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Review

Maternal Critical Care: A Narrative Review

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Abstract

Maternal critical care services are increasingly sought as more women have comorbidities and face complications during pregnancy and the peripartum period. Despite this, most intensive care units admit only a few cases each year. Physicians encounter unique challenges in delivering effective care, including managing pregnancy-related physiological changes, specific diseases, and concerns about fetal well-being. This article offers guidance for the general intensivist managing critically ill patients during this period.

Keywords: maternity; obstetrics; parturient; critical care; intensive care

1. Introduction

Maternal critical care presents significant challenges for the intensivist. Outside those specialised in obstetric medicine or anaesthesia, many may be unfamiliar with the distinct antenatal physiology or the specific diseases that can complicate pregnancy. Caring for pregnant patients often causes anxiety among physicians due to concerns about fetal harm from medical interventions, while simple differences such as altered physiological norms can hinder effective assessment [1].

Caring for the critically ill parturient is complex and involves a large multidisciplinary team, which creates challenges in determining the best place to care for patients [2]. Safe obstetric and neonatal care is provided in various settings, but it requires obstetric, midwifery, and paediatric-led care that is not available in adult intensive care units (ICUs). Units may also be situated some distance apart, necessitating significant resource input from either side, depending on the chosen location. A common theme Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK (MBRRACE-UK) reports is that critical care is regarded as a treatment, not a physical location; therefore, intensivists should anticipate supporting patient care outside the ICU [3]. Enhanced care is provided in labour suites for women at risk of critical illness, although these units are not designed to deliver advanced organ support interventions [4]. Decisions to escalate care are therefore made individually, with input from the patient and the wider multi-disciplinary team (MDT).

This narrative review aims to provide an overview of the key differences in care between a pregnant (or postpartum) patient and a non-pregnant adult for the general intensivist.

2. Epidemiology

In the UK, the rate of admission to adult intensive care during the peripartum period is low at 2.24 per 1000 pregnant patients. However, many ill patients may be managed outside of an intensive care unit due to the issues outlined above [5].

The most common reasons for admission were obstetric haemorrhage immediately postpartum or respiratory failure in the antenatal period. Many admissions in postnatal women are unrelated to pregnancy. Outcomes are generally good and associated with short lengths of stay.

3. Airway Management

3.1 Physiological Changes

The incidence of difficult airways may be up to four times higher in the obstetric population due to various factors [6]. During pregnancy, increased swelling and vascularity in the airway can lead to poorer views and a higher risk of bleeding [7]. The cephalad displacement of the diaphragm by the gravid uterus decreases functional residual capacity, reducing apnoeic time. Most women will also experience reflux because of elevated intragastric pressures and progesterone-induced relaxation of the lower oesophageal sphincter, which puts them at high risk of aspiration during airway management; hence, they should be considered as unfasted [8]. Critical illness can present additional challenges, such as hypoxia from respiratory disease, difficulty achieving optimal positioning compared to an operating table, or situations where waking the patient in a cannot intubate scenario is not feasible.

3.2 Practical ICU Implications and Management Strategies

Guidelines for managing the obstetric airway mainly focus on providing general anaesthesia for caesarean sections. The intensivist who needs to intubate a pregnant pa-

tient should be familiar with these guidelines to develop a safe airway plan. Given the increasing evidence that video laryngoscopy improves intubation success in both obstetrics and critical care, it should be used as the first choice when available [9]. Rapid sequence induction with cricoid pressure is recommended even for fasted patients to reduce the risk of aspiration [8]. In hypertensive conditions like pre-eclampsia, laryngoscopy may cause a further acute rise in blood pressure and intracranial pressure, increasing the risk of intracranial haemorrhage. The use of rapid-onset opiates (remifentanil or alfentanil) and intravenous antihypertensive medications (labetalol, esmolol) during anaesthetic induction can help reduce this response to laryngoscopy [10].

