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Intensive Care Challenges In Obstetric Patient Management: A Narrative Review Ahmad A. Alharbi

Ahmad A. Alharbi

Department of ICU, Faculty of Medicine, Jazan University, Jazan, Saudi Arabia
ORCID: https://orcid.org/0000-0001-8763-2008.
corresponding author: Ahmad A. Alharbi

ABSTRACT
The intensive care management of pregnant and postpartum patients presents distinct complexities due to the simultaneous need to safeguard maternal and fetal health, compounded by the physiological adaptations of pregnancy. Clinicians must be equipped to manage obstetric-specific conditions that may fall outside the scope of traditional critical care training. Common indications for ICU admission include hypertensive complications, severe bleeding following childbirth, and sepsis—each requiring tailored clinical approaches. Acute fatty liver of pregnancy and peripartum cardiomyopathy are less common, but because of their high risk, they must be recognized and treated at once. This review synthesizes current literature on ICU utilization among obstetric populations and identifies the criteria for critical care admission in these cases. It delves into vital practices such as mechanical ventilation in pregnancy and methods for fetal monitoring within the ICU setting. Detailed attention is given to the treatment protocols for leading complications like preeclampsia and postpartum hemorrhage. Furthermore, the assistance that critical care nurses provide for the beginning of breastfeeding is recognized. Coordinated efforts between intensivists, obstetricians, and anesthesiologists are essential to optimize outcomes, particularly when surgical delivery becomes necessary. Despite the clinical hurdles, outcomes for critically ill obstetric patients often surpass those of non-pregnant peers, emphasizing the value of multidisciplinary, specialized care.

Keywords: Obstetric intensive care, Preeclampsia, Postpartum hemorrhage, Maternal sepsis, Mechanical ventilation in pregnancy.

INTRODUCTION

Caring for pregnant individuals in the intensive care unit (ICU) poses a unique set of challenges for critical care providers, largely due to the physiological transformations that accompany pregnancy, as well as the evolution of medical conditions during gestation, the puerperium, and postpartum periods. These difficulties are exacerbated by the need to protect the fetus and the mother. A notable global pattern has been observed linking high maternal mortality rates to limited access to ICU care—nations with fewer ICU beds per capita also report the highest maternal death rates [1].

Compared to high-income nations, low- and middle-income countries often had significantly higher injury severity ratings upon ICU admission [2], highlighting the role that delayed access to advanced treatment plays in raising maternal mortality. Less than 1% of all ICU admissions are obstetric patients, with a proportion of 1 to 9 per 1,000 pregnancies necessitating ICU treatment [3].

Data from countries like the United Kingdom and the United States show that approximately 0.9% of all pregnancies involve ICU admission, with reported maternal mortality in these cases varying between 5% and 20% [4]. A retrospective analysis involving 1,023 critically ill obstetric patients [5] identified risk factors such as maternal age, racial background, socioeconomic status, and the adequacy of prenatal care. ICU admissions were prompted by pregnancy-specific complications (e.g., preeclampsia, postpartum hemorrhage, peripartum cardiomyopathy, puerperal sepsis), pre-existing non-pregnancy-related conditions (e.g., congenital or valvular heart disease, renal insufficiency, pulmonary hypertension), and other medical conditions exacerbated by pregnancy [6].

In general, obstetric ICU patients are younger and present with fewer preexisting conditions compared to the broader population of critically ill women. They also demonstrate lower mortality rates—approximately 2–3%—as opposed to the 20% mortality seen in the general female ICU cohort [7]. This study aims to assess the incidence, risk factors, and mortality outcomes associated with ICU admissions among pregnant and postpartum women.

METHODOLOGY

This study is a narrative review that aims to provide a comprehensive overview of intensive care management in obstetric patients. A structured literature search was conducted between January and May 2024 using electronic databases including PubMed, Google Scholar, and the Cochrane Library. The search strategy incorporated keywords such as "pregnancy," "postpartum," "intensive care unit," "critical care," and "maternal outcomes." Articles were selected based on relevance to the topic, focusing on epidemiology, indications for ICU admission, management strategies, and maternal-fetal outcomes.

As a narrative review, this study does not follow a systematic review protocol (e.g., PRISMA) and does not include formal risk-of-bias assessment or quantitative synthesis. Instead, the selected literature was analyzed qualitatively, and findings were synthesized thematically to highlight key clinical challenges and management approaches in obstetric critical care.

DISCUSSION

Most pregnancies proceed without serious medical issues. Global improvements in healthcare services and increased accessibility to maternal health resources have significantly contributed to the reduction in maternal mortality rates worldwide [8]. Nevertheless, a small percentage of pregnancies and childbirths are associated with complications that can necessitate advanced medical support in Critical Care Units (CCUs), such as Intensive Care Units (ICUs) or High Dependency Units (HDUs) [9].

1. Epidemiology:

Maternal mortality continues to be a significant global public health concern, with an estimated 287,000 to 303,000 women dying annually due to complications associated with pregnancy and childbirth [10,11]. A vast majority of these fatalities are concentrated in low-income regions—particularly sub-Saharan Africa—where healthcare access remains severely limited [11]. By 2030, the Sustainable Development Goals aim to reduce the global maternal mortality ratio to less than 70 deaths per 100,000 live births as part of the global health agenda [12].
Among women requiring admission to Critical Care Units (CCUs), including ICUs and HDUs, between 63% and 92% are in the postpartum stage. The median duration of stay differs based on timing, averaging 2 days for antenatal admissions and 1.1 days for postpartum patients [13]. The incidence of obstetric CCU admissions varies from 3.3% to 14%, with the lowest rates recorded in countries with structured and accessible healthcare systems [14]. Notably, research suggests that around half of maternal deaths could be avoided through timely identification and intervention in critically ill obstetric patients requiring critical care [4].

