent delivery of the baby when necessary. Extremely rarely, a woman might refuse caesarean delivery even if this might lead to the death of her baby. In the UK, if the woman has capacity, this remains her right as here, the fetus has no legal rights until birth and so its interests

should be considered only as an extension of its mother's. This may not be the case in other countries with differing cultural beliefs and legal practices. The medical team is likely to question the woman's capacity in this unusual situation but, in the UK, it must not proceed without an emergency court order authorising treatment. This will only be granted if the court believes that the woman lacks capacity and that enforced caesarean delivery is in her best interests. Emergency court orders in the UK can usually be acquired within an hour.

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Documentation Standards

17

Kate McCombe

The primary purpose of the medical record is to support on-going patient care. It provides a crucial central source of information in a health care system where shared-care, shift-work and frequent handovers are common. Any other function of the notes is secondary e.g. to provide defence against complaints. In its guidance on record keeping the General Medical Council (GMC) the professional body that regulates doctors in the UK, states, 'Record your concerns, including any minor concerns, and the details of any action you have taken, information you have shared and decisions you have made relating to those concerns.' [1].

Records must:

- Be clear, accurate and legible
- Be made contemporaneously or as soon as possible after each episode of patient care
- Include a date and time
- Record every consultation, e.g. at the bedside, by telephone, discussions with relatives about the patient
- Allow healthcare professionals accepting handover of care to follow the sequence of treatment decisions, the reasons for them and future management plans
- Be signed in a way that allows identification of the author
- Not be altered, amended or added to after the original episode of care. If corrections are necessary, the original entry should be scored through with one line, leaving it legible, and the replacement entry signed and dated
- Not contain unnecessary comments e.g. subjective judgements that are unprofessional

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- Avoid abbreviations
- Abnormal test results should be recorded in the notes along with a record of the subsequent actions taken

Electronic patient records are becoming more widespread and overcome the problem of illegibility. Care must still be taken to make a full and comprehensive entry into these records. Any entry into computer-generated notes, including alterations, will be logged and date and time stamped to provide an audit trail of activity.

The Anaesthetic Chart

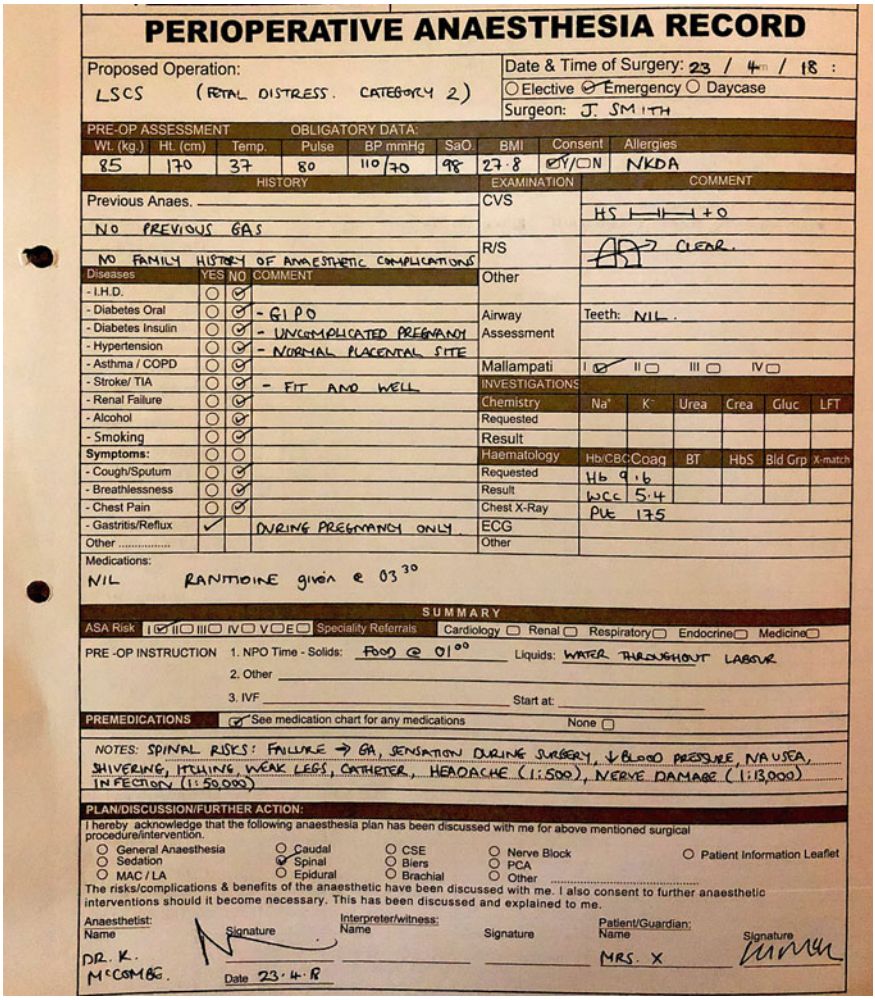
In addition to the usual information recorded on the anaesthetic chart, as a minimum you should also record the following information in the obstetric anaesthetic record:

- Documentation of the consent process; you should record the specific risks discussed and any questions addressed
- Time of request for epidural and start-time of the procedure
- Time of arrival into theatre
- Time of administration of anaesthesia
- Details of the anaesthetic procedure
- Checking the block: block height (upper and lower margins on each side), presence of motor block, modality of testing
- Start time of obstetric intervention
- Time of delivery
- Accurate timing of drug administration/interventions

An example of a completed chart is provided within Figs. 17.1 and 17.2.

Pain during caesarean delivery is the most common reason for litigation against anaesthetists. If the patient experiences discomfort or pain during the procedure, this must be documented, and the time recorded, on each occasion. You should record your discussion with the patient following their complaint and your subsequent management. If the patient refuses pain relief/general anaesthesia when offered, this too should be recorded [2]. Nerve injury is the second most common area of litigation concerning anaesthetists [3].

Should investigation or litigation follow an episode of care, the timing of each medical decision and intervention will be scrutinised. Therefore, in obstetrics especially, it is important to note accurately the timing of interventions and events. You should record your thought processes in the notes so that the reasons for your decisions are clear to those reading the notes at a later date. Remember, you are not restricted to the anaesthetic chart and may write in the patient's hospital notes as appropriate. Obstetric records must be preserved until the patient's (neonate's) 25th birthday and complaints may be filed after many years.



PERIOPERATIVE ANAESTHESIA RECORD

Proposed Operation: LSCS (FETAL DISTRESS. CATEGORY 2)

Date & Time of Surgery: 23 / 4m / 18 :

○ Elective ✓ Emergency ○ Daycase

Surgeon: J. SMITH

PRE-OP ASSESSMENT — **OBLIGATORY DATA:**

Wt. (kg.)	Ht. (cm)	Temp.	Pulse	BP mmHg	SaO	BMI	Consent	Allergies
85	170	37	80	110/70	98	27·8	✓Y/○N	NKDA

HISTORY

Previous Anaes. NO PREVIOUS GAS

NO FAMILY HISTORY OF ANAESTHETIC COMPLICATIONS

Diseases	YES	NO	COMMENT
- I.H.D.	○	✓	
- Diabetes Oral	○	✓	- GLPO
- Diabetes Insulin	○	✓	- UNCOMPLICATED PREGNANCY
- Hypertension	○	✓	- NORMAL PLACENTAL SITE
- Asthma / COPD	○	✓	
- Stroke/ TIA	○	✓	- FIT AND WELL
- Renal Failure	○	✓	
- Alcohol	○	✓	
- Smoking	○	✓	
Symptoms:	○	○	
- Cough/Sputum	○	✓	
- Breathlessness	○	✓	
- Chest Pain	○	✓	
- Gastritis/Reflux	✓		DURING PREGNANCY ONLY.
Other			

Medications: NIL RANITIDINE given @ 0330

EXAMINATION — **COMMENT**

CVS	HS I–II–I + 0
R/S	AS → CLEAR.
Other	
Airway Assessment	Teeth: NIL.
Mallampati	I ✓ II ○ III ○ IV ○

INVESTIGATIONS

	Chemistry	Na⁺	K⁻	Urea	Crea	Gluc	LFT
Requested							
Result							

	Haematology	Hb/CBC	Coag	BT	HbS	Bld Grp	X-match
Requested							
Result		Hb 9·6					
Chest X-Ray		WCC 5·4					
ECG		Plt 175					
Other							

SUMMARY

ASA Risk: I ✓ II ○ III ○ IV ○ V ○ E ○ Speciality Referrals — Cardiology ○ Renal ○ Respiratory ○ Endocrine ○ Medicine ○

PRE -OP INSTRUCTION 1. NPO Time - Solids: FOOD @ 0100 Liquids: WATER THROUGHOUT LABOUR

2. Other

3. IVF Start at:

PREMEDICATIONS ✓ See medication chart for any medications None ○

NOTES: SPINAL RISKS: FAILURE → GA, SENSATION DURING SURGERY, ↓BLOOD PRESSURE, NAUSEA, SHIVERING, ITCHING, WEAK LEGS, CATHETER, HEADACHE (1:500), NERVE DAMAGE (1:3,000) INFECTION (1:50,000)

PLAN/DISCUSSION/FURTHER ACTION:

I hereby acknowledge that the following anaesthesia plan has been discussed with me for above mentioned surgical procedure/intervention.

○ General Anaesthesia ○ Caudal ○ CSE ○ Nerve Block ○ Patient Information Leaflet
○ Sedation ✓ Spinal ○ Biers ○ PCA
○ MAC / LA ○ Epidural ○ Brachial ○ Other .....

The risks/complications & benefits of the anaesthetic have been discussed with me. I also consent to further anaesthetic interventions should it become necessary. This has been discussed and explained to me.

Anaesthetist: Name	Signature	Interpreter/witness: Name	Signature	Patient/Guardian: Name	Signature
DR. K. McCOMB.				MRS. X	

Date 23·4·18

Fig. 17.1 An example of an anaesthesia record with details of the preoperative assessment of a fictitious patient

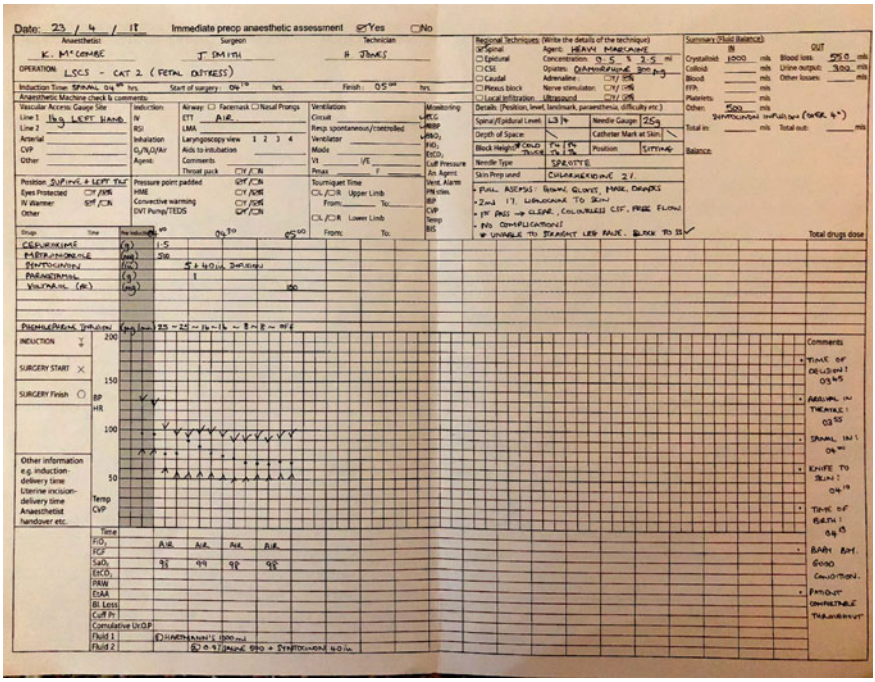


Fig. 17.2 An example of an anaesthesia record with details of the anaesthesia technique as well as information about the patient's intraoperative vital signs

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Umbilical Cord Prolapse

18

Angela Yan, Pervez Sultan, and Patrick O'Brien

Umbilical cord prolapse is an obstetric emergency in which the umbilical cord descends through the cervix alongside (occult) or past (overt) the presenting part of the baby. Pressure on, or spasm of, the umbilical cord impairs the flow of blood between the placenta and fetus, leading to fetal hypoxia.

Incidence

The incidence of umbilical cord prolapse is estimated to vary between 0.1 and 0.6%, rising to 1% in breech presentation [1]. Population characteristics such as multiple gestations are also known to have an impact on the incidence.

Risk factors, morbidity and mortality associated with umbilical cord prolapse are summarised in Tables 18.1 and 18.2, respectively.

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Table 18.1 Risk factors associated with the development of umbilical cord prolapse [1]

General	Intervention-related[a]
Multiparity	Artificial rupture of membranes (ARM) with an unengaged (high) presenting part
Congenital abnormalities	External cephalic version (ECV)
2nd twin	Internal podalic version of a second twin
Polyhydramnios	Manual rotation of the fetal head (to correct a malposition such as occipito-posterior)
Low birth weight	Amnioinfusion
Breech presentation	Intrauterine pressure catheter
Transverse/oblique/unstable lie	Transcervical balloon catheter
Unengaged presenting part	
Low-lying placenta	

[a]Where there is a predisposition to cord prolapse caused by the prevention of a close application of the presenting part to the lower part of the uterus and/or pelvic brim

Table 18.2 Fetal and maternal morbidity and mortality associated with umbilical cord prolapse [1, 2]

Fetus	Mother
Perinatal mortality rate: 91 per 1000 cases	Postnatal depression
Stillbirth rate: 2.1%	Post-traumatic stress disorder (PTSD)
Neonatal death rate: 4.2%	Fear of future childbirth

Preventative Measures

- Routine antenatal ultrasound examination is not recommended to prevent umbilical cord prolapse due to poor sensitivity and specificity; it can however be considered for women considering vaginal breech delivery who are at term.
- Consider admission to hospital if patient is ≥ 37 weeks' gestational age with transverse, oblique or unstable lie, or has a non-cephalic presentation and pre-term pre-labour rupture of membranes (PPROM).
- Umbilical cord presentation and prolapse must be excluded in every vaginal examination during labour (and particularly after spontaneous rupture of membranes if there are risk factors present); the fetal heart should also be auscultated after the examination.
- Avoid artificial rupture of membranes (ARM) if the presenting part is unengaged; if unavoidable, perform a controlled ARM and be prepared for immediate caesarean delivery.

- Avoid ARM if the umbilical cord is felt below the presenting part on vaginal examination; this is an indication for emergency caesarean delivery if in established labour.

When to Suspect Umbilical Cord Prolapse

- Abnormal fetal heart pattern in presence of membrane rupture.
- After membranes rupture if risk factors are present.

Immediate Management of Umbilical Cord Prolapse

Figure 18.1 describes the immediate management of umbilical cord prolapse once the diagnosis is established and explains the intrauterine resuscitative measures that must be undertaken. It is important to be aware that these measures should not result in unnecessary delay of delivery.

Anaesthetic Considerations for Delivery

If vaginal birth is not imminent:

Caesarean delivery is the recommended mode of delivery to prevent fetal hypoxia

- Category 1 (immediate-delivery) recommended if there is an associated suspicious or pathological fetal heart rate pattern (but without compromising the mother's safety).
- Category 2 (urgent) can be considered if fetal heart rate pattern is normal, provided there is continuous assessment of the fetal heart trace.
- If the cardiotocogram (CTG) becomes abnormal, re-categorization may be warranted.

Discussion between obstetrician and anaesthetist to decide the most appropriate form of anaesthesia. Generally, the choice of anaesthesia technique depends on 3 factors:

(1) Is the umbilical cord compressed?
(2) Is there fetal compromise?
(3) Are there relative/absolute contraindications to neuraxial or general anaesthesia?

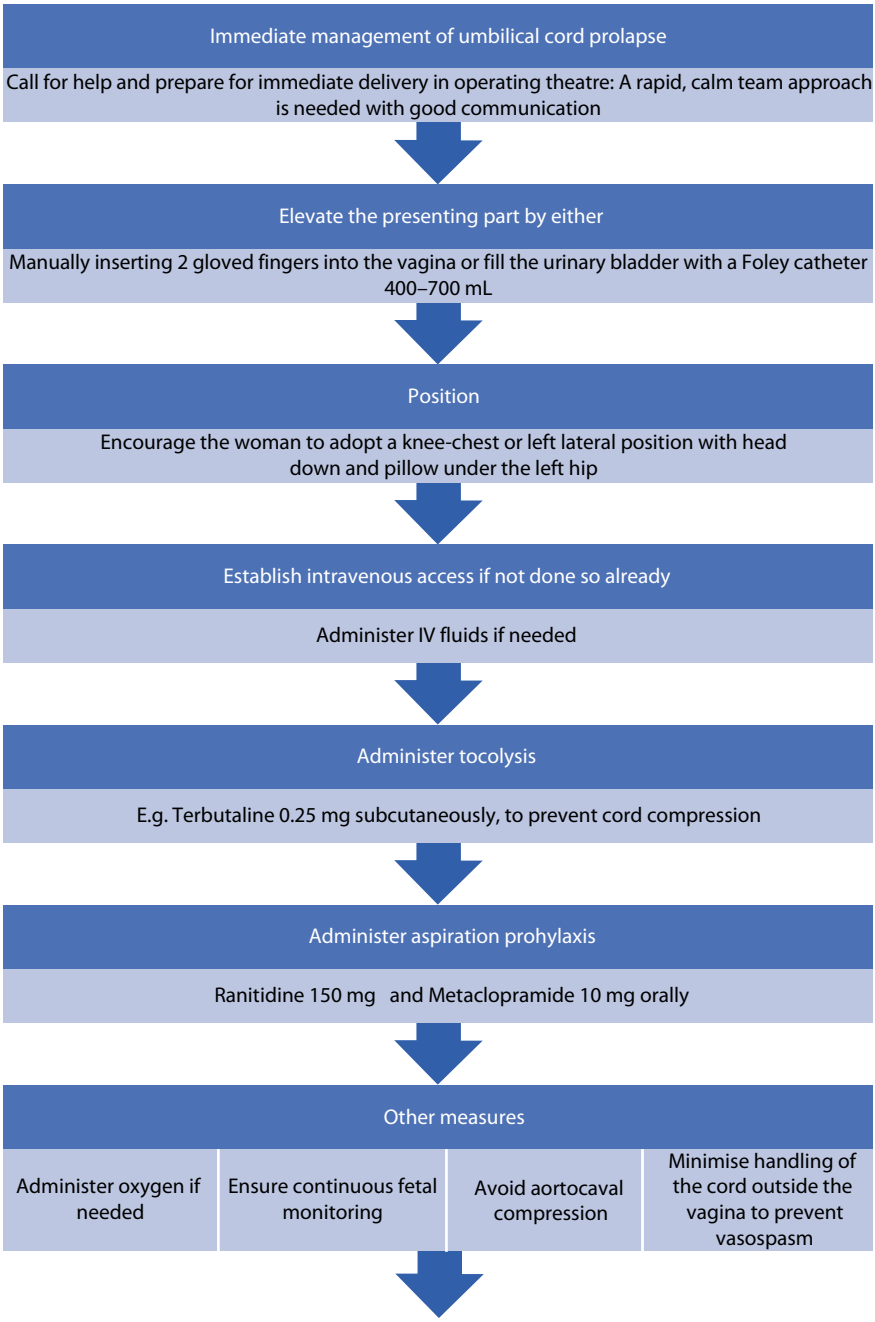

Fig. 18.1 Immediate management of umbilical cord prolapse

If the umbilical cord is not compressed and the fetus is not compromised, then the scenario may not be one of a category 1 emergency caesarean delivery. There may be circumstances for a category 1 caesarean delivery when an epidural top-up or a spinal anaesthetic may still be appropriate (see Chap. 6). General anaesthesia is usually performed for most other cases. Prolonged attempts at neuraxial anaesthesia are inappropriate when there is fetal distress if there are no significant maternal contraindications to general anaesthesia [2, 3].

If a neuraxial technique is chosen, during the procedure:

- Continue in utero fetal resuscitation
- Continuous fetal monitoring (CTG)
- Consider placing the mother in a lateral position for spinal anaesthesia as adopting a sitting position can cause occlusion/prolapse.
- Consider administering oxygen via a simple face mask.

If general anaesthesia is chosen—See Chap. 9.

Key Points in the Management of Umbilical Cord Prolapse

1. Preparation: multidisciplinary practice, anaesthetic equipment
2. Communication
3. Fetal assessment
4. Intrauterine resuscitation
5. If an epidural is already working well for labour analgesia an epidural top-up can be performed for caesarean delivery.*
6. If a labour epidural is not working well a spinal anaesthetic should be considered.
7. An early decision should be made to abandon a neuraxial technique and perform general anaesthesia if the fetal status is of immediate concern.

*We do not advise giving the entire epidural top-up in the delivery room due to safety concerns. The safest place to administer the epidural top-up is within the operating theatre, with full monitoring and emergency resuscitation facilities available. Variations in practice will depend on institutional protocol and support from other personnel.

Vaginal birth:

- If fully dilated, a vaginal birth can be attempted in most cases if it is anticipated that it can be achieved quickly and safely with standard techniques and minimal compression of the umbilical cord.
- Breech extraction can be considered in certain situations such as after internal podalic version of a second twin.

Obstetric and neonatology considerations:

- A practitioner trained in resuscitation of the newborn should be present at delivery.
- Arterial and venous umbilical cord blood samples should be obtained soon after birth for measurement of pH and base excess.
- Delayed umbilical cord clamping can be considered if the newborn is not compromised at birth; however, immediate resuscitation should be prioritised, if required.
- An opportunity for discussion of the events should be offered to the woman (and her partner) when appropriate.
- A critical incident form (or the activation of some form of internal alert process) should be completed.

Management if Gestational Age Is at the Threshold of Viability (Defined as 23+0 to 24+6 Weeks of Gestation)

Counselling should be offered to women on both continuation and termination of pregnancy. There is no evidence to support replacement of the umbilical cord into the uterus and there are no data available regarding optimal timing of birth.

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Expedited and Emergency Caesarean Delivery

19

Priyanka Sara, Patrick O' Brien, and Pervez Sultan

Definition

Caesarean delivery (CD) is a surgical procedure, which involves an incision through various layers of the abdominal wall and uterus to deliver the fetus.

Intended Benefits of Caesarean Delivery [1]

- To secure the safest and/or quickest route of delivery in the circumstances present at the time the decision is made, where the anticipated risks to mother and/or baby of an alternative mode of delivery outweigh those of caesarean delivery.

Categorisation of Caesarean Delivery by Urgency

Categorisation of urgency (1–4; see Table 19.1) of delivery is recommended by the UK Royal College of Obstetricians and Gynaecologists (RCOG) Good Practice Guideline, Number 11 [2]. It is based on the presence or absence of maternal or fetal compromise and its implication on the desired decision to delivery interval.

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Table 19.1 Categorisation of caesarean delivery (CD) urgency [2–4]

Category	Urgency	Definition	Usual DDI
1	Maternal or fetal compromise	Immediate threat to life of woman or fetus	30 min
2	Maternal or fetal compromise	No immediate threat to life of woman or fetus	75 min
3	No maternal or fetal compromise	Requires early delivery	3 h
4	No maternal or fetal compromise	At a time to suit the woman and maternity services	As feasible

DDI = decision to delivery interval; times are intended to be an audit standard. Each case should be evaluated separately

Table 19.2 Indications for emergency caesarean delivery (Category 1–3) [3, 4]

Category of urgency	Indication
1	Cord prolapse, placental abruption, uterine scar dehiscence/rupture, fetal bradycardia (fetal heart rate deceleration lasting for >3 min)
2	Failure to progress in the first stage of labour; failure to progress in the second stage when not suitable for instrumental delivery; chorioamnionitis with suspicious CTG; pathological CTG with fetal blood sampling showing pH <7.20; pathological CTG in early labour[a]
3	Failed induction of labour, previous caesarean delivery in early labour with risk favouring against safe vaginal delivery or choosing not to deliver vaginally, a patient who was booked for elective caesarean delivery attending in early labour

[a]Although this is category 2 (not immediately life threatening), the caesarean delivery should be performed as soon as possible to avoid further fetal hypoxia; CTG = cardiotocogram

1. Elective/planned (Category 4). See Chap. 5
2. Emergency CD (Category 1, 2, 3)

The category of urgency is decided by the obstetrician making the decision to perform caesarean delivery and urgency of procedure should be communicated to all the team members. The category should be reviewed in the operating theatre with the consent form and the WHO checklist as a Category 2 classification can change to Category 1 (and vice versa) depending on the maternal and fetal condition [4]. Indications for emergency caesarean delivery (Category 1–3) are outlined in Table 19.2.

Risks Associated with Caesarean Delivery

These are summarised in Table 19.3.

Table 19.3 Risks commonly quoted during consent for caesarean delivery [1]

		Description of risk	Incidence in CD population
Maternal	Common	Persistent wound and abdominal discomfort in the first few months after surgery	9 in 100 (common)
		Increased risk of repeat caesarean delivery when vaginal delivery attempted in subsequent pregnancies	1 in 4 (very common)
		Readmission to hospital	5 in 100 (common)
		Infection	6 in 100 (common)
		Blood transfusion[a]	4 in 1000 in elective 10 in 1000 in emergency cases (uncommon)
	Uncommon	Emergency hysterectomy	7–8 in 1000 (uncommon)
		Repair of damage to bowel or blood vessel	Rare
		Hemorrhage (>1 L)	5 in 1000 (uncommon)
		Need for further surgery, including curettage	5 in 1000 (uncommon)
		Admission to intensive care unit[a]	9 in 1000 (uncommon)
		Thromboembolic disease	4–6 in 10 000 (rare)
		Bladder injury	1 in 1000 (rare)
		Ureteric injury	3 in 10 000 (rare)
		Death	1 in 12 000 (very rare)
	Risk to future pregnancies	Increased risk of uterine rupture during subsequent pregnancies/deliveries	2–7 in 1000 (uncommon)
		Increased risk of antepartum stillbirth	1–4 in 1000 (uncommon)
		Increased risk in subsequent pregnancies of placenta praevia and placenta accreta	4–8 in 1000 (uncommon)
Fetal		Lacerations	1–2 babies in every 100 (common)

[a]Highly dependent on the reason for caesarean delivery

Counseling and Consent

- Emergency situations within the delivery area:
  - For Category 1 caesarean delivery—verbal consent is sufficient.
  - For Category 2/3—consent should be obtained by the obstetrician making the decision for caesarean delivery.

Preparation for Category 1 Caesarean Delivery

Preoperative:

Many of the following tasks can be performed by different members of the team simultaneously in order to maximise efficiency and reduce delays in delivering the fetus.

- An "AMPLE" history should be obtained prior to emergency anaesthesia:
  - Allergies, Medications, Past medical history, Last food/drink, Events surrounding admission.
  - It may also be prudent to enquire about back/airway problems and previous problems with anaesthesia.
- Intravenous (IV) access should be sited and blood sent for full blood count and group and save (or cross match if known antibodies are present in blood or if the patient is considered to be at high risk of haemorrhage).
- Surgery should not be delayed to wait for blood results to be reported by the laboratory.
- In emergency scenarios (category 1–2) there is usually inadequate time to achieve recommended fasting intervals, so administration of sodium citrate 0.3 M 30 mL and oral/IV ranitidine (150 mg PO/50 mg IV) and metoclopramide (10 mg PO or IV) can be used.

In the operating theatre:

- Following the placement of neuraxial anaesthesia or before induction of general anaesthesia, the woman should be placed supine on the operating table with a left lateral tilt of 15°.
- A modified World Health Organisation (WHO) surgical safety checklist for caesarean delivery should be completed and the time of entry into operating room and the time surgery commenced should be documented.
- If general anaesthesia is chosen, the patient should be catheterised and the obstetrician should perform a surgical scrub, prepare and drape the abdomen prior to induction of general anaesthesia. Otherwise the surgeon should perform the surgical scrub while the neuraxial blockade is being attempted.

- An indwelling Foley urinary catheter should be inserted and the skin prepared using an antiseptic solution (insertion of urinary catheter after neuraxial anaesthesia placement is preferred).
- Antibiotic prophylaxis before skin incision—choose an appropriate antibiotic that is effective against common organisms causing endometritis, urinary tract infection and wound infections, according to the local hospital protocol (usually a cephalosporin).

Anaesthesia Technique

Neuraxial anaesthesia is the preferred mode of anaesthesia in obstetrics due to the reasons highlighted in Table 19.4.

Neuraxial anaesthesia is widely regarded as safer than general anaesthesia and is associated with decreased maternal and neonatal morbidity. No direct maternal deaths were attributed to neuraxial anaesthesia in a recent UK maternal mortality report [6].

For women undergoing caesarean delivery under neuraxial anaesthesia, consider utilising a prophylactic vasopressor variable rate infusion such as phenylephrine, and volume co-loading with crystalloid to reduce the risk of spinal hypotension [7].

Table 19.4 Advantages of neuraxial anaesthesia versus general anaesthesia in obstetrics [5]

Maternal	Reduced anaesthesia related adverse events (cardiac, pulmonary, cardiac arrest)
	Reduced gastric aspiration risk
	Avoid pressor response to laryngoscopy in vulnerable populations e.g. pre-eclampsia
	Avoid awareness under general anaesthesia
	Higher incidence of failed intubation and difficult airway in obstetrics so avoids morbidity related to repeated tracheal intubation attempts
	Reduced uterine atony and haemorrhage
	Reduces surgical site infection
	Superior analgesia quality, systemic opioid sparing, reducing chronic post caesarean delivery pain
	Allows immediate post-delivery maternal skin-to-skin bonding with the baby and breastfeeding
	Improves maternal and partner participation in the birth
Fetal	Reduces risks of respiratory depression at delivery (Apgar <7 at 5 min, and requirement for NICU admission)
	Avoids in utero exposure to GA IV and inhalation agents with potential developmental neurotoxicity
	Enables benefits of post delivery skin-to-skin bonding and breastfeeding

NICU = neonatal intensive care unit; GA = general anaesthesia; IV = intravenous

Following surgery, if an epidural catheter has been sited, consider leaving it in situ if the patient has had a: (1) major haemorrhage; (2) received a massive transfusion; (3) has suspected coagulopathy; (4) if they are deemed high risk of experiencing further bleeding e.g. a Bakri (uterine) compression balloon is in situ or (5) anticipated to have severe postoperative pain e.g. if the patient experiences chronic pain.

- Spinal—for Category 1 caesarean delivery a "rapid sequence" spinal may be considered (Table 19.5) after the team agrees that spinal anaesthesia is appropriate [8]. This may be performed in the lateral position (or the sitting position, if no contraindication) in this situation due to a quicker onset of block. The lateral position may also be better tolerated by the mother and fetus.
- Combined spinal-epidural (CSE)—for complex patients either surgically where prolonged surgery is anticipated, or medically where a higher failure rate for the spinal component may be expected (as with scoliosis or previous failed spinal block) or difficulties with general anaesthesia are anticipated (for example high body mass index, anticipated difficult airway). Note that this technique is likely to take the longest time to establish a level of block appropriate for surgery.
- Epidural top-up—if a functioning epidural (providing good labour analgesia) is already in situ.

Assess the epidural by:

- checking the level of block/block height.
- asking the mother and midwife if the epidural has been providing adequate labour analgesia.
- Asking if the epidural catheter in situ has required clinician intervention/additional boluses.

Table 19.5 Summary of an expedited ("rapid sequence") spinal block technique

Factor	Spinal technique
Attire	Hat and sterile gloves (avoid touching the patient)
Seniority	Most senior/experienced anaesthetist present
Consider omitting the spinal opioid	Hyperbaric bupivacaine administered ± intrathecal fentanyl (increased time may be needed to obtain and prepare intrathecal diamorphine)
Limit number of attempts	Guided by obstetric team but aim for no more than one attempt.
Time between spinal and incision	Allowing the start of surgery before full establishment of the spinal block
Pre-oxygenate	Consider asking a colleague/assistant to pre-oxygenate the patient during attempted spinal so if unsuccessful, induction of general anaesthesia can be performed without further delay

This technique balances benefits of reducing anaesthesia time without compromising the sterility of the spinal technique

An epidural top-up can produce an anaesthetic block in less than 10 min (median [IQR] time 7 [5–8] minutes). A commonly described "rapid epidural mix" solution can be made by mixing [9]:

- 2% preservative-free lidocaine (20 mL),
- 100 mcg epinephrine (0.1 mL of 1:1000 epinephrine) to constitute a 1:200,000 solution
- 8.4% preservative-free sodium bicarbonate (2 mL)

Following administration of a **test dose**, the rapid mix epidural solution should be administered in increments **(e.g. 5 mL boluses up to 15–20 mL)** until the desired block height is achieved.

- General anaesthesia—consider if:
  - contraindications to neuraxial anaesthesia are present
  - neuraxial anaesthesia fails or attempts fail at siting neuraxial anaesthesia
  - general anaesthesia may be the safest and quickest way of delivering the fetus in many situations.
- Communication between the obstetric and anaesthesia teams is important in order to determine which technique is safest for each mother and fetus.

General anaesthesia for emergency caesarean delivery should include a rapid sequence induction (RSI) with pre-oxygenation and cricoid pressure (or a modified RSI, see Chap. 9) to reduce the aspiration risk. Consider the use of Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE or high flow oxygen via nasal cannulae) during induction and intubation attempts to prolong the time to oxygen desaturation [10].

Postnatal care:

- Assess the risk of thromboembolism pre and post caesarean delivery during the sign out stage of the WHO Surgical Safety checklist.
- Monitoring vital parameters- heart rate, blood pressure, respiratory rate, pulse oximetry, urine output and color of the urine as per local protocol and depending upon individual maternal condition.
- Check analgesia, thromboprophylaxis and antibiotic prescription (if there are signs of infection/chorioamnionitis).
- Check if the uterus is contracted and for the presence of vaginal bleeding.
- If haemodynamically stable and comfortable postoperatively and if it is not deemed to be high risk, the mother can be transferred to the postnatal ward.
- Remove the urinary catheter once mobilising and haemodynamically stable as per hospital protocol.
- Review by the team in the postnatal ward with counselling, postnatal care advice a delivery plan for subsequent pregnancies (and assessment for suitability for vaginal birth after caesarean delivery).
- Community Midwife or nurse follow-up after discharge.

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Operative Vaginal Delivery

20

John Dick and Caroline Borkett-Jones

Operative vaginal delivery, also called instrumental vaginal delivery, involves the application of traction during uterine contractions to aid the delivery of a fetus, in the second stage of labour. There are two methods (Fig. 20.1), vacuum extraction or forceps delivery. A vacuum extractor device, of which numerous types exist, includes a suction cup that is applied to the baby's head, connected to a handle held by the obstetrician e.g. Kiwi cup. Obstetric forceps consist of two separate blades, which are positioned around the baby's head and are then locked together e.g. Neville Barnes forceps.

As well as traction, rotation of a malpositioned baby's head can be achieved with a vacuum extractor or rotational forceps. The choice of instrument for delivery is based on the obstetrician's assessment of the situation and personal preference. Vacuum extraction has a higher chance of failure. Forceps require a greater amount of analgesia and are more likely to cause maternal perineal trauma.

Should an instrumental delivery fail, a caesarean delivery is likely to be necessary, therefore it is usually referred to as a 'trial of instrumental delivery'.

Indications

Fetal:

– Suspected fetal compromise (cardiotocography pathological, abnormal fetal blood sampling result, thick meconium)

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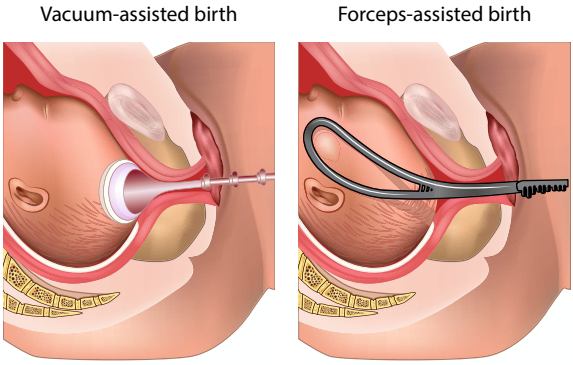

Fig. 20.1 Methods of operative vaginal delivery

Maternal:

- Nulliparous women – lack of continuing labour progress for 3 hours (total of active and passive 2nd stage labour) with neuraxial analgesia or 2 hours without neuraxial analgesia
- Multiparous women – lack of continuing labour progress for 2 hours (total of active and passive 2nd stage labour) with neuraxial analgesia or 1 hour without neuraxial analgesia
- Maternal fatigue or distress
- Medical indications to avoid Valsalva manoeuvre (e.g. certain cardiac conditions)

Combined:

- Maternal and fetal indications for assisted vaginal birth often coexist

Risk Factors for Operative Vaginal Delivery

Primiparous women and those with epidural analgesia in labour are at increased risk of requiring an operative vaginal delivery [1].

Location

An instrumental delivery may take place in the labour (delivery) room or in the operating theatre. A trial of instrumental delivery anticipated to have a greater chance of failure, should take place in a location where immediate progression to caesarean delivery can occur, and therefore should be performed in the operating theatre with the presence of an anaesthesiologist.

Increased incidence of failure of operative vaginal delivery is associated with [1]:

- Maternal BMI >30
- Estimated fetal weight >4 kg
- Occipito-posterior (OP) position of the fetus head
- Mid-cavity delivery (when 1/5th of the fetal head is palpable abdominally).

Anaesthetic Options

Local infiltration—if the instrumental delivery is performed in the delivery room, and the patient has no other prior analgesia (e.g. a labour epidural analgesic block), infiltration of local anaesthetic or a pudendal nerve block, administered by the obstetrician, may be the only analgesia used.

Epidural—if a labouring woman has an epidural in situ this can be "topped-up" (the block can be extended) to provide adequate anaesthesia for operative vaginal delivery. Low dose epidural mixture (10 to 20 ml) may be sufficient to cover a vacuum extraction or lift out (outlet) forceps in the delivery room (e.g. 0.1% bupivacaine and 2 mcg/ml fentanyl).

A trial of forceps delivery (with the need to proceed to caesarean delivery in the event of failure) in the operating theatre requires higher concentration local anaesthetic dosing to achieve a dense block to at least T10 (to cold sensation) but it is advisable to aim for a block to T4/T5 (to light touch) in case a caesarean delivery is urgently required.

Spinal/CSE—if a de novo spinal is used, the dose must be adequate for caesarean delivery In the UK most anesthesiologists perform de novo neuraxial anaesthesia utilising either a spinal or CSE technique aiming for a block to T4/T5 to cold sensation which would also be adequate for a caesarean delivery.

In other countries (e.g. USA) the anesthesiologist's epidural top-up initially aims for a level of block to T10 using lower volumes of local anaesthetic, and the epidural is then subsequently topped up further to a level of T4/T5 (for caesarean delivery) if the operative vaginal delivery is not successful. The rationale for using a graded top-up is to allow the mother to push in order to maximise chances of successful operative vaginal delivery. It should however be noted that epidural 3% chloroprocaine is available in the USA which allows for a more rapid extension of epidural block, which may explain why most institutions within the UK aim for a block to T4/T5 from the outset. Local practice and institutional guidelines should be followed regarding dosing strategies for trial of instrumental/operative vaginal delivery.

Preparation for the operating theatre

The patient should be pre-assessed and consented for the anaesthetic and the risk of conversion to a caesarean delivery. Antacid prophylaxis should ideally be administered for all procedures performed in the operating theatre.

Patient Positioning

Once in theatre the patient should be positioned on the operating table supine for an epidural top-up with a left lateral tilt to relieve aortocaval compression and maternal monitoring and fetal heart rate (CTG) monitoring applied.

As soon as the anaesthesia level is adequate, the patient is moved into the lithotomy position with a left lateral tilt for the instrumental delivery.

Complications

Forceps delivery is associated with a higher risk of post-partum haemorrhage due to trauma. Active third stage management is required, often with an oxytocin infusion or other uterotonics.

Perineal pain after an instrumental delivery is likely and adequate post-operative analgesia should be prescribed.

Caesarean delivery after a failed trial of operative vaginal delivery can be technically difficult due to impaction of the fetal head within the pelvis. Anesthesiologists can support the operating surgeon in this emergency scenario by administering nitrates such as GTN (e.g. 50–100 mcg as an i.v. bolus, or 400–800 mcg as a sublingual spray) or terbutaline (250 mcg subcutaneously) [2] to relax the uterus while the patient is still under a neuraxial blockade, although occasionally a general anaesthetic may be required. Caution is required with GTN which may produce uterine atony, profound hypotension, reflex tachycardia and transient hypoxaemia in rare cases. Many obstetricians use a Fetal Pillow® which is a balloon device designed to elevate the fetal head when it is deeply impacted before starting a caesarean delivery (Fig. 20.2).

Antibiotics

The use of prophylactic antibiotics is not routinely advised for instrumental delivery [1], however local guidelines should be consulted and followed. The obstetrician may request antibiotics if significant perineal trauma occurs.

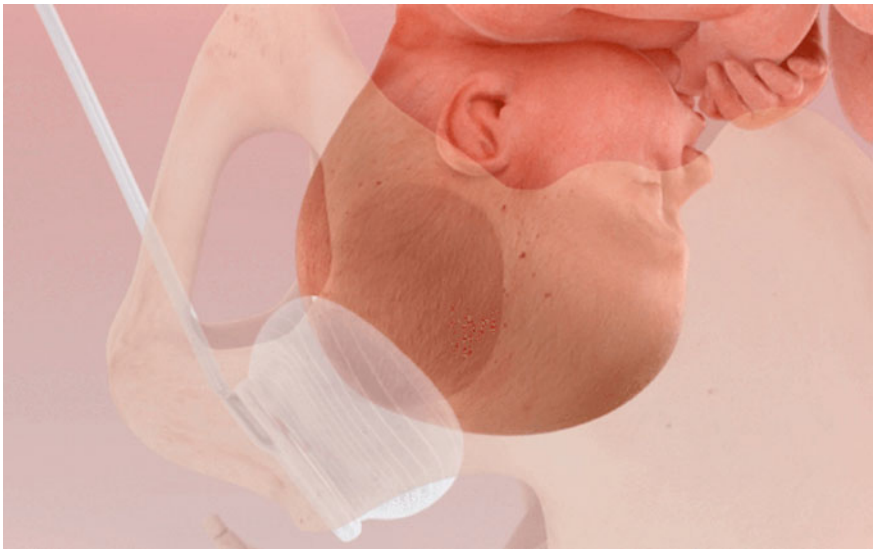

Fig. 20.2 Fetal Pillow. Reproduced with the kind permission of Dr. Rajiv Varma, Safe Obstetric Systems, Ltd., UK

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Massive Obstetric Haemorrhage

21

Rachel Collis and Lucy French

Definition

Massive obstetric haemorrhage can be defined as [1]:

- Blood loss of >1,500 ml
- A decrease in haemoglobin of >4 g/dL, or
- A transfusion of 4 or more units of red blood cells.

Causes and Associated Risk Factors

Tables 21.1 and 21.2.

Immediate Management

Call for help/assemble the multidisciplinary team at the bedside. Senior midwife/nurse, obstetrician and anaesthetist should attend. If immediate management is not successful escalation of care should include calling the most senior obstetrician and anaesthetist available, operating theatre team (if not already in theatre) and auxiliary staff trained to measure on-going blood loss.

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Table 21.1 Antepartum (APH): occurring after 24 weeks gestation and before delivery

Causes	Risk factors
Placental abruption	previous abruption, maternal hypertension or smoking, high parity, post-amniocentesis, cocaine use
Placenta praevia/accreta	previous caesarean delivery, multiple pregnancy, multiparity, previous myomectomy
Uterine rupture	previous uterine surgery/caesarean delivery particularly classical incision
Trauma	predominantly road traffic accidents/domestic violence

Table 21.2 Postpartum (PPH): can be divided into primary (within 24 hours of delivery) or secondary (24 hours to six weeks after delivery)

Causes	Risk factors	
Tone (uterine atony)	uterine over distension	macrosomia/multiple pregnancy/polyhydramnios/fibroid uterus
	uterine fatigue	grand multiparturient/induced or augmented labour/prolonged labour/uterine inversion
	intra-amniotic infection	prolonged rupture of membranes
	Intrinsic	previous postpartum haemorrhage (PPH)
Trauma	perineal tear/instrumental or caesarean delivery	
Tissue	perineal tear/instrumental or caesarean delivery	
Thrombin	coagulopathy	Rare as a primary cause **except** in severe placental abruption or amniotic fluid embolus (AFE)

Activate the massive haemorrhage protocol and measure on-going blood loss to facilitate appropriate escalation of care: **surgical swabs and blood clots should be weighed and suction contents measured in all birth settings**.

Follow an ABC approach [1]:

A Airway: assess and prepare to manage. If obtunded, plan to intubate and ventilate.
B Breathing: apply high flow oxygen (15L/min) via a non-rebreathing face mask.
C Circulation: lie the patient down.

- apply left lateral tilt to reduce the effect of aortocaval compression if APH
- position head down or raise legs if PPH (if any pre-existing neuraxial blockade allows)
- insert two large 14 G i.v. cannula (consider intraosseous access if difficult)
- take blood for: cross-match (4 units), full blood count (FBC), coagulation screen, point of care (POC) tests if available: Including haemoglobin (Hb), venous blood gas to assess lactate and viscoelastic haemostatic assays (VHA) using commercially available devices such as the TEG®

(thromboelastography), ROTEM® (rotational thromboelastometry) or the Quantra® (sonorheometry) analyser.

Monitor

- If outside the operating theatre, monitor on an early warning chart: pulse rate, non-invasive blood pressure, oxygen saturations and respiratory rate every 5 minutes with ongoing blood loss.
- Urinary output using a urinary catheter with an hourly measurement urinary catheter bag
- Consider arterial line monitoring (to aid cardiovascular monitoring and blood sampling)
- Repeat blood tests: FBC, (POC: lactate, Hb, calcium, VHA) and laboratory clotting every 500 mL of on-going blood loss.

Intravenous fluids:

- Infuse warm crystalloid fluid until blood is available (clear fluids should be restricted to maintaining cardiac output and up to 2 L [1]) Prepare a rapid flow rate fluid warmer.

Blood:

- Ideally blood should be given in response to the Hb level on a FBC or POC equivalent to keep Hb >80 g/L. In severe haemorrhagic shock, Hb can be falsely reassuring and clinical adjustments should be made for the rate of haemorrhage and the measured lactate concentration. (a lactate >4 mmol/L indicates significant shock)
- If immediate transfusion is required, give Group O, Rhesus D negative red blood cells. Change to group-specific or cross-matched blood as soon as possible.
- Consider intraoperative cell salvage [2] (contraindicated in sickle cell disease).

Coagulation: Follow local protocol on coagulation product replacement

- If point of care VHA is not available: give FFP (fresh frozen plasma) in a 1:1 ratio after the first 4 units of RBC have been transfused until coagulation results are available. Based on the results, transfuse FFP, cryoprecipitate or fibrinogen concentrate to keep the Clauss fibrinogen concentration >2 g/L and APTT (activated partial thromboplastin time) within the normal range [3].
- In cases of massive haemorrhage, VHA can be useful to help guide the type and amount of coagulation blood products required.
- There should be a locally agreed algorithm depending on the device available: ROTEM®, TEG® or Quantra® (Figs. 21.1 and 21.2).

Fig. 21.1 TEG® 6s (Haemonetics) and Quantra® (HemoSonics) point of care coagulation monitors. Published with kind permission from Haemonetics, Boston, USA and HaemoSonics, Charlottesville, USA

Fig. 21.2 The ROTEM Sigma® point of care coagulation monitor. Provided courtesy of Werfen

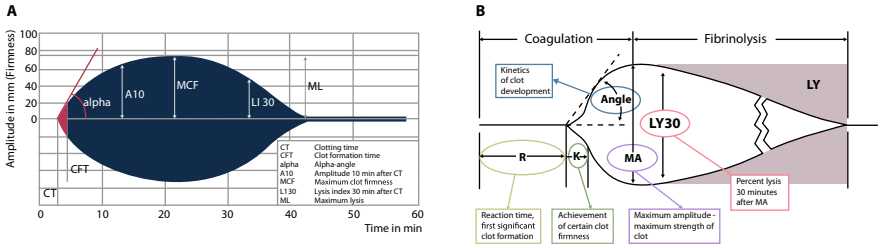

Fig. 21.3 A ROTEM trace showing parameters required for interpreting ROTEM PPH algorithm

- Fibrinogen is the first clotting factor to become abnormal during PPH and should be replaced first.
- If VHA is available, then replace fibrinogen when below 2 g/L guided by the manufacturer's equivalent [4].
- Deficiencies in other clotting factors are very rare and can be identified by any prolongation of the APTT on laboratory testing and prolonged CT (Clotting Time) on the ROTEM® EXTEM (an assessment of the extrinsic coagulation pathway), r time on the kaolin activated TEG® and CT on the Quantra® (Fig. 21.3). Prolongation outside the normal range will depend on individual manufacturer's normal range for these parameters.
- A validated ROTEM algorithm for PPH is shown (Fig. 21.4) although increased research on the other devices will result in equivalent information.
- The platelet count should be measured using the FBC with an agreed local policy for rapid lab testing during MOH (not derived from VHA) and replaced to keep the platelet count >75 $\times$ 10^9/L with on-going bleeding [3].
- Tranexamic acid 1 g [5] should be given with blood losses >1,000 mL as soon as possible after the onset of bleeding and repeated after 30 min if bleeding is on-going.
- Calcium replacement: hypocalcaemia exacerbates coagulopathy as well as myocardial dysfunction and is a consequence of massive rapid RBC transfusion. It can be accurately measured on most modern blood gas analysers. Keep Ionized Ca >1.0 mmol/L by giving 10 ml of intravenous 10% calcium gluconate.

Measure blood glucose: At least hourly until bleeding is controlled.

Monitor temperature: Every 15 min. Normothermia should be maintained with warmed fluids and an active warming device such as a Bair Hugger®.

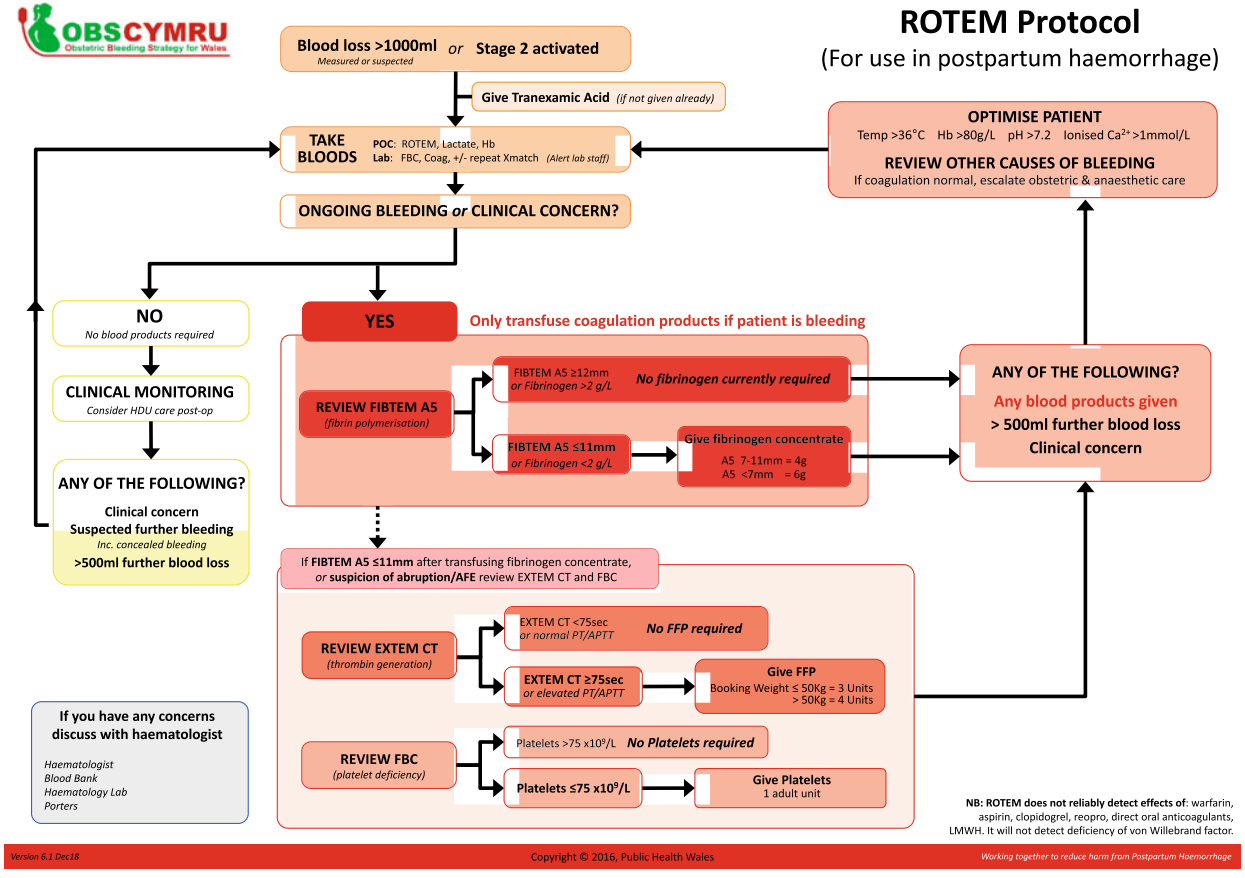

Fig. 21.4 Obs Cymru ROTEM algorithm for the management of coagulation products during PPH. Source: Published with permission from Dr. Sarah Bell on behalf of Obs Cymru

Therapeutic Targets During On-Going Haemorrhage [4, 6–9]

- Haemoglobin >80 g/L with ongoing blood loss
- Clauss fibrinogen >2.0 g/L If abnormal, give cryoprecipitate 2 units or 4–6 g fibrinogen concentrate. Correction of fibrinogen <2 g/L or VHA equivalent should be a priority as it is the only clotting factor deficiency that has been correlated with clinical outcomes.
- PT/APTT <1.0× control or abnormalities of VHA clot initiation time give 15 ml/kg fresh frozen plasma
- Platelets >75 × 10^9/L: give 1 unit of platelets
- Temperature >36 °C
- pH >7.2
- Ionised calcium (Ca) >1 mmol/L.

Obstetric Management of Massive Obstetric Haemorrhage [1]

Antepartum (APH): Most severe cases will require immediate delivery in the operating theatre. Ensure all monitoring is in place, resuscitation is commenced, appropriate blood tests are taken and blood and blood products have been requested.

Placental Abruption: A low fibrinogen is common. If the baby is still alive, immediate delivery is usually required. If the baby is not alive and the mother is stable then correction of clotting abnormalities prior to vaginal or surgical delivery should be attempted.

Postpartum (PPH): 80% of PPH is caused by atony and trauma of the genital tract.

Treatment of atony:

Physical

- If the uterus is atonic, 'rubbing up' a uterine contraction, and firm bi-manual uterine compression can temporarily control bleeding. It can help expel clots in the uterine cavity making further uterotonics more effective.

Pharmacological (only for PPH)

- Oxytocin: slow bolus of 5 units intravenously (i.v.). Give further 5 units i.v. if required followed by a continuous i.v. infusion (10 units oxytocin/hour).
- Ergometrine: 250–500 μg intravenously or intramuscularly. The maximum dose is 1 mg (mg).

Note: extreme caution must be used when administering ergometrine intravenously as it may cause significant hypertension, the preferred route is intramuscular. Due to its vasoconstrictive effects administration of ergometrine should be avoided in pre-eclamptic patients. It is also an emetogenic drug and an intravenous anti-emetic such as ondansetron 4mg should be given simultaneously.

- Carboprost: 250 μg by intramuscular or (rarely) intramyometrial injection. This can be repeated every 15 min, to a maximum dose of 2 mg.

Note: can cause bronchospasm and should be avoided in patients with asthma.

- Misoprostol 800–1000 μg sublingually or rectally.

Surgical

Surgical intervention may be required to stop the haemorrhage, and the specific intervention will depend on the cause and severity of bleeding, as well as the expertise of the surgeon. Appropriate analgesia and anaesthesia are required.

Surgical interventions include:

- examination under anaesthesia (EUA) and repair of genital tract trauma
- uterine packing
- intrauterine balloon insertion (e.g. Bakri balloon)
- B-Lynch suture (a type of compression surgical suture)
- uterine and internal iliac artery ligation
- hysterectomy.

Radiological

Internal iliac/aortic balloon placement on the delivery suite, as a temporary measure to reduce bleeding and facilitate surgical control, may be used in an emergency if facilities and expertise are available.

Selective embolisation of uterine and pelvic vessels may be required by an interventional radiologist. The procedure is usually carried out in an interventional radiology suite, so the patient should be cardiovascularly stable enough to be transferred to this external, often remote, area.

Evidence suggests that these interventions are unlikely to be successful unless coagulation deficits have been corrected.

Post-Haemorrhage Management

- Perform a multidisciplinary team debrief.
- Record measured blood loss, blood and blood product use.
- *Deactivate* the “major haemorrhage” protocol.

- Transfer the patient to the intensive care unit (ICU), or high dependency unit (HDU).
- Record an appropriate time for the epidural catheter to be removed and for the venous thromboprophylaxis protocol to be initiated. Thromboprophylaxis should be started 6–12 hours after the haemorrhage has been controlled because of a significant thrombosis risk after PPH.
- Record the extent of the haemorrhage (any blood loss >1,500 mL) and initiate any internal hospital procedures (e.g. clinical governance) which review the overall clinical care delivered to the patient. Detailed internal reviews of major haemorrhage cases have the potential for improving patient care in the future.

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Uterine Atony

22

Rachel Collis and Lucy French

Definition

Uterine atony is the failure of the uterus to contract after delivery, resulting in significant blood loss of >500 mL after a vaginal birth. A combination of atony and genital tract trauma account for 80% of postpartum haemorrhage (PPH) and frequently occur together [1].

The Royal College of Obstetricians and Gynaecologists Green-Top Guideline No. 52, on Postpartum Haemorrhage, Prevention and Management, is an important reference for this topic and is recommended reading for anaesthetists.

Risk Factors

- Overdistended uterus: multiple pregnancy, polyhydramnios, macrosomia, fibroid uterus
- Prolonged or augmented labour
- Grand multi-parturient (>4 previous deliveries)
- Previous history of PPH
- Infection: intra-amniotic or intra-uterine infection
- Retained products of conception: membranes or placental tissue
- Uterine inversion.

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Table 22.1 Regimens for uterotonic drugs at elective caesarean delivery, and caesarean delivery in labouring women

Elective caesarean delivery	Intrapartum caesarean delivery
Bolus 1 IU oxytocin and start an oxytocin infusion at 2.5–7.5 IU/hour (0.04–0.125 IU/minutes)	3 IU oxytocin over ≥ 30 seconds and start an oxytocin infusion at 7.5–15 IU/hour (0.125–0.25 IU/minutes)
If needed after 2 minutes, administer a further 3 IU over ≥ 30 seconds	
Consider a 2nd line agent early if there is a failure to produce sustained uterine tone	
Review the patient's clinical condition before stopping the infusion; this will normally be 2–4 hours after starting the infusion	

Pharmacological Management [2–4]

Oxytocin: A hormone which causes uterine contraction and peripheral vasodilation. 5–10 U can be given IM or IV as a prophylactic agent for uterine atony. If administered IV it should be administered as a slow bolus usually diluted to 1 unit/mL. This can be followed by a continuous infusion of 10 units/hour. If given quickly, it can cause significant hypotension. It is less effective if it has already been used for augmentation of labour. Alternative regimes are used in many institutions and a recently published international consensus on the use of uterotonic agents during caesarean delivery provides alternative strategies using lower doses of oxytocin depending on whether it is given for planned or emergency caesarean delivery (Table 22.1) [5].

Carbetocin: A long-acting oxytocin analogue and is used to prevent atony but is not licenced in the management of atony. It is usually given as a single 100 mcg IV or IM injection and can reduce the need for an oxytocin infusion. Both oxytocin and carbetocin should be kept refrigerated.

Give cautiously in women with cardiac disease

Ergometrine: An ergot alkaloid, which causes uterine and vascular smooth muscle contraction. Administered as 250–500 micrograms intramuscularly (IM). Intravenous administration is not recommended. The maximum IM dose is 1 milligram. It is a strong emetogenic so consider co-administration of an anti-emetic, and it can cause significant hypertension. It should be kept refrigerated.

Avoid in patients with pre-eclampsia and essential hypertension

Syntometrine: Ergometrine 500 micrograms/oxytocin 5 IU is a combined preparation for IM injection. It is commonly given as a prophylactic measure to reduce the risk of uterine atony in women at increased risk of atony. It can be repeated and may be useful as a first line treatment of uterine atony with PPH as IV access is not necessary and can safely be used in midwifery settings. It should be kept refrigerated.

Carboprost: 15-methyl prostaglandin F2-α is a third line uterotonic, which is given as a 250 microgram intramuscular or intramyometrial injection. This can be repeated every 15 minutes, to a maximum dose of 2 milligrams. It can cause nausea, vomiting and diarrhoea. It can also cause severe bronchospasm. It should be kept refrigerated.

Avoid in asthma

Misoprostol A synthetic prostaglandin E1 analogue and effective uterine constrictor. It can be given as a dose of 800–1000 micrograms sublingually or rectally. Misoprostol may cause nausea, vomiting or diarrhoea as well as bronchospasm (less severe than carboprost). An advantage is that it does not need to be refrigerated or given as an injection.

Surgical Management

Although pharmacological management is the mainstay of early atonic PPH management, repeated doses of the same drug are of no benefit and can cause delay in the management of significant bleeding. If the bleeding is on-going >1500 mL after the step-wise escalation of uterotonics, surgical intervention should be considered immediately.

- The bladder is emptied since a full bladder will exacerbate uterine atony
- Bi-manual compression
  - The surgeon uses one hand to make a fist within the vagina, while the other hand compresses the uterus by pushing downwards on the mother's abdomen. This can be a life-saving measure in severe PPH caused by atony. It should be used until uterotonics are effective or in on-going bleeding while the mother is transferred to the operating theatre.

- Examination under anaesthesia: the removal of blood clots, placental tissue, membranes and the concurrent suturing of tears are essential in the early management of ongoing PPH caused by atony.
- Uterine tamponade
  - Although uterine packing using multiple layers of surgical ribbon gauze can be used, it has largely been replaced by the use of an intrauterine balloon.
  - Intrauterine tamponade balloon [6]. Insertion of a specifically designed balloon (e.g. Bakri balloon) into the uterus and inflation with normal saline (usually 250–500 ml) can tamponade bleeding.
- Compression sutures [7]
  - If intrauterine packing or balloon insertion are ineffective, external mechanical compression of the uterus with sutures can be used. This involves a laparotomy where two sutures compress the upper segment of the uterus. A common example of a haemostatic compression or brace suture is the B-Lynch suture technique. Use of absorbable sutures mean subsequent pregnancies are unlikely to be affected.

Vascular control:

- Aortic compression: In an extreme emergency an initial life-saving manoeuvre is direct compression of the aorta against the spinal column. It can be performed during laparotomy and can reduce haemorrhage by around 40%, although clamping of the aorta by an experienced vascular surgeon may eventually be required. Aortic compression using external abdominal pressure has also been described.
- Uterine artery ligation can be performed at laparotomy and does not affect future pregnancies due to collateral circulation.
- Uterine artery embolization can be performed using interventional radiology techniques although it may have to be performed at a remote location away from the obstetric operating theatres.
- Internal iliac ligation.
- Hysterectomy
  - Can be live-saving.
  - Decision making and surgery should be performed by a senior obstetrician usually in conjunction with a gynaecologist.
  - Should be carried out promptly, if the patient is cardiovascularly compromised and once other methods have failed.

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Uterine Inversion

23

Sarah McDonald and Katarzyna Marciniak

Definition

Uterine inversion is a rare but potentially life threatening emergency due to massive potential blood loss and cardiovascular instability including bradycardia secondary to the parasympathetic response to traction on the uterine suspensory ligaments [1, 2].

Anatomical Classification of Uterine Inversion (Fig. 23.1) [4]

Part of the uterus indents towards, and eventually prolapses, through the cervix.

- 1st degree—fundus reaches the internal os
- 2nd degree—fundus inside the vagina
- 3rd degree—fundus outside vagina
- 4th degree—vagina, cervix and uterus completely turned inside out and visible [3].

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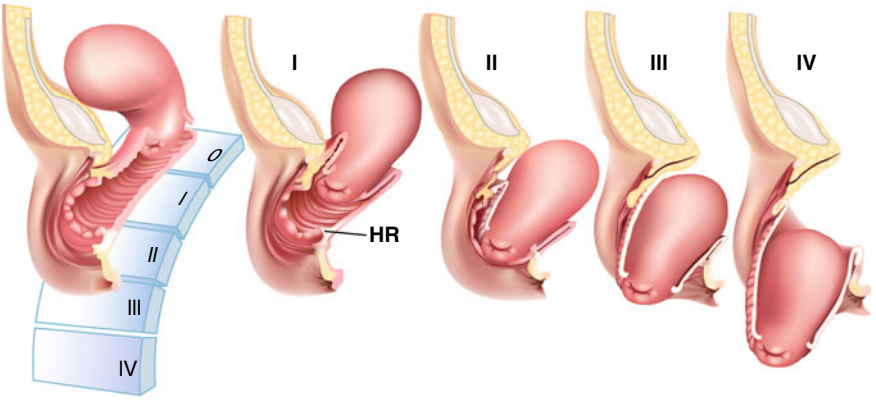

Fig. 23.1 Classification of uterine inversion; HR = Hymenal Remnants

Classification of Uterine Inversion (Fig. 23.1) [4]

Time-Course

- acute inversion occurs within 24 hours of birth predominantly in the 3rd stage of labour [5].
- subacute inversion occurs between 24 hours and 30 days postpartum
- chronic inversion occurs after 30 days postpartum and is very rare [6].

Risk Factors

- Premature or excessive cord traction, excessive fundal pressure [7]
- Short umbilical cord
- Fundal placenta implantation
- Retained placenta or abnormal adherence of placenta
- Chronic endometritis
- Vaginal birth after caesarean delivery (VBAC)/Trial of labour after caesarean delivery (TOLAC)
- Multiparity
- Uterine atony
- Macrosomia/Polyhydramnios
- Previous uterine inversion

- Use of tocolytics such as magnesium sulphate
- Uterus anomalies such as cornuate uterus
- Connective tissue disorders e.g. Marfan's syndrome.

Presentation

- Postpartum haemorrhage
- Lower abdominal pain
- Cardiovascular collapse, may be not proportional to the blood loss, bradycardia may be present
- Vaginal mass/inability to feel fundus (difficult in 1st or 2nd degree inversion).

Management

Important principles:

- maternal resuscitation whilst simultaneously attempting to replace the prolapsing uterus [8]
- do not attempt to remove placenta (if it is still attached) until the inversion is corrected
- prompt replacement of the uterus to reduce uterine oedema and subsequent replacement difficulties.

Resuscitation

- ABC approach, two wide bore intravenous cannulae, cross-match 4 units of blood, aggressive iv fluid resuscitation and blood products if needed (See Chap. 21) [9], administer oxygen, anticholinergics (atropine, glycopyrronium) to treat any bradycardia, vasoconstrictors (phenylephrine, ephedrine) if hypotensive in addition to fluid resuscitation and place a urinary catheter. Consider arterial and central venous monitoring if the patient's condition deteriorates.

Medical Management

Replacement of uterus

- Manual attempt to replace the uterus (temporarily stop any oxytocin infusion which may be being used and continue after successful uterine replacement).

Immediate administration of a general anaesthetic (GA) is usually required to facilitate uterine replacement unless a recently topped-up epidural catheter is already in situ (See Chap. 8). Volatile agents commonly used as part of a general anaesthetic agent will also cause a degree of uterine and cervical relaxation.

The use of tocolytics to increase cervical relaxation may be required (See Table 23.1). Monitoring of pulse and blood pressure should occur during administration if not already established.

- Hydrostatic replacement if manual attempt has failed
  - exclude uterine rupture
  - place the patient in the Trendelenburg position
  - The O'Sullivan Technique can sometimes be used. A minimum of 1 L of warm saline or sterile water is rapidly infused under pressure into the vagina using an intravenous line administration set which is suspended at least 1–1.5 m above the vagina. The end of the infusion tubing must be held inside the vagina in order for the fluid to distend and push the fundus upwards. The introitus is blocked by the operator's hand to reduce the leak and maintain

Table 23.1 Common tocolytic agents

Drug	Mechanism of action	Dose and route of administration	Side effects
Terbutaline	Beta-2 agonist	250 mcg i.v. or 250–500 mcg subcutaneously	Cardiac arrythmias, pulmonary oedema, myocardial ischemia, hypertension, tachycardia
Salbutamol	Beta-2 agonist	250 mcg i.v. bolus, or 500mcg subcutaneously or intramuscular	Cardiac or cardiopulmonary arrhythmias, pulmonary oedema, myocardial ischaemia, hypertension, tachycardia
Magnesium sulphate	Myosin light chain inhibitor	4 g over 10 min	Flushing, lethargy, headache, muscle weakness, diplopia, dry mouth, pulmonary oedema, cardiac arrest
Nitroglycerin	Conversion to nitric oxide by mitochondrial aldehyde dehydrogenase	50–100 mcg i.v. over 2 min or 1 metered puff/spray (equivalent to 400 mcg sublingually), repeated according to response	Severe hypotension, muscle twitching, retrosternal discomfort, palpitations

hydrostatic pressure. Creating a tight seal can be problematic and a silastic ventouse cup can alternatively be placed in the vagina to maintain a seal [10]

Surgical Management

Surgical options include the Huntington and Haultain procedures, laparoscopic-assisted repositioning, and cervical incisions with manual uterine repositioning.

- After successful replacement of the uterus: restart oxytocin, administer antibiotics and monitor the patient (re-inversion is possible).

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Amniotic Fluid Embolism

24

Neil Muchatuta and Stuart Younie

Amniotic fluid embolism (AFE) is a rare (incidence approximately 1 in 60,000) [1], but potentially catastrophic obstetric complication, and remains one of the leading direct causes of maternal mortality in high-income countries [2].

Pathophysiology

AFE is now thought to be a largely immunological, rather than a purely embolic, phenomenon. In AFE, fetal antigens that enter the maternal circulation during labour and delivery are thought to produce an abnormal host response (Fig. 24.1), which shares many similarities with anaphylactoid reactions [2].

Localised and systemic release of vasoactive and procoagulant substances precipitate [3]:

1. cardiovascular collapse
2. disseminated intravascular coagulation (DIC)
3. acute lung injury.

Presentation

There is wide variability in the presentation of AFE (Table 24.1), although cardiorespiratory collapse is common. It typically occurs during labour and delivery, but can more rarely occur during termination of pregnancy, amniocentesis and trauma [2].

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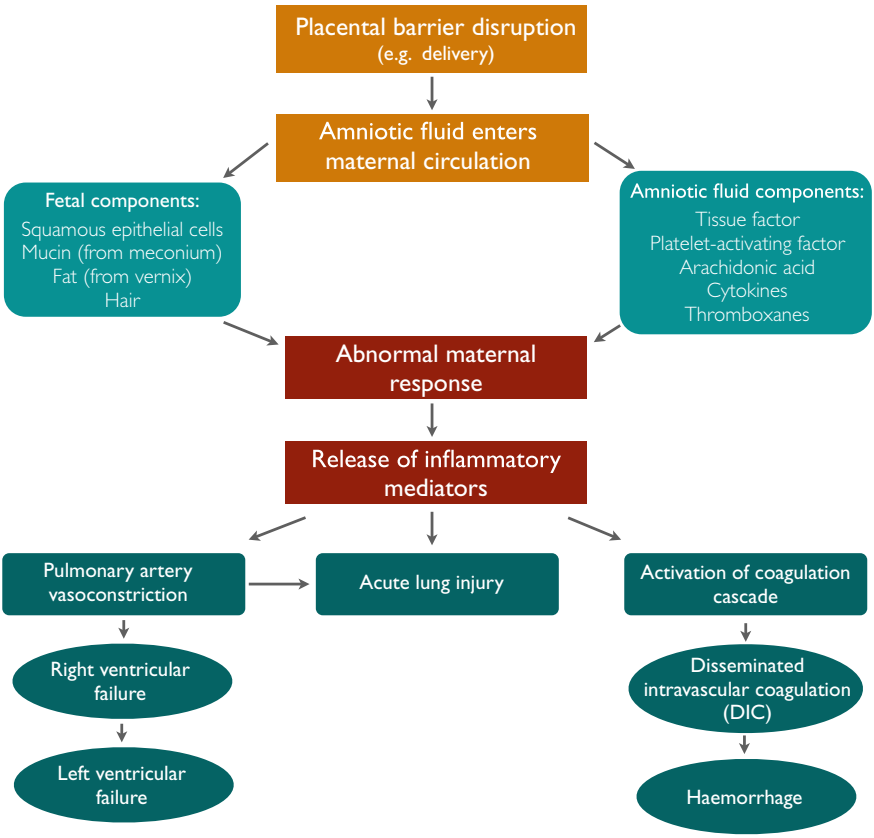

Fig. 24.1 Proposed pathophysiology of amniotic fluid embolism

Table 24.1 Presentation of amniotic fluid embolism

Cardiovascular	Respiratory	Haematological	Prodromal/Neurological
Cardiac arrest	Respiratory arrest	Coagulopathy	Altered mental state
Maternal collapse	Hypoxaemia	Haemorrhage	Agitation
Arrhythmia	Dyspnoea	DIC	Numbness
Tachycardia	Cyanosis	Hypofibrinogenaemia	Paraesthesia
Hypotension	Bronchospasm	Thrombocytopenia	Seizures
Heart failure	Pulmonary oedema	Fibrinolysis	Loss of consciousness

DIC: Disseminated Intravascular Coagulation

The clinical features of AFE can be considered in three phases [4], although in practice these phases may overlap in chronology:

Phase 1: Acute right ventricular failure and hypoxaemia

Immune-mediated release of vasoactive and pro-inflammatory substances cause pulmonary vasoconstriction and acute lung injury [5]. The rise in pulmonary vascular resistance (PVR) leads to acute right ventricular failure.

Phase 2: Left ventricular failure

Ballooning of the distended right ventricle into the left ventricular cavity exacerbates left ventricular failure and subsequent pulmonary oedema.

Phase 3: Disseminated intravascular coagulation

The release of procoagulant substances leads to widespread activation of the coagulation cascade, causing consumptive coagulopathy and DIC.

Diagnosis

AFE is largely a clinical diagnosis, with no definitive diagnostic tests. Whilst it can be argued that AFE is a diagnosis of exclusion, AFE remains the leading cause of sudden maternal collapse during labour and delivery [2].

Differential diagnoses include [5]:

- anaphylaxis
- sepsis
- pulmonary embolism
- obstetric haemorrhage
- anaesthetic emergencies: e.g. local anaesthetic toxicity and total spinal anaesthesia.

Management

The initial management of AFE is largely supportive. As an obstetric and medical emergency, it requires immediate senior anaesthetic, obstetric, haematological and critical care support.

Cardiovascular Management

Cardiac arrest:

If maternal cardiac arrest occurs, resuscitation should follow ALS (Advanced Life Support) guidelines [6]. Key interventions alongside effective cardiopulmonary resuscitation (CPR) include:

- Manual left uterine displacement.
- Perimortem caesarean delivery commenced within 4 min of collapse if no return of spontaneous circulation.

