14.19 Maternal critical care 2701

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ESSENTIALS Critical illness during pregnancy or after giving birth is rare: in the United Kingdom 0.29% of maternities involve admission to a critical care unit, and the maternal death rate is 0.01%. Over 80% of obstetric admissions to critical care occur in the post- partum phase, mainly due to complications of massive haemorrhage. Other pregnancy specific conditions that may require critical care support include pre-eclampsia (typically when diagnosis and treat- ment have been delayed), amniotic fluid embolism, peri-partum cardiomyopathy and acute fatty liver of pregnancy. Puerperal sepsis remains a major problem in resource-poor parts of the world. Pregnant women who survive critical illness may be particularly prone to long-term psychological morbidity. It is vital that, once physiological stability has been achieved, no time is wasted before a mother is reunited with her baby. Introduction When a pregnant woman or new mother requires admission to the critical care unit it is a cause of grave anxiety to all involved. Women and their partners usually envisage a normal labour and childbirth with minimal medical intervention. An admission to intensive care, with mechanical and pharmacological organ support, is an unwel- come departure from this agenda. For the medical teams involved, obstetric admissions to the critical care unit occur infrequently and it is difficult to accrue sufficient clinical experience in this area to feel at ease. A genuine commitment to multidisciplinary working is essen- tial to achieve the best outcome for mothers. Obstetricians and midwives who have only limited experience of the critical care en- vironment need to remain closely involved to advise on aspects of antenatal, intra-partum and postnatal care. Specialist physicians and surgeons from other disciplines may be required, and the crit- ical care physician must listen carefully to all these viewpoints and integrate them into a coherent treatment plan. Early warning scores with thresholds specifically modified for the obstetric population are now widely used in an effort to detect developing critical illness. Their utility is compromised by the ability of young fit women to compensate for deteriorating physiology until a point of catastrophic deterioration, and data on normal values may not reflect today’s obstetric population. Epidemiology Critical illness during pregnancy or after giving birth is rare. In the United Kingdom, 290/100 000 maternities involve admission to a critical care unit (for comparison the maternal death rate is now 10/100 000). A far higher number of women will become sick and require a period of enhanced care, single organ support, and close monitoring.

The incidence of a short period of morbidity may be as high as 1200/100 000 maternities. Over 80% of obstetric admissions to critical care occur in the post-partum phase and complications relating to massive haemor- rhage are by far the commonest reasons for admission. By contrast, admission during the antenatal period is almost always as a result of a nonobstetric condition. Severe infections (particularly pneu- monia) predominate, but the full range of critical illness that occurs in women of reproductive age can present, and the pregnancy may be an incidental feature. Short lived antenatal problems are often managed on the labour ward by obstetricians and obstetric anaesthetists. This can be par- ticularly appropriate if giving birth is an important part of the man- agement of the condition (e.g. pre-eclampsia or acute fatty liver of pregnancy). Critical care severity scores and models of predicted mortality overestimate the death rate in the maternity population. The critical care unit mortality for obstetric admissions is less than 2%. General issues in maternal critical care Location of care In an emergency situation, critical care support can be provided almost anywhere. Vital equipment and staff can be moved faster and more safely than an unstable patient. Obstetric complications can develop and resolve rapidly and may only require a brief period of organ support. In some units this can be provided within the 14.19 Maternal critical care Rupert Gauntlett

