07 October 2022
No. 18

Maternal Critical Care

Babalwa Ngxabi

Moderator: Dr C Chellan

School of Clinical Medicine

Discipline of Anaesthesiology and Critical Care

TABLE OF CONTENTS

INTRODUCTION

Whilst pregnancy is often a delightful experience with exciting outcomes, on the extreme end of the spectrum is critical illness which, although rare, may have catastrophic consequences for both the mother and the foetus. Critically ill obstetric patients pose a unique challenge due to the altered physiological adaptations and the consideration of the indwelling life whose outcome depends on maternal well-being(1). Favourable maternal and foetal outcomes require a multidisciplinary team approach that ensures that critically ill pregnant women receive the same standard of care for their critical illness and pregnancy- related needs by experts in the respective fields(2). There seems to be a paucity of clearly defined guidelines for the management of the critically ill obstetric patient, most intensivists apply general intensive care principles in the care of these patients. The reason for this is largely due to reluctance to include pregnant women in clinical trials(3). This has limited the body of evidence and progression of research on this population. More recently there has been an increase interest in the health of pregnant women particularly with critical illness and a shift in research institutes into including pregnant women in clinical trials(3).

There is no consistent definition of maternal critical illness, but it can be described according to:

- disease-specific criteria e.g., eclampsia;
- organ specific criteria or organ dysfunction e.g., heart failure
- treatment specific criteria e.g., requiring ventilation(3).

Inconsistencies in “peripartum” time frames is an additional cofounder in maternal critical illness epidemiology(3). For every pregnant woman who dies, nine other women develop severe maternal morbidity, most of which will require treatment in an intensive care unit or high dependency unit. Maternal death is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of duration or site of the pregnancy(4). While maternal mortality is an important marker of quality of maternal healthcare, maternal deaths in absolute numbers are rare(5). Maternal death is often referred to as the tip of the maternal morbidity iceberg, the size of which is unknown. The WHO has introduced the concept of maternal near miss to overcome this challenge. A “maternal near miss case” is defined as a woman who survived a life-threatening

condition or complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy(5). Severe adverse maternal (SAM) outcomes include both maternal near miss cases and maternal deaths(6).

Epidemiology of critical illness in pregnancy

According to the latest saving mothers triennial report (2017-2019), great progress has been made in reducing mortality rates in South Africa(7). The iMMR(institutional maternal mortality ratio) fell below 100 per 100000 live births for the first time in 2019(7).

The biggest contributors to maternal mortality and morbidity were the 5H's:

- **H**IV
- **H**aemorrhage
- **H**ypertensive disorder
- **H**eart conditions and other medical and surgical conditions
- Complications that occur in the first half **H**alf of pregnancy (miscarriages, ectopics & termination of pregnancies)(7).

We are however still far from achieving the UN SDG goal which aims to reduce maternal mortality rates to < 70 per 100 000 live births by the year 2030. During the COVID 19 pandemic there were marked increase in maternal mortality rates, with the greatest peak in mortality coinciding with the first wave(8), as depicted in *figure 1* below..

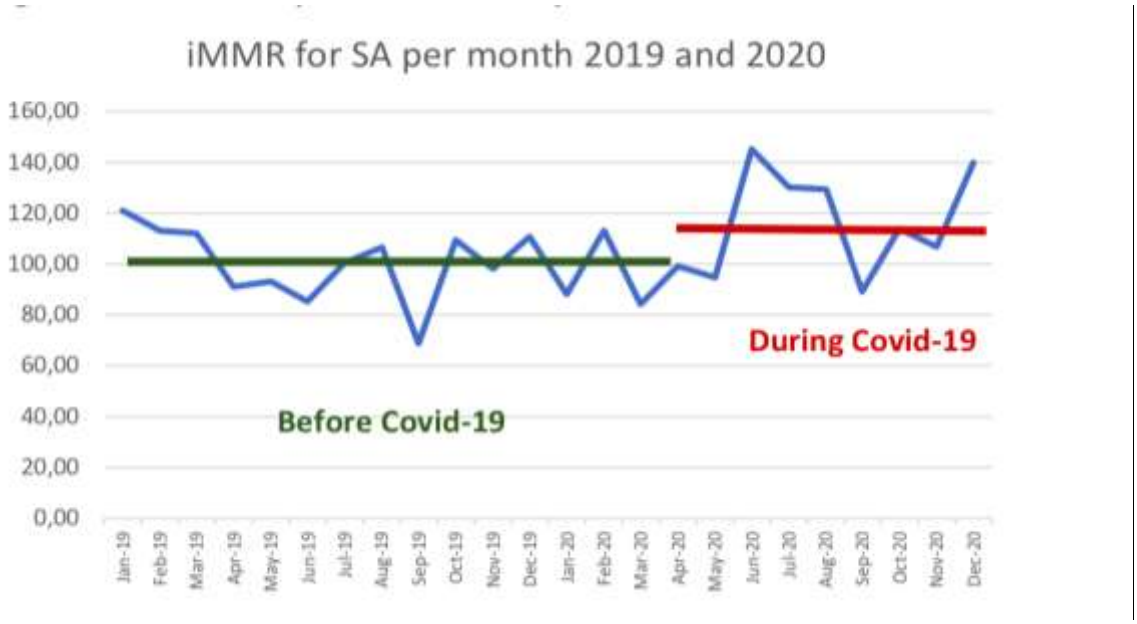

Figure 1. *iMMR in SA per month January to December 2020*

Where to care?

Women in the peripartum period should receive high quality critical care regardless of their location. The ideal location depends on several variables including the local organization of critical care services, whether the patient is intrapartum or not and the progression of the patient's organ failure(9). Ongoing collaboration by the critical care team, maternity team and anaesthetic team is needed at a senior level(9). Although delivery of the foetus in critical illness is not mandatory, it should be strongly considered in any woman who is near term who requires organ support(9). The final decision should be made by a multidisciplinary team on an individual basis, with careful consideration of risks, benefits, and timing(9).