Right ventricular (RV) failure:

Right ventricular failure is often present in the acute phase. Treatment priorities include:

- Avoiding:
  - hypoxia
  - hypercarbia
  - acidosis
  - excessive fluid administration
- Maintaining systemic vascular resistance (SVR):
  - SVR is vital for preserving right ventricular perfusion
  - use vasopressors (e.g. norepinephrine, vasopressin) to maintain mean arterial pressure (MAP) ≥ 60 mmHg
  - liaise early with cardiac and critical care specialists to perform echocardiography to guide the use of vasopressors and inotropes
  - arterial and central venous ($\pm$ pulmonary artery) pressure measurement to allow careful fluid management.
- Reducing pulmonary vascular resistance:
  - requires specialist cardiac input; and may include sildenafil, inhaled nitric oxide, and inhaled/intravenous prostacyclins.

Left ventricular (LV) failure:

- Optimise preload
- Use inotropes (e.g. dobutamine, milrinone) to improve LV contractility
- Assess the need for diuretic therapy or dialysis if heart failure is compromising respiratory function
- In refractory cardiogenic shock, liaise with cardiology specialists regarding mechanical ventricular assistance or extracorporeal membrane oxygenation (ECMO).

Respiratory Management

If respiratory function is compromised despite supplemental oxygen, consider:

- Mechanical ventilation using protective ventilation strategies.
- Avoiding hypercarbia and hypoxia, to minimise increases in pulmonary vascular resistance (PVR).

Haematological Management

DIC with a rapid fall in fibrinogen and platelet concentration is common, as is increased fibrinolysis. Early liaison with a haematologist is essential.

Principles of coagulopathy management:

- Use point-of-care coagulation testing e.g. viscoelastic haemostatic assays (VHA) if available to guide coagulation management (see Chap. 21). Commercially available VHA devices include TEG® and ROTEM®.
- Massive obstetric haemorrhage protocols should be activated.
- Fibrinogen levels fall precipitously in AFE; consider using cryoprecipitate (or fibrinogen concentrate) to increase fibrinogen levels instead of large volumes of fresh frozen plasma (FFP). FFP has much lower concentrations of fibrinogen and could therefore dilute the overall plasma fibrinogen concentration [7].
- Thrombocytopaenia is common; administer platelets empirically during massive haemorrhage with evidence of DIC. During haemorrhage, the platelet concentration should be maintained above 50×10^9/L [7].
- The safety of tranexamic acid in obstetric haemorrhage has been established [8], and should be given.
- Co-existing uterine atony is common, and uterotonics and surgical management should be used aggressively to control haemorrhage [9].
- Consider VHA to help guide coagulation management.

Prognosis

AFE was once considered almost universally fatal; but advances in anaesthetic, obstetric, critical care and haematological management means that mortality in the UK is now approximately 20% [1].

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Vaginal Birth After Caesarean Delivery

25

Hadia Farooq, Anwen Gorry, and Suyogi Jigajinni

The caesarean delivery (CD) rate in England was 31% in 2019–20 [1]. A significant number of women therefore re-present in subsequent pregnancies following previous surgical delivery. Many are offered a vaginal birth after caesarean delivery (VBAC) as opposed to a planned repeat caesarean delivery. This is also more accurately known as a trial of labour after caesarean delivery (TOLAC). Knowledge of the risks, benefits and management of VBAC/TOLAC is therefore important for anaesthetists.

Benefits of Successful VBAC vs. Planned Repeat Caesarean Delivery

- Shorter recovery and hospital stay.
- Increased likelihood of future vaginal delivery [2].
- Reduced risk of placenta praevia/accreta in in future pregnancies [2].
- Reduced overall morbidity [3].
- Avoids potential surgical morbidity (bowel, bladder, ureteric injury).
- Avoids long term risks of repeat caesarean delivery: intra-abdominal adhesions, chronic pelvic pain.

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Indications for VBAC

VBAC may be offered to women with a singleton pregnancy of cephalic presentation, who have had one previous uncomplicated caesarean delivery. The success rate with VBAC is 72–75% [2], further increased in women who have had previous vaginal deliveries.

Contraindications to VBAC

Absolute

- Previous uterine rupture [2].
- Previous classical caesarean delivery [4]—higher risk of uterine rupture (2–9%).
- Other contraindication to vaginal birth (e.g. placenta praevia Type IV) [2].

Relative

- 2 (or more) previous caesarean deliveries, or twin pregnancy—VBAC may be considered following risk/benefit analysis by a senior obstetrician.
- Previous uterine surgery.
- A case-by-case evaluation is required when considering VBAC in women who have other risk factors for uterine rupture (Table 25.1).

Risks of VBAC

Uterine rupture (0.5% risk, further increased in induced/augmented labour)

- Full thickness separation of the uterine wall, often extending to the bladder and broad ligament.
- Classically intrapartum (though rarely can occur ante/postpartum).

Table 25.1 Risk factors associated with uterine rupture [2, 4]

Risk factor	Comments
Previous uterine surgery	Increases with no. of CD/uterine incisions
Induced/augmented labour	2–3 times increased risk of uterine rupture
Multiparity	Risk increases with parity
Uterine over distension	Macrosomia, polyhydramnios
Short inter-delivery interval	<12 months since previous delivery

CD = caesarean delivery

Table 25.2 Clinical features suggestive of uterine rupture [2, 4]

Maternal features	Comment
Severe abdominal pain/scar tenderness	Pain between contractions and/or breakthrough pain despite epidural analgesia (7–10% cases)
Vaginal bleeding/haematuria	3–5% cases
Maternal haemodynamic instability	Tachycardia/hypotension/collapse (5–10% cases)
Referred diaphragmatic pain	Chest or shoulder tip pain, breathlessness
Cessation of previous uterine activity	
Change in abdominal contour	
Fetal features	**Comment**
Fetal compromise on CTG	~70% cases
Disengagement of the presenting part (head or breech) from the maternal pelvis—"loss of fetal station"	
Inability to locate fetal heart rate at previous transducer site	

CTG: cardiotocograph

- Most commonly associated with fetal distress, severe pain and maternal haemorrhage. This triad is however present in <10% of patients.
- Patients may have variable presentations (Table 25.2), early consideration of uterine rupture, followed by prompt operative delivery is therefore essential to minimise both fetal and maternal risk.

Failed VBAC (up to 28% cases)

- If VBAC fails (i.e. fetal distress, failed induction), emergency caesarean delivery may be required. The risk of adverse maternal and perinatal outcome is then higher than a planned repeat caesarean delivery.

Women are advised to deliver in a hospital based obstetric unit with access to blood transfusion, and continuous electronic fetal monitoring [2].

Anaesthetic Considerations

Anaesthetists may be involved in both the routine and emergency care of the VBAC patient.

Routine Care

Epidural labour analgesia is entirely appropriate for women attempting VBAC [2]. Furthermore, where VBAC is unsuccessful and operative delivery required, a well functioning epidural catheter can be utilised to rapidly provide surgical anaesthesia.

A previous school of thought existed that epidural analgesia may mask the pain of uterine rupture, however current evidence does not support this [4, 5]. Additionally, there is no evidence of an association between epidural analgesia and unsuccessful VBAC [5].

Emergency Care

Uterine rupture can cause severe and constant pain that 'breaks through' the analgesic effect of the low dose labour epidural solutions commonly utilised on most maternity units. If clinical assessment confirms an appropriately functioning epidural, then uterine rupture must be considered, and urgent obstetric opinion sought.

Where uterine rupture is strongly suspected and emergency caesarean delivery planned, the choice of anaesthetic technique should be made on an individual basis. Appropriate senior anaesthetic and obstetric support should be urgently obtained in all cases of uterine rupture.

Important things to consider regarding emergency surgery in patients attempting VBAC:

- Close communication with obstetricians are vital.
- Neuraxial anaesthesia (spinal/epidural top-up) may be appropriate if maternal and fetal condition permit.
- General anaesthesia may be required in certain instances—for example poor fetal condition, associated maternal haemorrhage and haemodynamic instability [4].

Anaesthetic Preparation for VBAC

Due to the risk of uterine rupture it is advisable to:

- Perform a complete anaesthetic assessment of all VBAC patients admitted to the labour ward [5].
- Ensure a large bore cannula is in situ and a valid blood type and antibody screen/cross-matched blood sample (hospital dependent) is available during the trial of labour, in case it is needed for urgent blood transfusion.
- Vigilance when troubleshooting a 'failing' labour epidural.

Such measures ensure optimal anaesthetic preparation for the patient undergoing attempted VBAC.

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Shoulder Dystocia

26

Priyanka Sara, Julie Whittington, and Pat O'Brien

Definition

Shoulder dystocia occurs when there is difficult delivery of the fetal shoulders following vaginal delivery of the fetal head. It is classically defined as a vaginal cephalic delivery that requires additional obstetric manoeuvres to deliver the fetus after the head has delivered and gentle traction has failed [1].

Mechanism of Shoulder Dystocia

Shoulder dystocia occurs when either the anterior fetal shoulder (more commonly) or the posterior shoulder (less commonly) or both (rarely) become impacted against the maternal bony pelvis such that they cannot negotiate (pass through) the pelvic diameter; this makes delivery of the rest of the fetal body difficult.

Incidence

<1% of vaginal births [2].

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Significance

Shoulder dystocia is associated with an increased risk of maternal and perinatal morbidity. It is an obstetric emergency and is also one of the most common causes of litigation in obstetrics due to the potentially long-term impact of the associated complications which include:

- Perinatal morbidity [2–4]

  1. Fetal hypoxia, hypoxic ischaemic encephalopathy (HIE).
  2. Brachial plexus nerve injury (4–16%):

     (i) Erb's palsy—C5, C6 nerve damage causing internal rotation and adduction of the shoulder, and pronation and extension of the elbow.
     (ii) Klumpke's palsy—C7, T1 nerve damage causing claw hand (due to paralysis of the intrinsic muscles of the hand) and supination of the forearm.
     (iii) Most palsies resolve spontaneously; however, there is a 10% risk of permanent neurological dysfunction, making them the third most litigated obstetric complication in the UK [3].

  3. Fractures: humerus, clavicle.

- Maternal morbidity [2, 4]

  1. Postpartum haemorrhage (11%).
  2. Injuries: 3rd and 4th degree perineal tears (3.8%).

Factors Associated with an Increased Risk of Shoulder Dystocia [2]:

Stage	Factor
Pre-labour	Fetal macrosomia >4.5 kg
	Maternal diabetes mellitus (irrespective of fetal size)
	Maternal BMI >30 kg/m^2
	Previous history of shoulder dystocia
	Induction of labour
Intrapartum	Prolonged labour—prolonged 1st and/or 2nd stage
	Secondary arrest of labour
	Assisted/instrumental vaginal delivery
	Augmentation with oxytocin

Management of Shoulder Dystocia:

Predicting shoulder dystocia helps the obstetric, midwifery and anaesthetic team to be prepared, but prediction can be difficult as the majority of cases have no pre-existing risk factors. There are a number of warning signs at the time of birth that can, however, alert the midwife or obstetrician to potential difficulty in delivering the shoulders [4]:

- 'Head bobbing'—This is when the fetal scalp is visible with pushing efforts, but in between contractions the scalp is no longer visible as the head returns to the birth canal.
- Difficult delivery of the face and chin.
- 'Turtle-sign'—the delivered head becomes tightly pulled back against the perineum following delivery the head.
- Failure to restitute. Restitution is a normal process during a vaginal birth and refers to the spontaneous realignment of the head with the shoulders, which should normally occur after delivery of the head.

Management of Shoulder Dystocia:

The aim of management is to deliver the impacted shoulder and aid delivery of the baby as soon as possible. A head-to-body delivery interval, the time from the head being delivered to the body being delivered, of more than 5 minutes is associated with an increased rate of HIE [4].

The main manoeuvres used to manage shoulder dystocia aim to:

- Increase the functional size of the bony pelvis.
- Narrow the bisacromial diameter (the distance between the two acromions of the scapula) of the fetus.
- Change the position of the bisacromial diameter within the bony pelvis.

The types of manoeuvres and the order in which they should be attempted are listed in Fig. 26.1. Each manoeuvre is attempted for approximately 30 seconds.

1st line Manoeuvres

McRoberts manoeuvre, Fig. 26.2: the mother is laid flat on the bed and her thighs are flexed onto her abdomen to hyperflex and abduct the hips. This helps by straightening the lumbosacral angle, rotating the pelvis and increasing the relative antero-posterior diameter of the pelvis. Normal axial traction should then be attempted. This manoeuvre alone will resolve 90% of cases of shoulder dystocia.

Suprapubic pressure: while in a McRoberts position, another person exerts downward and lateral suprapubic pressure from the side where the occiput or the back is, just above the maternal symphysis; either rocking or continuous pressure

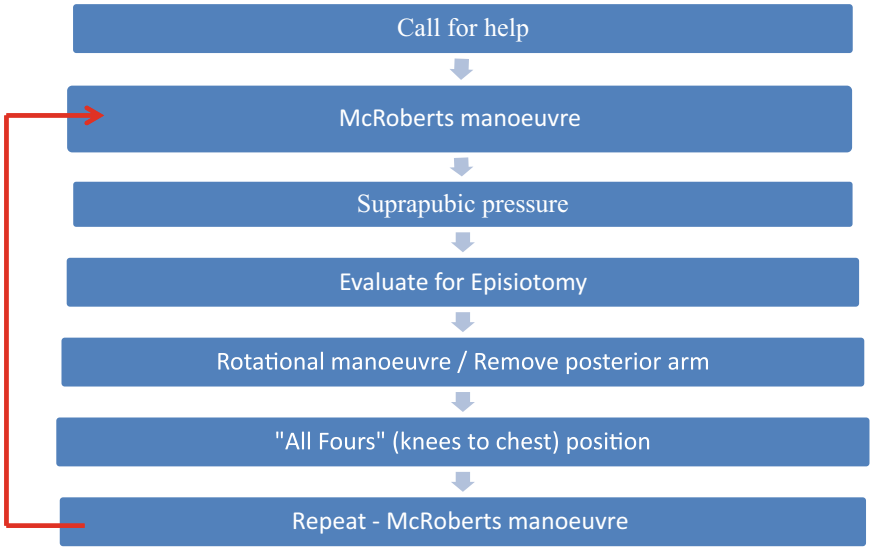

Fig. 26.1 Algorithm to manage shoulder dystocia

can be used. The force is directed in a way that aims to adduct the impacted anterior shoulder and relieve the shoulder dystocia.

2nd line Manoeuvres

Before 2nd line manoeuvres, episiotomy should be considered to gain access to perform these manoeuvres. Note that episiotomy itself does not relieve shoulder dystocia, which is a *bony*, not a soft tissue, problem.

Rotational manoeuvres: these aim to reduce the bisacromial diameter.

- Wood Screw manoeuvre, Fig. 26.3: the clinician's hand is introduced into the vagina to reach the baby's shoulders. Pressure is exerted on the posterior aspect of the anterior shoulder (i.e. pushing it forward) and on the anterior aspect of the posterior shoulder (i.e. pushing it backwards), causing rotation of the baby.
- Reverse Wood Screw manoeuvre, Fig. 26.4: pressure is exerted on the anterior aspect of the anterior shoulder (i.e. pushing it backwards) and on the posterior aspect of the posterior shoulder (i.e. pushing it forward), causing rotation of the baby and disimpaction from behind the pubic bone.
- Rubin's manoeuvre, Fig. 26.5: pressure is exerted on the posterior aspect of the anterior shoulder only.

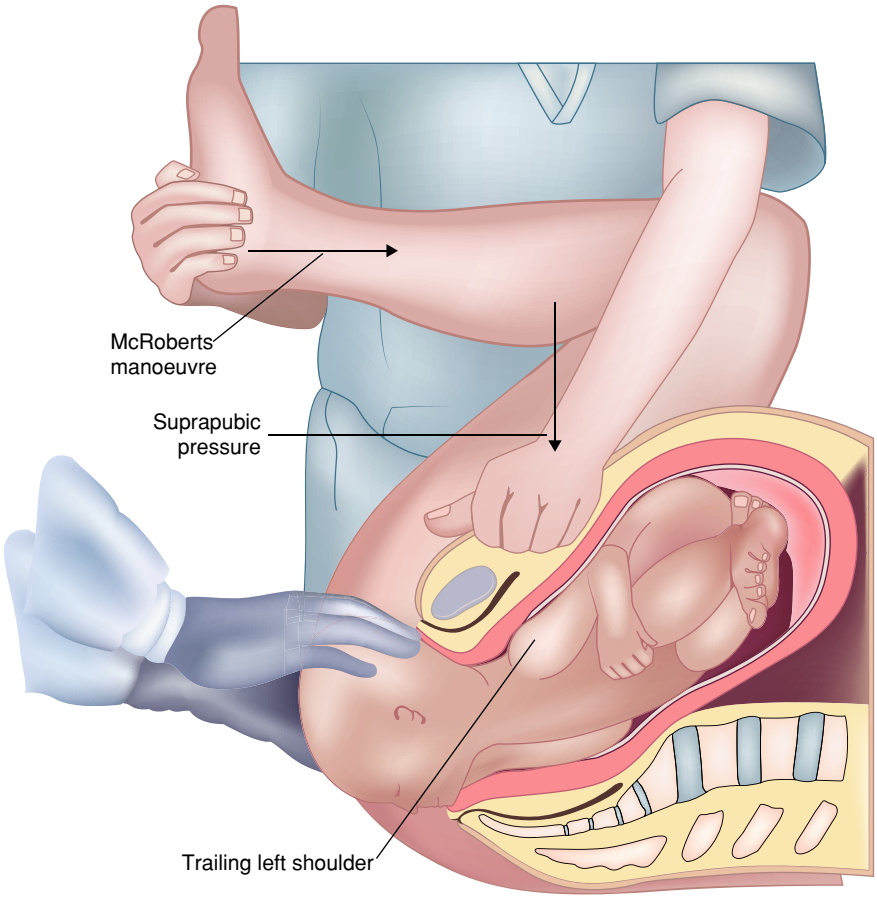

Fig. 26.2 McRoberts manoeuvre and suprapubic pressure

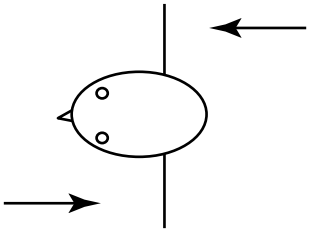

Fig. 26.3 Wood Screw manoeuvre

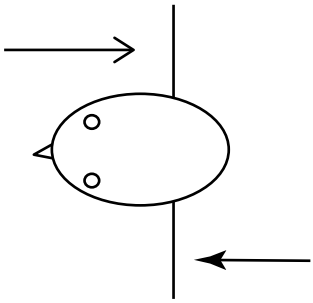

Fig. 26.4 Reverse Wood Screw manoeuvre

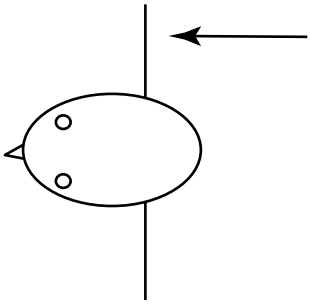

Fig. 26.5 Rubin's manoeuvre

Additional Manoeuvres:

- Removal of the posterior arm: alternatively, the posterior arm of the fetus can be delivered first. The clinician's hand is introduced into the vagina and along the baby to reach the baby's elbow. The elbow is flexed and the arm swept across the baby's chest and delivered. Once the posterior arm is delivered, there is space to deliver the anterior shoulder and the rest of the baby.
- "All Fours" manoeuvre: if the manoeuvres described above do not work, then the woman should be helped into a knee-chest/all fours position, as this helps to disimpact the shoulders. All of the manoeuvres described above should then be tried again in the same order.
- Delivery of the posterior shoulder: the obstetrician uses both middle fingers inserted into the posterior axilla of the fetus and pulls outward and downward to deliver the posterior shoulder which decreases the bisacromial diameter.
- Posterior axilla sling traction: a urinary or suction catheter is passed through the fetal posterior axilla and traction is placed on the catheter to deliver the posterior shoulder. Once in place, the sling can also be used to facilitate rotational manoeuvres described above.

3rd line Manoeuvres

These are rarely needed, as most cases of shoulder dystocia will be resolved by the steps described above [2].

1. Symphysiotomy: a procedure to divide the anterior fibres of the pubic symphysis ligament.
2. Fracture of the fetal clavicle using digital pressure: this reduces the bisacromial diameter.
3. Zavanelli manoeuvre: this involves pushing the fetal head back into the uterus, and then performing a caesarean delivery.

Useful Mnemonic

"HELPER" can aid remembering the steps for managing shoulder dystocia:

H	Call for Help (obstetrician, midwife coordinator, anaesthetist, neonatal team)
E	Evaluate for Episiotomy
L	Leg elevation/flexion—McRoberts manoeuvre
P	Suprapubic pressure
E	Enter the pelvis for rotational manoeuvres
R	Remove the posterior arm

If these steps fail, then go to "All Fours" and restart the manoeuvres.

Teamwork Exercises

Shoulder dystocia is often an unpredictable obstetric emergency requiring urgent manoeuvres to aid delivery of the baby and also to manage any complications thereafter. Therefore, participation in local skills and drills sessions are very important in preparing the team for this emergency; in the UK, various courses such as MOET (Medical Obstetric Emergencies and Trauma), ALSO (Advanced Life Support in Obstetrics) and PROMPT (Practical Obstetric Multi-Professional Training) incorporate such training.

Medicolegal Considerations

- All steps and manoeuvres undertaken during a shoulder dystocia event should ideally be recorded on a dedicated form.
- Umbilical cord blood gases should be checked for fetal acidaemia.
- The woman should be debriefed.

Anaesthetic Considerations

1. Setting—since a prolonged delay from delivery of the fetal head to delivery of the body is associated with HIE, shoulder dystocia is best managed where it is encountered—whether it occurs in the delivery suite or in the operating theatre. Transfer to the operating theatre is only indicated in extremely rare cases when all first and second line manoeuvres have failed and third line manoeuvres are needed.
2. Help the team in manoeuvres such as applying suprapubic pressure.
3. The anaesthetist should ensure intravenous access is available, check fasting status and administer antacid prophylaxis, particularly if transfer to the operating theatre for delivery/perineal tear repair or haemorrhage management is anticipated.
4. Optimize analgesia—if an epidural catheter is in situ, consider a low dose mixture epidural top-up (analgesic dose). Avoid intravenous opioids as these will cross the placenta and may impair neonatal respiration after delivery.
5. Prepare for postpartum haemorrhage (PPH) and repair of any perineal tears. This may require general anaesthesia if there is a major PPH or if there are any contraindications to a neuraxial technique. An epidural top-up may be appropriate if the mother is haemodynamically stable and an epidural catheter is in situ, otherwise spinal anaesthesia should be considered.
6. In the rare event of a caesarean delivery being needed after a Zavanelli manoeuvre, this is likely to be a category 1 caesarean delivery (see Chap. 19).

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Normal Labour

27

Priyanka Sara, Julie Whittington, and Nicola Lack

Definition

The World Health Organization (WHO) defines normal birth as [1]:

- Spontaneous Labor
- Low-Risk throughout labour and delivery
- Fetus in vertex presentation
- Spontaneous delivery (no operative assistance)
- Between 37 and 42 weeks
- Good condition of mother and infant after birth

The term however is also applied to successful unaided vaginal delivery after induction or augmentation of labour (see Chaps. 31 and 32).

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Terminology Used to Describe Cervical Status

(a) Cervical dilatation: 0–10 cm. 10 cm is full dilatation. The cervix must dilate (open) to allow passage of the baby through the birth canal.
(b) Cervical effacement: this refers to the thinning of the cervix and can range from 0% (no effacement, cervix is 2–4 cm long) to 100% (complete thinning of cervix). Cervical effacement can start before labour begins or can occur as labour progresses.
(c) Fetal station: Number of centimeters (cm) of the leading bony edge of the presenting part above or below the level of the ischial spines (denoted in ± numbers, see Fig. 27.1), measured clinically by palpation on vaginal examination.

Fetal station: 0 at level of ischial spine/mid-cavity, −1 to −3 above the level of ischial spine and +1 to +3 below the level of the ischial spine.

Stages of Normal Labour [2]

The stages of normal labour are summarized in Table 27.1.

The 1st stage is characterized by effacement and dilatation of the cervix, and descent of the presenting part. The passive 2nd stage can last up to 1 hour in primigravida women as natural descent of the presenting part takes place. If epidural analgesia is already in progress, then an additional hour of passive rest is allowed.

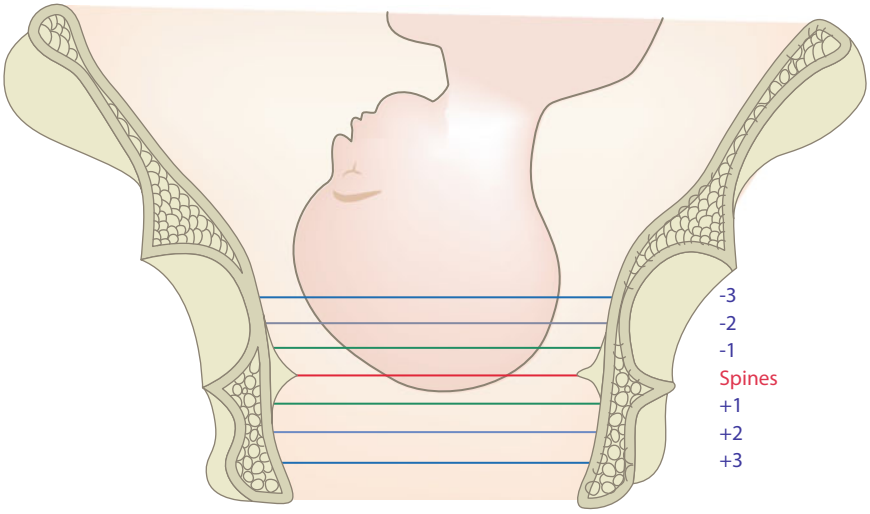

Fig. 27.1 Fetal station to measure (in cm) the descent of the presenting part below the ischial spines duringlabour

Table 27.1 .

Stage of labour		Description
1st stage	Latent phase	Cervical ripening from the onset of contractions until the cervix is dilated up to 4 cm
	Active/established phase	Stronger, regular uterine contractions from 4 cm to full dilatation
2nd stage	Passive/propulsive 2nd stage	Full dilatation of the cervix before or in the absence of involuntary expulsive contractions, when there is natural descent of fetal head onto the pelvic floor
	Active/expulsive 2nd stage	Baby is visible, or there is active maternal desire to push or maternal bearing down effort
3rd stage		From delivery of the baby to the complete delivery of the placenta and membranes

However, in clinical practice there are several scenarios where the passive stage may be reduced including cases where:

- the presenting part has naturally descended well into pelvis and the fetal station is low below the spines
- the maternal urge to push is present
- there are other conditions such as presence of meconium or infection
- to prevent complications associated with prolonged labour.

Mechanism of Normal Labour

The initiation of normal labour is complex and not fully understood, however it involves a hormonal cascade triggering the release of oxytocin, prostaglandins, growth factors and cytokines, which start the process of labour. Once uterine contractions begin, the cephalic presenting part enters the maternal pelvis and has to negotiate the pelvic brim/inlet, mid cavity at the level of the ischial spine and descend down through the pelvic outlet. The narrowest fetal diameter that can negotiate the pelvis easily is the sub-occipito-bregmatic diameter, which is around 9.5 cm in a well-flexed fetal head, which presents in the occipito-anterior position.

A successful vaginal delivery can be achieved with 3 P's:

(1) Power: strong and regular uterine contractions (95% women in active labour have 3–5 contractions in 10 minutes).
(2) Passage: spacious gynaecoid maternal pelvis.
(3) Passenger: an average sized fetus in a favorable position with a normal fetal heart rate.

Any abnormalities in the above 3 factors, isolated or mixed, can cause an abnormal course of labour leading to obstetric intervention in the form of labour augmentation, instrumental or caesarean delivery.

Duration of Labour

The duration of labour is variable and depends upon parity, gestation, size of the baby, whether the labour is spontaneous in its onset or has been induced, and previous labour duration.

The National Institute for Health and Care Excellence (NICE) recommend that women should be informed that while the length of established 1st stage of labour varies between women, a first labour (time from established labour until delivery) lasts on average 8 hours and is unlikely to last over 18 hours. Second and subsequent labours last on average 5 hours and are unlikely to last greater than 12 hours [2].

Progress of Labour

1st stage

Progress can vary up to 4 cm, however after 4 cm, once in established labour, a progress in cervical dilatation of at least 0.5 cm/hour is expected [2]. Descent of the fetal presenting part (usually the fetal head) is mainly a 2nd stage phenomenon and is used to gauge progress in the 2nd stage.

2nd stage

The passive stage can vary from 1 to 2 hours in primigravida women without and with epidural analgesia respectively. The active stage of maternal pushing is considered normal if <1 hour in primigravida women and <30 minutes in multigravida women. A prolonged 2nd stage of labour needs an obstetric evaluation to determine the cause. A partogram is a chart that is used to plot the progress of labour and is an essential tool in detecting delay/non-progress in labour (see Chap. 30).

3rd stage

If the placenta is not expelled within 30 minutes of delivery with active management of the 3rd stage of labour, usually with an intramuscular injection of oxytocin or an oxytocin/ergometrine combination, or within 60 minutes of physiological management, it is described as a "retained placenta." In this situation, to prevent postpartum haemorrhage (PPH), the patient should undergo a manual removal of placenta (MROP) procedure in the operating theatre under anaesthesia (see Chap. 12).

Indications for vaginal examination:

- On admission to the delivery area
- Every 4 hours in 1st stage and every hour in 2nd stage of labour
- Before analgesia administration (e.g. an epidural)
- Maternal urge to push
- Fetal heart rate abnormalities.

Maternal observations: record the following parameters on admission and at least 4-hourly if in normal labour, or more frequently if augmented labour/epidural analgesia.

- temperature,
- heart rate,
- blood pressure.

Fluids and Oral Intake During Labour

The UK, Royal College of Obstetricians and Gynaecologists (RCOG) guidelines for normal labour with and without an epidural state that women in normal labour can eat a light diet and drink as much fluid as they wish. Excessive oral fluid intake is however not encouraged due to the potential risk of developing hyponatremia [3]. Following the insertion of a labour analgesia epidural block, most UK hospital policies allow clear fluids to be consumed during labour.

Analgesic/Pain Relief Considerations (also see Chap. 3)

i. Non-pharmacological options: these include transcutaneous electrical nerve stimulation (TENS), acupuncture, hypnotherapy, aromatherapy, and immersion in water. While evidence may be lacking for the efficacy of these options in established labour, women wishing to use such techniques should be supported.
ii. Pharmacological analgesic options:

   a. Latent stage options include paracetamol, dihydrocodeine, stronger opioids such as morphine or diamorphine. Opioids are generally avoided in established labour as they can reduce CTG variability and are associated with short term respiratory depression in the neonate [2].
   b. When the mother is in established labour, analgesic options include inhalational using Entonox® (50:50 nitrous oxide and oxygen), pudendal nerve block performed by the obstetrician for low cavity instrumental delivery, perineal local anaesthetic infiltration, epidural or combined spinal-epidural (CSE) analgesia. Epidural analgesia can contribute to a prolonged 2nd stage of labour and need for labour augmentation with oxytocin, but does not increase the risk of caesarean delivery [4].

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Cardiotocography (CTG)

28

Muhammad Waseem Athar, Aliya Naz, and Fatima Khatoon

Cardiotocography (CTG) monitors fetal well-being, by continuously recording the fetal heart rate (FHR) as well as maternal uterine contractions. The FHR is recorded by using either an ultrasound transducer or a fetal scalp electrode whereas uterine contractions are measured by a pressure transducer placed on the mother's abdomen. It is imperative that obstetric anesthetists have a good grasp on the fundamentals of CTG. This will enable better communication with their obstetric colleagues, who often base the decisions for urgent delivery of the fetus on CTG changes.

Indications: Although it is common practice to use continuous CTG monitoring for all laboring women across many centers around the world, the 2017 NICE (National Institute for Health and Care Excellence) guidelines [1] do not endorse its use in mothers who are otherwise at low risk of complications. It is recommended in the following high-risk intrapartum conditions (this list is not exhaustive and may also include preexisting antepartum indications):

- suspected chorioamnionitis, sepsis, or temperature ≥ 38 °C
- severe hypertension ($\geq 160/110$ mmHg)
- oxytocin use
- significant meconium
- fresh vaginal bleeding.

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Interpretation:

CTG recording (Fig. 28.1) conventionally consists of a tracing of FHR (top of the graph) and a second tracing of uterine activity (bottom of the graph) plotted on a paper that is moving at a rate of 1 cm/min (3 cm/min in North America). Each large square is equal to one minute. The average FHR and number of uterine contractions are observed over a 10-min window averaged over 30 min. The interpretation of an antepartum CTG includes evaluation of the following [2]:

- timing and quality of the recording
- baseline FHR
- baseline FHR variability
- accelerations and decelerations
- uterine activity.

Baseline FHR: Normal FHR baseline: 110–160 beats/min.

Tachycardia: FHR baseline >160 beats/min. The most important cause to consider with fetal tachycardia is fetal hypoxia. Fetal tachycardia may also be observed with maternal fever or stress, excessive fetal movement, prematurity and uterine stimulation.

Bradycardia: FHR baseline <110 beats/min. Fetal bradycardia is commonly attributable to umbilical cord compression, fetal head compression and prolonged fetal hypoxia. It may also be associated with fetal post-maturity.

Baseline variability: FHR normally undergoes beat-to-beat fluctuations in amplitude and frequency, which is referred to as baseline variability. It is due to activation of the sympathetic and parasympathetic nervous systems. Variability can be classified as follows:

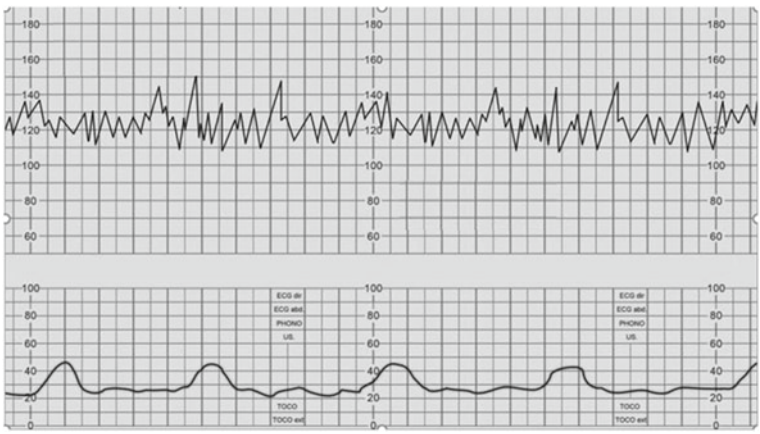

Fig. 28.1 Normal CTG. Figure reproduced from: Antepartum and intrapartum fetal evaluation. Jacquemyn Y, Kwee A. In Oxford Textbook of Obstetric Anaesthesia. Eds. Clark V, Van de Velde M, Fernando R. Oxford University Press 2016. Published with permission from Oxford University Press through PLSclear

- normal: 6–25 beats/min
- increased: more than 25 beats/min
- decreased: 3–5 beats/min
- absent: less than 3 beats/min.

Although the presence of normal baseline variability reflects adequate oxygenation of the central nervous system (CNS) and dependably predicts the absence of detrimental degrees of hypoxia-induced metabolic acidemia at the time it is observed [3], minimal or absent variability alone is a poor predictor of hypoxia. Other potential causes of reduced variability may include fetal sleep states, extreme prematurity, preexisting fetal neurologic anomalies and decreased CNS activity due to opioids or magnesium sulfate.

Acceleration: A clear and abrupt increase (>15 beats/min) in the FHR lasting for at least 15 s, is frequently associated with fetal movement, possibly mediated by stimulation of peripheral proprioceptors. The presence of FHR accelerations indicates the absence of clinically significant fetal hypoxia and fetal metabolic acidemia at the time they are observed [3], but an absence of accelerations may not necessarily be detrimental. Causes of absent FHR accelerations include fetal sleep cycles, arrhythmia, extreme prematurity, congenital anomalies, fetal anemia, and preexisting neurologic injury.

Decelerations: A transient reduction in FHR by at least 15 beats/min from baseline for at least 15 s. Decelerations are subdivided into early, late and variable decelerations based on their relationship to uterine contractions.

- In **Early** decelerations (Fig. 28.2), FHR starts to decrease gradually with the onset of contraction, nadirs at the peak of the contractions and resolves quickly

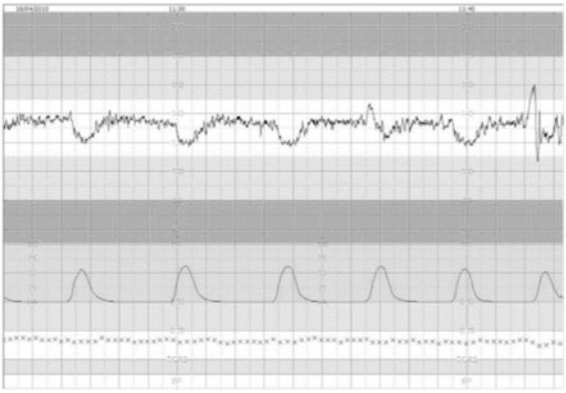

Fig. 28.2 Early Deceleration starts and nadirs at onset and peak of uterine contraction. Figure reproduced from: Antepartum and intrapartum fetal evaluation. Jacquemyn Y, Kwee A. In Oxford Textbook of Obstetric Anaesthesia. Eds. Clark V, Van de Velde M, Fernando R. Oxford University Press 2016. Published with permission from Oxford University Press through PLSclear

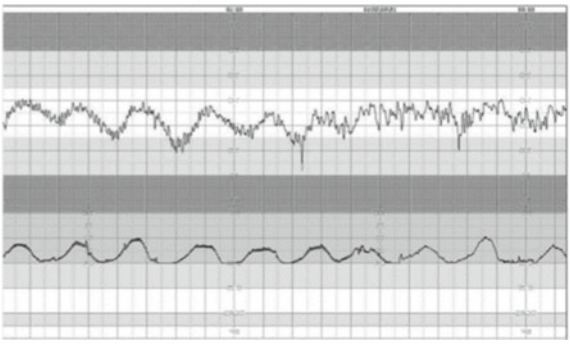

Fig. 28.3 Late Deceleration starts and nadirs after onset and peak of uterine contraction. Figure reproduced from: Antepartum and intrapartum fetal evaluation. Jacquemyn Y, Kwee A. In Oxford Textbook of Obstetric Anaesthesia. Eds. Clark V, Van de Velde M, Fernando R. Oxford University Press 2016. Published with permission from Oxford University Press through PLSclear

as the contraction subsides. They are clinically benign, occurring due to an autonomic response to changes in intracranial pressure and/or cerebral blood flow caused by fetal head compression during a uterine contraction and maternal expulsive efforts.

- In **Late** decelerations (Fig. 28.3), FHR starts to decrease gradually after the onset of contraction, nadirs after the peak of the contractions and resolves after the end of the contraction. These decelerations occur due to a chemoreceptor-mediated response to fetal hypoxemia. Late decelerations require prompt attention as they may indicate fetal acidosis.
- **Variable** decelerations (Fig. 28.4), These manifest a rapid drop, with onset to nadir less than 30 s, good variability within the deceleration, rapid recovery to

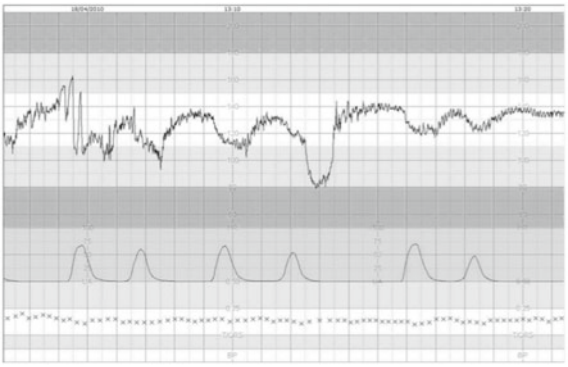

Fig. 28.4 Variable deceleration has no relation to uterine contraction. Figure reproduced from: Antepartum and intrapartum fetal evaluation. Jacquemyn Y, Kwee A. In Oxford Textbook of Obstetric Anaesthesia. Eds. Clark V, Van de Velde M, Fernando R. Oxford University Press 2016. Published with permission from Oxford University Press through PLSclear

the baseline and are varying in size, shape, and relationship to uterine contractions. Variable decelerations, with no concerning features are very common, can be a normal feature in an uncomplicated labour, and usually reflect the fetal autonomic reflex response to umbilical cord compression.

Categories:

Evidence suggests that the use of a standardized approach using three- tier FHR patterns proposed by the UK National Institute for Health and Care Excellence (NICE) [1] coupled with therapeutic interventions may improve neonatal outcomes [4]. It is important to recognize that FHR tracing patterns provide information only about the current acid–base status of the fetus. FHR patterns may move back and forth between the categories depending on the current clinical status and management strategies used. Consideration should also be given to patient-specific factors in the interpretation and management of FHR patterns (Tables 28.1 and 28.2).

Adjuncts to CTG:

Fetal scalp blood sampling (FSBS): This procedure assesses the presence of fetal acidemia by analyzing scalp pH and lactate levels in fetal capillary blood. Although the NICE guideline [1] recommends its use, recent Cochrane systematic reviews have shown that FSBS did not reduce caesarean delivery or operative vaginal births and did not influence any neonatal outcomes [6, 7].

ST Analysis (STAN) monitor: This monitors fetal electrocardiogram (ECG) obtained via a spiral electrode attached to the fetal scalp. Its use is based on the principle that fetal hypoxemia can result in elevation or depression of the ST segment. Although there is no evidence to suggest that it improves neonatal outcome, its use has shown to reduce the rates of fetal blood sampling, operative vaginal delivery and metabolic academia [8].

Fetal Pulse Oximetry: This is a non-invasive method of measuring fetal oxygen saturation using a sensor/catheter placed on the fetal scalp or cheek. Its use is based on the principle that in the presence of an abnormal FHR pattern, a fetal $SpO_2 < 30\%$ for greater than 10 min may increase the risk of fetal acidemia. However, evidence lacks the support of its clinical usefulness [9].

Table 28.1 Interpretation and management of FHR patterns. Adapted from NICE Guideline CG190. Intrapartum Care for healthy women and babies. 2017 [1]

	Reassuring	Non-Reassuring	Abnormal
Baseline FHR (beats/min)	110–160	100–109[a] 161–180	<100 >180
FHR variability	5–25	<5 for 30–50 min or >25 for 15–25 min	<5 for >50 min or >25 for >25 min or Sinusoidal pattern
Decelerations	None Early Variable without concerning[b] features for <90 min	Early Variable without concerning[b] features >90 min *OR* Variable with concerning[b] features in up to 50% of contractions for ≥ 30 min *OR* Variable with concerning[b] features in >50% of contractions for <30 min *OR* Late decelerations in >50% of contractions for <30 min, with no maternal or fetal clinical risk factors such as vaginal bleeding or significant meconium	Variable with concerning features[b] in >50% of contractions for 30 min (or less if any maternal or fetal clinical risk factors) OR Late decelerations >30 min (or less if any maternal or fetal clinical risk factors) OR Single prolonged >3 min
Management	Continue monitoring. No specific action needed	Correct any underlying causes More frequent or additional monitoring may be needed	Start aggressive intrauterine resuscitation[c]; if there is no improvement, caesarean delivery is indicated

[a]Baseline FHR 100–109 beats/min indicates a non-reassuring feature but continue usual care if there is normal baseline variability and no variable or late decelerations

[b]Concerning features: (1) lasting >60 s, (2) reduced baseline variability within the deceleration, (3) failure to return to baseline, (4) biphasic (W) shape, (5) No shouldering (brief increase in fetal heart rate from baseline immediately before and after a deceleration)

[c]Intrauterine resuscitation [1, 5]: (1) If uterine hyperstimulation-reduce/stop oxytocin infusion and/or use a tocolytic e.g. terbutaline 0.25 mg s/c, (2) Left lateral position, (3) IV fluids/vasopressors if hypotensive

Key points

- Basic understanding of the CTG may aid communication and appropriate management when the fetus is considered at high risk.
- Continuous CTG monitoring is strongly recommended in high-risk pregnancies.
- Categorization of the CTG using three-tier FHR patterns coupled with therapeutic interventions may improve neonatal outcomes.
- Patient specific factors must be considered during management of abnormal FHR pattern.

Table 28.2 Adapted from the ACOG Practice Bulletin Number 106 [2]

	Category I	Category II	Category III
Baseline FHR (beats/min)	110–160	<110 >160	<100
FHR variability	6–25	Minimal (<5 beats/min) Marked (>25 beats/min) Absent with no recurrent decelerations	Absent Sinusoidal pattern
Accelerations	Present or absent	Absence of induced accelerations after fetal stimulation	Sinusoidal pattern
Decelerations	None Early may be present No variable or late	Recurrent variable with minimal or moderate variability Prolonged deceleration >2 but <10 min Recurrent late decelerations with moderate baseline variability	Recurrent late decelerations Recurrent variable decelerations

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Antenatal Care for Uncomplicated Pregnancies

29

Shalini Chawla and Pervez Sultan

Pregnant women should be offered information based on current available evidence together with support to enable them to make informed decisions about their care. This information should include where they will be seen and who will undertake their care. The information presented in this chapter is based on recommendations from within the United Kingdom.

Schedule of Appointments

A schedule of antenatal appointments should be determined by the function of the appointments (Table 29.1) [1].

- For a woman who is nulliparous (no previous births) with an uncomplicated pregnancy, a schedule of 10 appointments should be adequate.
- For a woman who is parous (previous births) with an uncomplicated pregnancy, a schedule of 7 appointments should be adequate.

The UK National Institute of Health and Care Excellence (NICE) Quality Standard states that the initial booking appointment for a pregnant woman should take place by 10^{+0} weeks (*NICE Quality Standard QS 22. Quality Statement No. 1*) [2].

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Table 29.1 Schedule of antenatal appointments for uncomplicated pregnancy [1, 2]

First contact with healthcare professionals	• Folic acid supplementation • Food hygiene and lifestyle advice • Vitamin D supplementation (10 μg per day) • Antenatal screening discussion
10^{+0} weeks	*Booking appointment* • Identify women who may need additional care and plan the pattern of care for the pregnancy • Measure height and weight, calculate Body Mass Index (BMI) • Blood pressure (BP) and urinalysis for protein • Fetal anomaly ultrasound screening tests (18^{+0} to 20^{+6} weeks) if accepted • Full blood count (FBC), blood group and antibody testing, haemoglobin electrophoresis • HIV, hepatitis B, syphilis, rubella screening[a] • Mid Stream Urine testing to exclude asymptomatic urinary tract infection • Arrange screening for Down's syndrome (scan at 11^{+0} to 13^{+6} weeks and combined test (blood test and ultrasound screening) if the patient agrees • Arrange early scan (10^{+0} to 13^{+6} weeks) for gestational age assessment if Down's syndrome screening is declined • Arrange glucose tolerance test (GTT) if indicated to screen for gestational diabetes • Prescribe aspirin if indicated following a pre-eclampsia risk assessment • Ask about history of current or past mental illness
16 weeks	• Review antenatal screening test results • BP and urinalysis for proteinuria • Investigate if Hb < 11 g/dL, consider iron (Fe) supplements
18 to 20^{+6} weeks	• Fetal anomaly/anatomy scan (to detect structural anomalies)
28 weeks	• Measure Symphysis – Fundal Height (SFH) • BP and urinalysis • FBC and Fe supplements if required • Screen for atypical antibodies • Anti-D prophylaxis to Rhesus (Rh) D negative women (to prevent maternal anti-D antibodies crossing the placenta into the fetal circulation which can result in fetal anaemia, cardiac failure and fetal death)
34 weeks	• SFH, BP and urinalysis • 2nd dose of anti-D if Rh D negative • Discuss labour and birth/formulate a birth plan

(continued)

Table 29.1 (continued)

36 weeks	• SFH, BP and urinalysis • Check position of baby and offer external cephalic version (ECV) if in breech position • Discuss breast feeding, postnatal care, postnatal depression, Vitamin K prophylactic administration for the neonate (insufficient prenatal storage of vitamin K and insufficient vitamin K in breast milk that could predispose the neonate to haemorrhage due to deficiency of Factors II, VII, IX and X)
38 weeks	• SFH assessment • BP and urine for protein • Discuss management of pregnancy after 40 weeks gestation
41 weeks	• SFH, BP and urinalysis • Membrane sweep offered (lifts amniotic sac from the cervix which can sometimes help to induce labour by stimulating prostaglandin production) • Induction of labour (IOL) discussed/offered between 41 and 42 weeks (increased risk of fetal compromise and stillbirth after 42 weeks) • Women declining IOL after 42 weeks should be offered at least twice weekly CTG and ultrasound scan for liquor volume assessment
Nulliparous women are offered additional appointments at 25, 31 and 40 weeks of gestation. SFH, BP and urine for protein are checked at each visit	

[a]Rubella screening is now not offered routinely in the UK and many other countries
BMI = body mass index;
Hb = haemoglobin; weeks refers to gestational age

Antenatal Screening

Screening for haematological conditions

- Anaemia: women should be screened early in pregnancy and at 28 weeks gestational age, to allow enough time for treatment prior to delivery. Haemoglobin levels <11 g/dL at first contact or <10.5 g/dL at 28 weeks gestational age should be investigated and treated.
- Haemoglobinopathy: Screening for sickle cell disease and thalassaemia should be offered to all women. The type of screening depends upon the family history and ethnicity and testing can be carried out in either primary or secondary health

care settings. The father of the baby should be offered counselling and screening if the woman is a carrier of a clinically significant haemoglobinopathy.

- Blood grouping and red-cell alloantibodies (antibody response to non-self antigen): Blood group and Rh D status should be checked early in pregnancy. All non-sensitised pregnant women who are Rh D-negative should be offered routine anti-D prophylaxis at 28 and 34 weeks gestational age. Fetomaternal hemorrhage during pregnancy or delivery, is the commonest cause of sensitisation, which triggers the Rh-negative mother's immune system to develop antibodies against the antigens in her baby's Rh-positive blood. This is called Rh-sensitization or alloimmunisation and may necessitate additional Anti-D following discussion with the blood transfusion laboratory.
- Screening for atypical red-cell antibodies in early pregnancy and at 28 weeks gestational age should be offered to all women regardless of their Rh D status.

Screening for asymptomatic bacteriuria

- Send mid-stream urine (MSU) sample at booking appointment to detect asymptomatic bacteriuria.
- Asymptomatic bacteriuria in pregnancy, if left untreated, increases incidence of pyelonephritis and adverse pregnancy outcomes such as low birth weight and preterm labour.

Detection and appropriate treatment with antibiotics based on MSU culture sensitivities have been shown to reduce the incidence of pyelonephritis and adverse outcomes.

Screening for infections

- *Hepatitis B, HIV*: timely detection and treatment decreases the risk of mother-to-child transmission.
- *Syphilis*: screening should be offered to all pregnant women at the booking appointment as treatment of syphilis is beneficial to the mother and baby. Untreated early syphilis infection results in a high risk of poor pregnancy outcomes, including "saddle nose", skeletal abnormalities, miscarriages, premature births, stillbirths, or death in the newborn.
- *Rubella susceptibility screening*: to identify women at risk of contracting rubella infection and to enable vaccination in the postnatal period for the protection of future pregnancies. The classic triad for congenital rubella syndrome includes sensorineural deafness, eye abnormalities (e.g. retinopathy, cataract and microphthalmia) and congenital heart disease (e.g. pulmonary artery stenosis and patent ductus arteriosus). In many countries, including the UK, rubella screening is not offered routinely.
- Routine screening for *Group B streptococcus, Bacterial Vaginosis, Cytomegalovirus, Toxoplasmosis* and *Hepatitis C* is not recommended.

Screening for Down's syndrome

- This should be offered to all pregnant women.
- The *combined test* (ultrasound to assess nuchal translucency thickness and blood test for beta-human chorionic gonadotrophin (beta-HCG) and pregnancy-associated plasma protein-A) should be performed between 11^{+0} and 13^{+6} weeks gestational age.
- *Serum screening*—a triple test (alpha fetoprotein, estriol and beta-HCG) or quadruple test (inhibin A added to triple test) should be offered to women who book later in pregnancy between 15^{+0} and 20^{+0} weeks gestational age.

Screening for fetal anomalies

- Pregnant women are offered fetal anomaly screening in accordance with current UK National Screening Committee guidelines.
- Ultrasound screening for fetal anomalies (fetal anatomy and head/abdomen/leg/arm measurements) should be performed between 18^{+0} to 20^{+6} weeks gestational age.
- The routine anomaly scan should also include fetal echocardiography involving the four-chamber view of the fetal heart and outflow tracts.

Screening for medical conditions

- Screen all women for gestational diabetes (Table 29.2).
- Perform risk assessment for pre-eclampsia at booking (Table 29.3). BP and urinalysis for proteinuria should be performed at each visit.
- Perform risk assessment for venous thrombo-embolism (VTE) as per Royal College of Obstetricians and Gynaecologists (RCOG) guidance (See thromboembolism Chap. 42).

Screening for mental health

- Whooley Questions—mental health screening questions (Table 29.4).
- Past/current/family history of mental illness.

Table 29.2 Screening for gestational diabetes (*NICE Quality Standard QS 22. Quality Statement No. 6*) [3]

Risk Factors for gestational diabetes (GDM)
• BMI >30 kg/m^2
• previous macrosomic baby weighing $\geq$4.5 kg
• previous gestational diabetes
• family history of diabetes (first-degree relative with diabetes)
• *An ethnicity with a high prevalence of diabetes*

Table 29.3 Risk assessment for pre-eclampsia (*NICE Quality Standard 2013*) [4]

Risk factors for pre-eclampsia
Advise women with one high risk factor or two moderate risk factors for pre-eclampsia to take 75 mg of aspirin daily from 12 weeks gestational age until the birth of the baby
High risk factors: • hypertensive disease during a previous pregnancy • chronic kidney disease • autoimmune disease (systemic lupus erythematosus or antiphospholipid syndrome) • type 1 or type 2 diabetes • chronic hypertension (hypertension that is present at the booking appointment or before 20 weeks of pregnancy or women with pre-existing hypertension)
Moderate risk factors: • first pregnancy • age >40 years • pregnancy interval of more than 10 years • BMI ≥ 35 kg/m^2 at first visit • family history of pre-eclampsia • multiple pregnancy (e.g. twins, triplets)

Table 29.4 Assessment of mental health at antenatal booking

• During the past month, have you often been bothered by feeling down, depressed or hopeless? • During the past month, have you often been bothered by having little interest or pleasure in doing things? Also consider asking about anxiety using the Generalized Anxiety Disorder scale (GAD-2): • Over the last 2 weeks, how often have you been bothered by feeling nervous, anxious or on edge? • Over the last 2 weeks, how often have you been bothered by not being able to stop or control worrying?

(*NICE antenatal and postnatal mental health 2017*) [5]

Screening for female genital mutation

- Female genital cutting or circumcision (removal of some or all of the external female genitalia).
- Based on history taking and clinical examination.
- Plan intra-partum care based on antenatal examination.

Domestic violence

- Healthcare professionals should be aware of the symptoms and signs of domestic violence and create an environment where women feel secure to disclose such information.

Monitoring fetal growth and well-being

- SFH should be measured at each antenatal appointment from 24 weeks gestational age.
- Fetal presentation should be assessed at 36 weeks gestational age by abdominal palpation.
- Suspected fetal malpresentation should be confirmed by ultrasound.
- Fetal heart rate auscultation should not be offered routinely as it is unlikely to have any predictive value; unless requested by the patient for reassurance.

Indications for Referral to Anaesthetist

History of:

- scoliosis/spinal deformity/spinal surgery/other pathology affecting the spine
- easy bruising
- weakness, sensory loss, paraesthesia, neuropathic pain caused by spinal abnormality
- anaesthetic or local anaesthetic drug allergy
- family history of malignant hyperthermia (MH) or suxamethonium apnoea
- previous difficult neuraxial anaesthesia placement (prolonged attempts, failed attempts that required re-siting, accidental dural puncture/post dural puncture headache)
- previous problems with general anaesthesia such as accidental awareness under general anaesthesia (AAGA).

Women with:

- BMI >40
- anticipated difficult airway
- history of long-term anticoagulation (such as prophylactic or therapeutic low molecular weight heparin)
- haematological abnormalities such as thrombocytopenia, haemophilia, Von Willebrand's disease (VWD), coagulation factor deficiency, sickle cell disease
- cardiorespiratory disease (such as grown-ups with congenital heart disease, valvular disease or replacement/repair, peripartum cardiomyopathy)
- Renal disease (acute kidney or chronic renal failure)
- Increased risk for postpartum haemorrhage (such as placenta praevia, morbidly adherent placenta—(See Chaps. 35 and 36)
- Any woman who refuses blood products, e.g. Jehovah's Witnesses.

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Partogram

30

Priyanka Sara and Nicola Lack

Definition

A partogram is a pictorial/graphical record of key maternal and fetal events in labour plotted against time on a single sheet of paper.

History

The partogram was first designed by Philpott and Castle in the early 1970s as a screening tool in under-resourced countries, to indicate delay or non-progress in labour and to guide timely referral from community to the hospital. It has since been modified. The UK National Institute for Health and Care Excellence (NICE) recommends a system to record the key events of labour [1] and the latest World Health Organization (WHO) modified partogram has been incorporated as an essential birthing record tool in many maternity hospitals. The WHO modified partogram is shown in Fig. 30.1. The recording starts in established labour i.e. once the cervix is ≥ 4 cm dilated with regular uterine contractions.

Components

- Patient demographics:
  - Name

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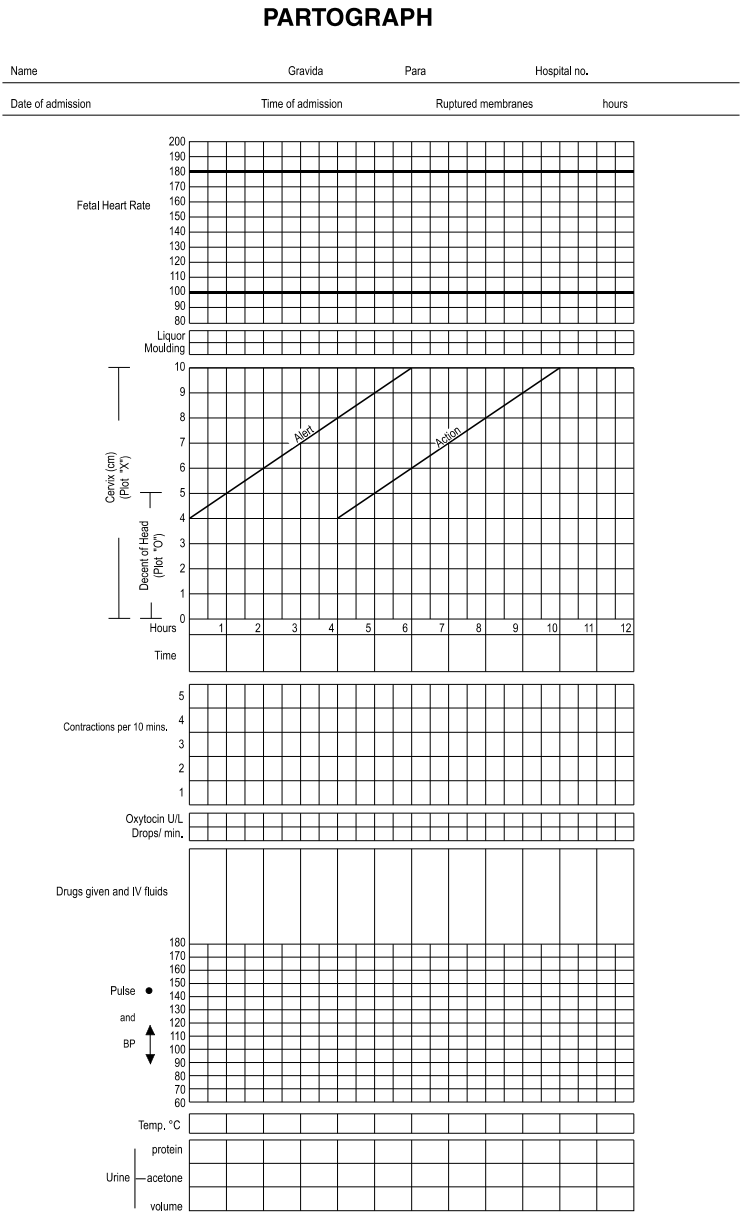

Fig. 30.1 The WHO Partograph. Reprinted from: Chapter 4, p.57: Preventing prolonged and obstructed labour. In: Managing prolonged and obstructed labour; Education material for teachers of midwifery - midwifery education modules - 2nd Edition. World Health Organisation (WHO) 2008. Published with the permission of the WHO

  - Age
  - Medical Record number
  - Obstetric history—gravidity/parity
  - Date of admission
  - Date and time of rupture of membranes.
- Maternal parameters:
  - Maternal heart rate every 30 min.
  - Blood pressure and temperature 4-hourly.
  - Urine output and urinalysis testing for protein, ketones (if available) and glucose.
  - Intravenous fluid intake.
  - Drugs administered (e.g. oxytocin in units/mL).
  - If any of these parameters (e.g. HR/BP) become abnormal, an increased frequency of observation and testing is required, and intervention may be needed.
- Fetal parameters—fetal heart rate (FHR) is recorded:
  - For a period of 1 min every 15–30 min after a contraction in the first stage of labour.
  - Every 5 min in the second stage of labour.
  - If abnormalities are noted, urgent delivery can be considered.
- Liquor:
  - Checked every 30 min.
  - Can be described as: clear, meconium stained (thick or thin), bloody or absent.
  - Thick meconium stained liquor suggests fetal distress, and closer monitoring of the fetus with continuous cardiotocogram (CTG; see Chap. 28) is indicated.
- Uterine contractions:
  - Frequency, duration and strength (assessed by abdominal palpation).
  - Recorded every 30 min in different colour shades from lighter to darker and number of boxes indicate number of contractions per 10 min. Plotting of contractions on the partogram is demonstrated in Fig. 30.2.
- Abdominal examination:
  - To assess descent of the fetal head into the pelvis.
  - Measured in fifths of fetal head palpable.

Interpretation of Labour Progress

The partogram has two important lines showing cervical dilatation and descent of fetal presenting part. The cervical dilatation is indicated as symbol “X” and descent of fetal presenting part in terms of fetal station is indicated as symbol “O”. See Fig. 30.2.

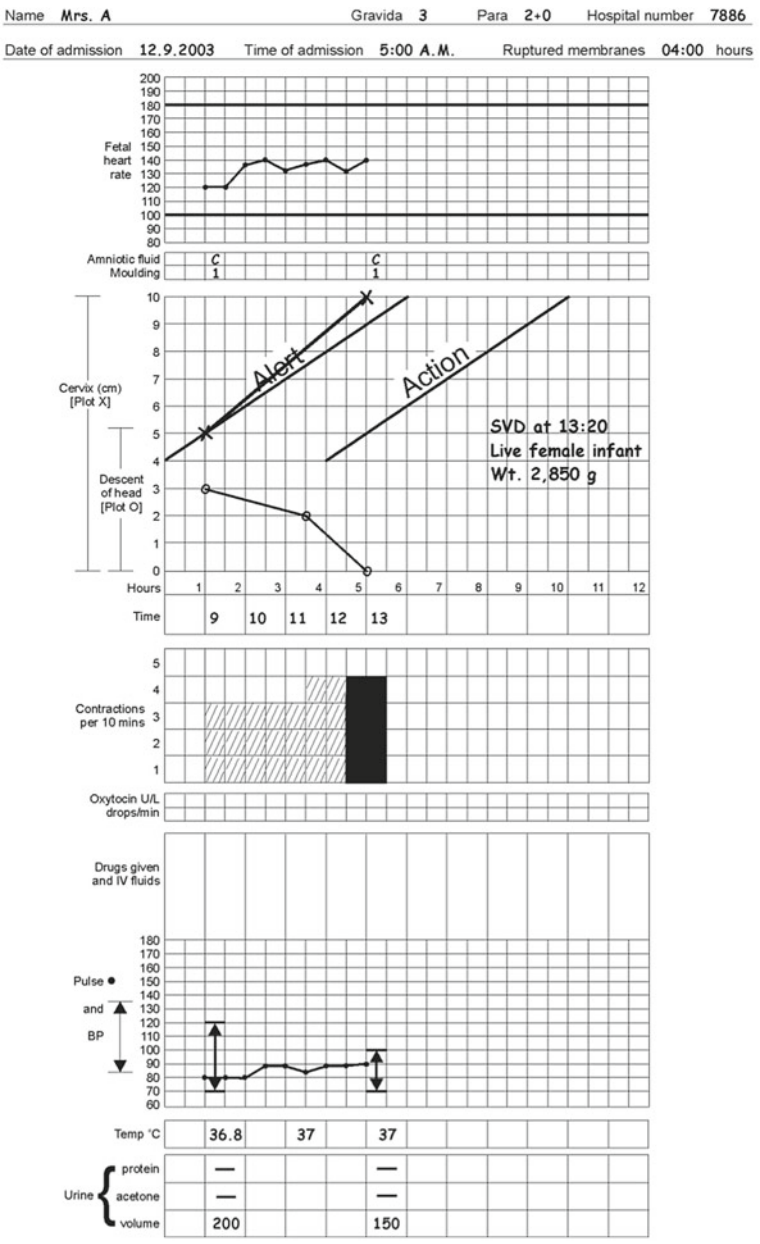

Fig. 30.2 Uterine contractions plotted on a partograph. Reprinted from: Chapter 4, p.76 (Case No. 1): Preventing prolonged and obstructed labour. In: Managing prolonged and obstructed labour; Education material for teachers of midwifery - midwifery education modules - 2nd Edition. World Health Organisation (WHO) 2008. Published with the permission of the WHO

(1) *Alert Line*

This is a straight line starting at 4 cm of cervical dilatation changing at the rate of 1 cm per hour in the active phase of labour, lasting up to the point of expected full dilatation of cervix (Fig. 30.1) As the name suggests, labour progress "falling" on this line indicates a delay in the course of normal labour and calls for evaluation of maternal and fetal factors that are affecting the progress of labour. For example, if maternal contractions are irregular and mild, augmentation with oxytocin should be considered. If malposition of the fetal head (e.g. occipitoposterior/occipitolateral) is suspected, the descent of the fetal head should be closely monitored or an attempt made at gentle manual rotation of fetal head, if the woman is fully dilated. Please note that malposition and malpresentation are different terms with malpresentation referring to presentations such as breech and transverse lie.

(2) *Action Line*

This is a straight line parallel and 4 h to the right of the alert line (Fig. 30.1). If the labour progress "falls" onto this line despite the corrective measures instituted while on the alert line, it calls for action in terms of attempting instrumental delivery if fully dilated or caesarean delivery for non-progress of cervical dilatation or fetal descent.

Advantages and limitations of utilising partograms [2]

The main reasons for utilizing this tool:

– aid diagnosis of prolonged or obstructed labour[1] facilitate timely obstetric intervention
– reduce subsequent maternal and neonatal morbidity.

Advantages:

- Provision of a composite record of all events during labour, which is available in a standard format.
- Consistency and regularity in recording the maternal and fetal observations, which allows any deviation or deterioration in trends to be quickly identified.

[1]**Prolonged labour**: Prolonged labour refers to a slower rate of cervical change than the accepted 0.5 cm per hour in active labour or if delivery has not occurred after 4 hours at full dilatation'.
Obstructed labour: Obstructed labour is where there is little or no change in cervical dilation or descent of the fetal head. It is a cause of prolonged labour or lack of labour progress and suggests the fetus is too large to delivery vaginally, commonly due to malposition (e.g. occiput posterior) or less often due to absolute cephalo-pelvic disproportion. It is associated with clinical findings of caput and moulding and of maternal haematuria.
The difference between slow progress and obstructed labour is that in slow progress, there is still *some* progress, whereas in obstructed labour there is *no* progress.

- The partogram is particularly useful in low resource settings or busy delivery area environments, to highlight the need for escalation of management or requirement for obstetric review.
- It can be used as a medicolegal document.
- It is a helpful training tool for midwives and obstetricians.

Limitations:

- Latent phase: the modified WHO partogram starts in active phase at 4 cm. Though it is effective to diagnose protracted or slow progress in active labour, the graph does not take into account the duration of latent labour.
- Rate of cervical dilatation: there may be deviations from the normal rate of cervical dilatation of 0.5 cm/h, though for practical purposes, the NICE guidelines recommend 0.5 cm/h as a normal rate of progress (2 cm/4 h) [1, 3]
- Missing Information: The Partogram does not include maternal oxygen saturation (SpO_2) or respiratory rate, which are important parameters of maternal wellbeing in labour. There is also no column to plot the position of fetal presenting part (e.g. occipitoposterior).
- Variations in use: Though training can help achieve consistency, there are widely reported variations in partogram use and inconsistencies in completing the chart can occur, particularly in busy settings [3].

Evidence

A Cochrane database systematic review in 2013 investigated the effect of partogram use on outcomes for women in spontaneous labour at term. They concluded that there were no differences in any clinical outcomes measured (e.g. caesarean delivery, duration of labour, oxytocin augmentation, amniotomy, labour epidural use, use of antibiotics in labour, Apgar scores or admissions to neonatal intensive care) following introduction of the partogram [4].

However, the authors acknowledged that in units using partograms, they have reported quality of care benefits in terms of: ease of recording, provision of a pictorial overview of labour progress, training of clinicians and handing over of patient care [4].

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Induction of Labour

31

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Definition

Induction of labour (IOL) is the artificial commencement of uterine contractions before its spontaneous onset leading to dilation of the cervix ≥ 24 weeks gestation, in the presence or absence of ruptured membranes [1]. It is now one of the most commonly performed procedures in current obstetric practice. National clinical guidelines in the UK recommend that IOL is only indicated when it is likely that a better outcome will result if labour is initiated, than if the pregnancy continues [1]. For instance, IOL may be recommended if the health of the mother or fetus is at risk.

Incidence

- The incidence of induction of labour in the UK has increased from 21% in 2009–2010 to 33% in 2019–20 [2].
- Worldwide, considerable variation exists in reported rates of IOL between countries:
  - United States: 23% [3]
  - Lowest rate in Europe is 6.8% (Lithuania)
- The rising IOL rate could possibly related to a rise in maternal age and body mass index (BMI) in the pregnant population.

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Important Considerations Associated with Induced Labour

- Induced labour has a profound impact on the birth experience of a woman
- It may be perceived as more painful
- It is more likely to result in an operative vaginal delivery (e.g. a forceps or ventouse delivery) or an emergency cesarean delivery in nulliparous women
- It is more likely to require neuraxial analgesia.

Indications for Induction of Labour [1, 4]

Indications for inducing labour are summarised in Table 31.1.

Table 31.1 Indications for inducing labour

Medical indications	Obstetric indications	Maternal indications	Fetal indications
Chronic/ Gestational Hypertension	Postdates pregnancy	Maternal age	History of reduced fetal movements at term
Diabetes	Premature rupture of membrane	Maternal anxiety	Intrauterine fetal death
Renal disease	Preeclampsia, Eclampsia, HELLP	Maternal request	Intrauterine growth restriction (IUGR) and suspected in utero fetal compromise
Chronic pulmonary disease	Chorioamnionitis		Suspected fetal macrosomia
Cardiac disease	Antepartum haemorrhage		Isoimmunisation
Anti-phospholipid syndrome	Obstetric cholestasis		Oligohydramnios
	Previous poor obstetric history		Fetal anomaly
			Twin pregnancy

Postdates pregnancy—a pregnancy that lasts longer than 42 weeks; two weeks past the normal 40-week gestation period.
Premature rupture of membrane—rupture of membrane before 37 weeks gestation.
Chorioamnionitis—inflammation of the chorion and the amnion, the membranes that surround the fetus. It is usually associated with a bacterial infection due to bacteria ascending from the mother's genital tract into the uterus to infect the membranes and the amniotic fluid;
Fetal macrosomia—birth weight over 4,000 g irrespective of gestational age which affects 3–15% of all pregnancies. More common in uncontrolled gestational diabetes.
Isoimmunisation—the process by which fetal Rh+ erythrocytes enter the circulation of a Rh− mother, causing her to produce immunoglobulin G antibodies, which can cross the placenta and destroy the erythrocytes (red blood cells) of Rh+ fetuses. Rh isoimmunisation can also be caused by blood transfusion with mismatched blood.
Obstetric cholestasis—a disorder which affects the liver during pregnancy. This causes an accumulation of bile acids within the body. Obstetric cholestasis is a multifactorial condition of pregnancy characterised by pruritus in the absence of a skin rash with abnormal liver function tests (LFTs), neither of which has an alternative cause and both which resolve after delivery;
Oligohydramnios—a condition in pregnancy characterised by a reduction of amniotic fluid, i.e., amniotic fluid volume <3rd centile.

Risks/Complications Associated with Induction of Labour [1, 5–11]

Maternal and fetal risks associated with induction of labour are summarised in Table 31.2.

Due to the risks outlined above, any woman undergoing IOL should ideally be pre-assessed by an anaesthetist, have a valid blood group type and screen performed with intravenous access also being preferable.

When planning IOL the obstetrician should discuss:

- the procedure fully with the woman
- explain the method to be used
- side-effects
- IOL failure and management options.

Women should have the opportunity to:

- make an informed decision about their care
- read written information regarding IOL
- give informed consent to the procedure.

It may be advisable for consent to be recorded accordingly; if it is not, a note should be made by the doctor in the woman's records and signed. As this is a medical intervention, indications for induction of labour should be clearly stated.

Timing of Induction of Labour [1]

- Term is defined as between 37 and 42 weeks
- The majority of women will go into spontaneous labour by 42 weeks
- At the 38 week hospital visit, all women should be offered information about the risk associated with pregnancies that last more than 42 weeks, including the increased risk of stillbirth.

Discussion should cover options of:

- membrane sweep (see below)
- IOL
- expectant management (no intervention)
- For the prevention of prolonged pregnancy, induction of labour should be offered between 41 and 42 weeks
- Other indications for IOL may be either fetal, maternal or a combination of both
- In absence of any other indications, IOL should not be carried out simply because the fetus is suspected to be macrocosmic (large for gestational age).

Table 31.2 Maternal and fetal risks/complications associated with induction of labour

	Risk/Complications	Incidence: IOL versus spontaneous labour
Maternal	Operative delivery – instrumental delivery – emergency caesarean delivery	15% versus 10–13% 26.5 versus 12.5%
	Uterine hyperstimulation[a]	1–5% in IOL
	Uterine rupture	Unscarred uterus (no previous uterine surgery): 0.007% in IOL versus 0.0051% spontaneous labour Scarred uterus (previous uterine surgery): 1% (IOL with oxytocin) versus 0.5% spontaneous labour
	Blood transfusion	0.33% versus 0.28%
	Postpartum haemorrhage (PPH)	8.4% versus 6.4%
	Cord prolapse	0.1–0.6% (similar rate with spontaneous labour)
	Failed induction due to an unfavourable cervix (a cervix that is not adequately prepared for a vaginal delivery—a Bishop's score of less than or 6). A favourable cervix is one with a Bishop's score > 6)	15% in IOL
Fetal	Shoulder dystocia[b]	0.41% versus 0.32%
	Admission to neonatal intensive care (NICU)	8% versus 7%

[a]Tachysystole or hypertonus may lead to fetal heart rate changes. Risk factors include grand multiparous women (a woman who has given birth 5 or more times), previous precipitate labour (a delivery, which results after an unusually rapid labour (<3 h)

[b]A case of obstructed labour after the delivery of the fetal head, when the anterior shoulder of the infant cannot pass below, or requires significant manipulation to pass below, the pubic symphysis. It is diagnosed when the shoulders fail to deliver shortly after the fetal head (see Chap. 26)

Contraindications to Induction of Labour [11]

Contraindications to IOL are the same as contraindications to a vaginal delivery. A few are absolute; others are relative. These are summarised in Table 31.3.