4. Ventilatory Support

4.1 Physiological Changes

During pregnancy minute ventilation increases by 30–50%, driven by up to a 50% rise in tidal volume [11]. Respiratory rate increases to the upper limits of the normal range. These changes are mediated by progesterone, leading to respiratory alkalosis with an increase in arterial partial pressure of oxygen (pO_2) and a decrease in arterial partial pressure of carbon dioxide (pCO_2) and serum bicarbonate. As the uterus enlarges during pregnancy the diaphragm is displaced upward at rest. Relaxin-mediated effects on musculoskeletal tissue result in an increase in the ribcage's capacity to expand laterally. Reductions in expiratory reserve volume and residual volume significantly decrease functional residual capacity by 20–30%. Most other lung volume measures, such as forced expiratory volumes, are not significantly affected. Oxygen demand at rest increases to approximately 20% above baseline by term [12].

4.2 Practical ICU Implications

Pregnant women may be admitted with respiratory failure caused by preexisting conditions such as asthma, interstitial lung disease, or cystic fibrosis; however, pregnancy also heightens the risk and severity of viral pneumonitis and thromboembolic disease. Pulmonary oedema may happen secondary to decompensation of cardiac disease or pre-eclampsia [13].

Blood delivered to the fetus via the umbilical vein has a lower oxygen saturation than the maternal arterial supply to the placenta; 80% vs 98% [14]. Maternal systemic hypoxaemia will therefore quickly lead to hypoxia and fetal distress. The fetus's ability to extract oxygen from the blood depends on fetal cardiac output and a higher fetal concentration of fetal haemoglobin (HbF), which lies to the left of adult haemoglobin on the oxygen dissociation curve. Carbon dioxide diffuses freely at the placenta down a diffusion gradient, meaning maternal hypercarbia will cause fetal acidosis; this will reduce HbF's oxygen-binding ability by shifting the curve to the right and also affect fetal oxygenation.

There is limited definitive data to guide ventilation targets in the pregnant population, but it is crucial to consider utero-placental blood flow and gas exchange. Guidelines recommend maintaining oxygen saturation above 95% and are mainly based on expert opinion [15]. Arterial pO_2 targets of 9.3 kPa (70 mmHg) are cited as necessary to ensure adequate fetal oxygenation, although these are derived from historical studies with small patient numbers [16,17]. A lower arterial pO_2 of 8 kPa (60 mmHg) has also been suggested [18].

4.3 Management Strategies

High-flow nasal oxygen (HFNO) and non-invasive ventilation (NIV) are recognised options for ventilatory support in pregnant patients with mild to moderate respiratory failure. The underlying cause of respiratory failure, the patient's comorbidities, and the expected clinical course should guide the choice of initial therapy. NIV should be avoided in patients with impaired airway reflexes because of the increased risk of aspiration. HFNO provides limited positive pressure and may not achieve the same recruitment as NIV. However, HFNO is often better tolerated by patients. A sensible approach is to try HFNO and escalate to NIV if necessary in cases of mild respiratory failure, and vice versa for moderate respiratory failure if the patient improves with treatment.

When invasive mechanical ventilation is necessary, there is no high-quality evidence indicating that pregnant patients should be managed differently from non-pregnant patients. Ventilatory strategies are guided by case series and historical data in Acute Respiratory Distress Syndrome (ARDS); however, it is notable that there has been a significant growth in published literature on pregnant patients since the Coronavirus Disease 2019 (COVID-19) pandemic. We recommend limiting tidal volumes to 4–8 mL/kg of predicted body weight with plateau pressures below 30 cm H_2O [19]. Positive end-expiratory pressure (PEEP) should be titrated to optimise lung recruitment, recognising that venous return may already be reduced by the gravid uterus and that further PEEP adjustments might exacerbate this, leading to hypotension and reduced fetal blood flow.

The use of permissive hypercapnia and restrictive oxygen targets is controversial in pregnant patients because of their potential impact on the fetus. Hypocarbia reduces uterine blood flow, so over-ventilation should be avoided. Fetal hypercarbia may be linked to poor outcomes around delivery, but evidence on its effects beyond that is limited. Severe respiratory acidosis should be prevented; however, mild hypercarbia is likely safe when necessary for lung-protective ventilation [20]. During pregnancy, spontaneous minute ventilation increases, so higher respiratory rates are probably needed [21]. Overall, maternal hypercarbia and respiratory acidosis should be avoided where possible. Managing oxygenation to keep saturations above

95% is often challenging, and pO_2 targets may be similarly difficult in patients with severe respiratory failure. The threshold for using rescue methods typically reserved for refractory hypoxaemia or respiratory acidosis should be lowered. Continuous fetal monitoring is recommended whenever possible to detect early signs of distress.

