Obstetric critical care: A blueprint for improved outcomes

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Introduction: **Obstetric patients are generally young and healthy. However, the potential for catastrophic complications is real, and despite the therapeutic advances of the last few decades, maternal morbidity and mortality continue to occur. This may be related to the pregnancy itself, aggravation of a preexisting illness, or complications of the (operative) delivery.**

Purpose: **The purpose of this review is two-fold: first, to provide an update on currently available reports pertaining to important critical care issues of the obstetric patient population and, second, to present current comprehensive treatment options for preeclampsia and massive obstetric hemorrhage because both are responsible for the majority of maternal mortality and morbidity worldwide.**

Results: **The most common reasons for intensive care unit admission are hypertensive disorders and massive obstetric hemorrhage. Timely delivery and prompt initiation of antihypertensive therapy for severe hypertension form the mainstay of care in preeclampsia. Restoration of circulating blood volume and rapid control of bleeding and impaired coagulation are the main factors in the management of massive obstetric hemorrhage. Puerperal morbidity has become the main topic of quality of care issues in maternity care. Although the Acute Physiology and Chronic Health Evaluation II score is commonly used in the intensive care unit, it does not seem to be appropriate for pregnant women because it overestimates their mortality rates. A high-dependency care unit suits the needs for at least half of the obstetric patient population in need of higher acuity care and will save considerable cost.**

Conclusion: **Emphasis on early detection of maternal problems and prompt referral to tertiary centers with intensive care unit facilities to provide optimum care of the circulation, blood pressure, and respiration at an early stage could minimize the prevalence of multiple organ failure and mortality in critically ill obstetric patients. (Crit Care Med 2006; 34[Suppl.]:S208–S214)**

Key Words: **pregnancy; preeclampsia; critical care; obstetric hemorrhage; maternal mortality**

Pregnancy induces a multitude of rather profound physiologic hemodynamic alterations. Among these are substantive increases in total blood volume, cardiac output, and uterine blood flow (1). The major cardiovascular and hematologic changes of pregnancy, and the particular pathologies unique to pregnancy, most importantly, (pre)eclampsia, contribute additional challenges and require additional understanding. Certain medical conditions present differently during pregnancy, and various therapies may have their effect on the developing fetus and may influence the plan for delivery. In addition, there are several acute circumstances, such as massive obstetric hemorrhage, specific to pregnancy that require a high degree of expertise for effective management.

Increasing numbers of women with underlying chronic medical conditions are now able to conceive and carry a fetus to term. For instance, women with longstanding diabetes mellitus or complex congenital cardiac defects are now counselled much more liberally when they present with the desire to raise a family. Such women obviously require a greater degree of medical care throughout the antepartum and postpartum periods. Management of such women throughout labor and delivery may require a period of observation in an intensive care unit (ICU). Knowledge of the special circumstances in which these women may present is essential for both the obstetricians and the intensivists who are responsible for their care. Through review of the current literature and an update on the pathophysiology of (pre)eclampsia and treatment of massive obstetric hemorrhage, this review aims to update the intensivist who is confronted with the obstetric patient.

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Overview

Admission of an obstetric patient to an ICU in developed countries occurs in roughly 2–4/1,000 deliveries (Table 1). Despite this low prevalence, the overall acuity of this group of patients is high. Perinatal ICU services vary widely from the dedicated obstetric ICU (2, 3) to the transfer of a critically ill obstetric patient to a medical/surgical ICU (4–8) or to an ICU in another hospital (9).

During the last 15 yrs, several reports from a variety of centers all over the world have described the characteristics and treatment of critically ill pregnant or puerperal women (Table 1). The studies report significant variations in patient populations, definition of major morbidity, ICU admission criteria, usage rates, outcomes, and treatment. In addition, differences in hospital settings, nursing policies, and management protocols may add to the observed variations. Differences in access to health care in the cited studies make comparisons of standard of care and recommendations for improvement difficult.