Approximately 75% of maternal deaths are due to direct obstetric causes, including severe hemorrhage, hypertensive disorders, and infections. Indirect causes, such as pre-existing health conditions exacerbated by pregnancy, also play a substantial role [10]. Advancing maternal age is linked to elevated mortality risk, particularly in women aged over 35 years [15]. While maternal death is relatively rare in high-income nations—often associated with chronic medical conditions—it remains a pressing and preventable issue in resource-poor settings due to deficient healthcare infrastructure [11]. Despite global initiatives to reduce maternal mortality, pronounced inequalities persist, underscoring the urgent need for improved healthcare access and targeted interventions.
Some of the studies discussed in this review are summarized in Table (1) to highlight their key characteristics.

Table (1): Summary of key characteristics of selected studies.

Authors	Study duration (years)	No. of women	Maternal age (y)	Gest age (w)	BMI (kg/m^2)	PG %	MG %	VD	CS
Leung et al. [16]	10	50	31	34	-	-	-	24	76
Ng et al. [17]	4	67	34	37	25	57	6	13	87
Vargas et al. [9]	5	66	31.8	33	28.9	33	7	5	95
Minville et al. [8]	6	211	31	32	29	-	28.4	66.1	33.9
Fatnic et al. [18]	3	84	-	33	29	-	-	2.17	97.8
Liu et al. [19]	4	152	-	-	-	47.9	-	6.25	87.5

Gest: gestational, BMI: body mass index, y: year, w: week, VD: vaginal delivery, CS: cesarean section delivery.

2. Indications of admission

Patients who need to be admitted to critical care units (CCUs) may have a mix of obstetric and non-obstetric diseases that require advanced medical procedures and ongoing invasive and non-invasive monitoring. Pre-existing autoimmune diseases (such as systemic lupus erythematosus, myasthenia gravis, and autoimmune thyroiditis), cardiovascular disorders (such as hypertension, valvular abnormalities, pulmonary hypertension, cardiomyopathy, arrhythmias, and congenital heart conditions), neurological and respiratory conditions like asthma and epilepsy, and chronic systemic illnesses like diabetes mellitus are some of the non-obstetric conditions that can make pregnancy more difficult. Pregnancy-related physiological and anatomical changes might sometimes exacerbate these underlying disorders [9].

Infections including pneumonia and pyelonephritis, thromboembolic events like pulmonary embolism and deep vein thrombosis, and pulmonary edema are other non-obstetric problems that can occur during pregnancy. Pregnancy-related physiological changes have an impact on these. Cholecystitis, appendicitis, trauma, and viral illnesses like H1N1 influenza are some accidental reasons of CCU hospitalization during pregnancy [20].

As for obstetric indications for CCU admission, hypertensive disorders are among the most frequent and critical, particularly preeclampsia and HELLP syndrome (Hemolysis, Elevated Liver Enzymes, and Low Platelet Count) [21]. These conditions pose serious risks for both maternal and fetal health and are associated with elevated rates of morbidity and mortality. Notably, HELLP syndrome can resemble numerous non-obstetric conditions, complicating diagnosis [22].

Diagnosis of HELLP syndrome is based on both clinical presentation and laboratory investigations. Symptoms may include hypertension—though approximately 15% of affected patients may maintain normal blood pressure—along with general malaise, nausea, and pain in the epigastric region [23]. Laboratory indicators include evidence of microangiopathic hemolytic anemia (such as schistocytes on peripheral smear, low hemoglobin, and elevated lactate dehydrogenase), liver enzyme elevations (serum glutamic-oxaloacetic and serum glutamic-pyruvic transaminase levels often reaching up to 70 IU/L), and thrombocytopenia (platelet count <100,000/µl).

The extreme end of the range of hypertensive pregnancy problems is eclampsia. It is characterized by the emergence of focal, multifocal, or tonic-clonic seizures without the presence of other underlying causes, such as substance addiction, ischemic stroke, epilepsy, or cerebral hemorrhage [24].

Table (2): Indications for ICU admission

Etiology (%)	Leung[16]	Ng [17]	Vargas[1]	Minville[8]	Fatnic[18]	Liu[19]
Non-obstetric causes	14	16	42.4	-	29.2	68.42
Obstetric causes	86	58	57.6	-	54.8	31.85
Antepartum causes	22	15	31	-	-	-
Antepartum hemorrhage	22	3	14	-	-	-
Postpartum hemorrhage	78	97	86	-	8.7	-
Pregnancy-induced hypertension	14	22	25	-	-	15.33
Pre-eclampsia toxemia	6	25	4.55	42	-	7.89
Eclampsia	4	13.4	6	11	-	2.63
HELLP syndrome	4	3	10.6	25	-	3.29
Retained placenta	2	-	1.5	-	-	-
Placenta previa	-	30	4.5	-	-	0.66
placental Abruption	4	15	3	-	-	0.66
Placenta accreta	-	-	14	-	-	5.92
Puerperal sepsis	2	-	1.5	-	-	3.29
ICU status: Rate: - Elective - Emergency	0.13 12 15	0.23 15 85	2.9 - -	N/A	N/A	N/A

Magnesium sulfate is administered to prevent the onset of seizures in patients with eclampsia, acting through mechanisms that may involve neuromuscular blockade or central nervous system effects. Its administration necessitates vigilant monitoring to prevent toxicity. This includes regular assessment of urine output, respiratory rate, vital signs, and deep tendon reflexes (specifically the patellar reflex), along with periodic evaluation of serum magnesium levels, which are considered therapeutic between 4 and 7 mEq/L [25].