Under exceptional circumstances, however IOL may be offered after discussing associated risks with the woman. If delivery is indicated for maternal or fetal reasons, women with history of previous caesarean delivery may be offered induction of labour, although most units will prefer to avoid using prostaglandins in

Table 31.3 Contraindications to induction of labour

Absolute contraindications	Relative contraindications
Placenta praevia	A high and floating fetal head[b] as cord prolapse could follow
Vasa praevia	History of precipitated labour[a]
Transverse fetal lie	Previous myomectomy
Malpresentation (e.g. breech)	Infection (maternal and/or fetal)
Umbilical cord prolapse or persistent cord presentation	
Active primary genital herpes infection	
Prior classical or other high-risk caesarean incision, for example J shaped or T shaped uterine incision	
Previous uterine rupture	
Invasive cervical malignancy	
Fetal distress	
Fetal congenital anomaly where obstructed delivery is anticipated	

[a]Precipitate labour is defined as delivery, which results after an unusually rapid labour (less than three hours)
[b]Floating head = high fetal head which is not engaged within the maternal pelvis

favour of mechanical methods (see below) to avoid potential uterine hyperstimulation.

Before the induction of labour:

A membrane sweep may be offered before medical induction of labour.

- Antenatally—a finger is inserted into the cervical canal during a vaginal examination.
- This action separates the amniotic sac from the cervix which causes prostaglandins to be released locally, which may help to avoid pharmacological induction. If the cervix will not admit a finger, massaging around the cervix in the vaginal fornices (upper areas of the vagina) may achieve a similar effect.
- Membrane sweeping is regarded as an adjunct to the induction of labour rather than an actual method of induction.
- Additional membrane sweeping may be offered if labour does not start spontaneously.

Methods of inducing labour [1]:

Pharmacological methods

- These are preferred and recommended by in the UK by NICE [1] (The National institute for Health and Care Excellence).

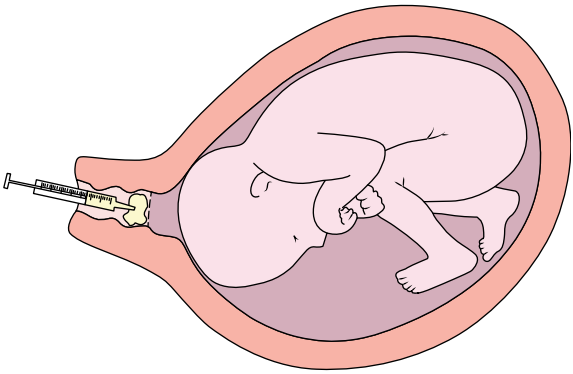

Fig. 31.1 Inserting PgE2 as a gel or a pessary

- A slow release pessary or prostaglandin gel (e.g. PgE2) with an applicator may be used to guide it to the upper portion of the vagina (PgE2; Fig. 31.1).

- A second dose of prostaglandin gel may be offered after 6 h if labour is not established, and sometimes a 3rd dose is necessary.
- When offering PGE_2 for IOL, healthcare professionals should inform women about the associated risks of uterine hyperstimulation.
- Once there is sufficient dilatation of the cervix, an artificial rupture of the membranes (ARM) should be performed (see Chap. 15).
- Since there is small risk of cord prolapse during this procedure, it should be performed within the safe environment of the delivery area. Some women may prefer to have epidural analgesia established before proceeding to artificial rupture of membranes because regular contractions can occur after ARM and some women may prefer to be in control of the pain before regular contractions start.
- When the membranes have been ruptured, an oxytocin infusion can be used if necessary, to stimulate uterine contractions.

The timing of starting an oxytocin infusion should be discussed with the patient and some period of expectant management (expectant management involves non-intervention at any particular point in time and allows the labour to progress on its own) is not uncommon. Therefore after ARM in IOL patients, women undergo no further obstetric intervention for either 2 h (Para 0) or 4 h (Para 1 and above), and if no progress or no contractions follow, then an oxytocin infusion is recommended.

- an oxytocin infusion is titrated to achieve 4–5 contractions in every 10 min.
- continuous fetal monitoring is advised.

- Since it may take some time for a woman to go into established labour on an oxytocin infusion, they may require epidural analgesia earlier than a spontaneously laboring woman.

Amniotomy (or ARM / Artificial Rupture of the Membranes), alone or with oxytocin, should not be used as a primary method of induction of labour unless there are specific clinical reasons for not using vaginal PGE2, in particular the risk of uterine hyperstimulation [1]. The rationale behind this is that if ARM is performed too soon with an unfavourable cervix, the only remaining option for inducing labour is an oxytocin infusion, which increases the risk of failed IOL. Therefore, it is preferable (as the UK NICE guidelines recommend) to use vaginal PGE2, whenever possible, as some women may go into labour spontaneously with PGE2.

Misoprostol and Mifepristone are not routinely administered for IOL in the UK. These agents should only be offered as a method of induction of labour to women who have intrauterine fetal death or in the context of a clinical trial [1].

If despite all efforts, IOL fails (labour not achieved), depending on specific circumstances and maternal wishes, a further attempt to induce labour or caesarean delivery should be offered.

Mechanical Methods

For women with a previous scar on their uterus, usually following previous caesarean delivery, prostaglandins are not commonly used as they are associated with a higher risk of uterine rupture [1, 11]. In these cases mechanical methods are be preferred. The goal of mechanical methods used for IOL is to cause the cervix to mechanically open without the use of drugs, and therefore reduced potential side-effects. Sometimes this will start labour spontaneously and sometimes it will simply make the cervix more favourable for amniotomy or for oxytocin to be commenced.

A Cook® cervical ripening balloon (or double balloon catheter) is used for mechanical dilation of the cervical canal. The first of the two balloons is inflated with normal saline on the uterine side of the cervix and the second is then inflated in the vaginal side of the cervix (Fig. 31.2). When the catheter is removed, the cervix will be assessed for dilatation and based on the findings, an amniotomy may be possible.

- The Cook® balloon should be kept in place for 12–24 h. until the cervix is suitable for an ARM.
- Other devices such as a Foley urinary catheter balloon can also be used to mechanically dilate the cervix.

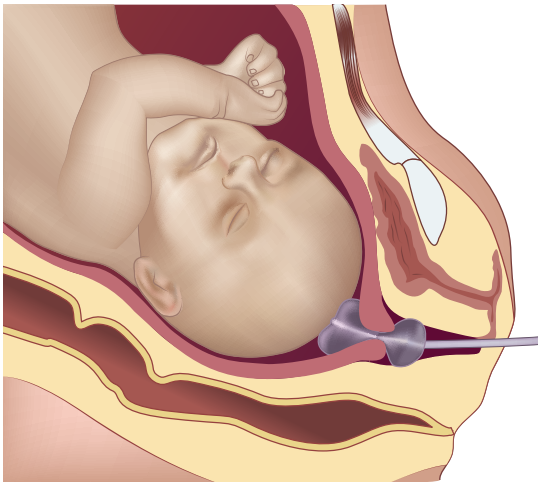

Fig. 31.2 Position of a Cook® cervical ripening balloon

- After an ARM, it is safe to use oxytocin for women who have had a previous caesarean delivery providing it is used carefully under the supervision of an experienced obstetrician.

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Augmentation of Labour

32

Priyanka Sara and Nicola Lack

Definition

Augmentation of labour is the process of stimulating the uterus to increase the frequency, duration and intensity of uterine contractions after the onset of spontaneous labour. It has commonly been used to treat delayed labour when uterine contractions are inefficient [1].

Methods Used to Augment Labour

The World Health Organisation (WHO) only recommends the following methods to augment a confirmed delay of progress in labour [1].

(1) Artificial rupture of the membranes (ARM)/Amniotomy (see Chap. 15)

The uterine contractions should be assessed by a midwife/obstetrician 2–4 h following ARM. Depending on the clinical response, the next step of augmentation with oxytocin should be discussed with the mother.

- In nulliparous women, ARM is usually followed by an oxytocin infusion, since an ARM alone may not produce effective uterine contractions [1, 2].

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- In multiparous women, ARM alone can be sufficient to augment and achieve strong contractions and progress in labour.

(2) Oxytocin infusion: This chapter covers the use of an oxytocin infusion to augment labour.

Mode of Action of Oxytocin

Oxytocin is a nonapeptide hormone produced in the hypothalamus and stored in the posterior pituitary gland. It acts on oxytocin receptors within the myometrium of the uterus to produce uterine contractions. This helps the cervix to dilate and efface (see Chap. 27) and therefore helps the fetal head to descend into the pelvis, enabling normal vaginal delivery [3]. Oxytocin is an endogenous hormone secreted during labour, which can also be used exogenously to further stimulate inefficient uterine contractions.

Oxytocin Infusion for Augmentation of Labour

Oxytocin is administered on the delivery ward after ARM with continuous fetal heart and uterine activity monitoring and with one-to-one midwifery/nursing care.

An example of a recommended oxytocin infusion protocol, which is commonly used to augment labour in many UK NHS hospitals is summarized in Table 32.1.

Table 32.1 Example of an oxytocin infusion rate used to augment labour [4]

Oxytocin Infusion: for dilution of 10 IU oxytocin in 500 ml		
Time from starting infusion (minutes)	Oxytocin dose (mU/minutes)	Volume infused (ml/hours)
0	1	3
30	2	6
60	4	12
90	8	24
120	12	36
150	16	48
180	20[a]	60
210	24	72
240	28	84
270	32	96
Once a total of 5 units oxytocin has been administered stop induction attempt if regular contractions not established; mU = milliunits		

[a]the maximum licensed dose is 20 mU/minutes, higher doses should be discussed with a senior obstetrician; the oxytocin infusion should be administered according to local hospital protocol. Most hospital protocols dilute oxytocin using 10 IU or 30 IU of oxytocin in 500 ml 0.9% NaCl

Oxytocin is given by infusion pump or syringe driver. Often the rates obstetricians are familiar with are the volumes infused per hour rather than the IU per minute. The maximum rate of oxytocin infusion that is used 96 ml/hour (for a dilution of 10 IU of oxytocin in 500 ml), though the licensed rate is 60 ml/hour. Therefore, any increase above 60 ml/hour must be the decision of a senior obstetrician.

In the United Kingdom, the Royal College of Obstetricians and Gynaecologists (RCOG) recommends the following dosage schedule (Table 32.1). A low volume variation of this regimen can be used in severe pre-eclampsia where fluid restriction protocols (e.g. 85ml/hour) may be implemented to reduce the incidence of pulmonary oedema. This dose is titrated to achieve 3-4 effective uterine contractions every 10 minutes which are strong in intensity.

Timing of Augmentation of Labour

The need for labour augmentation can occur in either the first or second stage of labour.

Second stage augmentation should only commence following obstetric assessment where inefficient uterine contractions are established as the cause of failure to progress in labour.

Providing fetal wellbeing is ensured (normal CTG) and there are no signs of obstructed labour on vaginal examination (moulding-fetal skull bones over lapping/caput-scalp swelling secondary to pressure from the cervix/station high - see Chap. 27) it is safe to proceed with oxytocin.

Uterine contractions can sometimes reduce in frequency/strength after epidural analgesia and may warrant the need for augmentation of labour with oxytocin infusion ± artificial rupture of membranes (ARM) [4].

Assessment of the Progress of Labour During Augmentation

Labour progress is usually assessed with a vaginal examination either:

- 4 hours after the onset of regular (3–4) uterine contractions every 10 minutes or
- 6 hours from the start of an oxytocin infusion (whichever occurs earlier).

The following assessments are made to check the progress of labour:

- cervical dilatation (1–10 cm): progress is expected at a rate of 0.5 cm/hour
- cervical effacement (no effacement to 100%/fully effaced): thinning and shortening of cervix (see Chap. 27)
- descent of the fetal head (from −3 to 3): in relation to the maternal ischial spines.

If there is delay in the progress of labour or signs of obstructed labour, despite augmentation with oxytocin and regular contractions, the obstetrician will usually advise an emergency caesarean delivery.

Advantages of Augmentation with Oxytocin

It can allow a woman to achieve adequate progress in labour with efficient uterine contractions, which can result in vaginal delivery [5].

Risks Associated with Augmentation with Oxytocin

(1) Uterine hyperstimulation: when uterine contractions are ≥ 6 in 10 min, this can cause fetal distress and fetal bradycardia. Therefore, it is important to carefully titrate and increase the oxytocin to only achieve up to 5 contractions in 10 min [6].
(2) Uterine rupture: the decision to augment labour with oxytocin should be made with caution, particularly in multiparous women or in parturients with a history of previous uterine surgery (myomectomy/previous lower segment caesarean delivery) as they are at higher risk for uterine rupture with stronger contractions. Obstructed labour should be excluded by the obstetrician if oxytocin augmentation is needed in multiparous woman due to non-progress of labour. The risk of scar rupture in vaginal birth after caesarean delivery increases from 1 in 200 to 1 in 100 in woman receiving oxytocin infusion [6].
(3) Haemorrhage: augmented labours are associated with a prolonged duration of labour and an increased risk of postpartum haemorrhage [6].
(4) Pain relief: as the contractions are stronger and more frequent, mothers often need stronger analgesia and studies show a higher epidural request rate [7].

Special Considerations

Cardiovascular Disorders

Oxytocin should be used with caution in patients who have a pre-disposition to myocardial ischaemia due to pre-existing cardiovascular disease (such as hypertrophic cardiomyopathy, valvular heart disease and/or ischaemic heart disease (including coronary artery vasospasm), to avoid significant changes in blood pressure and heart rate in these patients.

QT Syndrome

Oxytocin should be given with caution to patients with known 'long QT syndrome' or related symptoms and to patients taking drugs that are known to prolong the QTc interval.

Water Intoxication

Because oxytocin possesses a slight antidiuretic activity, its prolonged IV administration at high doses in conjunction with large volumes of fluid, as may be the case in the management of postpartum haemorrhage, may cause water intoxication associated with hyponatraemia. The combined antidiuretic effect of oxytocin and the IV fluid administration may cause fluid overload leading to acute pulmonary oedema without hyponatraemia. To avoid these rare complications, the following precautions must be observed whenever high doses of oxytocin are administered over a long time:

- an electrolyte-containing diluent such as normal saline must be used (i.e. not dextrose)
- the volume of infused fluid should be kept low (by infusing oxytocin at a higher concentration than recommended.)
- fluid intake by mouth must be restricted
- a fluid balance chart should be kept
- serum electrolytes should be measured when electrolyte imbalance is suspected.

Renal Impairment

Caution should be exercised in patients with severe renal impairment because of potential water retention and accumulation of oxytocin.

Evidence

When Oxytocin Inductions Were Compared with Expectant Management in a Systematic Review [5]

In the oxytocin group:

- More women delivered vaginally in 24 hours.
- More women requested epidural analgesia.
- More women were satisfied with oxytocin induction in the one study reporting this outcome.

Trials Comparing Amniotomy and Intravenous Oxytocin Versus Placebo or Other Specified Treament [7]

- More women delivered vaginally at 24 h than with amniotomy alone.
- Significantly fewer instrumental vaginal deliveries than placebo.
- More postpartum haemorrhage than vaginal prostaglandins.
- Significantly more women were satisfied with vaginal prostaglandins when compared to amniotomy and IV oxytocin.

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Pre-term Birth

33

Shalini Chawla and Pervez Sultan

Definitions

Pre-term labour (PTL) This refers to the presentation of symptoms and signs of labour before 37 weeks gestational age. It may be suspected, diagnosed or established pre-term labour depending on the patient's history, clinical examination and investigation findings [1].

Suspected pre-term labour

This refers to the scenario where there are symptoms of pre-term labour and a clinical assessment (including a speculum or digital vaginal examination) that confirms the possibility of pre-term labour, in the absence of established labour.

Diagnosed pre-term labour

This refers to suspected pre-term labour with a positive diagnostic test for pre-term labour.

Established pre-term labour

This refers to regular contractions with progressive cervical dilation from 4 cm before 37 weeks gestational age.

Pre-term birth (PTB) is defined as birth before 37 completed weeks of gestation.

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Pre-term pre-labour rupture of membranes (PPROM) is defined as rupture of membranes between 24 and 37 weeks gestational age. 24 weeks gestational age is considered as the cut-off for fetal viability.

Incidence

- According to World Health Organization, pre-term birth (PTB) is the leading cause of deaths in children under 5 years of age worldwide [2].
- It is the single biggest cause of neonatal mortality and morbidity in the UK and accounts for 7–8% of births [1]. The incidence is up to 15% in the USA and even higher in low income countries.
- 75% of women delivering pre-term do so after spontaneous pre-term labour, which may or may not be preceded by pre-term rupture of membranes. 25% of PTBs are planned for medical reasons when it is in the best interest of the mother or baby (e.g. in cases of pre-eclampsia or fetal growth restriction).
- PPROM complicates up to 3% of pregnancies and is associated with 1 in 3 PTBs.
- The incidence of PTB is on the rise due to an increase in spontaneous and planned PTBs. This mirrors a rise in multiple pregnancies (following use of assisted reproductive techniques) and medically complex pregnancies.

Neonatal Impact

- PTB is associated with a higher mortality rate: 21.1 deaths/1000 live births in pre-term babies compared to 1.4/1000 live births for term babies [3].
- Babies that survive PTB are at significant risk of associated morbidity both in the short and long term.
- Short term effects can involve morbidity associated with multiple organs including respiratory distress syndrome, intraventricular haemorrhage (IVH) and necrotising enterocolitis.
- Long term effects are primarily neurodevelopmental and encompass cerebral palsy, global development delay, visual and hearing impairment. PTB is also associated with chronic lung disease.
- Prognosis depends on various factors including gestational age, neonatal birth weight, condition of the neonate at birth, presence of infection, use of antenatal steroids and the use of magnesium. Prognosis improves with each additional week in-utero and each 100 g increase in birth weight.
- The EPICure study data (population-based studies of survival and later health status in extremely premature infants) is widely used to counsel regarding prognosis (Fig. 33.1). Prematurity is classified by severity and prognosis is dependent upon gestational age [4].

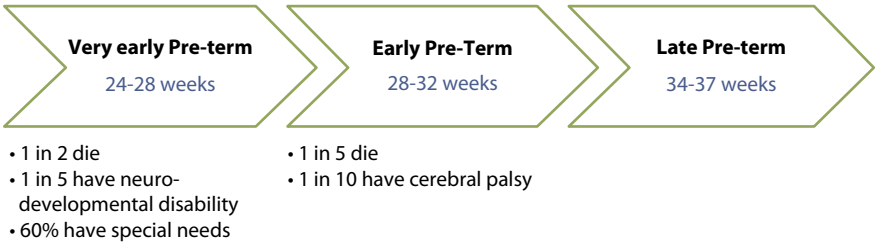

Fig. 33.1 EPICure study group data

Causes of Spontaneous Pre-term Labour (Fig. 33.2)

Risk Factors (Table 33.1).

Clinical Presentation

History

- Risk factors as outlined in Table 33.1.
- Abdominal pain/contractions.
- Vaginal discharge/vaginal bleeding.

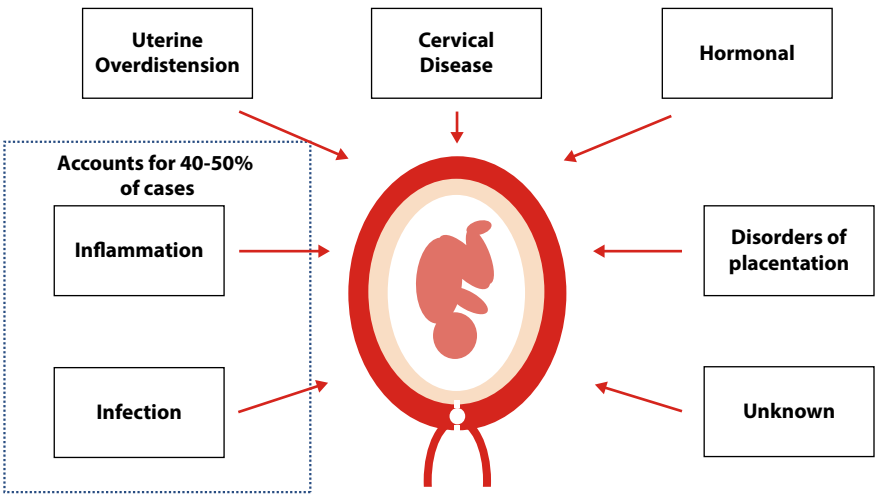

Fig. 33.2 'Pre-term parturition syndrome' illustrating multifactorial aetiology [5]

Table 33.1 Risk factors for development of PTL [6]

Patient factors	Afro-caribbean ethnicity
	Lower socio-economic class
	Smoking and illicit drug use
	Stress, depression, low BMI, poor nutritional intake
Obstetric factors	Previous PTB or late miscarriage
	Cervical surgery/short cervix e.g. cone biopsy/LLETZ
	Uterine anomalies e.g. bi-cornuate uterus
	Chorioamnionitis
	Multiple pregnancies
	Polyhydramnios
	Fetal growth restriction
	Pre-eclampsia
	Placenta praevia
Medical factors	Renal disease
	Pregnancy following total body radiation for leukaemia
	History of recurrent urinary tract infections
	Bacterial vaginosis, sexually transmitted infections
	Hypertension
	Diabetes/gestational diabetes

LLETZ = large loop excision of the transformation zone; PTB = pre-term birth; BMI = body mass index

- History suggestive of ruptured membranes and/or loss of liquor per vaginum.
- Urinary frequency/dysuria (symptoms suggestive of urinary tract infection).
- History suggestive of other systemic illness (e.g. appendicitis/pyelonephritis) that can predispose to PTL.
- Fever, malaise, flu-like illness that may be suggestive of chorioamnionitis.

Examination

- Maternal observations: heart rate/blood pressure/temperature/respiratory rate (pyrexia and tachycardia may suggest chorioamnionitis or other systemic illness).
- Uterine tenderness (suggests infection/abruption).
- Fetal presentation (to decide further management).
- Vaginal speculum examination: look for pooling of liquor if ruptured membranes/blood/discharge which may be purulent or offensive in the presence of underlying infection.
- Digital vaginal examination if intact membranes are present and if the extent of cervical dilatation cannot be assessed by speculum examination.

Investigations

- Full Blood Count (including white cell count (WCC))/C-reactive protein (CRP)/ pre-eclampsia blood tests if indicated.
- Mid-Stream Urine (MSU) sample for microscopy, culture and sensitivity.
- Vaginal swabs.
- Transvaginal ultrasound scan (TVS) to assess cervical length (CL) for diagnosis and risk prediction (explained below).
- Fetal fibronectin (FFN) for diagnosis and risk prediction (explained below).
- Bedside ultrasound scan to assess fetal presentation in order to plan further management.
- Fetal monitoring (with cardiotocogram [CTG] or intermittent auscultation) from 26 weeks gestational age.
- Perfrom a growth scan, if feasible, in order to estimate fetal weight and well-being.

Risk Prediction Tools

Cervical length scanning and FFN are used for predictive and diagnostic purposes.

Predictive: Women who are at high risk for PTB should be offered serial transvaginal measurements of cervical length (CL) between 16 and 24 weeks gestational age and considered treatment if cervical length is <25 mm (see below).

Diagnostic: Both these tests have high negative predictive value for PTB; this is very useful as it ***excludes*** a diagnosis of PTL. The National Institute for Health and Care Excellence (NICE) recommends using these tests when a woman is in suspected PTL (from 30 weeks gestational age) to guide management decisions such as the need for hospital admission, antenatal steroid or tocolytic administration, and in utero transfer. Before 30 weeks gestational age, treatment should be instituted on grounds of clinical suspicion.

Transvaginal Scan (Table 33.2).

NICE recommends using a cervical length cut-off value of ≤ 15 mm for diagnosing PTL in symptomatic women who are ≥ 30 30 weeks gestational age.

Table 33.2 Assessment of cervical length by transvaginal scan (TVS) [1]

	Cervical length (mm)	Risk of delivery
Symptomatic	≤ 15	49% within 7 days
	>15	1% within 7 days
Asymptomatic	<5 at 23/40	78% before 32/40
	>15 at 23/40	4% before 32/40

Number/40 denotes gestational age in weeks (e.g. 23/40 = 23 weeks gestational age)

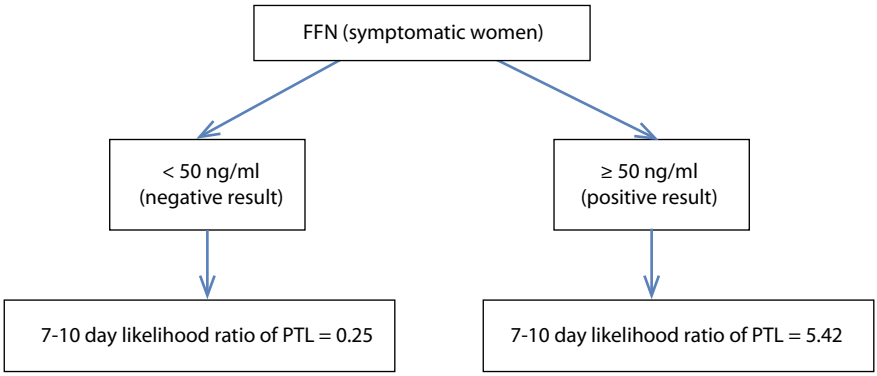

Fig. 33.3 Assessing the likelihood of PTL by measuring fetal fibronectin [1]

Fetal Fibronectin (Fig. 33.3).

FFN is a glycoprotein that is not usually found in cervico-vaginal secretions between 22 and 36 weeks gestational age. Increased levels of this protein correlate with a risk of PTL as illustrated in Fig. 33.3. NICE recommends performing this test if women are symptomatic and 30 weeks gestational age or more to determine the likelihood of birth within 48 hours, if transvaginal cervical length estimation is not available or acceptable. A FFN evaluation can be performed as a point of care test and a result can be provided within minutes.

Prevention

Progesterone [7]

Progesterone promotes myometrial quiescence (the physiological stage of active relaxation of myometrium that helps to maintain pregnancy) and prevents contractions. It is administered as a vaginal pessary or rectal suppository, started between 16 and 24 weeks and continued until 34 weeks gestational age.

Indications:

- In high risk women (one previous history of PTB <34 weeks gestational age or late miscarriage between 16–24 weeks gestational age), it reduces the risk of recurrence of PTB.
- In low risk women with an incidental finding of a short cervix (< 25 mm) between 16–24 weeks, progesterone reduces the risk of PTB by 45%.
- It is less effective in multiple pregnancies.

Cervical Cerclage [8] **(See Chap. 13)**

It is thought to provide structural support to a 'weak' cervix, maintain a cervical mucus plug and act as a barrier to ascending infection.

Indications:

- History indicated (3 previous late miscarriages/PTBs)—cerclage is usually performed as a planned procedure between 14 and 16 weeks gestational age.
- Ultrasound indicated—cerclage is recommended in women with a history of one or more spontaneous mid-trimester losses or PTBs with a CL of 25 mm or less on TVS before 24 weeks gestational age.
- Rescue cerclage—performed as an emergency procedure in response to cervical dilation/bulging membranes.

Cervical cerclage is usually inserted vaginally and, in some cases, abdominally. It is not recommended for multiple pregnancies.

Management of PTL

- **Steroids**: This is the most important intervention. It reduces risk of neonatal respiratory distress syndrome , intraventricular haemorrhage and neonatal death by 40%. Betamethasone (12 mg intramuscularly in two doses) should be offered between 24 and 34 weeks gestational age and a senior obstetric opinion sought outside this threshold.
- **Tocolytics**: There is no evidence that tocolytics improve neonatal mortality or morbidity. Therefore, their use is restricted to situations when prolonging the pregnancy by a few days would allow administration of steroids or an in-utero transfer to a maternity unit where appropriate high-level neonatal facilities are available. Nifedipine (calcium channel blocker) and Atosiban (oxytocin receptor antagonist) are recommended as the tocolytics of choice; however, nifedipine is not licensed for use in the UK. It has comparable efficacy to intravenously administered Atosiban but has the advantage of being cheaper and can be orally administered. Terbutaline (a beta-2 agonist) is not recommended due to its side effect profile.
- **Antibiotics**: The ORACLE study [9] showed a significant reduction in chorioamnionitis and improvement in neonatal outcomes following administration of antibiotics after PPROM. Erythromycin 250 mg four times a day for ten days is recommended after ruptured membranes are confirmed. Co-amoxiclav should be avoided as it is associated with increased risk of necrotising enterocolitis in the neonate. It should be noted that the ORACLE II study [10] concluded that antibiotics are ***not*** recommended for PTL with intact membranes as they may ***increase*** the risk of neonatal mortality and cerebral palsy.

- **Magnesium sulphate**: It has a neuroprotective effect and reduces the risk of cerebral palsy with greatest effect observed under 30 weeks gestational age. The recommended dose is a 4 g bolus intravenously followed by an infusion of 1 g/h until the birth, or for 24 hours (whichever is sooner). Its use should also be considered for PTB up to 34 weeks gestational age.
- **Planning of delivery**: The majority of women in spontaneous PTL have an uncomplicated vaginal delivery. Planned pre-term delivery for growth restricted babies or severe pre-eclampsia, for example, would usually be performed by caesarean delivery to ensure delivery is perfomed in a timely manner. With pre-term breech presentation, the risk of head entrapment with vaginal breech delivery is 10% and NICE guidance suggests that caesarean delivery should be considered after 26 weeks gestational age in this context. The general benefits and risks of caesarean delivery versus vaginal delivery should be discussed, highlighting the difficulties associated with performing a caesarean delivery for a pre-term birth, especially the increased likelihood of a vertical uterine incision and the implications of this for future pregnancies. An area of considerable debate is the mode of delivery in extreme prematurity (<27 weeks gestational age). Though a caesarean delivery may be considered less traumatic for the baby, the evidence supporting its use is limited and of poor quality. This perceived benefit has to be balanced against the higher incidence of complications encountered with extreme pre-term caesarean delivery such as haemorrhage, need for blood transfusion, infection and visceral injury. Additionally, the impact on future pregnancies such as the need for repeat caesarean delivery, morbidly adherent placenta and the risk of uterine rupture must be considered. Therefore, it is vital that decision making is shared with the family and multi-disciplinary discussion between obstetricians, anaesthetists and neonatologists takes place while planning delivery in these cases. The British Association of Perinatal Medicine (BAPM) have suggested a framework for counselling and shared decision making to facilitate individualised care. Figure 33.4 summarizes the outcomes for babies born alive between 22 and 26 weeks gestational age.
- In-utero transfer to a tertiary unit with neonatal care facilities appropriate to gestational age: This optimises outcomes for the baby and is better than ex-utero transfer and is now a prioritised NHS England recommendation.

Management of PPROM

This follows the same management principles as above.

Women are monitored closely for signs of chorioamnionitis (maternal tachycardia, pyrexia, increasing WCC, CRP, baseline fetal heart rate on CTG).

- If there are concerns regarding infection, intravenous broad-spectrum antibiotics are administered, and delivery is expedited.

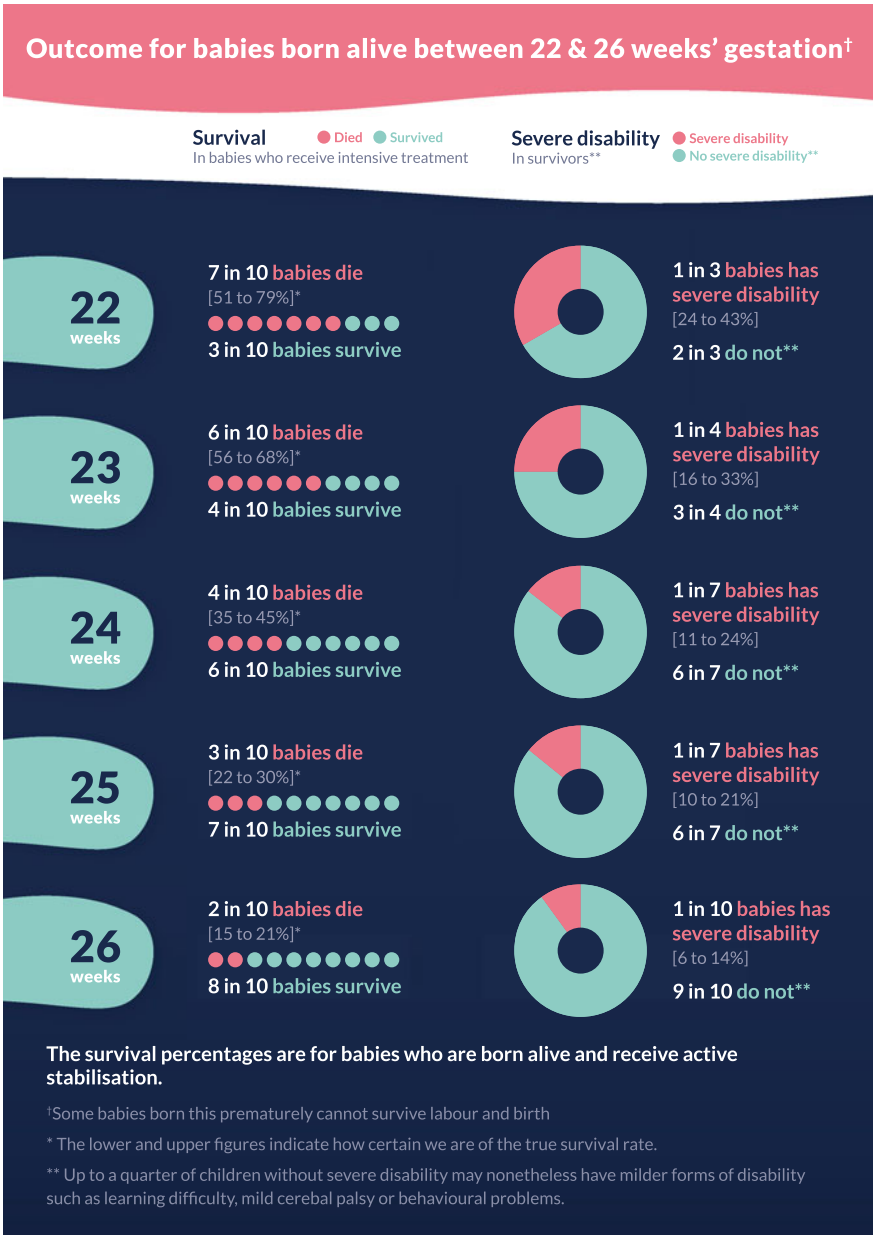

Fig. 33.4 Outcome for babies born alive between 22 and 26 weeks gestational age. Reproduced with permission from the British Association of Perinatal Medicine [11]

- If there are no concerns regarding infection and the woman has not gone into established PTL, outpatient management can be instituted with regular monitoring and expectant management offered until 37 weeks gestational age.

Anaesthetic Considerations

- Liaison with a senior obstetrician/neonatologist is essential.
  - A clear plan is needed about the mode of delivery, likelihood of operative intervention, type of preferred analgesia/anaesthesia, presence of paediatrician at delivery and neonatal resuscitation.
- There is a higher incidence of cord prolapse in pre-term neonates with non-cephalic presentations and ruptured membranes that may necessitate urgent delivery under general anaesthesia.
- Epidural analgesia for PTL may be beneficial as it can reduce the urge to push before full cervical dilation. This can also help to relax the pelvic floor and perineum, facilitating controlled delivery of a premature fetus, which is vulnerable to intracranial haemorrhage.

If a caesarean delivery is performed at a pre-term gestational age:

- If a caesarean delivery is performed at pre-term gestation, a vertical uterine incision, commonly known as a classical caesarean, may be required to facilitate surgical access and delivery of the fetus. A classical incision is associated with higher blood loss, the need for blood transfusion and/or hysterectomy and increased operative time. It is advisable to involve a senior obstetrician/senior anaesthetist in the management of such patients.
- Pre-term caesarean delivery may be associated with difficulty in delivering the neonate and trauma including head entrapment can occur. The obstetrician may request for the anaesthetist to administer terbutaline 0.25 mg subcutaneously/glyceryl trinitrate (GTN) 1–2 puffs sublingually, to relax the uterus in order to facilitate delivery. This may, however, increase the risk of postpartum haemorrhage.
- Caesarean delivery performed at a pre-term gestational age is associated with an increased risk of blood loss. Tranexamic acid, cross-matched blood and cell salvage techniques should be available and considered for these cases.
- Since the operative time may be prolonged, anaesthetists should consider using a combined spinal-epidural (CSE) anaesthetic technique.

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Malpresentation

34

Angela Yulia, Kasia Maksym, and Nicola Lack

Definitions

- Fetal lie refers to the relationship between the long axis of the fetus with respect to the long axis of the mother [1]. The long axis can be longitudinal, transverse or oblique (Fig. 34.1).
- The presentation of a fetus is defined by which anatomical part of the fetus is leading, i.e. which part is closest to the pelvic inlet of the birth canal. Therefore, the presentation could be cephalic (head first), breech (bottom first), shoulder (arm, shoulder or trunk), compound (when any other part presents along with the fetal head) (Fig. 34.2).
- A malpresentation is any presentation other than cephalic (Fig. 34.2 and Table 34.1).

General Management of Malpresentation

- Malpresentation is associated with increased labour complications such as cord prolapse and perinatal morbidity. The risk is around 1% for breech and up to 20% for transverse, oblique or unstable lie (a fetus which continues to change its position within the uterus) [2].

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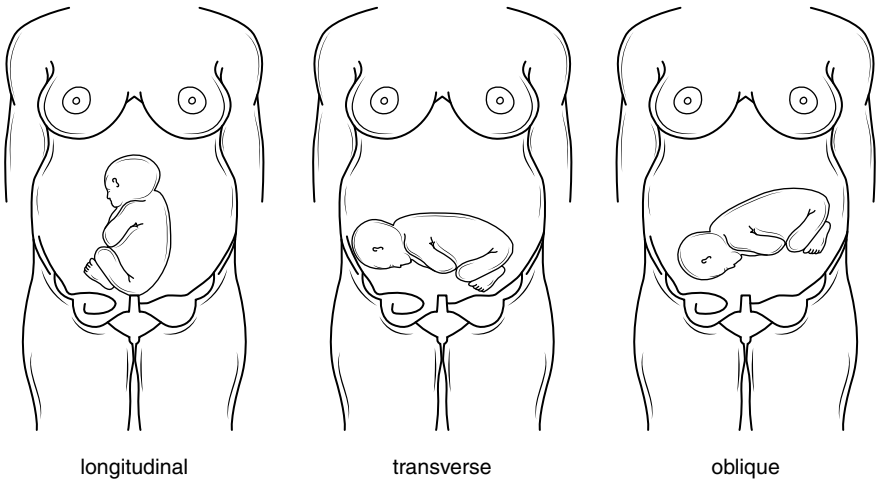

Fig. 34.1 Types of fetal lie

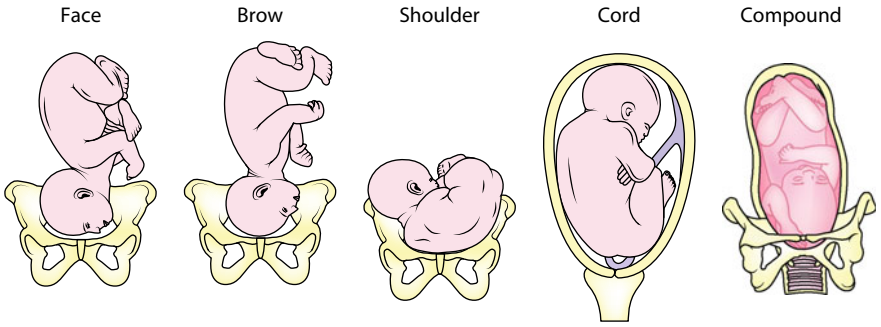

Fig. 34.2 Types of malpresentation

Table 34.1 Types of malpresentations [3]

Malpresentation	Incidence at term
Breech	3–4:100
Face	1:500
Brow	1:1000
Shoulder	1:300
Compound[a]	1:1000
Cord	1-6:1000

[a]Compound presentation is a fetal presentation in which an extremity presents alongside the part of the fetus closest to the birth canal. The majority of compound presentations consist of a fetal hand or arm presenting with the head

- The UK Royal College of Obstetricians and Gynaecologists (RCOG) advises that admission to hospital at around 37 weeks gestation should be discussed with women with transverse, oblique or unstable lie of the fetus [3].
- Depending on the stage of labour, caesarean delivery is the recommended mode of delivery for any malpresentation other than compound, and breech malpresentations (caesarean delivery not *always* recommended for woman presenting with a breech presentation in labour).

Breech Presentation

- the most common malpresentation is breech,
- the incidence of breech changes with advancing gestation. At 28 weeks of pregnancy about 20% of fetuses are breech, but by term the incidence drops to 3–4% [4].
- the incidence of presentations and type of breech presentation are summarized in Fig. 34.3.
- associations with breech presentation are summarised in Table 34.2.
- term babies with breech presentation have worse outcomes in terms of neonatal morbidity than cephalic ones, irrespective of the mode of delivery.
- current practice in the UK is to offer women with a breech presentation either an external cephalic version (ECV), to turn the fetus from breech to cephalic or an elective caesarean delivery (see Chap. 14) [4, 6].
- the incidence of vaginal breech deliveries decreased after the publication of the Term Breech Trial, which showed a small reduction in perinatal mortality if planned caesarean delivery was performed. Therefore, vaginal breech deliveries, particularly in primiparous women, are now uncommon [7].
- a decision to perform a planned caesarean delivery should be carefully balanced against the potential risks of this procedure and so women should be adequately counselled about all 3 options (ECV, elective caesarean delivery or planned vaginal breech delivery).

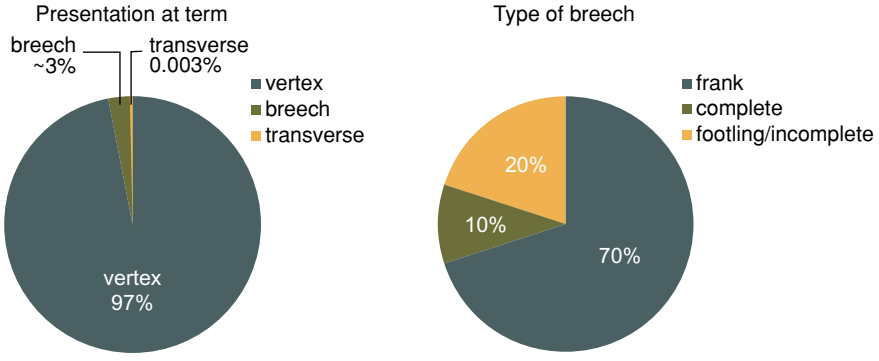

Fig. 34.3 Incidence of presentations at term and type of breech presentation

Table 34.2 Associations with breech presentation

Obstetric	Polyhydramnios (raised amniotic fluid index)
	Multiple pregnancy (e.g. twins, triplets)
	Abnormal placentation placental praevia
	High parity with lax abdominal and uterine musculature
	Uterine abnormalities, such as bi-cornuate, uni-cornuate, uterus didelphys, septate uterus, arcuate uterus, fibroidal uterus[a], pelvic mass.
	Recurrence in subsequent pregnancies. Relative risk of breech recurrence: • 2nd pregnancy = 3.2 (95% CI 2.8–3.6) • 3rd consecutive pregnancy = 13.9 (95% CI 8.8–22.1) [5]
Fetal	Fetal abnormalities, such as central nervous system (CNS) malformations (anencephaly, hydrocephalus[b]), neck masses, sacrococcygeal tumours, and aneuploidy. Fetal abnormalities are observed in 17% of preterm breech deliveries and in 9% of term breech deliveries
	Prematurity

[a]bi-cornuate—heart-shaped uterus or uterus with two horns, uni-cornuate—a one-sided uterus, it has typical banana shaped on imaging systems, uterus didelphys—double uterus and it may have double cervix and a vaginal partition, septate uterus—uterine septum or partition, arcuate uterus—mildly variant shape of uterus, fibroidal uterus—uterus with fibroids
[b]anencephaly—the absence of a major portion of the brain, skull and scalp, hydrocephalus—excess fluid on the brain, aneuploidy—the presence of an abnormal number of chromosomes in a cell

Inevitably some breech babies will be delivered vaginally, either because of maternal choice, or because they remained undiagnosed and will present in established labour when a caesarean delivery may not be the safest option. In such a situation the management should depend on [4]:

- stage of labour
- labour progress
- maternal and fetal wellbeing
- presence of factors, which may increase the risk of complications. Factors regarded as unfavourable for vaginal breech birth are summarised in Table 34.3.

Table 34.3 Factors regarded as unfavourable for vaginal breech delivery

Obstetric Factors	Clinically inadequate pelvic capacity
	Footling or kneeling breech presentation
	Previous caesarean delivery
	Other contraindications to vaginal birth (e.g. placenta praevia, cord prolapse in non-imminent delivery circumstances)
	Absence of a clinician trained in vaginal breech delivery
Fetal Factors	Large baby (>3,800 g)
	Evidence of intrauterine growth-restricted fetus (<2,000 g) or congenital anomaly
	Hyperextended fetal neck in labour

- A senior obstetrician should be present at delivery to improve outcomes [7].
- Caesarean delivery should not be routinely offered in the 2nd stage of labour. If possible, ultrasound examination should be carried out to assess the position of fetal legs and head, as well as a fetal weight estimation.
- Women should be counselled as with planned vaginal breech delivery.

Vaginal Breech Delivery

When vaginal breech delivery is planned [4]:

- Induction of labour (IOL) should be avoided.
- Augmentation with oxytocin can be offered but in reality this is not common practice.
- Slow labour progress could indicate fetopelvic disproportion and decision to augment labour should be taken very carefully.
- Continuous fetal monitoring may improve neonatal outcome.
- Both semi-recumbent and all fours positions can be adapted for delivery of a breech.
- Delivery, however, should be assisted if there is:
  - Delay of more than 5 min from the delivery of buttocks to the head, or
  - Delay of more than 3 min from the delivery of the umbilicus to the head as significant cord compression is common in breech deliveries.

Techniques used in assisted breech delivery include [4, 8]:

- Gentle rotation without traction to ensure the back of the baby remains anterior and delivery of arms by inserting a finger in the elbow and flexing them across the chest.
- Head is delivered with the Mauriceau–Smellie–Veit manoeuvre or with assistance of forceps.
- Suprapubic pressure will aid flexion of the head if there is delay due to an extended neck.

In spontaneous preterm breech, caesarean delivery should not be routinely recommended; however, it should be offered if preterm breech delivery is planned due to maternal or fetal compromise. Emergency caesarean delivery rates with planned vaginal birth vary from 29 to 45% [4].

Episiotomy should be performed when indicated to facilitate delivery. With regards to episiotomy for vaginal breech delivery, there is no evidence as to whether advice for breech delivery should differ from that for cephalic delivery [4]. The incidence of post-partum haemorrhage is not significantly increased in vaginal breech delivery compared to vaginal cephalic delivery.

Anaesthetic Management of Breech Presentation

- The vast majority of women diagnosed with breech presentation will be scheduled for an elective caesarean delivery (see Chap. 5).
- Anaesthesia for ECV is covered in Chap. 14.
- Women undergoing planned vaginal breech delivery should deliver within the delivery ward in the presence of medical staff. These patients should be assessed early by an anaesthetist as the need for obstetric intervention and caesarean delivery is increased.
- Epidural analgesia should not be routinely advised; women should however have a choice of analgesia during breech labour and birth [4, 9].
- Women should be informed that the effect of epidural analgesia on the success of vaginal breech birth is unclear, but that it is likely to increase the risk of intervention and the risk of assisted vaginal delivery. Vaginal breech birth is usually easier if a mother is able to bear down effectively and an epidural may interfere with this.

When there is a difficulty in the delivery the fetal head during caesarean delivery:

- The anaesthetist can administer tocolytic drugs such as 250 micrograms of subcutaneous terbutaline or glyceryl trinitrate (GTN) buccal spray [10].
- Surgically, the obstetrician can attempt to deliver fetal head with the Mauriceau–Smellie–Veit manoeuvre or with the assistance of forceps. If these fail, then the uterine incision should be extended to a J or T shape to deliver the breech. Care should be taken to avoid hyperextension of the fetal neck.

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Placenta Praevia

35

Nadir Sharawi, Julie Whittington, and Pervez Sultan

Definition

Placenta praevia occurs when the placenta is inserted wholly or partly into the lower segment of the uterus [1].

The placenta can be implanted in a variety of places on the uterus (Fig. 35.1), including anterior, posterior, fundal, and praevia.

Classification

Praevia is divided into four grades depending on the relationship and distance to the internal cervical os:

- **Grade I**: low-lying placenta (Fig. 35.2): placenta lies in the lower uterine segment, but its lower edge does not abut the internal cervical os (i.e. the lower edge is 0.5-5.0 cm from the internal os).
- **Grade II**: marginal praevia (Fig. 35.3): the placental tissue reaches the margin of the internal cervical os, but does not cover it

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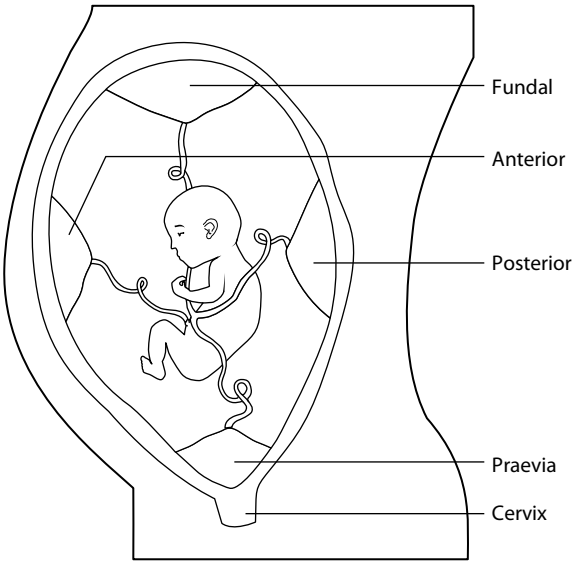

Fig. 35.1 Placental location sites

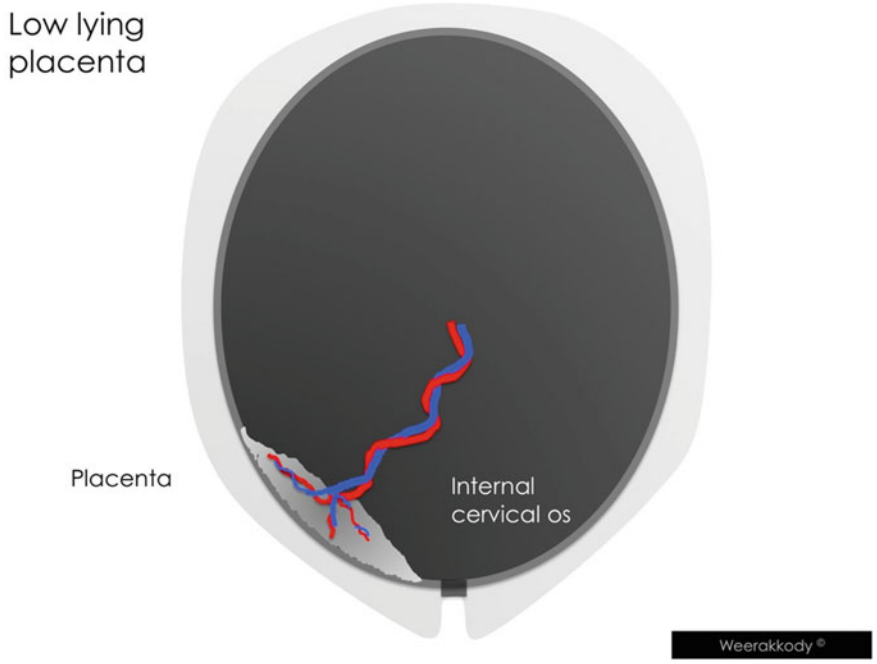

Fig. 35.2 Low lying placenta. Reproduced with permission from Dr. Yuranga Weerakkody, Radiopaedia.org, rID: 13502

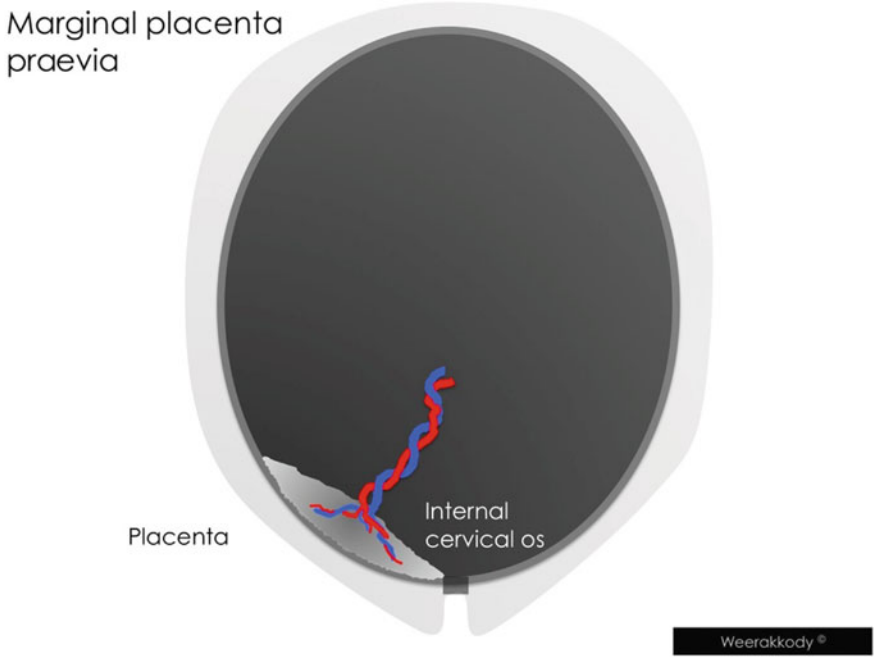

Fig. 35.3 Marginal placenta praevia. Reproduced with permission from Dr. Yuranga Weerakkody, Radiopaedia.org, rID: 13502

- **Grade III**: partial praevia (Fig. 35.4): the placenta partially covers the internal cervical os
- **Grade IV**: complete praevia (Fig. 35.5): the placenta completely covers the internal cervical os

Sometimes Grades I and II are termed "minor" or "partial" placenta praevia, and Grades III and IV are termed "major" placenta praevia

Incidence

- The overall incidence is approximately 1:200 births.
- Complete placenta praevia occurs in approximately 1:1000 births.

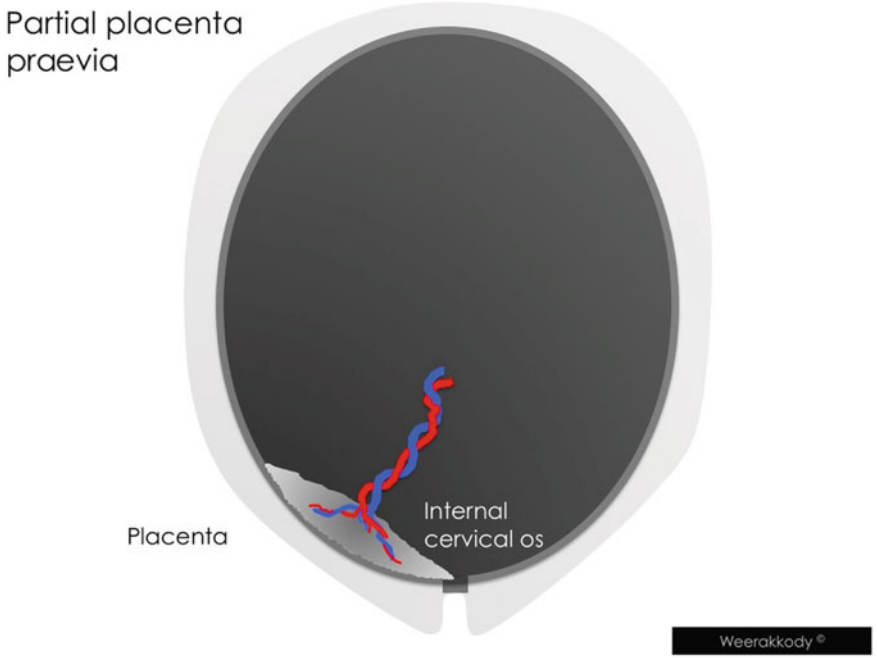

Fig. 35.4 Partial placenta praevia. Reproduced with permission from Dr. Yuranga Weerakkody, Radiopaedia.org, rID: 13502

Risk Factors

- Previous uterine scar (the risk increases significantly after three caesarean deliveries).
  - Presence of placenta praevia increases risk of placenta accreta spectrum (see Chapter 36).
- Advanced maternal age.
- Previous history of placenta praevia.
- Multiparity.

Presentation

- Asymptomatic—an incidental finding diagnosed during routine ultrasonography.
- Classically presents with painless vaginal bleeding, usually after 28 weeks gestational age due to contractions or cervical dilation. May present with provoked bleeding after sexual intercourse. Rarely, haemorrhage can be life threatening.

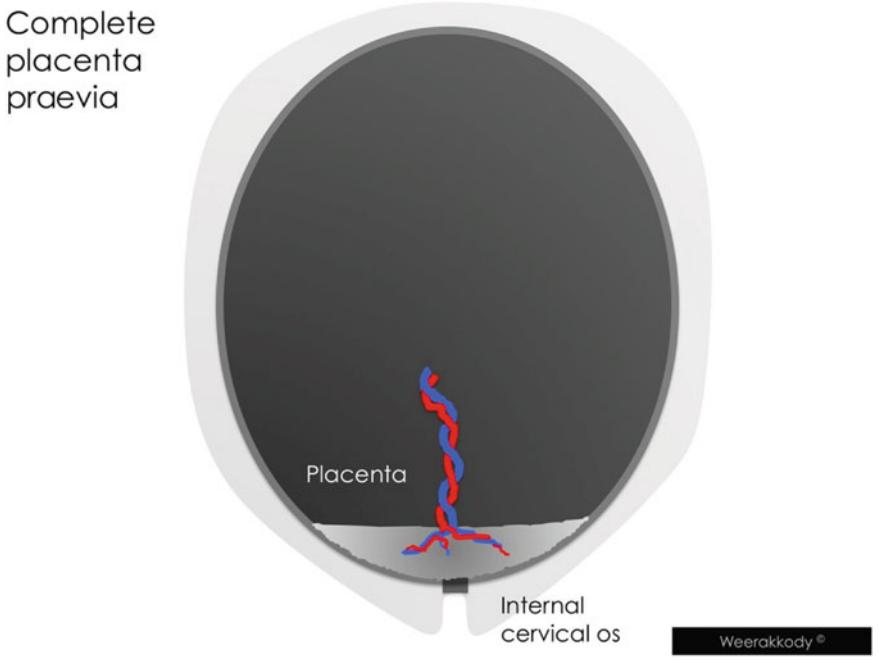

Fig. 35.5 Complete placenta praevia. Reproduced with permission from Dr. Yuranga Weerakkody, Radiopaedia.org, rID: 13502

- There is a risk of pre-term labour.
- A high presenting part or abnormal lie with vaginal bleeding should raise suspicion of placenta praevia, irrespective of reported placental location on previous imaging.

The differential diagnosis is placental abruption, which classically presents with abdominal pain, vaginal bleeding and uterine tenderness. Complications associated with placenta praevia are listed in Table 35.1.

Table 35.1 Pregnancy complications

Pregnancy complications associated with placenta praevia [2]	
Maternal	Hypertensive disorders of pregnancy
	Gestational diabetes
Obstetric	Pre-term pre-labour rupture of membranes
	Pre-term delivery
	Oligohydramnios
	Vaginal bleeding in pregnancy
	Placental abruption

Diagnosis

The placental location is determined at the 20-week fetal anomaly scan for all women. If the placenta appears low on a transabdominal scan, a transvaginal scan (TVS) should be performed to confirm the diagnosis.

- Women with suspected major placenta praevia (Fig. 35.6) or accreta (See Chapter 36) should have a follow-up scan at 32 weeks gestational age to confirm placental location and allow time for planning of the delivery.
- Women with suspected marginal or low-lying placenta praevia (grade I or grade II) (Fig. 35.7) can wait until 36 weeks gestational age for a confirmatory scan.
- Women with a previous caesarean delivery require a higher index of suspicion as there are two diagnoses to exclude: placenta praevia and placenta accreta spectrum.

Management

- The mode of delivery should be based on clinical judgement supplemented by sonographic information and the woman's preference.
- A woman with a placental edge less than 2 cm from the internal os in the 3rd trimester is likely to need a caesarean delivery. However, in a retrospective study

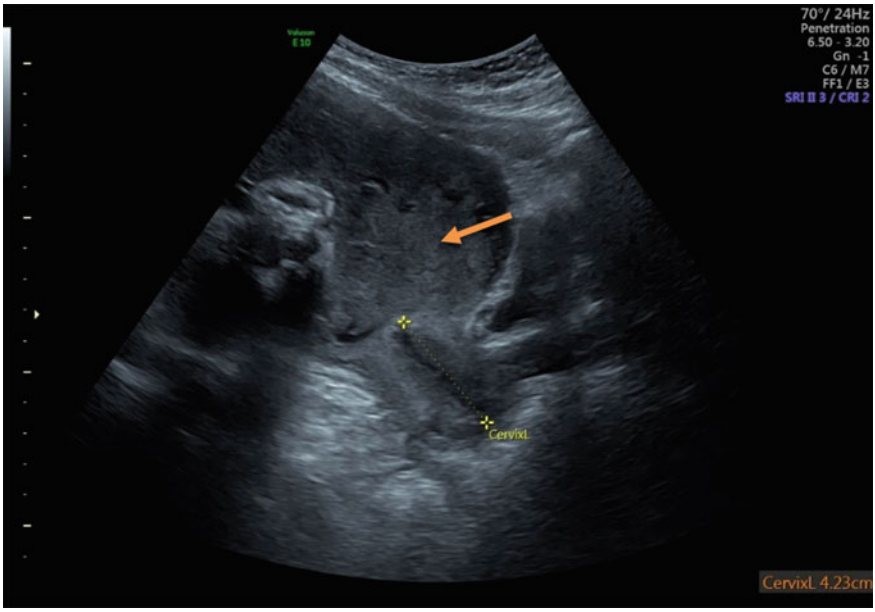

Fig. 35.6 Major placenta praevia. The placenta is covering the internal cervical os. Yellow calipers = cervix in cross section; Orange arrow = placental tissue; Published with permission from theUniversity of Arkansas for Medical Sciences, Arkansas, Little Rock, USA

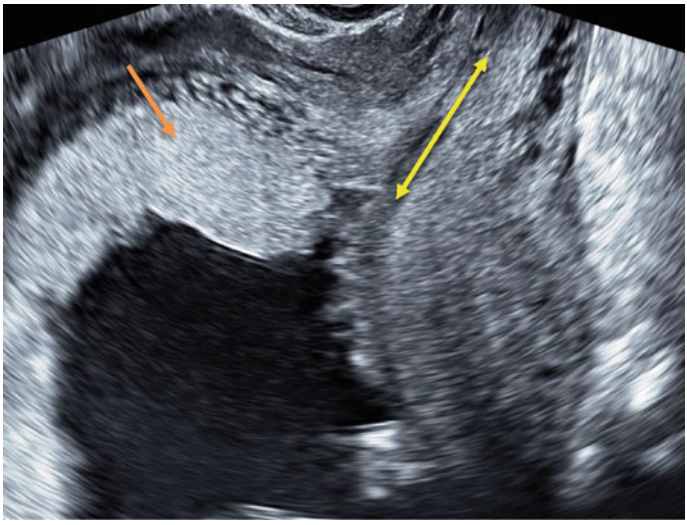

Fig. 35.7 Marginal placenta praevia (grade II). The placenta abuts but does not cover the internal os of the cervix. Orange arrow = placental tissue; Yellow area = cervical canal; Published with permission from the University of Arkansas for Medical Sciences, Arkansas, Little Rock, USA

of 34 patients with a placenta edge 1–2 cm from the internal os attempting vaginal delivery, 76.5% went on to deliver vaginally [3].

- Vaginal delivery can be considered if the fetal head is engaged and below the leading edge of the placenta on transvaginal ultrasound in the third trimester.
- Delivery is usually planned at 38–39 weeks gestational age to minimize neonatal morbidity as recommended by the UK Royal College of Obstetrician and Gynecologists' (RCOG). Although this may need to be brought forward if there are antepartum hemorrhage episodes. This recommendation varies regionally and can span anywhere from 36-39 weeks gestational age.
- Before delivery, all women with placenta praevia and their partners should have a discussion regarding delivery, indications for blood transfusion and the potential need for emergency hysterectomy.
- Women with atypical antibodies form a particularly high-risk group and discussion with blood transfusion services may be needed.

Anaesthetic Considerations

Placenta praevia caesarean delivery carries a risk of major obstetric haemorrhage and hysterectomy, and should therefore be carried out in an institution with an onsite blood bank and facilities for providing high dependency care. In a systematic

review, the rate of hemorrhage at time of caesarean delivery with placenta praevia was 22.3% [4].

- A consultant obstetrician and anaesthetist should be readily available [5].
- Initiate resuscitation and a major haemorrhage protocol if there is massive obstetric haemorrhage. In such circumstances, an emergency caesarean delivery may have to be performed under general anaesthesia (GA).
- Anticipate haemorrhage during surgery; establish two large bore IV cannulae and cross-matched blood should be immediately available.
- Other measures to facilitate resuscitation include invasive blood pressure monitoring, rapid fluid infusion devices (Level 1®, Belmont®), fluid warming, forced air warming and blood cell salvage (Cell Saver®) if available.
- The anaesthetic technique will depend on physician preference, condition of the mother and fetus along with the potential for haemorrhage (especially if the placenta is anterior).
- Epidural analgesia for labour may be useful in the event that caesarean delivery is required.
- General and neuraxial anaesthesia are both acceptable for caesarean delivery.
- Combined spinal-epidural (CSE) or epidural anaesthesia allow extension of the neuraxial block compared to a single shot spinal.
- The early use of additional uterotonic medications, B-Lynch suture (a surgical adjunct to controlling obstetric hemorrhage or uterine atony), or intrauterine balloon tamponade may be needed.
- Consider caesarean hysterectomy if the above methods are ineffective.

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Placenta Accreta Spectrum

36

Nadir Sharawi, Julie Whittington, Pervez Sultan, and Shalini Chawla

Definition

Placenta accreta spectrum refers to conditions where the placenta implants over a previous uterine scar (e.g. after previous caesarean delivery or uterine surgery). The morbidly adherent placenta penetrates through the decidua basalis and through the myometrium to a varying degree. This results in the placenta being unable to separate from the uterus after delivery which may lead to massive haemorrhage.

Depending upon the degree of penetration, it is classified into 3 groups summarised in Table 36.1 and illustrated in Fig. 36.1.

For ease of description, the term placenta accreta spectrum will be used to describe all these conditions.

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Table 36.1 Types of placenta accreta spectrum (PAS)

Term	Definition
Placenta accreta	The placenta penetrates the uterine endometrial layer to attach to the myometrium (muscular layer of the uterus)
Placenta increta	The placenta penetrates deep into the myometrium
Placenta percreta	The placenta breaches the myometrium into the serosal tissue layer (outer layer of the uterus) and sometimes adjacent organs, such as the bladder, pelvic side wall, or rectum

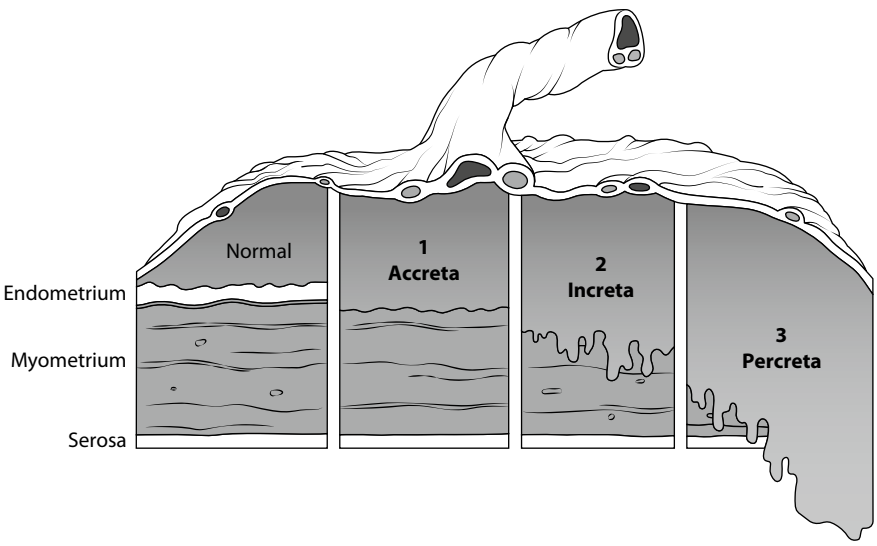

Fig. 36.1 Diagrammatic representation of placenta accreta spectrum (PAS)

Incidence of Placenta Accreta Spectrum

- Approximately 1:2,500 deliveries
- The incidence is rising due to an increase in caesarean deliveries.
- In patients with placenta praevia and a history of 2 previous caesarean deliveries, the incidence of placenta accreta is 40%. This increases to over 60% with placenta praevia and >3 cesarean deliveries [1].

Risk Factors

- Previous caesarean delivery or uterine surgery (e.g. myomectomy)
- Placenta praevia
- Maternal age >35 years old (Table 36.2).

Complications of Placenta Accreta

- Delayed haemorrhage and coagulopathy
- Damage to surrounding structures especially bladder and ureters.

Diagnosis

- Ultrasound (performed abdominally and/or transvaginally) is the primary imaging modality to diagnose placenta accreta antenatally. 3D power Doppler has 100% sensitivity, 85% specificity and 88% positive predictive value [2].
- Not all placenta accreta cases are diagnosed antenatally. It may therefore be an unexpected intraoperative finding.
- Imaging should be performed at around 32 weeks gestational age to clarify the diagnosis and allow planning for third-trimester management, further imaging and delivery.
- MRI may be useful in equivocal cases to confirm the diagnosis.
- Definitive diagnosis can only be made at surgery (Fig. 36.2).

Table 36.2 Relationship between number of previous caesarean deliveries and risk of placenta accreta, placenta praevia and hysterectomy [1]

No. of previous CD	% of women with placenta accreta (%)	Risk of accreta if placenta praevia (%)	% of women requiring hysterectomy (%)
0	0.24	3	0.65
1	0.31	11	0.42
2	0.57	40	0.9
3	2.13	61	2.4
4	2.33	67	3.49
5	6.74	67	8.99

CD = caesarean delivery

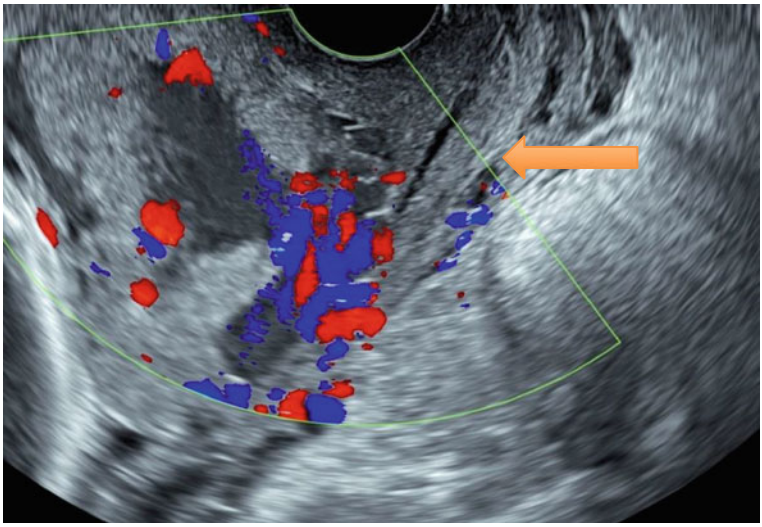

Fig. 36.2 Ultrasound of morbidly adherent placenta. Orange arrow: cervix. Placental tissue with increased vasculature and lacunae overlying the cervix, consistent with abnormally invasive placental tissue. Published with permission from the, University of Arkansas for Medical Sciences, Arkansas, Little Rock, USA

Management

Women who have had previous caesarean delivery and have either placenta praevia or an anterior placenta underlying the previous caesarean delivery scar at 32 weeks of gestation, are at increased risk of placenta accreta. Such women should be managed as if they have placenta accreta with appropriate preparation for surgery.

- Elective caesarean delivery is recommended at 36–37 weeks of gestation (with antenatal steroid cover to promote fetal lung maturity) for suspected placenta accreta. The timing of caesarean delivery is a balance between risk of life-threatening hemorrhage to the mother with advancing gestation and the risks to the fetus of preterm delivery (see Chap. 33).
- The care bundle for suspected placenta accreta spectrum (Box 36.1) should be applied in all cases where there is a placenta praevia and a previous caesarean delivery or an anterior placenta underlying the old caesarean scar.
- If the patient requires caesarean delivery, out-of-hours senior staff should be informed as soon as possible.
- If application of the care bundle (see below) is not feasible due to lack of availability of facilities or if the woman refuses donor blood, consideration should be given to transferring the patient to a tertiary obstetric care centre.

Box 36.1. Placenta accreta spectrum care bundle [3]

Placenta accreta care bundle

- Senior obstetrician planning and directly supervising delivery
- Senior anaesthetist planning and directly supervising perioperative management
- Blood and blood products available
- Multidisciplinary involvement in pre-operative planning
- Discussion and consent including possible interventions (such as hysterectomy, leaving the placenta in place, cell salvage and interventional radiology)
- Local availability of a critical care bed

Preoperative Management

- 2 peripheral large bore IVs cannulae, rapid infusion catheters, or central lines
- Invasive blood pressure monitoring and prepare vasoactive drugs.
- Rapid infusion devices (for example: Level 1® or Belmont®).
- Blood products and cell salvage available in the operating room before surgery.
- Counsel patient regarding the possible need for hysterectomy and blood transfusion.
- May require an immediate pre-operative scan to determine the extent of placental invasion and decide the type of abdominal and uterine incision needed for surgical exposure.
- There are regional variations in the use of interventional radiology for prophylactic catheter placement for balloon occlusion or embolization (efficacy still under evaluation).

- Balloons can be inflated to occlude the aortic, internal iliac, or uterine blood supply.

– Consider in women who refuse blood products.
– Balloon catheters may be used in an emergency situation if the patient is haemodynamically stable.
– However, emergent insertion of balloon catheters may be associated with an increased risk of complications such as haemorrhage, thrombosis and aneurysm formation.

Intraoperative Management

- General anaesthesia or neuraxial anaesthesia (see below).
- Early activation of the major haemorrhage protocol.
- Patient warming (fluids, warmed mattress or forced air warming device).
- Pharmacological agents (see Chaps. 21 and 22).
- If available, the use of viscoelastic haemostatic testing using devices such as the ROTEM® may guide resuscitative efforts and aid in the correction of coagulopathy (see Chap. 21).