Usually, women are young and frequently primipara. Most admissions, therefore, occurred in low-risk pregnancies without contributory obstetric history. In general, for most obstetric patients, rapid recovery followed correction of the acute insult. This is reflected in that most women were admitted to an ICU for <48 hrs. Expectedly, this is shorter than the mean length of stay in the nonpregnant population. The most frequent admission reason

Table 1. Overview of literature

Author (Reference No.) Year	City, Country	Time Span, yrs	No. (%) of Deliveries	Admission Diagnosis, %	Antepartum Postpartum, %	Maternal Death, n (%)	Perinatal Death, %	Chronic Medical Disease, %	ICU Utilization Rate, %	Duration of ICU Stay, Days
Mabie and Sibai (2) 1990	Memphis, TN, US	3	200 (0.9)	P = 46 H = 10	NS	7 (3.5)	NS	NS	0.9	Mean, 2.5
Kilpatrick and Matthay (5) 1992	San Francisco, CA, US	5	32 (0.4)	P = 22 H = 16	AP = 34	4 (12)	NS	NS	NS	Mean, 5.4
Collop and Sahn (4) 1993	Charleston, SC, US	3.3	20 (0.3)	P = 30 H = NS	AP = 85 PP = 15	4 (20)	35	50	NS	Mean, 8
Monaco et al. (6) 1993	Chapel Hill, NC, US	8	38 (0.3)	P = 32 H = 5	AP = 29 PP = 71	7 (18)	12	NS	NS	Mean, 5.4
Umo-Etuk et al. (9) 1996	London, UK	5	39 (0.6)	P = 33 H = 33	AP = 15 PP = 85	1 (0.4)	NS	26	NS	Median, 2
Wheatley et al. (22) 1996	London, UK	5	144 (0.9)	P = 66 H = 19	AP = 8 PP = 92	3 (4.3)	6	16	12	Median, 3
Tang et al. (11) 1997	Hong Kong, China	8	49 (0.1)	P = 14 H = 53	NS	2 (4.1)	10	NS	NS	NS
Platteau et al. (10) 1997	Durban, South Africa	1	122 (NS)	P = 66 H = NS	NS	26 (21)	NS	NS	14	Mean, 4.4
Lapinsky et al. (7) 1997	Toronto, Canada	5	65 (0.3)	P = 40	AP = 9 PP = 91	0	11	29	NS	Mean, 2.9
Bewley and Creighton (46) 1997	London, UK	2	30 (0.5)	P = 40 H = 47	NS	2 (7)	NS	28	NS	Median, 2
Baskett and Sternadel (47) 1998	Halifax, Canada	14	55 (0.1)	P = 25 H = 22	AP = 18 PP = 82	2 (3.6)	NS	NS	NS	Mean, 5
Mahutte et al. (48) 1999	Montreal, Canada	8	131 (0.3)	P = 21 H = 26	AP = 23 PP = 78	3 (2.3)	NS	38	NS	Mean, 2.5
Cohen et al. (49) 2000	Petak Tiqva, Israel	4	46 (0.2)	P = 32 H = 24	AP = 7 PP = 93	1 (0.5)	22	NS	2	Mean, 2
Ryan et al. (24) 2000	Dublin, Ireland	4	123 (1.0)	P = 45 H = 21	AP = 15 PP = 85	0	8	NS	NS	Median, 3
Panchal et al. (50) 2000	Maryland, US	14 (Statewide)	1023 (0.1)	P = 37 H = 29	NS	34 (3)	NS	8.6	NS	Median, 2
Quah et al. (51) 2001	Singapore, Singapore	NS	239 (0.7)	P = 50 H = 24	NS	3 (1.3)	4	NS	NS	Median, 2
Afessa et al. (52) 2001	Jacksonville, FL, US	8	74 (NS)	P = 45 H = NS	AP = 42 PP = 58	2 (3)	11	50	NS	Median, 2.5
Loverro et al. (53) 2001	Bari, Italy	11	41 (0.2)	P = 76 H = 15	AP = 0 PP = 100	2 (4.9)	111	17	NS	Mean, 5
Hazelgrove et al. (19) 2001	Southern UK	3	210 (0.2)	P = 40 H = 33	AP = 19 PP = 81	7 (3.3)	20	NS	2	Median, 1
Olarra et al. (54) 2002	Madrid, Spain	7	149 (0.3)	P = 50 H = NS	NS	11 (7.5)	13	45	NS	NS
Heinonen et al. (55) 2002	Kuopio, Finland	6.5	22 (0.1)	P = 32	AP = 3 PP = 19	1 (5)	NS	4.5	NS	Median, 6
Gilbert et al. (17) 2003	New Brunswick, NJ, US	8	233 (0.5)	P = 46 H = 24	AP = 28 PP = 72	8 (3)	NS	42	NS	Mean, 4
Cheng and Raman (56) 2003	Singapore, Singapore	5	43 (0.3)	P = 35 H = 40	AP = 6 PP = 33	2 (5)	NS	NS	1	Median, 3
Demirkiran et al. (57) 2003	Istanbul, Turkey	5	125 (0.9)	P = 74 H = 11	AP = 1 PP = 124	13 (10)	NS	NS	3	Mean, 4
Zeeman et al. (3) 2003	Dallas, TX, US	2	483 (1.7)	P = 42	AP = 20 PP = 80	1 (0.2)	NS	13	NS	Median, 1
Okafor and Aniebue (58) 2004	Enugu, Nigeria	6	18 (0.3)	P = 50	AP = 1 PP = 17	6 (33)	NS	NS	2	Median, 2.5
Karnad et al. (15) 2004	Mumbai, India	5	453 (0.5)	P = 56 H = 24	AP = 38 PP = 62	98 (22)	52	8	NS	Median, 4
Anwari et al. (59) 2004	Riyadh, Saudi Arabia	6	99 (0.2)	P = 29 H = 32	AP = 1 PP = 98	1 (1)	NS	11	2	Mean, 2
Mirghani et al. (23) 2004	Abu Dhabi, Arab Emirates	6	60 (0.3)	P = 25 H = 28	NS	2 (3.3)	NS	32	2	Mean, 2
Selo-Ojeme et al. (60) 2005	London, UK	10	33 (0.1)	P = 39 H = 36	AP = 10 PP = 90	1 (3)	NS	15	1	Mean, 8