The UK department of health described 4 level of cares for obstetric patients(10):

- **Level 0:** Care can be provided to low risk women in a general ward
- **Level 1:** Patients require non-invasive monitoring
- **Level 2:** Single organ support is required
- **Level 3:** Two or more organ support or mechanical ventilation for respiratory support is required

Level 1 & 2 patients can be admitted in a high dependency unit, whereas level 3 patients require care in ICU(10).

Pregnancy induced alterations in physiology and laboratory results

Pregnancy results in major alterations to almost all maternal systems including cardiovascular, respiratory, renal, haematological, and metabolic systems(11). These changes will result in affectation of various laboratory measurements and few labs will provide normal reference ranges for pregnant women(11). It is important for clinicians managing these patients to be aware of these normal variations. *Table 1* below depicts average physiological changes associated with pregnancy as adopted from the textbook Morgan and Mikhail(12). The altered laboratory values are attached as an appendix to this booklet – *Appendix B*.

Table (i)

Cardiovascular		**Respiratory**		**Haematological**	
Parameter	Change	Parameter	Change	Parameter	Change
Blood volume	+ 35%	Oxygen consumption	+ 20-50%	Haemoglobin	- 20%
Plasma volume	+ 55%	FRC	- 20%	Platelets	- 10%
Cardiac output	+ 40%	Minute ventilation	+ 50%	Clotting factors	+ 30-250%
Stroke volume	+ 30%	Tidal volume	+ 40%	**Renal**	
Heart rate	+ 20%	Respiratory rate	+ 15%	Parameter	Change
Systolic BP	- 5%	PaO2	+ 10%	Glomerular Filtration rate	+ 50%
Diastolic BP	-15%	PaCO2	- 15%	**Neurological**	
Peripheral resistance	-15%	HCO3	- 15%	MAC(minimum alveolar concentration)	- 40%

Identifying the critically ill pregnant woman

Early recognition of the critically ill pregnant woman using early warning systems such as the **Modified Early Obstetrics Warning System** (MEOWS) allows timeous escalation of monitoring and treatment care(13). However, there is still insufficient evidence in literature on the impact of such scoring systems in improving maternal morbidity. Prognostic criteria such as **APACHE** (acute physiology and chronic health evaluation) II and **SOFA** (sequential organ failure assessment) scores routinely used in non-pregnant critically ill patients may not as accurately predict mortality in pregnant patients(13). The reason for this is the physiological changes in pregnancy eg. an increased heart rate and alteration in white cell count may affect the scoring system(13).

Certain disease related obstetric risk scoring systems may be useful in this population(13). These include the **obstetrically modified qSOFA** (omqSOFA) for sepsis, the **miniPIERS** for pre-eclampsia and the **Shock Index** (SI) for major haemorrhage.

The omqSOFA is a bed side assessment tool that can be used without the need for awaiting biochemical results.

Table ii

Clinical parameter	Score
Systolic BP < 90mmHg(<100mmHg in non-pregnant patient)	1
Respiratory rate>25/min(>22/min in non-pregnant patient)	1
Altered mentation(GCS<15)	1
Infection + omqSOFA 2 or more = maternal sepsis. SOFA(sequential organ failure assessment)	

The **miniPIERS** which is the pre-eclampsia intergrated estimate of risk prediction model identifies the woman with pre-eclampsia who is at an increased risk of major complication or death(13). It includes the following parameters: parity, gestational age, headache/visual disturbances, chest pain/dyspnoea, vaginal bleeding with abdominal pain, systolic blood pressure and dipstick proteinuria(13).

The **shock index**, which is the ratio between the heart rate and the systolic BP, is a reliable tool in predicting early hemodynamic compromise in the bleeding obstetric patient even when individual vital signs are still within normal ranges. Scores of < 0.9 indicate a low risk of need for massive resuscitation and > 1.4 indicates an urgent need for intervention and possibly transfer to a greater level of care such as a tertiary care facility(13).

Indications for admissions of critically ill obstetric patients

Obstetric patients admitted to ICU may suffer from obstetric or non-obstetric conditions(10).

The obstetric conditions include:

- Complications of hypertensive disorders – including pre-eclampsia, eclampsia and HELLP syndrome

- Major obstetric haemorrhage – antepartum, postpartum haemorrhage and the bleeding ectopic
- Genitourinary infections – endometritis, chorioamnionitis
- Peripartum cardiomyopathy(10).

The non-obstetric indications include (10):

- Pre-existing medical conditions that worsened in pregnancy (e.g., cardiovascular diseases such as valvular heart lesions, autoimmune diseases e.g., SLE, myasthenia gravis, respiratory disease e.g. asthma, endocrine disorders e.g. diabetes mellitus)
- Conditions that are associated with the pregnancy e.g. infectious disease (pneumonia, pyelonephritis) and thrombo-embolic phenomena (DVTs, PE).
- Coincidental conditions that are not related to the pregnancy such as trauma, appendicitis, and cholecystitis.

Peripartum admission to ICU is generally considered a poor outcome. However, mortality amongst obstetric critical care patients is relatively low especially for those patients who are admitted for an obstetric related indication.

CPR in the pregnant woman

Maternal cardiac arrest is a low frequency event associated with high stakes, with the possibility of losing 2 lives with inappropriate and delayed response. Team preparedness needs to be enhanced by regular review of maternal arrest response plans as well as didactic and simulation sessions(14). Although cardiopulmonary resuscitation (CPR) of the pregnant woman is similar to that of a standard adult resuscitation, there are several unique aspects.

The American Heart Association recommends high quality chest compressions with minimal interruptions and hands placed on the centre of the chest like the non-pregnant patient(14). Previous recommendations to place hands higher up on the sternum were not backed by any scientific data.

Historically a left lateral tilt has been used to relieve aortocaval compression. The left lateral tilt has been shown to displace the heart laterally compromising the quality of the

chest compressions which has major impact on the success of the resuscitation(14). Continuous manual left uterine displacement is preferred over lateral tilt. This is a class I recommendation, with level C evidence.