Surgical Considerations

- Midline vertical incision may improve exposure.
- The uterine incision should be distant from the placenta to allow delivery of the infant without disturbing the placenta. This allows either conservative management or hysterectomy.
- There may be poor contraction of the lower uterine segment after delivery causing haemorrhage. Additional uterotonic drugs may be required.
- If the placenta *fails to separate* either [4]:
  - close the uterus with the placenta intact.
  - close the uterus and proceed to a hysterectomy.
  - these options are associated with less haemorrhage than trying to separate the placenta.
- If the placenta *partially separates* [4]:
  - deliver the separated portion(s) and expect major haemorrhage.
  - adherent portions can be left in place, but blood loss in such circumstances can be large.
- Conservative management:
  - includes leaving the placenta in place and waiting for placental involution to occur over time.
  - additional measures are usually required such as intramuscular methotrexate therapy (1 mg/kg every 96 h for three doses) or surgical internal iliac artery ligation.
  - may be useful where the preservation of fertility is important.
  - complications may still occur such as delayed hemorrhage, sepsis and subsequent need for hysterectomy.
- Other options to control hemorrhage include:
  - intrauterine balloon tamponade (e.g. Bakri balloon).
  - uterine compression sutures (e.g. B-Lynch suture).
  - angiographic arterial embolization (an option for intraoperative bleeding if stable enough for interventional radiology).

- bilateral surgical ligation of the uterine arteries.
- manual compression of the aorta—either aortic compression against a vertebral body, aortic cross-clamp by a vascular surgeon, or aortic balloon occlusion.
- hysterectomy—definitive treatment to control major haemorrhage.

Postoperative Management

- Correct coagulopathy, anaemia and electrolytes.
- Maintain normothermia.
- Check coagulation and platelet parameters postoperatively before removing the epidural catheter.
- Patient controlled epidural analgesia or abdominal wall nerve blocks can provide good analgesia when used as part of a multimodal technique.

Choice of Anaesthetic Technique

- The choice of a neuraxial technique versus general anaesthesia will depend on the expected severity of blood loss, assessment of the patient's airway, and physician and patient preference [5].
- Massive transfusion may worsen airway oedema making endotracheal intubation more challenging.
- When a difficult airway is anticipated, general anaesthesia is preferred as this eliminates the need to manipulate the airway during surgery.
- If neuraxial anaesthesia is chosen, epidural or combined spinal-epidural (CSE) is preferred for prolonged surgery.
- A higher sensory level of anesthesia may be required to avoid patient discomfort if a vertical incision is performed.
- Approximately 30% conversion rate [5] of neuraxial to general anaesthesia due to:

1. necessity for airway protection in haemodynamically compromised patients.
2. an altered level of consciousness.
3. oxygenation becoming impaired secondary to pulmonary oedema or transfusion related acute lung injury (TRALI).

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Intrauterine Growth Restriction

37

Julie Whittington, Everett F. Magann, and Nadir Sharawi

Background

Intrauterine growth restriction (IUGR) has been associated with perinatal morbidities including low cord blood gas pH, intraventricular hemorrhage, respiratory distress, and sepsis [1]. Growth restricted fetuses are often delivered at earlier gestational ages due to concerns raised during antenatal testing. Growth restricted fetuses also have an increased risk of perinatal mortality—especially those fetuses with an estimated fetal weight less than the 3rd percentile for gestational age. This makes IUGR a significant concern for obstetricians and optimal management of these fetuses is therefore important. The risk factors for this condition are reviewed in Table 37.1.

Definition

Estimated fetal weight < 10th percentile [2]

Some obstetricians use abdominal circumference < 5th or < 10th percentile [3, 4]

Diagnosing fetal growth restriction relies upon accurate estimation of gestational age in accordance with usual obstetric guidelines (ultrasound before 20 weeks gestational age).

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Table 37.1 Risk factors

Maternal	Advanced maternal age (>35 years old at time of birth) Hypertension (including preeclampsia) Diabetes Hyperthyroidism Systemic lupus erythematosus (SLE) and other autoimmune disorders Heart disease Antiphospholipid syndrome Poor nutritional status Medication exposures (antihypertensives, steroids, warfarin, antiepileptic drugs) Substance abuse (tobacco, cocaine, alcohol)
Fetal	Infections (cytomegalovirus, toxoplasmosis, rubella) Anomalies (cardiac, renal, or brain malformations) Chromosomal abnormalities (Trisomy 21, 18 and 13) Multiple gestations Constitutional (parents of small stature)
Placental	Placental mosaicism (abnormal placental cells, normal fetal chromosomes) Single umbilical artery Velamentous cord insertion (eccentric insertion, umbilical vessels are not protected by Wharton's jelly near the insertion site) Bi-lobate placenta Small placenta for gestational age

Incidence

12.4% of first pregnancies are affected

The incidence decreases with subsequent pregnancies, however if a prior pregnancy was affected the recurrence risk is 20% [2].

Antenatal Testing

Antenatal fetal testing is accomplished by fetal kick counts, non-stress tests/biophysical profile with assessment of amniotic fluid volume. Growth ultrasounds are continued every 2–4 weeks until delivery along with assessments of amniotic fluid. Doppler ultrasound is also used as an adjunct to this testing.

Fetal kick counts—Fetal kick counts are performed daily by the mother—she should feel her fetus kick ten times in one hour, this period can be extended to two hours. If kicks are not met the patient can then call for advice, present to her physician or go to the hospital for further evaluation.

Non-stress Test (NST)—Non-stress tests are typically performed in a clinic setting and involve placing the fetus on the cardiotocographic monitor while also monitoring contractions. Non-stress tests are either reactive or non-reactive.

A reactive NST contains 2 or more accelerations in fetal heart rate in a 20-minute period.

Biophysical profile (BPP)—Biophysical profiles are performed using ultrasonography and can require up to 30 min to complete the testing [3]. A score of 8 or 10 out of 10 is reassuring for fetal well-being. Components of the biophysical profile are reviewed in Table 37.2.

Umbilical artery (UA) Doppler—UA Doppler is helpful to further stratify risk and is the primary method of surveillance in reducing morbidity and mortality in the growth restricted fetus. In a normal fetoplacental unit, there should be preservation of forward flow in the umbilical cord during diastole as the placenta is a low resistance organ. Typical UA Doppler waveforms are shown in Figs. 37.1, 37.2, and 37.3. Terms which are used to describe various UA Doppler indices include systolic: diastolic ratio (S:D), pulsatility index (PI) and resistance index (RI).

Middle cerebral artery (MCA) Doppler—MCA Doppler has also been used in fetal growth restriction to further stratify fetuses at risk. In the MCA, decreases in cerebral blood flow impedance and increases in placental blood flow impedance lead to brain sparing, which is seen with some growth restricted fetuses. The UK Royal College of Obstetricians and Gynecologists (RCOG) uses the MCA pulsatility index to guide delivery timing.

Ductus venosus (DV) Doppler—DV Doppler has been used in fetal growth restriction. The ductus venosus has a characteristic triphasic flow pattern with forward flow throughout the cardiac cycle. Reversal of the "a" wave portion of this cycle suggests a high risk of fetal death within one week, and requires hospital admission and consideration for delivery [2].

Table 37.2 Biophysical profile scoring

	Normal (2 points)	Abnormal (0 points)
Fetal breathing	One or more episodes of fetal breathing lasting at least 30 seconds	No episodes of fetal breathing lasting at least 30 seconds
Gross body movements	3 or more discrete limb or body movements	2 or less discrete limb or body movements
Tone	One or more episodes of active extension and flexion or opening and closing of a hand	No episodes of active extension and flexion or opening and closing of a hand
Amniotic fluid	A single deepest pocket of fluid measures 2 cm or greater	A single deepest pocket of fluid is less than 2 cm
Non-stress test	Reactive	Non-reactive

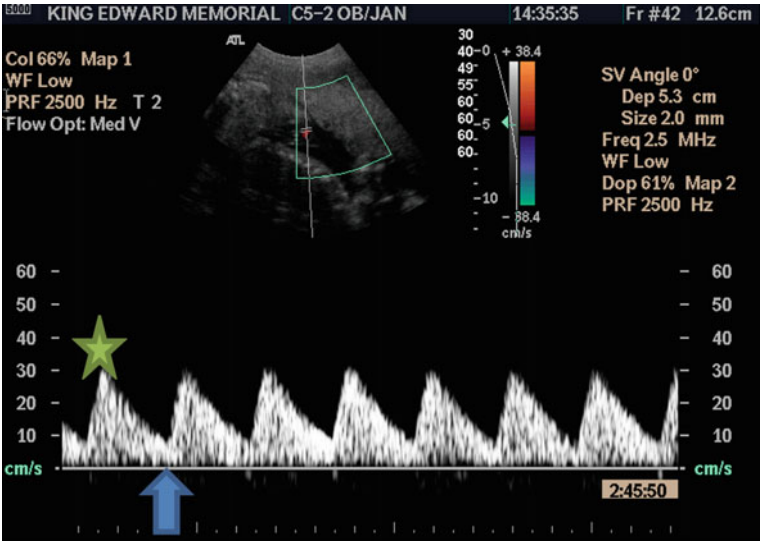

Fig. 37.1 Normal: forward flow in the umbilical artery Doppler. Star—peak systolic flow, arrow—diastolic flow Published, with permission, courtesy of Dr EF Magann

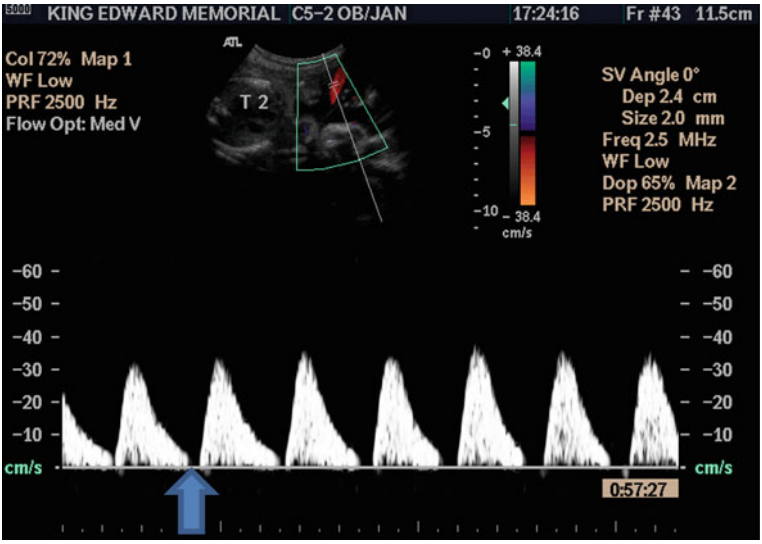

Fig. 37.2 Abnormal UA Doppler: absent flow in the umbilical artery Doppler. Arrow—absence of diastolic flow. Published with permission, courtesy of Dr. EF Magann

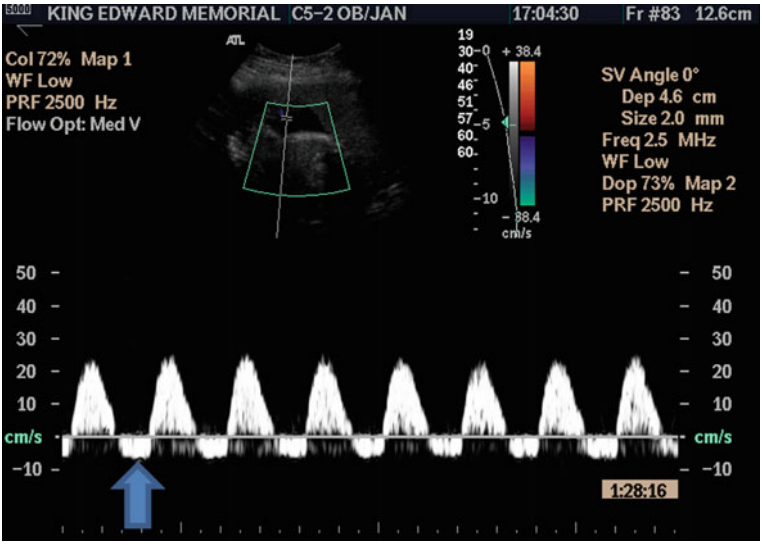

Fig. 37.3 Abnormal UA Doppler: reversed flow in the umbilical artery Doppler. Arrow—reversal of diastolic flow. Published with permission, courtesy of Dr. EF Magann

Table 37.3 Timing of delivery based on ultrasonic findings

	American College of Obstetricians and Gynecologists (ACOG)	UK Royal College of Obstetricians and Gynecologists (RCOG)*
Reversal of flow—UA Doppler	32 weeks	30-32 weeks
Absence of flow—UA Doppler	34 weeks	32 weeks after steroid administration
S:D ratio >95th percentile or EFW <5th percentile (ACOG) MCA PI or RI > 2 SD above the mean (RCOG)	37 weeks	37 weeks
EFW < 10th percentile with normal Dopplers and reassuring testing	39 weeks	Offer delivery at 37 weeks

S:D ratio = systolic: diastolic ratio; PI = pulsatility index; RI = resistance index; EFW = estimated fetal weight; MCA = middle cerebral artery; UA = umbilical artery; SD = standard deviation

Timing of Delivery (Table 37.3)

Delivery timing is dependent on results of antenatal testing as above and amniotic fluid status [2]

Route of Delivery

Route of delivery is dependent on usual obstetric indications. Growth restricted fetuses with normal or elevated umbilical artery Doppler values may be more likely to tolerate a vaginal delivery. Fetuses with absent or reversed umbilical artery Dopplers may not have reassuring fetal monitoring, however, and may require caesarean delivery. It must be clear that growth restriction alone is not an indication for caesarean delivery [3].

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Multiple Gestation

38

Umar Mushtaq and Sikha Shastham Valappil

A twin, triplet, or higher-order pregnancy (four or more babies) is called a multiple pregnancy.

Incidence

The incidence has increased in the UK from 10/1000 births in the 1980s to 16/1000 births in 2009 mainly due to advanced maternal age and assisted reproductive technologies (ART) [1].

Types of Placentation

- Dizygotic twins—two separate ovum fertilized by two separate sperm resulting in two placentas and two gestational sacs (Fig. 38.1).
- Monozygotic twins—the fertilized embryo divides later into two and depending on the stage during which it divides, this results in different types of twin pregnancies as described below:
  - Dichorionic diamniotic (DCDA)—each fetus has its own placenta with its own outer membrane called a 'chorion' and its own amniotic sac
  - Monochorionic monoamniotic (MCMA)—a single shared placenta and gestational sac.

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  - Monochorionic diamniotic twins (MCDA)—a single shared placenta and two gestational sacs.

- Monochorionic twins depend on a single shared placenta which can result in twin to twin transfusion syndrome (TTTS). TTTS is due to a placental vascular anastomosis which can lead to transfusion of blood from donor twin to recipient twin with the donor twin becoming hypovolemic, anemic and developing growth restriction and oligohydramnios. The recipient twin becomes hypervolemic, polycythemic and can develop polyhydramnios, which may present as a sudden increase in the size of the abdomen or breathlessness for the mother.
- Monochorionic monoamniotic—cord entanglement can occur hindering fetal movement and development and can complicate labor. So delivery is recommended by 32 weeks of gestation after corticosteroid administration for fetal lung prematurity.

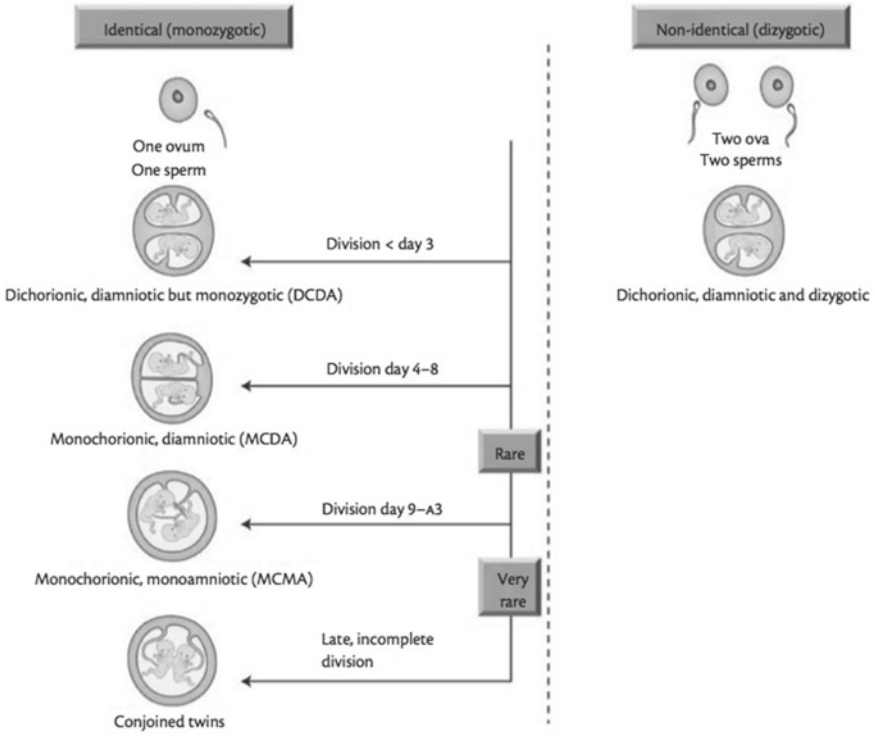

Fig. 38.1 Types of placentation. Figure reproduced from: Prematurity, multiple gestation and abnormal presentation. Keag O, Cooper ES. In Oxford Textbook of Obstetric Anaesthesia. Eds. Clark V, Van de Velde M, Fernando R. Oxford University Press 2016. Published with permission from Oxford University Press through PLSclear

Anatomical Changes

- large gravid uterus
- increased amniotic fluid volume
- increased cervical length shortening (compared to singleton pregnancy) predisposes the mother to premature delivery (see Chap. 33).
- maternal weight gain up to 25 kg.

Physiological Changes

Circulatory System

- multiple gestation results in a 20% increase in cardiac output as compared to a singleton mother. This increase in cardiac output is due to an increased stroke volume of 25–30% and an increased heart rate of 15–20%.
- multiple gestation predisposes the mother to potential further aortocaval compression and developing the supine hypotension syndrome due to a greater fetal weight and an increase in the amount of amniotic fluid.
- pre-eclampsia and gestational hypertension is much more common in multiple gestation pregnancies.

Respiratory System

- multiple gestation results in diaphragmatic elevation which causes a reduction in functional residual capacity (FRC), total lung capacity (TLC), residual volume (RV) and expiratory reserve volume (ERV) especially near term. These changes are compensated by the flaring of the ribs and an increase in both the antero-posterior and transverse diameters of the thoracic cage.
- Ventilation increases, which is due to hormonal changes and increased carbon dioxide production. There is much greater increase in the progesterone level which results in increased sensitivity of the central respiratory centre to arterial blood carbon dioxide level ($PaCO_2$) which acts as a direct respiratory stimulant. These changes result in a hyperventilation state, caused by an increase in minute ventilation, alveolar ventilation (70%) and tidal volume (45%), whereas the respiratory rate remains unchanged.

Central Nervous System

Spinal anesthesia drug is said to spread higher, although this is not evidence based. This may be related to compression of the vena cava and engorgement of the epidural venous plexus, which can compress the subarachnoid space and lead to a more cephalad spread of local anesthetic.

Gastrointestinal System

- Elevated progesterone levels result in decreased gastric peristalsis and lower esophageal sphincter tone. The enlarging gravid uterus displaces the stomach upwards displacing the intra-abdominal segment of esophagus into the thorax. These factors contribute to the greater risk of aspiration during general anesthesia. Gastric emptying is unchanged during pregnancy but may be prolonged in laboring mothers or those receiving any form of opioid analgesia (e.g. via systemic or neuraxial routes). The frequent use of progesterone injections or suppositories during pregnancy can lead to complaints including a bloated abdomen, gastritis, constipation or breast discomfort.
- HELLP (Hemolysis, Elevated Liver enzymes, Low platelets) syndrome and acute fatty liver is more common with triplets as compared to twin pregnancy.

Hematological System

The plasma volume increases by an additional 750 ml in twin pregnancy. This can result in an exaggerated dilutional thrombocytopenia and relative anemia.

Antenatal Care

- Difficult fetal heart sounds assessment using handheld sonic devices
- Need for frequent ultrasound scans for fetal assessment (including growth, and placentation) (Table 38.1)

Anesthesia Considerations

- Difficult airway and potentially rapid desaturation during general anesthesia secondary to a reduced FRC and a higher oxygen consumption (VO_2)
- Increased aortocaval compression/supine hypotension syndrome
- Higher spread of local anaesthetic drugs during neuraxial block

Table 38.1 Complications of multiple gestation

Maternal complications	Fetal complications
Preterm labor (PTL) Premature rupture of membranes (PROM) Hypertensive disorders of pregnancy Gestational diabetes Prolonged labor Placenta abruption Uterine atony Obstetric trauma—OASIS (Obstetric anal sphincter injuries) [4] Maternal hemorrhage Disseminated intravascular coagulation (DIC) Instrumental delivery Higher incidence of caesarean delivery Nosocomial infections due to frequent admissions and prolonged hospital stay	Premature delivery Congenital anomalies Intra uterine growth restriction (IUGR) Polyhydramnios Malpresentation Twin to twin transfusion syndrome Cord entanglement Umbilical cord prolapse Increased mortality

- Anaemia and thrombocytopenia
- Increased risk of uterine atony and postpartum haemorrhage (PPH)
- Increased risk of venous thromboembolism (VTE)

Mode of Delivery

- Many obstetricians prefer caesarean delivery for triplets and higher order (four or more babies) pregnancies.
- With twin pregnancy the mode of delivery depends on the presentation and the lie of the fetuses [2].
- Both fetuses have a vertex presentation in 30–50% of cases of twin gestation and in 25–40% of cases the presentation is a vertex/breech combination.
- Most obstetricians prefer a trial of labor when both fetuses present in the vertex position.
- Some obstetricians prefer caesarean delivery if Twin A presents with a breech or shoulder presentation, but there is controversy about management if Twin A has a vertex presentation and Twin B has a non-vertex position.

Planned Trial of Labour / Normal Vaginal Delivery

- An early labour epidural is required which may improve maternal relaxation to avoid premature pushing, enable breech extraction and which can be extended if an emergency cesarean delivery is required.

- An anesthetist should be immediately available during a twin delivery—e.g. to extend a pre-existing epidural analgesic block to provide anesthesia during an internal podalic version (here the fetus is turned within the uterus so that one foot or both feet present through the cervix allowing a breech extraction), instrumental delivery or external cephalic version (ECV) of the second twin.
- Ensure nitroglycerine (2 sprays −400 micrograms/spray) is available for uterine relaxation if needed during delivery of twin B. There is no strong evidence available to support nitroglycerine use.

Planned Caesarean Delivery

Neuraxial anesthesia (See Chaps. 6 and 7) or general anesthesia (Chap. 8) are both options for cesarean delivery, but neuraxial anesthesia is preferable.

Exaggerated aortocaval compression, hypotension and increased cephalad spread of local anesthetics can occur, but most anesthetists use the same standard dose of spinal local anesthetic for twin pregnancies as for singleton pregnancy. One study has showed that there is no greater hemodynamic instability or vasopressor use during cesarean delivery of multiple pregnancy under spinal anesthesia when compared to a singleton pregnancy [3].

Unplanned Caesarean Delivery

An anesthetist should be available during a twin delivery to extend an existing labour epidural in order to provide anesthesia for emergency cesarean delivery. Alternatively, a spinal, combined spinal epidural (CSE) or general anesthetic can be used depending on individual clinical circumstances.

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Pre-eclampsia and HELLP Syndrome

39

Elizabeth Combeer and Namita Sharma

Definition

Pre-eclampsia is a multisystem, hypertensive condition of pregnancy. The diagnosis is based on the presence of **new onset of hypertension** after 20 weeks of pregnancy **accompanied by evidence of proteinuria or specific involvement of at least one other organ system** [1, 2]. Both the UK National Institute for Health and Care Excellence (NICE) and the American College of Obstetricians and Gynecologists (ACOG) define hypertension in such circumstances as:

- Two readings four hours apart of ≥ 140 mmHg systolic blood pressure, or 90 mmHg diastolic blood pressure.
- However, a single measurement of systolic blood pressure of ≥ 160 mmHg, or diastolic blood pressure of ≥ 110 mmHg (a level that both NICE and ACOG recognise as "severe hypertension"), also satisfies ACOG diagnostic criteria as this facilitates rapid commencement of antihypertensive medication in severely affected women.

In addition to fulfilling diagnostic criteria for new onset of hypertension, evidence of proteinuria or involvement of one or more specific other organ systems must be evident. The precise criteria differ slightly between NICE and ACOG guidance (Table 39.1). It should be noted that although proteinuria is classically viewed as a feature of pre-eclampsia, its presence is no longer a prerequisite for diagnosis.

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Table 39.1 Diagnostic criteria for organ system involvement for confirmation of pre-eclampsia

	National Institute of Health and Care Excellence [1]	American College of Obstetricians and Gynecologists [2]
Proteinuria (any one of the following):	• Urine protein: creatinine ratio of $\geq$30 mg/mmol • Albumin: creatinine ratio $\geq$8 mg/mmol • < 1 g/L [2 +] on dipstick testing	• $\geq$300 mg per 24 hour urine collection (or extrapolated from a timed collection) • Protein: creatinine ratio of $\geq$0.3 mg/dL • Dipstick reading of 2+ (used only if other quantitative methods not available)
Renal insufficiency:	• Creatinine $\geq$90 μmol/L • $\geq$1.02 mg/100 ml	• Serum creatinine concentration >1.1 mg/dL • Doubling of serum creatinine concentration in the absence of other renal disease
Liver involvement:	• Elevated transaminases: alanine aminotransferase (ALT) or aspartate aminotransferase (AST) > 40 IU/L ± right upper quadrant or epigastric pain	• Liver transaminases of twice normal values
Neurological involvement:	• Eclampsia • Altered mental status • Blindness • Stroke • Clonus • Severe headaches • Persistent visual scotomata	• New-onset headache unresponsive to medication and not accounted for by alternative diagnoses • Visual symptoms
Haematological involvement:	• Thrombocytopenia with platelet count <150 × 10^9/L • Disseminated intravascular coagulation (DIC) • Haemolysis	• Thrombocytopenia with platelet count <100 × 10^9/L
Respiratory involvement:		• Pulmonary oedema
Uteroplacental involvement:	• Fetal growth restriction • Abnormal umbilical artery doppler waveform analysis • Stillbirth	

ACOG guidance defines pre-eclampsia with severe features as severe hypertension with any of the ACOG criteria in Table 39.1, but also including any of the following:

- severe persistent right upper quadrant pain
- epigastric pain unresponsive to medication and not accounted for by alternative diagnoses [2].

NICE guidance defines severe pre-eclampsia as pre-eclampsia with severe hypertension that does not respond to treatment or is associated with any of the following:

- ongoing or recurring severe headaches
- visual scotomata
- nausea or vomiting
- epigastric pain
- oliguria
- progressive deterioration in laboratory blood tests such as rising creatinine or liver transaminases, or falling platelet count
- failure of fetal growth or abnormal doppler findings [1].

Eclampsia is the occurrence of convulsions on a background of pre-eclampsia. It may be the presenting feature of pre-eclampsia that has not been previously diagnosed.

Pathophysiology

- The precise pathophysiology is incompletely understood and immune maladaptation may play a role.
- Impaired trophoblastic cell invasion results in failure of spiral artery dilatation, leading to placental hypoperfusion, ischaemia and reperfusion injury.
- Consequent placental release of cytokines and inflammatory factors into the maternal circulation triggers endothelial dysfunction (increasing vascular reactivity and permeability) and coagulation cascade activation. Multisystem organ dysfunction results [3].

Airway

- Laryngeal and pharyngeal oedema.

Respiratory

- Pulmonary oedema.

Cardiovascular

- Hypertension.
- Increased sensitivity to endogenous and exogenous catecholamines.
- Elevated systemic vascular resistance (SVR).
- Reduced circulating blood volume.

Neurological

- Visual disturbance.
- Headache.
- Hyper-reflexia.
- Cerebrovascular oedema and haemorrhage.
- Eclampsia.

Haematological

- Thrombocytopenia.
- Hypercoagulability [4].
- DIC.
- Haemolysis.

Renal

- Intrarenal vasospasm causing reduction in glomerular filtration rate (GFR) and consequent oliguria.
- Proteinuria due to increased glomerular permeability to large molecules.
- Hyperuricaemia. Uric acid levels rise with advancing pregnancy but tend to be higher in women with pre-eclampsia [2]. There is no universally accepted level that can confirm diagnosis and the precise level is a poor predictor of adverse maternal and fetal outcomes [5].

Hepatic

- Abnormal liver function tests develop as a consequence of ischaemia and hepatic tissue necrosis. Ultimately, synthetic function deteriorates resulting in abnormal coagulation.
- Subcapsular haemorrhage.
- Liver rupture.

Fetal

- Intrauterine growth restriction (IUGR) (Please see Chap. 37).
- Oligohydramnios.
- Placental ischaemia and infarction.
- Placental abruption.
- Pre-term labour (Please see Chap. 33).

Haemolysis, Elevated Liver enzymes and Low Platelet count (HELLP) Syndrome

HELLP is associated with pre-eclampsia but can occur in the absence of hypertension or proteinuria. It is considered to be on a spectrum of disease due to overlap of pathology and symptoms.

It is diagnosed by the presence of:

- *H*aemolysis (lactate dehydrogenase >600 IU/L, total bilirubin >20 μmol/L, or on a blood film)—haemolysis is often the last abnormality to occur.
- *E*levated *L*iver enzymes (AST, ALT or gamma-glutamyl transferase (GGT) >70 IU/L); and
- *L*ow *P*latelets ($<100 \times 10^9$/L).
- The biochemical and haematological changes occur due to a microangiopathic haemolytic anaemia, platelet consumption, and hepatic ischaemia with periportal haemorrhage.
- HELLP is characterised by rapid clinical deterioration and confers a higher risk of maternal death [6].

Management of Pre-eclampsia

The ultimate treatment for pre-eclampsia, and HELLP, is delivery of the placenta. However, the disease process may worsen (or first present) after delivery, before recovery starts. Timing of delivery is determined by the severity of disease. Generally, the balance of maternal and fetal risks favour conservative management until 37 weeks gestation after which time the balance favours delivery [1, 2]. The mode of delivery is determined by routine obstetric considerations [1, 2].

Prevention

NICE guidance recommends aspirin 75–150 mg (ACOG guidance recommends 81 mg, tablets being available in this dose in the USA) daily from 12 weeks' gestation until delivery for any woman with one high, or two or moderate, risk factors (Table 39.2).

Table 39.2 NICE moderate and high risk factors for the development of pre-eclampsia [1]

High risk factors	Moderate risk factors
Hypertensive disease during a previous pregnancy	First pregnancy
Chronic kidney disease	Age $\geq$ 40 years
Autoimmune disease	Pregnancy interval $\geq$ 10 years
Type 1 or 2 diabetes mellitus	Body mass index (BMI) $\geq$ 35 kg/m^2 at first visit
Chronic hypertension	Family history of pre-eclampsia
	Multiple pregnancy

ACOG guidance classifies multiple pregnancy as a high rather than moderate risk factor. ACOG moderate risk factors differ in that they state age $\geq$35 years and BMI $\geq$30 kg/m^2 and also include:

- sociodemographic characteristics (such as African American race and low socioeconomic status)
- personal history factors (such as low birth weight, small for gestational age, previous adverse pregnancy outcome) [2].

Blood Pressure Management

- Blood pressure should be controlled to below 135/85 mmHg [1].
- Oral labetalol is the first choice, initially 200 mg twice to three times daily. Alternatives include oral nifedipine and methyldopa [1].
- In severe hypertension, intravenous (IV) therapy may be required using labetalol (5–10 mg IV every 10 minutes) or hydralazine (5 mg IV increments to a maximum of 20 mg). Continuous IV infusion therapy may then be required. Invasive monitoring and high dependency (Level 2) care should be considered with IV treatment [7].

Seizures

- IV magnesium sulphate is indicated for prevention and treatment of eclamptic seizures and should be considered in women with pre-eclampsia with severe features who are in a critical care setting if delivery of the fetus is planned within 24 hours [1, 8].

- A loading dose of magnesium sulphate 4–5 g over 5–15 minutes is followed by an infusion of 1 g/hour for 24 hours. The infusion should be continued for 24 hours following a seizure [1, 2], or after delivery, whichever is the later [2].
- Recurrent seizures are treated with further 2–4 g boluses of magnesium sulphate [1].
- Patients should be monitored for signs of magnesium toxicity (suppression of patellar reflexes and hypoxia secondary to respiratory depression) and, if present, levels checked (adverse effects being seen at levels above 3.5 mmol/L) [2]. Magnesium is predominantly renally excreted and so oliguria may have a significant impact on serum levels [2].

Fluid Management

- Fluid restriction (1 ml/kg/h to a maximum of 80 ml/h, to include drugs, oral and IV intake) in pre-eclampsia with severe features reduces the risk of pulmonary and cerebral oedema [1].
- Fluids in excess of this may be required in the event of haemorrhage or on initiation of IV hydralazine (which may result in profound hypotension and fetal compromise) [1].
- Treatment of pulmonary oedema is with oxygen, fluid restriction, diuretic treatment (e.g. furosemide boluses of 20–60 mg), and urgent delivery of the fetus.
- Non-invasive ventilation (such as continuous positive airway pressure by face mask) should be considered if pulmonary oedema is unresponsive to medical management or if there is significant hypoxaemia, acidosis or respiratory distress. Intubation and ventilation may be required for severe cases.

Analgesia and Anaesthesia for the Pre-eclamptic Patient

Labour Analgesia

- Epidural analgesia is the technique of choice for labour. It offers the benefits of vasodilatation, reduction of surges in blood pressure associated with contractions, and the means by which rapid anaesthesia may be achieved for urgent caesarean delivery.
- The Society for Obstetric Anesthesia and Perinatology (SOAP) suggests that a platelet count of 70×10^9/L is a safe lower limit for neuraxial techniques (in the absence of a possible or diagnosed underlying bleeding disorder, or clinical signs of coagulopathy) [9]. However, the Association of Anaesthetists of Great Britain and Ireland (AAGBI) and SOAP both emphasise that risk is a continuum, rather than a binary state, and that the risk of a neuraxial technique should be viewed in the context of other risks in a given situation, including those posed by general

anaesthesia, and consideration should be given to the relatives risks posed by spinal anaesthesia (smaller needle, less likely to cause bleeding) over epidural analgesia [9, 10].
- The interval between platelet count and neuraxial technique is determined by the severity of pre-eclampsia, the nature of the disease process (a more rapid decline may be seen in HELLP), and the overall trend. A platelet count used to inform a decision regarding a neuraxial technique should be recent, ideally taken within the preceding 6 hours [10].
- If platelet count is $<100 \times 10^9$/L, it is important to demonstrate a normal coagulation screen [10].
- Platelet function testing using thromboelastrography (TEG) or rotational thromboelastometry (ROTEM) may allow neuraxial techniques at platelet counts $<70 \times 10^9$/L. (see Chap. 21)
- A platelet count should be checked before removing an epidural catheter if it has previously been low, intervening haemorrhage has occurred, or there have been other indicators of deterioration in maternal condition.

Anaesthesia for Caesarean Delivery

Neuraxial Anaesthesia

- In the absence of contraindications, epidural and spinal anaesthesia are the techniques of choice for caesarean delivery in pre-eclampsia [2].
- Pre-eclamptic women may be less susceptible to the hypotensive effects of spinal anaesthesia and vasopressors may have an exaggerated effect [11].
- Invasive monitoring or minimally invasive cardiac output monitoring to guide vasopressor use should be considered.
- Effective postoperative analgesia is required. Non-steroidal anti-inflammatory drugs (NSAIDs) remain preferable to opioid analgesia in pre-eclampsia [2], but should be avoided in patients with or at high risk of acute kidney injury [12].
- An escalated level of care should be considered.

General Anaesthesia (GA)

- Risks of general anaesthesia include hypertensive responses to airway instrumentation and a difficult airway caused by laryngeal oedema.
- GA may be unavoidable in uncontrolled seizures, pulmonary oedema, coagulopathy, or thrombocytopenia.
- A smaller tube size may be required in the presence of laryngeal oedema. Indirect laryngoscopy or awake fibre optic intubation should be considered.

- A ramped position (elevation of the torso and head accompanied by slight neck extension to bring the tragus of the ear in the same horizontal line as the suprasternal notch) facilitates oxygenation and intubation, and reduces passive regurgitation. However, such positioning encourages venous pooling in the lower limbs which may contribute to hypotension under anaesthesia.
- Pharmacological options to obtund the laryngeal response include IV remifentanil (1 mcg/kg), lidocaine (1.5 mg/kg), esmolol (1 mg/kg) and alfentanil (10–20 mcg/kg one minute before induction) [13–15].
- Prior administration of magnesium sulphate may lead to an absence of fasciculations after administration of suxamethonium and may prolong the action of non-depolarising muscle relaxants such as rocuronium [2].
- Adequate analgesia should be ensured before extubation to avoid a hypertensive response to pain.
- The presence of an air leak should be assured after cuff deflation prior to extubation; the absence of a leak would imply significant airway oedema.
- An escalated level of care should be considered post-operatively [1].
- Pharmacological venous thromboembolism (VTE) prophylaxis should be instituted after surgery if indicated by a VTE risk assessment unless any contraindications are present, including a low platelet count or bleeding.

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Cholestasis of Pregnancy

40

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Pathophysiology

Definition: Intrahepatic Cholestasis of Pregnancy (Obstetric Cholestasis) is a pregnancy-specific liver disease which manifests as maternal pruritus with deranged liver transaminases and/or elevated serum bile acids [1, 2] (>10 μmol/L) [3]. Presentation is usually in the late second or third trimester of pregnancy [2, 3].

Incidence: 0.7% of pregnancies in the UK are affected [1, 2], with 9.2 per 10,000 pregnancies being classified as severe obstetric cholestasis (Bile acids > 40 μmol/L) [2]. However, ethnicity plays a role and the incidence in Asian populations may be twice as high [1] while the incidence in South American populations may reach 4% [3].

Pathogenesis: The pathogenesis is poorly defined but may result from increased hepatic metabolism of oestrogen and/or progesterone [4]. Studies in animals and human tissue samples suggest that bile acids may have an effect on myometrial contractility [2], oxytocin receptor expression [3] and sensitivity [2, 3], placental vasoconstriction [3], fetal colonic motility [2], fetal cardiomyocytes (predisposing to arrhythmias) [2, 3] and fetal pulmonary atelectasis with inflammation [2].

Symptoms: Pruritus (without a rash) is particularly prevalent on the palms of the hands and soles of the feet and classically occurs at night [1]. Presentation may occur earlier in a multiple pregnancy [2].

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Investigations: Liver Function Tests (LFTs) elevated above normal pregnancy ranges and/or elevated bile acids without another cause, both of which resolve after delivery [1]. Liver function tests do not accurately correlate with serum bile acids [2]. In some cases, steatorrhoea (pale stools with excess fat content) can lead to decreased Vitamin K absorption and prolongation of prothrombin time (PT).

Prognosis: Maternal disease manifests as severe pruritus with consequent sleep deprivation [1], although maternal outcomes are generally good. LFTs may initially rise in the 10 days postpartum [1] but complete resolution occurs after delivery [2]. The importance of diagnosing the condition relates to the associated increased maternal morbidity & perinatal morbidity & mortality:

- Increased incidence of fetal distress (of unknown aetiology but higher serum concentrations of bile acids appear to increase the risk).
- Twice the incidence of pre-term labour; some cases are due to an obstetric decision to expedite delivery.
- Increased incidence of meconium staining of the amniotic fluid, which at birth is associated with lower Apgar scores, lower umbilical cord pH and increased admissions to the neonatal intensive care unit due to meconium aspiration.
- Increased incidence of stillbirths (perinatal mortality rate: 18 per 1,000 births). Stillbirths occur more commonly at later gestations (>40 wks).
- Increased risk of fetal intracranial haemorrhage (ICH) and maternal postpartum haemorrhage (PPH) secondary to the malabsorption of vitamin K from the intestine [2, 3].

The severity of maternal symptoms & the degree of abnormality of liver function tests do not correlate with obstetric outcome. The risk of adverse outcome is related to bile acid levels with risks of adverse outcome rarely reported with levels <40 μmol/L. There is a high likelihood of recurrence in subsequent pregnancies (60–100%) and an association with future hepatobiliary disease.

Management

Obstetric Management:

- Obstetric cholestasis is a diagnosis of exclusion and alternative causes of pruritis and hepatic dysfunction in pregnancy must be explored [1]. Liver ultrasound to exclude extrahepatic obstruction, hepatitis screen (this includes screening hepatitis A, B, C, Epstein Barr Virus and Cytomegalovirus serology) and an autoantibody screen to exclude pre-existing liver disease.
- Close surveillance with weekly LFTs [1] and monitoring of serum bile acids is advised.

- Treatment with Ursodeoxycholic Acid is used orally to decrease pruritus [1–3], reduce serum bile acids and prolong pregnancy [3], although benefits to the fetus are unproven [1–5].
- Oral vitamin K is indicated in the treatment of a prolonged prothrombin time and given from 34 weeks gestation [1].
- Given the increased risk of adverse neonatal outcomes, obstetricians favour an early delivery from 37 weeks [1].

Anaesthetic Considerations:

- Women may present for elective or emergency caesarean delivery, triggered by a deterioration in biochemical markers.
- Alternatively, patients may request an epidural following induction of labour for cholestasis of pregnancy.
- Existing data shows that risk of coagulopathy is low [6], although it may develop as a result of decreased intestinal absorption of oral Vitamin K [7].
- A coagulation screen is recommended before any neuraxial technique, and since changes do not occur rapidly, an INR ≤ 1.4 within 24 h is acceptable [7].
- PPH has not been shown to correlate with bile acid concentrations [3] and the reported incidence varies—from no increased risk in those with normal coagulation screens [6] to an increased risk in those with prolonged coagulation times [1].
- Given the potential for coagulopathy, there may be a role for point of care testing during caesarean delivery and haemorrhage management.

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Gestational Diabetes

41

Vanessa Cowie

Introduction

Diabetes is known to affect maternal and fetal health (Table 41.1). Tight glucose control during pregnancy is important in optimising obstetric outcomes.

Women who have diabetes in pregnancy fall into three groups:

1. Gestational Diabetes Mellitus (GDM) is any degree of glucose intolerance with an onset or first recognition during pregnancy.

   - Diagnosed if the woman has either a fasting plasma glucose of ≥ 5.6 mmol/L (≥ 100 mg/dL) OR a 2-hour plasma glucose (as part of glucose tolerance test) of ≥ 7.8 mmol/L (≥ 140 mg/dL) [2].
   - Managed with diet, oral hypoglycaemics, or insulin.

2. Type 1 Diabetes Mellitus (DM)—a chronic condition where the pancreas produces little or no insulin by itself.

   - Patients are likely to have this diagnosis before pregnancy, and will be treated with insulin.
   - Their treatment regimen is likely to be changed, due to the increased insulin requirement.

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Table 41.1 Maternal and fetal risks secondary to diabetes mellitus

Maternal	Fetal
Miscarriage	Stillbirth
Pre-eclampsia	Congenital malformations[a]
Pre-term labour	Macrosomia (birth wt. >4000 g)
Diabetic complications:	Birth injury (secondary to macrosomia)
• diabetic ketoacidosis	Perinatal mortality (two-fold risk)
• hyperosmolar hyperglycaemic state	Sudden unexplained fetal death
• increased risk of infections (e.g. urinary)	
• worsening of:	
- retinopathy/nephropathy	
- neuropathy	
- micro/macro angiopathy	
- hypoglycaemia	

[a]e.g. Sacral agenesis, situs inversus, duplex ureter, cardiac anomalies [1]

3. Type 2 Diabetes Mellitus—The body is unable to respond properly to the action of insulin.

   - Patients may have this before they get pregnant. This can be treated with diet, oral hypoglycaemics or insulin.
   - Patients are often on oral hypoglycaemics when they become pregnant, these may need to be changed due to the risk of teratogenesis (with all hypoglycaemic drugs except metformin and glyburide) and some may need to start taking insulin.

Epidemiology

Approximately 5% of women who give birth in the UK either have pre-existing diabetes or gestational diabetes.

Of women who have diabetes in pregnancy:
- 87.5% have GDM
- 7.5% have Type 1 DM
- 5% have Type 2 DM.

The prevalence of Type 1 and especially Type 2 DM is increasing. The incidence of GDM is also increasing due to higher rates of obesity and pregnancy in older women.

Management of Diabetes in Pregnancy

The aim of management is to achieve near normoglycaemic levels to prevent adverse perinatal outcomes.

Screening:

- Screening for GDM is offered to patients with at least one risk factor:
  - Body Mass Index (BMI) >30
  - Previous baby weighing >4.5 kg at birth
  - Previous GDM
  - One or more siblings with DM
  - Family origin: South Asian, China, African-Caribbean or Middle Eastern.
- An oral glucose tolerance test (GTT) is performed between 24 and 28 weeks gestation.

Antenatal Care:

- It is recommended that pregnant women with any form of diabetes should maintain a capillary blood glucose (CBG) below the following targets:
  - Fasting 5.3 mmol/L (95 mg/dL) AND
  - 1 hour after meals: 7.8 mmol/L (140 mg/dL) OR
  - 2 hours after meals: 6.4 mmol/L (115 mg/dL) [2].
- An anaesthetic assessment is recommended in the 3rd trimester for all women with diabetes who also have co-morbidities such as obesity or autonomic dysfunction.
- Diabetic treatment during pregnancy [3]
  - Type 1 and 2 DM is usually jointly managed by endocrine and obstetric teams and will involve stopping all oral hypoglycaemics except metformin (or glyburide) due to the risk of fetal teratogenesis. An insulin regimen would normally consist of individualised multiple daily subcutaneous (sc) injections.
  - GDM management involves a combination of diet and exercise with the addition of medications if these measures do not control the blood sugar levels.
    - 70–80% of patients diagnosed with GDM can control their GDM with lifestyle modification alone [4, 5].
    - Patients with greater initial degrees of hyperglycaemia may require early initiation of pharmacological therapy.
    - Oral glyburide may be inferior to sc insulin injections and oral metformin due to an increased risk of neonatal hypoglycaemia and macrosomia [6, 7].
    - Metformin is associated with a lower risk of maternal hypoglycaemia and potential weight gain. It may be preferable to insulin if it successfully controls hyperglycaemia [8].
- The patient must be informed of the risks and management of hypoglycaemia.

Timing of delivery:

- Patients with pre-existing diabetes are advised to have an elective birth (induction of labour or caesarean delivery) between 37 and 38 + 6 weeks if there are no maternal or fetal complications, or earlier if there are complications.
- GDM patients with no maternal or fetal complications should give birth no later than 40 + 6 weeks or be offered an induction of labour or (if indicated) caesarean delivery if they have not delivered by this time. Those with maternal or fetal complications should be offered elective birth before 40 + 6 weeks.

Intra-partum Care:

- Hourly blood sugar monitoring during labour and birth, aiming for a level between 4 and 7 mmol/L (75–125 mg/dL). This is because maternal hyperglycaemia may cause neonatal hypoglycaemia [9].
- An intravenous variable rate intravenous insulin infusion (VRIII) using a syringe infusion pump should be considered for all women with type 1 diabetes from the onset of established labour, and for women whose blood sugar is not maintained between 4 and 7 mmol/litre (75–125 mg/dL)
  - A typical VRIII (Table 41.2) [10] consists of 50 international units (IU) of human soluble insulin added to 49.5 ml of normal saline (NaCl) 0.9% (1 IU per ml). This should be labelled and infused into the same cannula as the intravenous fluid infusion (5% dextrose). The rate of this infusion is then altered depending on the capillary blood glucose level.
  - The patient should receive a 5% dextrose infusion along with the insulin. This should be supplemented with potassium depending on the plasma potassium level (the patient's urea and electrolyte levels should be monitored at least daily). This is because patients on VRIII are at risk of hypokalaemia as insulin causes the movement of potassium ions intracelluarly.
  - Patients receiving steroids, for example to promote fetal lung maturity in preterm labour, are at risk of a deterioration in blood glucose control. Their VRIII will need to be adjusted accordingly.
- Autonomic neuropathy can complicate DM and present with non-specific symptoms such as nausea, vomiting and dizziness.

Postnatal Care: maternal blood glucose control, medicines and breastfeeding:

- Pre-existing DM on insulin: patients should reduce their insulin immediately after birth and monitor blood glucose levels carefully to establish the appropriate dose.
- GDM: discontinue blood glucose-lowering therapy immediately after birth.
- Pre-existing Type 2 DM: patients can resume their usual medications, while taking in to consideration the implications of breastfeeding and the increased risk of hypoglycaemia.

Table 41.2 An example of a VRIII for use during labour (50 units Actrapid® or Humulin® S insulin in 49.5 ml 0.9% NaCl via a syringe driver pump). Published with permission from the British Diabetic Association / Diabetes UK

	DOSING ALGORITHM (Please see the guide below)		
Algorithm >	**1**	**2**	**3**
	For most women	For women not controlled on algorithm 1 or needing > 80 units/day of insulin	For women not controlled on algorithm 2 (after specialist advice)
CBG Levels (mmol/L)	Infusion Rate (units/hr = ml/hr)		
< 4	STOP INSULIN FOR 20 MINUTES Treat hypo as per guideline (re-check CBG in 10 minutes)		
4.0 – 5.5	0.2	0.5	1.0
5.6 – 7.0	0.5	1.0	2.0
7.1 – 8.5	1.0	1.5	3.0
8.6 – 11.0	1.5	2.0	4.0
11.1 – 14.0	2.0	2.5	5.0
14.1 – 17.0	2.5	3.0	6.0
17.1 – 20.0	3.0	4.0	7.0
> 20.1	4.0	6.0	8.0

ALGORITHM GUIDE

- **ALL** women with diabetes should have Capillary Blood Glucose (CBG) testing hourly in established labour and at least once on admission for induction of labour or elective C-section
- Start VRIII and Fluids if CBG > target (see below) or at the start of established labour if the woman has type 1 diabetes

Algorithm 1 Most women will start here

Algorithm 2 Use this algorithm for women who are likely to require more insulin (on steroids; on > 80 units of insulin during pregnancy; or those not achieving target on algorithm 1)

Algorithm 3 Use this for women who are not achieving target on algorithm 2 (No patient starts here without diabetes or medical review)

If the woman is not achieving targets with these algorithms, contact the diabetes team (out of hours: Medical SpR on call)

Target CBG level = 4 – 7 mmol/L

Check CBG every hour whilst on VRIII and every half an hour during anaesthesia

Move to the higher algorithm if the CBG is > target and is not dropping

Move to the lower algorithm if CBG falls below 4 mmol/L or is dropping too fast

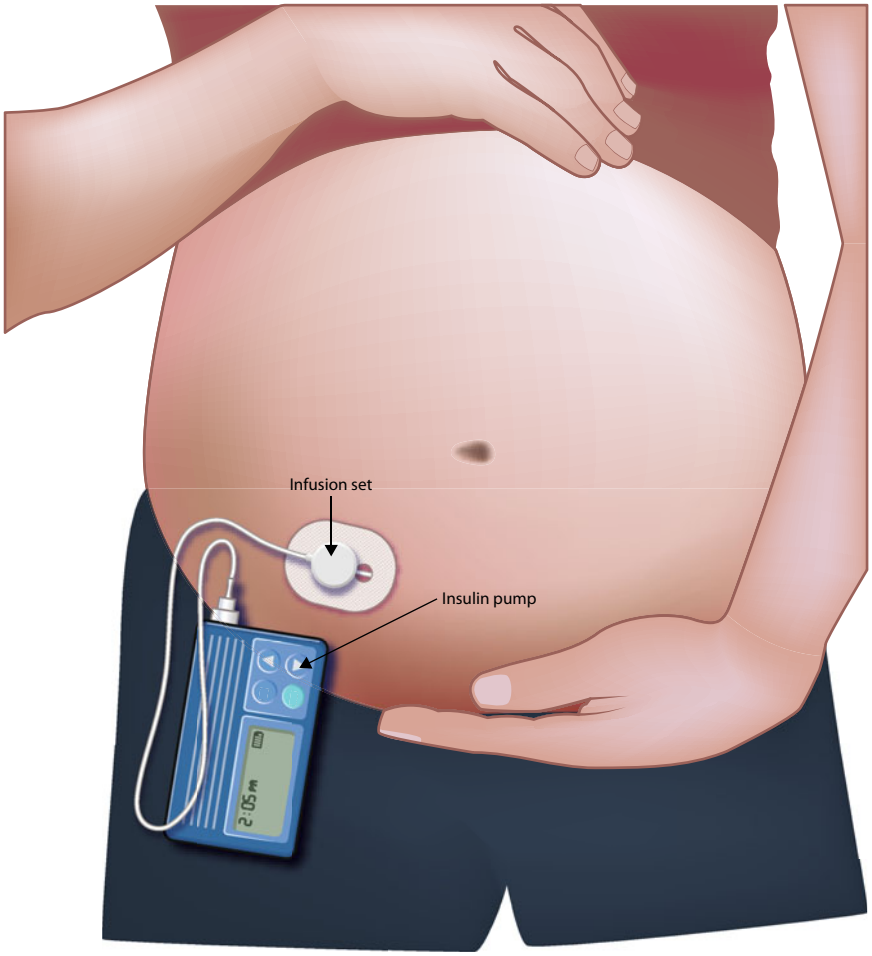

Fig. 41.1 Miniature insulin pump delivering subcutaneous insulin

Recent Developments for Treating Diabetes

A small proportion of pregnant patients are now using miniature insulin pumps (delivering sc insulin) (Fig. 41.1). Some pumps have inbuilt sensors and automatically change the dose of insulin delivered; however, the majority of pumps rely on the patient to perform glucose testing and manually change the pump settings. Many pumps can deliver bolus doses along with continuous infusions. The site of the subcutaneous cannula may need to be changed if surgery is required and the cannula is within the surgical field. The efficacy of these pumps in terms of tight glucose control is thought to be superior [11] although evidence in this area is limited.

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Obstetric Venous Thromboembolism

42

Matthew Samuel and Sarah Armstrong

Background

- Venous thromboembolism (VTE) remains the leading cause of direct maternal death (i.e. resulting from an obstetric complication of pregnancy) in the UK [1]
- Maternal mortality from Pulmonary Embolism (PE) has fallen in the last two decades [2], which has been attributed to better identification of those at risk and appropriate use of thromboprophylaxis
- There is a 4–fivefold increase in the relative risk of VTE in pregnancy compared to non-pregnant women of the same age [3, 4]
- Incidence of VTE is 1 in 1000 pregnancies [5]
- Fatal VTE can occur at any point during the antenatal or postnatal period but the relative risk rises with gestational age and is greatest immediately post-partum [5]
- Most pregnant or recently pregnant women who die from PE will have had identifiable risk factors [6]
- Therefore, VTE assessment is important in identifying women at greater risk who would benefit from thromboprophylaxis
- Decisions about thromboprophylaxis and treatment of VTE should be made by a multidisciplinary team comprising obstetricians, anaesthetists and haematologists.

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Prevention

- VTE assessment should occur either before or in early pregnancy, and should be repeated on admission to hospital, during development of any intercurrent illness and again during the postpartum period
- Many hospitals have an online mandatory VTE evaluation process during a patient admission episode, which is linked to the hospitals' electronic health record (EHR) system
- Risk factors can be divided into maternal risk factors and additional risk factors relating to events around the time of delivery (Table 42.1)
- Identification of these risk factors at the antenatal and postnatal stage can lead to stratification into low, intermediate and high-risk groups (Tables 42.2 and 42.3).

Important Points

- The first postnatal low molecular weight heparin (LMWH) dose should be given as soon after delivery as possible
- Careful consideration to thromboprophylaxis should be given following a postpartum haemorrhage [PPH], bearing in mind that PPH is itself a risk factor for VTE
- Appropriate intervals for thromboprophylaxis after neuraxial anaesthesia are detailed in Table 42.4.
- All women who have had a caesarean delivery in labour and women who have undergone an elective caesarean delivery and have one or more additional risk

Table 42.1 Risk factors divided into those related to the mother, which are present from or predate conception and additional risk factors related to events around delivery

Maternal	Additional peripartum or postpartum
Previous VTE	Preterm delivery (<37 weeks)
Age >35 years	Stillbirth
Obesity (BMI ≥ 30)	Antepartum haemorrhage
Multiparity (>2)	Caesarean delivery
Smoking	Postpartum haemorrhage
Medical illness e.g. Sickle cell, heart disease, SLE	Postpartum infection
Varicose veins	Blood transfusion
Immobility	
Pre-eclampsia	
Hyperemesis	
Assisted reproductive technology	
Multiple pregnancy (twins, triplets)	

SLE systemic lupus erythematosus; **LMWH** low-molecular-weight heparin; **VTE** venous thromboembolism; **BMI** body mass index

Table 42.2 Antenatal assessment of risk factors divided according to associated risk, [2]. Adapted from Green-top Guideline No. 37a (Appendix I); Reducing the Risk of Venous Thromboembolism during Pregnancy and the Puerperium. Reproduced with the permission of the Royal College of Obstetricians and Gynaecologists UK (RCOG)

High risk: any of following risk factors Plan: antenatal LMWH (as early as possible)	- any previous VTE, except single event related to major surgery
Intermediate risk: any of following risk factors Plan: consider antenatal prophylaxis with LMWH	- any antenatal hospital admission - single previous VTE after major surgery - high risk thrombophilia + no VTE - medical comorbidities e.g. cancer, heart failure, SLE - any surgical procedure - ovarian hyperstimulation syndrome (OHSS)
Intermediate risk: 4 or more of following risk factors Plan: LMWH thromboprophylaxis from 1st trimester	- BMI >30 - age >35 - parity ≥ 3 - smoker - gross varicose veins - co-existing pre-eclampsia - immobility - family history of unprovoked VTE - low risk thrombophilia - multiple pregnancy - assisted reproductive technology
Intermediate risk: 3 of following risk factors Plan: LMWH thromboprophylaxis from 28 weeks	
Low risk: if less than 3 of following risk factors Plan: encourage mobilisation/avoid dehydration	

VTE venous thromboembolism; **LMWH** low-molecular-weight heparin; **BMI** body mass index; **SLE** systemic lupus erythematosus

factors are at intermediate risk and therefore should receive postnatal thromboprophylaxis

- Women at high risk of haemorrhage (in addition to high thrombotic risk) should be managed with anti-embolism stockings and intermittent pneumatic compression devices. Unfractionated heparin (UFH) should also be considered.
- Women with VTE associated with high risk thrombophilia e.g. antithrombin deficiency, antiphospholipid syndrome are often managed with higher dose thromboprophylaxis guided by specialist input from a senior haematologist.

Pharmacological Agents

Low Molecular Weight Heparin (LMWH)

- LMWH is the preferred agent where antenatal and postnatal thromboprophylaxis is indicated

Table 42.3 Postnatal assessment or risk factors divided according to associated risk, [2]. Adapted from Green-top Guideline No. 37a (Appendix I); Reducing the Risk of Venous Thromboembolism during Pregnancy and the Puerperium. Reproduced with the permission of the Royal College of Obstetricians and Gynaecologists UK (RCOG)

High risk: any of the following factors Plan: 6 weeks minimum - postnatal LMWH thromboprophylaxis	- previous VTE - receiving antenatal LMWH - high risk thrombophilia - low-risk thrombophilia + family history
Intermediate risk: any of the following risk factors Plan: 10 days minimum - postnatal LMWH thromboprophylaxis	- caesarean delivery in labour - BMI >40 - readmission/ prolonged admission in puerperium - any surgical procedure in puerperium except repair of perineum - medical comorbidities e.g. cancer, heart failure, SLE
Intermediate risk: 2 or more of the following risk factors Plan: 10 days minimum - postnatal LMWH prophylaxis	- age >35 - BMI >30 - parity ≥ 3 - smoker
Lower risk: 1 of the following risk factors Plan: Encourage mobilisation and avoidance of dehydration	- family history of unprovoked VTE - low risk thrombophilia - gross varicose veins - current systemic infection - immobility - co-existing pre-eclampsia - multiple pregnancy - pre-term delivery - stillbirth - operative delivery - prolonged labour >24 h - PPH >1L or blood transfusion

VTE venous thromboembolism; **LMWH** low-molecular-weight heparin; **PPH** postpartum haemorrhage

Table 42.4 Recommended intervals relating to LMWH and neuraxial block performance [7]

	Acceptable time after drug for block performance	Acceptable time after neuraxial block or epidural catheter removal for the next LMWH dose
LMWH subcutaneous prophylaxis	12 h	4 h
LMWH subcutaneous therapeutic	24 h	4 h

LMWH low-molecular-weight heparin

- Doses are based on the antenatal clinic booking weight, it does not require coagulation monitoring and women are advised to continue to self-administer LMWH until labour begins
- Recommended intervals between LMWH administration and neuraxial block performance are detailed in Table 42.4.

Unfractionated heparin (UFH)

- UFH may be used in preference to LMWH in patients where there is high risk of both thrombosis and haemorrhage
- Due to the short duration of action of UFH compared to LMWH, UFH offers greater flexibility in the timing of neuraxial anaesthesia as well as reducing the risk of haemorrhage.
- Recommended intervals between UFH administration and neuraxial block performance are detailed in Table 42.5.

Warfarin (Vitamin K Antagonist)

- Women on long-term warfarin should be counselled about the teratogenic risks to the fetus and advised to change to LMWH as soon as pregnancy is confirmed
- Warfarin is safe in breastfeeding, so these women may revert to back to warfarin early in the postpartum period.

Other Agents

- Antithrombin dependent inhibitors of Factor Xa e.g. Danaparinoid and Fondaparinux can be used in heparin intolerance e.g. allergy, heparin-induced thrombocytopenia with advice from a senior haematologist

Table 42.5 Recommended intervals relating to UFH and neuraxial block performance [7]

	Acceptable time after drug for block performance	Acceptable time after neuraxial block or epidural catheter removal for the next UFH dose
UFH subcutaneous prophylaxis	4 h	1 h
UFH subcutaneous therapeutic	4 h	4 h

UFH unfractionated heparin

Table 42.6 Clinical signs and symptoms of venous thromboembolism

DVT	PE	Both
Leg pain and swelling	Dyspnoea	Low grade pyrexia
Lower abdominal pain	Chest pain	Leucocytosis
	Haemoptysis	
	Cardiovascular collapse	

DVT deep vein thrombosis; **PE** pulmonary embolus

- Novel oral anticoagulants (NOAC) e.g. Rivaroxaban, Dabigatran, Apixaban should be avoided in pregnant women and are not recommended during breastfeeding.

Investigation and Diagnosis of Obstetric VTE (Table 42.6)

See Fig. 42.1.

Treatment of Obstetric VTE

- Facemask oxygen and Airway, Breathing, Circulation assessment
- Administer therapeutic dose LMWH
- UFH is preferred in massive PE with cardiovascular compromise
- Involve senior clinicians (obstetricians, anaesthetists and critical care specialists)
- Urgent bedside echocardiogram or computed tomography pulmonary angiogram (CTPA) if haemodynamically compromised
- Consider thrombolysis (using streptokinase, urokinase, alteplase) in confirmed massive PE with haemodynamic compromise
- Maintenance with therapeutic dose LMWH for the remainder of the pregnancy and for a minimum of 6 weeks postpartum or until a total of 3 months treatment is completed (before reverting to a prophylactic dose for the remainder of the pregnancy)
- Neuraxial anaesthesia techniques are contraindicated until 24 hours after a therapeutic dose of LMWH so consider alternative analgesic and anaesthetic options e.g. intravenous remifentanil patient-controlled analgesia and general anaesthesia in the event of a caesarean delivery.

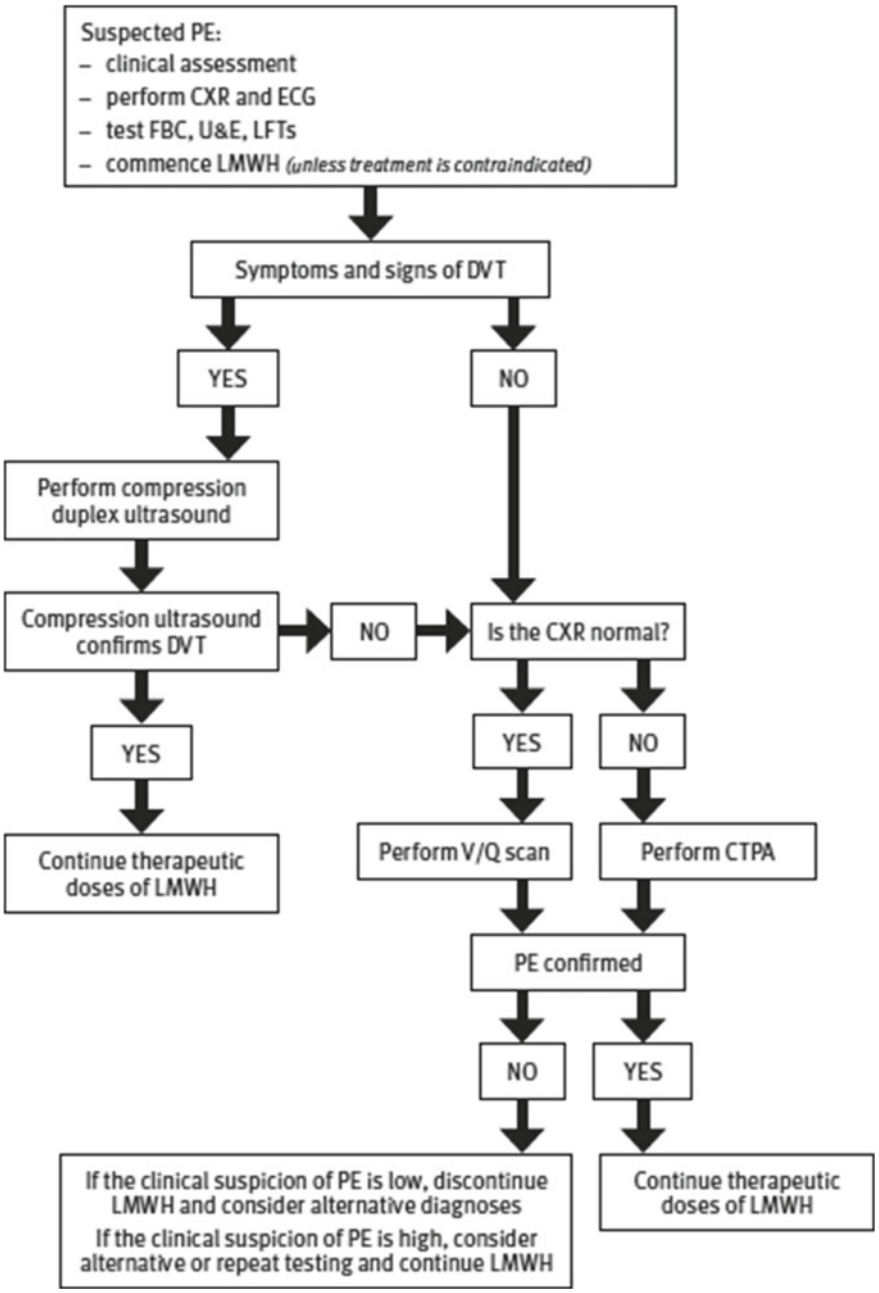

Fig. 42.1 Algorithm for the investigation and initial management of suspected PE in pregnancy and the puerperium [3]. Green-top Guideline 37b (Appendix 1). Thromboembolic Disease in Pregnancy and the Puerperium: Acute Management. Reproduced with the the permission of the Royal College of Obstetricians and Gynaecologists UK (RCOG) **CTPA** computed tomography pulmonary angiogram; **CXR** chest X-ray; **DVT** deep venous thrombosis; **ECG** electrocardiogram; **FBC** full blood count; **LFTs** liver function tests; **LMWH** low-molecular-weight heparin; **PE** pulmonary embolism; **U&E** urea and electrolytes; **V/Q scan** ventilation perfusion scan

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Obesity

43

Sarah Armstrong

Obesity is classified using Body Mass Index (BMI) as:

Class I, BMI $\geq$ 30 kg/m^2.
Class II BMI $\geq$35 kg/m^2.
Class III BMI $\geq$40 kg/m^2.

Worldwide approximately 64% of women of reproductive age are overweight with around 20% of the antenatal population being obese [1].

Obstetric Implications

Obesity increases the complexity of obstetric management due to associated co-morbidities, the incidence of which is increased in these patients; [2]

Pregnancy-related complications	• Gestational diabetes mellitus (GDM) • Gestational hypertension • Pre-eclampsia • Fetal macrosomia • Stillbirth
Labour complications	• Necessity for induction of labour / augmentation • Higher incidence of caesarean delivery
Monitoring	• CTG monitoring may be more challenging • Maternal monitoring (e.g. NIBP)

(continued)

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Fetal complications	• In-utero fetal abnormality diagnosis (by ultrasound) - may be technically challenging • Fetal macrosomia and increased risk of shoulder dystocia
Caesarean delivery	• Increased incidence: - intraoperative blood loss - operative time - post-operative wound infection / endometritis - need for classical caesarean - decision to delivery interval in category 1/2 caesarean delivery

Anaesthetic Implications

Airway	• Difficult intubation more likely (1:300) - Fat pad at the back of the neck - Increased neck soft tissue - Large breasts • Increased aspiration risk
Respiratory	• Obstructive sleep apnoea • Reduction in function residual capacity (FRC) and desaturation in the supine position
Cardiovascular	• Increased incidence of - Hypertension - Hyperlipidaemia - Ischaemic heart disease - Heart failure • Aortocaval compression may be more pronounced
Thromboembolic	• Increased risk of venous and pulmonary thromboembolism • Implications for neuraxial blockade with anticoagulants (therapeutic/prophylactic)

Anaesthetic Management

All women with BMI ≥ 40 kg/m^2 should be assessed antenatally by an experienced obstetric anaesthetist. This should allow early:

- Assessment of the airway for general anaesthesia
- Recognition of logistical problems which may influence the availability of certain equipment:
  – Extra length (≥ 11 cm) epidural/spinal/CSE needles (Fig. 43.1)

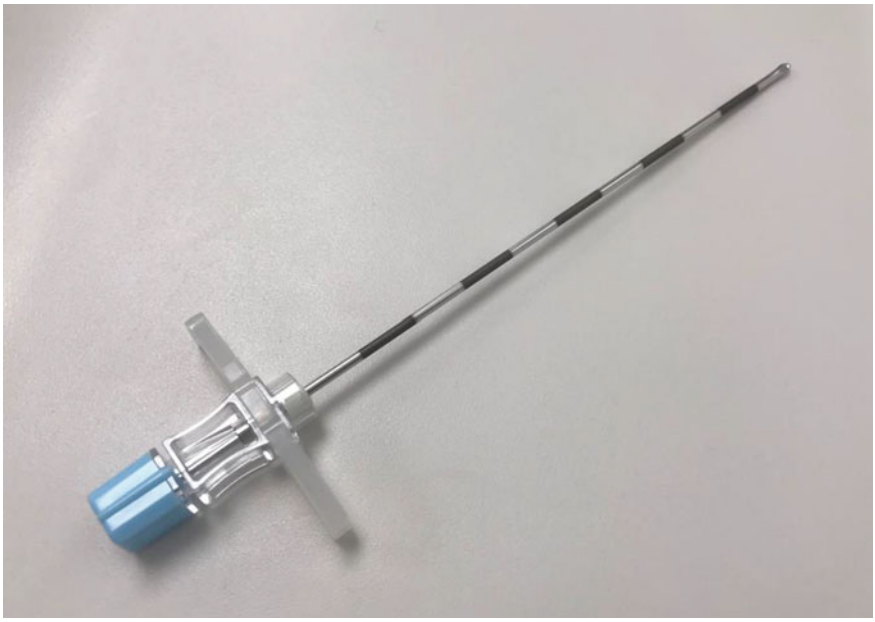


Fig. 43.1 An 11 cm epidural needle (Smiths Medical) Reproduced with the permission of Smiths Medical, Plymouth, MN, USA

  - Larger non-invasive blood pressure (NIBP) cuff OR invasive blood pressure monitoring
  - Operating tables with increased weight limits
  - Hover mattresses (e.g. HoverMatt®) to prevent pressure sores (Fig. 43.2) and to facilitate moving the patient (e.g. from the bed to the operating table)
  - Hoists for moving anaesthetised patients
  - Difficult airway equipment (short handled laryngoscopes, Oxford HELP® intubation pillow (Figs. 43.3, 43.4 and 43.5)), videolaryngoscopes (Fig. 43.6), Proseal® LMA (Fig. 43.7), nasal oxygen delivery systems (e.g. Optiflow THRIVE®) for preoxygenation)

- Discussion with the mother regarding early epidural placement and plan for labour

In the event of an operative procedure being required:

- Antacid prophylaxis should be instituted (eg oral omeprazole 40 mg preoperatively, oral sodium citrate 0.3 M in theatre)
- Caution must be taken with the timing of therapeutic or prophylactic thromboprophylaxis (more likely in obese patients) and subsequent neuraxial

Fig. 43.2 HoverMatt® air transfer system. The HoverMatt® is placed under the patient then filled with a continuous flow of air. The patient can then be transferred from one bed to another without staff having to lift or strain (published with the permission of HoverTech International, Pennsylvania, USA)

anaesthesia. Ensure appropriate venous thromboembolic prophylaxis is prescribed post-operatively (see Chap. 46)

- Beware of increased bleeding risk and ensure that blood has been taken for a valid blood type and antibody screen in good time. Consider cell-salvage if appropriate.