ICU, intensive care unit; P, preeclampsia; H, hemorrhage; AP, antepartum; PP, postpartum; NS, not stated.

was mechanical ventilation. Most of such patients underwent general anesthesia for emergency cesarean section. In those cases, considerable intraoperative blood loss and replacement required short-term continuation of mechanical ventilation in the postoperative period. Prolonged ventilatory or inotropic support was only needed in a minority of these patients.

As can be seen in Table 1, the most common reasons for ICU admission were preeclampsia-related complications and postpartum hemorrhage. Causes of hemorrhage included placenta previa, placental abruption, uterine atony, and often secondary, profound coagulopathies. Preeclampsia-related complications include eclampsia, intracerebral hemorrhage, pulmonary edema, renal insufficiency, liver rupture, and placental abruption. In South Africa, pregnancy-related hypertensive disorders accounted for 66.4% of ICU admissions (10), whereas in China, massive postpartum hemorrhage accounted for 53% (11). Perhaps this is a reflection of the prevalence of these conditions in those parts of the world during pregnancy and delivery. Studies from India, Sri Lanka, and Brazil have shown that rheumatic valvular heart disease, cerebral venous thrombosis, malaria, and viral hepatitis are important reasons for ICU admission during pregnancy and also significant causes of maternal mortality (12–15).

The cited studies are interesting but also have major limitations; data are usually collected retrospectively and sample sizes are small. This makes it difficult to determine the prognostic factors and differences between survivors and nonsurvivors. Second, when studies are performed in tertiary care centers, the conclusions may not apply to other patient populations. Lastly, it is generally not possible to identify preventable conditions that may have led to ICU admission.

Lack of ICU Scoring Systems for Critically Ill Obstetric Patients

Little is known regarding the ability to assess severity of illness and predict outcomes in obstetric patients. There are no models that are designed specifically for use in obstetric patients. Several investigators have applied a variety of scoring tools derived from nonobstetric populations, such as the Acute Physiology and Chronic Health Evaluation (APACHE) II, Mortality Probability Model, and the Simplified Acute Physiology Score (SAPS) II, to obstetric populations in an attempt to predict the probability of hospital mortality, with conflicting results (7, 16–19).