When serum magnesium concentrations rise excessively, magnesium toxicity may occur, necessitating critical care intervention. In severe cases, renal replacement therapy such as dialysis may be needed to eliminate excess magnesium [26]. In patients with severe preeclampsia, meticulous fluid management is critical. It is essential to strike a balance that avoids both pulmonary edema from fluid overload and acute kidney injury resulting from fluid restriction. Some studies have suggested a conservative infusion rate of around 80 ml per hour of intravenous fluids; however, current evidence remains insufficient to establish a definitive guideline [27].

Ultimately, the definitive management of preeclampsia and eclampsia involves prompt delivery of the fetus, with careful consideration of both maternal and fetal health status [22].

Massive obstetric hemorrhage and subsequent hypovolemic shock remain among the principal indications for CCU admission in pregnant patients. Antepartum bleeding commonly results from ruptured ectopic pregnancies, placental abruption, or abnormal placental attachment such as placenta accreta, while postpartum hemorrhage (PPH) remains a leading cause of maternal death [22,25]. Defined as blood loss exceeding 1,500 mL or accompanied by shock symptoms, major hemorrhage demands urgent intervention [28]. Atonic uterus is the predominant cause of PPH, guided by the "4Ts"—Tone, Trauma, Tissue, and Thrombin [29]. Hemodynamically unstable patients should be closely monitored, with transfusion indicated for hemoglobin <8 g/dL or coagulation dysfunction. Management includes oxytocin (10 U/h), ergometrine (0.5 mg IV/IM), and rectal misoprostol (up to 800 µg), coupled with uterine massage [30]. If these interventions fail, uterine artery embolization or cesarean hysterectomy may be necessary to prevent fatal outcomes [31].

Amniotic fluid embolism (AFE)—also known as anaphylactoid syndrome of pregnancy—is a rare but highly lethal condition (~80% mortality). It is triggered by maternal exposure to fetal antigens during delivery, leading to acute pulmonary and systemic vascular resistance, impaired cardiac output, and coagulopathy [32,33]. AFE is diagnosed based on clinical presentation—severe hypoxia, cardiovascular collapse, and coagulopathy—since no definitive diagnostic test exists [34]. Treatment is largely supportive, including CPR, fluid resuscitation, blood product replacement, anticoagulation, and oxygenation or mechanical ventilation [33].

3. Physiological Changes in Pregnancy

3.1. Cardiovascular Adaptations:
Pregnancy induces significant increases in plasma volume (~1,500 mL) and cardiac output, due to elevated heart rate and stroke volume. Despite this, systemic vascular resistance drops, leading to slightly reduced blood pressure early in pregnancy, which rises again near term [35–38]. Uterine artery flow increases to over 300 mL/min by week 36, contributing to up to 20% of maternal cardiac output. Any maternal compromise such as hypoxia or hypotension can drastically reduce placental perfusion, causing fetal acidosis or demise [39].

3.2. Respiratory Changes:
Anatomical changes include upper airway edema and diaphragm elevation, resulting in decreased functional residual capacity (FRC) by 15–20% at term [40]. Progesterone drives a 40–50% increase in minute ventilation via enhanced tidal volume, leading to compensated respiratory alkalosis ($PaCO_2$: 28–32 mmHg; bicarbonate: 18–21 mEq/L) [41,42].

3.3. Hematological, Renal, and GI Changes:
Dilutional anemia occurs due to plasma expansion. Coagulability increases with elevated fibrinogen and clotting factors, while renal hyperfiltration reduces serum creatinine [43,44]. Lower esophageal sphincter tone and increased intra-abdominal pressure raise aspiration risk [45].

4. ICU Admission Timing
Pregnant women may require ICU care at any gestational stage. Notably, unrecognized pregnancies contributed to 19% of antepartum ICU admissions in one report. Early consultation with obstetric teams is essential to manage the pregnancy stage effectively. Fetal loss risk is significant, especially in first-trimester admissions (~65% loss rate) [46]. Viability becomes crucial after 23–24 weeks, where neonatal resuscitation may be feasible [39,47].

5. Patient Positioning in ICU
Proper positioning minimizes complications such as edema, thrombosis, aspiration, and pressure injuries. Supine positioning can lead to aortocaval compression, reducing venous return and cardiac output—potentially causing maternal collapse. Therefore, a left lateral tilt (achieved with a wedge under the right hip) is recommended. Critically unstable patients should be placed fully in the left lateral position [39,51].

6. Airway Management Challenges
Pregnancy presents unique challenges in airway control due to anatomical and physiological changes: airway edema, reduced FRC, increased oxygen consumption, and aspiration risk. Obesity further complicates ventilation and intubation, which may require smaller endotracheal tubes and rapid sequence induction. Experienced personnel should manage intubation due to the higher failure rate [40,45,52,53].

7. Vascular Access Considerations
Pregnancy-induced vasodilation may facilitate peripheral IV access. Central venous access remains anatomically feasible but the femoral route is discouraged due to thrombosis risk. Central line complications such as infection and thrombosis can significantly impact maternal and fetal outcomes, necessitating anticoagulation or surgical intervention [54,55].