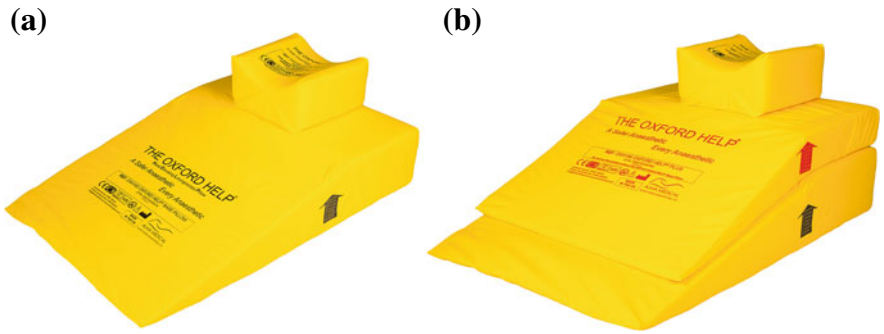


Fig. 43.3 The Oxford HELP Set A consists of an Oxford base pillow to which is added an Oxford Headrest (**a**). The Oxford HELP Set A Plus consists of an Oxford HELP Plus pillow which is added on top of the Oxford HELP Set A (base pillow and headrest) to increase the head elevation and to further improve the view at laryngoscopy (**b**). It is recommended for patients with a BMI over 50 (Published with the permission of Alma Medical, UK)

Fig. 43.4 Patient position **before** using the Oxford HELP® pillow (Published with the permission of Alma Medical, UK)

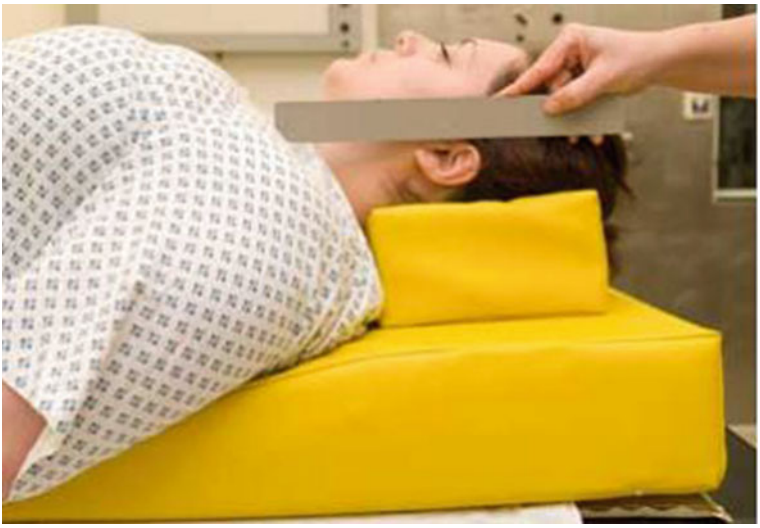


Fig. 43.5 Patient position **after** positioning with the Oxford HELP® pillow (Published with the permission of Alma Medical, UK)

- Discuss with the obstetric team their preferred choice of uterotonic (e.g. if there is a risk of post-partum haemorrhage they may choose to use IV Carbetocin 100 mg as a single iv bolus OR a bolus of 3–5 IU of IV oxytocin followed by a post-operative syntocinon infusion of 10 IU per hour for 4 hours) if appropriate
- Invasive arterial blood pressure monitoring may be required if an upper arm NIBP cuff is difficult to place.
- Establishing neuraxial anaesthesia in the obese patient may be easier with the operating table tilted towards the anaesthetist to compensate for the patient's lumbar lordosis.
- Combined spinal-epidurals have the benefit of allowing extension of the spinal block in the event of a long operative time. In addition, locating the epidural space first may aid location of the dura with the spinal needle using a single interspace needle-through-needle technique. (see Chap. 2)
- In the event of general anaesthesia being required:
  - Ensure (if possible) a senior anaesthetist/"second pair of hands" is available
  - Difficult airway equipment should be available (see above)

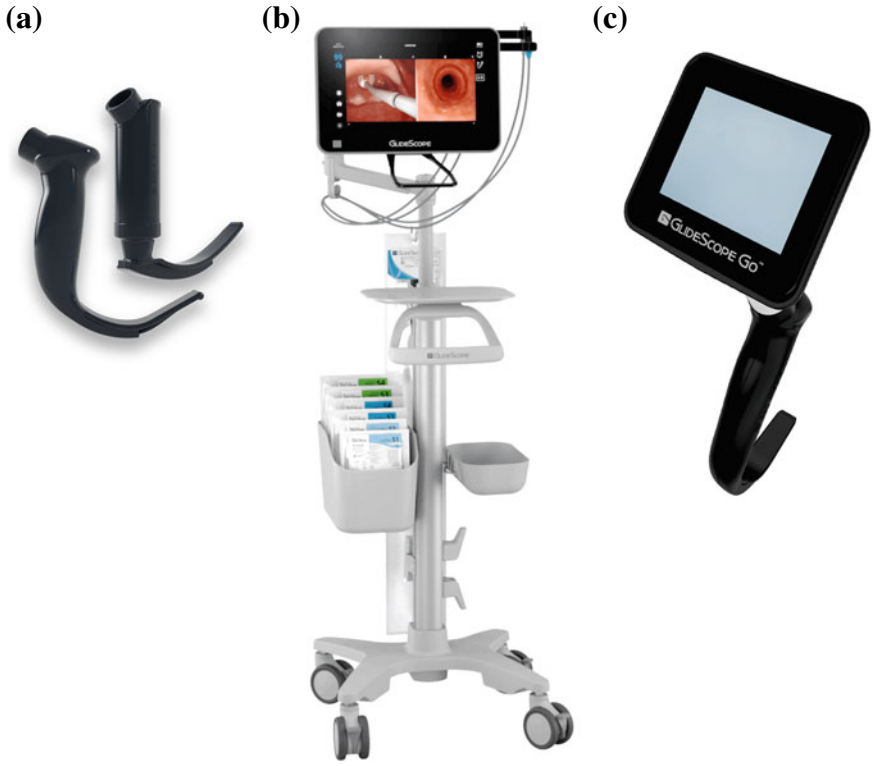
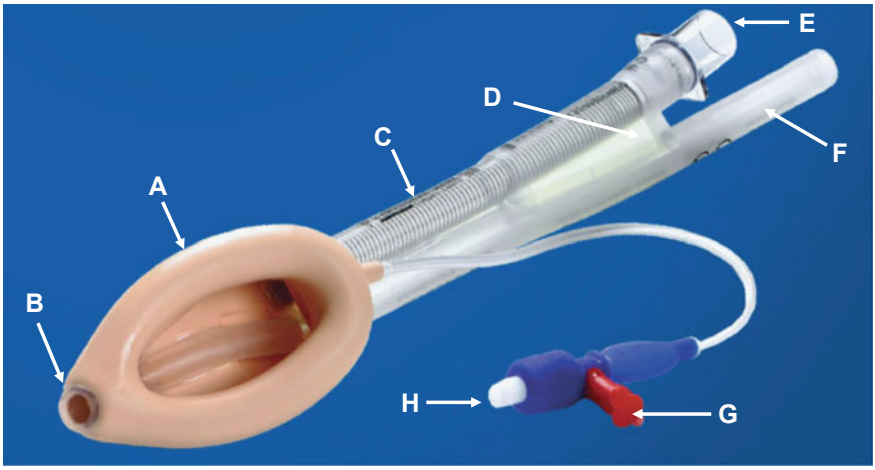


Fig. 43.6 GlideScope® Spectrum single use video laryngoscope blades (**a**) which can be used with the GlideScope® Core monitor (**b**) or the more portable GlideScope® Go handheld system (**c**). Published with permission from Verathon Inc., Washington, USA

- A plan should be communicated to all staff regarding what to do in the event of a failed intubation (following the Obstetric Anaesthetists' Association / Difficult Airway Society (OAA/DAS) difficult airway guidelines in obstetrics [3])
- The head-up, "ramped" position should be used for pre-oxygenation and intubation to maintain the functional residual capacity (FRC) and prolong the time before oxygen desaturation.
- Use appropriate weight-related doses of induction and muscle relaxants.
- Consider the use of postoperative non-invasive ventilation and high dependency unit (HDU) care if there is a history of obstructive sleep apnoea and/or obesity hypoventilation syndrome. A STOP-BANG questionnaire may be useful pre-operatively. (see Fig. 43.8)



- A = oropharyngeal seal
- B = oesophageal seal
- C = wire reinforced airway tube
- D = bite block
- E = 15 mm connector to anaesthesia circuit
- F = oesophageal drain tube
- G = manual vent
- H = LMA cuff inflation one way valve

Fig. 43.7 Features of the Proseal® LMA

STOP-BANG Sleep Apnea Questionnaire

Chung F et al Anesthesiology 2008 and BJA 2012

STOP		
Do you SNORE loudly (louder than talking or loud enough to be heard through closed doors)?	Yes	No
Do you often feel TIRED, fatigued, or sleepy during daytime?	Yes	No
Has anyone OBSERVED you stop breathing during your sleep?	Yes	No
Do you have or are you being treated for high blood PRESSURE?	Yes	No

BANG		
BMI more than 35kg/m2?	Yes	No
AGE over 50 years old?	Yes	No
NECK circumference > 16 inches (40cm)?	Yes	No
GENDER: Male?	Yes	No

TOTAL SCORE		

High risk of OSA: Yes 5 - 8

Intermediate risk of OSA: Yes 3 - 4

Low risk of OSA: Yes 0 - 2

Fig. 43.8 STOP-BANG Questionnaire

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Peri-Partum Cardiomyopathy

44

Ranil Soysa and Daryl Dob

Definition and Incidence

Peri-partum Cardiomyopathy (PPCM) is a rare but potentially fatal condition. It is defined as the development of heart failure in the absence of previous cardiac disease, presenting between the last month of pregnancy to five months post-partum. The prevalence of PPCM has generally been quoted between 1 in 1,000 and 1 in 4,000 worldwide [1], but regions such as Haiti and North Nigeria have shown the prevalence to be as high as 1% [2]. Mortality varies widely but may be as high as 50% [3].

Risk factors for PPCM[a]	
Demographic	Maternal Age (Age >30 years) Race—more likely in women of African descent Lower socioeconomic class (if outside Europe) [4]
Obstetric	Multiple gestation Increased parity Pre-eclampsia
Maternal	Obesity Smoking Diabetes Concurrent hypertension Family history

[a]90% of cases present postpartum

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Pathophysiology

There are three main theories, although none have been proved conclusively.

1. **Nutritional**:

   Iron deficiency resulting in anaemia and cardiac failure together with selenium deficiency leading to a reduction in cardio-protective enzymes.
2. **Hormonal**:
   Prolactin secreted from the pituitary gland causes cardiac endothelial apoptosis, resulting in ischemia of cardio-myocytes and systolic ventricular dysfunction. Oral bromocriptine a prolactin antagonist has been tried with varying results.
   Fms-like Tyrosine Kinase-1 (sFlt1), is a placental hormone which blocks vascular endothelial growth factor (VEGF), reducing angiogenesis, causing cardio-myocyte dysfunction and subsequently cardiac failure. Levels of sFlt1 have been shown to be reduced in peripartum cardiomyopathy [5].
3. **Maternal**:
   The circulatory changes of pregnancy can lead to cardiac stress. These changes, however, are well known to occur earlier in pregnancy.

Symptoms and signs

Clinical manifestations of PPCM	
Symptoms	Signs
Orthopnoea	Sinus tachycardia
Dyspnoea	Raised jugular venous pressure
Fatigue/malaise	Oedema
Neurological deficit from cardiogenic thrombus[a]	Left ventricular displacement
	Pulmonary oedema

[a]A left ventricular thrombus may occur, due to a reduced ejection fraction, in patients with peripartum cardiomyopathy. This can then enter the cerebral circulation leading to an ischaemic stroke

Pre-existing cardiac disorders such as cardiomyopathies (specific, idiopathic and familial), conduction and valvular defects, hypertensive diseases, myocardial infarction and congenital heart disease should be excluded with echocardiography

Management

PPCM is managed using the same principles as any other systemic ventricular failure (e.g. congestive cardiac failure, ischaemic cardiomyopathy).

Available drug therapy can be limited by risks of fetal teratogenicity and breastfeeding.

Angiotensin Converting Enzyme (ACE) inhibitors (e.g. enalapril, ramipril, lisinopril) and angiotensin-receptor blockers (e.g. candesartan, irbesartan, losartan) should be avoided during pregnancy, as they may cause fetal kidney disease secondary to both hypotension and reduced fetal renal blood flow. After delivery ACE inhibitors are used in the treatment of ongoing heart failure.

Specific therapies include:

- Furosemide, a loop diuretic, can be used to reduce plasma volume, by eliminating free water through the kidneys.
- Beta Blockers (e.g. metoprolol) are safe. They reverse cardiac remodelling, slow the heart rate to allow increased filling time, prevent arrhythmias and lower both afterload and preload. As they are negatively inotropic they must be used carefully if the systemic ventricular ejection fraction is less than 50%.

Complications

Thromboembolism and arrhythmias are the two main complications of PPCM.

Anticoagulation is used to reduce the risk of thromboembolism. Warfarin is known to cause numerous congenital malformations in the first trimester. Its use is also associated with spontaneous abortion and still-birth. It can be used cautiously in the third trimester, but most clinicians favour giving low molecular weight heparins (LMWH), at a therapeutic dose, which do not cross the placenta.

There are no trials supporting the use of novel oral anticoagulants such as rivaroxiban in pregnancy. Due to the risk of bleeding and placental transfer, they are contraindicated in pregnancy.

Potentially fatal tachyarrhythmias, such as ventricular fibrillation cause 25% of mortality, in PPCM. Mothers who experience these may need implantable cardioverter-defibrillators (ICD). Other dysrhythmias that may occur include supraventricular tachycardia and atrial fibrillation.

In severe cardiac failure, (an ejection fraction of less than 40% which is unresponsive to medical intervention), women may require ventricular assist devices such as an intra-aortic balloon pump, left-ventricular assist devices or extra-corporeal membrane oxygenation (ECMO) while awaiting cardiac transplantation. Transplant mortality rates are higher after PPCM compared to other cardiomyopathies. This is due to an increased incidence of organ rejection in young mothers. However, most return to normal cardiac function following a cardiac transplant.

Women who have had peripartum cardiomyopathy may be at risk of recurrent heart failure and death in subsequent pregnancies [6–8].

Anaesthetic Considerations

Delivery and management of any parturient with cardiac disease requires a multidisciplinary approach. This should include obstetricians, anaesthetists, cardiologists, obstetric physicians and neonatologists.

Labour:

The parturient should be monitored appropriately depending on risk. This may require continuous ECG monitoring if the risk of arrythmias is high. Blood pressure and oxygen saturations should be monitored regularly. There should be active attempts to avoid aortocaval compression.

Early epidural analgesia is recommended to reduce the sympathetic response, reducing plasma catecholamines and for the effect of a reduction in the systemic vascular resistance. Timing of epidural placement needs to be considered in patients who are anticoagulated. An arterial line before epidural placement is useful for continuous invasive blood pressure measurement.

There should be a low threshold to obtain an echocardiogram if there are any changes in symptoms or haemodynamic parameters during labour- to accurately assess cardiac function.

Delivery:

Vaginal delivery is safe with low dose epidural analgesia to reduce the stress of labour and delivery on the cardiovascular system. Early low dose epidural and a low outlet/'lift out' forceps delivery to shorten the second stage of labour to less than 30 min, minimises the strain on the cardiovascular system during labour.

Invasive arterial blood pressure monitoring or minimally invasive cardiac output monitoring (e.g LidCO™, PiCCo™) is useful for timely intervention with vasoconstrictors and inotropes.

Anaesthesia for caesarean delivery, if necessary, can be performed with a low dose incremental neuraxial technique such as a combined spinal epidural (CSE) or an epidural block. These incremental techniques may reduce cardiovascular instability. If a general anaesthetic is required invasive blood pressure monitoring is essential before inducing anaesthesia. A haemodynamically stable anaesthetic should be given, and attempts made to obtund the hypertensive response to laryngoscopy. Referral to the intensive care or coronary care areas for postoperative monitoring may be required due to postpartum fluid redistribution and the potential for fluid overload.

Anaesthetic Aims for a Patient with Peripartum Cardiomyopathy

- Maintain sinus rhythm—avoidance of tachycardia and arrhythmias
- Avoid hypotension

- Optimise cardiac output
- Avoid fluid overload, but maintain preload (aim for normovolaemia)
- Maintain cardiac contractility
- Avoid increases in afterload (SVR).

Uterotonics

There is a higher risk of major haemorrhage in mothers with cardiac disease, so it is important to administer uterotonics when necessary.

Uterotonic drugs, such as oxytocin and ergometrine have significant cardiovascular side effects. Commercially available oxytocin, which contains the preservative chlorbutol a negative inotrope, can be given as a slow infusion at a reduced dose. Ergometrine may be useful, since it does not reduce blood pressure. However, as it causes an increase in afterload as well as coronary and pulmonary vasoconstriction it should be used with caution. Prostaglandin F2α (Carboprost®) may cause pulmonary oedema and bronchospasm. Carbetocin is a modified version of oxytocin, which has a longer half-life. It is associated with less nausea and vomiting but has similar effects on the cardiovascular system. It should also be given, as a slow bolus injection.

Conclusion

- PPCM is rare in pregnancy.
- PPCM has strict diagnostic criteria.
- Heart failure and arrhythmias are common complications of PPCM.
- A multidisciplinary team approach is required to care for these patients.
- Standard heart failure treatment is required (e.g. beta blockers and diuretics).
- Pre-conceptual counselling should be offered to all women with previous PPCM.

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Complex Congenital Heart Disease and Pregnancy

45

Daryl Dob and Clare Ivermee

Congenital heart disease affects 0.8% of all live births. It is more common than Down's Syndrome (0.11%) and cleft lip and palate (0.14%). Survival to adulthood is now 86%, even for neonates with complex and single ventricle circulations [1].

The physiological changes of pregnancy and childbirth may put a significant strain on congenital heart circulations. Women with adult congenital heart disease have a 1 in 200 risk of death compared to a 1 in 14,000 risk for mothers with normal anatomy.

The key to dealing with complex congenital heart disease circulations is to understand the normal circulation. It can be divided into 7 logical features (Fig. 45.1).

1. The veno-atrial connections are concordant i.e. the superior and inferior vena cava, which drain venous blood from the circulation, are connected to the right atrium. The four pulmonary veins are connected to the left atrium.
2. There is no atrial septal defect (ASD) and the situs (or the position of the chambers) is correct i.e. the left atrium is on the left and the right atrium is on the right.
3. The atrioventricular connections are concordant i.e. the right atrium is connected to the right ventricle; the left atrium is connected to the left ventricle.
4. No valvular abnormalities exist between the atria and the ventricles.
5. There is no ventriculo-septal defect (VSD).
6. The ventriculo-arterial connections are concordant i.e. the right ventricle is connected to the pulmonary arterial trunk and the left ventricle is connected to the aorta.

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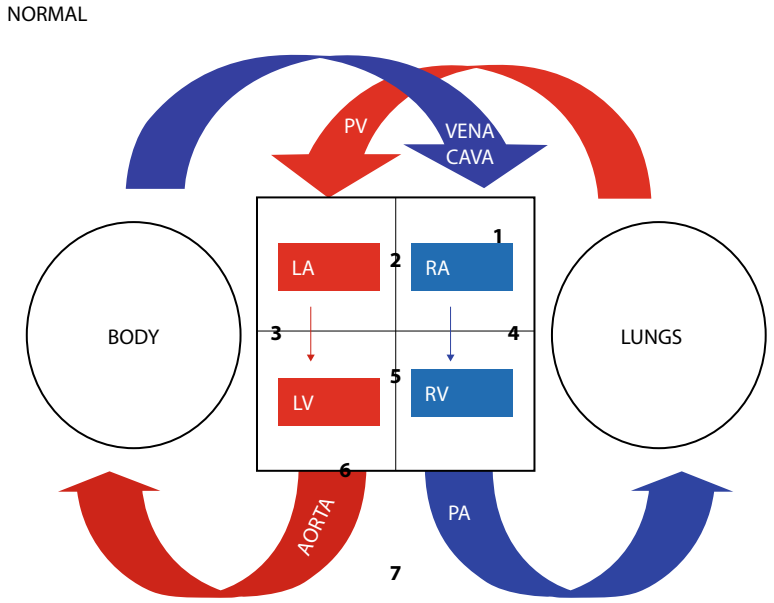

Fig. 45.1 Normal circulation. LA = left atrium; RA = right atrium; LV = left ventricle; RV = right ventricle; PV = pulmonary vein; PA = pulmonary artery

7. There are no semilunar valvular abnormalities e.g. aortic stenosis or pulmonary atresia and no connections between the great vessels (i.e. the pulmonary artery and the aorta) such as a patent ductus arteriosus.

With this knowledge any complex congenital heart disease can be described and understood (Table 45.1).

Table 45.1 Congenital heart disease associated with defects for each feature

Abnormal feature	Congenital heart defect
1	Anomalous pulmonary venous drainage
2	Atrial septal defect, patent foramen ovale, situs inversus
3	Congenitally corrected transposition of the great arteries
4	Mitral or tricuspid valve disease, tricuspid atresia
5	Large ventricular septal defect, single ventricle, ventricular hypoplasia
6	Transposition of the Great Arteries, double outlet left or right ventricle, congenitally Corrected Transposition of the Great Arteries
7	Aortic or pulmonary valve disease, patent ductus arteriosus

Antenatal Care and Delivery Strategies

Mothers with complex congenital heart disease should have multidisciplinary care in specialist centres. The 40% increase in cardiac output associated with pregnancy, reaches its peak from 20 to 24 weeks gestation until delivery. Ventricular failure (right, left or combined single ventricle) can occur. Since the neonates are often small for gestational age and premature, spontaneous vaginal delivery, or short second stage instrumental delivery to avoid a Valsalva manoeuvre when pushing, is preferred.

In very high-risk pregnancy, with severe pulmonary hypertension, for example, elective caesarean delivery is often chosen to facilitate the presence of all the different specialists.

Anaesthetic Strategies

- Vaginal delivery—early low dose combined spinal epidural (CSE) or epidural analgesia reduces the sympathetic response to pain and stress on the circulation. Invasive arterial monitoring or minimally invasive cardiac output monitoring is useful but not always essential. Pulse oximetry and ECG are helpful.
- Caesarean delivery—slow incremental combined spinal-epidural (CSE) or epidural anaesthesia with invasive arterial monitoring provides cardio-stable anaesthesia. Central venous access is often avoided since the information gained is difficult to interpret and usually does not outweigh the risk of infection and arrhythmias due to the guidewire used for placement of the central line.
- Previously general anaesthesia with high dose opioids was a common technique in patients with complex circulations undergoing surgery, but is used much less frequently now.
- Oxytocin and carbetocin are both associated with significant negative inotropy and vasodilatation, and should be given carefully as a slow bolus injection or as an infusion.

Important Complex Congenital Heart Disease Circulations and Repairs

1. Transposition of the Great Arteries (Fig. 45.2)

   There is ventriculo-arterial discordance, with the aorta and pulmonary artery incorrectly connected to the left and right ventricles respectively. The Arterial Switch (Jatene) procedure restores the anatomy. The left ventricle may still fail

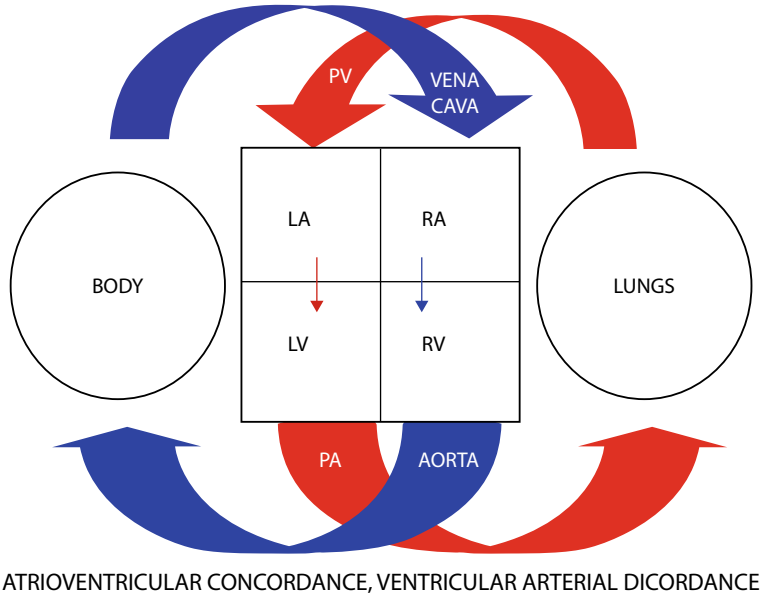

Fig. 45.2 Simple Transposition of the Great Arteries. LA = left atrium, RA = right atrium, LV = left ventricle, RV = right ventricle, PA = pulmonary artery, PV = pulmonary vein

during pregnancy, but this is rare. Low dose epidural analgesia for labour and non-invasive monitoring is useful [2].

Atrial Switch (Mustard or Senning) operations divert blood flow at the atrial level and normalise oxygenation at the expense of a systemic right ventricle still attached to the aorta. Patients may be prone to ventricular failure and pulmonary oedema.

2. Single ventricle physiology and the Total Cavo-Pulmonary Connection (TCPC) —Modern Fontan Repair

   TCPC is now performed for any circulation with a single functioning ventricle that can't be converted back into a biventricular circulation. This is usually caused by a very large ventricular septal defect leading to free mixing of oxygenated and deoxygenated blood in the single ventricle. This poorly oxygenated blood is pumped into both the aorta and the pulmonary artery (Fig. 45.3).

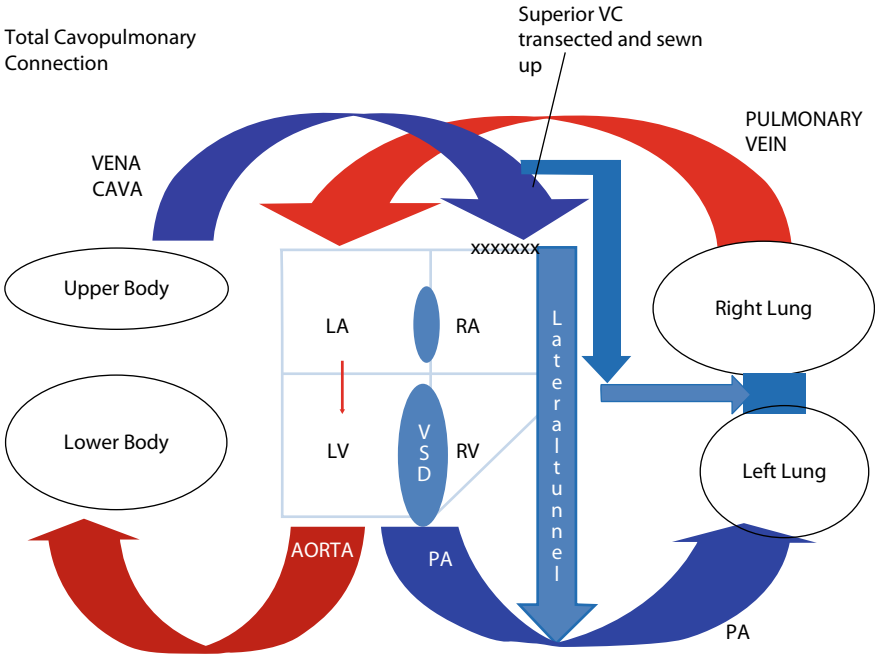

Fig. 45.3 Total Cavopulmonary connection: LA = left atrium, RA = right atrium, LV = left ventricle, RV = right ventricle, PA = pulmonary artery, VC = vena cava

The TCPC separates oxygenated blood from deoxygenated blood by diverting systemic venous return directly to the pulmonary artery confluence, preventing mixing in the single ventricle. Blood flow through the lungs relies on the remaining kinetic energy from the systemic single ventricle pump, and the negative intra-thoracic pressure of spontaneous ventilation to draw venous blood through the lungs. The oxygenated blood is returned to the single ventricle, which after the pulmonary outflow tract is oversewn, returns the blood to the body through the aorta [3, 4]

3. Pulmonary Hypertension and Eisenmenger's Syndrome

High blood flow through a left to right shunt may cause pulmonary hypertension. If severe enough this will reverse, so that deoxygenated blood joins the systemic circulation in preference to the pulmonary circulation and causes cyanosis. Mortality in pregnancy with pulmonary hypertension is 35%. If pregnancy is

Table 45.2 Congenital heart disease and anaesthesia for delivery

Type of circulation	Analgesia for vaginal delivery	Anaesthesia for caesarean delivery
Transposition of the great arteries Arterial switch (Jatene) repair	Early LDE, NIBP	Standard spinal anaesthesia, if good left ventricular function, NIBP or minimally invasive cardiac output monitoring
Transposition of the great arteries Mustard or senning atrial switch repair	Early LDE, IABP	Slow incremental CSE, IABP, Risk of systemic RV failure
Total cavo-pulmonary connection	Early LDE, NIBP	Slow incremental CSE, IABP Maintain spontaneous ventilation and avoid IPPV if possible
Eisenmenger's syndrome	Vaginal delivery is not usually attempted	GA or slow incremental CSE Invasive monitoring Cardiopulmonary bypass available

LDE = low dose epidural labour analgesia, IABP = invasive arterial blood pressure monitoring, NIBP = non-invasive blood pressure monitoring, CSE = combined spinal and epidural, GA = general anaesthetic, RV = right ventricle, IPPV = intermittent positive pressure ventilation

continued, delivery is often by general anaesthesia with invasive monitoring and cardiopulmonary bypass on standby. A slow incremental combined spinal epidural (CSE) technique may also be used consisting of a low spinal dose of local anaesthetic (e.g. followed by an incremental epidural topup). This technique is said to offer greater cardiovascular stability compared to a standard spinal technique for caesarean delivery (Table 45.2).

Conclusion

Pregnant women with complex congenital heart disease are presenting for delivery with increasing frequency. Knowledge of the normal circulation provides a template for an understanding of any congenital heart circulation, which allows anaesthetic techniques to be manipulated to suit individual women.

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Thrombophilias

46

Roulhac D. Toledano and Lisa Leffert

Thrombophilias are inherited or acquired deficiencies in proteins that inhibit the coagulation cascade. These disorders predispose patients to enhanced hypercoagulability (beyond the physiologic hypercoagulable state of pregnancy) and account for an estimated 50% of the thromboembolic complications during pregnancy [1]. Overall, there is insufficient evidence presented in the literature to firmly establish a link between most thrombophilias and recurrent abortion, stillbirth, preeclampsia, fetal growth restriction, and abruption [2].

Common Inherited and Acquired Thrombophilias

Factor V Leiden Mutation

Caused by a mutation in the Factor V gene that results in resistance to the anticoagulant effects of activated Protein C, Factor V Leiden is the most common inherited thrombophilia.

The abnormal Factor V retains its procoagulant activity, predisposing the host to thrombosis. The heterozygous state accounts for a large portion of thromboembolic complications of pregnancy (up to 40%), particularly in the setting of a personal and/or family history of venous thromboembolism. In the homozygous state, which

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is far less common (<1% of the population), a pregnant woman with a family and/or personal history of thrombosis has a 17% risk for venous thromboembolism during pregnancy [2].

Protein S Deficiency

A deficiency in this circulating anticoagulant impedes the inactivation of Factors Va and VIIIa in the coagulation cascade. Diagnosis may be complicated by the physiologic decline in free, functional, and total protein S levels during pregnancy. The risk of thrombotic events in women with this disorder is low (6–7%) [2], and thromboprophylaxis is generally not indicated. However, neonates who are homozygous for protein S or C deficiency (see below) are at risk for neonatal purpura fulminans (a rare, life-threatening condition marked by disseminated intravascular coagulation and necrotic skin lesions).

Prothrombin Mutation

The prothrombin G20210A mutation results in increased circulating levels of prothrombin and, ultimately, in more thrombin. The risk of developing thromboembolic complications during pregnancy is low in heterozygous carriers of this mutation in the absence of a personal or family history of venous thromboembolism. Homozygous women with a family and/or personal history of thrombosis and those with both the prothrombin mutation and Factor V Leiden thrombophilia are at high risk for thromboembolism.

Protein C Deficiency

Protein C, together with protein S, regulates thrombin production by inhibiting Factors Va and VIIIa and inhibits synthesis of plasminogen-activator inhibitor 1; its deficiency results in an increased risk for venous thromboembolism during pregnancy, particularly in the setting of a personal and/or family history of thrombosis. The phenotypic expression of the many mutations responsible for protein C deficiency is highly variable. As a result, not all individuals with this deficiency are at risk for thromboembolic events.

Antiphospholipid Syndrome (APS)

This disorder is marked by the presence of antiphospholipid antibodies, which have been associated with arterial and venous thrombosis, autoimmune thrombocytopenia, placental insufficiency, preeclampsia, fetal growth restriction, preterm delivery, and fetal loss. The risk of venous thrombosis, which accounts for most of

the thrombotic events in patients with APS, increases substantially during pregnancy. Less commonly, arterial thrombosis may occur in digital, cerebral, retinal, and coronary arteries. Thrombocytopenia occurs in 40–50% of patients with APS, and is clinically similar in presentation to immune thrombocytopenia (ITP) [3]. The antibodies most implicated in APS include lupus anticoagulant, which is prothrombotic, anticardiolipin antibodies, and anti-β_2-glycoprotein antibodies. Other illnesses associated with antiphospholipid antibodies include systemic lupus erythematosus (SLE), autoimmune hemolytic anemia, transverse myelitis, and chorea gravidarum.

Incidence

Some thrombophilias are more common than others. Factor V Leiden thrombophilia in its heterozygous form is present in up to 15% of the population, while the homozygous variant affects less than 1%. In contrast, the incidence of antithrombin III deficiency (activity <60%), Protein C deficiency (activity <50%), or protein S deficiency (<55%) is far lower (0.02–0.4%).

Clinical Implications

- Pregnant patients with thrombophilias are at increased risk of hypercoagulability and thromboembolic events.
  - There is insufficient evidence presented in the literature to firmly establish a link between most thrombophilias (other than antiphospholipid syndrome) and placenta-mediated complications, such as preeclampsia and abruption.
- Anticoagulation with low, intermediate or higher doses of low molecular weight heparin (LMWH), depending on disease severity, family history, and personal history of venous thromboembolism, should be initiated early in pregnancy as indicated by national guidelines. Low dose, shorter-acting unfractionated heparin (UFH) is sometimes substituted in later gestation to minimize the delay in initiating neuraxial blockade for labor analgesia or caesarean delivery.
  - The anticoagulant can often be discontinued at the onset of labor or prior to induction of labor or scheduled cesarean delivery, to minimize the risk of bleeding complications.
- Lupus anticoagulants in patients with APS result in prolonged clotting time in vitro despite the procoagulant effect in vivo; the aPTT is likely to remain prolonged despite discontinuation of heparin and may therefore be unhelpful in assessing coagulation status.
- Postoperative low dose anticoagulation may be resumed for at-risk patients according to the recommendations outlined in the Society for Obstetric Anesthesia & Perinatology (SOAP) Consensus Statement [4] and the Association of Anaesthetists [5].

Timing of Neuraxial Analgesia or Anesthesia (see Chap. 49)

- Optimal peri-delivery planning involves minimizing the chance that a laboring woman or one requiring a caesarean delivery has recently received a dose of anticoagulant.
  - Consideration should be given to the timing of the last dose of anticoagulant medication to determine optimal timing of epidural catheter placement or removal (see specific recommendations outlined in the Society for Obstetric Anesthesia & Perinatology (SOAP) Consensus Statement [4] and the Association of Anaesthetists) [5].
  - Patients receiving UFH for greater than 4–5 days are at (rare) risk for developing heparin-induced thrombocytopenia (HIT)
  - Thrombocytopenia may also complicate anesthetic management of patients with APS.

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Haemophilias

47

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Haemophilias are inherited, or rarely, acquired defects in proteins that control coagulation. Haemophilia A and Haemophilia B are X-linked recessive disorders associated with deficiencies of Factors VIII and IX, respectively. Males are affected disproportionately and are at a higher risk of severe bleeding complications, but female carriers, females with inherited disease, and women who acquire haemophilia may experience bleeding tendencies of varying degrees. Factor XI deficiency (i.e., Haemophilia C) is an autosomal recessive disease common among Ashkenazi Jews that results in a particularly high incidence of bleeding complications among women.

Although the physiologic increase in Factor VIII and IX levels during pregnancy offers some protection against bleeding complications, haemophilia can be a cause of severe obstetric haemorrhage.

Mode of Inheritance

Haemophilia A and B are X-linked recessive inherited disorders. Male children of female carriers have a 50% chance of having the disease, while female offspring have a 50% chance of being carriers, Fig. 47.1. Because of variable gene expression, the bleeding risk among carriers varies but is typically mild. In rare cases, a female can be affected with the severe form of Haemophilia A or B due to a genetic mutation, another X-chromosome abnormality, or inheritance of the abnormal gene

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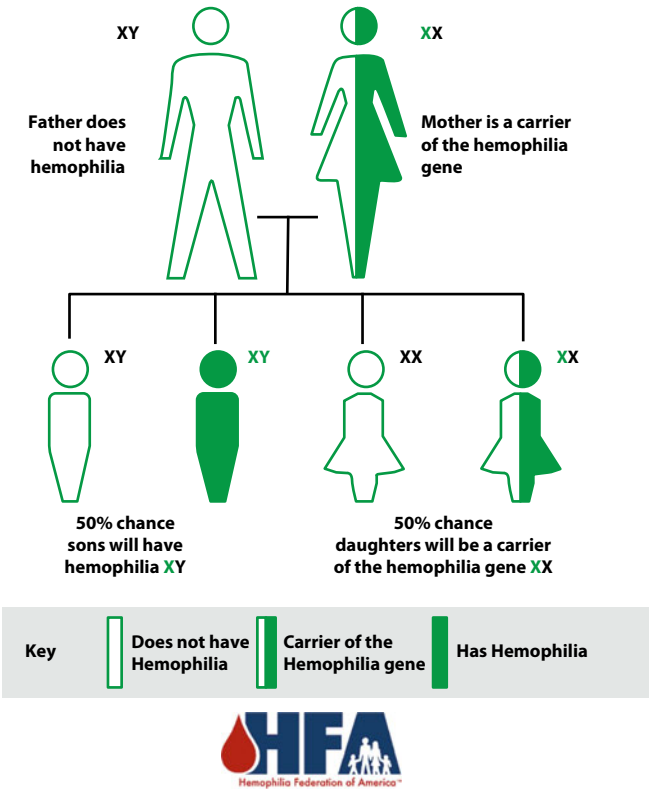

Fig. 47.1 Haemophila Inheritance Pattern. Published with the permission of the Hemophilia Federation of America

from both parents. Male children of women with Haemophilia A or B will have the disease; the daughters will be carriers. Sons and daughters of parents with Haemophilia C will be carriers.

Acquired Haemophilias

Haemophilias can also develop spontaneously or can be acquired with the development of antibodies to factors, most commonly after factor replacement therapy or as a complication of an underlying autoimmune disorder. Acquired factor deficiencies may develop during pregnancy and the postpartum period [1].

Incidence

Haemophilia A is far more common than Haemophilia B, affecting 1 in 5000 live male births compared to 1 in 30,000 live male births, respectively.

Laboratory Findings

Patients with Haemophilia A and B have prolonged activated partial thromboplastin time (aPTT), indicating an abnormality in the intrinsic coagulation pathway. However, the aPTT may be normal in patients with mild disease. The platelet count and prothrombin time (PT) should be normal. Factor levels (VIII and IX) are usually <40% of normal healthy controls.

Clinical Implications

Pathophysiology

- Males with Haemophilia A or B may develop spontaneous bleeding into the joints and muscles, oropharynx, genitourinary tract, and, rarely, brain. They may also suffer severe bleeding after traumatic injury and surgical (or other invasive) procedures.
  - Male neonates with haemophilia may experience protracted bleeding after circumcision.
- Female carriers have sufficient factor level activity to prevent clinical bleeding (i.e., 50% of normal factor level activity, with a normal range equal to 50–150%). In general, the bleeding risk is directly related to the Factor VIII or XI levels; parturients with levels below 10–20% may develop bleeding complications during caesarean or vaginal delivery, intravenous line placement, intubation of the trachea, and placement or removal of an epidural catheter.
- Placenta-mediated complications, such miscarriage, may present in association with the primary disease or with a co-existing autoimmune disease, such as systemic lupus erythematosus (SLE).
- Patients with Factor VIII deficiency should have von Willebrand factor antigen testing to exclude von Willebrand disease (see Chap. 48).

Treatment

Several therapies may attenuate bleeding complications associated with haemophilia.

- The administration of desmopressin (DDAVP) may result in increased levels of Factor VIII in patients with mild Haemophilia A.
- Factor VIII (plasma concentrates or recombinant products) administration is recommended when levels drop below 10%, or higher in pregnant patients before and during delivery.
- Prothrombin complex concentrate (PCC) or Factor IX (plasma concentrates or recombinant products) may be necessary for parturients with Hemophilia B.
- Antifibrinolytic therapy with tranexamic acid (TXA) has been used successfully in the management of postpartum hemorrhage (PPH) in women with bleeding disorders and may be particularly effective in patients at high risk of delayed PPH [2]. Antifibrinolytic agents should not be administered simultaneously with PCC due to an increased risk of thromboembolism.
- The development of inhibitors (or neutralizing alloantibodies) after repeated exposure to factor concentrates can dramatically impair successful therapy.

Obstetric Management

- Factor VIII levels should be monitored and kept at >50% during labor and at >80% for caesarean delivery. Patients should be counseled regarding the risks and benefits of both vaginal and caesarean delivery, as there is insufficient evidence in the literature to determine the optimal mode of delivery. Caesarean delivery is recommended for a breech fetus at risk for hemophilia; the option for caesarean delivery should be offered to female carriers of haemophilia with male fetuses.
- Whenever possible, instrumental delivery should be avoided in parturients with severely reduced Factor VIII and IX levels. Lacerations and episiotomies should be kept to a minimum.
- It is prudent to avoid placement of fetal scalp electrodes during labor if other options are available.
- Parturients with acquired haemophilias may develop severe haemorrhage, which may present in a delayed fashion.

Anaesthetic Management

- Parturients with known haemophilia should have a consultation with hematological experts, determination of factor levels and coagulation parameters, and a thorough assessment of bleeding tendencies.
  - A low index of suspicion and prompt diagnosis and treatment are essential for women with no known history of bleeding disorders who experience unexplained PPH.

- Neuraxial techniques may be used in carriers with normal factor levels, but are probably best avoided in patients with untreated haemophilia or persistent factor deficiencies [3]. Coagulation factors can be replaced on the advice of hematologists.
- Anticoagulant administration may complicate the timing and feasibility of neuraxial blockade due to concerns for spinal epidural haematoma formation.
  - Neurologic function should be assessed, and an epidural catheter should be removed only after the patient's coagulation status is optimized.
- If general anaesthesia is needed for caesarean delivery, avoid trauma during airway manipulation.
- Preparations for possible haemorrhage after vaginal or caesarean delivery should be made, including large-bore intravenous lines, availability of blood products and factor replacement therapy.
- Avoid intramuscular injections.

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Von Willebrand Disease

48

David J. Combs and Lisa Leffert

Von Willebrand disease (VWD) is the most common inherited bleeding disorder, with equal frequency in men and women, with an overall prevalence of approximately 1% [1]. Although many patients are asymptomatic, affected individuals have a personal or family history of bleeding episodes, including heavy periods, peri-surgical bleeding or postpartum haemorrhage (PPH).

Pathophysiology

VWD is caused by impaired production or function of von Willebrand factor (VWF) [1, 2]. VWF is made by vascular endothelial cells and megakaryocytes (platelet precursors). VWF promotes hemostasis in two ways. First, it forms stabilizing crosslinks between platelets and subendothelial molecules that are exposed during tissue injury. Second, it serves as carrier protein for Factor VIII, whose half-life and concentration are decreased without VWF binding, Fig. 48.1.

VWD is classified into three types, with Type 2 being split into four subtypes (Table 48.1).

Most patients with VWD will have a normal prothrombin time (PT), a normal platelet count (except Type 2B, where it can be low), and a normal or prolonged activated partial thromboplastin time (aPTT), depending on the reduction in Factor VIII level. Laboratory testing for VWD also includes determination of plasma VWF antigen levels, plasma VWF activity (ristocetin cofactor activity), and Fac-

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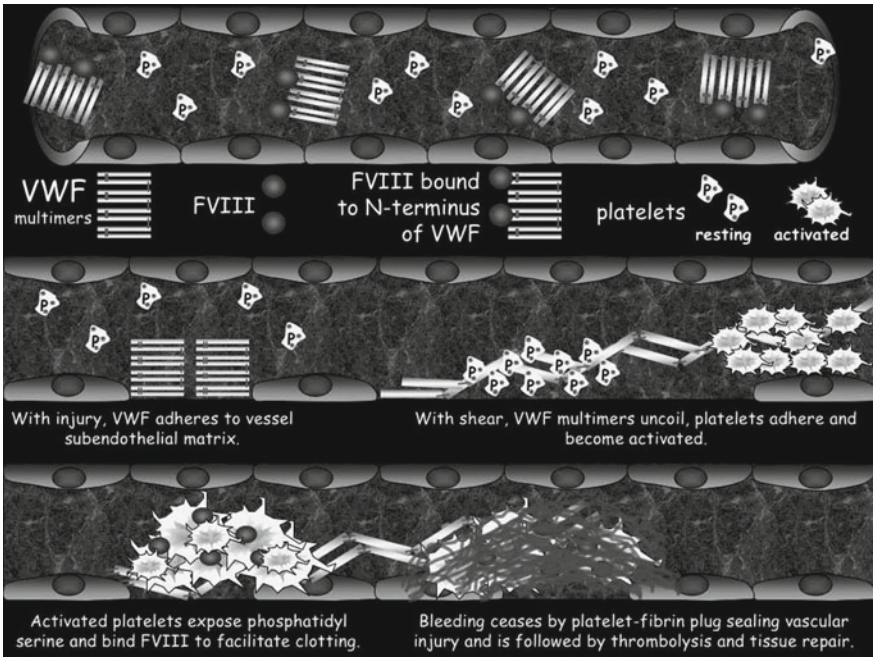

Fig. 48.1 From "The Diagnosis, Evaluation and Management of von Willebrand Disease" NHLBI 2007. A blood vessel in cross-section showing stages of clot formation. In the normal state (*top panel*), VWF does not interact with platelets or the vascular endothelium. Vascular injury (*middle panel*) exposes the subendothelial matrix permitting VWF binding. Shear forces on bound VWF uncoils the VWF structure, allowing platelet activation and adherence. The activated platelets (*bottom panel*) bind clotting factors, enabling fibrin deposition and formation of a platelet–fibrin plug to seal the site of vascular injury. Published with the kind permission of Robert R Montgomery MD, Wisconsin, USA

tor VIII activity. Low (<30 IU/dL) levels of VWF antigen or activity confirm the diagnosis, and further testing can establish the type of VWD.

VWD can also, rarely, be an acquired condition resulting from antibody-mediated reduction (usually in the setting of a neoplastic or autoimmune process), proteolysis from high sheer stress (e.g., stenotic vascular lesions, hypertrophic obstructive cardiomyopathy, extracorporeal membrane oxygenation, left ventricular assist devices), and other processes.

Pregnancy and VWD

- Levels of VWF normally rise two- to three-fold during the second and third trimesters in women with VWD [2–5].

Table 48.1 Characteristics of von Willebrand types 1–3

Type	Inheritance	% of cases	VWF defect	Bleeding severity
Type 1	Autosomal dominant	75	Partial quantitative deficiency	Mild to severe
Type 2A	Autosomal dominant	10–20	Primarily qualitative defect; impaired protein binding	Moderate to severe
Type 2B	Autosomal dominant	5	Qualitative; increased affinity for platelets	Moderate to severe
Type 2 M	Autosomal dominant	<5	Qualitative; decreased platelet adhesion	Moderate to severe
Type 2 N	Autosomal dominant	<5	Qualitative; impaired Factor VIII binding	Similar to Hemophilia A; joint, soft tissue, urinary bleeding
Type 3	Autosomal recessive	<5	Complete deficiency	Severe

  - In most cases of VWD Type 1, VWF will be at in the normal range by the third trimester of pregnancy
  - Qualitative defects (Type 2 disease) will persist.
- Pregnant women with Type 1 disease whose VWF levels do not normalize, those with a history of severe bleeding or with Type 2 or 3 disease should be managed on an individual case basis for prenatal care and delivery by a multidisciplinary team with expertise in high risk obstetrics.
- Coordination of care with a hematologic expert is essential.
- DDAVP (Desmopressin), when indicated, is considered generally safe for mother and fetus
  - vigilance for severe hyponatremia at delivery is necessary given frequent concomitant oxytocin use and large volume IV fluid resuscitation [3].
- Instrumented vaginal deliveries are best avoided in the setting of unknown fetal VWD status.
- Caesarean deliveries should be reserved for obstetric indications.

Management

The management of VWD depends, in part, on the type of VWD and the baseline level of clotting factors.

- Desmopressin (DDAVP)
  - Triggers the release of VWF from Weibel-Palade bodies (WPBs) within the endothelial cells [1, 2, 4].
  - Type 1 and typically Type 2 VWD are DDAVP-responsive

- DDAVP should **not** be used in Type 2B VWD as it can worsen thrombocytopenia
  - Type 3 VWD is not DDAVP responsive
  - DDAVP responsiveness should ideally be trialed, first, under elective conditions. Common DDAVP regimens include:
- 0.3 mcg/kg (max of 20–30 mcg) IV infused over 20–30 min which yields a three- to five-fold increase VWF and Factor VII levels after 30–60 min.
- Response duration: 6–12 hours.
- A second dose can be given at 8–12 hours, if needed, with 1–3 additional days of therapy
- Tachyphylaxis and hyponatremia can occur with repeated dosing
- Antifibrinolytic agents
  - Tranexamic acid (TXA) and epsilon aminocaproic acid can be effective to treat mild bleeding in patients with VWD.
  - Do **not** increase VWF or Factor VIII levels
  - Considered as second line therapy.
- VWF replacement
  - May be used in the setting of planned surgery or major haemorrhage or in patients with severe disease or who have failed other treatments [1, 2, 4].
  - Available factor replacement products vary in their purity/potency, the amount of Factor VIII activity, and their availability in different countries.
  - VWD treatment in the general population has evolved from plasma-derived concentrates of VWF/FVIII to recombinant VWF [6]. Dose and frequency for factor replacement, along with the potential need for separate Factor VIII supplementation depend on the particular replacement product. The site and degree of bleeding also impacts dosing considerations.
  - VWF levels target ranges are typically 50–100%.
  - For highly purified VWF products (*e.g.* recombinant VWF), recombinant Factor VIII dosing may also be required.
  - In the absence of available VWF preparations, cryoprecipitate can also be used, typically, several units (e.g. 10 units or two 5 unit doses, each in 100 ml volume).

Neuraxial Anaesthesia

Consultation with a hematologic expert, prior to delivery, can help to facilitate appropriate work-up and laboratory investigations and facilitate decision-making regarding neuraxial anaesthesia.

- VWF and Factor VIII levels at or above 50 IU/dL in the third trimester of pregnancy are generally considered safe to proceed with neuraxial anaesthesia in pregnant women with Type 1 VWD disease, provided that other coagulation parameters are normal [1, 6].
- Reports document patients with Type 2 disease safely receiving neuraxial anaesthesia [7–9].

  - the qualitative nature of the VWF defect can make it difficult to assess whether there will be adequate hemostasis.
- Neuraxial anaesthesia is generally avoided for patients with Type 3 disease.
- Epidural catheter removal is best done soon after delivery because factor levels can rapidly decrease.
  - If removal of the epidural catheter is delayed, laboratory testing should be repeated, and abnormal factor levels corrected prior to catheter removal.
  - Similar considerations impact the decision to proceed with an epidural blood patch in the setting of a post-dural-puncture headache (PDPH).

Major Obstetric Haemorrhage

- Among women with VWD, 16–29% will have a postpartum hemorrhage (PPH) within 24 hours of delivery, and 20–29% will have delayed hemorrhage [2, 4].
- Major obstetric hemorrhage in patients with VWD should be approached similarly to patients without VWD, apart from measures taken to correct any untreated coagulopathy with the agents described.

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Low Molecular Weight Heparin, Unfractionated Heparin and Neuraxial Anaesthesia

49

David J. Combs and Lisa Leffert

In pregnancy and the puerperium, platelet aggregation is enhanced, certain coagulation factor levels rise, and Protein C and S are reduced. This increases the risk of venous thromboembolism (VTE). Low molecular weight heparin (LMWH), and in some cases, unfractionated heparin (UFH) are used for venous thromboembolism (VTE) prophylaxis and therapy in pregnancy. Whereas UFH is a mixture of polysaccharides, LMWH products contain primarily shorter chain-lengths. Both types of heparin bind to and activate anti-thrombin (AT) and thereby enhance AT-mediated inhibition of Factor Xa (See Fig. 49.1). However, thrombin inhibition requires higher molecular weight heparins that are mostly absent from LMWH. Unlike warfarin, neither LMWH nor UFH cross the placenta or are teratogenic.

Key differences between LMWH and UFH include:

LMWH

- Better bioavailability and safety profile
- Easier to administer
- More predictable dosing
- Lower risk of heparin-induced thrombocytopenia (HIT) and osteoporosis.

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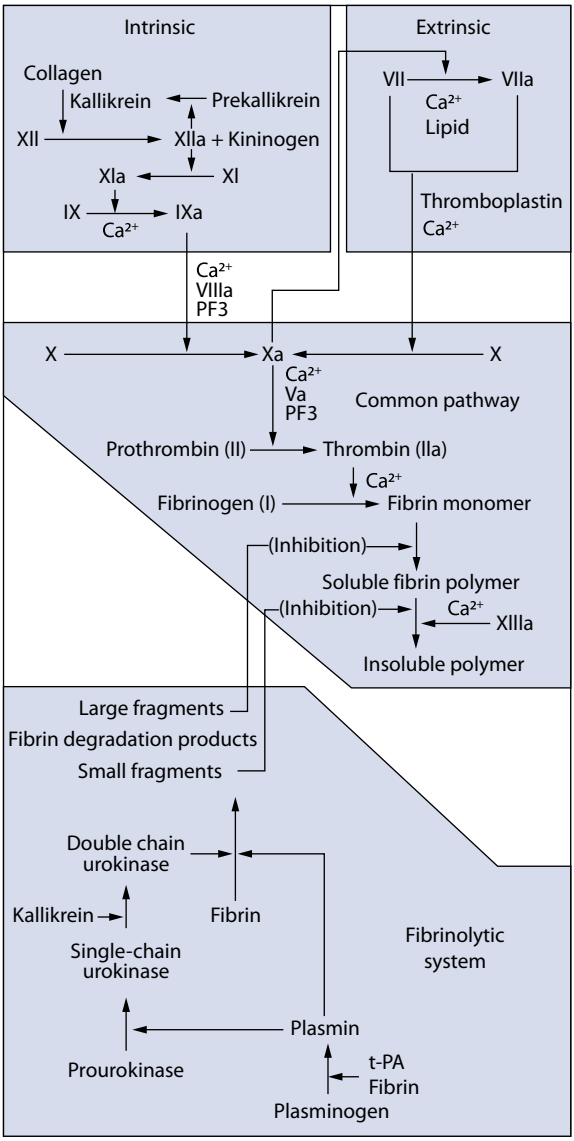

Fig. 49.1 A simplified schematic diagram of the coagulation cascade

UFH

- Shorter half-life
- Effects can be reversed by protamine, although protamine administration carries potential side effects, including hypotension, severe pulmonary hypotension, pulmonary oedema, and anaphylaxis.

Heparin Dosing

The nomenclature describing UFH and LMWH dosing is not standardized. For example, thromboprophylactic UFH dosing recommendations vary between 5,000 and 10,000 U twice daily, depending on the guidelines and the pregnancy trimester. LMWH thromboprophylaxis may or may not be weight-based. Table 49.1 presents a common dosing scheme in the USA whilst Table 49.2 is the dosing scheme used within the UK.

'Intermediate dosing' refers to a higher dose than prophylactic (e.g. Dalteparin 5,000 U 12 hourly subcutaneously, rather than 5,000 U a day which is a prophylactic dose). The intermediate dose may be given due to the difference in pharmacokinetics and pharmacodynamics of pregnancy, a higher volume of distribution and different renal clearance as well as increasing weight gain, all of which require a change in dose to achieve the desired anticoagulant effect.

The physiology of pregnancy alters heparin pharmacology:

- Increased volume of distribution due to increased maternal plasma volume.
- Enhanced clearance due to increased renal blood flow and glomerular filtration rate.
- Limited available pharmacokinetic data on anticoagulants in pregnancy suggest that, for a given low dose of UFH or LMWH, measures of anticoagulant effect (e.g. aPTT) are lower in pregnant than in non-pregnant women [4, 5].

Table 49.1 Alternative dosing of UFH and LMWH: American College of Chest Physicians (ACCP); American College of Obstetricians and Gynecologists (ACOG) [1, 2]

Heparin	Prophylactic dose	Intermediate dose	High dose
UFH	1st Trimester: 5,000–7,500 U SQ Q12 2nd Trimester: 7,500–10,000 U SQ Q12 3rd Trimester: $\geq$ 10,000 U SQ Q12		IV dose adjusted to achieve an aPTT 1.5- to 2.5-fold higher than the control or baseline at 6 h. Can also be given SQ
Enoxaparin	40 mg SQ QD 30 mg SQ Q12	40 mg SQ Q12	1 mg/kg SQ Q12 1.5 mg/kg SQ QD
Dalteparin	5000 U SQ QD	5000 U SQ Q12	200 U/kg SQ QD 100 U/kg SQ Q12
Tinzaparin	4500 U SQ QD		175 U/kg SQ QD
Nadroparin	2850 U SQ QD		86 U/kg SQ Q12

aPTT, activated partial thromboplastin time; IV, intravenous; QD, once daily; Q12, once every 12 hours; SQ, subcutaneous.

Table 49.2 Suggested thromboprophylaxis doses (subcutaneous) for antenatal and post-natal LMWH: Royal College of Obstetricians and Gynaecologists (RCOG, United Kingdom) [3]

Weight	Enoxaparin	Dalteparin	Tinzaparin (75 u/kg/day)
<50 kg	20 mg daily	2500 units daily	3500 units daily
50–90 kg	40 mg daily	5000 units daily	4500 units daily
91–130 kg	60 mg daily[a]	7500 units daily	7000 units daily[a]
131–170 kg	80 mg daily[a]	10 000 units daily	9000 units daily[a]
>170 kg	0.6 mg/kg/day[a]	75/U/kg/day	75 U/kg/ day[a]
High prophylactic dose for women weighing 50–90 kg	40 mg 12 hourly	5000 units 12 hourly	4500 units 12 hourly

[a]May be given in 2 divided doses

Indications for Heparin During Pregnancy

Recommendations from major professional organizations regarding VTE thromboprophylaxis vary regarding which patients should receive anticoagulant and at what dose. For VTE thromboprophylaxis, LMWH has several advantages listed above, although high-quality evidence to demonstrate the superiority of LMWH over UFH is lacking [6].

Common indications for antepartum anticoagulant therapy include:

High Dose:

- Acute Venous Thromboembolism (VTE):
  - Deep Venous Thrombosis (DVT)
  - Pulmonary Embolism (PE)
- History of VTE on long-term anticoagulation
- Cerebral Sinus Thrombosis (CVT)
- Atrial Fibrillation/Flutter (AF)
- Mechanical Prosthetic Heart Valves

Low/Intermediate Dose:

- History of VTE
- Antiphospholipid Syndrome (APL)
- Sickle Cell Disease (SCD)
- Factor V Leiden (FVL)
- Prothrombin Gene Mutation (PGM)

- Protein C deficiency
- Protein S deficiency.

Dosing and Timing of Heparin Administration in Relation to Neuraxial Anaesthesia

Optimal care of obstetric patients receiving anticoagulation requires multidisciplinary communication, and formal, standardized protocols to manage dosing, coordination of obstetric procedures and delivery. Antenatal anaesthetic consultation is recommended for patients with comorbidities or for those on higher dose anticoagulation.

To minimize the risk of spinal epidural haematoma, national anaesthesia professional organizations have issued recommendations regarding neuraxial anaesthesia for patients on heparin (Tables 49.3 and 49.4) [7–10]. For obstetric patients, the risks of a general anesthetic may exceed the risks of spinal epidural haematoma. A working party of three major UK anaesthesia organisations have published joint guidelines on the managment of patients with abnormalities of coagulation [7], and more recently the Society for Obstetric Anesthesia and Perinatology (SOAP) published a multidisciplinary consensus statement to guide identification, preparation and management of pregnant women in the antepartum, intrapartum and postpartum periods [8]. These statements include guidance for stopping heparin in the setting of planned procedures, rupture of membranes, vaginal bleeding, or labor. In the United States, some pregnant women on LMWH may be switched to UFH near term or earlier in certain cases (e.g. maternal co-morbidities, high risk of pre-term labor or urgent caesarean delivery) to facilitate neuraxial anaesthesia.

Patients on UFH for greater than 4 days should have their platelet count checked in the rare event that they develop heparin-induced thrombocytopenia (HIT). Patients on low dose UFH (e.g., 5000 U SQ Q12) may have indwelling epidural catheters with placement and removal of the catheters according to the suggested time intervals.

Patients with indwelling epidural catheters should not receive intermediate or high-dose LMWH; they may receive low-dose LMWH (e.g. enoxaparin 40U SQ, daily) if it is administered once rather than twice daily as per the guidelines.

Table 49.3 UFH and timing of neuraxial anesthesia

Interval	Timing-United Kingdom [7]	Timing-United States [8, 9]
From UFH dose until neuraxial procedure		
• Low Dose (5000 U SQ Q12 or Q8) • Intermediate Dose (7500–10,000 U SQ Q12) • High Dose (>10,000 U SQ Q12) • IV Heparin	4 hr or normal coagulation N/A N/A 4 hr or normal coagulation	4–6 hr or normal coagulation 12 hr AND normal coagulation 24 hr AND normal coagulation 4–6 hr AND normal coagulation
From neuraxial procedure until UFH	1 hr	1 hr
From UFH dose to catheter removal Low Dose (5000 U SQ Q8 or Q 12) IV heparin	 4 hr or normal coagulation 4 hr or normal coagulation	 4–6 hr or normal coagulation 4–6 hr AND normal coagulation
From catheter removal until UFH	1 hr	1 hr

IV, intravenous; SQ, subcutaneous; Q12, every 12 hours; Q8, once every 8 hours

Table 49.4 LMWH and timing of neuraxial anesthesia

Interval	Timing-United Kingdom [7]	Timing-United States [8, 9]
From LMWH until neuraxial procedure		
• Prophylactic dose • Intermediate dose • Therapeutic (high) dose	12 hr N/A 24 hr	12 hr 24 hr 24 hr
From neuraxial procedure until LMWH		
• 1st dose (non-traumatic placement) • 1st dose (traumatic placement) • 2nd dose and start of Q 12 dosing	4 hr 24 hr	At least 12 hr 24 hr 24 hr after 1st dose
From epidural catheter removal until LMWH	4 hr	12 hr after needle insertion **or** 4 hr after epidural catheter removal

N/A-Not applicable; Q12, once every 12 hours

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Accidental Dural Puncture

50

Stephen Ramage, Sarah Armstrong, Nolan McDonnell, and Elizabeth Beattie

Definition

Accidental dural puncture (ADP) refers to the unintentional puncture of the dural membrane (dura mater) and underlying arachnoid mater, generally during the performance of a neuraxial block such as an epidural placed for labour analgesia. Most commonly this is caused by the puncture of the dural membrane by the tip of the epidural needle. More rarely, it may be caused either through the penetration of the epidural catheter through the dura (perhaps already breached by an epidural needle) or through puncture of the dural membrane by a (spinal) introducer needle when performing spinal anaesthesia/analgesia.

Incidence

The reported incidence varies considerably. Quoted figures range from 0.04% to 6% following the placement of an epidural catheter for labour neuraxial analgesia [1, 2].

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Risk Factors

Patient

- Extremes of body weight, including both low and high body mass index (BMI) [3, 4]. (Although high BMI has also been associated with a reduced risk of post-dural puncture headache (PDPH) following ADP) [5]
- Increased depth of the epidural space [6]
- Inability for the patient to remain still during the neuraxial procedure e.g. maternal distress correlating with increased cervical dilation [7, 8].

Operator

- Multiple attempts to locate the epidural space (8)
- Inexperience, although there is conflicting data.

Recognition

ADP may be recognised at the time of the procedure by the free flow of cerebrospinal fluid (CSF) from the epidural needle. CSF has a similar appearance to saline and this may create confusion when a loss of resistance to saline (LORS) epidural technique has been performed, especially if large volumes of saline are injected into the epidural space at the same time as part of the LORS technique. If ADP occurs, the fluid flowing from the epidural needle may be analysed to differentiate between CSF and saline:

- CSF is warm, pH 7.5–8.5 and contains small amounts of both glucose and protein.
- Normal saline is cold, pH is 5–7.5 and there is no glucose or protein present.

From a practical perspective, fluid analysis is rarely performed since the clinical priority would be to initiate analgesia by one of the methods discussed below.

Management

The prompt recognition of ADP is an essential component for safe clinical care. When the dura is punctured with a large bore epidural needle (e.g. 16–18G), CSF will often flow back freely, however this may not always occur and therefore a high

degree of suspicion is required. Epidural catheters should always be aspirated before any drugs are administered, although this is not foolproof. It is recommended that all epidural drugs are given in slow, incremental doses.

Should a recognised ADP occur in a labouring woman, three main management options are available, the choice of which will depend on a number of factors with maternal safety being prioritized.

Initially, the loss of further CSF should be prevented by reinsertion of the epidural needle stylet while further options are considered.

1. *Intrathecal catheter:* insertion of the epidural catheter through the punctured dural membrane at the time of the ADP and provision of spinal analgesia using the same epidural catheter. While the use of an intrathecal catheter has been shown to reduce the incidence of PDPH, a recent meta-analysis reported no firm evidence to corroborate this finding [9–11]. An intrathecal catheter can provide excellent labour analgesia but must be countered with the risks associated with intrathecal drug administration, especially the risk of drug error. Approximately 4 cm of catheter should be inserted into the intrathecal space. Although it is possible to consider patient controlled spinal analgesia (using a PCEA pump) it is most usually recommended that intrathecal top-ups should only be administered by an anaesthetist, which is safer but more labour-intensive. Extreme care must be taken in relation to the dose and volume administered, to avoid the complications of inappropriately high spinal blockade including haemodynamic collapse and a total spinal.

   Anaesthesia for a caesarean or instrumental delivery may be provided by cautious, small incremental doses of a hyperbaric bupivacaine solution.
2. *Repeat the epidural procedure:* this can be performed at a different interspace. As the dura has already been punctured, care should be taken as drugs administered epidurally may cross the dural membrane more readily into the intrathecal space. For this reason, many centres recommend that all subsequent epidural top-ups are only administered by an anaesthetist.
3. *Abandon epidural analgesia:* consider alternative techniques such as I.V. opioids (e.g. fentanyl or remifentanil patient-controlled analgesia).

Postnatally, patients should be closely followed up for symptoms and signs of a post dural puncture headache (PDPH) and offered appropriate treatment should this occur (See Chap. 51). Additional complications include chronic headache, subdural haematoma, seizures and cranial nerve palsies. If the patient is discharged home, she should be provided with clear information regarding ADP and PDPH, including what symptoms to look out for, when to seek medical advice and whom to contact with appropriate contact details.

Documentation

Accidental dural puncture is a recognised complication of neuraxial techniques. Where possible, women should be consented for this risk before performing the procedure. This discussion should include the potential consequences of an accidental dural puncture, including the development of a PDPH.

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Post Dural Puncture Headache

51

Stephen Ramage, Sarah Armstrong, Nolan McDonnell, and Elizabeth Beattie

Incidence

Post dural puncture headache (PDPH) is a relatively common complication of neuraxial anaesthesia; it may occur following either epidural or spinal techniques and is a cause of significant postnatal morbidity. The incidence of PDPH following unintended dural puncture with an epidural needle such as a Tuohy has been shown to be as high as 80% [1] while a headache as result of deliberate puncture with a significantly smaller spinal needle is much rarer. In 90% of cases, symptoms develop within the first 72 hours following dural puncture. Rarely, symptoms can be immediate or present up to 14 days after this event. The symptoms can often be severe and PDPH can be associated with a prolonged length of hospital stay and difficulty providing postpartum care to the new baby.

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Mechanism

Cerebrospinal fluid (CSF) provides buoyancy to the brain by reducing its effective weight and offers protection from mechanical stresses. Leakage of CSF at a rate greater than CSF production reduces CSF pressure causing the brain to "sink" within the skull which may result in pain secondary to traction on attached structures including the meninges, blood vessels and cranial nerves. As CSF pressure falls, so does intracranial pressure (ICP). In accordance with the Monro-Kellie doctrine there is a compensatory reflex venodilatation of the cranial vessels to maintain ICP, further worsening the headache. Typical MRI features of a CSF leak associated with a PDPH are illustrated within Fig. 51.1.

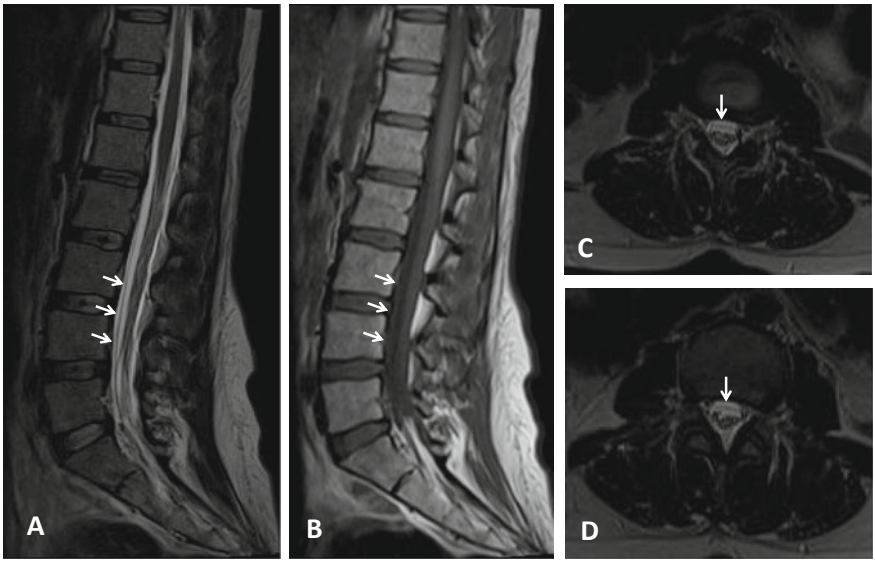

Fig. 51.1 **(A)** T2W sagittal image of the lumbar spine demonstrating T2W hyperintense (brighter) collection (arrowed) ventral to the theca and displacing the dura dorsally. **(B)** T1W sagittal image demonstrates that the collection is T1W hypointense (darker), with signal characteristics similar to CSF. Axial T2W images through the CSF collection (**C**) and **(D)** demonstrate the T2W hyperintense (brighter) collection in the epidural space ventral to the theca (arrowed): Reproduced with the kind permission of Dr. Harpreet Hyare, University College London Hospitals NHS Foundation Trust, London, UK

Risk Factors for Developing PDPH

Needle Considerations

- Large needle size (e.g. a 16 G needle has a greater risk of causing PDPH than an 18 G needle).
- Cutting tip (non-Pencilpoint)
- Multiple needle insertions

Operator Considerations

- Risk increases with operator inexperience.

Patient Considerations

- Risks are reduced at extremes of age and therefore there is an increased risk at childbearing age.
- Female sex—risks are at least two-fold.
- Previous history of migraine
- Body mass index (BMI): The effect of BMI on the risk of PDPH is inconclusive. While some studies demonstrate a lower incidence of PDPH in obese patients following accidental dural puncture, other studies describe no association.

Diagnosis

Following a recognised accidental dural puncture (ADP) with an epidural needle, a high index of suspicion and early management of PDPH can minimise both short and long term sequelae. Classically, the headache associated with dural puncture is bilateral and described as occipito-frontal, often radiating to the neck and shoulders. The key feature is that the headache has ***a postural component***; the headache worsens within 15 minutes of sitting or standing and improves within 15 minutes after lying and may be associated with one or more of the following:

- tinnitus
- neck stiffness
- hypoacusis (hearing impairment)
- photophobia
- nausea

Table 51.1 Differential diagnoses of post-partum headache

Infective	Meningitis, encephalitis, sinusitis
Metabolic	Dehydration, caffeine withdrawal
Vascular	Migraine, cerebral vein thrombosis, cerebral infarction, subdural haematoma, subarachnoid haemorrhage
Neoplastic	Space occupying lesion
Other	Tension headache, pre-eclampsia, PDPH, benign intracranial hypertension (BIH), pneumocephalus

Assessment

PDPH shares common features with many other causes of headache, these include some serious and life-threatening pathologies [2] (Table 51.1).

History:

- A full medical and obstetric history
- Features of the headache and associated symptoms
- Review documentation of the neuraxial block (e.g. epidural) insertion.

Examination:

- The skin over the epidural or spinal puncture site should be inspected for CSF leak, inflammation and tenderness.
- Gutsche's test (relief of headache on abdominal compression when standing) can be performed but is unreliable.

Investigation:

- PDPH is primarily a clinical diagnosis; a headache with a *postural component* following dural puncture is usually sufficient to make the diagnosis.
- Maintain a high index of suspicion for other more serious pathologies and consider early diagnostic imaging (e.g. MRI or CT imaging).
- Other investigations may be useful in cases of clinical uncertainty e.g. FBC (full blood count), CRP (C reactive protein), LFT (liver function test), blood culture, lumbar puncture.

Management

Resolution of PDPH requires the CSF leak to reduce and the CSF pressure to normalise, this occurs either spontaneously or can be expedited by performing an

epidural blood patch (EBP). 70% of PDPH will resolve within 7 days with no intervention [3].

Ensure the patient is well-informed of the cause, likely symptoms, treatment options and prognosis as well as being provided with written information. An example of written information can be found here:

https://www.labourpains.com/assets/_managed/cms/files/Headache_after_epidural.pdf.

Clear documentation of examination, management and communication with the patient is essential. Written or electronic communication with the patient's family physician is also strongly recommended especially once the patient is discharged from hospital.

Conservative management

- Regular simple analgesia (paracetamol ± non-steroidal anti-inflammatory drugs, NSAIDs)
- Opioids are unlikely to be of any added benefit
- Anti-emetics (e.g. ondansetron)
- Stool softeners (e.g. lactulose) to reduce exacerbation of symptoms caused by straining which may increase the CSF leak.
- Deep vein thrombosis (DVT) risk assessment is essential. Encourage the patient to mobilise if possible and wear anti-embolism stockings. If the patient is receiving low molecular weight heparin (LMWH) this will have implications for the timing of an epidural blood patch (EBP) should it be required.
- Fluid therapy: while the avoidance of dehydration is advised for symptom management, there is no evidence to support the theory that fluid administration either prevents or resolves dural puncture headaches by altering CSF production.
- Caffeine is controversial [4]. Therapeutic doses are associated with arrhythmias and a lower seizure threshold and there is little, if any, evidence to support its use in the management of PDPH.

Epidural blood patch (see Chap. 52)

- **Alternative/novel therapies**: 2 neuraxial anaesthetic techniques have been described to treat PDPH, offering effective alternatives to EBP, should it be contraindicated. While early observational studies and case reports have been promising, more rigorous clinical trials are required before these techniques can be recommended [5].
  - Bilateral **sphenopalatine ganglion block** by transnasal application of local anaesthetic has proved efficacious in the treatment of PDPH [6]. It is a low risk, non-invasive procedure and is relatively simple to perform.
  - **Greater occipital nerve blocks** have also been shown to improve PDPH symptoms, supporting the theory that the headache, in part, is caused by mechanical traction of the meninges, in particular the dura.

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Epidural Blood Patch

52

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An epidural blood patch (EBP) is the injection of a patient's own (autologous) blood into the epidural space and is considered the definitive management of a suspected post dural puncture headache (PDPH). It has been shown to significantly reduce the incidence and severity of PDPH when compared to conservative treatment [1, 2].

Mechanism

The aetiology of PDPH is thought to be a result of both traction on intracranial structures including nerves and reflex venodilatation resulting from reduced cerebrospinal fluid (CSF) pressure secondary to its leakage from the dural puncture site (see Chap. 51). The exact mechanism by which an EBP resolves PDPH is unclear, but it is thought to be multifactorial:

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- Injection of blood into the epidural space around the site of the suspected dural puncture forms a clot which effectively seals the defect made in the dural membrane, limiting the further loss of CSF.
- The blood clot may then stimulate a series of inflammatory and proliferative events that result in collagen repair of the dural defect.
- Direct compression of the dural sac by the volume of blood likely increases both spinal and intracranial CSF pressure which may explain the often rapid resolution of the headache reported in many cases.

Patient Selection

Appropriate patient selection for an EBP is important. There are a number of causes of headache in post-partum women and a high index of suspicion for alternative and potentially serious causes is required. Women most likely to benefit include those with moderate to severe PDPH symptoms, which are having a significant impact on their ability to care for their newborn.

Most contraindications are relative and include:

1. Documented blood infection (as this may increase the risk of meningitis/abscess).
2. Coagulopathy (due to the risk of neuraxial haematoma).
3. Local infection at the puncture site.
4. Haematologic malignancy.
5. Atypical headache requiring investigation.
6. Jehovah's Witnesses—this should be discussed with the woman on a case-by-case basis. Colloid may be a less effective but potentially a suitable alternative to an EBP.
7. Patient refusal.