Prone positioning in pregnancy appears to be a safe strategy, as supported by an increasing number of case reports, mainly from the COVID-19 pandemic [22]. Continuous fetal monitoring seems feasible even when in the prone position. The potential benefits of proning may be slightly diminished in pregnant patients due to the positively altered respiratory physiology in the supine position during normal pregnancy. An increased baseline cardiac output enhances apical perfusion, leading to improved ventilation-perfusion matching, while an increased anteroposterior diameter of the chest improves alveolar ventilation. Despite this, there is enough evidence to endorse its use, and a trial of prone positioning should be considered when indicated, with minor adaptations for the altered anatomy and physiology [23].

Inhaled nitric oxide (iNO) and prolonged neuromuscular blockade can be considered in cases of refractory hypoxaemia and severe ventilator desynchrony, respectively. iNO lacks a robust evidence base for reducing mortality [24], even in the non-pregnant population, and should only be regarded as a bridge to adjunctive therapies such as Extracorporeal Membrane Oxygenation (ECMO). Non-depolarising muscle relaxants are likely to cross the placenta in very small amounts, but the effects of prolonged use on the fetus remain unknown.

ECMO should be considered for pregnant patients experiencing refractory hypoxaemia or hypercapnia. Evidence from case series indicates that survival rates are favourable for both mother and fetus [25]. Early consultation with ECMO centres is recommended, as patients may benefit from tertiary intervention for acute respiratory failure without needing to proceed to ECMO.

4.4 Controversies

A common topic of discussion in the case of the mechanically ventilated pregnant patient is the timing of delivery. Increased intrapleural pressure and cephalad shift of the diaphragm caused by the gravid uterus may be alleviated by delivering the fetus, although the improvement in respiratory dynamics may not necessarily lead to better outcomes [13,26]. The haemodynamic effects of delivery, which are usually well tolerated by healthy mothers, can be poorly tolerated by patients with existing right ventricular dysfunction associated with severe respiratory failure.

Any decision regarding the timing of delivery should balance the potential benefits to the mother against the risks of iatrogenic prematurity to the fetus. In cases without standard maternal and fetal indications for delivery in pregnant patients, an individualised, multi-disciplinary team (MDT) approach; including obstetricians, anaesthetists, and intensivists, is recommended for deciding on operative delivery [13]. This may also involve seeking support from legal and/or ethical advice where appropriate.

5. Cardiovascular Support

5.1 Physiological Changes

During pregnancy, there is a 30–50% increase in cardiac output, mainly due to an increased stroke volume with a smaller rise in heart rate. Peripheral vascular resistance decreases in the first half of pregnancy and gradually returns to pre-pregnancy levels in the second half. Additionally, circulating volume increases while plasma colloid oncotic pressure decreases. The gravid uterus may compress the aorta and inferior vena cava (IVC) when in the supine position, which can significantly contribute to hypotension after 20 weeks of gestation. This is known as Supine Hypotensive Syndrome when it occurs in isolation.

5.2 Practical ICU Implications

IVC compression should be ruled out as a contributing factor in all shocked states. In conscious patients, the left lateral decubitus position is recommended to reduce compression of abdominal vessels and enhance uteroplacental blood flow. However, during critical illness this may not be feasible and a 15–30 degree lateral tilt might be necessary. It is important to recognise that there is considerable individual variation in the position and tilt angle needed to alleviate IVC compression which can significantly influence patient care [27].

Fluid resuscitation in pregnancy demands greater caution than in the general population due to the reduced oncotic pressure associated with physiological pregnancy. The 30 mL/kg recommended by the Surviving Sepsis campaign may result in a higher incidence of clinically significant oedema [28,29]. Measuring serum lactate is a helpful indicator of perfusion. It is important to recognise that levels may be markedly elevated during and immediately after labour but should otherwise stay within the typical range.

5.3 Management Strategies

Vasoactive drugs all impact the uteroplacental unit and fetus as the uterine artery responds to alpha-adrenergic stimulation. The most commonly used vasopressors in pregnancy are noradrenaline and phenylephrine. Noradrenaline maintains cardiac output more effectively due to beta receptor activity and has not been shown to harm the fetus, making it the preferred first-line vasopressor in critically ill obstetric patients [28].