8. Obesity in Critical Care
The global rise in maternal obesity is associated with elevated obstetric risks. In critical care, obesity complicates positioning, increases DVT risk, affects airway management and ventilation, and alters drug pharmacokinetics [40]. It also heightens surgical difficulty and hemorrhage risk during cesarean

sections [56–59]. While "obesity paradox" data exist for non-pregnant ICU patients, no protective effects are confirmed in obstetric populations [60,61]

9. Respiratory Monitoring and Blood Gases:

The literature on mechanical ventilation strategies in critically ill pregnant patients is limited, and current clinical approaches often draw from evidence in non-obstetric populations. Determining appropriate ventilation parameters is challenging, even in the absence of underlying pulmonary disease. It remains uncertain whether the physiological maternal respiratory alkalosis should be replicated in these patients. While this has been recommended by some, clinical practice does not consistently aim to maintain such alkalosis, as case series suggest a more relaxed approach [45,62].

Further complexity arises in scenarios involving severe pulmonary pathology, such as acute respiratory distress syndrome (ARDS), or in cases where specific pCO_2 targets may benefit maternal conditions like elevated intracranial pressure. In these situations, oxygenation remains a primary goal; however, there is limited robust evidence to define precise PaO_2 targets. Moderate levels of hypoxia may be clinically tolerated in critical care settings, although individualized management is advised, as discussed in the literature on acute respiratory failure in pregnancy [62,63].

9.1. Ventilation Strategies in Pregnant ICU Patients

Positive pressure ventilation can be administered non-invasively (NIPPV) or invasively via endotracheal intubation or tracheostomy. When considering NIPPV, certain clinical conditions must be met—such as intact respiratory drive, hemodynamic stability, and minimal airway secretions [64]. NIPPV has shown clinical benefits in pregnant patients with obstructive lung conditions and sleep-disordered breathing [65].

Despite some favorable outcomes reported in case studies, NIPPV must be used cautiously in pregnancy due to an increased risk of aspiration. Therefore, clinicians are advised to maintain a low threshold for converting to endotracheal intubation. Ventilation protocols should be tailored to the unique respiratory physiology of pregnancy. For instance, upper airway swelling common in pregnancy necessitates using smaller endotracheal tubes to avoid complications like increased resistance and weaning difficulties during prolonged ventilation.

In cases where standard ventilation fails, advanced techniques like Airway Pressure Release Ventilation (APRV) and High-Frequency Oscillatory Ventilation (HFOV) have been explored, though further studies are needed to validate their safety and efficacy in pregnant populations [66].

Table (3): ICU procedures in the studied literatures

Procedure	Leung	Ng	Vargas	Fatnic	Liu
Intubation	-	10	32	21.7	65.8
Cardiopulmonary resuscitation	-	3	-	8.7	16.45
Mechanical ventilation	58	2	68	-	65.8
Invasive positive pressure ventilation	57	-	-	69.6	-
Blood/component transfusion	-	54	48	-	51.3
Venous line	52	27	-	-	-
Arterial line	66	36	-	-	-
Use of Inotropes	16	3	-	-	-

There are limited but notable reports documenting the effective use of prone positioning in pregnant patients [67]. However, these are primarily based on small-scale studies and case series, and to date, no clear evidence demonstrates a survival advantage. Although pregnancy was historically seen as a contraindication for prone ventilation, successful individual cases have been described. When utilized, continuous fetal monitoring is advisable to ensure fetal well-being during the procedure.

Extracorporeal membrane oxygenation (ECMO) was employed in 12 pregnant patients during the 2009 H1N1 influenza outbreak. It is recommended for early use in severe respiratory failure that does not respond to conventional oxygen therapy. Despite its potential benefits, ECMO carries significant drawbacks, particularly the exposure of the fetus to extracorporeal circulation and maternal systemic anticoagulation. Additionally, ECMO is generally only accessible in high-level tertiary care centers, and maternal bleeding remains a serious and potentially fatal complication [68].

10. Challenges in Sedation and Analgesia:

In critically ill pregnant patients, the use of sedatives and analgesics is generally guided by the same indications as in non-pregnant adults, with the rare exception of laboring women in intensive care. However, most clinical trials exclude pregnant participants, leaving a gap in evidence specific to this group. Nonetheless, anesthesia literature supports the safety of standard induction agents and opioids during pregnancy. Similarly, neuromuscular blockers are considered safe due to their minimal placental transfer [45].

Frequently utilized ICU sedatives—such as benzodiazepines (e.g., midazolam), opioids (e.g., morphine, fentanyl), and propofol—are commonly administered in pregnancy. These agents do cross the placenta and may have fetal implications [69]. Despite this, teratogenic effects have not been observed with typical anesthetic dosages, although limited data exist on long-term ICU exposure [45]. A case outside the ICU setting reported fetal cerebral vasoconstriction during extended morphine administration, which resolved upon switching to fentanyl [70]. Significant differences in sedation protocols have been noted globally, as highlighted by a case series documenting varied combinations in different centers [62].

Evidence on newer agents like dexmedetomidine in pregnancy remains scarce. Although the drug crosses the placenta, its retention in placental tissue reduces fetal exposure compared to clonidine. While its use in obstetric anesthesia has been reported, ICU-specific data are limited to case reports [69]. No definitive teratogenicity has been established, but clinicians must balance maternal benefit against fetal risk [71]. When sedatives are used, their potential impact on fetal assessments must be considered. Prolonged opioid exposure in utero may lead to neonatal abstinence syndrome [72].

11. Fluid Therapy

In the later stages of pregnancy, a significant portion of maternal cardiac output is directed toward the uteroplacental circulation. Consequently, maternal hypovolemia or shock can rapidly result in fetal compromise. Thus, prompt restoration of volume status and cardiac output is essential. However, current research does not support a specific fluid type for resuscitation in pregnant ICU patients, as many fluid studies have excluded pregnant participants or failed to disclose their inclusion [73,74].