 labour ward; in others transfer to a critical care facility is more ap- propriate. Women should receive high quality care by healthcare professionals with the appropriate skills and experience to manage their problems, the exact location where this is provided, and the designation of the staff involved is of secondary importance. For women who require prolonged or advanced organ support, safe transfer to a critical care facility should be immediately avail- able. Pregnant women admitted to a critical care unit should be reviewed daily by an obstetrician. There must be a clearly docu- mented plan for monitoring the pregnancy and robust arrange- ments for emergency delivery. Pregnancy monitoring will vary according to gestational age and fetal viability but may include cardiotocography and serial ultrasound scans to assess growth and placental circulation. Monitoring Frequent or continuous monitoring of physiological parameters is a universal feature of higher levels of care. Arterial lines may be easier to place during pregnancy because of the hyperdynamic cir- culation, but central venous line insertion can be more difficult. It is unpleasant and potentially harmful to position a pregnant woman supine and head-down. Tissue oedema can complicate both land- mark and ultrasound vessel location. Femoral vessels may be dif- ficult to access and maintain due to the gravid uterus. Pulmonary artery catheters are now rarely used in favour of less invasive cardiac output monitoring techniques (such as arterial pulse contour ana- lysis). Experiences of using a variety of cardiac output monitoring devices on pregnant women have been reported. Point of care echo- cardiography for assessment of volume status and myocardial func- tion is becoming routine in critical care, but lack of familiarity with normal echo findings in pregnancy can complicate the interpret- ation of images. Respiratory support The growing uterus has a visible mechanical effect on respiratory function. A fall in functional residual capacity as pregnancy pro- gresses causes rapid hypoxaemia during induction of anaesthesia, particularly if there is a delay to intubation or intercurrent respira- tory disease. High-flow nasal cannulae and other forms of noninvasive venti- latory support can be used in pregnancy when they are indicated. Gastric distension in a woman who is already suffering from re- flux as a result of increased intra-abdominal pressure and reduced sphincter tone associated with progesterone can be a significant problem. Intubation of obstetric patients is associated with a high risk of failure. No mode of mechanical ventilation has been demonstrated to be superior in providing respiratory support. When blood gases are used to assess

the adequacy of gas exchange the physiological respiratory alkalosis of pregnancy and normal values of pCO_2 must be considered. Circulatory support The cardiovascular changes in pregnancy occur very early in gesta- tion, with increase in cardiac output and decrease in systemic vas- cular resistance occurring before 14 weeks. These changes must be kept in mind when assessing a woman in shock. There are no preg- nancy specific data to inform the choice of vasopressors or inotropes. The effect on the fetal circulation of high dose or potent vasopressors cannot be beneficial. Acute renal replacement therapy in pregnancy Renal function (including glomerular filtration rate and creatinine clearance) is upregulated from early pregnancy. Assessment for acute kidney injury must be made against expected pregnancy values of creatinine, or else the early stages of renal dysfunction may be over- looked. Severe acute kidney injury is rare in the obstetric patient. Vascular access for dialysis/haemofiltration is usually by the sub- clavian or internal jugular veins. The femoral veins may be difficult to access, and vascular catheters may be kinked or compressed by a pregnant abdomen. There are no specific recommendations about the mode of renal replacement therapy used in pregnancy, but ex- perience from managing chronic dialysis patients in pregnancy sug- gests that the dose should be increased to mimic rates of clearance expected in pregnancy. Decision to deliver in antenatal critical illness The decision on whether to end a pregnancy (by planned birth or termination) in order to improve the chance of maternal survival is a clinical and ethical dilemma. There is conflicting clinical practice and outcome data for mothers and infants are often incomplete or inconsistent. Miscarriage is common in antenatal patients who be- come critically ill in early pregnancy, and it is hard to imagine that utero-placental function in a critically sick mother at any stage of pregnancy remains conducive to normal fetal development and growth. By contrast, the risks of premature birth are well quantified. A managed birth is usually less traumatic than a precipitous labour and unanticipated birth on a critical care unit. Criteria that have been suggested for ending the pregnancy are included in Table 14.19.1. Recent experience of managing women with severe H1N1 infection (including those who received extracorporeal membrane oxygen- ation) guides against delivering the woman, but follow-up studies of childhood growth and development are not available. Psychological sequelae and breastfeeding There is growing awareness of the long-term psychological mor- bidity among survivors of critical illness. Anecdotal evidence suggests that pregnant women may be particularly prone to these problems, perhaps because of the gap between expectation and reality in their maternity experience or linked to a sense of missing out on the baby’s first hours or days of life. It is vital that, once physiological stability has been achieved, no time is wasted before a mother is reunited with her baby. Table 14.19.1 When to offer planned childbirth to a critically sick woman Obstetric conditions which improve after the pregnancy has ended (severe pre-eclampsia, AFLP) Inadequate gas exchange/severe respiratory compromise Severe bacterial sepsis Rapidly deteriorating maternal condition despite organ support/treatment Multiorgan failure Fetal compromise AFLP, acute fatty liver of pregnancy.