Efficacy

The success of an EBP is dependent on a number of factors including;

- The *timing* of the EBP in relation to the suspected dural puncture. Performing the EBP less than 24 hours following dural puncture reduces the success rate, the optimal timing is thought to be from 48 hours after the dural puncture occurred, although this should not be delayed if the patient is severely affected [3].
- The *volume* of blood injected. The amount required for symptom resolution is unclear; while evidence supports a minimum volume of at least 20 ml, volumes between 20 and 30 ml have not been shown to be superior [4, 5].
- The *size and type* of needle that caused the dural puncture. A larger gauge needle used to create the dural puncture reduces the likelihood of resolution of headache

symptoms. With a PDPH caused by accidental dural puncture with an epidural needle such as a Tuohy needle (16–18 G), complete relief with an EBP can occur in approximately 30% of patients with partial relief occurring in a further 50–80% [1], whilst relief rates of up to 95% have been reported from spinal needles (24–27 G) induced PDPH.

If, after an EBP, the headache persists or if there is only a partial or transient resolution of symptoms the procedure may be repeated with success rates following a second EBP similar to that of the first. If the patient remains symptomatic following a second EBP, it is unlikely that further attempts will be successful and may put the patient a greater risk of complications such as repeated dural puncture. Differential diagnoses of postpartum headache should be considered (see Chap. 51) alongside a lower threshold for further investigations, including radiological imaging (e.g. MRI/CT scan), as well early discussion with a neurologist.

Procedure

Where possible, a senior experienced anaesthetist should perform the procedure to minimise the risk of further accidental dural puncture. Two anaesthetists are usually required; the most senior to locate the epidural space while the second performs the venepuncture. Informed, written consent must be obtained.

Complications associated with EBP include:

- Back pain. (common following the procedure and usually resolves within 2 days)
- Failure (10–50%)
- Radiculopathy
- Another ADP
- Nerve damage
- Central nervous system (CNS) infection/seizures/epidural abscess.

Location: The EBP should be performed in a familiar clinical environment such as the anaesthetic room, if available, or in the operating theatre.

Position: The procedure can be performed in either the sitting or lateral position; patients will generally be more comfortable lying laterally, but this may be a less familiar position for the anaesthetist performing the EBP, increasing the risk of dural puncture and potentially increasing the duration and difficulty of the procedure.

Infection control: Both blood collection and the epidural injection should be performed using a strict aseptic technique (hat, mask, gown, gloves, and a skin preparation solution such as chlorhexidine or povidone iodine to prepare the back in the absence of contraindications).

Site: The epidural space should be accessed at the same level or one space below the original puncture site as MRI imaging suggests that the injected epidural blood tends to spread more cephalad than caudad.

Injection: On reaching the epidural space, a syringe containing autologous blood is directly connected to the epidural needle and blood is slowly injected until the patient feels some discomfort or "fullness", or up to 30 ml of blood have been injected, whichever occurs first.

Post-procedure management:

- The patient should remain supine for a minimum of 2 hours to allow stabilisation of the clot before sitting up and then gently mobilising. Avoidance of heavy lifting/straining is advised.
- It is not uncommon to have mild back discomfort, which can be managed with simple analgesia and reassurance.
- If the procedure is successful, and following a short period of ward-based observation, patients can be discharged home once able to resume normal activities and when other standard postnatal discharge criteria have been met.
- Follow-up by the anaesthesia team should be offered to ensure that the patient has a clear understanding of the reasons for their headache, the implications with any future neuraxial procedures and notification of the patient's primary care physician is recommended [6]. Details of who to contact in an emergency must also be provided should the patient experience "red flag" symptoms such as fever, leg weakness or continence problems.

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Intrapartum Fever

53

Selina Patel and Pervez Sultan

Definition

There is no universal definition for intrapartum fever (IPF).

- UK guidelines define IPF as maternal temperature ≥ 38 °C on a single occasion or two temperature readings ≥ 37.5 °C one hour apart [1].
- US guidelines define IPF as maternal oral temperature ≥ 39 °C on a single occasion, or two oral temperature readings 38–38.9 °C, 30 min apart [2].

Causes

Etiology can be infectious or non-infectious (Table 53.1). Any infection (viral or bacterial) can be a source for IPF.

Epidural related maternal fever

- Non-infectious IPF is more common in women who receive epidural analgesia during labor (Fig. 53.1).
- Epidural-related maternal fever has been reported in approximately 26% of women who receive epidural analgesia during labor [3].
- After adjusting for other confounding factors, women receiving labor epidural analgesia in a large study (>16,500 women) had 5.5 times greater odds of

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Table 53.1 Common causes of IPF

Infectious causes	Non-infectious causes
Intraamniotic infection (chorioamnionitis)	Epidural-related maternal fever
Urinary tract infection	Thromboembolism
Upper respiratory tract infection	Overheated labor and delivery room
Lower respiratory tract infection/pneumonia	Drug fever—usually a diagnosis of exclusion

Fig. 53.1 Graph demonstrating epidural-related maternal fever. Mean vaginal temperature (ºC) measured in two groups of patients during labour. • pethidine analgesia, ○ epidural analgesia, vertical bars - standard error of the mean; from Fusi L et al. Maternal pyrexia associated with the use of epidural anaesthesia in labour. Lancet. 1998;1(8649):1250–2. Published with the permission of Elsevier

developing maternal fever compared to women not receiving labor epidural analgesia [4].

- Emerging evidence suggests that epidural-related maternal fever may be caused by immune changes, or changes in thermoregulatory mechanisms, induced by local anesthetics in laboring women.
- Further studies are needed to further elucidate the precise mechanisms responsible for this phenomenon, which has only been described in obstetric patients.

Maternal Consequences

- Maternal consequences of IPF depend on the cause.
- Women who develop IPF are more likely to receive antibiotics and are at increased risk of cesarean delivery.
- IPF due to intraamniotic infection is associated with [5]:
  - uterine atony
  - postpartum haemorrhage (PPH)
  - endometritis

– pelvic thrombophlebitis

Fetal Consequences

- Maternal IPF due to both infectious and non-infectious causes has been associated with adverse neonatal outcomes.
- IPF is a risk factor for meconium aspiration syndrome, neonatal seizures, assisted ventilation and early mortality in the neonate [6].
- Infectious IPF due to intraamniotic infection can lead to neonatal sepsis, pneumonia and death [7].
- Non-infectious IPF due to epidural analgesia has been linked to low 1 min APGAR scores, hypotonia and increased need for respiratory support in the neonate [8].

It is therefore advised that neonatologists are consulted early to ensure appropriate evaluation and management of these newborns at birth.

Management

- A detailed history and examination should be conducted to elicit the cause of IPF and direct management.
- Determining whether IPF is due to an infectious or non-infectious cause in the absence of clinical symptoms (vaginal discharge, productive cough or urinary symptoms) and negative urinalysis can be challenging during labor.
- Normal labor is associated with an increased respiratory rate, heart rate and white cell count, which are also the signs usually used to diagnose infection.
- Recent guidelines encourage obstetricians to consider a diagnosis of intraamniotic infection in any case of IPF and to actively treat with broad-spectrum antibiotics, antipyretics and expeditious delivery [9].
- Due to the increased risk of uterine atony and postpartum haemorrhage (PPH), proactive management with uterotonics and resuscitation should be implemented.

If infectious IPF with septic shock is evident, then aggressive treatment with critical care involvement is advised.

Anesthetic Implications

- There are no specific guidelines on the provision of anesthesia in the presence of IPF and therefore advice from a senior anesthesiologist should be sought early.

- The choice of anesthesia must be made on an individual basis taking into consideration the potential cause of IPF, the maternal clinical status, as well as risks and benefits of utilizing a neuraxial technique.

Neuraxial Anesthesia

- Central nervous system (CNS) infections (meningitis, epidural abscess and arachnoiditis) are rare following neuraxial anesthesia, but remain a theoretical risk for any parturient demonstrating evidence of bacteremia.
- Current evidence would suggest that administration of neuraxial anesthesia is safe in parturients with IPF due to systemic infection, provided that treatment (antibiotics and antipyretics) has been administered, which has resulted in an adequate response (e.g. decrease in maternal temperature) [10].
- If neuraxial anesthesia is thought to be appropriate, then early epidural placement for laboring patients may prove beneficial as parturients with IPF are at higher risk of dysfunctional labor and emergency cesarean delivery. However, when IPF is due to a localized infection over the injection site, this is an absolute contraindication to neuraxial anesthesia and alternative options of analgesia and anesthesia should be discussed and offered to the patient.
- Thorough asepsis is prudent whenever administering neuraxial anesthesia, but is of particular importance when there is suspicion of systemic infection.
- The risk of developing an epidural space infection increases with the length of time an epidural catheter remains in situ, however short-term use of epidural analgesia or anesthesia during the peripartum period is most likely to be safe even in the presence of IPF [9].
- Parturients in whom neuraxial anesthesia was established after a diagnosis of IPF must be followed up vigilantly as timely diagnosis and management of any CNS infection is required for the best clinical outcomes.

General Anesthesia

- If IPF occurs due to an infectious cause and is accompanied with hemodynamic instability (severe sepsis/septic shock), neuraxial anesthesia may be contraindicated and general anesthesia will most likely be required in the event of cesarean delivery.
- Pre-oxygenation is vital in these patients as sepsis is associated with an increased metabolic rate and oxygen consumption, predisposing patients to rapid oxygen desaturation.
- Additional challenges for airway management may occur if respiratory infection is present (airway irritability and increased secretions), and difficult intubation equipment must be readily available for all general anesthesia cases in the obstetric setting.

- Ideally all parturients with a diagnosis of sepsis should be adequately resuscitated before induction of general anesthesia in order to facilitate fetal resuscitation in utero. However this may not be possible in the emergency cesarean delivery setting, and the use of ketamine and etomidate may be considered in these patients as they are generally associated with greater hemodynamic stability (less effect on systemic vascular resistance and blood pressure) compared with propofol and thiopentone.
- The combined effects of general anesthesia on uterine tone and potential coagulopathy secondary to sepsis can cause significant hemorrhage with worsening hypotension. Resuscitation in these patients may therefore require invasive monitoring and blood transfusion.

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Failed Epidural Analgesia During Labour

54

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The rate of failure for epidural analgesia in labour is approximately 12–14% and should be discussed when consenting the patient for neuraxial labour analgesia [1, 2]. While approximately half of these failed epidural catheters can become functional after employing the measures discussed below, approximately 7% of all originally working catheters will require re-siting [2].

Assessment and management of a poorly functioning epidural in labour **is essential**; accepting suboptimal analgesia is not only distressing to the mother but may also create difficulties for the anaesthetist should an emergency caesarean delivery be required.

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Risk Factors for Failed Labour Epidural Analgesia

1. *Maternal factors;*

   - **High body mass index (BMI)**.

     Epidural block failure may be due to difficulty identifying the midline (increasing the likelihood of one-sided or partial analgesia) and depth of the epidural space, which may require a longer epidural needle or ultrasound guided placement.

     Inadequate analgesia, despite successfully finding the epidural space, may occur due to epidural catheter migration as the patient moves from the sitting to the supine position *after* securing the epidural catheter to the skin. It may therefore be preferable to secure the epidural catheter to the skin using an epidural catheter fixation device with the woman in the lateral position in order to reduce epidural catheter movement [3, 4].

   - **Abnormal vertebral anatomy** (e.g. scoliosis or previous spinal surgery). Structural back abnormalities may result in inadequate spread of epidural drug solution within the epidural space.

   - **Abnormal neuraxial anatomy**. Fibrous epidural bands and, rarely, a median epidural septum can result in "missed segments" or a unilateral block.

   - **Chronic back pain** may be associated with delayed onset of analgesia.

2. *Obstetric factors;*

   - **Rapid cervical dilation**. The onset of epidural analgesia can take up to 15–20 minutes, which may present as inadequate analgesia in women with rapid cervical dilatation.
   - **Fetal presentation**. Abnormal lie, in particular the occipito-posterior position, can cause both nerve compression and excess pressure on bony structures such as the sacral spine. The associated breakthrough pain can be severe and difficult to treat.

3. *Anaesthetic factors;*

   - **Experience of the anaesthetist**. The failure rate (and rate of accidental dural puncture) is higher when an epidural is sited by more inexperienced anaesthetists.

Causes of Failed Labour Epidural Analgesia

1. ***Epidural catheter migration;***

   (a) **Laterally**—resulting in a unilateral block. "Transforaminal escape" of the epidural catheter may occur if an excess length of epidural catheter is passed into the epidural space [5].
   (b) **Intravascularly**—risking local anaesthetic toxicity. Detection by routine aspiration of the epidural catheter prior to fixation may help reduce the incidence of inadvertent intravascular injection of the local anaesthetic mixture.
   (c) **Intrathecally**—risking a high block with associated cardiovascular and maternofetal compromise and possibly total spinal anaesthesia. Clinicians should maintain a high index of suspicion should an unexpectedly rapid onset of anaesthesia, motor block or sudden drop in blood pressure be observed.
   (d) **Subdurally**—in the potential space between the dura and the arachnoid mater. Subdural drug delivery can result in an unpredictable block in terms of motor and sensory effects (usually described as "high and patchy").

2. ***Incorrect location of the epidural catheter*** (drug delivery to the wrong site):

   (e) **Complete dislodgement** from the epidural space following initial siting in the correct anatomical location.
   (f) A **false loss of resistance** may be observed when the epidural needle tip lies within subcutaneous tissues and as a result the catheter is passed superficial to the epidural space.

3. ***Device failure*** *(if an infusion device is used to deliver epidural drugs)*:

   (g) **Power failure**.
   (h) **Disconnection** of the infusion device from the epidural catheter.
   (i) **Mechanical obstruction** by either a blocked or kinked epidural catheter (single orifice catheters are more likely to block than multiorifice catheters or the newer single orifice, wire-reinforced catheters).

4. ***Pharmacological/pharmacogenetic factors;***

   (a) **Incorrect total dose** of local anaesthetic
   (b) **Resistance** to local anaesthetics (rarely associated with complex medical syndromes, e.g. Ehlers Danlos syndrome).

Assessment of Inadequate Labour Epidural Analgesia

- **Documentation review**. The depth of the epidural space as assessed by the loss of resistance technique, the length of epidural catheter left in the epidural space and any difficulties encountered while performing the procedure.
- **Pain assessment**. Identify the site and quality of discomfort and whether the patient is experiencing pain or pressure. Use a subjective pain score such as mild/moderate/severe or a numerical grading scale e.g. 0–10.
- **Consider other differential diagnoses**. Exclude other causes of pain such as uterine rupture (particularly in patients who have constant abdominal pain and who have had a previous caesarean delivery) and low anterior pain associated with bladder distension. In many delivery units urinary catheterisation is routinely performed following epidural insertion, however urinary catheter obstruction is possible.
- **Examine the epidural catheter insertion site**. Assess for catheter migration/leak/kinking.
- **Block assessment**. Map the dermatomal distribution of the epidural analgesia, most commonly using ethyl chloride (cold) spray. Ensure both upper and lower levels, bilaterally, are assessed. Assess for the presence (or absence of) warm feet, which usually will indicate sympathetic blockade.
- **Check the epidural infusion device, administration set and epidural catheter connections**. Disconnection at the epidural filter site is common. Epidural infusion device (e.g. patient controlled epidural analgesia; PCEA pump) failure should be excluded.

Troubleshooting Considerations

A suggested algorithm for how to manage failed labour epidural analgesia, is provided in Fig. 54.1.

1. **Has the epidural ever worked?** If not, the epidural catheter is unlikely to have been placed within the correct space.

    - Have a low threshold to resite the epidural catheter although consider the extent to which labour has now progressed or any technical challenges met during previous insertion attempts.

2. **Is it partially working?**

    - If **bilateral block**, If the block is bilateral, administer 10 ml boluses of low dose mixture (LDM) of local anaesthetic and opioid (such as 0.1% bupivacaine and 2 mcg/ml fentanyl), which can be given to increase the height of

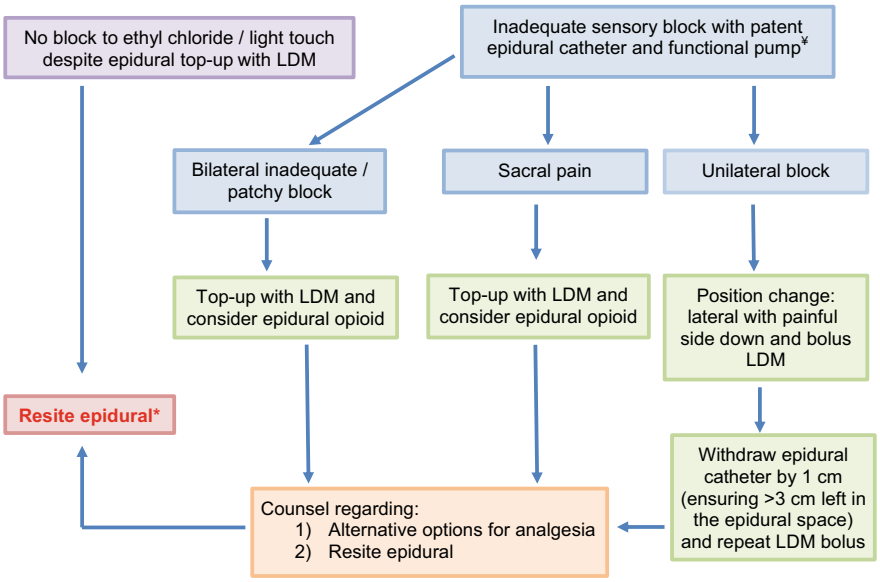

Fig. 54.1 Management of failed labour epidural analgesia. **LDM**: Low Dose epidural Mixture (e.g. 0.1% bupivacaine and 2 mcg/mL fentanyl). **Top up**: For example, 10 mL of LDM administered over 1 minute (if no or minimal effect a further 10 mL is given after 5 minutes and after checking the block level) **Epidural opioid**: fentanyl 50–100 mcg; choice and volume of agent may vary depending on individual institutional protocols. Arrows represent decision making if the outlined strategy fails. ¥ If intravenous catheter detected during any stage of assessment, epidural should be resited. * If decision taken to resite, then consider performing a combined spinal-epidural (CSE)

the sensory block, allowing time between doses to assess efficacy and to detect adverse effects such as a high block or cardiovascular instability.

- For a **unilateral block** or a **patchy block**, withdraw the epidural catheter by 1 cm (ensuring sterility is maintained) and administer a bolus of 10 ml LDM with the patient in the lateral position, painful side down. Ensure at least 3 cm of catheter remains within the epidural space.

3. **Where is the pain?** Low **sacral** pain might reflect an abnormal fetal position, in particular the occipto-posterior or "back-to-back" position. **Perineal** pain may result from nerve root compression.

- Sacral blockade may be optimised by giving an additional bolus (e.g. 10 ml) of LDM. While many clinicians advocate administering this with the patient sitting upright there exists little evidence to support this practice; a volume of LDM given at a fast rate alone may improve sacral spread of the drug with any effect of the patient's position being negligible.

- For perineal pain consider adding a lipid-soluble opioid. Dilute 100 mcg fentanyl in 10 ml 0.9% saline and give 50–100 mcg (5–10 ml). This might also improve sacral discomfort.

If all the above measures are performed and no further satisfactory analgesia is achieved, consider resiting the epidural catheter. The parturient should be informed that a repeat epidural may also fail to provide satisfactory analgesia. A combined spinal-epidural (CSE) may provide faster analgesia and minimise the chance of subsequent unilateral block [6]. If further neuraxial blockade is technically challenging or unsuccessful, intravenous remifentanil patient-controlled analgesia (PCA) may be a suitable alternative in some centres, depending on both its availability and availability of appropriately trained midwifery staff.

Follow up

Post-epidural review of patient experience and satisfaction should be undertaken to address concerns and audit quality of the hospital epidural analgesia service.

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Failed Spinal Anaesthesia for Caesarean Delivery

55

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Introduction

The reported incidence of failed spinal anaesthesia for caesarean delivery (CD) varies widely from less than 1% through to 17% [1–3]. An incidence of pain (as reported by the parturient) of less than 5% and 15% during elective and emergency cases, respectively, is recommended by the UK Royal College of Anaesthetists as a standard for best practice [4].

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Definition of Failed Spinal Anaesthesia for Cesarean Delivery

Failure of spinal anaesthesia for CD may be considered as either

- Attempted spinal anesthesia, **with no resultant block** or, more commonly;
- Attempted spinal anaesthesia leading to **inadequate block** for the intended surgery. More specifically, this may describe inadequacy of:
  - block height
  - quality of the block
  - duration of local anaesthetic action [1].

The consequences of failed spinal anaesthesia for CD are significant;

- Spinal anesthesia is **safer** than general anaesthesia in the pregnant patient. The significant shift from general anesthesia to neuraxial anesthesia for CD has played a major role in improving patient safety as highlighted in audits of maternal mortality from the past 60 years [5].
- **Medicolegally**, claims for inadequate neuraxial anaesthesia for CD are represented prominently in both the American Closed Claims Database and the UK Clinical Negligence Scheme for Trusts [6, 7]. Given the increasing use of neuraxial anaesthesia for CD, it therefore follows that a high rate of failure of spinal anaesthesia places women at potential risk of harm from higher rates of conversion from neuraxial to general anaesthesia.

Presentation and Causes of Failed Spinal Anaesthesia

Failed spinal anaesthesia may present in a number of ways:

1. **Complete absence of block (sensory/motor)**

   (a) Failure to deliver anaesthetic drugs into the cerebrospinal fluid (CSF), which may be secondary to;

   - difficulty siting the spinal needle in the dural space, usually due to poor patient positioning, difficult body habitus or incorrect identification of anatomical landmarks.
   - inability to obtain CSF despite an apparently well-placed needle (sometimes called a “dry tap”).
   - incorrect identification of CSF within the spinal needle hub. Occasionally the infiltrated local anaesthetic solution or a previous epidural top-up will siphon into the spinal needle causing the practitioner to mistake it for CSF and therefore correct needle placement.

(b) Rarely a complete absence of block can be due to 'pseudo-successful' spinal needle placement into CSF-filled perineural cysts, which do not communicate with the subarachnoid space [8].
(c) Controversially, faulty or inactive local anaesthetic preparations have been implicated in failure to provide anaesthesia. However, an examination of Product Defect Notification reports from one drug manufacturer showed that all samples returned for analysis were within product specifications [1].

2. **Evidence of block, but inadequate level to commence surgery.** This may be secondary to:

(a) **Inadequate local anaesthetic dose selection**. Up-down sequential allocation studies have established the effective dose of spinal anaesthesia medications to achieve a bilateral sensory block to the T6 dermatome within 10 min for CD in 50% (ED50) and 95% (ED95) of the population [9, 10] (Table 55.1). The use of doses of local anaesthetic below the ED95 value, increases the need for intraoperative supplementation.
(b) **Failure to deliver an adequate local anaesthetic dose** to the intrathecal space. This may be due to leakage from a syringe connection or if the spinal needle tip straddles the dural membrane leading to only a portion of the drug dose being administered into the intrathecal space (Fig. 55.1) [1]. Additionally, the dura may potentially act as a flap valve, allowing successful aspiration of CSF following dural puncture, but on spinal injection, the flap moves away and a portion of the injectate flows into the either the epidural or subdural spaces (Fig. 55.2).
(c) **Inadequate post-spinal management**. Time constraints often associated with urgent and emergency CD can limit the time available to perform and establish anaesthesia. Similarly, the use of prolonged reverse Trendelenburg or a sitting position together with hyperbaric local anaesthetic can result in a low block after an otherwise successful spinal procedure. Additionally, inadequate testing of spinal anaesthesia can lead to either an under- or over-estimation of the block height and in turn may cause a perfectly good spinal block to be labelled a "failure", or conversely allow surgery to

Table 55.1 Effective dose for spinal anaesthesia for caesarean delivery in 50 and 95% of the population (ED—effective dose; mcg—micrograms; mL—millilitres), volumes of 0.5% bupivacaine presented in parentheses

Intrathecal drugs	ED_{50} for operative success (Volume in mL)	ED_{95} for operative success (Volume in mL)
Isobaric 0.5% bupivacaine (+fentanyl 10 mcg and morphine 200 mcg) [9]	7.25 mg (1.45)	13.0 mg (2.6)
Hyperbaric 0.5% bupivacaine (+fentanyl 15 mcg and morphine 75 mcg) [10]	6.0 mg (1.2)	12.6 mg (2.52)

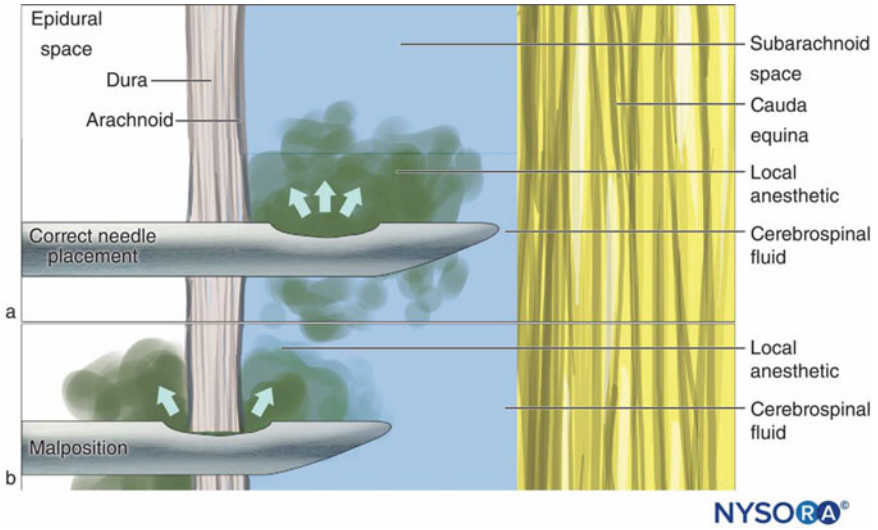

Fig. 55.1 Correct needle placement with **a** all drug delivered to CSF and **b** malposition where some of the drug is lost into the epidural space. Reproduced with kind permission of NYSORA.COM

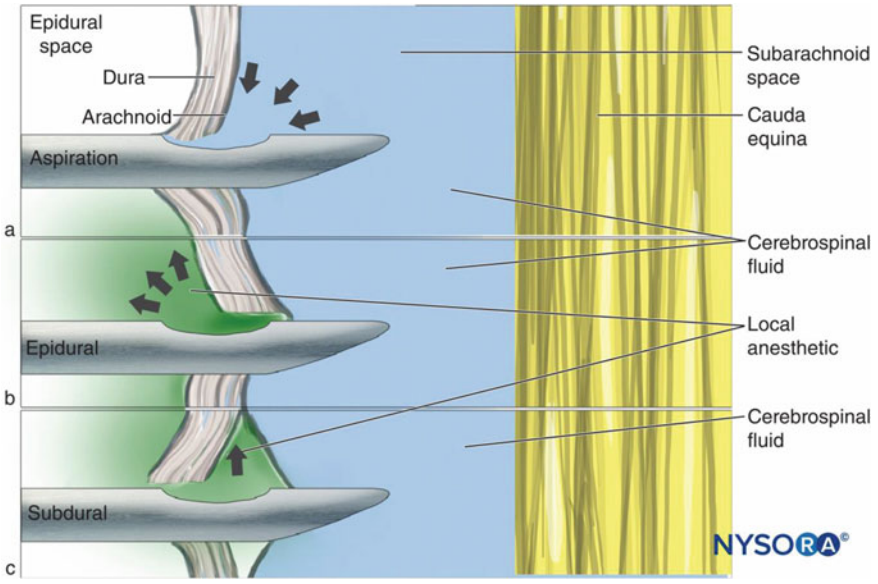

Fig. 55.2 The flap valve effect: **a** CSF is aspirated but on injection the meningeal layers move, resulting in **b** epidural or **c** subdural injection of drug. Reproduced with kind permission of NYSORA.COM

proceed on a patient without adequate level of anaesthesia. Adequacy of spinal anaesthesia for CD is considered to be an upper limit of block to light touch to the T5 dermatome bilaterally. However, surveys of obstetric anesthetists suggest that in practice most favour an upper limit of block to cold up to the T4 dermatome bilaterally [11].

3. **A patchy or unilateral block.** Patchy or unilateral blocks are uncommon and may be associated with anatomical abnormalities. Block spread may be impeded or limited by:

   (a) major abnormalities of the spinal column, such as kyphosis or scoliosis.
   (b) spinal pathological lesions, such as spinal stenosis
   (c) adhesions secondary to spinal surgery
   d) rarely, intrathecal septae (divisions) which limit the circulation of subarachnoid local anaesthetic.

4. **Adequate block to commence surgery, but inadequate anaesthesia for the duration of surgery.** The risk of intraoperative pain (following an apparently adequate spinal anaesthetic) is increased by:

   (a) prolonged/complex surgery
   (b) patient anxiety
   (c) spinal anaesthetic doses less than the ED95 values (Table 55.1).

Detailed preoperative discussion involving both the patient and surgeon may help to minimise the occurrence of intraoperative pain; consideration of both surgical factors and patient factors may help to determine both local anaesthetic dose selection as well as anaesthetic technique (spinal versus combined spinal-epidural [CSE] versus general anaesthesia). Where complex and prolonged surgery is unforeseen, expeditious and effective management of breakthrough pain (including consideration of conversion to general anaesthesia) is essential to limit any distress caused to the mother and to facilitate surgery.

Management of Failed Spinal Anaesthesia

The management of failed neuraxial anesthesia for CD is generally similar for anaesthesia administered via an epidural top-up, CSE or spinal injection.

Consideration of the stage of the delivery will help to formulate a structured approach to the management of failed spinal anaesthesia:

1. **Before the start of surgery.** Failure is most commonly identified following:

   (a) inability to locate the subarachnoid space

(b) adequate block height not achieved after siting the spinal

Rapid discussion and decision-making between the anaesthetist, obstetrician and patient is required to ascertain whether the clinical situation allows enough time for a further attempt at providing neuraxial anaesthesia. If it is not possible, general anaesthesia must be provided.

If a further attempt is made to perform neuraxial anaesthesia, the chosen technique must be carefully considered. If only a partial spinal block was achieved during the previous attempt, further subarachnoid doses of local anaesthetic could theoretically place the patient at risk of a high or total spinal block. If time allows, consideration of a CSE will allow the repeat spinal dose to be lowered by 20–30% in an attempt to reduce the risk of high block, while allowing the security of additional epidural doses of local anaesthetic, should the block remain low [12]. Additionally, the presence of a definitive loss of resistance to saline, on insertion of the Tuohy needle, increases the likelihood that the spinal needle will enter the subarachnoid space for administration of the repeat dose.

2. **Intraoperative failure, *before* delivery.** If spinal failure becomes evident after the start of surgery, but before delivery, the anesthesiologist will face two challenging issues:

   (a) Delaying delivery of the fetus to manage spinal failure may contribute to fetal morbidity and mortality
   (b) Neonatal side-effects from maternal administration of drugs

Conflicting evidence regarding neonatal side-effects means that it is probably wise to avoid intravenous (IV) opioid supplementation until after umbilical cord clamping. If analgesic supplementation is required, small boluses of short-acting opioids such as alfentanil (250–500 μm) or fentanyl (25–50 μm) can be administered. Oxygen supplementation and capnography should be considered given the risk of opioid-induced respiratory depression. The pediatrician should be informed that opioids have been given and preparations made to perform neonatal resuscitation if required. 50% nitrous oxide and 50% oxygen are both readily available on anaesthetic machines and familiar to most pregnant women, providing a useful short-term solution, as a bridge to cord-clamping or while preparations are made for inducing general anaesthesia.

All interventions should be underpinned by clear reassurance and communication with the patient and birth partner, if present. However, general anaesthesia should always be discussed with the patient, along with the risks and benefits.

Intraoperative Failure, *After* Delivery

Following delivery of the neonate, there are more options for the management of failed spinal anaesthesia as the risks of mortality and morbidity to the neonate are no longer of concern. Again, reassurance and communication remain the cornerstones of the initial approach and inhaled nitrous oxide can be considered as an analgesic holding measure while further interventions are considered. Vigilance for signs of respiratory and central nervous system depression is essential due to the risks of hypoxia, regurgitation and aspiration, which can be associated with some of the following measures:

(a) short-acting **opioid** analgesia, e.g. alfentanil or fentanyl. Again, a low threshold for supplementary oxygen and capnography is advised.
(b) **ketamine** (suggested IV dose is 0.2 mg/kg), a useful non-opioid alternative for moderate pain. It is, however, associated with emergence phenomena, which the patient may find undesirable. Ketamine should be avoided in hypertensive patients.
(c) **local anaesthetic** infiltration by the surgeon may be of use if pain is localised to the surgical field but this is rarely used.
(d) titrated doses of **benzodiazepines** may be considered if anxiolysis is required. It is vital to counsel the patient about the potential risk of anterograde amnesia associated with this class of drug.

As in all cases of failed spinal anaesthesia for CD, when all possible attempts to optimise analgesia have been unsuccessful, general anaesthesia should be offered. Thorough and contemporaneous documentation not only of medications given but also of all discussions with the mother regarding analgesia or anaesthesia options, is not only good practice, but is essential should the case require retrospective review.

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Pain and Distress During Caesarean Delivery

56

Ryan Howle and Tauqeer Husain

The majority of surgical management in obstetrics is performed with the patient awake, under a neuraxial anaesthetic. This is usually safe, well tolerated, provides excellent analgesia and has numerous benefits over general anaesthesia. However, obstetrics is one of the largest areas of malpractice litigation in anaesthesia and pain experienced during caesarean delivery constitutes a significant proportion of these claims [1, 2]. Therefore, adherence to best practice and detailed documentation is recommended in all cases.

Causes

The causes of pain or distress during caesarean delivery can be classified by the symptoms present, or the form of anaesthesia administered.

Pain

- Complete neuraxial block failure.
- Inadequate block—e.g. "patchy" anaesthesia or an "unblocked segment"; pain on particular surgical manoeuvres, such as exteriorisation of the uterus or swabbing paracolic gutters.
- Starting surgery before adequate anaesthesia has been established.
- Neuraxial block has regressed before completion of surgery—e.g. inadequate anaesthesia dosing or prolonged surgery.

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Distress

- Inadequate warning or inability to cope with the expected and inevitable mechanical sensations e.g. pulling and pressure during the operation.
- Breathlessness—can be subjective secondary to psychological factors or objective intercostal muscle dysfunction from a high neuraxial block.
- Shivering.
- Psychological factors—e.g. generalised anxiety; catastrophisation.
- Anxiety over neonatal condition—e.g. known birth defects; sudden emergency delivery; trauma during delivery; neonatal resuscitation.
- Maternal complications—e.g. haemorrhage; eclampsia; amniotic fluid embolism.

Failure of spinal anaesthesia (see Chap. 55) [3]

- Inadequate local anaesthetic dose.
- Inadequate time for neuraxial block to work.
- Incorrect spinal needle placement erroneously identified as a dural puncture.
- Incomplete delivery of anaesthetic drug—e.g. movement of the spinal needle or partial dural puncture (the orifice of a pencil-point spinal needle can sometimes overlap the dura allowing both intrathecal and extradural injection).
- Anatomical variation of the spine or dural sac.
- Inappropriate patient positioning—e.g. steep head up or prolonged sitting position after the administration of hyperbaric local anaesthetic.

Failure of epidural anaesthesia (see Chap. 54)

- Inadequate local anaesthetic dose.
- Inadequate time for neuraxial block to work.
- Inadequate volume of local anaesthetic to achieve epidural spread.
- Slow injection of epidural top-up of local anaesthetic—superior spread of local anaesthetic within the epidural space is observed with high pressure/rapid injection of an epidural bolus. However, precautions must be taken to minimise the risk of accidental injection of large doses of local anaesthetic into the intravenous or intrathecal spaces. In emergency situations, high doses of local anaesthetic should be administered in divided doses after an appropriate test dose.
- Suboptimal epidural catheter position on insertion or subsequent migration of epidural catheter out of the epidural space.

Management

Preoperative

- Test and document the extent of block using multiple modalities
  - Cold temperature sensation can be assessed with ice or ethyl-chloride (cold) spray.
  - Light touch can be assessed by the initial "blowing" sensation of ethyl-chloride spray, or with cotton wool or tissue paper.

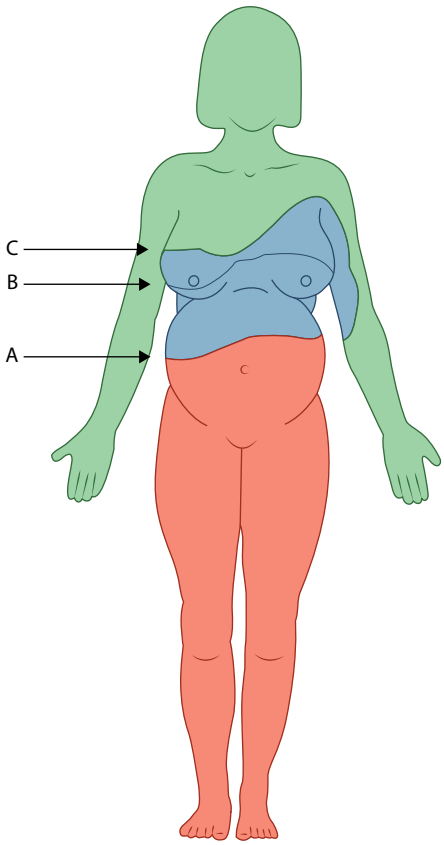

Fig. 56.1 Assessing the sensory block height after neuraxial anaesthesia using cold sensation (e.g. using an ethyl chloride spray): **A** represents the upper limit of a "complete anaesthesia zone" (Red) where a sensory stimulus, such as cold, cannot be felt at all. **B** represents the point where "icy cold is first felt. **C** represents the beginning of the 'completely un-anaesthetised" zone (Green) where there is complete appreciation of cold sensation. **A–C** represents a "transition zone" (Blue) where there is some blunted appreciation of stimulus. Modified from Yentis S. Height of confusion: assessing regional blocks before caesarean section. Int J Obstet Anesth (2006);15: 2–6

  - Care should be taken to differentiate completely anaesthetised levels (e.g. absolutely no appreciation of cold) from transition zones where there is some blunting of sensation (e.g. some appreciation of cold) and non-anaesthetised areas (e.g. where there is complete appreciation of cold), as shown in Fig. 56.1.
  - A reference area for comparing anaesthetised and non-anaesthetised sensation should be chosen so that it cannot be affected by a very rapidly ascending block. The cheek or forehead in supplied by cranial nerves and so is ideal, although care should be taken with ethyl chloride to not spray into the patient's eyes!
  - In the anaesthetic literature, adequacy of neuraxial anaesthesia for caesarean delivery has been quoted as an upper block level to light touch up to the T5 dermatome bilaterally. However, surveys of obstetric anaesthetists suggest that in practice most favour an upper block height to cold up to the T4 dermatome bilaterally [4].
  - Good clinical practice will be influenced by local guidelines and personal clinical experience. However, it should include assessment and documentation of upper levels and sacral blockade to both light touch and cold.
- Explain to the patient what sensations are to be expected (e.g. uterine fundal pressure) and what should not occur during surgery under neuraxial anaesthesia (e.g. sharp pain).
- Do not allow surgery to proceed unless the block is adequate, and be prepared to repeat neuraxial techniques, or offer general anaesthesia if adequate anaesthesia cannot be achieved.

Intraoperative

- Always acknowledge any concerns that the patient may have and provide reassurance.
- Alert the surgical team and ask them to stop the surgery. Situations in which this may not be possible include:
  - Fetal concerns (e.g. prolonged fetal bradycardia) which have led to an emergency caesarean delivery with the safe birth of the neonate being the main priority.
  - A uterine incision has already been performed, before delivery of the neonate.
  - Uncontrolled intraoperative bleeding
- If pain occurs before delivery, consider:
  - Epidural top-up (local anaesthetic ± opioid) if an epidural catheter is in place.
  - Inhaled nitrous oxide in oxygen via the anaesthetic machine—a 50:50 mixture will mimic the effects of Entonox® that many women are familiar with using during labour.
  - Intravenous opioids—alert the paediatrician to the possibility of neonatal respiratory depression (uncommon) after delivery.

- If pain occurs after delivery, consider:
  - All of the above
  - Intravenous opioids
    alfentanil—200 mcg boluses (recommended due to its rapid onset time, short duration and ease of titration)
    fentanyl—20 mcg boluses (delayed onset and longer duration of action)
    remifentanil—50 mcg bolus followed by an infusion of 0.1 mcg/kg/min (co-administration of oxygen is usually needed) [5]
  - Intravenous ketamine—low dose, up to 0.5 mg/kg [6]
  - Benzodiazepines or propofol have been used to alleviate anxiety unrelated to pain. However, care must be taken not to over-sedate a patient who remains at a high risk of reflux of gastric contents
- Regardless of the type of analgesia given, always reassess the patient to ensure adequate comfort has been established.
- If pain persists, offer conversion to general anaesthesia.

Postoperative

- Ensure good contemporaneous documentation.
- Listen to patient, empathise and apologise if appropriate.
- Offer anaesthetic follow-up on the postnatal ward and/or out-patient clinic appointment.
- Alert the family doctor or general practitioner by letter if further follow-up is needed.

Repeat (2nd) Spinal?

If neuraxial blockade is unsuccessful in providing adequate neuraxial anaesthesia, then a repeat spinal block may be considered if time allows. Various methods of managing this scenario have been proposed but there is no consensus on best practice:

- Spinal (standard dose)—Some would advocate this in total block failure or inadequate epidural top-up with no previous spinal anaesthesia. However, caution is advised due to the risk of developing a high block or a total spinal.
- Spinal (20–30% dose reduction)—recommended due to compression of dural sac from fluid in epidural space or compound haemodynamic effect if initial block was also a spinal [1].
- CSE—also allows for a spinal dose reduction (thus minimising the potential risk of high block or total spinal), but with the ability to supplement the spinal block if needed by using the epidural catheter if necessary.

Intraoperative Analgesia

The choice of analgesia will depend on:

- The degree of surgical urgency.
- The stage of delivery of the neonate.
- Whether stopping surgery will risk fetal wellbeing, such as after uterotomy but before delivery.
- If the pain is expected to be transient, such as with fundal pressure.
  - such situations can sometimes be managed with explanation and reassurance to alleviate anxiety.
- The availability of nitrous oxide in oxygen.
- If surgical duration is expected to outlast anaesthesia.
  - pain due to spinal block recession before the end of surgery requires a discussion of analgesic options with the patient.
  - an epidural top-up can be administered if available and surgery should be paused until it is effective.
  - if surgical closure is imminent, short-acting opioids can bridge the period until the end of surgery but may cause unwanted nausea or sedation.
  - universally, if pain results from inadequate neuraxial anaesthesia, general anaesthesia should be offered as an alternative with explanation of associated risks.

Follow Up

Childbirth can be a traumatic experience if delivery is urgent, complications occur, or severe pain is experienced. Some women also go on to develop a post-traumatic stress disorder (PTSD) [7]. A debrief can identify women at risk and allow opportunity for questions and discussion of events, so follow-up with an anaesthetist and/or a clinical psychologist is essential.

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Backache After Neuraxial Anesthesia

57

Adel Alqarni and Christian Loubert

Backache post neuraxial anesthesia refers to low back pain in patients who have had neuraxial anesthesia. This pain is usually localized to the lower back and rarely radiates to the lower extremities.

Incidence

Backache is a common complaint during pregnancy, occurring in 50% of all pregnant women [1]. Persistent low back pain for 6 months and 3 years after delivery has been reported in 43% and 23% of patients, respectively [2, 3]. Musculoskeletal changes that occur in pregnancy and may precipitate back pain during normal pregnancy are shown in Fig. 57.1.

Etiology

Its etiology is poorly understood. Although ligament trauma caused by larger blunt epidural needles has been suggested to be the cause for the back pain [4], several studies have failed to find a causal relationship between neuraxial anesthesia and postpartum backache [5, 6].

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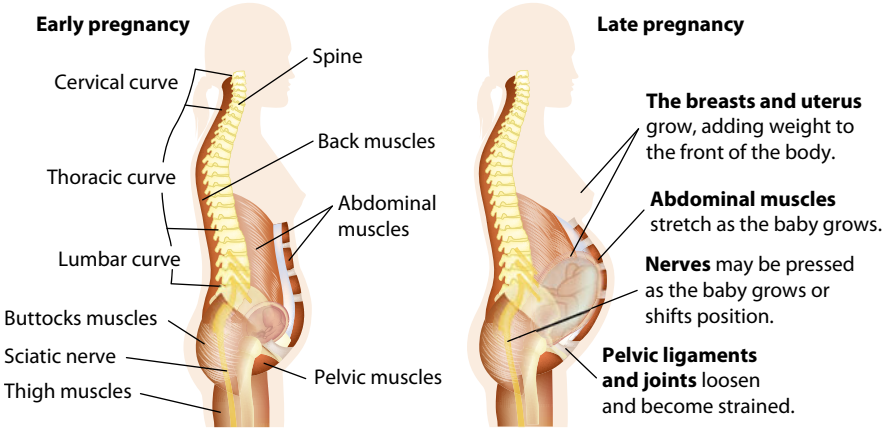

Fig. 57.1 Mechanisms of backache during pregnancy

Mechanism

In addition to patient and obstetric factors contributing to backache, neuraxial techniques can theoretically cause backache by two main mechanisms:

1. Needle-induced tears in the ligaments, fascia or bone with localized bleeding;
2. Musculoskeletal mechanisms including spinal immobility, relaxation of the paraspinal muscles under anesthesia, increase in the normal lumbar convexity and stretching of paraspinal ligaments and capsules.

Risk Factors for Postpartum Backache

1. Antenatal back pain
2. Weight gain during pregnancy
3. Increased body mass index (BMI)
4. Multiple attempts at neuraxial block placement.

Risk factors for persistent postpartum backache (back pain lasting for at least six months after delivery) are the presence of back pain before pregnancy, lumbopelvic pain during pregnancy and performing heavy physical activities [2, 7].

Prevention

In addition to controlling patient and obstetric risk factors, several anesthetic interventions have been tried to decrease the incidence of backache post neuraxial anesthesia:

1. Ultrasound-guided lumbar neuraxial block to decrease the risk of multiple attempts at needle placement especially in case of anticipated difficult neuraxial techniques (including scoliosis and obesity)
2. Addition of dexamethasone to the epidural local anesthetic may decrease the incidence of back pain (shown in the non-obstetric population) [8].
3. Addition of an anti-inflammatory drug such as ketorolac to the local anesthetic used during skin infiltration at the time of epidural placement [9].

Note: for the last two preventative measures, more research is needed to confirm their effectiveness.

Management

Localized backache secondary to tissue trauma at the needle puncture site is usually a mild and self-limited condition, which may be associated with muscle spasm. Its treatment consists of conservative measures such as hot or cold compresses and non-opioid mild analgesics such as non-steroidal anti-inflammatory drugs (NSAIDs).

Severe back pain, especially when associated with neurological symptoms, may be indicative of more serious complications such as an epidural abscess or hematoma and should be excluded. In such circumstances, consulting a neurologist or neurosurgeon and CT or MRI imaging may be necessary after a careful medical history and physical examination have been performed.

In cases of severe or persistent backache, referral to a pain management clinic is warranted.

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Peripheral Nerve Lesions After Neuraxial Anesthesia

58

Adel Alqarni and Christian Loubert

Introduction

Postpartum peripheral neuropathy refers to sensory and/or motor impairment during the postpartum period. Although it is often assumed to be due to neuraxial anesthesia, it is most commonly secondary to obstetric causes. Only 20% of all postpartum peripheral nerve lesions are anesthesia related complications [1].

Incidence

The reported incidence of postpartum peripheral neural lesions is between 0.6 and 92 per 10,000 [2].

Risk Factors

- Persistent occiput posterior (OP) fetal presentation
- Fetal Macrosomia (large baby)
- Cephalopelvic disproportion (a condition in which the head of the fetus is larger than the mother's pelvis)

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- Prolonged second stage of labor
- Forceps-assisted delivery
- Prolonged lithotomy position
- Difficult neuraxial procedure (e.g. severe pain during drug injection, paraesthesia on needle insertion, multiple attempts to site the neuraxial block)
- Late initiation of neuraxial anesthesia [1].

Neuraxial anesthesia may theoretically indirectly increase the risk of prolonged peripheral nerve compression by masking paresthesia or discomfort, which would otherwise prompt a change in the patient's position.

Etiology

While postpartum peripheral nerve lesions are well identified, their etiology is more controversial. Most published data indicate that these complications are mostly related to compression or traction on nerve roots, nerve plexuses and/or peripheral nerves due to obstetrical factors (see Figs. 58.1 and 59.1 and Table 58.1). The anesthesia-related causes associated with peripheral nerve injuries are mainly radiculopathies following needle or epidural catheter injuries (see Fig. 59.1) [3, 4]. Most of these anesthesia-related neuropathies are transient, with recovery occurring within 3 months [3, 5–7] .

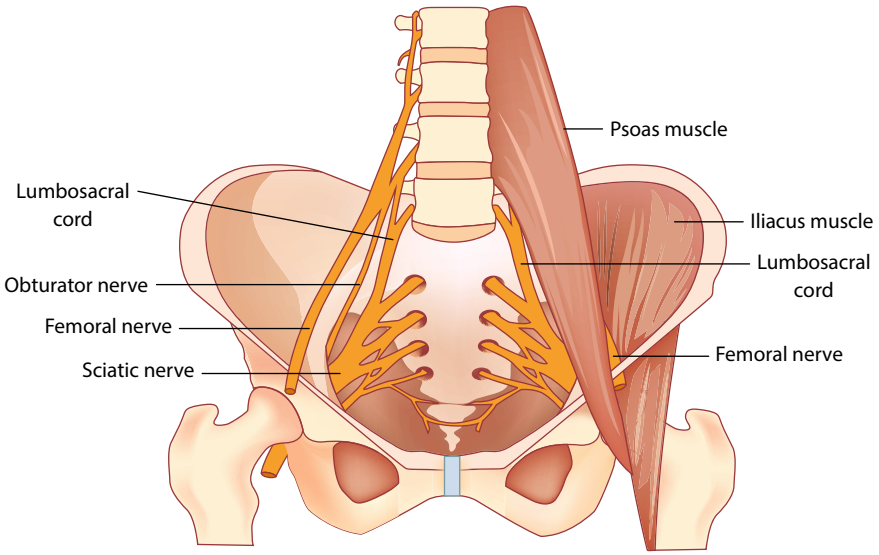

Fig. 58.1 Principal trunks and nerves of the pelvis

Prevention

- During neuraxial anesthesia, the presence of paraesthesia mandates an immediate halt of epidural or spinal needle advancement and a subsequent needle redirection. Complete removal of the epidural or spinal needle/epidural catheter is mandatory in case of persistence paraesthesia.
- Avoid prolonged positioning, which could contribute to nerve compression.
- Encourage the parturient to change her position regularly.
- When using a low dose local anaesthetic/opioid combination, the new onset of numbness or weakness may be signs of nerve compression. Such symptoms should prompt an immediate change of position.

Table 58.1 Common peripheral nerve lesions

Nerve	Roots	Mechanism	Symptoms
Lumbosacral Trunk	L4–L5	• Forceps delivery • Fetal head compression	• Foot drop[a] • Sensory disturbance mainly involving the L5 dermatome
Femoral	L2–L4	• Prolonged flexion, abduction, and external rotation of hip joint • Prolonged lithotomy	• Weak hip flexion • Absent or ↓ patellar reflex • Sensory impairment of thigh and medial aspect of leg
Lateral Femoral Cutaneous (*meralgia paresthetica*)[b]	L2–L3	• Pregnancy (30 weeks): nerve compression caused by large gravid uterus • Surgical retractors used during pelvic surgery	• Paresthesia affecting the anterolateral aspect of the thigh
Sciatic	L4–S3	• Prolonged siting • Hip wedge misplaced during caesarean delivery	• Mistaken for lumbosacral lesion • Sensory (sparing medial aspect of leg) and motor impairment below knee
Obturator	L2–L4	• Fetal head	• Weakness of hip adduction and internal rotation • Sensory disturbance over the upper inner thigh
Peroneal	L4–S2	• Prolonged squatting • Compression of lateral side of the knee by a hard object	• Foot drop[a] • Sensory impairment of anterolateral of the calf and dorsum of the foot

[a]Foot drop is a term that refers to a weakening of the muscles that normally allow for flexing of the ankle and toes

[b]Entrapment of the nerve as it passes around the anterior superior iliac spine beneath or through the inguinal ligament

Diagnosis and Management

- Detailed anaesthetic and obstetric history:
  - spinal level of neuraxial needle puncture
  - presence of paraesthesia during needle placement
  - number of attempts
  - presence of obstetric risk factors: such as patient positioning, forceps delivery, leg stirrups and duration of labour

- Physical examination: neurological
- Exclude surgical emergencies: e.g. epidural abscess and haematoma
- Neurological and/or neurosurgical referral
- Consider the need for CT, MRI and electro-neurophysiology studies
- Reassure the patient that in most cases these symptoms are transient
- Inform the patient that these complications are not necessary due to neuraxial anaesthesia.

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Spinal Cord Lesions After Central Neuraxial Blockade

59

Mary Mushambi and Asif Mahmood

Neurological complications may follow neuraxial (spinal and epidural) analgesia and anaesthesia. These can be divided into spinal cord lesions and peripheral nerve injuries (see Chaps. 58 and 60).

Any neurological complication occurring in the postpartum period requires careful assessment and follow-up. Urgent neurological consultation and investigations may be required.

Incidence

The incidence of neurological injury after neuraxial anaesthesia varies greatly. It may be influenced by the experience of the practitioner, the circumstance surrounding the insertion and the clinical state of the patient. Table 59.1 gives the incidence of neurological complications following neuraxial blockade.

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Spinal Cord Pathologies Following Central Neuraxial Blockade

- Spinal haematoma (Table 59.2)
- Epidural abscess (Table 59.3)
- Direct cord injury (Table 59.4)
- Arachnoiditis (Table 59.5)
- Meningitis (Table 59.6)
- Cauda equina syndrome (Table 59.7)
- Summary of neurological deficits after nerve root trauma (Table 59.8)
- Sensory nerve distributions useful distinguishing central from peripheral nerve lesions (Fig. 59.1).

Table 59.1 Risk of neurological complications after central neuraxial blockade. Estimates provided by the Obstetric Anaesthetists' Association (OAA) [1]

	Neuraxial anaesthesia
Nerve damage (e.g., numb patch on the leg or foot, leg weakness)	Effects lasting less than six months: Rare—about 1 in 1,000 Effects lasting more than six months: Rare—about 1 in 13,000
Meningitis	Very rare—about 1 in 100,000
Epidural Abscess	Very rare—about 1 in 50,000
Spinal Haematoma	Very rare—about 1 in 170,000
Epidural abscess or haematoma causing severe injury, including paralysis (paraplegia)	Extremely rare—about 1 in 250,000

Table 59.2 Spinal haematoma [2]

Timing	• Often early (Day 1–2)
Presentation	• Suspect if the effects of the regional block persist for more than 8 hours after the last dose of local anaesthetic • Local tenderness at insertion site • Back pain • Radicular pain ± neurology
Investigation	• Urgent imaging—MRI or computerized tomography (CT) scans
Treatment	• Urgent neurosurgical review • Haematoma drainage • Coagulopathy correction
Commentary	Risk factors for spinal haematoma include: • Pre-existing coagulopathy before central neuraxial block • Coagulopathy at the time of epidural catheter removal • Bony spinal pathology that may necessitate multiple attempts resulting in traumatic insertion of either spinal or epidural needle or epidural catheter

Table 59.3 Epidural abscess [3]

Timing	• Days later (up to a month): median time 8 days post neuraxial block
Presentation	• Similar to a spinal haematoma (Table 59.2) • Backache, local tenderness ± neurology • Fever and systemic signs and symptoms of sepsis • Raised white cell count
Investigation	• Urgent imaging—MRI or CT scans • Blood cultures
Treatment	• Urgent neurosurgical review • Sepsis management if present • Surgical drainage or CT guided drainage • Antibiotics for 6 weeks
Commentary	• The most common organisms are staphylococcus aureus and staphylococcus epidermis • Organisms may arise from endogenous bacteria circulating at the time of insertion • Organisms may be introduced from an external source such as the patient's skin or the operator

Table 59.4 Direct cord injury [4, 5]

Timing	• Immediate/24 hours
Presentation	• Severe pain during needle insertion or with injection of medication followed by abnormal neurology
Investigation	• Urgent MRI
Treatment	• Urgent neurological review • May recover spontaneously over time • Steroid administration (not evidence based)
Commentary	• The spinal cord commonly terminates as the conus medullaris at L1; in 2–20% of individuals, it ends at the lower level of L2 • Spinal injection should occur below the level of the conus medullaris • Tuffier's line is not a reliable indicator of the L4/5 level • Therefore spinal injection should occur at the lowest possible interspace • Any pain during insertion of needle or during injection of medication should result in discontinuing the procedure and re-assessing the spinal level • If in doubt, ultrasound should be used to identify the spinal levels

Table 59.5 Arachnoiditis [6]

Timing	• Immediate symptoms followed by severe abnormal neurology over weeks and months
Presentation	• Immediate neuropathic pain followed by significant worsening of neurology, several days or even months after neuraxial block. • Catastrophic neurological injury, paraplegia/mortality have been described
Investigation	• Urgent imaging—MRI or CT scans
Treatment	• Urgent neurosurgical opinion • No clear guidance because of the poor outcome despite surgery
Commentary	• Arachnoiditis is an inflammatory process with poor prognosis • Causes include meningitis, trauma or injection of neurotoxic chemicals e.g. high concentrations of chlorhexidine used for skin asepsis • Recommendations: − use lower concentrations of chlorhexidine (0.5%) − allow the chlorhexidine or other antiseptic skin preparations to fully dry before starting the procedure − protect neuraxial anaesthesia equipment from chlorhexidine contamination • A case report has highlighted inadvertent intrathecal administration of tranexamic acid, causing significant neurological deficit and mortality • Drugs containing preservatives should never be used for neuraxial anaesthesia

Table 59.6 Meningitis [7, 8]

Timing	• Often early (day 1–2)
Presentation	• Fever • Vomiting • Headache • Neck stiffness • Photophobia • Convulsions • Altered conscious level
Investigation	• Lumbar puncture • CSF biochemistry, microscopy & cultures • Blood cultures • Brain MRI/CT scans
Treatment	• Urgent neurology referral • Appropriate antibiotics
Commentary	• Meningitis can be bacterial such as streptococcus viridans, pneumonia or neisseria meningitis, viral or aseptic (chemical) • Aseptic meningitis commonest cause is chlorhexidine contamination of epidural and spinal equipment • Strict aseptic technique should be followed to avoid iatrogenic cause of meningitis

Table 59.7 Cauda equina syndrome [9]

Timing	• Often early (day 1–2) but can be up to several days
Presentation	Cauda equina syndrome is characterised by varying degrees of: • Sacral anaesthesia • Sphincter dysfunction: faecal incontinence/urinary retention • Paraplegia • Lower back pain
Investigation	• Urgent MRI
Treatment	• Neurosurgical review
Commentary	• Cauda equina syndrome may be caused by pressure, haematoma, ischaemia, trauma or contact with toxic chemicals • The use of spinal microcatheters with 5% hyperbaric lidocaine has been implicated • In 1992 the US Food and Drug Administration (FDA) withdrew intrathecal microcatheters (27–32G) from clinical use after reports of neurologic injury in non-obstetric patients • Subsequent laboratory animal studies demonstrated that nerves exposed to 5% hyperbaric lidocaine are permanently damaged • 28 G intrathecal catheters have since been demonstrated in a large prospective, randomised, double blind study to be safe when used with bupivacaine and sufentanil [10]

Table 59.8 Neurological deficit following nerve root trauma

Nerve root	Motor loss	Sensory loss	Reflexes
L2	Hip flexion Thigh adduction	Upper anterior thigh	
L3	Knee extensors Quadriceps	Lower anterior thigh Medial thigh	
L4	Ankle dorsiflexion Knee extensors	Lateral thigh Medial leg	Patella
L5	Great toe dorsiflexion Ankle dorsiflexion	Lateral leg Dorsum foot	
S1,2	Ankle plantar flexion	Lateral foot	Ankle
S2,3,4,5	Anal and urethral sphincters	Perineum	

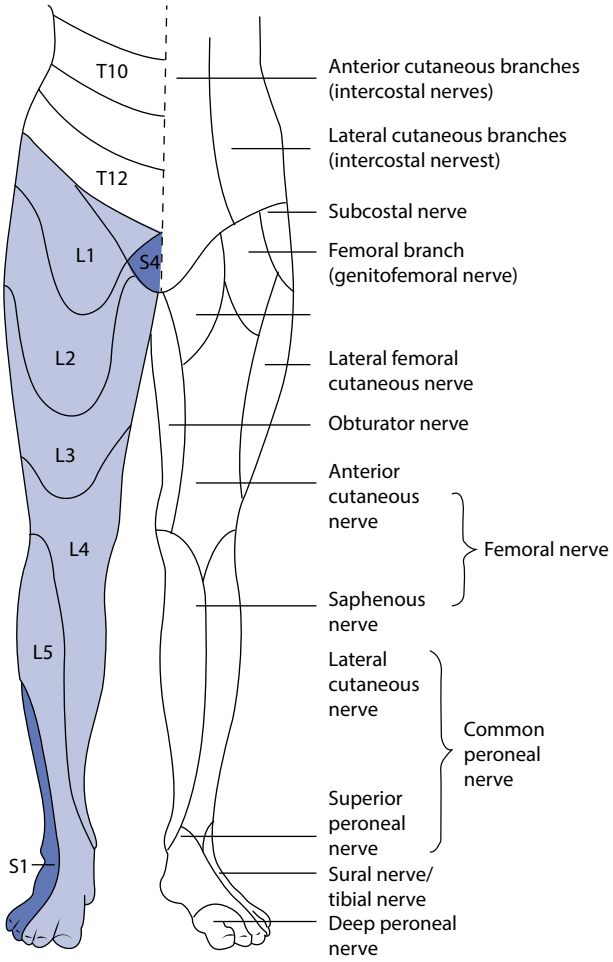

Fig. 59.1 Segmental (*right leg*) and peripheral (*left leg*) sensory nerve distributions which are useful in distinguishing central from peripheral nerve lesions

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Obstetric Nerve Palsies: Common Lesions and Causes

60

Asif Mahmood and Mary Mushambi

Neurological complications after childbirth are often assumed to be due to neuraxial anaesthesia, but they are more likely to be due to the process of childbirth and more so in the case of peripheral nerve palsies. Nerve conduction studies may be required to identify the correct site of nerve damage. The majority of obstetric nerve palsies are due to neuropraxia and recovery is often expected within 3 months (Table 60.1). Spinal cord lesions are covered separately (see Chap. 59).

Incidence

The reported incidence of peripheral nerve palsies related to obstetric causes ranges from 0.008 to 0.92% [1].

Lumbosacral Trunk

The lumbosacral trunk (L4-5) is susceptible to compression at the pelvic brim by the descending fetal head (Fig. 60.1). This compression is more likely to cause injury to the medial fibres that form the peroneal nerve rather than the tibial nerve. Factors that pre-dispose to compression of the lumbosacral trunk include: a disproportionately large fetal head, fetal malposition, a prolonged and difficult vaginal delivery and abnormal maternal pelvic anatomy	
Presentation	Often present as a unilateral foot drop with sensory disturbance usually affecting the lateral calf and medial foot (L5 dermatome)

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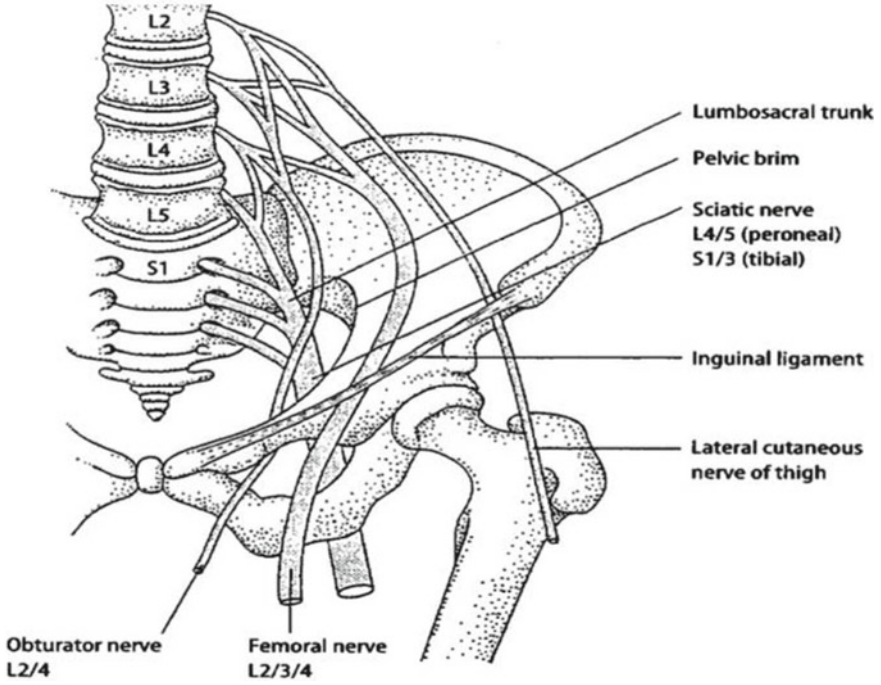

Fig. 60.1 Pelvic nerves and nerve trunks, which may be susceptible to compression injury during childbirth. (Reproduced with kind permission from Holdcroft A, Thomas TA. In: Principles and Practice of Obstetric Anaesthesia. 2000, Oxford: Blackwell Science)

Obturator Nerve Palsy

The obturator nerve (L2-4) is susceptible to injury at the pelvic brim (Fig. 60.1) with injury occurring during labour, caesarean or forceps delivery	
Presentation	Weakness of hip adduction and internal rotation and sensory deficit over upper medial thigh

Femoral Nerve Palsy

The femoral nerve (L2-4) does not pass through the pelvis but passes underneath the inguinal ligament (Fig. 60.1) where it is vulnerable to stretching from prolonged flexion, abduction and external rotation of hips during labour and prolonged lithotomy position	
Presentation	Hip flexion and knee extension are weakened which makes climbing the stairs difficult. An absent or reduced knee reflex is the most reliable sign of femoral nerve palsy. Sensory loss is over the anteromedial thigh and anteromedial calf

Lateral Cutaneous Nerve of Thigh

Lateral cutaneous nerve of the thigh (L2-3) neuropathy occurs most commonly from entrapment of the nerve as it passes around the anterior superior iliac spine below the inguinal ligament. Compression of the nerve arises from increased intra-abdominal pressure during pregnancy as well as during the second stage of labour	
Presentation	As the nerve is purely sensory, patients present with paraesthesia of the antero-lateral aspect of the thigh

Sciatic Nerve Palsy

Sciatic nerve (L5-S2) palsy can be caused by compression of the nerve in the buttock. The presence of a neuraxial blockade may prevent position change during labour and this increases the chance of nerve palsy. An incorrectly placed hip wedge during caesarean delivery, prolonged lithotomy position and pressure from the fetal head causing compression at the pelvic brim during descent into the pelvis can cause sciatic nerve palsy	
Presentation	Loss of sensation below the knee (but sparing the medial side). Reduced movement below the knee

Common Peroneal Nerve Palsy

The common peroneal nerve (L5-S2) is susceptible to injury as it passes around the fibula head. Injury can occur from prolonged squatting (a delivery position), excessive knee flexion, direct external pressure applied to the lateral aspect of the knee and prolonged lithotomy position	
Presentation	Foot drop, characterised by a steppage gait, usually dragging the toes of the affected leg due to inability to lift the toes or dorsiflex the ankle. Sensory impairment of anterior-lateral calf and dorsum of foot

Other Nerve Palsies

Pregnancy can lead to the development of peripheral oedema, which can cause direct pressure on nerves thereby causing nerve palsy. Other injuries include carpal tunnel syndrome (median nerve) and Bell's palsy (facial nerve / VII cranial nerve).

Bladder Dysfunction

A prolonged second stage of labour, episiotomy, perineal laceration and high birth weight of the newborn (>4000 g) are known risk factors for postpartum bladder dysfunction [2]. Therefore bladder dysfunction is most likely to be due to obstetric causes. However, if neuraxial anaesthesia is administered, bladder over distension must be prevented.

Safeguards to Minimise Peripheral Nerve Damage

- Be aware of the patient's position and encourage changing position during labour
- Avoid prolonged positions such as lithotomy, hip flexion and abduction [3]
- Hip wedge requires accurate placement against the bony pelvic rather than the buttock
- Low dose epidural medication (such as 0.1% levobupivacaine) should be used to minimise motor and sensory block and to encourage mobilising during labour [4, 5].

Table 60.1 Common obstetric nerve palsies—motor and sensory loss

Nerve	Motor loss	Sensory Loss	Reflexes
Lumbosacral trunk (L4-5)	Foot drop	Lateral Calf Medial foot	
Obturator (L2-3)	Hip adduction Internal rotation	Upper medial thigh	
Femoral Nerve L2-4)	Hip flexion Knee extension	Anteromedial thigh Anterolateral calf	Knee
Lateral cutaneous nerve of thigh (L2-3)	Nil	Anterolateral thigh	
Sciatic Nerve L5-S2)	All motor below knee	All below knee (Except medial)	Ankle
Common peroneal L5-S2)	Foot drop	Anterolateral calf Dorsum of foot	Ankle

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Reported Awareness Under General Anaesthesia

61

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Awareness under general anaesthesia (GA) refers to recall of events while under a general anaesthetic.

Although neuraxial anaesthesia for caesarean delivery is now the norm in the UK, general anaesthetics (GAs) are still administered, most often in the emergency setting.

In 2014, the 5th National Audit Project (NAP5) of the RCoA (Royal College of Anaesthetists, UK) and the Association of Anaesthetists examined the incidence of accidental awareness under general anaesthesia (AAGA) [1]. Obstetric cases accounted for 1 in 670 general anaesthetics, much higher than the 1 in 19 000 for all GAs. As a result of this, the DREAMY (Direct Reporting of Awareness in MaternitY patients) study [2] was launched, a prospective, multi-centre observational cohort study to provide quantitative and qualitative data on AAGA in obstetric patients. The results of this revealed high rates of accidental awareness during general anaesthesia for obstetric surgery.

The reasons for AAGA are debatable, but there is no doubt that obstetric general anaesthesia encompasses most of the risk factors for awareness, as described below.

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Risk factors for AAGA

Patient

Previous awareness, female gender, younger adults, obesity, difficult airway.

Anaesthetic Technique

Total intravenous anaesthesia (TIVA), neuromuscular blockade, rapid sequence induction, thiopental (see Fig. 61.1).

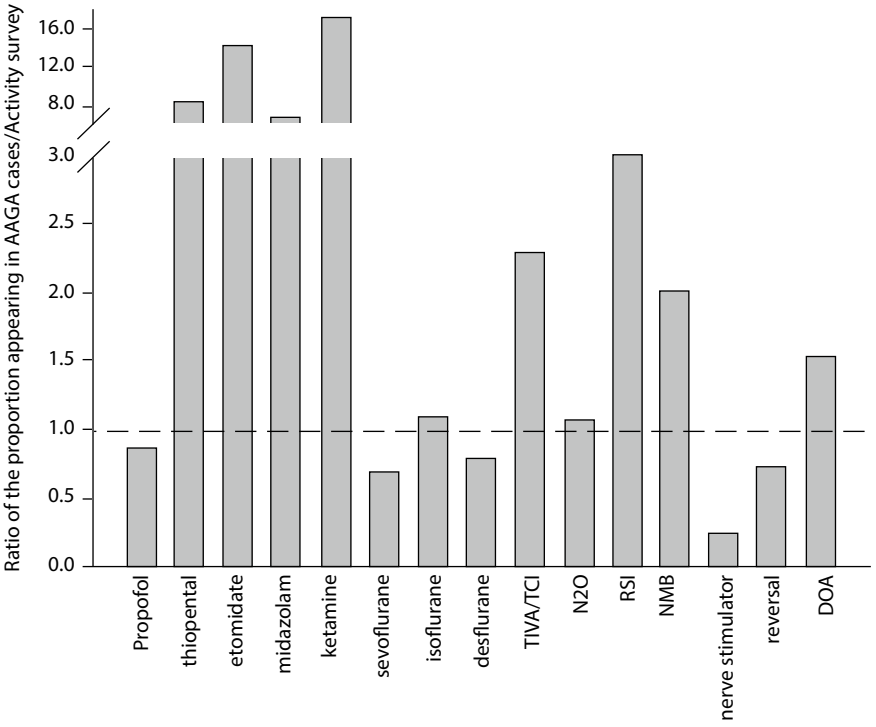

Fig. 61.1 Elements of anaesthesia contributing to reports of AAGA collected during NAP5. The horizontal dotted line at unity indicates the proportions being equal. The larger the bar, the greater is the feature represented in the AAGA report; the smaller the bar, the less is the feature represented in the AAGA report. (TIVA/TCI: total intravenous anaesthesia/target-controlled infusion; N_2O: nitrous oxide; RSI: rapid sequence induction; NMB: neuromuscular blockade; DOA: specific depth of anaesthesia monitor. Reproduced from the 5th National Audit Project (NAP5) with the kind permission of the Royal College of Anaesthetists, London, UK

Surgery

Emergency, cardiac, obstetric, neurosurgical.

Environment

Out-of-hours, out-of-theatre, junior anaesthetists.

Recognition: During Anaesthesia

Close attention should be paid to all monitoring and clinical signs. When the following occur, it is important that awareness be included in the potential differential diagnoses:

Clinical Signs

Hypertension, tachycardia, lacrimation, sweating, large non-central pupils, tachypnoea, limb movement (if muscle relaxants are not used).

Anaesthesia

Low volatile end tidal concentrations.

TIVA (total intravenous anaesthesia) with a high BIS (bispectral index) value.

Prolonged time from intravenous induction of general anaesthesia to "steady state" maintenance of anaesthesia with a volatile agent e.g. difficult airway.

Recognition: Postoperative

AAGA can be reported at any time: as early as in the recovery unit to as late as months or even years after the event. Regardless of when it is reported, it is important to clarify the exact nature of the awareness. The Brice protocol [3] is widely used as a research tool and may be a good starting point.

The Brice Protocol [3]

1. What was the last thing you remember before going to sleep?
2. What is the first thing you remember on waking up?
3. Can you remember anything in between?
4. Did you dream during the procedure?
5. What was the worst thing about your operation?

Ideally the protocol is used three times: on waking from general anaesthesia, within in the next 24–48 hours and the subsequent 2–3 weeks

It is important to determine *what* the patient recalls: for example, dreams, voices, music, paralysis, pain, choking and inability to breathe have all been reported. This may influence subsequent psychological impact and its management as well as future anaesthetics.

Steps to Minimise AAGA and Its Impact

Consent

Managing realistic expectations of what the patient might experience is important, particularly in the obstetric setting when anxiety levels can be high. Inform patients about the risk of awareness when seeking their consent for GA, including warning them if (as is usual in obstetrics) you are planning to use cricoid pressure prior to loss of consciousness and/or to extubate them fully awake.

Documentation

Document discussions fully. Ensure good record keeping of the perioperative course; dose of drugs, vital signs, interventions given, any clinical signs of light anaesthesia (such as sweating, tears, hypertension and tachycardia) if awareness suspected intra-operatively.