Most other vasopressors have undesired effects and should be used with caution. Vasopressin may induce uterine contractions and should be avoided. Ephedrine has been shown to worsen fetal acidaemia in a dose-dependent manner around delivery. Adrenaline may cause arrhythmias in the fetus but can be used in emergency situations [30,31].

Hydrocortisone is routinely used in vasopressor-refractory shock and may be used during pregnancy. Prednisolone and hydrocortisone are preferred steroids for maternal indications, as the placenta inactivates them in significant quantities [32].

There is limited evidence for the use of most inotropic drugs, although both dobutamine and levosimendan have been utilised to treat cardiogenic shock in pregnancy [33].

Veno-arterial ECMO should be considered in cases of refractory cardiogenic shock and pregnancy-specific conditions such as amniotic fluid embolism or pre-eclampsia with pulmonary oedema and haemodynamic instability [25].

5.4 Controversies

Goal-directed fluid therapy is challenging as most non-invasive cardiac output monitors are not validated in pregnancy. Most products rely on (non-pregnant) demographic data to estimate haemodynamic parameters and may therefore be inaccurate. Lithium poses an additional risk to the fetus, especially in the first trimester, so lithium dilution techniques should be avoided [34]. Predicting preload responsiveness may be possible using certain measures from pulse contour analysis, such as stroke volume variation. Serial bedside echocardiography or oesophageal Doppler can both be used to guide resuscitation, but these are more labour-intensive than other techniques and exhibit inter-operator variability, particularly in inexperienced hands. Appropriate training and accreditation processes are therefore essential.

6. Renal Support

6.1 Physiological Changes

During pregnancy the glomerular filtration rate (GFR) increases by 50% leading to a reduction in creatinine and urea levels. Mild physiological hydronephrosis is common due to compression of the ureters by the gravid uterus, but it is usually asymptomatic and of little clinical significance [35].

6.2 Practical ICU Implications and Management Strategies

Pregnancy-related acute kidney injury (Pr-AKI) can be caused by normal renal pathologies as well as pregnancy-specific causes such as pre-eclampsia (PET). Although acute renal replacement therapy (RRT) is rare during pregnancy intensivists must be aware of its key differences. Firstly, haemodialysis in pregnancy requires more frequent and longer sessions due to the physiological increase in GFR. When using haemofiltration, a higher effluent flow rate than in the general population may be necessary. Secondly, urea is toxic to the fetus, so a lower serum threshold of 17–20 mmol/L should be used to initiate RRT [36]. Beyond this, the thresholds for acute RRT are the same as in the non-pregnant population.

Hydronephrosis is usually managed conservatively but occasionally requires intervention in cases of pain, infection, or acute kidney injury due to obstructive uropathy [37].

6.3 Topics for Further Research

None of the commonly used creatinine-based formulas to calculate estimated GFR and creatinine clearance is validated in pregnancy. These formulas have been shown to be unreliable due to hyperfiltration and volume expansion during pregnancy. Further research is needed to develop a pregnancy-specific formula for estimating renal function in pregnancy [38,39].

7. Haematology

7.1 Physiological Changes

The normal physiology of pregnancy leads to a hypercoagulable state, which protects against haemorrhage but raises the risk of venous thromboembolic disease. There is an upregulation of clotting factors and a reduction in anticoagulant and fibrinolytic substrates. Additionally, an increase in venous capacitance causes stasis. Platelet function also changes, resulting in greater platelet aggregation [40].

7.2 Practical ICU Implications and Management Strategies

Thromboembolic disease is a major cause of maternal mortality and morbidity. Pregnant patients should receive prophylactic low molecular weight heparin (LMWH) during their ICU stay. The increased thrombotic risk extends beyond pregnancy and, although UK national guidance does not specify critical illness as a risk factor, prolonged prophylaxis for six weeks postpartum should be considered on an individual basis [41]. If deep vein thrombosis (DVT) or pulmonary embolus (PE) occurs, treatment-dose LMWH should be started.