Isotonic crystalloids are considered a safe first-line option for fluid replacement in this setting. Albumin may also be used safely, except in cases involving traumatic brain injury. On the other hand, synthetic colloids like starches are associated with serious adverse effects such as allergic reactions, kidney injury [41], and elevated mortality [43], and are therefore not recommended [73,75].

Determining fluid therapy in pregnancy is complicated. Without underlying cardiovascular or respiratory pathology, central venous pressure and pulmonary artery occlusion pressures tend to mirror non-pregnant levels [36]. However, the already expanded blood volume in pregnancy increases susceptibility to pulmonary edema if fluids are not carefully managed [76]. This risk is further heightened in patients with cardiac or hypertensive disorders [77]. As in other ICU settings, avoiding iatrogenic volume overload and maintaining neutral fluid balance is crucial. While diuretics should be used judiciously, furosemide can be effective in managing fluid overload when indicated [78].

12. Hemodynamic Monitoring

Managing hemodynamics in pregnant ICU patients requires a nuanced approach that blends clinical expertise with extrapolated data from general ICU populations. Evaluation of perfusion must consider the vasodilated physiological state of pregnancy and should include assessments of maternal organs and placental-fetal health [35].

Indications for invasive monitoring—such as the insertion of central or arterial lines—are similar to those in non-pregnant patients. However, studies in this population often lack detailed descriptions of interventions [14]. Research in obstetric high dependency units suggests that 30–40% of patients require invasive monitoring or central access [79,80]. ICU-based studies report a broader range: 12–15% for central lines and up to 70–75% for arterial lines [81–84].

Bedside echocardiography is increasingly advocated for use in critically ill pregnant women, especially those presenting with circulatory or respiratory distress. It is also useful in emergency situations such as maternal collapse, helping identify causes like pulmonary embolism [78]. Blood pressure during pregnancy varies based on gestational age, obesity, and parity [38]. Though no definitive ICU targets exist for pregnant patients, a MAP of 65 mmHg is often used, particularly in septic presentations [88]. Nonetheless, ovine studies suggest that systolic blood pressure below 80 mmHg may quickly lead to fetal hypoxia and bradycardia, requiring individualized management [89].

Vasopressors or inotropes may be necessary to support circulation. While limited data exist to guide their selection in pregnancy, concerns typically focus on uterine vasoconstriction and impaired placental perfusion. Uterine arteries are particularly sensitive to adrenergic stimuli [38]. Noradrenaline is currently recommended as the first-line vasopressor [38,88,90], and one study demonstrated superior performance compared to phenylephrine during surgical delivery [91]. Vasopressin may be employed as a secondary agent [88]. For inotropic support, adrenaline and dobutamine are commonly used. Levosimendan has been trialed in cases of peripartum cardiomyopathy [92,93], whereas data on milrinone use are lacking. In severe cases unresponsive to medication and mechanical ventilation, ECMO has proven life-saving in select pregnancies [49,39]

13. Renal Challenges:

As in other ICU patient populations, renal failure in the pregnant ICU patient may be prerenal, renal, or postrenal, and may or may not require renal replacement therapy. Women may develop acute kidney injury due to a pregnancy-related illness such as preeclampsia or peripartum cardiomyopathy, a complication of labor and delivery such as postpartum hemorrhage (PPH), or as part of another superimposed disease process such as sepsis. Women with chronic kidney disease may also become pregnant and require ICU care [35].

There is very little literature regarding the intensive care management of renal failure in the pregnant patient. In general, ICU management is similar to the non-pregnant population, with the focus on defending renal perfusion by optimizing the volume state, cardiac output, and blood pressure, treatment of the underlying condition, and avoidance of aggravating factors such as nephrotoxic drugs. Optimal strategies regarding the mode, timing, and intensity of renal replacement therapy in the general ICU population are still being evaluated. In the non-ICU pregnant population on long-term hemodialysis, there is evidence that intensified dialysis is required and that it improves maternal and fetal outcomes, although it is unclear how this translates into the ICU setting [94-96].

14. Metabolic Monitoring

Pregnancy is naturally accompanied by physiological respiratory alkalosis. This change leads to a slight metabolic acidosis with a normal anion gap, mainly as a compensatory mechanism resulting from increased renal bicarbonate excretion. These adaptations must be considered when interpreting blood gas analyses. If a superimposed metabolic acidosis is suspected, clinicians should calculate the anion gap just as in non-pregnant patients. Notably, venous lactate concentrations remain consistent between pregnant and non-pregnant individuals. Elevated lactate levels, however, have been linked to more severe infections and higher mortality rates in pregnant women with sepsis in the UK cohort [97,98].

In late gestation, pregnant women are more prone to developing ketosis—even without preexisting or gestational diabetes [99,100]. This "starvation ketosis" may occur rapidly after brief periods of fasting or vomiting and can trigger serious metabolic abnormalities. The mechanism is believed to involve relative insulin deficiency exacerbated by placental hormones [100]. Other acid–base disturbances should also be investigated using the same principles applied to non-pregnant patients.

For ambulatory pregnant individuals with diabetes mellitus, tight glycemic control is encouraged—without inducing hypoglycemia [101]. However, overly strict glucose regulation has been associated with higher mortality in general ICU populations, and hypoglycemia alone is a known independent risk factor for death in critically ill patients [102]. Since there is a lack of pregnancy-specific guidance, glycemic management in critically ill pregnant women should largely follow general ICU protocols, focusing on the avoidance of both hypo- and hyperglycemia, even though precise therapeutic thresholds remain uncertain [103].