The recommendations with regards to defibrillation are similar to those of non-pregnant patients(14). Transthoracic impedance is unaltered with pregnancy and therefore energy requirements for defibrillation are the same. The medical therapy used during maternal cardiac arrest is like that of non-pregnant patients. We use the usual drugs, usual dosing, and time intervals. The FDA categories of foetal risk do not apply in the setting of cardiac arrest(14). Even though physiological changes of pregnancy may alter the volume of distribution and clearance of certain medications there is insufficient evidence to recommend a change in current drug dosing(14).

In terms of breathing and airway management, it is well known that pregnant patients have limited oxygen reserve and higher metabolic demands. Hypoxemia as a potential cause of maternal cardiac arrest should always be considered and earlier attention to airway and ventilatory support may be necessary. The recommendations are endotracheal intubation should be performed by an experienced laryngoscopist, with no more than 2 attempts at direct or video laryngoscopy prior to supraglottic airway device placement. Cricoid pressure is not routinely recommended, if it is used it should be removed if there is suboptimal laryngoscopy view(14).

Why perform a peri-mortem caesarean delivery?

The American Heart Association 2015 guidelines recommend that a perimortem caesarean delivery (PMCD) should be done at 4 minutes after failed resuscitative efforts(14). This was a Class I recommendation, level of evidence C. The time interval was chosen to reduce the risk of neurological damage that occurs after 4-6 minutes of an anoxic cardiac arrest. Shorter arrest to delivery times were associated with better outcomes. Several case reports of PMCD after maternal cardiac arrest resulted in ROSC and better maternal hemodynamic status. The woman should not be transferred to OT, but the PMCD should be done at the site of the resuscitation with an abbreviated antiseptic pour and a scalpel. This should be done to minimize the time spent waiting for surgical equipment and on lengthy antiseptic procedures. These were Class IIa recommendations, level C evidence(14).

Ethics of obstetric HCU and ICUs

Critically ill pregnant women pose multiple ethical dilemmas in critical care(13).

- In a brain dead parturient with a near viable gestational age: Should organ support be prolonged to maximize foetal outcomes?
- Decisions around timing of delivery of the critically ill mother: Is there an ideal time?
- Foetal distress in the critically ill term pregnant woman: Should termination of the pregnancy be rushed to save the baby vs risking mother's life? Saving the life of the mother should be the main priority(13).

However, in certain situations the decision may not always be straightforward when faced with the possibility of losing both lives. Decisions related to viability, beginning and end of life are complex and multi-faceted. They require shared decision making of a multidisciplinary team of experienced specialists, the family who may act as surrogates for the critically ill mother and ethical committee(13).

Somatic support after brain death in a pregnant woman

The term somatic support refers to the provision of non-neurological care and continued artificial life support for a brain-dead pregnant woman to act as an incubator for the maturing foetus(15). In such a scenario the intensivist must decide whether to attempt immediate delivery of the foetus who is past age of viability, continue to offer full support of the mother with the intention to allow time for foetal maturity or immediate discontinuation of the life support with the understanding that the foetus will also demise(15). This raises several ethical dilemmas. The economic cost of providing continued intensive somatic support is undeniably high. In a resource limited setting where critical care services are in demand the principle of distributive justice comes into play. Some points that require careful consideration in decision making process are, the gestational age of the foetus at time of maternal brain death, the wishes of the mother if they were previously indicated, the wishes of the next-of-kin, particularly the father of the foetus and the economic costs(15). Another ethical consideration in this scenario are the interests and rights of the foetus over the next of kin's decision to terminate support(15). In case of disagreement among family members or between physicians and family,

intervention by courts may be required. Finally, when considering the economic burden, the cost of caring for an extremely premature infant in neonatal ICU who may require a prolonged stay should be factored into the decision making(15).

Airway Management

The obstetric airway in the critically ill obstetric patient poses a uniquely challenging and stressful situation. The pregnant state which increases risk of anatomical and physiological airway difficulty is now compounded by extremely poor physiological reserves of critical illness. These patients may have acute respiratory failure, pulmonary oedema, hypotension, severe metabolic acidosis, and intracranial hypertension in setting of eclampsia. Taking all these into account there is the additional stress of foetal wellbeing.

The use of high flow humidified nasal oxygen, also known as transnasal humidified rapid insufflation ventilatory exchange (THRIVE), to increase apnoeic oxygenation time has gained momentum in critical care and has widespread applications in anaesthesia and intensive care(16). The physiology of apnoeic oxygenation is that it allows the bulk flow of oxygen from the pharynx to the alveoli and allows continued oxygen uptake in the alveoli even without lung expansion and diaphragmatic movement(16). High flow humidified oxygen results in a constant fraction of inspired oxygen, continued carbon dioxide clearance, a washout of anatomical dead space, good humidification and provides a low level of continuous positive airway pressure (CPAP)(16). It has been shown to increase safe apnoeic oxygenation time in non-pregnant patients(16). Although there is paucity of evidence surrounding its use in pregnant women, its routine use in the preoxygenation of the critically ill obstetric patient seems relevant and logical. It also has the additional benefit of hands-free oxygenation allowing the anaesthetist or intensivist to multi-task during a time critical situation(16).

Mechanical ventilation

ARDS(adult respiratory distress syndrome) accounts for as many as 19% of obstetric ICU admissions and is associated with high maternal mortality(17). The commonest causes

are community acquired pneumonia, HIV related opportunistic infections, aspiration pneumonitis, septic abortions, eclampsia/pre-eclampsia and more recently the SARS COVID-19 virus(17). The number of pregnant patients admitted to ICU in respiratory failure increased dramatically in the year 2020 during the first and second waves of the COVID-19 pandemic.

The clinical criteria for intubation are similar to those of non-pregnant patients. Blood gas criteria may vary as a normal $PaCO_2$ should be interpreted as a sign of impending respiratory failure in pregnancy(17). Foetal oxygenation requires PaO_2 > 70mmHg and maternal oxygen saturation > 95%. The physiological effects of pregnancy result in a reduction in chest wall compliance, FRC and residual volume. These increase the risk of alveolar collapse especially in the dependent areas of the lung. With the increased demands of pregnancy, a low tidal volume ventilatory strategy may not be adequate to maintain arterial oxygen saturations(17). Though permissive hypercapnia has not been studied in pregnancy it could theoretically cause maternal respiratory acidosis resulting in foetal acidosis(17). This could shift the foetal oxyhaemoglobin curve to the right, impairing oxygenation. In patients who have failed low tidal volume ventilation APRV(airway pressure release ventilation) should be considered as an alternative in severe ARDS. APRV may be the ideal mode in pregnant patients with severe ARDS in that it increases mean alveolar pressure with short release time allowing recruitment of collapsed lung while preventing overdistension of ventilated alveoli(17).