APACHE and SAPS II tend to overestimate mortality in obstetric patients (17, 19, 20). This is partly because normal physiologic variables in obstetric patients are scored as abnormal, such as the lower creatinine, blood urea nitrogen, and hematocrit and the higher respiratory rate and heart rate of pregnancy. Another problem with the current scores is that for obstetric patients with hypertensive disorders, tests of liver function and platelet count are important in the assessment. These variables are not affected in available scoring systems for critical illness. In general, one can conclude that when obstetric patients are admitted for medical disorders, the predicted mortality rate more often matches the observed mortality rate. On the other hand, in patients with obstetric disorders, observed mortality rate is usually much lower than the predicted mortality rate.

Obstetric High-Dependency Care Unit

There are no detailed guidelines from any specialty organization that describe a plan of care of critically ill obstetric patients. Thus, it is reasonable to use the guidelines for intensive and intermediate care from the American College of Critical Care Medicine (21) as the basis for obstetric critical care, as summarized in Table 2. Owing to their special problems, combined with the frequent chronic shortage of costly ICU beds, some have suggested that obstetric patients should be referred to specialized obstetric ICUs (22). This is not unreasonable because two large descriptive reports showed that about half of all women were thought to have illness that was sufficiently severe to necessitate ICU admission, whereas the remaining half were thought to be suitable for intermediate or high-dependency care (19, 23). The intermediate or high-dependency care unit (HDU) may be appropriate for patients who are conscious and who have single-organ dysfunction. Patients requiring advanced respiratory support, two or more organ system support, and those with chronic system insufficiency and requiring support for acute reversible failure of another organ system are considered to need ICU admission.

HDUs have not been assessed formally for obstetric patients; however, several referral centers have actually incorporated these concepts. In this environment, care is provided by one nurse to two patients and usually supervised by maternal–fetal medicine specialists and obstetric anesthesiologists rather than by intensive care specialists. Studies reporting on the availability of an HDU report low ICU rates and HDU utilization rates that average 1% (2, 3, 24). This possibly suggests a lower threshold for admission to the HDU. Zeeman et al. (3) described a 2-yr audit of the obstetric intermediate care unit. General criteria for admission to this unit that were in place during the 2-yr audit are shown in Table 3. Criteria for admission or transfer to a medical/surgical ICU include all women whose conditions require mechanical ventilation. Other reasons included major trauma, neurosurgical injuries, or cardiothoracic injuries. This intermediate care unit allowed for the continuation of care by obstetricians and resulted in fewer transfers to medical/surgical ICUs.

The advantages of an HDU within an obstetric setting are numerous, for instance, the concurrent availability of expert obstetric care and critical care man-

Table 2. Summary of guidelines from the American College of Critical Care Medicine (1998) of conditions or diseases that could qualify for intermediate care

Cardiac	Rule out infarction, stable infarction, stable arrhythmias, mild-to-moderate congestive heart failure, hypertensive urgency without end-organ damage
Pulmonary	Stable patients for weaning and chronic ventilation, patients with potential for respiratory failure who are hemodynamically stable
Neurologic	Stable central nervous system, neuromuscular, or neurosurgical conditions that require close monitoring
Drug overdose	Hemodynamically stable
Gastrointestinal	Stable bleeding, liver failure with stable vital signs
Endocrine	Diabetic ketoacidosis, thyrotoxicosis that requires frequent monitoring
Surgical	Postoperative major procedures or complications that require close monitoring
Miscellaneous	Early sepsis, patients whose condition requires closely titrated intravenous fluids, pregnant women with severe preeclampsia or other medical problem

Table 3. Criteria for admission to the obstetric intermediate care unit or medical/surgical intensive care unit