7.3 Controversies

Evidence regarding the treatment of high-risk (massive) and intermediate-high-risk (sub-massive) PE is limited to case series. Stratification of risk can be carried out similarly to the non-obstetric population, but it is important to remember fetal distress as an additional marker of end-organ failure. All reperfusion strategies should be considered, including systemic and catheter-directed thrombolysis. ECMO has been used in cases of refractory shock [42]. In a systematic review of more than 100 pregnant women with high-risk PE, of whom 83 received systemic thrombolysis, survival was 94%, although this favourable rate may reflect reporting bias. The risk of major bleeding was significantly higher (58%) in the postpartum period than during pregnancy (18%), and careful multidisciplinary decision-making is required to balance these risks against the dangers of deterioration or death from pulmonary embolism [43].

Table 1. Common sedative & analgesic drugs.

Drug	Safety profile	Considerations and evidence
Propofol	Safe	Limited evidence base in critically ill pregnant patients but has been used widely for general anaesthesia in pregnancy [46]. Historically, there have been concerns regarding fetal neurotoxicity in animal models [47].
Ketamine	Safe with caveats	Evidence extrapolated from ketamine use in non-critically ill patients suggests there is a risk of fetal neurotoxicity [48]. It should be used when clinically indicated such as in status asthmaticus but not as a first line agent [49].
Midazolam (benzodiazepines)	Safe with caveats	Avoided it in the first trimester, as it is associated with congenital heart defects, but it can be used thereafter. It has been used successfully in refractory status epilepticus [50]. There are risks of neonatal withdrawal symptoms, neonatal hypothermia, hypotonia, and respiratory depression.
Dexmedetomidine	Safe	It crosses the placenta in negligible amounts and is therefore likely to be a suitable adjunct for sedation [51].
Morphine/fentanyl/other opioids	Safe with caveats	It is not known to be a major teratogen and therefore can be used as usual. However, there is a risk of neonatal abstinence syndrome.
Remifentanil	Safe	It is used for general anaesthesia during pregnancy and can be used similarly to other opioids [46].
Nonsteroidal anti-inflammatory drugs	Safe with caveats	It is associated with premature closure of the ductus arteriosus. Short term use is acceptable before 28 weeks' gestation. [52].
Paracetamol	Safe	Not known to be harmful.

8. Sedation, Analgesia and Paralysis

All sedative drugs used will affect the fetus, and there is little evidence to suggest that one is superior to another. A pragmatic approach to selection is therefore to minimise the use of prolonged infusions of sedatives wherever possible. It is acknowledged that this may be unavoidable in patients with extended stays in critical care, and the safest approach is to follow local sedation protocols. In the event of delivery there are risks of respiratory depression and withdrawal syndromes in the neonate. Details of sedation prior to delivery should be communicated to neonatal teams in advance of delivery whenever possible.

Neuromuscular blocking agents are generally considered not to cross the placenta in significant quantities and can be used as normal. Although plasma cholinesterase levels are significantly reduced, this does not cause a clinically relevant prolongation of the block when suxamethonium is used. Previously, sugammadex has been avoided due to concerns about its ability to encapsulate progesterone and *in vitro* evidence of inducing neuronal apoptosis. However, there is no evidence of harm in case series, and its use in "can't intubate, can't ventilate" situations is necessary [44,45].

Commonly used sedatives and analgesics in intensive care generally do not require major changes for pregnant patients. Propofol is used as a first-line agent in most ICUs, and this practice should be continued with pregnant patients. Second-line agents are generally safe, with some caveats outlined in Table 1 (Ref. [46–52]). Remifentanil should be considered the first-line opioid for sedation in pregnant patients, as there appears to be reliable fetal metabolism following delivery [53].

9. Nutrition

9.1 Physiological Changes in Pregnancy

There is a lack of evidence regarding critical care nutrition during pregnancy, so exact requirements can be difficult to determine. There is no increase in calorie needs in the first trimester, but as the metabolic rate rises by about 15%, it is recommended to provide an additional 340 kcal/day in the second trimester and 452 kcal/day in the third trimester [54].

9.2 Practical ICU Implications and Management Strategies

The protein content of feed should be increased during pregnancy and breastfeeding, and micronutrients such as folic acid, iron, calcium, and zinc may need to be supplemented [54]. Propofol can contribute significantly to calorie intake when used for continuous sedation and should be accounted for.