Respiratory physiology, blood gas changes and interpretation in pregnancy

Both respiratory mechanics and gaseous exchange are altered during normal pregnancy(11). The upward displacement of the diaphragm by the enlarged gravid uterus leads to a 20% reduction in functional residual capacity at term(11). Oxygen consumption increases by 20 – 50%, and to compensate for this maternal minute ventilation increases by up to 50%(12). The increase in minute ventilation is achieved mainly by an increase in tidal volume and to a lesser extent an increase in respiratory rate. As a result of this increase in minute ventilation a mild respiratory alkalosis and compensatory metabolic acidosis are found throughout pregnancy(12). The reduction in FRC and increase in maternal oxygen consumption results in poor maternal oxygen reserve, making the

pregnant patient at high risk of hypoxia even during short periods of apnoea. The table below compares normal arterial blood gas values of non-pregnant adult to those of a pregnant patient.

Table iii

Arterial Blood Gas Values		
Parameter	**Non-pregnant adult**	**Pregnant adult**
pH	7.35 – 7.45	7.40 – 7.47
P_aCO_2	35 – 45 mmHg	28 – 32 mmHg
P_aO_2	80 – 100 mmHg	>100 mmHg
HCO3	22 – 26 mmHg	18 – 21 mEq/L

Haemodynamic monitoring and fluid status assessment in obstetrics

Indications for haemodynamic monitoring in pregnancy can be classified into cardiac, pulmonary, and renal indications:

- Cardiac conditions include severe valvular heart disease (severe stenotic lesions with or without pulmonary hypertension), cardiomyopathy with significantly impaired LV EF and sudden CVS collapse with suspected AFE or PE.
- Pulmonary indications include severe ARDS, acute pulmonary oedema associated with severe pre-eclampsia and severe pulmonary disease complicated with pulmonary hypertension.
- Renal indications include severe pre-eclampsia with persistent oliguria
- Miscellaneous indications: septic shock refractory to fluid resuscitation and vasopressor therapy(18).

Monitoring can be divided into:

- Clinical monitoring: heart rate, respiratory rate, CRT, skin perfusion, urine output, level of consciousness
- Biochemical monitoring: lactate, mixed venous oxygen saturation, SvO_2, veno-arterial CO_2 difference, base deficit

- Haemodynamic monitoring: cardiac output, cardiac index, systemic vascular resistance, etc.(19)

Haemodynamic **monitoring modalities available** include invasive, minimally invasive, and non-invasive systems(20). Hemodynamic monitoring systems used in conjunction with treatment algorithms have the potential to improve patient outcomes.

Invasive monitors: the pulmonary artery catheter, first introduced in 1970, remains the gold standard hemodynamic monitor for measuring cardiac output many decades later(19). Concerns regarding the risk of complications with its use has limited its role in obstetric patients. However, its usual complications (subclavian injury, pneumothorax, arrhythmias, and cardiac injury) are no greater in pregnancy as compared to the general population(19).

Minimally invasive: the less invasive methods of measuring cardiac output utilize pulse contour and pulse power analysis and analyse the area under the arterial pressure waveform(19). The systems are divided into calibrated (PiCCO, LiDCOplus, volume view/EV1000 system) and non-calibrated (Flotrac, Vigileo, LiDCOrapid).

Haemodynamic variables that can be generated by the calibrated systems:

- Preload variables: Global End Diastolic Volume (GEDV), intrathoracic blood volume (ITBV), stroke volume variation (SVV), pulse pressure variation (PPV)
- Afterload parameters: Systemic vascular resistance(SVR)
- Contractility variables: Global ejection fraction (GEF), cardiac function index (CFI), maximum left ventricular contractility (dPmax)
- Excess lung water parameters: Extravascular lung water (EVLW), pulmonary vascular permeability index (PVPi) (19)

Most of these systems have not been validated in pregnancy with the exception of the LiDCOplus(20). LiDCOplus showed good agreement with low bias when validated against the PAC in 18 severely pre-eclamptic women. This system can be used in pregnant women after the first trimester due to lithium exposure being associated with risk of Ebstein's anomaly(20).

Non-invasive: these systems measure cardiac output based on aortic blood flow (transthoracic/transoesophageal echo, transoesophageal/suprasternal doppler),

changes in electrical resistance induced by vascular flow(bioimpedance, bioreactance) and based on non-invasive blood pressure monitoring(continuous non-invasive arterial pressure CNAP)(20). TTE allows rapid and reliable method of hemodynamic evaluation. It's low cost, portability and non-invasiveness make it an ideal CO monitor in pregnancy. However, expert training is required to obtain quality images for accurate estimation of stroke volume and cardiac output(20).

Role of haemodynamic monitors in severe pre-eclampsia:

Haemodynamic monitoring in setting of pre-eclampsia may assist in guiding the correct management of refractory oliguria, refractory hypertension and pulmonary oedema(11).

Refractory oliguria may be caused by three different haemodynamic subsets:

i. Intravascular volume depletion: the PAWP is low, SVR increased with hyperdynamic LV function – the treatment is volume resuscitation
ii. Renal arterio-spasm: the PAWP is increased, SVR and CO are normal – treatment is focused on reducing renal vasospasm
iii. Increased systemic vascular resistance and decreased cardiac output. These patients will respond to a reduction in afterload and diuresis to improve ventricular function.(11)

Refractory hypertension:
PAC may be useful in determining the cause and guide management of patients with refractory hypertension not responding to hydralazine and labetalol(11). However, its routine use in severely pre-eclamptic women cannot be recommended. The choice of haemodynamic monitor should be individualized according to the physician's best clinical judgement.