Intermediate care unit	
Obstetric complications	
	Severe preeclampsia or eclampsia or HELLP syndrome
	Severe hemorrhage and/or coagulation disorders
	Complicated peripartum hysterectomy
	Acute fatty liver of pregnancy
	Sepsis
Surgical or anesthesia complications	
Medical or surgical disorders	
	Diabetic ketoacidosis
	Thyrotoxicosis
	Hemofiltration/plasmapheresis
	Severe asthma or pneumonia; complicated cholecystitis, pancreatitis, or appendicitis
Medical-surgical intensive care unit	
Mechanical ventilation	
Inotropic drugs	
Life-threatening arrhythmia	
Coma	

HELLP is a syndrome comprising hemolysis, elevated liver enzymes, and low platelets.

agement. Antenatal patients admitted to the HDU have the option of continuous fetal monitoring with on-hand expertise in its interpretation. The hazards of emergency transport of the obstetric patient differs from adult transport in several respects; there are two or more patients and these women are particularly at risk of improper positioning. The obvious advantages of keeping mother and infant together combined with the improved continuity of antenatal and postnatal care are further benefits of critical care facilities within this setting.

Maternal Morbidity as Indicator for Quality of Care

Current maternal mortality rates in developed countries are extremely low, ranging from 2.4/100,000 in Canada to 9.5/100,000 in Japan (25). Developing countries report exponentially higher rates such as 340/100,000 in South Africa, 440/100,000 deliveries in India, to 2,300/100,000 in Rwanda (15, 26). This usually reflects the poor availability of healthcare services including prenatal care. The two preventable factors that adversely affect the maternal mortality rate are inadequate utilization of prenatal services and a delay of >24 hrs between onset of acute illness and ICU admission.

Maternal mortality rates are generally used to evaluate the quality of maternal care. Maternal mortality rates in North American and European ICUs range from 3% to 20%, whereas this may be doubled in less-developed regions of the world (Table 1). Heterogeneity of the patient population and differences in disease severity may account for the differences in the reported ICU mortality rates. In general, mortality rate is higher in patients with medical disorders than in patients with obstetric diseases. The question is whether clinical guidelines and recommendations when based on unusual events such as maternal death are of much value. It is possible that information on severe acute maternal morbidity as indicated by "near-miss" cases and obstetric admission to the ICU are more meaningful when assessing the quality of care (24). In fact, it has been shown that, after exclusion of maternal thromboembolism, there may be >100 near misses for each direct maternal death (27). Thus, in western countries, where a dramatic decrease in maternal mortality has been obtained, puerperal morbidity has become the main topic of quality-of-care investigation, especially if severe enough to require admission into the ICU.

Preeclampsia

Preeclampsia is a multiple-system disorder that develops in previously normotensive women after 20 completed weeks of gestation. It is characterized by hypertension and proteinuria, both of which resolve by the sixth postpartum week. Eclampsia is defined as the occurrence of tonic–clonic convulsions in pregnant or puerperal women with preeclampsia. Other dramatic neurologic presentations, albeit uncommon, include blindness, altered state of consciousness, and coma. HELLP is a syndrome comprising hemolysis, elevated liver enzymes, and low platelets. It occurs in 4–12% of patients with severe preeclampsia. Hypertension may or may not be present. Symptoms include vague symptoms of nausea and vomiting and right upper quadrant or epigastric pain.

Preeclampsia is relatively common, with the average rate of preeclampsia in the United States estimated to be 26/1,000 deliveries (28). Recent estimates of the prevalence of eclampsia in the United States range from 0.6 to 3/1,000 live births (28–30). Along with hemorrhage, thromboembolism, and infection, preeclampsia is accountable for the world's large maternal mortality rates; approximately 50,000–65,000 deaths are thought to occur per year worldwide. In the United States, 23% of maternal deaths recorded in 1997 were related to pregnancy hypertension (1). The acute cerebral complications of (pre)eclampsia, such as intracranial hemorrhage or massive cerebral edema, account for ≥75% of such fatalities, particularly in the presence of HELLP syndrome (31). Less well known is that (pre)eclampsia also accounts for nearly 50% of (mostly clinically reversible) pregnancy-related ischemic strokes (32). Improvement in antenatal and intensive care has reduced the prevalence of and death attributable to eclampsia in western countries during the past decade. Modern maternal mortality rates of <0.5% are now reported (33, 34).