Drugs

- Ensure adequate drug doses are given for induction of anaesthesia. Be mindful that extreme anxiety and/or high body mass index may mean that larger than normal doses are needed.
- Consider giving short acting opioids such as fentanyl at induction.

- "Mind the gap!" Beware the potential delay from intravenous induction to "steady state" with volatile anaesthetics, a common time for awareness to occur. anaesthetise in the operating theatre (particularly for emergency cases)
- Consider administering further intravenous induction agent if airway management is difficult and maintenance of anaesthesia is delayed
- Consider giving a higher than normal initial concentration of volatile agent (over-pressure) to reduce the time to achieve an effective alveolar concentration.
- Pay scrupulous attention to monitoring volatile agent end tidal concentrations—set alarms to indicate low levels.
- Do not use low volatile agent concentrations to minimise uterine relaxation after delivery. Rely on uterotonic drugs instead.
- If using TIVA in obstetrics **always** use a depth of anaesthesia monitor (but be aware that in the context of all other monitoring, they are not infallible!) and use established TIVA protocols.
- Give intravenous opioid once the baby has been delivered.
- If full neuromuscular blockade is not required for surgical access, consider allowing muscle relaxants to 'wear off'/regress intraoperatively without supplementation.

Management

Sequelae from AAGA range from non-emotive recall to anxiety, depression and post-traumatic stress disorder (PTSD), so correct management cannot be overemphasised.

It is vital that the patient be listened to sympathetically and their claims investigated. There should be a named consultant to whom such cases should be referred, and they should be followed up accordingly.

Suspected Intraoperative Awareness

- Deepen anaesthesia; increase volatile agent concentration or give boluses of intravenous agent.
- Reassure patient during the operation (you do not know if they can hear you!)
- Check/replace the anaesthesia delivery mechanism; ensure the volatile or intravenous agent is actually being delivered to the patient.
- Inform surgeons; stop operating if possible until the depth of anaesthesia increases.

Postoperatively

Review the patient.

Use of the Brice protocol to facilitate the postoperative anaesthetic review.

If the patient confirms unexpected recall:

- Record details of recalled events: explicit documentation is paramount.
- Reassure and offer further support: refer to a named anaesthetist if possible, confer with senior colleagues
- Review the patient as an inpatient/outpatient
- Consider early input from a psychologist
- Inform family physician/general practitioner
- Discuss the case with a senior colleague or mentor. AAGA can be distressing for the anaesthetist involved, so seek support. Your employer may need to be informed, depending on local protocols.

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The Patient Requesting Neuraxial Anaesthesia with Previous Spinal Surgery

62

Thierry Girard

Patients with previous spinal surgery can be a challenge to the obstetric anaesthetist. Examples of expected difficulties are [1, 2]:

- difficult positioning of the patient for neuraxial block due to the limited mobility of the spine
- difficult or impossible insertion of the spinal or epidural needle due to existing metal implants
- abnormal epidural spread of local anaesthetic due to "scar tissue" within the epidural space following surgery. This is often referred to as a "patchy block".
- a higher incidence of accidental dural puncture (ADP) with an epidural needle due to surgical damage of the normally intact ligamentum flavum.

The severity of scoliosis is usually quantified by the Cobb angle (Fig. 62.1). A Cobb angle above 45° is considered severe scoliosis. In patients with surgically corrected scoliosis placement of neuraxial labour analgesia is more difficult and time consuming [3]. Once sited correctly, efficiency seems not to be different [3]. Surgical techniques have evolved substantially. This is especially true for metal implants and surgical correction of scoliosis. The use of Harrington rods has almost completely disappeared and lateral implants—sparing the midline regions—are typically used. In a study by Bauchat et al., success of neuraxial labour analgesia in patients with lumbar microdiscectomy operations did not differ from matched controls, with the exception of an increased number of attempted interspaces [4]. A higher incidence of neurologic complications (1.1%, 95% confidence interval 0.5–2%) has been found in patients with spinal stenosis, lumbar disc disease or prior spinal surgery [5].

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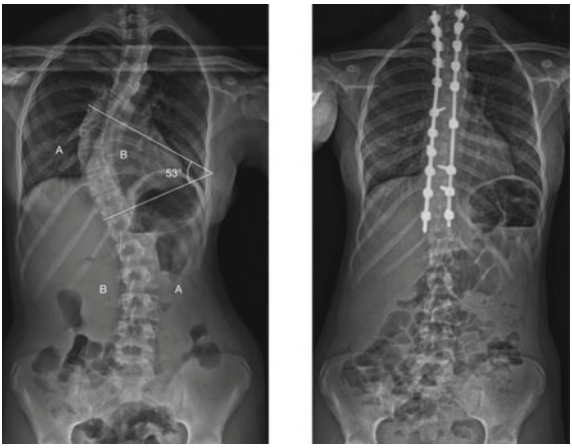

Fig. 62.1 Severe scoliosis with a Cobb angle of 53° before and after surgical correction. The letters 'A' mark the convex side of the thoracic and lumbar spine, respectively. Letters 'B' mark the concave side. Images are published with permission from Professor Carol Hasler, University Children's Hospital, Basel, Switzerland

Contraindications

Patients with previous back surgery may be cautious in consenting to any neuraxial procedure due to concerns about the recurrence of previous (or aggravation) residual back pain [2]. Contra-indications are no different from neuraxial procedures in patients without spinal surgery:

- Patient refusal
- Infection around the area of the planned neuraxial block
- An abnormal coagulation profile.

Spinal surgery frequently includes the use of implants. Since these implants are essentially implanted foreign material, they are prone to infection and therefore a meticulous aseptic technique is of utmost importance.

Procedure Specific Problems

If available then X-ray, magnetic resonance imaging and computer tomography should be reviewed in detail. Extensive or less common surgical procedures should ideally be discussed with a specialized spinal surgeon (Fig. 62.2). Surgical approaches may affect neuraxial anaesthesia as follows:

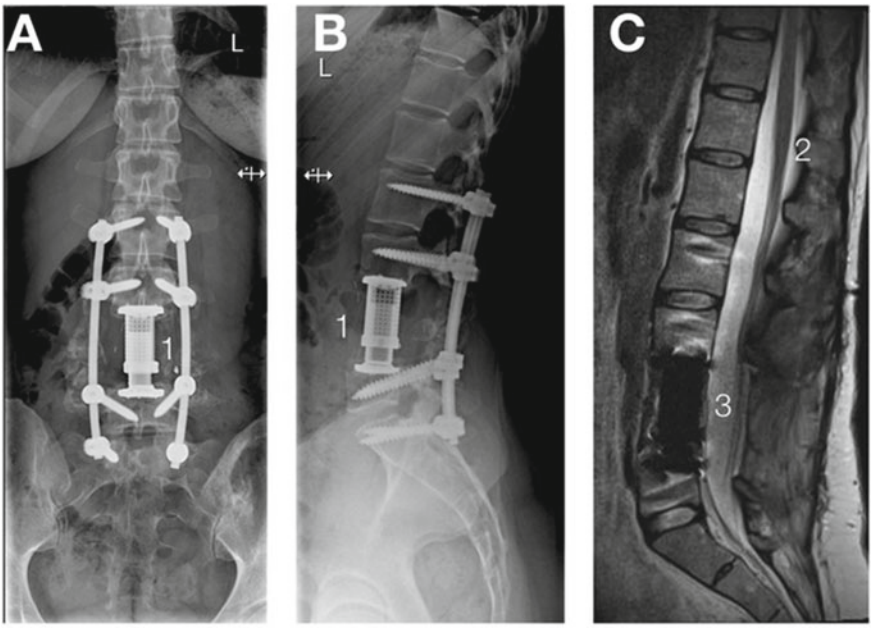

Fig. 62.2 The patient had a combined anterior and posterior surgical approach to remove the L4 vertebra, which had a benign bone tumour. After this spondylectomy procedure a metal implant (a spacer) was inserted in order to maintain stability of the spinal column (Panel **A** and Panel **B**). Magnetic resonance images (MRI) (Panel **C**) give a good view of the intrathecal space. Uneventful spinal anaesthesia for a scheduled caesarean delivery (18 months following the back surgery) was technically easy to perform. Anterior (Panel A) and lateral (Panel B) X-rays. Panel C: MRI. 1: Spacer, 2: Conus medullaris, 3: dural sac. Images are published with permission from Professor Stefan Schaeren, University Hospital Basel, Switzerland

- Anterior approach: Instrumentation via an anterior surgical approach has no impact on posterior structures and access, as well as on the distribution of drugs within the epidural or intrathecal space.
- Posterior approach: The use of bilateral rods and pedicle screws frequently spare the epidural space and distribution of local anaesthetics might be unaffected.
- Laminectomy: Spinal stenosis or lumbar disc herniations can be reasons for laminectomy. There can be damage to the ligamentum flavum and "scarring" within the epidural space.

After a posterior surgical approach to the spine, it is possible that the ligamentum flavum may have been damaged by the procedure. This could theoretically lead to a lack of an end point, the loss of resistance to saline or air, before the needle reaches the epidural space. In addition the posterior boundary of the epidural space may be

deficient, which could lead to the leakage of the local anaesthetic solution outside the epidural space. In addition, scarring within the epidural space impedes local anaesthetic distribution and might lead to a patchy block.

Neuraxial Procedures

If the surgical intervention was above L3–L4, then it is recommended to choose an insertion site **below** the level of spinal instrumentation, i.e. below the surgical scar [2].

In these patients an epidural approach has a higher failure rate, compared to an intrathecal injection. For caesarean delivery a single shot spinal technique is therefore preferable. In case of labour analgesia, an epidural approach might be more desirable compared to a combined spinal epidural (CSE) technique [3]. This allows the epidural catheter to be readily assessed.

In patients with scoliosis it is recommended to start with a median approach and then to divert the needle towards the convex side, as the epidural space is substantially wider on the convex side (Fig. 62.3).

Ultrasonography can be a great help to localise the best site of insertion and direction of the needle. In such patients a higher level of technical expertise with ultrasonography of the spine is needed.

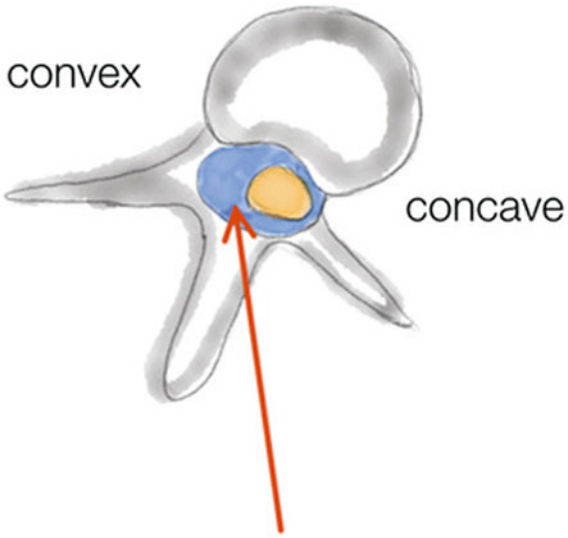

Fig. 62.3 Needle approach for neuraxial techniques in patients with scoliosis. A median approach with the needle angled to the convex side. The epidural space (blue) on the convex side is substantially larger

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Breastfeeding and Anaesthesia

63

Nuala Lucas and Richard Doyle

Breastfeeding confers significant health benefits on the mother (reduced incidence of breast and ovarian cancer) and baby (reduced risk of sudden infant death by more than a third, and in low-and middle-income countries it has been estimated that about half of all diarrhoeal episodes and one third of respiratory infections could be avoided by breastfeeding) [1]. There is some evidence for babies that it may also protect against obesity and diabetes in adult life. The World Health Organization (WHO) recommends exclusive breastfeeding for six months followed by a continuation of breastfeeding with the introduction of complementary foods for two years or longer as mutually desired by mother and infant.

Considerations for Anaesthesia

- Safety of anaesthetic and analgesic drugs in breastfeeding women.
- Impact of intrapartum analgesia and anaesthesia on breastfeeding.

Safety of Anaesthetic and Analgesic Drugs in Breastfeeding Women [2–5]

The safety of drugs in the breastfeeding woman depends on:

- Amount of drug that passes into breast milk.
- Oral absorption of the drug by the infant.

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- Infant's age
- Drug potential to produce adverse effects on the breastfeeding infant.

Drugs Used in Anaesthesia

The safety in breastfeeding women of commonly used drugs in anaesthesia are shown in Tables 63.1 and 63.2. A useful summary is shown in Fig. 63.1.

Perioperative Strategies to Maximise Safety and Minimise the Impact of Anaesthetic Drugs on Breastfeeding [4, 5, 6]

- Avoid/postpone non-urgent surgery until breastfeeding has been discontinued.
- Encourage a breastfeeding woman to express and store breast milk ahead of surgery to ensure a continuous supply of milk.
- Employ strategies to maintain milk production–minimise fasting times and maintain a woman's hydration including with intravenous fluid if required.
- Utilise regional/neuraxial techniques where possible.
- Use multimodal analgesic techniques to minimise opioid requirements.

Table 63.1 Commonly used anaesthetic drugs and safety in breastfeeding women

Intravenous anaesthetic agents	• Concentrations of commonly used induction agents such as propofol and thiopentone in mature breast milk and colostrum following a single bolus dose for induction of anaesthesia are minimal • Regarded as safe for the breastfeeding infant [7]
Volatile anaesthetic agents	• Minimal data about using anesthetic gases in breastfeeding mothers • Volatile agents rapidly excreted with poor bioavailability. • Breast milk levels are likely to be virtually non-existent
Muscle relaxants	• Low oral bioavailability • Do not cross the blood-milk duct membranes (relatively large molecular size, low lipid solubility and ionized nature) • Safe for breastfeeding women
Reversal agents	• Neostigmine and glycopyrrolate (quaternary ammonium compounds) do not penetrate the blood–brain barrier and unlikely to cross into milk ducts • Minimal data about sugammadex excretion into breast milk • Low oral absorption of sugammadex with no expected effects on breastfeeding. Considered safe in breastfeeding women

Table 63.2 Commonly used analgesic drugs and safety in breastfeeding women

Intravenous opioids	• All opioids cross the placenta and can potentially affect the baby in the early postpartum period • Women who have received systemic opioids should receive appropriate support to establish breastfeeding • Short acting opioids may be preferable to longer acting agents
Codeine	• Codeine is metabolised in the liver by CYP2D6 (an isoenzyme of cytochrome P450) to morphine. Rarely, as a result of genetic variation of CYP2D6, some individuals are ultrarapid metabolisers of codeine. In these individuals, morphine levels following codeine can reach high levels • Following an isolated case report of the death of a 13-day-old infant from opioid toxicity whose mother had received codeine, various international agencies (FDA[a]/EMA[b]) issued cautionary advice about the use of codeine in breastfeeding mothers. The child's mother, who took codeine while breastfeeding, was found to have ultrarapid metaboliser status, leading to the conclusion that the child died from opioid toxicity due to enhanced maternal conversion of codeine to morphine, with the subsequent passage of large amounts of morphine into breast milk • In 2020, the evidence used to underpin this guidance was questioned [8], and the original authors have officially retracted the case report. Despite the retraction, national regulatory bodies have made no changes to the guidance about the use of codeine in maternity care
Dihydrocodeine	• Dihydrocodeine is metabolised in the liver by CYP2D6. The analgesic effect of dihydrocodeine appears to be mainly due to the parent compound • However it is generally recommended that it is used in the lowest dose and duration of use should be limited
Tramadol	• Tramadol is metabolised via isoenzymes of CYP3A4 and CYP2D6 and glucuronidation in the liver. The metabolite O-desmethyltramadol is pharmacologically active • The relative infant dose is <1% of active metabolite and there are no reported harmful effects in babies, however the FDA has advised against its use in breastfeeding women, although the EMA has not issued similar advice
NSAIDs	• Negligible to low transfer to breast milk and considered safe

[a]FDA (United States) Food and Drug Administration
[b]EMA European Medicines Agency

Impact of Intrapartum Techniques on Breastfeeding

- Many studies have investigated the impact of intrapartum anaesthesia and analgesia, particularly low-dose epidural techniques with fentanyl, on the initiation of breastfeeding in postpartum women.
- There has been controversy about whether epidural labour analgesia negatively impacts on breastfeeding outcomes.
- A causative mechanism between poorer breastfeeding outcomes and low-dose neuraxial techniques has **not** been established although it has been attributed to epidural fentanyl.

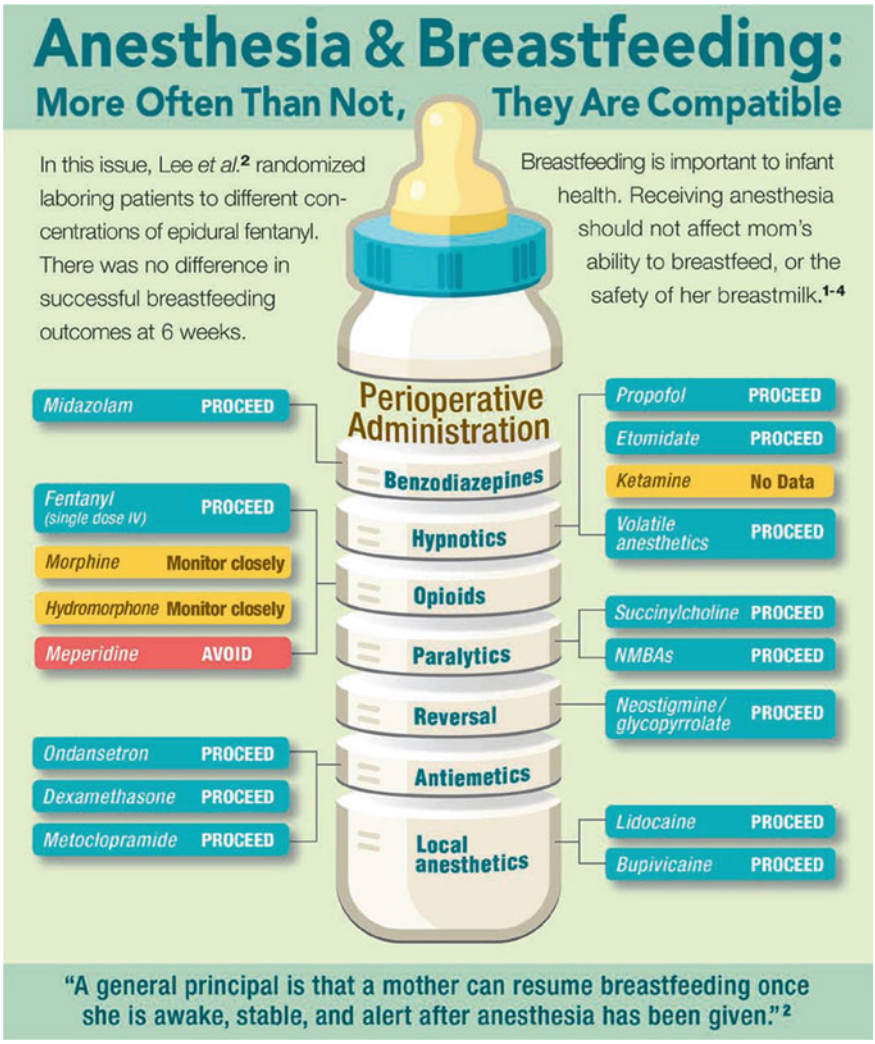

Fig. 63.1 IV = intravenous; NMBAs = neuromuscular blocking agents. Infographic references (1–4): 1. Lee AI et al. Anesthesiology 2017.127:614–24; 2. Cobb B et al. Transl Perioper Pain Med. 2015.1:1–7; 3. Dalal et al. Paediatr Anaesthesia 2014;24:359–71; 4. Drugs and Lactation Database. US National Library of Medicine (LactMed). https://toxnet.nlm.nih.gov/newtoxnet/lactmed.htm. Infographic created by Jonathan P. Wanderer, Vanderbilt University Medical Center, and James P. Rathmell, Brigham and Women's Health Care/Harvard Medical School. Illustration by Annemarie Johnson, Vivo Visuals. Published with the permission of Wolters Kluwer

- A systematic review published in 2016 evaluated 23 studies of labour epidural analgesia and breastfeeding outcomes with conflicting results [9].
  - 12 showed negative associations between epidural analgesia and breastfeeding success, 10 studies showed no effect, and 1 study showed a positive association.
  - The conclusion of this review must be balanced against the limitations of the included studies; most were observational studies with a small sample size or inadequate study power; there was variation in methodology and dose of analgesia and differences in timing, definition and method of assessing breastfeeding success.
- Two major studies [10, 11] exploring the relation between intrapartum low-dose epidural analgesia with fentanyl and breastfeeding, did not demonstrate negative effects on breastfeeding outcomes.
- The obstetric anaesthetist should encourage and support strategies to promote breastfeeding e.g. skin to skin after delivery and judicious use of opioid prescribing after caesarean delivery.

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Difficult and Failed Intubation in Obstetric Anaesthesia

64

Sioned Phillips and Roshan Fernando

Most pregnant women will deliver without the need to have a general anaesthetic (GA) and requirement for intubation and ventilation; indeed, the number of caesarean deliveries (CD) under GA is decreasing [1]. However, when the need arises for intubation of the pregnant woman, there are many factors to consider regarding airway difficulties and its repercussions.

What is the incidence of failed intubation in obstetric anaesthesia?

A recently published literature review by the joint Obstetric Anaesthetists' Association/Difficult Airway Society (OAA/DAS) difficult airway guidelines group looked at all published data on failed intubations in obstetric patients from 1970 to 2015 [2]. Over that time period the incidence of failed intubation was unchanged at 2.6 per 100,000 anaesthetics (1 in 390) for obstetric general anaesthetics and 2.3 per 100,000 GA for caesarean delivery [2]. Disappointingly there has been no improvement in the rate of maternal mortality from failing to establish an airway since 1970.

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Reasons for Airway Difficulty

There are many factors, which cause difficulty with the obstetric airway.

Maternal factors

- Anatomical and physiological changes of pregnancy.
- The airway mucosa is more oedematous and vascular; this causes a change in the Mallampati score from pre-pregnancy and can lead to potential problems with bleeding during instrumentation.
- Other causes of airway swelling during pregnancy and labour are:
  - pre-eclampsia
  - intravenous (IV) fluids
  - oxytocin (intrapartum use causing fluid retention with potential airway swelling)
  - Valsalva manoeuvre
- Desaturation occurs more quickly in the apnoeic pregnant patient due to an increased metabolic rate and reduction in functional residual capacity (FRC).
- Gastric reflux leading to aspiration may occur due to decreased lower oesophageal sphincter tone and from delayed gastric emptying that can accompany painful labour and opioid administration.

Situational factors

- These may play a large role in a high stress situation.
- A GA may be administered because of a failed neuraxial block therefore the anaesthetist is already under a degree of pressure to successfully provide an alternative anaesthetic.
- GA is often required for urgent delivery of the fetus, which can add time pressure. This is likely to have a detrimental effect on the preparation, planning and performance of anaesthesia related tasks.
- As the number of GAs is decreasing, so are the training opportunities allowing exposure in dealing with the obstetric airway.

The recent DAS/OAA guidelines for failed intubation are shown in Figs. 64.1, 64.2, 64.3, 64.4, 64.5 and 64.6. Figure 64.2 highlights the importance of planning and preparation for intubation. Airway assessment may not always predict intubation difficulty, and in fact two thirds of patients in a recent review were not reported to have an anticipated difficult airway after assessment, but difficult endotracheal intubation was subsequently reported [2]. As well as prediction of difficult endotracheal intubation, anticipated ease of mask ventilation, supraglottic airway device (SAD; such as a laryngeal mask airway) insertion, and front of neck access (FON) should also be considered. Any predicted difficult airway should be highlighted during the antenatal period and a specific management plan documented.

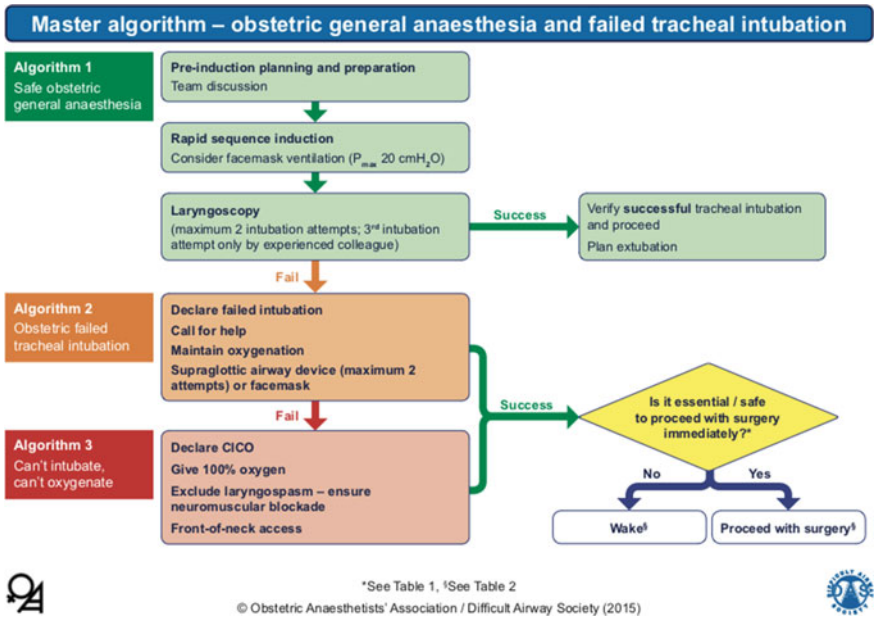

Fig. 64.1 **Master OAA / DAS algorithm** outlining the steps to be taken during a failed intubation when performing general anaesthesia for obstetrics. Reproduced from: Mushambi MC, Kinsella SM, Popat M, Swales H, Ramaswamy KK, Winton AL, Quinn AC. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management of difficult and failed tracheal intubation in obstetrics. Anaesthesia 2015; 70: 1286–1306, with permission from the Obstetric Anaesthetists' Association (OAA) / Difficult Airway Society (DAS)

Women undergoing elective obstetric surgery should be fasted in the same way as for non-obstetric surgery—6 hours for food and 2 hours for clear fluids [3]. Women should be encouraged to take a H_2 receptor antagonist the night before surgery and the morning of surgery.

In the UK, labouring women are stratified into high or low risk in terms of their requirement for GA, from this risk assessment decisions regarding oral intake are made:

- Low risk women may eat a light diet
- High-risk women or those who have received opioids, can have clear fluids only and receive oral H_2 receptor antagonists [4].

If women require GA, oral sodium citrate should also be administered before induction.

IUR (intrauterine resuscitation) must be started as soon as concern regarding fetal wellbeing has been raised. On arrival to the operating theatre the fetal condition should be re-evaluated which may influence both the type of anaesthesia and speed of surgery.

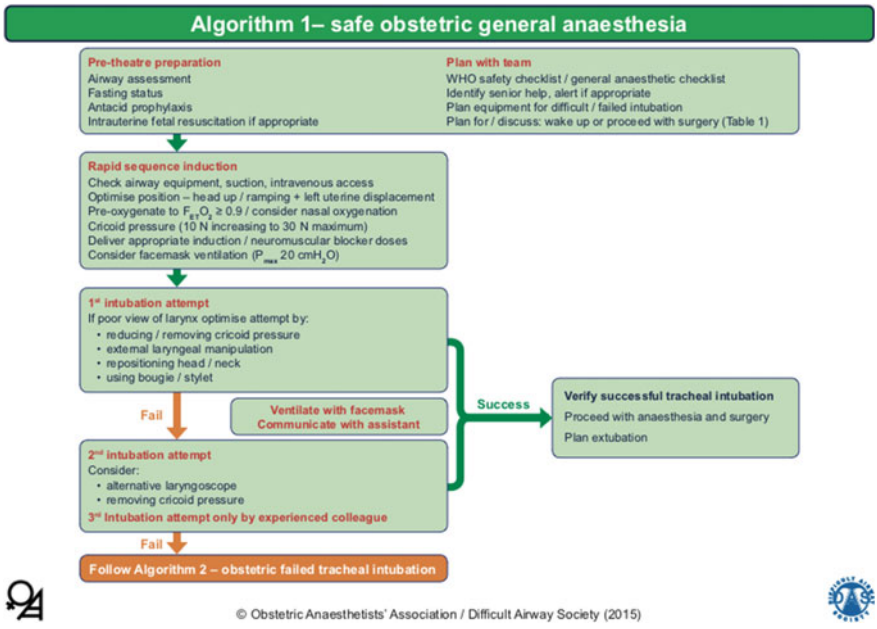

Fig. 64.2 **Algorithm 1** from the DAS / OAA guidelines, which outlines the safe planning for induction of general anaesthesia for obstetrics. Reproduced from:Mushambi MC, Kinsella SM, Popat M, Swales H, Ramaswamy KK, Winton AL, Quinn AC.Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management ofdifficult and failed tracheal intubation in obstetrics. Anaesthesia 2015; 70: 1286–1306, with permission from the Obstetric Anaesthetists' Association (OAA) / Difficult Airway Society (DAS)

The whole team must be involved in the planning of care for the obstetric patient. The clinical state of the patient and the urgency of surgery should be stated. The WHO (World Health Organisation) checklist can be modified, allowing this information to be part of the WHO sign in. Other important checks include how to contact a second anaesthetist and whether the patient should be woken up from anaesthesia if failed intubation (FI) occurs. A videolaryngoscope should be available. These should be considered at first attempt, to provide the best view possible or second attempt at laryngoscopy after direct laryngoscopy has failed.

Should Surgery Proceed After Failed Intubation?

DAS/OAA have produced a table outlining factors to aid this decision (Fig. 64.5). The table is divided into factors present before induction of anaesthesia and those after.

Factors to consider before induction are:

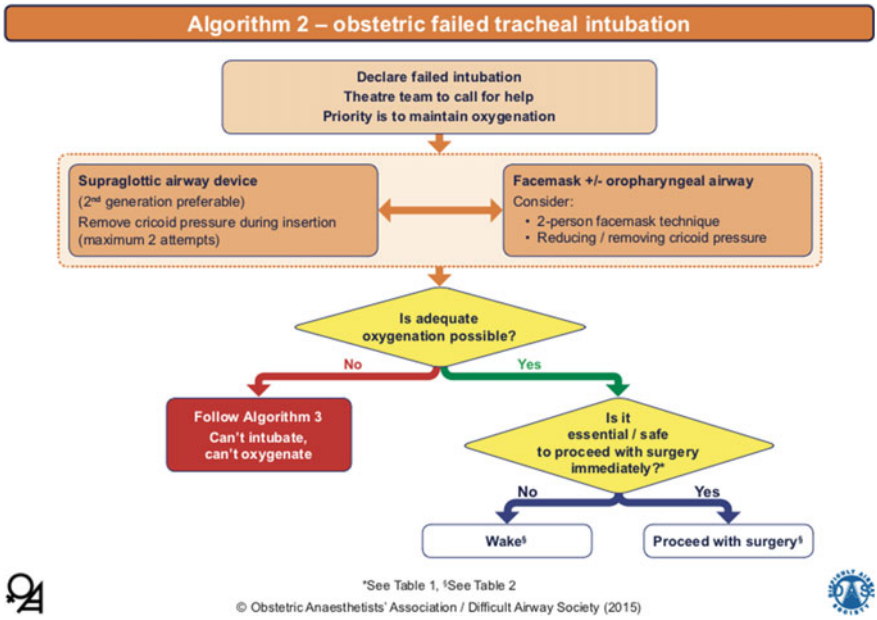

Fig. 64.3 **Algorithm 2** from the DAS / OAA guidelines, outlining the steps to be taken after failed intubation during general anaesthesia for obstetrics. Reproduced from:Mushambi MC, Kinsella SM, Popat M, Swales H, Ramaswamy KK, Winton AL, Quinn AC.Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management ofdifficult and failed tracheal intubation in obstetrics. Anaesthesia 2015; 70: 1286–1306, with permission from the Obstetric Anaesthetists' Association (OAA) / Difficult Airway Society (DAS)

- maternal and fetal condition
  - experience of the anaesthetist
  - body mass index (BMI) of the patient
  - surgical factors
  - aspiration risk
  - appropriateness of alterative anaesthetic strategies

The table is a novel idea, it can be used to guide rapid decision making in an emergency situation. It is also helpful as a teaching tool to stimulate discussion during training.

Traditionally anaesthetists have been taught to wake the mother after failed intubation. Waking the patient is an attempt to allow spontaneous ventilation and regain adequate airway control. However smooth emergence is unlikely to occur in the emergency situation potentially leading to hypoxia. For example, there will be a degree of neuromuscular block (from suxamethonium) whilst waiting for a patient to emerge from anaesthesia after failed intubation. This may lead to inadequate ventilation and hypoxia.

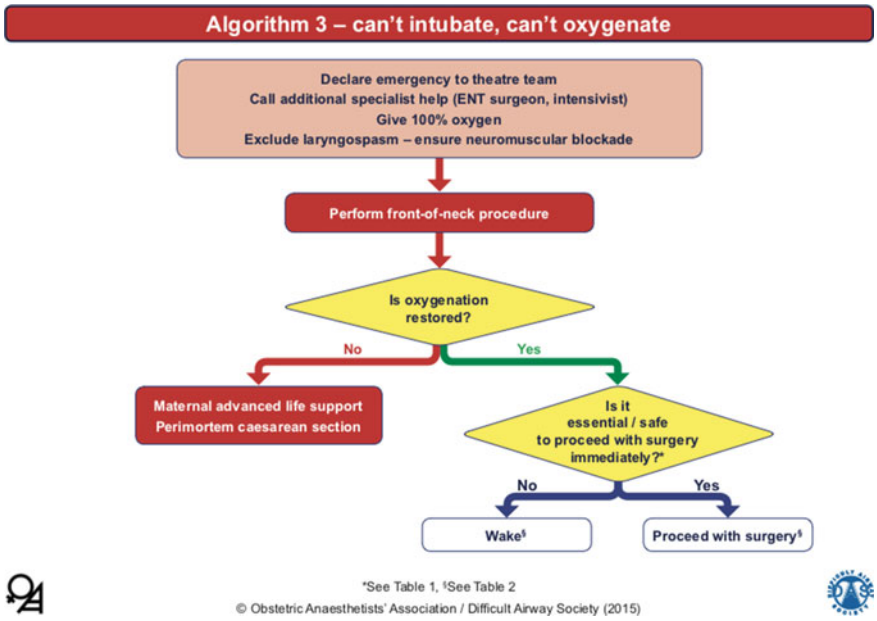

Fig. 64.4 **Algorithm 3** from the DAS / OAA guidelines, outlining the steps to be taken during a "Can't intubate, can't oxygenate" situation during general anaesthesia for obstetrics. Reproduced from:Mushambi MC, Kinsella SM, Popat M, Swales H, Ramaswamy KK, Winton AL, Quinn AC. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management ofdifficult and failed tracheal intubation in obstetrics. Anaesthesia 2015; 70: 1286–1306, with permission from the Obstetric Anaesthetists' Association (OAA) / Difficult Airway Society (DAS)

Change in Practice

There has been a gradual trend to proceed with surgery after failed intubation in obstetrics. In their literature review, the OAA/DAS guideline group found that in 73% of all identified failed intubations, cases continued with general anaesthesia and surgery [5].

Reasons behind this change may include:

- Increasing experience with a SAD.
- Literature describing the safe use of SADs for elective CD and publications that support the use of SAD after FI in the general and obstetric population [6–8].
- An emphasis to safely deliver the fetus as opposed to the traditional teaching of the mother being the primary patient.

Table 1 – proceed with surgery?

	Factors to consider	WAKE			PROCEED
Before induction	Maternal condition	• No compromise	• Mild acute compromise	• Haemorrhage responsive to resuscitation	• Hypovolaemia requiring corrective surgery • Critical cardiac or respiratory compromise, cardiac arrest
	Fetal condition	• No compromise	• Compromise corrected with intrauterine resuscitation, pH < 7.2 but > 7.15	• Continuing fetal heart rate abnormality despite intrauterine resuscitation, pH < 7.15	• Sustained bradycardia • Fetal haemorrhage • Suspected uterine rupture
	Anaesthetist	• Novice	• Junior trainee	• Senior trainee	• Consultant / specialist
	Obesity	• Supermorbid	• Morbid	• Obese	• Normal
	Surgical factors	• Complex surgery or major haemorrhage anticipated	• Multiple uterine scars • Some surgical difficulties expected	• Single uterine scar	• No risk factors
	Aspiration risk	• Recent food	• No recent food • In labour • Opioids given • Antacids not given	• No recent food • In labour • Opioids not given • Antacids given	• Fasted • Not in labour • Antacids given
	Alternative anaesthesia • regional • securing airway awake	• No anticipated difficulty	• Predicted difficulty	• Relatively contraindicated	• Absolutely contraindicated or has failed • Surgery started
After failed intubation	Airway device / ventilation	• Difficult facemask ventilation • Front-of-neck	• Adequate facemask ventilation	• First generation supraglottic airway device	• Second generation supraglottic airway device
	Airway hazards	• Laryngeal oedema • Stridor	• Bleeding • Trauma	• Secretions	• None evident

Criteria to be used in the decision to wake or proceed following failed tracheal intubation. In any individual patient, some factors may suggest waking and others proceeding. The final decision will depend on the anaesthetist's clinical judgement.

Fig. 64.5 **Table 1** from the DAS/OAA guidelines, can be used as a decision aid regarding either waking the obstetric patient after failed intubation or proceeding with surgery. Reproduced from: Mushambi MC, Kinsella SM, Popat M, Swales H, Ramaswamy KK, Winton AL, Quinn AC. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management ofdifficult and failed tracheal intubation in obstetrics. Anaesthesia 2015; 70: 1286–1306, with permission from the Obstetric Anaesthetists' Association (OAA) / Difficult Airway Society (DAS)

Key Messages from the DAS/OAA Failed Tracheal Intubation Guidelines

- The use of ("gentle") facemask ventilation during rapid sequence intubation (RSI) is acceptable and can provide oxygenation during induction.
- Cricoid pressure can be released during failed intubation to potentially improve the view of the glottis before tracheal intubation.
- A SAD should be used in the early stages of a failed intubation with cricoid pressure being temporarily released to facilitate its placement. The effectiveness of cricoid pressure once a SAD is placed is unclear.
- Neuromuscular blocking drugs (e.g. rocuronium) should be used before front of neck (FON) access is attempted.

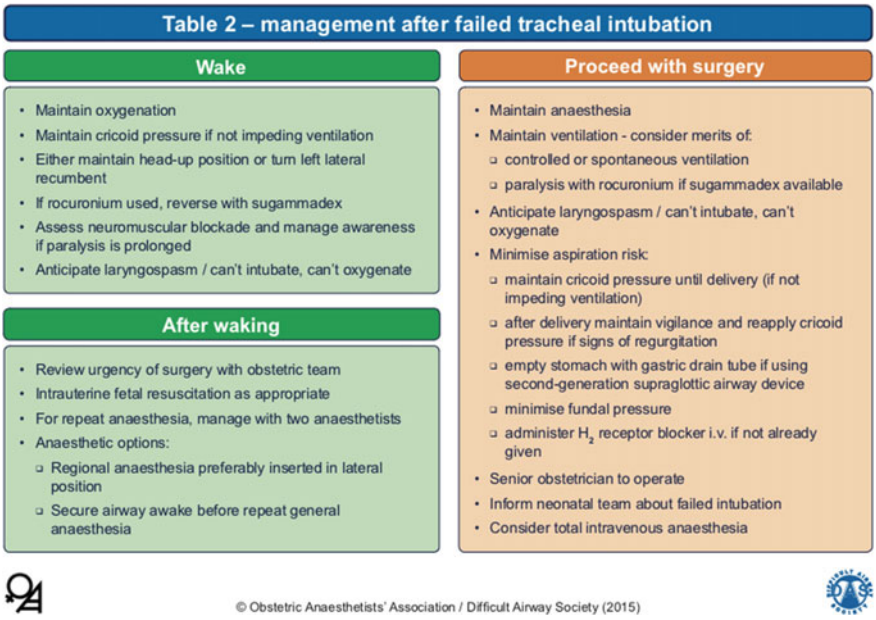

Fig. 64.6 **Table 2** from the DAS / OAA guidelines outlining the management of obstetric patients after failed intubation. Reproduced from:Mushambi MC, Kinsella SM, Popat M, Swales H, Ramaswamy KK, Winton AL, Quinn AC.Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management ofdifficult and failed tracheal intubation in obstetrics. Anaesthesia 2015; 70: 1286–1306, with permission from the Obstetric Anaesthetists' Association (OAA) / Difficult Airway Society (DAS)

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Recognition and Management of High Spinal Anaesthesia

65

Adrienne Stewart and Rachel Coathup

Introduction

There is no strict definition of what constitutes a high spinal. Variations include a block above the level required for surgical anaesthesia, a block above the level of the T4 dermatome, and an excessively high block requiring tracheal intubation usually associated with profound hypotension/cardiovascular collapse [1–3]. The term complete or total spinal refers to a situation where the local anaesthetic (LA) spreads intracranially, ultimately resulting in a loss of consciousness. In practice however the anaesthetist should not wait until unconsciousness has occurred before taking action.

Spread of anaesthesia when using neuraxial techniques, is known to be variable [4]. Excessively high spread causes sympathetic inhibition, resulting in serious complications for both mother and baby. Many anaesthetists find it reassuring to achieve a block to the high thoracic dermatomes due to fear of litigation and risks associated with intraoperative pain during caesarean delivery as a consequence of a low level of block [2]. However, such a scenario can lead to conversion to general anaesthesia. High blocks can be managed safely as long as the anaesthetist remains vigilant and responds to any adverse signs quickly and appropriately. It is therefore a careful balance between achieving adequate surgical anaesthesia, while minimising any adverse effects to both mother and fetus.

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The reported incidence of high neuraxial block is also variable. A large prospective study reported high or total spinal block occurring with 1 in 16,200 epidurals [5]. The UK Obstetric Anaesthetists' Association (OAA) neuraxial anaesthesia information card quotes a 1 in 2,000 risk of experiencing a high spinal block and the epidural information card quotes a 1 in 100,000 risk of accidental unconsciousness [6, 7].

Causes

– Excessive intrathecal spread of local anaesthetic (LA) following spinal injection.
– Accidental/unrecognised intrathecal catheter during epidural catheter insertion.

Recognition

When administering neuraxial analgesia on the labour and delivery ward, early recognition of a high block is crucial to enable prompt interventions to be made to minimise risks to the mother and baby. Rapid onset of analgesia, motor block and/or hypotension should make an anaesthetist suspect accidental intrathecal catheter placement.

- In the operating theatre the height of the neuraxial block should be checked regularly.
- Continuous maternal monitoring of heart rate and blood pressure should alert the anaesthetist to a potentially high rising block.
- The importance of maintaining good verbal communication with the mother at all times is vital to allow early recognition of any concerning signs (see Table 65.1).

Table 65.1 Clinical features of an ascending neuraxial block

Dermatomal level of neuraxial block	Clinical features
Upper thoracic (T1-T4)	• bradycardia (due to blockade of the cardioacceleratory fibres) • hypotension
Lower cervical (C6-C8)	• paraesthesia/weakness in upper limbs • difficulty in breathing
Upper cervical (C3-C5)	• shoulder weakness • breathing difficulty
Intracranial	• slurred speech • sedation • loss of consciousness • apnoea

Management

For blocks extending up to the high thoracic dermatomes, it can be possible to manage the patient with slight head up positioning, treating any cardiovascular compromise with appropriate medications and providing reassurance.

Cardiovascular compromise

Placental blood flow is not auto-regulated, therefore it is important for fetal well-being that hypotension is treated aggressively.

- Ensure left lateral tilt/left uterine displacement.
- Ensure large bore intravenous (IV) access is in situ.
- Give a rapid intravenous fluid bolus.
- Use vasopressor and anticholinergic drugs as necessary to maintain maternal systolic blood pressure (see Fig. 65.1).

Respiratory compromise

If the consciousness level reduces or the ability to breath becomes compromised, it will be necessary to induce general anaesthesia, intubate and ventilate the mother.

- Provide 100% oxygen through a facemask.
- Briefly explain the situation to any accompanying family members and ask a member of staff to escort them from the room.
- Call for help: senior/second anaesthetist, anaesthetic assistant, senior obstetrician and midwife/obstetric nurse.
- Follow local hospital protocol/practice for administering general anaesthesia within the delivery suite. Smaller doses of induction agents will be required in the presence of cardiovascular compromise.
- Once the airway is secure, consider the immediate delivery of the baby.
- Ensure anaesthesia is maintained until the neuraxial block has worn off sufficiently that the mother is able to support her own ventilation and maintain her own airway. This may take some time and therefore may require transferring her to an intensive care unit for ventilatory support.

Other Important Considerations

- Ensure accurate and detailed documentation.
- Debrief: with all staff members present.
- Explain what has happened to both the patient and her family. It can be a very traumatic event and on-going psychological support should be offered.

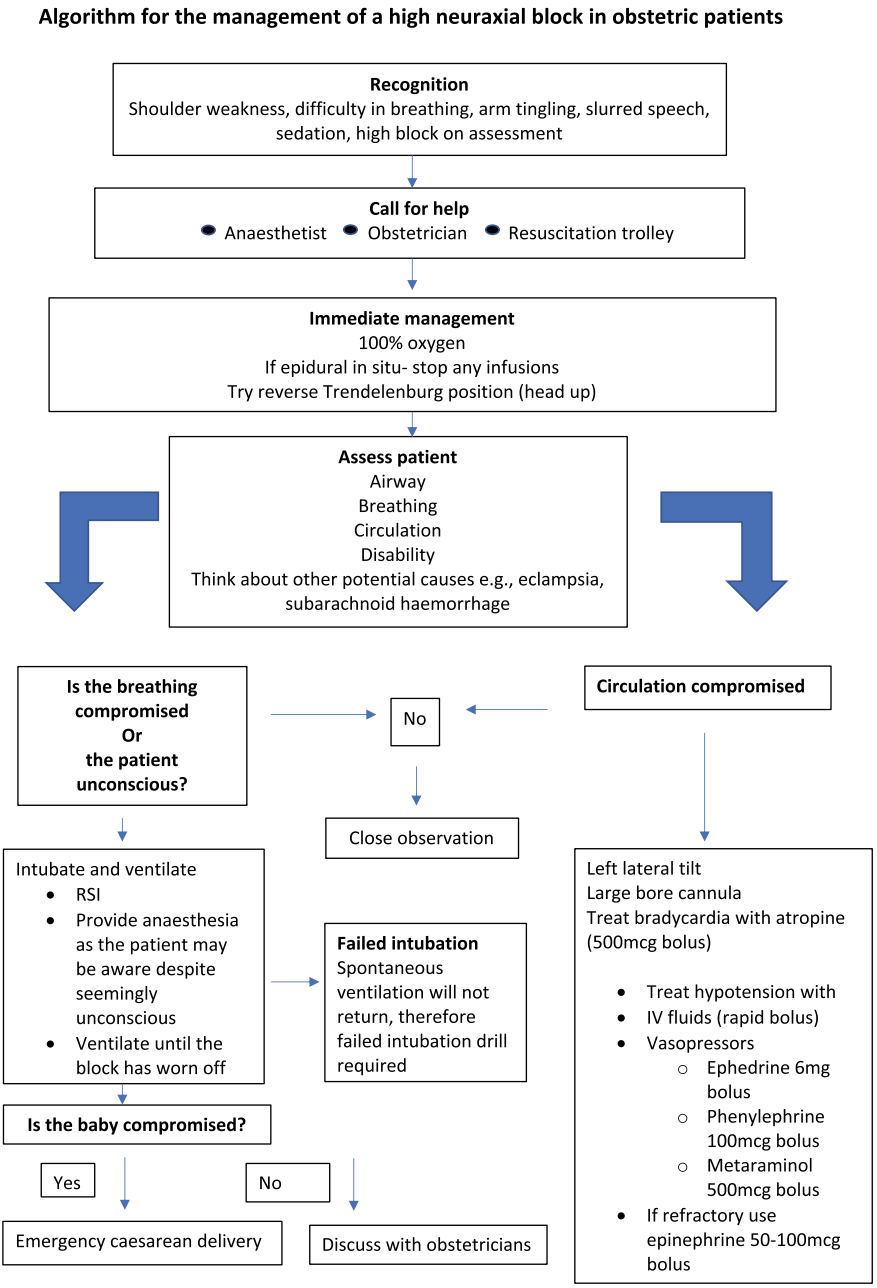

Fig. 65.1 Management of high neuraxial block. RSI - rapid sequence intubation

- Further educational learning for the delivery suite team: e.g. within a multidisciplinary case presentation meeting to include discussion of learning points and potential management improvements.

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Aspiration of Gastric Contents

66

Cristian Arzola and Yusuke Mazda

- Aspiration of gastric contents into the respiratory tract occurs in the absence of a cough reflex, which is largely associated with general anesthesia as the main risk factor. Other factors observed in pregnant women are emergency surgery, obesity, gastroesophageal reflux, and airway problems during general anesthesia [1].
- Aspiration pneumonitis is the acute chemical lung injury that develops after the inhalation of the regurgitated gastric contents. The morbidity and mortality depend on the chemical and physical nature of the aspirate, and the volume. While the aspiration of solids could result in asphyxiation, animal studies have demonstrated that an increase in the volume of aspirate is associated with a higher risk [2]. The gastric volume that puts a patient at risk has not been determined. However, a reasonable goal of prophylactic therapy is a gastric pH greater than 2.5 and a gastric volume as low as possible [3].
- Clinically, it may include gastric contents in the oropharynx, wheezing, coughing, shortness of breath, cyanosis, pulmonary edema, hypotension, and hypoxemia, which may progress rapidly to severe acute respiratory distress syndrome and death. However, aspiration may also be clinically silent, manifesting only as arterial oxygen desaturation with radiologic evidence of aspiration [1].

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- Although aspiration accounted for the majority of anesthesia-associated maternal deaths in the middle of the 20th century, encouraging neuraxial anesthesia, adopting pharmacological prophylaxis and regulating oral intake during labor have contributed to the dramatic reduction of this complication. Nevertheless, maternal deaths related to aspiration are still being reported [4, 5] mainly due to difficulties in airway management.

Associated Morbidity and Mortality

- Maternal death by aspiration: 1 in 3,000,000 [4].
- The incidence of aspiration is:
- 1 in 1,000 (pregnant),
- 1 in 2,500 (non-pregnant) [5].
- **Aspiration is highly associated with a difficult airway** [5].
- Aspiration is also reported frequently during extubation [5].

Immediate Management

- Secure the airway by intubation.
- Remove large particles by suction and/or bronchoscopy.
- Ventilate with continuous positive airway pressure and positive end expiratory pressure, of at least 5 cm H_2O.
- **NOT** recommended: lung lavage, prophylactic antibiotics, routine corticosteroids [1].

Late Management

- Lung protective strategies similar to the treatment of adult respiratory distress syndrome (inspiratory plateau pressure <30 cm H_2O, low tidal volume 6 mL/kg).
- Minimize other risks (sepsis, gastric bleeding, thromboembolism).

Prophylaxis

Pregnancy does not delay gastric emptying unless labor begins or parenteral opioids have been given. However, the decreased lower esophageal sphincter tone and a higher risk for difficult intubation (See Chap. 64) are the primary factors that dictate the need for pharmacologic prophylaxis. Although a cuffed endotracheal tube

remains the standard of care for airway protection during general anesthesia, the application of cricoid pressure (Sellick Maneuver) remains controversial due to conflicting evidence of its effectiveness and a deterioration of the laryngoscopy view during intubation [6, 7].

Pharmacological Prophylaxis

- Non-particulate antacid: sodium citrate 0.3 M (30 mL) orally.
- H_2-receptor antagonist: ranitidine 150 mg PO/50 mg iv, famotidine 20 mg orally or intravenously.
- Prokinetic agent: metoclopramide 10 mg orally or intravenously.
- The combination of non-particulate antacids and H_2-antagonists is more effective than no intervention, and superior to antacids alone in increasing gastric pH. When a single agent is used, antacids alone are superior to H_2-antagonists, which are superior to proton pump inhibitors (PPI) for increasing gastric pH [3].
- There is no strong evidence to support giving proton pump inhibitors (PPI) routinely for preventing aspiration in the pregnant population. A meta-analysis comparing the risk of aspiration between ranitidine and PPI including elective caesarean delivery under general anaesthesia showed that both medications have equivalent efficacy [8]. Therefore, PPI, such as omeprazole 40 mg orally (PO) or intravenously (iv), would be preferable only if an H_2-anatagonist is contraindicated.
- Metoclopramide is able to reduce gastric volume in 15 min, [9] but it is worth considering the risk of extrapyramidal side effects. Current evidence does not support routine administration of pharmacological prophylaxis to all parturients in normal labor or undergoing elective caesarean delivery, especially those under neuraxial anesthesia [3, 10]. However, the Guidelines for Enhanced Recovery After Surgery (ERAS) in caesarean delivery strongly recommends premedication of antacids and H_2-antagonists, despite stating the evidence is weak [11]. Therefore, taking into account the most updated recommendations, pharmacological prophylaxis may be implemented in a stratified manner (Table 66.1).

Physical removal of gastric contents

- There are some controversies regarding the prophylactic use of a gastric tube for preventing aspiration during caesarean delivery. As long as parturients are awake (without sedation), the benefit of removing gastric contents before surgery are negligible, when pharmacological prophylaxis has been properly implemented. However, inserting a gastric tube at the completion of surgery before emergence from general anaesthesia can be considered in specific situations, such as urgent caesarean delivery, because aspiration can occur during extubation [4].

Table 66.1 Pharmacological prophylaxis for caesarean delivery

		Sodium citrate	H_2-receptor antagonist	Metoclopramide
Elective	neuraxial	–	- *	- *
	general	–	PO	PO
Urgent	neuraxial	–	IV	IV
	general	20 min before induction**	IV	IV

PO: oral administration, on the night before, and on the morning of surgery; *: when converting to general anesthesia, intravenous administration (IV) should be considered. **: if emergency, give sodium citrate in the operating room

- Since pregnant women are at a higher risk of epistaxis, a nasogastric tube would not be a prudent choice. The anesthesiologist should insert a 14 to 18 French orogastric tube. Of note, it is not guaranteed to remove all gastric contents through the gastric tube; therefore, pharmacological prophylaxis should be performed at the same time. If sodium citrate is not given before induction of general anaesthesia, the gastric tube can also be used as a means for neutralizing the gastric contents.
- Inserting a gastric tube before induction of general anaesthesia is not common in current obstetric anaesthesia practice. It would only be considered when a parturient has evidence of gastric distention with gastrointestinal obstruction.

Gastric Ultrasound

- Bedside gastric ultrasonography is a promising point-of-care diagnostic tool in the assessment of individual risk of aspiration and clinical decision-making [12, 13].
- Examination: in a 45° semi-recumbent position, first supine and then full right lateral (RL) position using a low frequency (2–5 MHz), curvilinear probe.
- The gastric antrum is scanned in a sagittal to right parasagittal plane between the left lobe of the liver and the pancreas at approximately the level of the aorta or inferior vena cava.
- Pattern recognition.

a. Empty stomach (Grade 0): minimal clear fluid/air content, flat antrum or 'bull's eye' pattern in both supine and RL.
b. Clear fluid: distended antrum with hypoechoic content

    i. Grade 1: fluid visible in RL only, suggesting low gastric volume compatible with baseline gastric secretions.

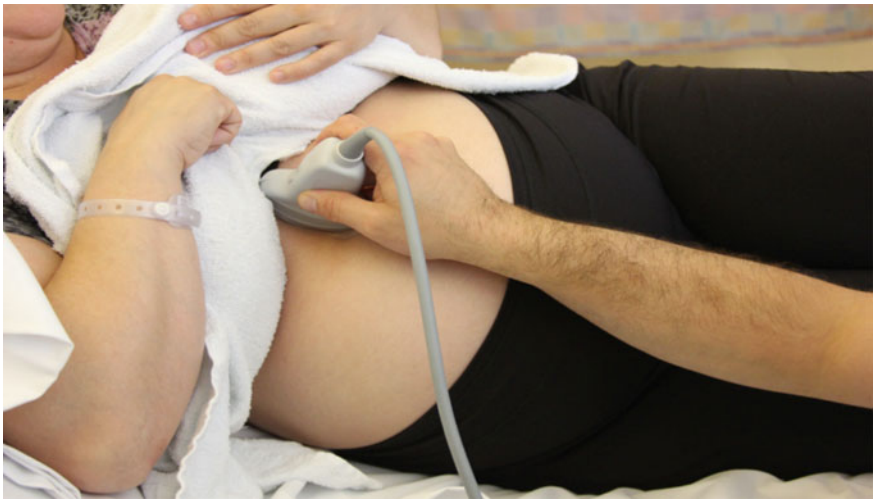

Fig. 66.1 Examination position: 45° semi-recumbent, right lateral position

ii. Grade 2: fluid visible in both supine and RL, suggesting high gastric volume beyond baseline gastric secretions.

c. Thick fluid or solid: distended antrum with hyperechoic/heterogeneous content.

- Volume estimation: various mathematical models exist, based on measuring the antral cross-sectional area (CSA) in 45° semi-recumbent right lateral position. Particularly from research on pregnant patients:

a. Upper normal limit of CSA in fasted term pregnant women: 10.3 cm^2.
b. Volume (mL) = 27 + [14.6 x CSA (RL) cm^2] − [1.28 xAge].

Gastric ultrasound is an emerging point-of-care application in anesthesia education and practice. In obstetrical anesthesia, the technical aspects of this diagnostic test and the conceptual clinical framework require further research to determine its role in the peripartum period (Figs. 66.1, 66.2, 66.3, 66.4, 66.5 and 66.6).

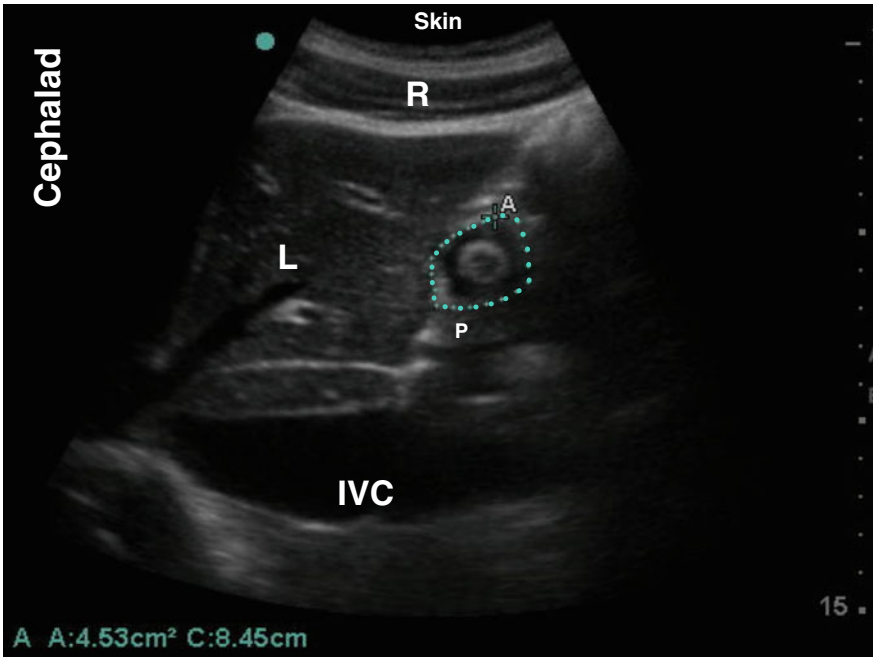

Fig. 66.2 Empty stomach: "bull's eye" or "target" pattern. A: antrum, L: liver, P: pancreas, IVC: inferior vena cava, R: rectus abdominis muscle, Dashed green line: cross-sectional area

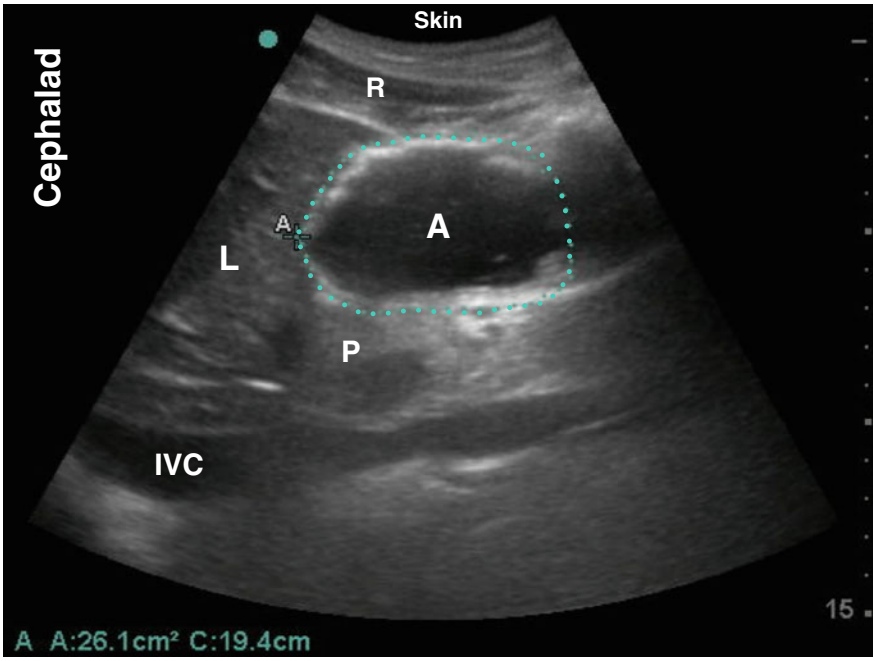

Fig. 66.3 Clear fluids. A: antrum, L: liver, P: pancreas, IVC: inferior vena cava, R: rectus abdominis muscle, Dashed green line: cross-sectional area

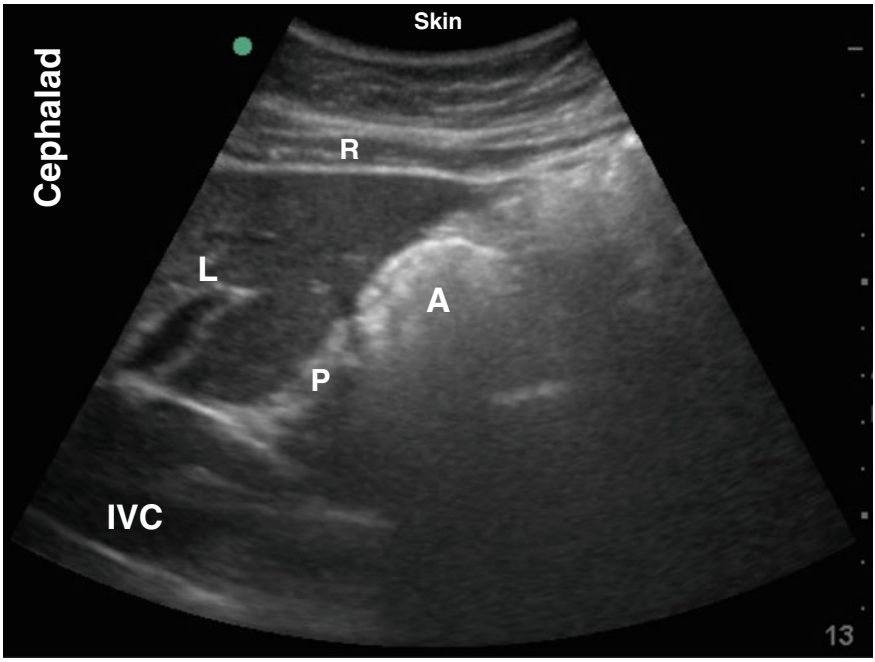

Fig. 66.4 Solid early stage: "frosted-glass" pattern. A: antrum, L: liver, P: pancreas, IVC: inferior vena cava, R: rectus abdominis muscle

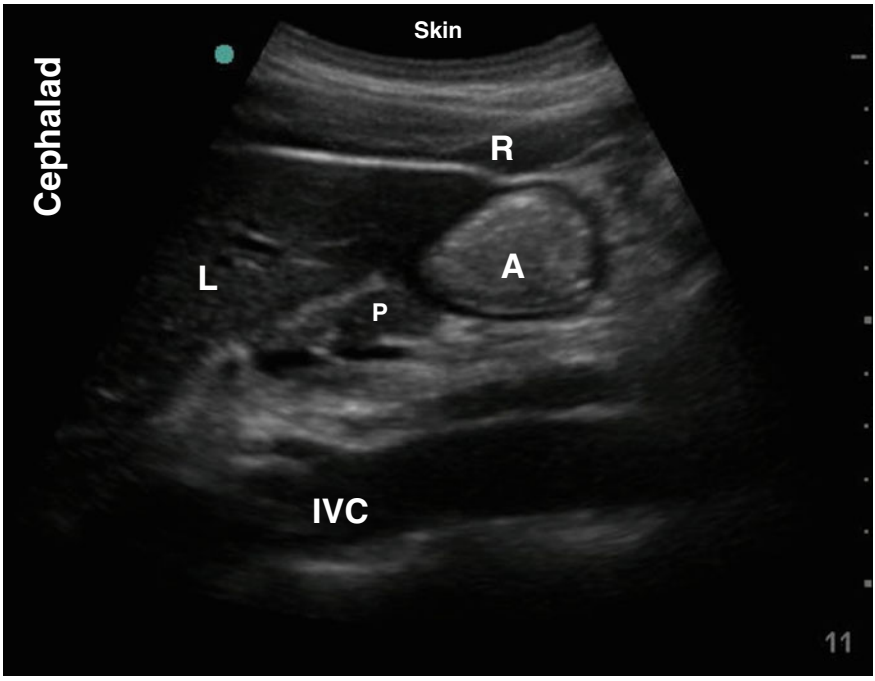

Fig. 66.5 Solid late stage. A: antrum, L: liver, P: pancreas, IVC: inferior vena cava, R: rectus abdominis muscle

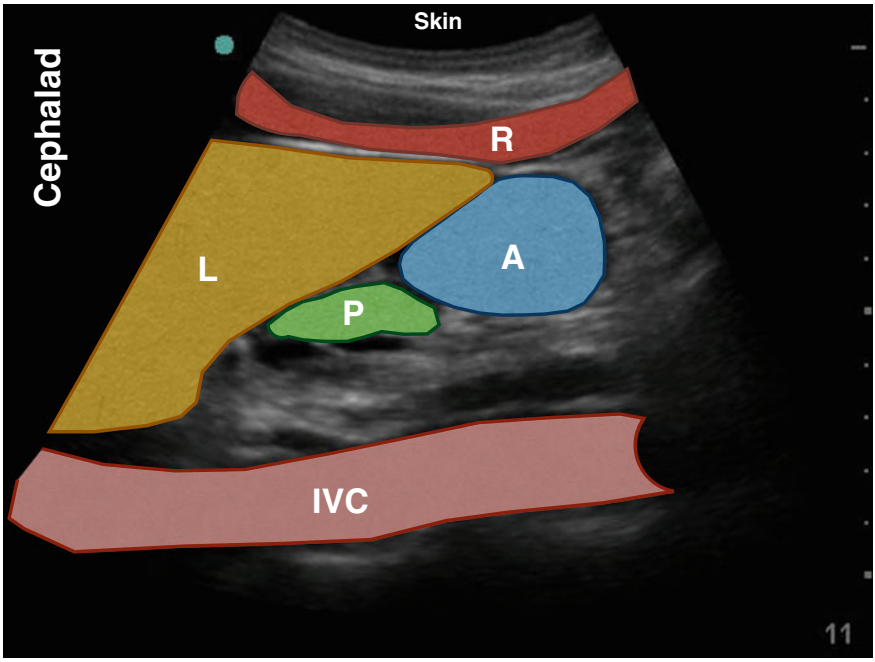

Fig. 66.6 Schematic representation in solid late stage. A: antrum, L: liver, P: pancreas, IVC: inferior vena cava, R: rectus abdominis muscle

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Local Anaesthetic Toxicity

67

Sioned Phillips

Obstetric analgesia and anaesthesia frequently involve neuraxial anaesthesia and the administration of local anaesthetic drugs. Therefore these women are at risk of local anaesthetic systemic toxicity (LAST). Propensity to develop LAST will depend upon the site of administration, the rate of injection and the total dose administered. Intravascular injection may accidently occur via either 'wrong route' administration, when local anaesthetic intended for the epidural space has been administered via a peripheral venous cannula (which is a serious incident caused by human error), or via an epidural catheter which has inadvertently been placed in an epidural vein.

Maximum doses of local anaesthetics should be calculated before administration to avoid toxic doses of local anaesthetics being administered. The quoted doses below are the recommended maximal doses. These doses are theoretical, as dosing of local anaesthetics is complicated and is dependent on patient specific information, pharmacokinetics and pharmacodynamics.

Maximum doses of local anaesthetics are:

- Lidocaine 3 mg/kg
- Lidocaine with epinephrine 7 mg/kg
- Bupivacaine (with or without epinephrine) 2 mg/kg
- Levobupivacaine 2 mg/kg
- Ropivacaine 3 mg/kg

Examples of typical doses given during labour analgesia and for caesarean delivery are given below:

- Establishing epidural analgesia with 15 to 20 ml of 'low dose epidural mixture', 0.1% bupivacaine = 15 to 20 mg bupivacaine

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- Epidural top-up for caesarean delivery, using either:
- 20 ml of 0.5% (racemic) bupivacaine = 100 mg bupivacaine
- 20 ml of 2% lidocaine with 1 in 200,000 epinephrine = 400 mg of lidocaine + 100 mcg epinephrine
- 20 ml of 0.75% ropivacaine = 150 mg ropivacaine

The British National Formulary (BNF) states that 150 mg of bupivacaine can be administered within a 4-hour period and up to 400 mg in a 24-hour period [1]. For prolonged use of a labour epidural followed by the epidural being used for surgery, attention should be paid to cumulative doses. This also becomes important when an epidural top-up has failed, and further local anaesthetic doses are required.

This use of epinephrine with lidocaine increases the total amount of lidocaine, which can be administered.

Local Anaesthetic Toxicity and Obstetric Anaesthesia

Knowledge of maximum doses is increasingly important within obstetric anaesthesia since truncal nerve blocks, used to supplement neuraxial anaesthesia following caesarean delivery, are becoming more popular. For example, a woman may have an epidural top-up for caesarean delivery and then have either transverse abdominal plane (TAP) blocks or quadratus lumborum blocks, (QL) to provide analgesia post-surgery. Both TAP and QL blocks are "volume blocks" and therefore require a significant dose of local anaesthetic to be administered bilaterally. In such cases where large volumes are used levobupivacaine should be considered for use instead of racaemic bupivacaine. Levobupivacaine is the S-enantiomer of bupivacaine and is less cardiotoxic, providing a better safety profile when compared to a racemic mixture of bupivacaine.

Risk Factors in Obstetric Anaesthesia

Pregnant patients are at a higher risk of LAST, as they have lower alpha-1-acid glycoprotein levels, and a higher cardiac output. This leads to increased perfusion (at site of local anaesthetic injection) and rapid absorption with a higher peak of free local anaesthetic concentration [2].

The regular use of epidural analgesia and anaesthesia in obstetric anaesthesia practice with infusions of local anaesthetics may lead to wrong route administration including intravenous local anaesthetic administration. In an attempt to prevent these errors, the NRFit™, which is a dedicated non-Luer connector for neuraxial devices, has been introduced following a new ISO (International Organisation for Standardisation) 80369-6:2016 Standard (Fig. 67.1). This will replace the previously used Luer standard for regional anaesthesia connectors which are also used

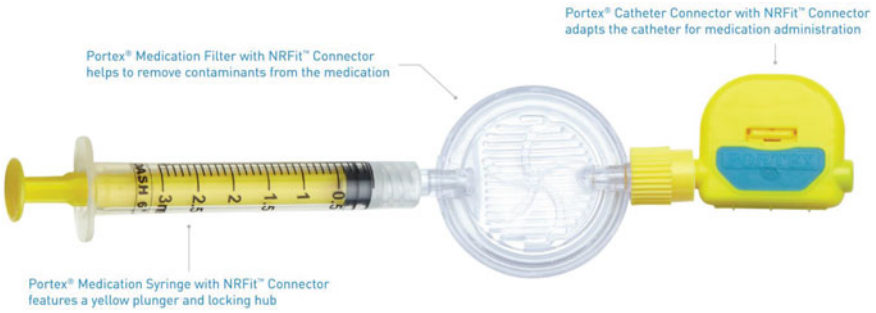

Fig. 67.1 Image reproduced with permission from Smiths Medical

for intravenous administration. Other regional anaesthesia manufacturing companies have produced their own non-Luer connectors.

Presentation of Local Anaesthetic Systemic Toxicity

LAST presents with central nervous system (CNS) signs and symptoms before cardiovascular complications.

- Initial CNS manifestations:

– Excitatory
– Anxiety
– Confusion
– Perioral paraesthesia
– Tinnitus

- Followed by CNS depression:

– Loss of consciousness
– Seizures

- Cardiovascular symptoms:

– Hypotension
– Arrhythmias (sinus bradycardia, conduction blocks, ventricular tachycardia, ventricular fibrillation)
– Cardiac arrest.

Management of Local Anaesthetic Systemic Toxicity

The management of LAST should follow an airway, breathing, circulation assessment. Administration of intravenous lipid emulsion (Intralipid) 20% should be a priority after airway management. Basic management of LAST is outlined below:

- Local anaesthetic infusions should be stopped immediately
- Get help
- Ventilate with 100% oxygen and avoid hyperventilation
- Benzodiazepines are the drug of choice for seizure control
- Hypotension and bradycardia require prompt treatment
- Patients may require prolonged monitoring
- Do not exceed 12 mL/kg lipid emulsion (large doses are not usually required to treat LAST)

The (UK) Association of Anaesthetists guidelines for the management of LAST are provided below (Figs. 67.2 and 67.3). Each delivery suite should have readily available intralipid with staff trained in the recognition of signs and symptoms of LAST. Specific 'treatment boxes' or 'rescue kits' for LAST are encouraged by international societies in order to have rapid access to the correct drugs and equipment to manage LAST. This would be expected to include 20% intralipid, syringes, needles, intravenous (IV) administration sets and the national guidance on the management of LAST.

Lipid Emulsion Doses

The dose of lipid emulsion used in the Association of Anaesthetists guidelines, based on weight, may be challenging to calculate and administer in an emergency situation. The American Society of Regional Anesthesia and Pain Medicine (ASRA), has simplified the dose, using a calculation based on a patient weighing either more than 70 kg or less that 70 kg (Fig. 67.4).

Cardiac Arrest and LAST

In the cardiac arrest situation that has been precipitated by LAST, there are some specific management issues:

- Avoid using local anaesthetics, calcium channel blockers, beta-blockers or vasopressin.
- A lower dose of epinephrine should be used. This is a maximum bolus dose of <1 mcg/kg. This is guidance from the ASRA checklist for treatment of LAST 2021 [3].