Pulmonary oedema:
Pre-eclamptic patients are at high risk of pulmonary oedema due to reduced colloid oncotic pressure. Iatrogenic fluid overload due to overzealous use of large volume of crystalloids for resuscitation can further compound this problem. Preload measurement is therefore a useful for the fluid management in these high-risk cases(11).

Feeding and nutritional support

Critical illness induces inflammatory, metabolic, and endocrine responses independent to the physiological nutritional needs of pregnancy(11). While there is extensive research on nutrition in critical illness in adult non-pregnant patients, evidence for appropriate and adequate nutrition for the critically ill pregnant patient is lacking. The same principles of nutrition should still apply to pregnant women. This includes the establishment of early enteral feeds within 24 – 48 hours of ICU admission(11). Feeding of the obstetric patient should never be delayed on the presumption of short ICU course. The advice of a dietician should be sought early for supplemental vitamins and trace elements appropriate for pregnancy(9).

Considering the gastrointestinal system alterations of pregnancy (reduced gastro-esophageal sphincter tone, reduced peristalsis and delayed gastric emptying), the usual strategies to reduce aspiration should be applied(9). These include 45 degrees head up and the use of a prokinetic agent.

Analgesia and sedation

A thorough knowledge of pregnancy induced pharmacokinetic and pharmacodynamic changes is essential in the optimal prescription for the critically ill parturient(17). In addition to this the knowledge of placental transfer, metabolism, foetal effects, and handling of drugs is also important. For ethical reasons experimental data on the pharmacology of drugs in parturient are limited. Many drugs used for analgesia and sedation are not licensed for use in pregnancy due to insufficient data, some of these drugs are used on an “off-label” basis. Available knowledge for prescribing certain drugs may be based on theoretical consideration, application of basic principles and weighing benefits against potential risks.

Remifentanil and fentanyl seem to be reasonable options for analgesia due to the organ independent elimination and unlike morphine, have no active metabolites(17). All opioids have the theoretical risk of increasing vagal tone resulting in a foetal bradycardia, reduced foetal heart rate variability and respiratory depression(17).

Midazolam seems to be a reasonable option for sedation(17). In a randomized controlled trial done by Esmaoglu et al comparing midazolam and dexmedetomidine in 40 eclamptic patients admitted to ICU, dexmedetomidine group was found to require less antihypertensive treatment and a shorter duration of ICU stay(21).

Thromboprophylaxis

The obstetric ICU patient has four times higher chance of developing deep vein thrombosis than the non-obstetric patient(17). This is due to the potentiation of all 3 components of Virchow's triad during pregnancy:

- The compression of the IVC by the gravid uterus results in stasis
- Increased production of clotting factors leads to hypercoagulability
- Vascular injury to the uteroplacental vessels during delivery causes endothelial injury(17).

All pregnant women admitted to ICU should be considered for VTE prophylaxis(1). Anticoagulation therapy may be mechanical or pharmacological. Both unfractionated and low molecular weight heparin do not cross the placenta and are considered safe in pregnancy(17). There is limited available on more novel anticoagulants. They should be avoided unless safer options are contraindicated, e.g. in the presence of heparin induced thrombocytopaenia(1).

Timing and mode of delivery

Decision to deliver should be individualized and decided upon by members of a multidisciplinary team including the intensivist, obstetrician, foetal medicine specialist, obstetric anaesthesiologist, neonatologist, and other concerned specialists(13). Resuscitative efforts should primarily focus on maternal stabilization. If steroids are to be given for foetal lung maturity, they should only be given if time allows and there are no maternal contra-indications(13). The possibility of an unplanned preterm delivery in ICU should always be kept in mind and a delivery set should be kept in ICU. The role of tocolytics require a joint decision to be made by the obstetrician, intensivist and anaesthetist(13).

Maternal sepsis care bundles

Sepsis is one of the main contributors to maternal morbidity and mortality(22). Although quality improvement kits have been instrumental in reduction of morbidity and mortality secondary to haemorrhage and hypertension, there remains room for improvement in the outcomes of women who experience sepsis during the peripartum period(22).

The sepsis task force advisory group from California have compiled practical and simple recommendations for the recognition and management of maternal sepsis. One of the major findings of the task force was that adult screening tools for sepsis performed poorly in pregnancy due to altered physiology of pregnancy may mask signs of sepsis and the impact of labour which may significantly raise lactic acid levels(22). They recommend a two-step approach with greater sensitivity and specificity with fewer missed cases and fewer false positives as seen in *Figure 2* below(22). The first screening step which is limited to vital signs and white cell count is adjusted for pregnancy. The second step uses end organ injury with values adjusted for pregnancy(22). Although the utility of lactic acid is debatable during labour, elevated values still require careful individual consideration.

Upon recognition of sepsis, early administration of broad spectrum, empiric antibiotic to cover the most likely pathogens should be initiated within an hour(22). Blood cultures should be drawn even if antibiotic therapy has been started. For infections that require source control, timely initiation of surgery, drainage or debridement in the least invasive approach is recommended. Appropriate fluid resuscitation should be initiated(22).