Adequate oxygenation, urine output, and blood pressure are typical therapeutic goals in the management of critically ill ICU patients, even more so in preeclampsia. Low cardiac filling pressures, high systemic vascular resistance, and low cardiac output characterize this condition (1). This is thought to result from altered endothelial permeability, extravasation of plasma into the interstitium, and vasoconstriction.

Pulmonary Edema. A significant number of maternal deaths in preeclampsia are related to pulmonary edema. The risk of the development of pulmonary edema is aggravated by exogenous fluid administered in the belief that these women are at risk of renal failure. Renal failure is, however, extremely unusual. Oliguria is fairly common after delivery and does not require treatment because the large majority of postpartum women with preeclampsia will enter the diuretic phase within the first 24–48 hrs postpartum. Fluid challenges are potentially dangerous in preeclampsia because much of the fluid will be lost from the vasculature into the interstitium. Only rarely is the use of a pulmonary artery catheter required because persistent refractory oliguria in the presence of pulmonary edema is extremely rare. The relationship between central venous pressure and pulmonary artery occlusion pressure in severe preeclampsia is inconsistent. Hemodynamic monitoring using central venous pressure data in severe preeclampsia is unreliable and should not be used. Until a reliable noninvasive method is available to measure left ventricular preload, pulmonary artery occlusion pressure is the measurement of choice when invasive hemodynamic monitoring is necessary in patients with severe preeclampsia (35).

Hypertension. Aggressive blood pressure control is an important end point in the treatment of these young patients in whom acute increases of blood pressure may pose significant risk. The aim is to prevent cerebral hemorrhage and hypertensive encephalopathy. The blood pressure in preeclampsia is variable and can fluctuate on a minute-to-minute basis. Blood pressure should be measured manually using standard aneroid sphygmomanometers because automated blood pressure monitors are notoriously unreliable in women with (pre)eclampsia (36). The most commonly used antihypertensive agents are hydralazine, labetalol, and nifedipine. Therapy can be given by continuous or bolus infusion, which ideally requires direct measurement of intraarterial blood pressure to rapidly achieve end points while avoiding excessive decrease in blood pressure.

Eclampsia. Convulsions occur antenatally in 38%, intrapartum in 18% and postpartum in the remaining 44%, usually in the first 24–48 hrs after delivery. Although prodromal symptoms, mainly headache and right upper quadrant pain, are usually present in women who develop eclampsia, about 20% might convulse unexpectantly, with a relatively normal blood pressure and no specific signs for the development of eclampsia (28).

Eclampsia seems rarely associated with persistent, clinically recognizable, neurologic morbidity, and epilepsy is not a recognized long-term complication. However, intracerebral hemorrhage is a well-known complication of eclampsia, frequently leading to maternal death or major permanent disability. In general, therapy should be directed toward lowering blood pressure so as to limit the further development of vasogenic cerebral edema and subsequent ischemia.

Magnesium sulfate ($MgSO_4$) is the anticonvulsant drug of choice because it is effective for prevention and treatment of seizures (Table 4) (37). In cases of recurrent seizure, it is safe to give a second bolus of 2 g of $MgSO_4$. Polypharmacy is to be avoided to treat seizures because this dramatically increases the risk of respiratory arrest. Only when seizures continue, despite administration of a second bolus, should diazepam or thiopental be administered intravenously. Intubation then becomes necessary to protect the airway and ensure adequate oxygenation. Further seizure activity should be managed by ventilation and muscle relaxation. One of the main concerns that many have is the fear of magnesium toxicity. However, when using the cited dosage regimen in the absence of renal insufficiency, therapy can be monitored safely by measurement of the patellar reflexes and respiratory rate. In case of overdose, first ensure adequate ventilation, then 1 mg of 10% calcium gluconate can be given in a 10-min period.