15. Blood Transfusion Challenges

In scenarios lacking active bleeding, such as postpartum hemorrhage (PPH), guidance on transfusion practices in critically ill pregnant women is limited. Major ICU studies that examine transfusion thresholds often omit pregnant participants entirely or fail to identify them in their data sets [104,105]. Evidence from non-ICU obstetric populations suggests that transfusion may sometimes be administered unnecessarily, indicating potential overuse [106]. One retrospective review linked blood transfusion in the ICU setting to an increased risk of fetal loss [46].

Current recommendations favor a restrictive transfusion strategy, suggesting a hemoglobin threshold of 70 g/L—similar to non-obstetric ICU patients [106]. When transfusion is necessary, cytomegalovirus (CMV)-negative blood is preferred. Additionally, identifying and managing maternal alloantibodies is critical, as these can complicate blood typing and matching, thus limiting the availability of suitable blood products [107].

In cases of massive obstetric hemorrhage, rapid diagnosis and coordinated multidisciplinary care are imperative. Well-established protocols exist to manage such situations, encompassing surgical options, interventional radiology, and comprehensive transfusion guidelines. All healthcare facilities providing maternity care should have predefined PPH emergency protocols in place [108,109].

15.1. Hemorrhage Management

Obstetric hemorrhage can result from several etiologies, including uterine atony, abnormal placentation (such as previa or accreta variants), uterine rupture, and trauma to the genital tract. First-line treatments involve uterotonics, uterine massage, controlled cord traction, and interventions like intrauterine balloon tamponade or uterine artery embolization. However, in some cases, even surgical approaches like hysterectomy may fail to stop the bleeding [66].

Conventional vital signs may lag in detecting hemorrhagic shock. The Shock Index (SI)—calculated as heart rate divided by systolic blood pressure—offers a more sensitive metric. In obstetric patients, an SI of 0.7–0.9 is considered normal. SI values of 0.9, 1.4, and 1.7 are used to determine referral needs, ICU admission, and high-risk status, respectively, although more validation is needed before widespread adoption [110,111].

Low plasma fibrinogen levels are predictive of worsening hemorrhage. A concentration below 2 g/L early in PPH correlates with a higher likelihood of severe blood loss [113]. Each 1 g/L drop in fibrinogen raises the risk of severe PPH by approximately 2.6 times [112]. Thus, early administration of fibrinogen concentrates based on thromboelastography can be life-saving [114]. Additionally, FIBTEM assays—particularly the A5 reading available within 10 minutes—offer earlier detection of fibrin depletion than standard fibrinogen measurements [115].

There is no universally accepted blood component ratio for managing PPH. However, common massive transfusion protocols include either a 4:4:1 or a 1:1:1 ratio of red blood cells, plasma, and platelets [116]. Although formula-driven transfusion strategies are widely used, goal-directed therapy based on real-time coagulation testing (e.g., thromboelastography or rotational thromboelastometry) is emerging but remains investigational [117].

Early intervention with fibrinogen concentrate and tranexamic acid has shown potential, though more robust clinical data are needed [118]. Activated recombinant Factor VII has also gained traction as a salvage therapy for life-threatening PPH and hysterectomy prevention, though it is costly, lacks FDA approval, and awaits stronger evidence before becoming a routine intervention [119].

16. Deep Venous Thrombosis Prophylaxis:

Pregnancy increases the risk of deep vein thrombosis (DVT) at any stage, with over 80% of cases affecting the left leg, particularly involving the ileofemoral or isolated iliac veins [120]. The use of indwelling vascular catheters adds to the thrombotic risk. Risk factors for antepartum DVT include maternal age above 35 years, obesity (BMI $\geq$ 30 kg/m^2), and hospital stays for non-delivery reasons longer than three days [121]. The postpartum period—especially after emergency cesarean section, preterm birth, or infection—is the most vulnerable phase for developing DVT [122,123].

Although ICU admission is a known DVT risk in the general population, its prevalence among critically ill pregnant women is poorly characterized. Most major ICU studies exploring DVT prophylaxis omit pregnant participants [124]. While obstetric thromboprophylaxis guidelines do not list ICU admission as a direct risk, other related factors—like immobility or existing comorbidities—substantially elevate DVT risk [125,126].

Heparins, including unfractionated and low molecular weight heparins (LMWH), are the preferred pharmacologic prophylaxis as they do not cross the placenta. LMWH is favored for its reliable dosing and safety profile in pregnancy. Additionally, mechanical methods such as sequential compression devices may be used alongside pharmacologic agents, though their efficacy in pregnancy remains under-evaluated [126].

17. Nutritional Support

The nutritional management of critically ill patients remains complex, with ongoing debate regarding the ideal formulation, dosage, and route of administration. These uncertainties are further compounded in pregnancy due to the absence of specific evidence or inclusion of pregnant patients in validated screening tools that guide nutritional therapy [127].

Both undernutrition and excessive caloric intake during pregnancy can negatively affect outcomes [128]. In women with a normal BMI, calorie and macronutrient needs increase modestly in the second and third trimesters. Additionally, late-pregnancy metabolic changes, such as increased risk of starvation ketosis—even without diabetes—must be accounted for [100].

In critically ill pregnant women, artificial nutrition must address both the pregnancy-specific and illness-related metabolic demands. Factors like the woman's pre-illness nutritional status and ICU diagnosis will further influence needs. Following general ICU protocols, enteral nutrition is preferred and should ideally commence within 24 to 48 hours of admission. However, the best method for estimating caloric requirements—whether by indirect calorimetry or predictive equations—remains unclear. In such cases, input from a clinical dietitian is highly recommended [129].