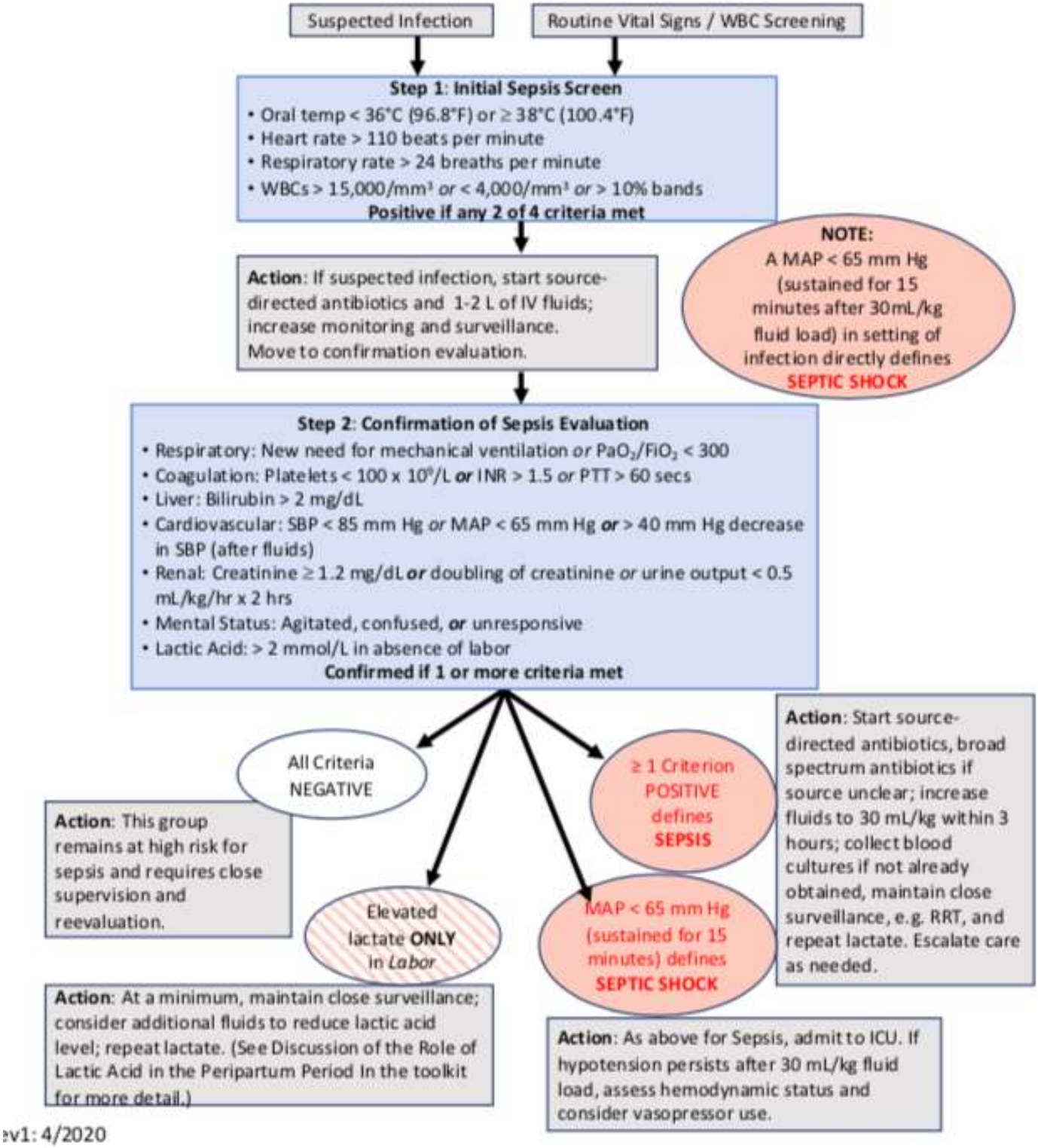
Suspected Infection
Routine Vital Signs / WBC Screening
Step 1: Initial Sepsis Screen
• Oral temp < 36°C (96.8°F) or ≥ 38°C (100.4°F)
• Heart rate > 110 beats per minute
• Respiratory rate > 24 breaths per minute
• WBCs > 15,000/mm³ or < 4,000/mm³ or > 10% bands
Positive if any 2 of 4 criteria met
Action: If suspected infection, start source-directed antibiotics and 1-2 L of IV fluids; increase monitoring and surveillance. Move to confirmation evaluation.
NOTE: A MAP < 65 mm Hg (sustained for 15 minutes after 30mL/kg fluid load) in setting of infection directly defines SEPTIC SHOCK
Step 2: Confirmation of Sepsis Evaluation
• Respiratory: New need for mechanical ventilation or PaO2/FiO2 < 300
• Coagulation: Platelets < 100 x 10⁹/L or INR > 1.5 or PTT > 60 secs
• Liver: Bilirubin > 2 mg/dL
• Cardiovascular: SBP < 85 mm Hg or MAP < 65 mm Hg or > 40 mm Hg decrease in SBP (after fluids)
• Renal: Creatinine ≥ 1.2 mg/dL or doubling of creatinine or urine output < 0.5 mL/kg/hr x 2 hrs
• Mental Status: Agitated, confused, or unresponsive
• Lactic Acid: > 2 mmol/L in absence of labor
Confirmed if 1 or more criteria met
All Criteria NEGATIVE
Action: This group remains at high risk for sepsis and requires close supervision and reevaluation.
≥ 1 Criterion POSITIVE defines SEPSIS
Action: Start source-directed antibiotics, broad spectrum antibiotics if source unclear; increase fluids to 30 mL/kg within 3 hours; collect blood cultures if not already obtained, maintain close surveillance, e.g. RRT, and repeat lactate. Escalate care as needed.
Elevated lactate ONLY in Labor
Action: At a minimum, maintain close surveillance; consider additional fluids to reduce lactic acid level; repeat lactate. (See Discussion of the Role of Lactic Acid in the Peripartum Period In the toolkit for more detail.)
MAP < 65 mm Hg (sustained for 15 minutes) defines SEPTIC SHOCK
Action: As above for Sepsis, admit to ICU. If hypotension persists after 30 mL/kg fluid load, assess hemodynamic status and consider vasopressor use.
ev1: 4/2020

Figure 2

What about the foetus?

“Is this safe for the baby?” is a question that often arises during the care of the critically ill obstetric patient(17). As a general rule the best way to maintain fetal well-being is to maintain maternal homeostasis as close to normal as possible. The focus of intensive care treatment should be primarily on restoring maternal physiology and only secondarily on the possible effects of interventions on the fetus(17). Hasty deviations from standard of practice trying to keep the fetus “safe” may cause additional risk to the health of the mother and thereby, that of the fetus. The treating physician should however be aware of uteroplacental physiology and the transplacental pharmacokinetics(17). Fetal surveillance by cardiotocography should be commenced and interpreted on the viable fetus by the obstetrician, ideally after stabilization of maternal condition. In the pre-viable fetus daily monitoring of the fetal heart by a handheld fetal doppler device should suffice to exclude fetal demise. In the case of suspected fetal demise an ultrasound examination may be valuable in confirming or excluding the demise.