Delayed gastric emptying is common during pregnancy, as is constipation. These should be anticipated, and prokinetic and laxative drugs should be used as needed. Proton pump inhibitors are frequently prescribed during pregnancy and can be utilised to reduce aspiration risk and prevent ulcers. Parenteral nutrition has been effectively used in pregnancy, although it has been studied extensively only in cases of chronic intestinal failure [55].

Lactation support and expression of breastmilk should be available to patients in the ICU. When patient preferences are known, it may be in the patient's best interest to initiate breastmilk expression while sedated [56]. It is important to remember that drugs given to the mother may affect the neonate, so consultation with a lactation pharmacist may be necessary.

9.3 Controversies

There is no consensus on targets for blood glucose during critical illness in pregnancy. Intensive glucose control can be potentially harmful during critical illness, and UK best practice guidelines for general ICU patients support a more liberal target of 7.5–10 mmol/L [57]. However, in pregnancy (outside of critical illness), even mild hyperglycaemia is linked to worse outcomes, and National Institute for Health and Care Excellence (NICE) guidelines recommend maintaining glucose levels between 4 and 7.8 mmol/L [58,59]. Therefore, it is reasonable to aim for the upper end of this range (i.e., 6–8 mmol/L) for critically ill pregnant patients.

10. Imaging

Imaging during pregnancy often raises concerns for both doctors and patients due to fetal radiation exposure. This hesitation has been linked to poorer outcomes in patients who are not critically ill [60]. Imaging therefore, should not be postponed when it is necessary. In conscious patients consent must include a discussion of fetal risks. The level of ionising radiation exposure to the fetus mainly depends on the area being examined, with low exposure in head, neck, and chest scans (<0.1 mGy). Abdominal and pelvic imaging can result in exposure levels up to 50 mGy, which is associated with a childhood cancer risk of 1 in 200 [61]. Typically, a single examination remains below the threshold dose for teratogenesis.

Iodinated contrast used is safe during pregnancy and breastfeeding, although there is a theoretical risk of neonatal hypothyroidism. Screening is sometimes recommended in the first week of life, but in the UK, it is routinely performed on all neonates at 5 days of age as part of the heel prick blood test. Gadolinium contrast conversely is associated with various fetal complications, including stillbirth and neonatal death, and should be avoided during both pregnancy and breastfeeding.

Non-contrast magnetic resonance imaging (MRI) and ultrasound are both safe during pregnancy and should be considered as suitable alternatives when appropriate.

Point of care ultrasound has become a standard component in both intensive care and obstetric care. Lung, cardiac, haemodynamic, and DVT scans are all commonly performed in the ICU and can be essential for diagnosing the root causes of physiological disturbances. Intensivists should also be familiar with the capabilities of obstetric teams as transvaginal and abdominal ultrasound can be used to evaluate persistent bleeding or abdominal pain by identifying retained products of conception or collections [62].

11. Psychology

The long-term psychological effects of birth trauma are increasingly recognised and have recently been examined in a UK parliamentary enquiry [63]. Admission to intensive care is also well known to be associated with a high incidence of post-traumatic stress disorder [64]. Key risk factors for birth trauma related to critical care admission include [65]:

-Lack of or loss of control.

-Fear for the baby's health or life.

-Intensity of pain or physical discomfort.

-Separation from the baby after delivery.

Efforts should be made to minimise separation from the newborn, which may require significant coordination to facilitate baby-to-mother or mother-to-baby transfers. Using an intensive care diary to record early contact with the child in sedated patients could be beneficial. The impact on partners should also be taken into account, and group visits can be advantageous.

While psychological support after critical care is a recognised standard in the UK, debriefing following traumatic birth is often available but not universally recommended [66]. There may therefore be multiple services (obstetric, medical, anaesthetic and intensive care) offering follow-up. Shared appointments should be considered to ensure all issues are addressed and to reduce the appointment burden during the postpartum period.

12. Assessment by Obstetric Teams

Obstetricians and midwives should be involved in the care of patients in late pregnancy and those immediately postnatal. Most hospitals will adopt a shared care model between parent teams and obstetric services. It is worth discussing patients in early pregnancy; however, intervention may be limited below the threshold of infant viability. This has previously been defined as 23^{+0} weeks to 24^{+6} weeks of gestation, but may now be considered as early as 22 weeks gestation [67]. Decisions around infant viability are complex and should involve the neonatal team.