AAGBI Safety Guideline

Management of Severe Local Anaesthetic Toxicity

1 Recognition

Signs of severe toxicity:
- Sudden alteration in mental status, severe agitation or loss of consciousness, with or without tonic-clonic convulsions
- Cardiovascular collapse: sinus bradycardia, conduction blocks, asystole and ventricular tachyarrhythmias may all occur
- Local anaesthetic (LA) toxicity may occur some time after an initial injection

2 Immediate management

- Stop injecting the LA
- Call for help
- Maintain the airway and, if necessary, secure it with a tracheal tube
- Give 100% oxygen and ensure adequate lung ventilation (hyperventilation may help by increasing plasma pH in the presence of metabolic acidosis)
- Confirm or establish intravenous access
- Control seizures: give a benzodiazepine, thiopental or propofol in small incremental doses
- Assess cardiovascular status throughout
- Consider drawing blood for analysis, but do not delay definitive treatment to do this

3 Treatment

IN CIRCULATORY ARREST
- Start cardiopulmonary resuscitation (CPR) using standard protocols
- Manage arrhythmias using the same protocols, recognising that arrhythmias may be very refractory to treatment
- Consider the use of cardiopulmonary bypass if available

GIVE INTRAVENOUS LIPID EMULSION
(following the regimen overleaf)
- Continue CPR throughout treatment with lipid emulsion
- Recovery from LA-induced cardiac arrest may take >1 h
- Propofol is not a suitable substitute for lipid emulsion
- Lidocaine should not be used as an anti-arrhythmic therapy

WITHOUT CIRCULATORY ARREST
Use conventional therapies to treat:
- hypotension,
- bradycardia,
- tachyarrhythmia

CONSIDER INTRAVENOUS LIPID EMULSION
(following the regimen overleaf)
- Propofol is not a suitable substitute for lipid emulsion
- Lidocaine should not be used as an anti-arrhythmic therapy

4 Follow-up

- Arrange safe transfer to a clinical area with appropriate equipment and suitable staff until sustained recovery is achieved
- Exclude pancreatitis by regular clinical review, including daily amylase or lipase assays for two days
- Report cases as follows:
  in the United Kingdom to the National Patient Safety Agency (via **www.npsa.nhs.uk**)
  in the Republic of Ireland to the Irish Medicines Board (via **www.imb.ie**)

If Lipid has been given, please also report its use to the international registry at **www.lipidregistry.org**. Details may also be posted at **www.lipidrescue.org**

Your nearest bag of Lipid Emulsion is kept _____

This guideline is not a standard of medical care. The ultimate judgement with regard to a particular clinical procedure or treatment plan must be made by the clinician in the light of the clinical data presented and the diagnostic and treatment options available.

Fig. 67.2 Reproduced with kind permission from The Association of Anaesthetists

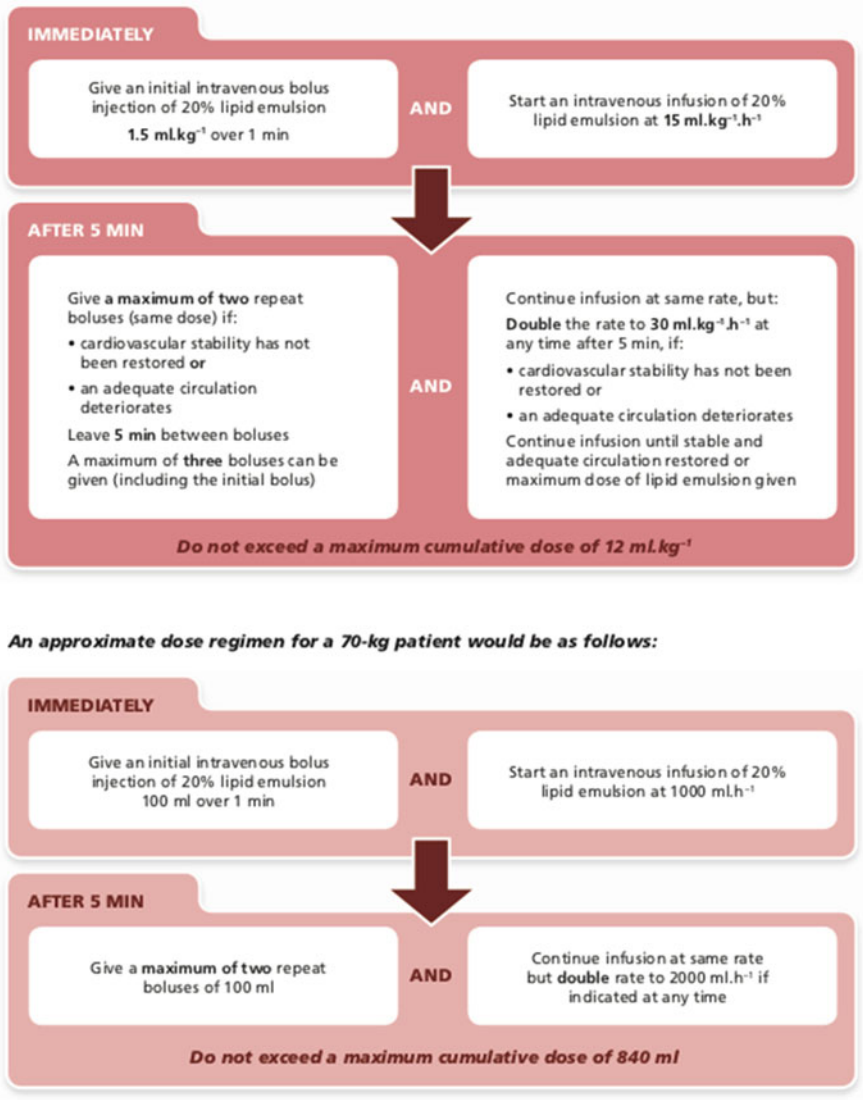

Fig. 67.3 Reproduced with kind permission from The Association of Anaesthetists

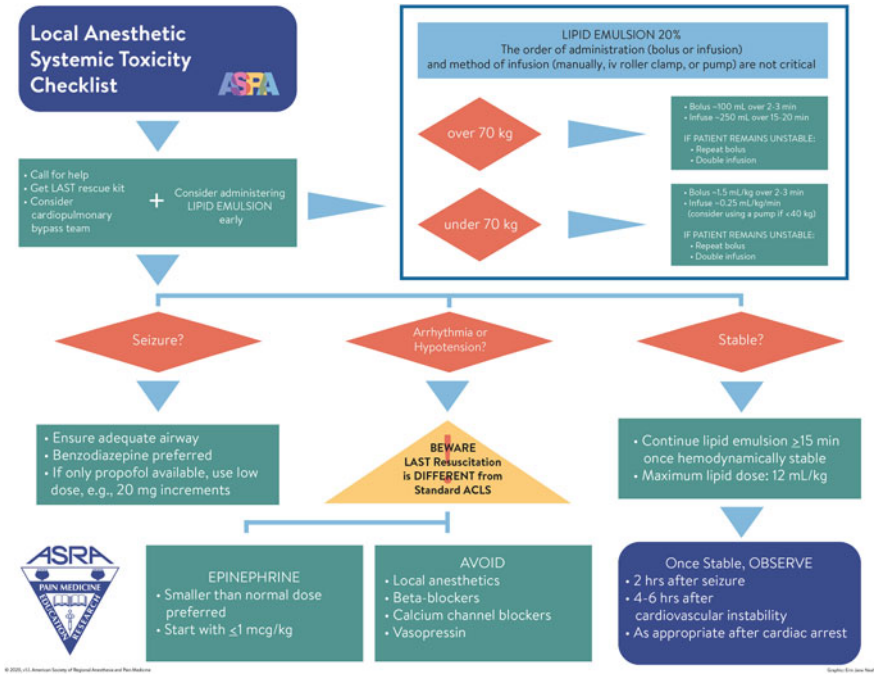

Fig. 67.4 American Society of Regional Anesthesia and Pain Medicine guidance on the dose of lipid emulsion in the management of LAST. Reproduced with permission of the American Society of Regional Anaesthesia and Pain Medicine who own the material

Prolonged monitoring (2-6 hours) of patients who have signs of LAST should occur. This is due to the depressive effects of some local anaesthetics on the cardiovascular system which may reoccur [3].

All episodes of LAST should be reported to the lipid rescue website: www.lipidrescue.org

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Anaphylaxis

68

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Anaphylaxis is a rare, life threatening, IgE mediated hypersensitivity reaction. It occurs when an allergen binds to IgE on mast cells leading to the release of histamine and serotonin. This leads to a systemic reaction which is characterised by:

- Airway and or breathing compromise
- Facial swelling, airway oedema, stridor, bronchospasm
- Cardiovascular compromise
- Tachycardia, hypotension, shock, cardiac arrest
- Skin and mucus changes
- Erythema, urticarial, angioedema

The UK Royal College of Anaesthetists' 6th National Audit Project (NAP6) focused on perioperative anaphylaxis. NAP6 uses the following classification table when discussing anaphylaxis [1].

Grade	Features
1. Not life threatening	Rash, erythema and or swelling
2. Not life threatening	Unexpected hypotension- not severe e.g. not requiring treatment and/or bronchospasm- not severe e.g. not requiring treatment ± Grade 1 features
3. Life threatening	Unexpected severe hypotension And/or severe bronchospasm And/or swelling with actual or potential airway compromise ± Grade 1 features

(continued)

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(continued)

Grade	Features
4. Life threatening	Fulfilling indications for CPR
5. Fatal	Fatal

CPR = cardiopulmonary resuscitation

Presentation of anaphylaxis occurs rapidly within minutes of exposure to the allergen in the majority of cases [1] and may cause significant fetal compromise in a pregnant woman. Interestingly NAP6 found that skins signs were rare in the severe forms of anaphylaxis, in some cases only occurring after resuscitation. [1].

The most common triggers according to the NAP6 national audit are antibiotics, muscle relaxants, chlorhexidine (commonly used for skin antisepsis) and patent blue dye (used for marking lymphatic vessels, arteries and most commonly sentinel lymph nodes when combined with a radiotracer) [1]. The drugs with the highest incidence of anaphylaxis per 100,000 administrations are 1. teicoplanin, 2. patent blue dye, 3. suxamethonium, 4. co-amoxiclav (amoxicillin and clavulanic acid) [1]. However in the obstetric population NAP6 did not identify any cases of anaphylaxis due to antibiotics but did identify anaphylaxis due to neuromuscular blockers (suxamethonium and atracurium) and chlorhexidine [1].

NAP6 reports an incidence of severe perioperative anaphylaxis of 3.4 per 100,000 anaesthetics, in the obstetric population, which is lower than in non-obstetric patients (9.92 per 100,000) undergoing anaesthesia. There were eight cases of severe perioperative anaphylaxis in the year of data collection, each being grade 3 anaphylaxis, six of these patients had neuraxial anaesthesia and two had general anaesthesia. In each case both maternal and neonatal outcomes were good.

Management of Anaphylaxis

(see Fig. 68.1).

- The patient should be managed using an ABCDE, (airway, breathing, circulation, disability and exposure) approach.
- Call for help.
- Remove any obvious trigger for the anaphylaxis (e.g. stop antibiotic administration).
- Manage the patient in an appropriate position—sitting upright if there are obvious airway and breathing issues, lie flat and elevate legs if cardiovascular collapse is the predominant problem.
- Administer high flow oxygen initially—this can be titrated as appropriate later.
- Apply monitoring- three lead ECG, pulse oximeter and non-invasive blood pressure (NIBP) monitoring.

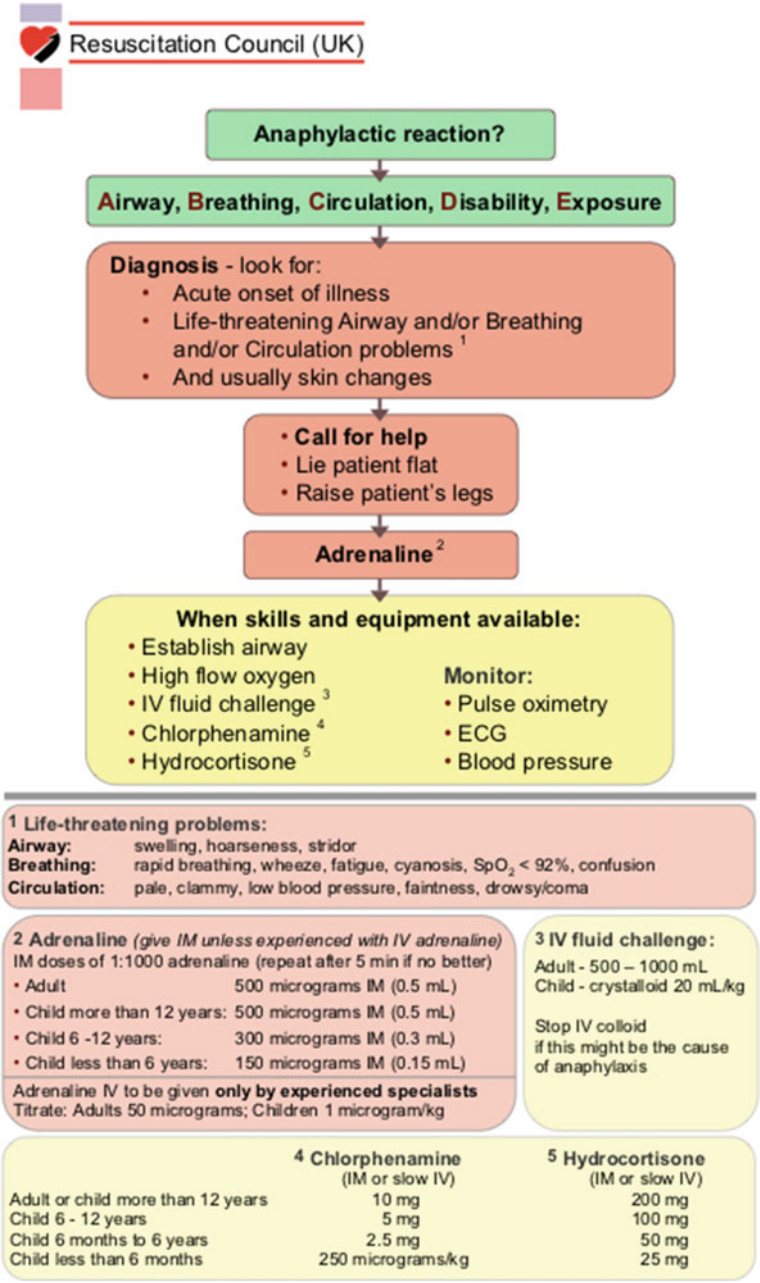

Fig. 68.1 Anaphylaxis treatment algorithm. Reproduced with kind permission of the Resuscitation Council UK

- Epinephrine should be administered as soon as possible. Concerns over the detrimental effects of epinephrine on the fetus via uteroplacental vasoconstriction, are not substantiated. The maintenance of maternal blood pressure is the absolute priority and will improve fetal well-being.
- Intravenous (IV) epinephrine should only be administered by those who are familiar with its use. Doses of **50 mcg IV** should be administered according to response **(0.5 ml of 1:10,000 = 50 mcg**).
- Some patients may require infusions of epinephrine.
- **500 mcg IM** epinephrine every 5 min should be administered until improvement is seen **(0.5 ml of 1:1000 epinephrine = 500mcg)** if the clinician is not familiar with the IV route.
- Large volumes of intravenous fluids may be required. Fluid challenges of 500-1000 ml are likely to be required. Crystalloids should be used.
- Second line treatment involves antihistamines and steroids.
- chlorphenamine 10 mg IV/IM
- hydrocortisone 200 mg IV/IM.
- Early intubation should be considered in patients with signs of airway swelling (hoarse voice, swollen tongue/lips, oropharyngeal swelling).

Investigation of Anaphylaxis

Mast cell tryptase levels should be taken immediately, at 2 hours from the onset of symptoms and 24 hours [2] (a potassium ethylenediaminetetraacetic acid (EDTA) or Serum Separator Tube is usually required). Patients should be referred to an immunologist where appropriate for further testing and advice. It is useful for an immunologist to test a variety of drugs within the class of drug suspected to have caused anaphylaxis. For example, if atracurium is thought to have caused anaphylaxis, then testing for sensitivity to rocuronium, vecuronium and suxamethonium, may provide safe alternatives of neuromuscular blocking drugs to be used in the future. It is not recommended that pregnant women undergo allergy testing due to potential harm to the fetus. This should be delayed until post-delivery, however in the non-pregnant patient, the ideal time for skin testing is at 6 weeks post initial exposure.

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Malignant Hyperthermia

69

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Malignant hyperthermia (MH) is a rare genetic disorder of abnormal skeletal muscle metabolism. It is triggered by exposure to the muscle relaxant suxamethonium and volatile anaesthetic agents. It has autosomal dominant inheritance and is caused by abnormal calcium ion homeostasis during the excitation-contraction coupling process of skeletal muscle. The majority of cases are caused by mutations of the ryanodine receptor, which is an intracellular calcium ion channel. The incidence of MH is between 1:10,000–1 in 220,000 anaesthetic procedures [1, 2] With the use of intra-operative monitoring and treatment with the calcium channel antagonist, dantrolene, mortality rates have fallen dramatically to less than 5% [3]. Prior to the use of dantrolene mortality rates were much higher at 70–80% [3].

For any patient where there is concern regarding MH susceptibility a history should be taken to establish any previous reactions, family history of adverse events under anaesthesia and results of any testing performed.

MH susceptible patients include [4]:

- Patients with a family history of malignant hyperthermia
- Previous adverse reaction to general anaesthesia when a trigger agent has been used (see the list of presenting signs of MH below)
- Rhabdomyolysis after general anaesthesia (when other myopathies have been excluded)
- Exertional rhabdomyolysis/ recurrent rhabdomyolysis or persistently raised creatine kinase level of unknown cause
- Exertional heat stroke, with no other precipitating factors, that has led to hospitalisation

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- Myopathy and proven pathogenic mutations of the RYR1 gene (ryanodine receptor expressed in skeletal muscle).
- Family history of unexplained death after general anaesthesia

National MH Diagnostic Centres can be contacted directly for information and will hold results of all patients tested within the country. Every pregnant patient with MH should be referred to a high-risk obstetric anaesthesia clinic to ensure that a multidisciplinary plan is devised regarding the safe conduct of anaesthesia if required during labour and delivery. The obstetric anaesthetist for the delivery area should be notified when any parturient with known or suspected family history of MH arrives. During emergency situations, when details may not be available, the patient should be managed as being MH susceptible.

MH Susceptibility in Pregnancy

Pregnancy poses two situations if there is a concern over MH susceptibility:

- If the mother is MH susceptible, the fetus may be MH susceptible
- If the father is MH susceptible, but the mother is not, the fetus may be MH susceptible.

MH Safe Anaesthesia

The European Malignant Hyperthermia Group (EMHG) has issued guidance on the management of anaesthesia in pregnant patients susceptible to MH. They recommend neuraxial anaesthesia as the preferred technique for caesarean delivery when the mother or fetus are MH susceptible [6]. If neuraxial anaesthesia is contraindicated then an MH safe general anaesthetic can be performed. This involves:

- The avoidance of suxamethonium and volatile agents,
- A total intravenous anaesthesia (TIVA) technique with propofol (and opioids) is required if neuraxial anaesthesia is contra-indicated.
- TIVA can be performed safely in parturients undergoing obstetric and non-obstetric surgery [5].
- The EMHG recommend that rocuronium at a dose of 1 mg/kg (ideal body weight) should be used to facilitate tracheal intubation, with sugammadex 16 mg/kg available.

If only the father is MH susceptible, trigger agents for MH, which can cross the placenta should be avoided until delivery. Suxamethonium is a highly charged molecule, which is unlikely to cross the placenta to any significant degree and can

theoretically be used. However, the EMHG have not been able to reach a consensus on the use of suxamethonium in this situation due to the lack of knowledge about how much suxamethonium crosses the placenta and the fact that there are safer alternatives to suxamethonium.

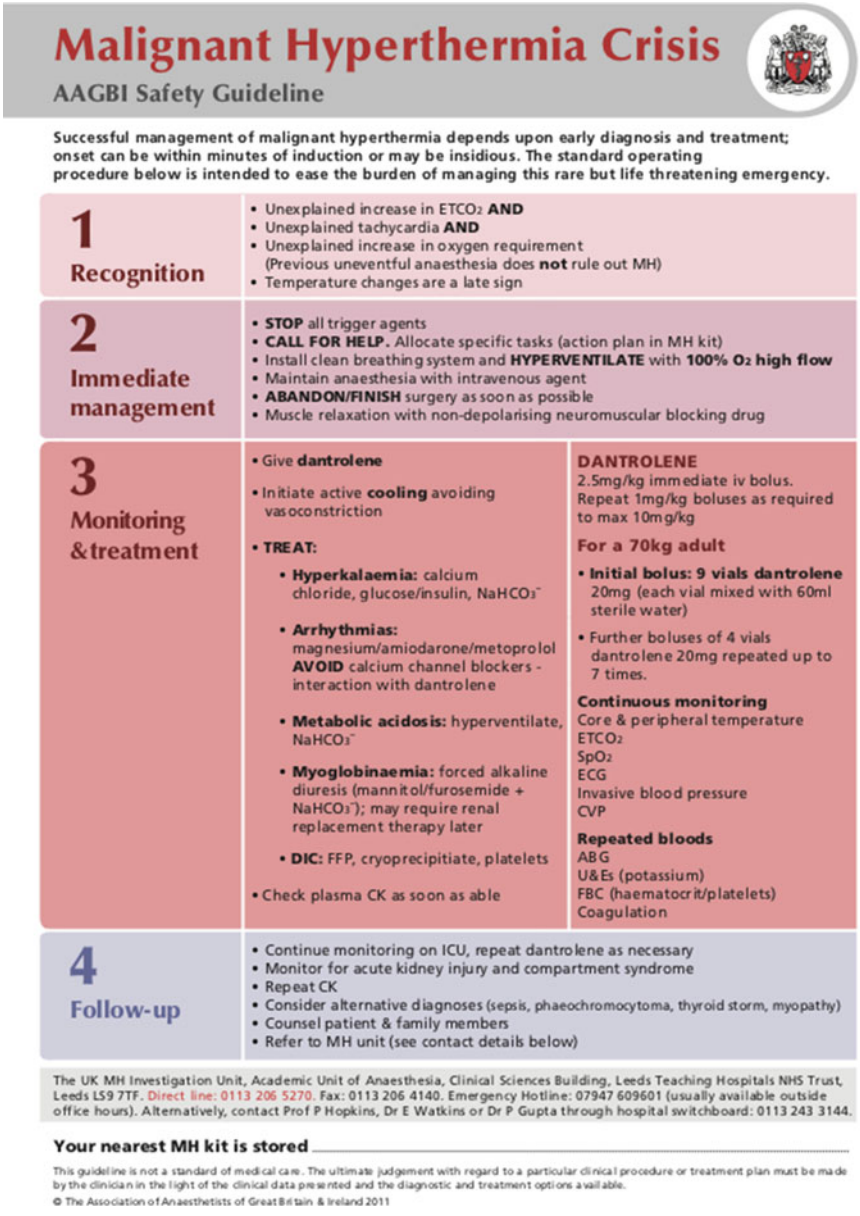
Presentation of MH

Clinical signs:

- Masseter spasm
- Raised end tidal carbon dioxide (CO_2)
- Oxygen de-saturation
- Tachycardia
- Cardiovascular instability and dysrhythymias
- Generalised rigidity
- Pyrexia

Management of MH

- The management of MH should involve an airway, breathing, circulation approach.
- All volatile agents should be stopped, and maintenance of anaesthesia provided with propofol ± opioid.
- High flow (100%) oxygen should be administered to flush the anaesthetic machine of trigger agents, during which time either a volatile agent free machine can be obtained or activated charcoal filters can be connected to the inspiratory and expiratory limbs of the breathing circuit. Activated charcoal filters work by a process called adsorption and filter out volatile anaesthetic agents.
- An emergency should be declared to alert all members of the theatre team of the situation. Surgery should be terminated as soon as possible.
- Dantrolene should be obtained and administered
- Active cooling should be initiated. This can be performed using cold fluids administered intravenously or by body cavity irrigation (e.g. bladder). External cooling can be performed with wet sheets, ice packs (usually placed in the axilla or groin) or devices used more commonly in targeted temperature management after cardiac arrests such as the Artic Sun® 5000.
- The Association of Anaesthetists guidelines for the management of MH (Fig. 69.1) should be readily available in every theatre area. they are particularly helpful in prompting early recognition and treatment of the metabolic and physiological derangements that occur with MH.



Malignant Hyperthermia Crisis

AAGBI Safety Guideline

Successful management of malignant hyperthermia depends upon early diagnosis and treatment; onset can be within minutes of induction or may be insidious. The standard operating procedure below is intended to ease the burden of managing this rare but life threatening emergency.

1 Recognition

- Unexplained increase in $ETCO_2$ **AND**
- Unexplained tachycardia **AND**
- Unexplained increase in oxygen requirement (Previous uneventful anaesthesia does **not** rule out MH)
- Temperature changes are a late sign

2 Immediate management

- **STOP** all trigger agents
- **CALL FOR HELP.** Allocate specific tasks (action plan in MH kit)
- Install clean breathing system and **HYPERVENTILATE** with **100% O_2 high flow**
- Maintain anaesthesia with intravenous agent
- **ABANDON/FINISH** surgery as soon as possible
- Muscle relaxation with non-depolarising neuromuscular blocking drug

3 Monitoring & treatment

- Give **dantrolene**
- Initiate active **cooling** avoiding vasoconstriction
- **TREAT:**
  - **Hyperkalaemia:** calcium chloride, glucose/insulin, $NaHCO_3^-$
  - **Arrhythmias:** magnesium/amiodarone/metoprolol **AVOID** calcium channel blockers - interaction with dantrolene
  - **Metabolic acidosis:** hyperventilate, $NaHCO_3^-$
  - **Myoglobinaemia:** forced alkaline diuresis (mannitol/furosemide + $NaHCO_3^-$); may require renal replacement therapy later
  - **DIC:** FFP, cryoprecipitiate, platelets
- Check plasma CK as soon as able

DANTROLENE
2.5mg/kg immediate iv bolus.
Repeat 1mg/kg boluses as required to max 10mg/kg

For a 70kg adult

- **Initial bolus: 9 vials dantrolene** 20mg (each vial mixed with 60ml sterile water)
- Further boluses of 4 vials dantrolene 20mg repeated up to 7 times.

Continuous monitoring
Core & peripheral temperature
$ETCO_2$
SpO_2
ECG
Invasive blood pressure
CVP

Repeated bloods
ABG
U&Es (potassium)
FBC (haematocrit/platelets)
Coagulation

4 Follow-up

- Continue monitoring on ICU, repeat dantrolene as necessary
- Monitor for acute kidney injury and compartment syndrome
- Repeat CK
- Consider alternative diagnoses (sepsis, phaeochromocytoma, thyroid storm, myopathy)
- Counsel patient & family members
- Refer to MH unit (see contact details below)

The UK MH Investigation Unit, Academic Unit of Anaesthesia, Clinical Sciences Building, Leeds Teaching Hospitals NHS Trust, Leeds LS9 7TF. Direct line: 0113 206 5270. Fax: 0113 206 4140. Emergency Hotline: 07947 609601 (usually available outside office hours). Alternatively, contact Prof P Hopkins, Dr E Watkins or Dr P Gupta through hospital switchboard: 0113 243 3144.

Your nearest MH kit is stored

This guideline is not a standard of medical care. The ultimate judgement with regard to a particular clinical procedure or treatment plan must be made by the clinician in the light of the clinical data presented and the diagnostic and treatment options available.

Fig. 69.1 Malignant hyperthermia treatment plan. Reproduced with kind permission of the Association of Anaesthetists (UK)

These include:

- hyperkalaemia
- cardiac arrhythmias
- metabolic acidosis
- myoglobinaemia
- DIC (disseminated intravascular coagulation)
- All patients suspected of having MH after an adverse reaction to anaesthetic agents should be referred to the national MH Diagnostic Centre.

Diagnosis

Diagnosis is confirmed by:

In vitro muscle contracture tests (IVCT)

IVCT has the highest sensitivity for detecting MH susceptibility. It involves pharmacological challenging freshly excised skeletal muscle using caffeine and halothane. During the IVCT, electrical stimulation initially confirms tissue viability, after which separate muscle biopsies are exposed to either caffeine or halothane in increasing amounts. The diagnostic end point is the development of a contracture.

Or

Molecular genetics

These test for mutations on the RYR1 gene. The tests are carried out either as a screening test (if a family member has been proven to have a mutation) or as a diagnostic test. Tests involve either targeted analysis of a known MH mutation or screening of entire coding regions within the RYR1 gene.

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Maternal Resuscitation

70

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The maternal mortality rate in the developed world varies from 3.8 (Finland) to 26.4 (USA) per 100,000 live births [1]. The 2016–2018 MBRRACE-UK (Mothers and Babies: Reducing Risk through Audits and Confidential Enquires across the UK) report states the maternal mortality rate in the UK and Ireland at 9.7 per 100,000 live births [2].

Maternal death can be divided into direct and indirect causes. Direct deaths result from obstetric causes due to being pregnant, indirect deaths are not related to pregnancy (i.e. cause of death which could occur at any time). The 2016–2018 MBRRACE-UK report lists thromboembolism as the leading cause of direct maternal death with death from massive haemorrhage (and suicide) the second largest cause. Cardiac disease is the leading cause of indirect maternal death [2].

Leading causes of cardiac arrest in pregnancy differ to leading causes of death. A population based study, looking at the incidence, management and outcomes of cardiac arrest in pregnant women, found anaesthesia to be the most common cause of cardiac arrest [3]. Sixteen out of 59 cardiac arrests were directly attributable to anaesthesia and of these 13 were caused by high neuraxial block and 3 because of difficulty with intubation. All patients survived, presumably because of prompt and effective resuscitation skills initiated by anaesthetists.

Common causes of cardiac arrest in pregnancy [4]:

- cardiac disease (congenital and acquired)
- pulmonary embolism
- psychiatric disorders (suicide)
- hypertensive disorders of pregnancy
- sepsis

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- haemorrhage
- amniotic fluid embolism (AFE)
- ectopic pregnancy

The pregnant patient in cardiac arrest should be managed by the Advanced Life Support (ALS) algorithm (see Fig. 70.1). However there are several modifications that need to occur [4].

- After commencing advanced life support, an obstetrician, anaesthetist and neonatologist (if not already present) must be called to facilitate resuscitation of both the mother and the fetus.
- The standard hand position for chest compressions (middle of the lower half of the sternum) may need to be higher in a pregnant patient.
- From 20 weeks gestation there is potential for the gravid uterus to cause inferior vena caval (IVC) obstruction, this can cause a decrease in the venous return and reduced cardiac output. The implications of this are:
  - the effectiveness of chest compressions may be limited
  - IV / interosseous (IO) access should be inserted into a vein above the diaphragm (for example a vein in the antecubital fossa or IO access in the humerus).
- Manual displacement of the uterus (to the left) should be performed and is preferred over both left lateral tilting whilst on an operating table and the use of a uterine wedge. Left lateral tilt can be performed if the patient is on a rigid surface allowing effective chest compressions. A tilt of 15–30° needs to be applied.
- Preparation for peri-mortem caesarean delivery (PMCD) needs to occur rapidly as the fetus should be delivered with 5 min of the cardiac arrest (if initial attempts at resuscitation fail). At less than 20 weeks gestational age, a peri-mortem caesarean delivery is not considered necessary, as the size of the gravid uterus is unlikely to cause IVC obstruction and the fetus is not viable. At 20–23 weeks gestational age, caesarean delivery should be performed in an attempt to resuscitate the mother (reducing IVC obstruction from the fetus), the fetus is very unlikely to survive at this gestational age. At >24 weeks gestational age, caesarean delivery is performed in an attempt to resuscitate both the mother and the fetus.
- Since pregnant women are at high risk of pulmonary aspiration, early tracheal intubation should be performed. This is potentially more difficult in a pregnant patient (see Chap. 64).

Specific reversible causes of cardiac arrest in pregnancy should be evaluated and treatedõ during the resuscitation attempt. These include [4]:

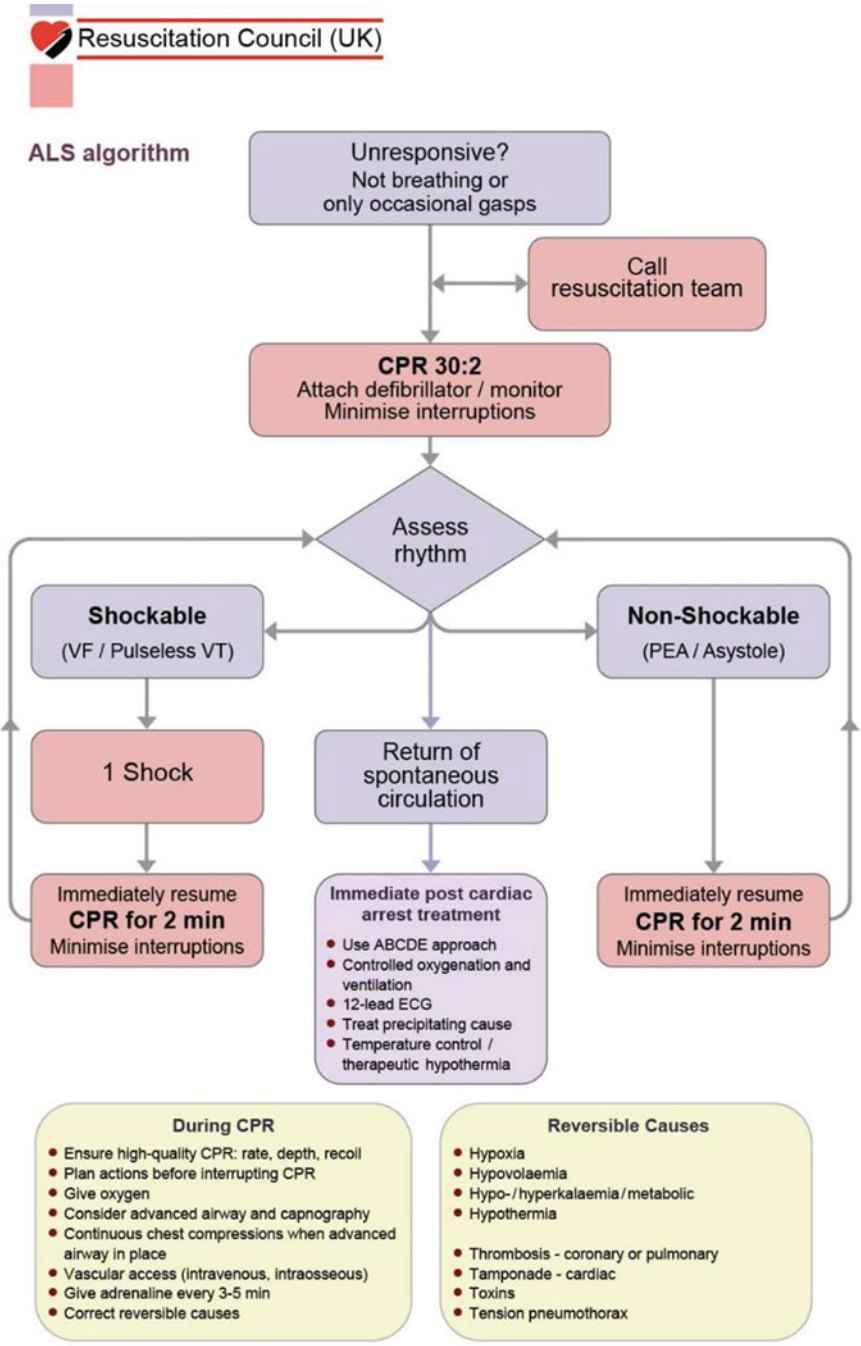

Fig. 70.1 Adult life support algorithm for patients in cardiac arrest. Reproduced with the kind permission of the Resuscitation Council UK

- Haemorrhage
  - This may be antepartum or postpartum. A massive obstetric haemorrhage protocol should be initiated, and attempts made to stop bleeding.
- Drugs
  - Women on magnesium infusions to treat eclampsia, who become oliguric, are at risk of magnesium toxicity and subsequent respiratory depression and hypoxia. Calcium chloride 10%, 10 ml IV is used to treat a magnesium overdose.
- Cardiovascular disease
  - Acquired cardiovascular disease during pregnancy includes peripartum cardiomyopathy, aortic aneurysms and dissection. Acute coronary syndrome may present with atypical features (vomiting and epigastric pain). Percutaneous coronary intervention is the first line management choice.
- Amniotic Fluid Embolism (AFE)
  - This can present with sudden cardiovascular collapse and rapid progression to disseminated intravascular coagulopathy (DIC) at the time of delivery (see Chap. 24). Treatment is supportive.
- Pulmonary embolism (PE)
  - This is a leading cause of cardiac arrest in pregnancy. The decision to administer thrombolytic therapy needs careful consideration, especially if a peri-mortem caesarean delivery is being performed. If despite all efforts, return of spontaneous circulation does not occur and pulmonary embolism is a likely cause of the cardiac arrest, thrombolytic therapy should be administered.

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Intrauterine Resuscitation

71

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Fetal distress represents progressive fetal hypoxia, anaerobic metabolism and resultant acidaemia. Intrauterine resuscitation (IUR) involves measures to improve oxygen delivery to the placenta and subsequent transfer to the distressed fetus in an attempt to reverse hypoxia and normalise the fetal pH. These interventions may improve the fetal condition and allow for normal delivery or improve fetal well-being before an emergency operative delivery, giving time for an epidural top-up or spinal anaesthetic to become effective, thereby avoiding the need for general anaesthesia.

Identification of Fetal Distress

The fetal heart rate (FHR) is assessed through continuous cardiotocography (CTG) and the recording is categorised as either normal, suspicious, or pathological. Typically, late decelerations, atypical variable decelerations and prolonged bradycardia suggest likely fetal hypoxia and compromise. A full explanation of CTG monitoring can be found in the chapter on the CTG (See Chap. 28).

Fetal scalp blood sampling may also be carried out to measure both fetal pH and lactate levels. A fetal pH < 7.2 or a lactate > 4.9 mmol/L are considered abnormal and usually require IUR followed by expedited delivery.

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Table 71.1 Mechanisms of fetal hypoxia

Maternal	Hypoxia, hypotension from any cause (including aortocaval compression and neuraxial anaesthesia), cardiac disease, anaemia, metabolic acidosis
Uterine	Hyperstimulation or uterine rupture
Placental	Premature separation, abruption, vascular degeneration or infarction
Cord	Cord prolapse, nuchal cord[a], cord knotting
Fetal	Infection, malformation, anaemia, haemorrhage

[a]When the umbilical cord becomes wrapped around the neck of the fetus

Mechanisms of Fetal Hypoxia

Fetal hypoxia can be caused by several factors, as outlined in Table 71.1. The underlying cause should be actively sought, as each cause often requires specific treatment.

Aortocaval Compression

Aortocaval compression (ACC) is usually asymptomatic due to sympathetic compensation such as peripheral vasoconstriction which promotes the development of collaterals for venous return. However, 10% of parturients may be unable to compensate and suffer from the 'supine hypotension syndrome' [1]. Neuraxial anaesthesia may disrupt this normal compensation leading to profound hypotension.

Recent research using magnetic resonance imaging (MRI) has shown that the aorta is not commonly compressed in supine term parturients, however the IVC is significantly compressed compared to non-pregnant controls and 15% of lateral tilt was ineffective in restoring the IVC volume [2]. This has challenged the dogma that 15 degrees of left uterine tilt is adequate to relieve IVC compression, as results have shown that 30 degrees or more is in fact necessary. A recent randomised clinical trial revealed that the use of 15 degrees lateral tilt in healthy parturients undergoing elective caesarean delivery under spinal anaesthesia did not alter neonatal acid base status if blood pressure was maintained with an adequate fluid co-load and a prophylactic vasopressor infusion [3].

In summary, left lateral tilt does not seem to be necessary in the majority of women undergoing elective caesarean delivery if there is careful attention to the maternal blood pressure during neuraxial anaesthesia [4]. However, this evidence is not generalisable during maternal hypotension or fetal distress. **During IUR the mother should be placed in the full lateral position** to maximise blood pressure and uteroplacental blood flow [4]. This position should be used during IUR to either

pre-oxygenate a parturient for general anaesthetic, or administer neuraxial anaesthesia for operative delivery.

Techniques for Intrauterine Resuscitation

The type and the technique for IUR is dependent on the mechanism of fetal hypoxia and cause of fetal distress. The cause should be sought and treated appropriately. Amnioinfusion (the instillation of isotonic fluid into the amniotic cavity to thin meconium or relieve cord compression) should not be offered due to the underdetermined benefit and risk of serious complications [6].

Table 71.2 describes management techniques to facilitate IUR.

Table 71.2 Techniques for intrauterine resuscitation

Intervention	Comment
Call for help	Ensure **senior anaesthetic and obstetric help** is present
Position	**Full left lateral position** in an attempt to relieve aortocaval compression. If there is no improvement in the FHR, attempt other positions such as right lateral or knee-chest position
Tocolysis	**Stop oxytocin** or remove prostaglandin intravaginal pessaries immediately **Active tocolysis is often recommended** to decrease uterine contraction frequency and general uterine tone **Terbutaline 250 mcg by subcutaneous injection** is the recommended drug of choice. Note that beta stimulants may result in maternal and fetal tachycardia. They may also result in poor uterine tone after caesarean delivery, which should be actively managed using uterotonics **Glyceryl trinitrate (GTN)** is an alternative, which is given at a dose of 800 mcg (2 metered puffs) by sublingual spray (unlicensed use). This can be repeated every minute to a maximum of 3 doses. Monitor blood pressure closely and avoid GTN if the patient is hypotensive
Intravenous Fluids	Rapid administration of **1000 mL of a balanced crystalloid solution** [5] If the patient is fluid restricted or fluid overloaded, has cardiac disease or pre-eclampsia, more judicious 250 mL fluid boluses are recommended
Treat hypotension	Treat hypotension with an intravenous vasopressor such as phenylephrine 50 mcg or ephedrine 3–6 mg IV boluses titrated to BP to maintain uteroplacental flow while awaiting intravenous fluid volume expansion
Exclude an acute event	Placental abruption, cord prolapse, sepsis and haemorrhage should be excluded and/or treated accordingly
Oxygen	Maternal oxygen administration is **not routinely recommended** for IUR because of its unproven benefit and possible risk of hyperoxia to the fetus. Maternal oxygen is therefore **only advised if it is for maternal indications** such as maternal hypoxia or as part as preoxygenation before general anaesthesia [6]

GTN = glyceryl trinitrate; BP = blood pressure

Transfer to the Operating Theatre and Emergency Caesarean Delivery

- It is critically important that nothing delays the parturient's transfer to the operating theatre if a decision for emergency caesarean delivery has been made by the obstetric team.
- Continue IUR during transfer and initiation of anaesthesia.
- Electronic fetal monitoring using CTG should be restarted in theatre and be kept on for as long as possible before caesarean delivery [4].
- The fetal condition and labour progression should rapidly be reassessed on arrival to the operating theatre, as these findings will determine the most appropriate method of anaesthesia and delivery depending on each particular situation.

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Neonatal Resuscitation

72

Sioned Phillips

After delivery all babies require immediate assessment. The majority of neonates establish normal respiration and circulation without any intervention. In healthy babies the first breath is usually taken within the first 60–90s. This will lead to successful transition from the fetal state of respiratory exchange via the placenta, to that of a neonate with respiratory exchange via the lungs.

Assessment of the newborn involves immediate drying and wrapping of the baby whilst making a simultaneous assessment of:

- Breathing—regular, gasps, none
- Heart rate—fast, very slow or absent
- Tone—good, reduced, floppy

If resuscitation is required it is likely to be successful in the majority of newborns [1]. The sequence of events to resuscitate a neonate is as follows and summarized in Fig. 72.1:

Dry and Cover the Baby

Babies must be dried and kept warm. Wet towels must be disposed of.

Assess the need for any intervention

- Is the baby breathing? If there is no regular breathing or only gasps present after drying and stimulation intervention is required.

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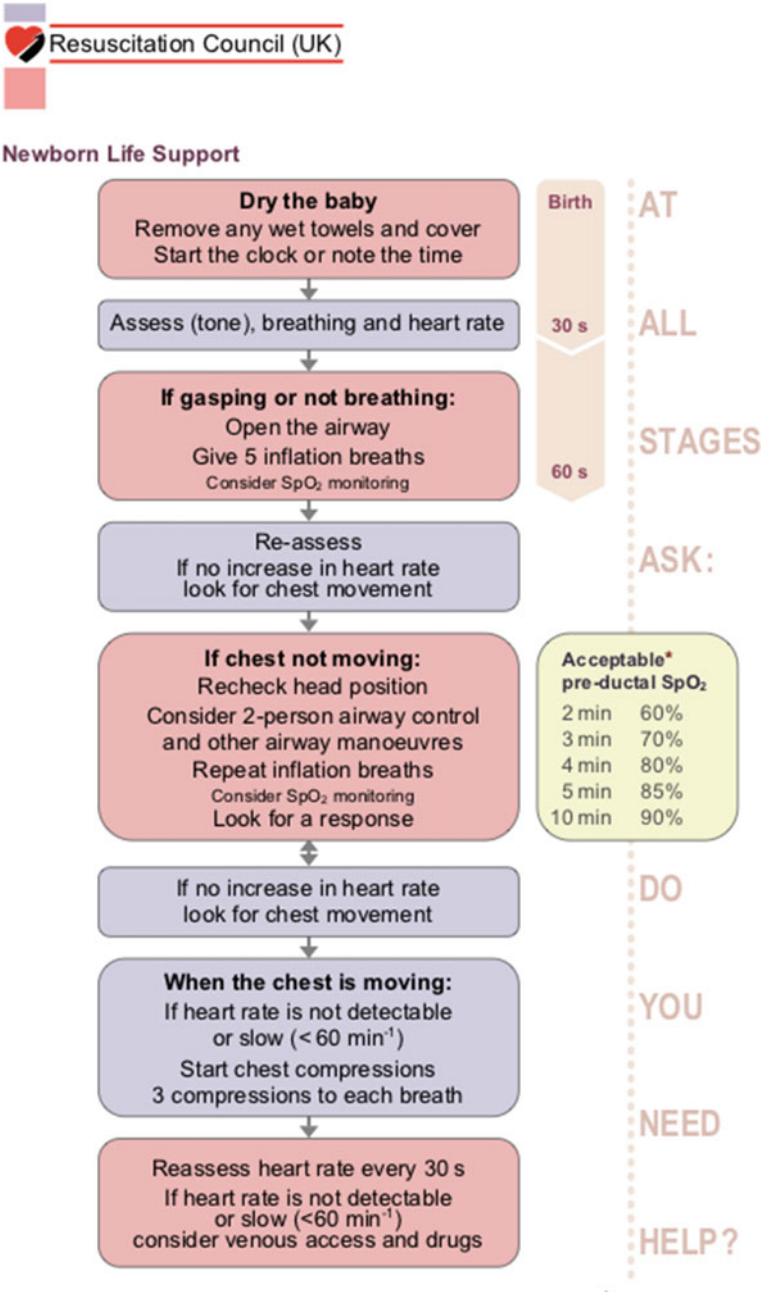

Fig. 72.1 Newborn life support algorithm. Reproduced with the kind permission of the Resuscitation Council UK

- What is the heart rate? This is best assessed using a stethoscope. A normal neonatal heat rate is 120–150 beats min-^{1}.

Call for Help if Required

Open the Airway

- The baby should be positioned with the head in the neutral position. A folded towel may be placed under the shoulders to help maintain this position (avoid over extension of the neck), see Fig. 72.2.
- A jaw thrust may also be required to open the airway.

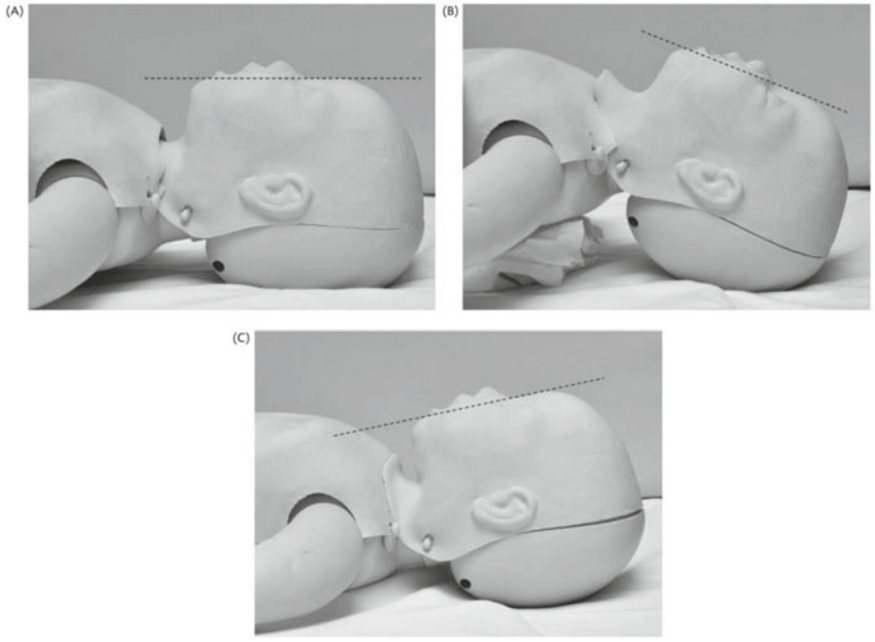

Fig. 72.2 Position (A) shows the neutral position, position (B) is over extended and (C) hyperflexed and potentially causing airway obstruction. Images reproduced from Oxford Textbook of Obstetric Anaesthesia, V Clark, M Van de Velde, R Fernando, Editors. Oxford Press. Reproduced with permission of the licensor through PLSClear

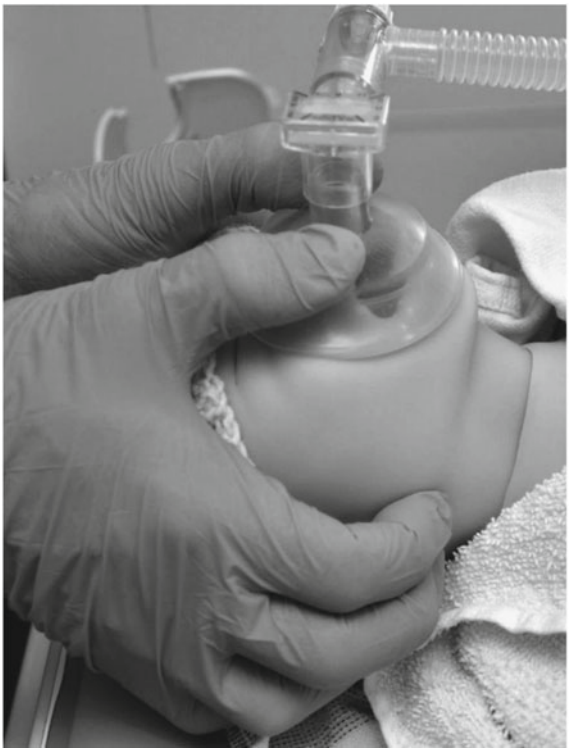

Fig. 72.3 Correct size and position of facemask, with jaw thrust being performed to open and maintain the airway. Images reproduced from Oxford Textbook of Obstetric Anaesthesia, V Clark, M Van de Velde, R Fernando, Editors. Oxford Press. Reproduced with permission of the licensor through PLSClear

Inflate the Lungs

- If the baby is not breathing or only gasps are present, 5 inflation breaths should be administered.
- The aim is to aerate the lungs, displacing lung fluid with air.
- Air rather than oxygen should be used initially.
- An appropriately sized mask with a pressure-limiting device set at 30 cmH_2O (or a self-inflating 500 ml bag with a pressure relief valve set at 30 cmH_2O) should be used (Fig. 72.3).
- Each breath should last for 2–3 seconds and chest movement should be assessed.
- Adequate chest wall movement may not be seen for the first few breaths as fluid is being replaced by air.
- At the end of the 5 inflation breaths the baby should be reassessed with regard to breathing, heart rate and tone.
- If there is no improvement and adequate chest wall expansion has not been seen, the 5 inflation breaths may need to be repeated.

- If the lungs have not been aerated, check that the head is still in the neutral position, consider jaw thrust ± an oropharyngeal airway and consider if there is obstruction either at the oropharynx or within the trachea.
- If the heart rate increases this indicates that the lungs have been aerated.

If the baby is still apnoeic despite adequate chest wall movement after inflation breaths then ventilation breaths must be administered. These are given at a rate of 30–40 per min. Re-assessment must occur every 30 seconds.

Chest Compressions

- Chest compressions should only be started once the lungs have successfully been aerated (Fig. 72.4). Inflation breaths must be continued until chest expansion has been seen.
- If the heart rate remains slow at less than 60 min^{-1} or absent after successful inflation breaths, chest compressions must be started.
- Both hands should encircle the chest wall with the thumbs over the lower third of the sternum.

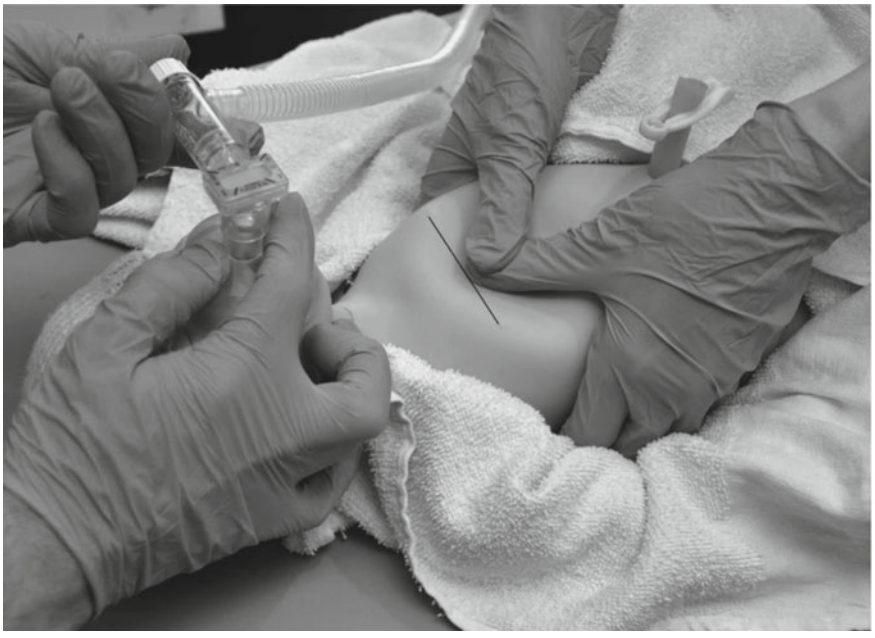

Fig. 72.4 Two-person CPR technique. The person performing chest compressions encircles the chest wall and places both thumbs over the lower third of the sternum. Images reproduced from Oxford Textbook of Obstetric Anaesthesia, V Clark, M Van de Velde, R Fernando, Editors. Oxford Press. Reproduced with permission of the licensor through PLSClear

- The chest should be compressed to a third of its antero-posterior diameter and full chest wall recoil allowed to occur.

The ratio of chest compressions to inflation breaths is 3:1
Drugs (rarely used)

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- The use of drugs for resuscitating neonates is rare and would be guided by a neonatologist. These may include adrenaline, sodium bicarbonate and 10% dextrose.
- The dose of epinephrine in neonatal resuscitation is 10 mcg/kg (0.1 ml/kg of a 1:10,000 epinephrine solution)

Monitoring

Pulse oximetry

- Pulse oximetry should be placed during resuscitation. The probe needs to be placed on the right hand or wrist in order to obtain pre-ductal saturations.
- Pre (and post) ductal oxygen saturations refer to the arterial oxygen saturations in blood vessels leaving the aortic arch pre (before) and post (after) the ductus arteriosus.
- The ductus arteriosus is a connection between the aorta and pulmonary artery that in utero allows blood to flow between the right and left side of the heart largely bypassing the fetal lungs which are not yet functional. Once born the duct will begin to close.
- If the duct does not close, there will be a right to left shunt and a discrepancy in the pre and post ductal oxygen saturations.
- Pre ductal oxygen saturations will increase as the neonate starts to breathe and the lungs aerate. Acceptable pre ductal oxygen saturations from the age of 2 min up to 10 min are shown in Fig. 72.1.
- Pulse oximetry provides a continuous heart rate, which is useful during resuscitation as the use of a stethoscope may not be as accurate.
- Pulse oximetry should be continued after a resuscitation attempt and may guide oxygen therapy.

ECG

- ECG monitoring will provide a continuous heart rate, and if available should be used during resuscitation (and post resuscitation care).

Post Resuscitation Care

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- Glucose levels should be monitored for any preterm neonate or infant who has undergone extensive resuscitation. Normoglycemia should be maintained.
- Therapeutic hypothermia should be considered for near term and term neonates who have signs of evolving moderate to severe hypoxic ischemic encephalopathy (HIE).

Apgar Score

The Apgar score was produced to provide a rapid assessment of the neonate at 1 min and help guide any required breathing support. It is now commonly used at 1 min, 5 and 10 min to document the clinical status of the newborn. The Apgar score is made up of 5 components, with each component being scored from 0 to 2;

	0 points	1 points	2 points
Muscle tone	Absent	Flexed arms/legs	Active
Heart rate	Absent	<100 bpm	>100 bpm
Reflexes	Floppy	Minimal response to stimulation	Prompt response to stimulation
Colour	Blue/pale	Pink body, blue extremities	Pink
Respiration	Absent	Slow and irregular	Good cry

The Apgar score is used as a standardised approach to document the (subjective) physiological state of the newborn and cannot be used as a predictor of neurological outcome or mortality.

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Anesthetic Management of Pregnant Patients with Novel Coronavirus

73

Maria Sheikh, Gillian Abir, and Pervez Sultan

Background

Coronavirus disease 2019 (COVID-19), caused by novel coronavirus (named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)) presents unique challenges to obstetric healthcare workers, in particular to anesthesiologists. The main source of transmission is through respiratory droplets produced when an infected person coughs or sneezes. Spread is more likely when people are in close contact (within approximately 2 m). It may also be possible that a person can become infected with SARS-CoV-2 by touching a contaminated surface or object and then touching their mouth, nose, or eyes although this constitutes a low risk of transmission.

Clinical Presentation

Symptoms may overlap with common symptoms associated with pregnancy such as nasal congestion, headache, nausea and vomiting, or patients may be asymptomatic [1]. Therefore, COVID-19 should be a differential diagnosis for all women presenting to delivery units. Clinical manifestations of COVID-19 are summarized in Table 73.1. Chest radiographic findings in patients with COVID-19 can show

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Table 73.1 Signs and symptoms of Coronavirus disease 2019 [12, 13]

Fever	Nausea
Fatigue	Vomiting
Cough	Headache
Myalgia	Chest pain
Shortness of breath	Anosmia (loss of smell) or ageusia (loss of taste)
Sore throat	Lymphocytopenia
Diarrhea	Elevated LDH

LDH = lactate dehydrogenase

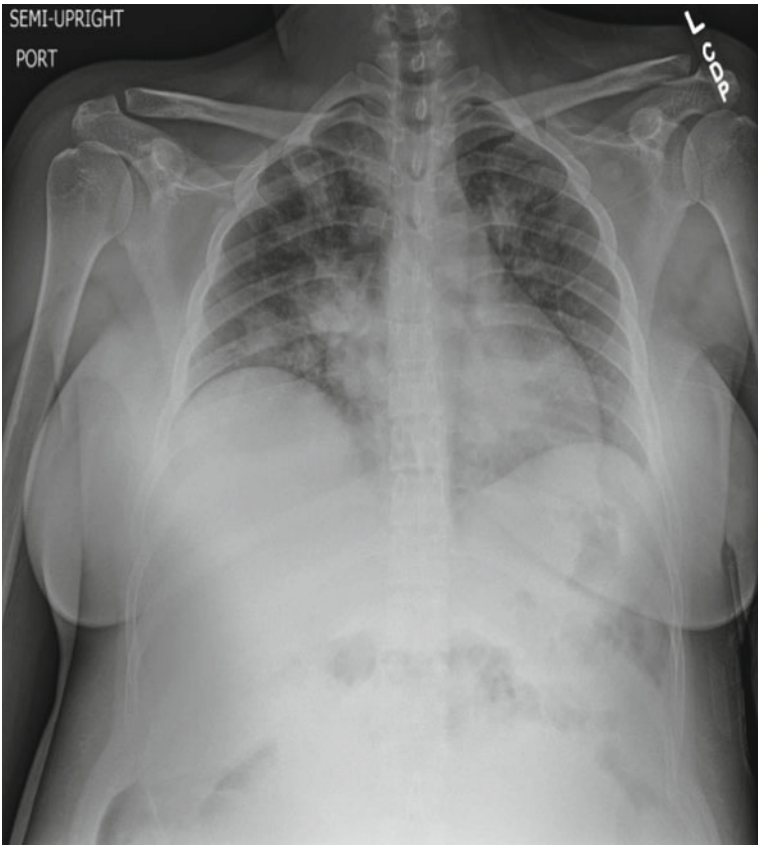

Fig. 73.1 Chest radiograph (CXR) of a pregnant patient with Coronavirus disease 2019. Bilateral patchy lung consolidation on Day 10 following the onset of symptoms can be seen on the CXR. Image used after obtaining written informed consent from the patient

patchy, bilateral infiltrates (Fig. 73.1). Up to 13% of women infected with SARS-CoV-2 may be asymptomatic and may not display any signs or symptoms until labor or in the postpartum period, increasing the risk of exposure to healthcare workers and family members [2].

Testing

The proportion of women tested on delivery units will vary depending on institutional policies (e.g. universal vs. non-universal testing). Testing can be performed with a nasopharyngeal (NP) swab using reverse-transcriptase polymerase chain reaction (RT-PCR) of SARS-CoV-2 RNA, with results reported within a few hours (laboratory dependent). Accuracy of the RT-PCR test depends on the anatomical test site (e.g. NP vs. nasal mid-turbinate) and quality of the sampling technique. The sensitivity of the PCR test ranges from 71 to 98%, with a false negative rate of 2–29%, therefore a negative PCR [3] result in a person under investigation (PUI) with symptoms, and/or exposure to a person positive for SARS-CoV-2 (with or without COVID-19) should be interpreted with caution, as it can lead to false reassurance for healthcare workers caring for these patients, and it risks disease dissemination in the community.

Personal Protective Equipment (PPE)

Policies vary between institutions and countries. Figure 73.2 summarizes the guidance for appropriate PPE from the United Kingdom Obstetric Anaesthetists' Association.

(1) **RESPIRATORS:** The World Health Organization (WHO) recommends FFP2 (filtering facepieces) and N95 (Non-Oil proof) respirators for aerosol generating procedures (AGP) and these are widely used in other countries (filtering at least 94% and 95% of airborne particles, respectively). Fit testing or checking (according to the manufacturers' guidance) is necessary when a respirator is donned to ensure an adequate seal has been achieved.

(2) **SURGICAL GOWNS AND APRONS:** A **fluid repellent** long sleeve surgical gown provides sufficient protection, a **reinforced** long sleeve surgical gown is not routinely necessary. All gowns must be removed after each patient encounter in a particular location. Staff must NOT walk around the general delivery suite area wearing potentially contaminated surgical gowns, aprons or other (PPE). Long sleeved disposable fluid repellent gowns must be worn when a disposable plastic apron provides inadequate cover of staff uniform or clothes for the procedure or task being performed, and when there is a risk of splashing of body fluids such as during AGPs in higher risk areas or in operative procedures. If **non-fluid-resistant gowns** are used, a disposable plastic apron should be worn. If extensive splashing is anticipated, then use of additional fluid repellent items may be appropriate.

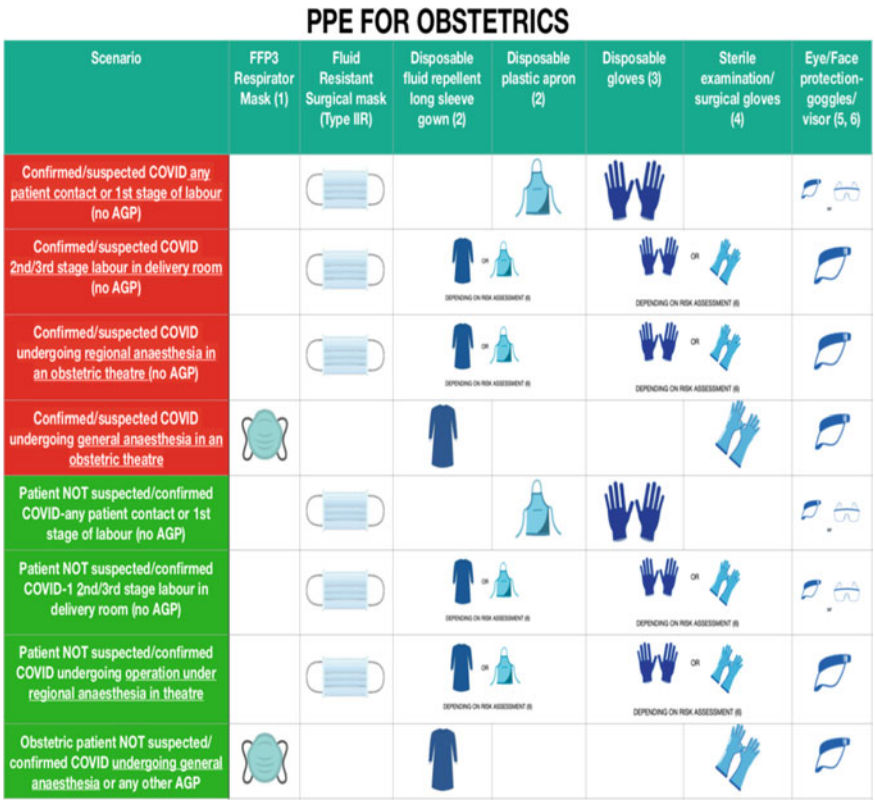

Fig. 73.2 Obstetric Anaesthetists' Association (OAA) Guidelines: PPE for Obstetrics (https://www.oaa-anaes.ac.uk/assets/_managed/cms/files/Covid-19%20Resources%20Page/Obstetric%20PPE%20-%20Hartopp%20-%20Darent%20Valley%20Hospital.pdf). Published with permission from the Obstetric Anaesthetists' Association.

(3) **DISPOSABLE GLOVES:** Sterile surgical gloves can alternatively be used depending on the individual's need to maintain sterility as part of their clinical role.

(4) **STERILE SURGICAL GLOVES:** No exposed skin should be visible between the cuff of the long-sleeved gown ending and the cuff of the gloves (normal sterile surgical gloves are adequate). Extended cuff gloves can also be worn as appropriate for the clinical task being performed e.g. manual removal of placenta.

(5) Dispose or decontaminate reusable items after each patient contact as per Standard Infection Control Precautions.

(6) **RISK ASSESSMENT** refers to utilisation of PPE when there is an anticipated/likely risk of contamination with splashes, droplets of blood or body fluids and the nature of the procedure the individual is performing. This is to be determined by the individual staff member for the care episode.

Table 73.2 Comparison of respirator masks

Respirator standard	Filter capacity (%)
FFP1 & P1	≥80
FFP2 & P2	≥94
N95	≥95
N99 & FFP3	≥99
P3	≥99.95
N100	≥99.7

(Data presented as the % of particles ≥0.3 microns in diameter which are filtered by each type of respirator/mask) FFP = filtering facepiece; P = oil proof; N = Non-oil proof

The most frequently used respirator mask in the United States is the Non-oil proof (N95) facemask, whereas in Europe healthcare workers commonly use the filtering facepiece (FFP) respirator mask. The different respirator masks are compared in Table 73.2.

The novel coronavirus is estimated to be between 60 and 140 nm (approximately 0.1 micron) in diameter. High-filtering efficiency at 0.3 microns is adequate as particles <0.3 microns exhibit Brownian motion, which makes them easier to filter.

Many hospitals have implemented a universal face masking policy for healthcare workers, patients, and visitors. When carrying out a clinical interaction <2 m from a patient positive for SARS-CoV-2 or PUI (e.g. a consultation or intravenous line placement), the same PPE precautions should be taken as when performing a neuraxial labor analgesia technique [4]. Some practitioners may choose to wear an N95 respirator instead of a surgical mask for personal indications (e.g. if they are immunocompromised, on immunosuppressant medication, have pre-existing respiratory disease or if >60 years old). For cesarean delivery (CD), a fit-tested (Fig. 73.2 legend) N95 respirator is preferred due to the risk of conversion from neuraxial anesthesia to general anesthesia (GA) involving an aerosol-generating procedure (AGP), such as mask ventilation, intubation, and extubation. If a healthcare worker is unknowingly exposed to a patient positive with SARS-CoV-2 without wearing appropriate PPE, self-isolation and monitoring for symptoms are advised, along with testing according to local institutional protocols.

General Considerations for Peripartum Patients Positive for SARS-CoV-2 (symptomatic and asymptomatic) or PUIs (patients under investigation)

- If there are multiple delivery units within a hospital system, consider designating one institution to care for patients with SARS-CoV-2 [5]
- Place PUI or positive patients in negative pressure isolation rooms [6]

- Establish a back-up team to care for patients with SARS-CoV-2 as putting on and taking off PPE, patient transport, providing anesthetic care, and performing surgery are time-intensive for the primary team
- Designate an operating room (OR) with dedicated trays and/or carts containing supplies necessary for neuraxial analgesia and GA to minimize contamination of other anesthetic equipment
- Establish early multidisciplinary team involvement to determine level of care, monitoring, and delivery planning
- Emphasize effective communication among obstetricians, anesthesiologists, neonatologists and nurses, as uncontrolled transfers to the OR and emergency CD with GA can contribute to unnecessary healthcare worker's exposure [7]

Antepartum Considerations for Patients Positive with SARS-CoV-2 or PUIs

- One provider should conduct a comprehensive anesthetic evaluation to limit unnecessary encounters including vital signs, physical examination, review of laboratory tests (complete blood count, comprehensive metabolic panel, and arterial blood gas (ABG), as indicated)
- If the patient is preterm, discuss risks vs. benefits of administering steroids for fetal lung maturity, magnesium for fetal neuroprotection, and indomethacin for tocolysis, as there is concern that these drugs may worsen COVID-19 [6]

Intrapartum Considerations for Patients Positive with SARS-CoV-2 or PUIs

- Frequent vital sign monitoring (heart rate, blood pressure, respiratory rate, oxygen saturation (oxygen saturation goal $\geq 95\%$) and temperature) tailored to the patient's clinical status, plus strict input and output measurements to assure fluid restriction in symptomatic patients [7]
- Symptomatic patients with respiratory compromise (e.g. requiring supplemental oxygen) should have ABG analysis to determine appropriate escalation of care and need for (non-invasive or invasive) ventilation, if necessary
- High flow nasal oxygen or non-invasive ventilation may be considered but some may discourage this approach due to potential for aerosolization of virus
- Early endotracheal intubation with airborne precautions (in a controlled manner) is recommended to avoid an emergent situation with unnecessary aerosolization exposure to healthcare workers

Vaginal Delivery in Patients Positive for SARS-CoV-2 or PUIs

- The patient should wear a procedure face mask at all times to limit droplet spread
- All healthcare workers should adhere to droplet, contact and potentially airborne precautions by wearing an impermeable gown, gloves, N95 mask, and eye protection
- Early placement of neuraxial labor analgesia is recommended to:

  1. Avoid exacerbation of respiratory symptoms (if applicable) with labor pain
  2. Reduce likelihood of GA and AGP in the event of an intrapartum CD

- Thrombocytopenia (<150,000 $\times$ 10^6/L) may occur in patients with COVID-19 infection [8]
- Given the low incidence (0.2%) of spinal-epidural hematoma [9] at platelet counts between 70,000 and 100,000 $\times$ 10^6/L and much higher risk of respiratory compromise with GA, consider neuraxial procedures at lower platelet count ranges
- Suspend use of nitrous oxide for labor analgesia (see Table 73.3) [6]
- High flow oxygen for fetal distress does not improve fetal outcomes (irrespective of SARS-CoV-2 status) and should be suspended [6]

Table 73.3 Peripartum drug use in patients positive for SARS-CoV-2 and PUI

Medication	Considerations
Nitrous oxide [6]	Insufficient information about cleaning, filtering of nitrous oxide delivery equipment; potential aerosolization of nitrous oxide
Remifentanil/fentanyl [14]	Avoid IV opioids for labor analgesia due to concern for respiratory depression and increased risk for emergent airway instrumentation
Ketorolac/ibuprofen [6]	Controversial whether NSAIDs aggravate COVID-19, continue to use in postpartum asymptomatic or mildly symptomatic women if their pain is not well controlled (to avoid IV opioids)
Dexamethasone [6]	Prolonged high-dose exposure to steroids has shown worsening of COVID-19 symptoms in the general population
Carboprost tromethamine [14]	Prostaglandin F2 alpha causes bronchoconstriction and pulmonary vasoconstriction—consider higher dose oxytocin and methylergonovine as 2nd-line uterotonics
Magnesium sulfate [6]	If symptomatic, assess risks vs. benefits due to a possible depressant effect on the central nervous system and risk of pulmonary edema with Mg toxicity

PUI = person under investigation; COVID-19 = Coronavirus disease 2019; IV = intravenous; NSAID = non-steroidal anti-inflammatory drug; Mg = Magnesium

Cesarean Delivery in Patients Positive with SARS-CoV-2 or PUIs

- Ongoing communication is critical to allow for safe transfer to the OR and adequate time for placement of neuraxial anesthesia (if the patient does not have a functional labor epidural catheter in situ), with a combined spinal-epidural (CSE) technique to avoid the need for potential conversion from a single-shot spinal technique to GA
- If the patient is a PUI, airborne protection with N95 respirator masks is recommended for all healthcare workers in the OR in case of an urgent conversion to GA involving an AGP
- Prophylactic use of an intravenous phenylephrine infusion (or boluses) is recommended as a normal standard of care to prevent hypotension from neuraxial anesthesia so that the maternal blood pressure and placental perfusion are maintained, however in patients positive with SARS-CoV-2 this will have the added benefit of reducing the incidence of vomiting which can cause aerosolization
- Avoid dexamethasone as high-dose steroids may worsen COVID-19 infection [6]
- Special considerations for commonly used medications are summarized in Table 3

Postpartum Considerations for Patients Positive with SARS-CoV-2 or PUI with a Postpartum hemorrhage

- Carboprost tromethamine for uterine atony may cause bronchoconstriction and further aerosolization of the virus with management of bronchospasm
- Consider higher dose oxytocin and/or methylergonovine as 2nd-line uterotonics
- Balance benefits of transfusion with risk of fluid overload and worsening pulmonary status

Postoperative analgesia

- It is controversial whether non-steroidal anti-inflammatory drugs worsen the clinical course of COVID-19, however they are recommended in asymptomatic or mildly symptomatic patients [6]

Post-dural puncture headache (PDPH)

- No unintentional dural puncture resulting in PDPH has been reported to date
- Follow usual treatment guidelines and assess contraindications for epidural blood patch (e.g. fever, coagulopathy)
- Postpone performing an epidural blood patch in acutely ill women due to concern for viral seeding in the epidural space [6]
- Avoid sphenopalatine ganglion blocks as they may cause aerosolization of virus

Vertical Transmission

Initial reports do not support transplacental transmission of SARS-CoV-2 from mother to fetus, however this remains controversial and studies are limited [10].

Breastfeeding

To reduce the risk of postnatal SARS-CoV-2 transmission, the mother should maintain a distance of at least 2 m from the infant. If she chooses to breastfeed or express milk with a breast pump, she should perform hand hygiene and wear a face mask and gloves [11].

Conclusion

We recommend practicing donning (putting on) and doffing (removing) PPE and performing simulation scenarios to become familiar with caring for pregnant and postpartum patients positive for SARS-CoV-2 or PUIs. It is prudent for delivery units to appropriately test and isolate patients who are positive for SARS-CoV-2 and PUIs to minimize dissemination of the virus and decrease the risk of unnecessary exposure to healthcare workers.

Disclaimer It should be noted that information provided in this chapter is up-to-date as of June 2021. Recommendations may change as new evidence emerges. Institutional protocols should be followed when managing pregnant patients who are suspected or known to be positive for novel coronavirus.

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Index

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