 Women who have suffered a period of critical illness should not be denied the chance to breast feed. Milk can be expressed manu- ally or by breast pumps, and a review of maternal medication (in conjunction with advice from a neonatologist) can inform a deci- sion about whether breast milk can be given to the baby or should be discarded. Pregnancy specific conditions Obstetric major haemorrhage Complications arising from major haemorrhage and massive trans- fusion are the most common reasons for a woman to be admitted to intensive care around the time of childbirth. The common causes of severe obstetric bleeding are listed in Table 14.19.2. The blood supply to the uterus and placenta at term is usually estimated to be over

500 ml per minute, and the remainder of the genital tract is well vascularized and can contribute to rapid blood loss. The initial management of bleeding is in the domain of the obstetrician and obstetric anaesthetist. They must work together to control the blood loss by a combination of surgical and pharmacological techniques. In some centres interventional radiology may also be involved. It is important to utilize blood products early (rather than large volumes of clear intravenous fluids) in a major bleed. In addition to red cell replacement the use of other clotting products is vital to promote haemostasis. Pregnancy is a hypercoagulable state with up regulation of fibrinogen and most clotting factors. A low fibrinogen level heralds major obstetric haemorrhage and the early replace- ment of fibrinogen (with cryoprecipitate or fibrinogen concentrates) is increasingly recommended. Fresh frozen plasma has low levels of fibrinogen and administration of large volumes of fresh frozen plasma before fibrinogen replacement may be unhelpful. Platelet transfusion may also be indicated. Near patient tests of coagula- tion (e.g. thromboelastography), can be used to guide transfusion. Haemodilution, hypothermia, and acidaemia must be avoided or reversed as they can impede clot formation and stability. In the setting of a major bleed, most women will have been anaes- thetised and ventilated. At the end of a definitive surgical procedure, even if the clinicians are confident about haemorrhage control, a period of stabilization and observation may be indicated. Rapid blood loss and massive transfusion are a major physiological insult and there may be legitimate concern about immediate waking and extubation. The priorities in critical care management following ob- stetric major haemorrhage are • Careful review of the total quantities of blood products and fluid administered against the estimated blood loss • Administration of additional blood, clotting products, or antifibrinolytic agents as indicated by the post-haemorrhage full blood count and coagulation screen • Measurement and replacement of critical electrolytes including calcium • Temperature monitoring with active warming if indicated • Close monitoring for signs of further haemorrhage or haemostatic complications • On-going management of specific surgical and radiological inter- vention (e.g. removal of balloons or vascular catheter sheaths) • Monitoring for the complications of massive transfusion including transfusion related acute lung injury • Provision of adequate analgesia • Thromboprophylaxis should be prescribed as early as practic- able. A rebound hypercoagulable state has been described in the recovery phase of massive obstetric haemorrhage and low mo- lecular weight heparin should be administered soon after control of haemorrhage has been achieved Admission to the intensive care unit (ICU) after major blood loss is often brief and straightforward. Once stability has been achieved and organ function restored, a high priority should be given to waking, weaning, and extubation. An early return to the labour ward and as much participation as possible in the care of a newborn infant is a powerful motivator toward recovery. Complications of pre-eclampsia The range of hypertensive disease encountered in pregnancy is de- scribed in Chapters 14.4 and 14.5. Almost all pre-eclampsia is man- aged by obstetricians using practice guidelines and evidence-based recommendations. Key principles include aggressive control of hyper- tension, fluid restriction to avoid pulmonary oedema, magnesium sul- phate to prevent eclampsia and early induction of labour or caesarean section. When these principles are followed, very few women pro- gress to serious complications of pre-eclampsia. Admission to critical care more frequently involves women whose diagnosis and treatment has been delayed, or who present with fulminant disease or a serious complication. Complications of severe pre-eclampsia that necessitate critical care admission are listed in Table 14.19.3. The central import- ance of bringing the pregnancy to an end in the management of severe pre-eclampsia mandates that women are often cared for on the labour ward rather than on a critical care unit. Invasive blood pressure monitoring is indicated if women re- quire continuous infusions (or frequent intravenous boluses) of antihypertensive agents.