18. Sepsis in Pregnancy

Maternal sepsis accounts for around 15% of pregnancy-related deaths globally [130]. A significant gap exists in standardized sepsis definitions and treatment guidelines for pregnant women, which has prompted the Royal College of Obstetricians and Gynaecologists (RCOG) to create specific protocols, including risk assessment tools and clinical scoring systems [131].

Sepsis in pregnancy often presents atypically due to physiological changes, making early diagnosis more difficult. Furthermore, the standard signs of sepsis may be absent or blunted in pregnant patients, and no universal definition of sepsis for this group has been established [66].

In developed countries, puerperal sepsis and urinary tract infections are leading causes. In contrast, HIV, malaria, and pneumonia are more prevalent causes in lower-resource settings. Septic shock most commonly results from infections like pyelonephritis, chorioamnionitis, and endometritis [132,133]. Certain infections, including those caused by hepatitis E, herpes simplex, and malaria, tend to be more severe during pregnancy [134]. Besides systemic symptoms, localized signs like pelvic pain, urinary urgency, or diarrhea may be present. Prognosis is often better for pregnant patients compared to the general ICU population due to younger age, fewer chronic illnesses, and usually a localized source of infection [135].

18.1. Use of Antimicrobials

Effective antimicrobial therapy and prompt source control are essential in managing sepsis. In addition to blood cultures, specimens should be obtained from the uterus or vagina for culture and sensitivity testing. Imaging modalities like pelvic ultrasound or CT may assist in detecting abscesses or pyometra. Selecting the optimal antibiotic regimen involves balancing fetal safety with antimicrobial efficacy [136].

Commonly used combinations in obstetric sepsis include ampicillin, gentamicin, clindamycin, or metronidazole. Treatment typically lasts 7–10 days, but de-escalation is challenging because most infections are polymicrobial [137].

The U.S. FDA categorizes drugs from A (safest) to X (contraindicated) based on fetal risk. Common antibiotics like penicillins, cephalosporins, macrolides, and acyclovir fall into Category A, while aminoglycosides, quinolones, vancomycin, and amphotericin are Category C. This classification should guide ICU physicians' prescribing decisions. The general rule, "avoid unnecessary medications during pregnancy," remains valid. Due to hormonal changes, pregnant women are prone to vaginal candidiasis. Topical azoles are the recommended first-line treatment in the first trimester.

Oral fluconazole (Category D) has been linked to a heightened risk of miscarriage and teratogenic effects, especially at high doses [66].

19. Post-treatment Prognostic Tools

Assessing severity and anticipating outcomes in critically ill obstetric patients is vital for guiding care and determining ICU admission criteria. Although these tools were originally validated in non-pregnant populations, scoring systems such as APACHE II (Acute Physiology and Chronic Health Evaluation), SOFA (Sequential Organ Failure Assessment), SAPS II (Simplified Acute Physiology Score), and the Mortality Prediction Model (MPM) have been proposed for use in critically ill pregnant women [138].

Table (4): Scoring systems in the studied literatures

Authors (year)	SOFA	TISS	SAPS	APACHI
Leung et al. (2010)	3.7	-	28	16
Vargas et al. (2019)	4	30	26	-
Minville et al. (2022)	2	20	14	7
Range	2 – 4	20 – 30	14 – 28	7 – 16
Mean ± SD	3.23 ± 0.82	25.0 ± 5.0	22.7 ± 5.78	11.5 ± 4.5

El-Solh and Grant [139] observed that the mortality predictions for obstetric patients admitted to the ICU, as calculated using APACHE II, SAPS II, and MPM II scoring systems, were comparable to those observed in non-obstetric patients of similar age. Similarly, research by Aarvold et al. [140] showed that the Sepsis in Obstetric Score did not offer any additional predictive value over general scoring tools when applied to septic obstetric patients. Therefore, although these scoring systems are frequently used as adjunctive measures in critical care, none have consistently demonstrated reliable prognostic value for obstetric populations.

A key reason for this limitation is that physiological alterations in pregnancy—such as increased heart rate, leukocytosis, and reduced serum creatinine—can falsely elevate scores like APACHE II, potentially overstating mortality risk. Notably, several studies have reported better-than-expected outcomes when scoring systems are applied to obstetric cases [141]. Moreover, many clinical parameters significantly improve post-delivery, further complicating mortality risk assessments during the peripartum period. Lastly, there is currently no research comparing the effectiveness of these scoring systems specifically within Critical Care Unit (CCU) settings [9].

Table (5): Duration of ICU and hospital stay

Authors (year)	ICU duration (days)	Hospital stay (days)
Leung et al. (2010)	2	10
Ng et al. (2014)	1.8	6
Vargas et al. (2019)	5	18
Minville et al. (2022)	3.4	13
Fatnic et al. (2023)	21	20
Range	1.8 – 21	6 – 20
Mean ± SD	6.03 ± 4.99	13.4 ± 4.48