Table 4. Magnesium sulfate for prevention and treatment of eclampsia

1. Loading dose: 4–6 g diluted in 100 mL of intravenous fluid administered during 15–20 mins (give in 5 mins instead when actively seizing)
2. Maintenance dose of 1–2 g/hr in 100 mL of intravenous maintenance infusion
3. Serum levels should be maintained between
   a. 4–7 mEq/L
   b. 4.8–8.4 mg/dL
   c. 2–4 mmol/L
4. Discontinue infusion 24 hrs after delivery or last convulsion

On the basis of pathology and imaging findings and the similarities in clinical presentation, attention has been directed to hypertensive encephalopathy as a model for the cerebrovascular abnormalities in eclampsia (38). Strictly speaking, during a period of hypertensive encephalopathy, a relatively acute and excessive intravascular pressure increase causes forced dilation of intrinsic myogenic tone of cerebral arteries. This decreases cerebrovascular resistance and increases pressure on the microcirculation, thereby causing vasogenic edema formation. In the clinical setting, this phenomenon has recently been coined reversible posterior leukoencephalopathy syndrome (39). Endothelial dysfunction is generally considered to play a key role in the clinical manifestation of reversible posterior leukoencephalopathy syndrome and in preeclampsia.

Neuroimaging studies could generally be limited to those women who have additional focal neurologic signs, prolonged coma, atypical or recurrent convulsions, and those who have a prolonged return to complete recovery after delivery. In such women, hemorrhage or other serious abnormalities such as sinus thrombosis must be excluded. Magnetic resonance imaging is well known for its far more superior soft-tissue contrast and multiplanar resolution compared with computed tomography. This technique is therefore extremely effective for the diagnosis of hemorrhage and ischemia or cerebral edema in women with (pre)eclampsia. Whereas computed tomography is often reported as normal in eclampsia, fluid-attenuated inversion recovery (FLAIR) magnetic resonance imaging demonstrates transient T2 lesions in the (sub)cortical regions of the parietoccipital lobes, suggestive of cerebral edema. Occasional involvement of basal ganglia or brainstem is also reported (40). These hyperintense lesions are typically thought to resolve without long-term sequelae. Studies using additional diffusion-weighted imaging sequences showed that the origin of brain edema in eclampsia is primarily vasogenic but, less commonly, may be associated with ischemic/cytotoxic changes. It seems that 20–25% of women with eclampsia demonstrate minute lesions consistent with cerebral infarction on later follow-up, although such women seemed asymptomatic (40). The long-term significance of this is currently being investigated.

Hemorrhage

In the United States and other industrialized nations, massive obstetric hemorrhage has generally ranked among the top three causes of maternal death, despite modern improvements in obstetric practice and transfusion services. Massive obstetric hemorrhage usually occurs intrapartum or within the first hour after delivery. Massive obstetric hemorrhage is most commonly due to uterine atony, which complicates 5% of deliveries and results in excessive blood loss when adequate myometrial contraction fails to occur after placental expulsion.

The main factor in its management is the restoration of the circulating blood volume. A delay in the correction of hypovolemia, in diagnosis and treatment of impaired coagulation, and in the surgical control of bleeding are the avoidable factors in most maternal mortality cases caused by hemorrhage. Uterotonic agents, such as oxytocin, are used in the management of uterine atony (41). This synthetic nonapeptide is a first-line agent because of the paucity of side effects and the absence of contraindications. Methylergonovine, an ergot alkaloid, is used as a second-line uterotonic agent in the setting of massive obstetric hemorrhage due to atony. Hypertension is an absolute contraindication.

Injectable prostaglandins may also be used when oxytocin fails. Prostaglandin E_2 and prostaglandin F_2 stimulate myometrial contractions and have been used for refractory hemorrhage due to uterine atony. Such prostaglandins and their several analogs are used either intramuscularly or intravenously. A major contraindication to their use is asthma, and there is a considerable risk for myocardial infarction, when used in the presence of severe hypovolemia, due to coronary artery spasm.