Fetal monitoring is likely indicated in a pregnant critical care patient beyond the gestational age of viability. Regular fetal auscultation, with or without ultrasound, should be considered a minimum as this can exclude intra-uterine death. There are no national or consensus guidelines on antenatal cardiotocography (CTG), so a local decision should be made to determine the frequency and type of fetal monitoring. CTG can be used from 26–28 weeks onwards to assess fetal distress and potentially guide maternal optimisation; however, it requires expert interpretation [68].

13. Specific Conditions

There are several specific pregnancy complications that may require critical care intervention. A brief overview of these and the main challenges in intensive care is outlined below.

13.1 Post-Partum Haemorrhage

The most common reason for maternal ICU admission in the UK is post-partum haemorrhage (PPH) [5]. There are no standard definitions of major obstetric haemorrhage (MOH), although thresholds of 500 mL in vaginal delivery and 1000 mL in caesarean are often used. Blood volume increases in pregnancy to about 100 mL/kg, but this shows significant variability between individuals so shock can occur at much lower volumes than expected [69]. The causes of PPH are usually classified as the "four Ts": tone (uterine), trauma to the birth canal, tissue (retained products), or thrombin (coagulopathy).

Uterine atony is the most common cause of postpartum haemorrhage, and treatment involves a combination of pharmacological and surgical interventions. The involvement of the obstetric team is essential and management in theatre is often necessary. Intensivists should be familiar with the main classes of uterotonic drugs: oxytocin analogues, ergot alkaloids, and prostaglandin analogues. In cases of persistent uterine bleeding a Bakri balloon (a device used to achieve intra-uterine tamponade) may be employed and can remain in situ for up to 24 hours [70]. Interventional radiology techniques such as uterine artery embolisation may be required if bleeding is uncontrolled. ICU staff may be unfamiliar with palpating the uterus to confirm adequate contraction therefore serial measurement of symphysis-fundal height may provide an objective measure to support this.

Trauma to the birth canal or perineum can also cause significant blood loss. Treatment is mainly surgical but might include leaving vaginal packs in place. Retained packs have led to considerable morbidity; therefore it is advised that the presence of a vaginal pack be documented during patient handover. ICUs should be aware of local safety protocols [71]. Retained tissue may cause early or delayed bleeding. Small amounts of bleeding are normal within the first four days but ongoing bleeding, foul discharge, or infection with an unclear cause should prompt further examination [72].

Coagulopathy is rarely the primary cause of MOH but may complicate any of the above causes. Large volume red cell transfusions may have been administered resulting in a dilutional coagulopathy. Local approaches to MOH treatment will vary but it is essential to rule out fibrinogen deficiency as a cause of persistent bleeding. Measurement of fibrinogen through direct laboratory testing or viscoelastic testing can reliably identify this. During pregnancy fibrinogen levels are higher than in the general population, so a higher target of >2 g/L is used in resuscitation. Fibrinogen concentrate or cryoprecipitate, rather than fresh frozen plasma, should be used where available [70]. Tranexamic acid is currently recommended in all PPH [73].

13.2 Sepsis

Maternal sepsis remains one of the leading causes of maternal mortality [60]. It can be difficult to identify intrapartum, as increases in temperature, white cell count, and lactate may occur temporarily with normal vaginal delivery. There should be a low threshold for initiating antibiotic therapy and investigating for an underlying source of infection. Intra-uterine infection can occur at any point during the peripartum period. Most antibiotics are safe to use during pregnancy and breastfeeding.

13.3 Pre-Eclampsia

Pre-eclampsia (PET) is a complex condition characterised by placental hypoperfusion/hypoxia and the subsequent release of antiangiogenic markers, which leads to widespread endothelial dysfunction, vasoconstriction, and immune dysregulation [74]. The condition is defined as hypertension exceeding 140/90 mmHg alongside signs of end-organ dysfunction after 20 weeks of pregnancy [75].

Severe features such as cardiac, respiratory, renal, hepatic, neurological, and haematological failure may all develop as a result of microvascular changes [76]. HELLP syndrome (haemolysis, elevated liver enzymes, and low platelets) is a recognised variant of PET reflecting this widespread organ dysfunction and can occur in the absence of hypertension.