Post – ICU recovery

Morbidity following discharge after an ICU admission for a mother can be classified into physical and psychological groups(17).

Physical morbidity

Physical morbidity associated with critical illness is multifactorial as depicted in *Figure 3* below. ICU-acquired weakness can occur as a result of the primary pathology, prolonged immobility, ventilation and sedation(17). Risk factors include presence of SIRS, multiple organ failure, sepsis, malnutrition, hypercapnia, hypoxia, treatment with corticosteroids and muscle relaxants, initial heavy sedation and poor glycaemic control(17). The basis of treatment of ICU acquired weakness is early mobilization and prevention. Preventative measures include aggressive management of sepsis and multiorgan failure, cautious use of steroids, judicious use of sedatives, daily sedation holds and tight glucose control(17).

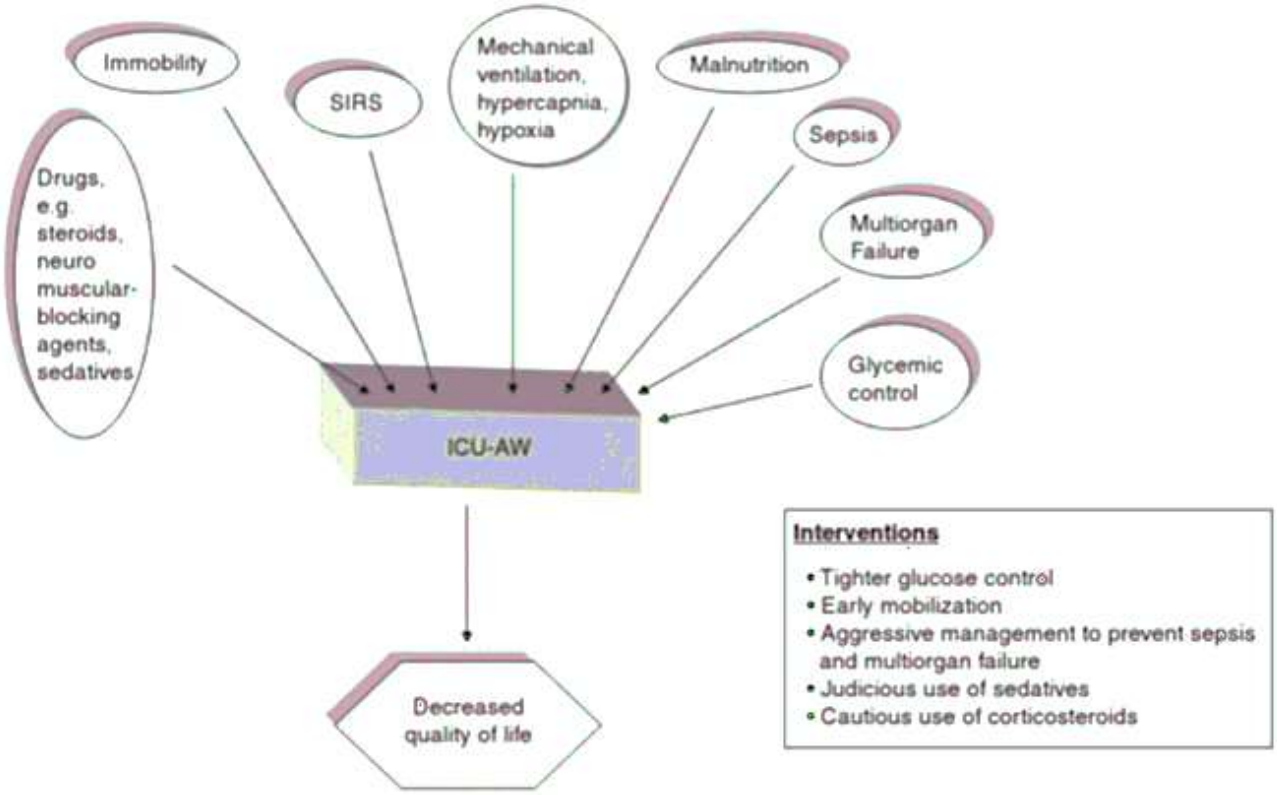

Figure 3

Psychological morbidity

The incidence of post-partum depression is reported to be between 7 and 15% in the first 3 months post-delivery(17). The incidence of depression amongst critical illness survivors ranges between 25 – 50%(17). Other psychiatric illnesses common in ICU survivors are anxiety, post-traumatic stress disorder, cognitive impairment, and delirium, all of which contribute to the decline in quality of life. Potential pathways that contribute to the development of psychiatric problems are organ dysfunction, pain, sleep deprivation, ICU treatment and medication, hypoxemia, neurotransmitter dysfunction, elevated cytokines, and stress-related activation of the hypothalamus pituitary axis(17). Screening for depression and PTSD should start in ICU and continue during follow up and rehabilitation phase(17). Early detection and psychological support should be offered to these patients especially after a prolonged ICU admission.

CONCLUSION

Very few events are as tragic as a maternal mortality. A poor maternal outcome has negative effects on the morale of both critical care and obstetric teams. It also has widespread and negative implications on surviving children, families, health care staff and society as a whole. A comprehensive multidisciplinary team approach should ensure that all critically ill pregnant women receive excellent quality of care for their critical care needs as well their obstetric needs. The acronym MUM's FASTHUG can be used to ensure that all necessary components of critical care has been considered – see *Appendix B* (17).

This booklet has highlighted some of the unique challenges encountered when managing this population group in the intensive care setting. The early collaboration by obstetricians, obstetric anaesthetists, intensivists, critical care outreach teams, neonatologists and midwives could assist in the reduction of morbidity and mortality experienced by women in the peripartum period.