Titration of vasoactive agents should be aimed at achieving consistent systolic blood pressure of less than 150 mm Hg and diastolic pressures of 80–100 mm Hg. Intravenous drugs used by infusion in the management of severe pre-eclampsia in- clude labetalol, hydralazine, nicardipine, and sodium nitroprusside. When a woman is admitted to the critical care unit with a severe complication of pre-eclampsia it is important that a firm focus on the underlying management strategies (strict blood pressure control, cau- tious fluid balance and use of magnesium sulphate) are continued. Ignorance of the blood pressure treatment targets for pre-eclampsia or insufficient appreciation of the susceptibility of the lung to pulmonary oedema must not be overlooked. Fluid management decisions in pre- eclampsia can be difficult. Central venous pressure does not predict fluid responsiveness or volume dependent pulmonary oedema. Post-partum pre-eclampsia, particularly where symptoms worsen in the period 24–48 hours after childbirth, is associated with a higher risk of severe complications. Table 14.19.2 Common causes of obstetric major haemorrhage Antepartum Postpartum Placental abruption Atonic uterus Placenta previa Retained placenta Ruptured uterus Trauma to the genital tract

Section 14 Medical disorders in pregnancy 2704 Maternal susceptibility to neurological complications (including intracerebral bleeding, posterior reversible encephalopathy syn- drome and hypertensive encephalopathy) is believed to be higher in pregnancy than at the same levels of hypertension in the nonpregnant state. Amniotic fluid embolism Amniotic fluid embolism is a rare, poorly understood condition that is characterized by the abrupt development of shock during labour or after childbirth, which cannot be explained by other pathologies. There are several associations (e.g. rapid labour and cervical lacer- ations), but the precise aetiology remains unclear. The clinical picture usually consists of maternal collapse with hypotension, hypoxaemia, and severe coagulopathy. The term anaphylactoid syndrome of pregnancy has been used to explain some features of the condition; others prefer the name sudden obstetric collapse syndrome. There are no specific therapies for amniotic fluid embolism and management depends on the rapid initiation of organ support. Intubation with positive pressure ventilation and circulatory support with fluids and vasopressors can be lifesaving. Severe coagulopathy is a near universal feature of the condition and should be treated with rapid blood product infusion. Case reports in the literature de- scribe the use of extracorporeal membrane oxygenation, mechanical assist devices for the right ventricle, and nitric oxide in the successful management of women with the condition. Peri-partum cardiomyopathy This condition is described in Chapter 14.6. Critical care therapy is similar to other causes of severe cardiac failure. Arrhythmias are more common than in other causes of heart failure and thromboprophylaxis is important. Critical care support in the most severe cases has included the use of ventricular assist devices, aortic balloon pumps, and cardiac transplantation. Acute fatty liver of pregnancy This condition is described in Chapter 14.9. Critical care will be re- quired if a woman develops fulminant hepatic failure or encephal- opathy. Ending the pregnancy is curative but can be complicated by haemorrhage as a result of coagulopathy. A very few women reach a level of disease severity where transplantation is indicated. The criteria for liver transplant are the same as for other causes of acute liver failure. Other specific conditions requiring critical care in pregnancy Cardiac arrest in pregnancy International guidelines describe the recommended management of cardiac arrest, with two important additions for the special circum- stance of a cardiac arrest during pregnancy. • Manual displacement of the uterus • Peri-mortem caesarean section Compression of the vena cava, reducing venous return, is a well described feature of late pregnancy and it is vital that resuscitation efforts are not compromised by this effect. The preferred technique to avoid this complication is manual displacement of the