Supportive management focuses on controlling blood pressure, which is vital to prevent cerebral bleeds. Commonly used antihypertensive drugs include labetalol (oral or intravenous), hydralazine (intravenous), and nifedipine (oral). Due to the risk of pulmonary oedema, patients with PET should be fluid restricted to 80 mL/hr, which can be challenging in an ICU setting. Spikes in blood pressure must be avoided, especially during invasive procedures or airway management. A frequently adopted strategy for induction of anaesthesia and intubation is to use a high dose, short-acting opioid to minimise the hypertensive response to stimuli such as laryngeal manipulation.

Eclampsia refers to new-onset seizures associated with hypertension during pregnancy. The mainstay of treatment for eclampsia is intravenous magnesium sulphate. Conventional anti-epileptic drugs are generally avoided; in fact, they are rarely needed, and prolonged seizures despite magnesium treatment should prompt consideration of an alternative diagnosis [77]. Definitive treatment involves delivering the placenta; however, PET may develop or persist up to 6 weeks postpartum.

13.4 Hepatic Failure

Acute Fatty Liver of Pregnancy (AFLP) is a rare but serious condition. Immediate delivery of the fetus is crucial

for survival and mortality is then around 4%. It presents with subacute abdominal discomfort and malaise but can progress to acute liver failure, jaundice, coagulopathy, encephalopathy, and hypoglycaemia. Although a liver biopsy showing microvesicular steatosis is required for a definitive diagnosis, it is rarely performed. Clinical suspicion and the use of the Swansea criteria scoring system are used to guide diagnosis and delivery [78].

13.5 Amniotic Fluid Embolism

Amniotic fluid embolism (AFE) is a rare condition but one with a high mortality rate. It is usually described during labour and delivery but may occur up to 6 hours postpartum. It is characterised by sudden cardiovascular collapse, hypoxaemic respiratory failure, and disseminated intravascular coagulation, often with altered mental status. The pathophysiology is not fully understood but is believed to be caused by amniotic fluid and fetal debris entering the maternal circulation. Evidence from animal models suggests this leads to severe acute pulmonary hypertension that causes cardiovascular collapse. Widespread activation of clotting factors may subsequently result in disseminated intravascular coagulation (DIC) and microvascular occlusion, leading to end-organ failure [79].

Management is supportive, focusing on maintaining cardiac output and oxygen delivery, as well as correcting coagulopathy. In the event of cardiac arrest, a perimortem caesarean section should be performed. Patients who survive the initial event will typically require intensive care for cardiorespiratory support. Mortality rates can be as high as 30%, and 9–15% of survivors sustain permanent neurological injuries [80].

14. Conclusion

High-risk obstetric care is increasing in the UK. Intensive care physicians will increasingly be involved in caring for these patients and must understand the key challenges posed by the altered physiology of pregnancy, concurrent critical illness, and pregnancy-related conditions. Many aspects of maternal critical care are very similar to general adult critical care, and obstetric patients should not be denied vital investigations and treatments unless there is a compelling reason. However, modifications are necessary in certain situations, and this review offers practical guidance on managing these patients. In some areas, the evidence base is limited or lacking, so expert advice should be sought in complex cases. Early delivery of the fetus is often recommended in obstetric syndromes such as pre-eclampsia and HELLP. Conversely, in cases of non-obstetric causes of critical illness, the benefits are less clear and the timing of delivery should be a personalised, multidisciplinary decision.

Key Points

• The demand for maternal critical care is rising, driven by the increasing complexity of obstetric patients and initiatives aimed at improving equity of access to services.

• Complex decisions regarding fetal viability, delivery timing, and routine ICU therapies often require individualised judgment and multidisciplinary input due to a lack of clear evidence and guidelines.

• For the general intensivist, these patients can prove challenging due to altered physiology, pregnancy-specific pathologies, and the management of the fetus.

• Many general principles of adult critical care remain unchanged in pregnancy so obstetric patients should not be denied vital investigations and treatments unless there is a compelling reason to do so.

Availability of Data and Materials

Not applicable.

Author Contributions

BN supervised and provided the main conceptual outline for the article. AWW and KS researched and drafted the main content of the manuscript. All authors contributed to revising the manuscript critically for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

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Conflicts of Interest

The authors declare no conflicts of interest.

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