Appendix A: Laboratory values in non-pregnant and pregnant patients

Normal haematological values		
	Non-pregnant	**Pregnant**
Haemoglobin	12 -16 g/dL	11.5 – 15 g/dL
Haematocrit	36 – 48 %	32 – 36.5 %
White blood cells	4 – 10.6 (x1000 cu mm)	6 – 20 (x1000 cu mm)

Normal values for renal function		
	Non-pregnant	**Pregnant**
Serum Creatinine	0.6 – 1.4 mg/dL [53 – 124 umol/L]	0.53 – 0.9 mg/dL [47 – 80 umol/L]
Serum Urea (BUN)	7 – 31 mg/dL [2.5 – 11 mmol/L]	8 – 10 mg/dL [2.9 – 3.6 mmol/L]
Serum Uric Acid	2.4 – 8.2 mg/dL	2 – 5.8 mg/dL
Urine Creatinine Clearance	90 – 130 ml/min	150 – 200 ml/min
Urine Uric Acid	150 – 990 mg /24h	Increases
Urine Glucose	60 – 115 mg/dL [3.3 – 6.4 mmol/L]	Increases

Normal hepatic values		
Liver enzymes	**Non-pregnant**	**Pregnant**
ALT	14 – 67 U/L	Unchanged
AST	6 – 58 U/L	Unchanged
ALP	38 – 150 IMU/ml	> Up to 2 – 4 times
LDH	117 – 224 U/L	Upper end of normal to 700 U/L

Appendix B : MUMS' FAST HUG PROTOCOL (17)

	ITEM	FEATURES
M	**M**onitor foetal well being	• Growth and development • Real-time fetal well-being
U	**U**ndertake routine antenatal care	• Confirmation of pregnancy • Estimation of gestational age • MDT planning of delivery
M	**M**aternal complications	• Pre-eclampsia and its complications • Gestational diabetes
S	**S**pecial considerations	• Effective communication between intensive care and maternity teams • Impact of pregnancy on maternal physiology
F	**F**eeding	• Additional nutritional needs and supplements for pregnancy
A	**A**nalgesia	• Women should not experience pain • Avoid excessive opioid analgesia that could result in neonatal respiratory depression at birth
S	**S**edation	• Mother should be kept calm and comfortable without excessive sedation
T	**T**hromboprophylaxis	• Mechanical thromboprophylaxis should be considered in all critically pregnant patients
H	**H**ead elevation	• Optimal head up 45 degrees, unless contra-indicated • Avoid aortocaval compression
U	**U**lcer prophylaxis	• Should not be used routinely • When indicated consider H_2Antagonists & proton pump inhibitors
G	**G**lycaemic control	• Maintain euglycaemia • Maternal hyperglycaemia associated with poor outcomes

REFERENCES

1. Kaur M, Singh PM, Trikha A. Management of critically ill obstetric patients: A review. Journal of Obstetric Anaesthesia and Critical Care. 2017;7(1):3.
2. Girotra V, Mushambi M. MATERNAL CRITICAL CARE ANAESTHESIA TUTORIAL OF THE WEEK 310 27TH OCTOBER 2014. 2014.
3. Einav S, Leone M. Epidemiology of obstetric critical illness. International Journal of Obstetric Anesthesia. 2019;40:128-39.
4. Walls A, Plaat F, Delgado A. Maternal death: lessons for anaesthesia and critical care. BJA education. 2022;22(4):146-53.
5. Chhabra P. Maternal near miss: an indicator for maternal health and maternal care. Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine. 2014;39(3):132.
6. Organization WH. The WHO near-miss approach for maternal health. World Health Organization. 2011.
7. Moodley J. Saving mothers 2017-2019: Seventh triennial report on confidential enquiries into maternal deaths in South Africa. Technical Report.
8. Soma-Pillay P, Moodley J, Pattinson R, Fawcus S, Gebhardt S, Niit R, editors. The effect of the first wave of Covid-19 on use of maternal and reproductive health services and maternal deaths in South Africa. Obstetrics and gynaecology forum; 2020: In House Publications.
9. Banerjee A, Cantellow S. Maternal critical care: part I. BJA education. 2021;21(4):140.
10. Koukoubanis K, Prodromidou A, Stamatakis E, Valsamidis D, Thomakos N. Role of Critical Care Units in the management of obstetric patients. Biomedical Reports. 2021;15(1):1-6.
11. Gandhi A, Malhotra N, Malhotra J, Gupta N, Bora NM. Principles of Critical Care in Obstetrics: Volume II: Springer; 2016.
12. Butterworth JF, Mackey DC, Wasnick JD. Morgan & Mikhail's clinical anesthesiology: McGraw-Hill New York; 2013.
13. Pandya ST, Mangalampally K. Critical care in obstetrics. Indian journal of anaesthesia. 2018;62(9):724.

14. Jeejeebhoy FM, Zelop CM, Lipman S, Carvalho B, Joglar J, Mhyre JM, et al. Cardiac arrest in pregnancy: a scientific statement from the American Heart Association. Circulation. 2015;132(18):1747-73.
15. Mallampalli A, Guy E. Cardiac arrest in pregnancy and somatic support after brain death. Critical care medicine. 2005;33(10):S325-S31.
16. Tan P, Dennis A. High flow humidified nasal oxygen in pregnant women. Anaesthesia and Intensive Care. 2018;46(1):36-41.
17. Van de Velde M, Scholefield H, Plante LA. Maternal critical care: a multidisciplinary approach: Cambridge University Press; 2013.
18. Karim HMR, Mitra JK, Bhattacharyya P, Roy J. Significance of hemodynamic monitoring in perioperative and critical care management in obstetric practice. Astrocyte. 2015;1(4):295.
19. Rojas-Suarez J, Borré D, Zapata R. Hemodynamic Monitoring of the Critically Ill Obstetric Patient.
20. Bijl RC, Valensise H, Novelli GP, Vasapollo B, Wilkinson I, Thilaganathan B, et al. Methods and considerations concerning cardiac output measurement in pregnant women: recommendations of the International Working Group on Maternal Hemodynamics. Ultrasound in Obstetrics & Gynecology. 2019;54(1):35-50.
21. Esmaoglu A, Ulgey A, Akin A, Boyaci A. Comparison between dexmedetomidine and midazolam for sedation of eclampsia patients in the intensive care unit. Journal of critical care. 2009;24(4):551-5.
22. Gibbs R, Bauer M, Olvera L, Sakowski C, Cape V, Main E. Improving diagnosis and treatment of maternal sepsis: a quality improvement toolkit. Stanford, CA: California Maternal Quality Care Collaborative; 2020.