The Obstetric Early Warning Score (OEWS) has emerged as a highly reliable tool for predicting outcomes in obstetric patients admitted to Critical Care Units (CCUs) [142]. It integrates several clinical indicators typically used in early warning systems—such as systolic and diastolic blood pressure, respiratory rate, heart rate, body temperature in degrees Celsius, oxygen requirements to maintain saturation above 96%, and the patient's level of consciousness. The method of delivery (vaginal or cesarean) is also considered during the assessment. Based on the scoring, a value of 0

implies normal care, while scores of 1 and 2 signify yellow and red alert levels, respectively, reflecting increasing clinical concern [143].
Evidence indicates that OEWS is particularly effective in identifying patients at risk of deterioration, a conclusion supported by both the American College of Obstetricians and Gynecologists and the Royal College of Obstetricians and Gynaecologists [4,13]. However, although OEWS shows promise in risk stratification, its definitive role in reducing maternal mortality has yet to be validated through larger studies [144]. Thus, OEWS should be viewed as a supplementary tool, and final care decisions must be based on clinical judgment, patient and family preferences, and a multidisciplinary approach [9].
Despite the severity of complications experienced by many pregnant individuals, only a small subset are admitted to CCUs. These units, recognized for delivering high-quality care, are often not necessary for every obstetric complication. Many such patients primarily require supportive care and non-invasive monitoring. Therefore, setting up dedicated intermediate care units tailored for obstetric patients could help reduce patient stress and healthcare burden [145]. Oversight of these specialized units should be entrusted to an experienced obstetrician, supported by a multidisciplinary team that may include anesthetists, intensivists, fetal medicine specialists, and neonatologists. The development of structured protocols and care pathways—based on the underlying condition and reasons for admission—is crucial for ensuring timely identification of high-risk patients and determining appropriate care levels. Such frameworks not only elevate patient care but may also streamline resources by minimizing unnecessary CCU admissions [20,145].

20. Fetal Monitoring in the ICU

Guidelines for fetal monitoring in critically ill pregnant women are sparse and practices vary widely across regions. Monitoring modalities include continuous cardiotocography (CTG), fetal heart auscultation, biophysical profiling, and obstetric ultrasound. However, interpretation can be challenging due to the effects of maternal illness, sedation, or medical interventions. These procedures should always be carried out by experienced personnel familiar with maternal-fetal physiology [69,70].
In scenarios involving maternal cardiac arrest, CTG monitoring should be promptly initiated and continued until maternal clinical stability is restored [39]. In early gestation, detecting a fetal heartbeat is often adequate to confirm viability. In later stages, comprehensive fetal monitoring should be considered only when fetal viability is established and when delivery is being considered for either maternal or fetal benefit [35].

21. Delivery Considerations in Critical Care

When a critically ill pregnant woman has reached a viable gestational age, the healthcare team should begin preparations for potential delivery—even if immediate delivery is not anticipated. Decisions to proceed with delivery should weigh maternal and fetal conditions and require collaboration among specialists, including intensivists, obstetricians, anesthesiologists, neonatologists, and possibly hematologists [35]. If the woman is conscious and capable, she should be included in the decision-making process. If not, her partner or next of kin should be consulted.
The delivery route should adhere to standard obstetric guidelines [41]. Although general improvements in maternal status post-delivery have not been universally demonstrated, some women with critical respiratory conditions may benefit from childbirth [62]. Delivery should not be used solely to enhance maternal oxygenation or ventilatory capacity, except in the context of an unresponsive maternal cardiac arrest. In such emergencies, perimortem cesarean section is "strongly advised" [39]. Ideally, this should be performed within five minutes of maternal collapse. However, this time frame has been questioned for its clinical practicality and evidence base [146].

Table (6): Incidence of maternal and fetal mortality in the ICU

Mortality	Maternal (%)	Neonatal (%)
Leung et al. (2010)	6	8
Ng et al. (2014)	3	6
Minville et al. (2022)	0.47	7.58

Fatnic et al. (2023)	6.52	4.35
Range	0.47 – 6.52	4.35 – 8.0
Mean ± SD	4.45 ± 2.17	6.48 ± 1.31

22. Conclusion:

Critical care in obstetrics presents unique clinical challenges requiring prompt recognition and a well-coordinated multidisciplinary approach. Physiological adaptations during pregnancy influence disease presentation, complicating diagnosis and treatment. Management strategies, though often adapted from general ICU practice, must be tailored to maternal-fetal physiology. Conditions such as preeclampsia, obstetric hemorrhage, sepsis, and cardiopulmonary complications dominate reasons for maternal ICU admission. Scoring systems such as OEWS show promise but still require further validation to replace general severity indices like APACHE II or SOFA, which often overestimate mortality. Interventions including appropriate respiratory management, fluid balance, sedation, metabolic monitoring, and fetal surveillance must be carefully considered and individualized.

23. Future Perspectives:

Going forward, several areas need urgent attention:

1. **Standardized Guidelines for Obstetric ICU Care**: There is a need for globally accepted, pregnancy-specific ICU protocols, including validated scoring systems, fluid and sedation management, and sepsis definitions.
2. **Large-Scale Multicentric Research**: Due to the exclusion of pregnant women from most critical care trials, future research should specifically include obstetric patients to derive evidence-based recommendations.
3. **Specialized Obstetric Intermediate Care Units**: Establishing step-down units between maternity wards and ICUs may optimize resource use, prevent unnecessary ICU admissions, and improve outcomes.
4. **Advanced Monitoring Tools**: Development and integration of tools for early recognition of clinical deterioration and accurate prediction of maternal and fetal outcomes will enhance care.
5. **Training and Multidisciplinary Teams**: Continued investment in obstetric critical care training and collaboration among intensivists, obstetricians, anesthetists, neonatologists, and nursing staff is vital for optimal outcomes.
6. **Technological Integration**: The application of AI-assisted decision-making, electronic early warning systems, and real-time fetal-maternal monitoring holds potential to revolutionize critical obstetric care.

Addressing these challenges through innovation, clinical vigilance, and policy reforms will help bridge the current gaps in maternal critical care and contribute toward achieving global maternal mortality reduction targets.

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