Recombinant activated factor VII (NovoSeven, Novo Nordisk A/S, Bagsvaerd, Denmark) has recently shown to be an adjunctive hemostatic measure for the treatment of severe obstetric hemorrhage (42). Based on the mechanisms of action, circulating factor VII is active after it binds to tissue factor, which is exposed at sites of vessel injury. This complex initiates coagulation on activated platelet surfaces adhering to the site of injury and resulting into formation of a localized fibrin clot. The drug can be administered in obstetric cases with life-threatening hemorrhage, even in the presence of disseminated intravascular coagulation–like coagulopathy. A dose of 90–200 μg/kg seems to be appropriate. Controlled trials, however, have not been performed.

The use of a hydrostatic balloon has been advocated as an alternative to uterine packing for controlling hemorrhage due to uterine atony (43). The inflated Rusch balloon can conform to the contour of the uterine cavity and provides an effective tamponade. Life-threatening hemorrhage can also be treated by arterial embolization (44). In cases of continuing hemorrhage, a variety of surgical techniques can be used to avoid a hysterectomy, such as bilateral uterine artery ligation or internal iliac artery ligation. More recently, the use of a B-Lynch brace suture, which compresses the uterus without compromise of the major vessels, has been advocated (45). In general, poor outcomes stem from a delay in performing any of the above measures or a firm hesitation in performing a lifesaving hysterectomy.

Who Cares for the Critically Ill Obstetric Patient?

The high variability of mortality rates of critically ill obstetric patients correlates not only with the severity of underlying disease but also with clinical recognition of the unique needs of this patient population. Critically ill obstetric patients present an interesting challenge in terms of medical management and often require the input of several specialties. Most centers report that obstetric patients are treated by critical care staff physicians, often represented by anesthetists or intensivists. Monitoring is often invasive and requires special skills. Most obstetricians do not see sufficient cases to acquire and maintain these skills. There can be little doubt that intensivists in an ICU best treat these patients. Likewise, it is crucial that someone who is knowledgeable in maternal and fetal physiology be included in the treatment team, particularly in the care for the preeclamptic woman. Care must include the consideration of pregnancy-induced physiologic changes, normal laboratory alterations, and continued fetal well-being if antepartum. This presents unique medical and ethical dilemmas with which obstetricians are more familiar. Ideally, a working group that consists of members from both disciplines routinely reviews all admissions. The goal of this group is to ensure cohesive coordinated care.

Conclusions

Hypertension-related complications and massive obstetric hemorrhage due to uterine atony in previously low-risk women are the leading causes for admission of obstetric patients to the ICU. The admission rate to intensive care and the problems faced by critically ill parturients may be reduced by improving the management of hypertensive disease during pregnancy and by reducing the prevalence of hemorrhagic complications by emphasis on early detection and anticipation. When complications arise early, intervention and treatment on a multidisciplinary basis, which may involve ICU admission for ventilatory support, invasive monitoring, and vasoactive drug infusions, can alleviate progression of organ dysfunction and improve prognosis.

Institutional capabilities and the frequency and acuity of serious obstetric complications largely will be the main factors to determine the need for critical care facilities. An intermediate care unit should fulfil the needs of most tertiary care centers. Academic centers will benefit because such units are important for resident and fellow education and experience. Smaller hospitals may not be able to fulfill the requirements for an intermediate care unit (21), or they may not encounter enough critically ill women to maintain contemporaneous skills. Implications regarding individual hospital volume of deliveries, as the volume relates to the care of the critically ill obstetric patients, is yet to be determined and requires future investigation.

Maternal death has become an extremely rare event in developed countries, which weakens the value of such rates as a quality-assurance indicator for maternity care. There is growing interest in the use of major morbidity, so-called near miss, as an indicator of the quality of hospital-based obstetric care. The need to transfer to the ICU is used as an indicator of illness severity. Scoring systems such as the APACHE II or the SAPS score accurately predict hospital mortality among obstetric patients admitted to the ICU for medical reasons but perform poorly in predicting deaths from patients admitted purely for obstetric reasons. Ideally, future studies should try to estimate the predictor factors of severe obstetric morbidity to improve prenatal care, perinatal management, and anesthetic procedures. With reliable predictor factors, the number of obstetric patients who require critical care would be reduced and the rates of maternal and fetal morbidity and mortality lowered.

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