uterus. The use of a steep left lateral tilt during resuscitation may reduce the quality of cardiac compressions. A plan to empty the uterus by peri-mortem caesarean section (also known as a resuscitative hysterotomy) must be enacted as soon as cardiac arrest is diagnosed. Resuscitation guidelines suggest a target of knife to skin at four minutes and extraction of the fetus within five minutes of maternal cardiac arrest. The recommendation to empty the uterus is not to salvage the fetus but to enhance resus- citation of the mother. Peri-mortem caesarean section is generally recommended in women who are more than 20 weeks' gestation. A check-list of potentially treatable causes of maternal car- diac arrest has been promoted by the American heart association (Table 14.19.4). Severe sepsis in pregnancy Puerperal sepsis remains a major cause of maternal mortality around the world. In countries with well-resourced healthcare systems the incidence of severe maternal sepsis is lower, but still occurs with a prevalence of at least 45 per 100 000 maternities. Infection rates may also be influenced by the community prevalence of streptococcal in- fection, patterns of antibiotic usage and outbreaks of influenza. Table 14.19.3 Complications of pre-eclampsia leading to critical care admission Neurological Intracerebral bleeding Ischaemic stroke Cerebral oedema Posterior reversible encephalopathy syndrome Recurrent seizures Respiratory Pulmonary oedema Adult respiratory distress syndrome Cardiac Left ventricular failure Renal Acute kidney injury caused by cortical or tubular necrosis Hyperkalaemia Severe oliguria Abdominal Liver capsular rupture Hepatic infarction Massive blood loss secondary to low platelets (HELLP)
or disseminated intravascular coagulation Intractable hypertension requiring prolonged intravenous agents Table 14.19.4 Causes of cardiac arrest in pregnancy (American Heart Association) BEAU-CHOPS Bleeding/DIC Embolism—pulmonary, amniotic fluid, coronary Anaesthesia complications—including local anaesthetic toxicity Uterine atony Cardiac disease—myocardial infarction, cardiomyopathy, coronary or aortic dissection Hypertension—eclampsia or other complications Other unusual differentials Placental abruption/previa Sepsis DIC, disseminated intravascular coagulation.

14.19 Maternal critical care 2705 The susceptibility to a variety of infections and the severity of the illness produced is due in part to the modulation of the immune system that occurs during pregnancy. Physical changes in pregnancy also predispose women to some infections. Stasis and decreased ureteric sphincter tone cause increased susceptibility to ascending urinary tract infection. Chemical changes and physical damage to the mucosa of the genital tract may also compromise the barrier to infection. In identified bacterial infection two organisms are particularly important. Group A streptococcus, which has a high attack rate during pregnancy, and E. coli infections of the urogenital tract. Pregnant women are more susceptible to influenza and its compli- cations at all stages of pregnancy. Early detection of sepsis can be a particular problem during la- bour when mild degrees of pyrexia and a leucocytosis are normal. Clinical trials in sepsis almost always exclude pregnant women, but general sepsis care recommendations are still applied to maternity cases. Management priorities are: • High clinical suspicion and early identification using obstetric specific early warning systems • Measurement of serum lactate, blood culture, and early adminis- tration of appropriate antibiotics in a sepsis care bundle • Source control (this may need to include evacuation of the uterus) • Low threshold to end the pregnancy when sepsis has progressed to multiorgan failure FURTHER READING American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics (2016). Practice bulletin No. 170: Critical care in pregnancy. Obstet Gynecol, 128(4), e147–54. Gauntlett R on behalf of the MBRRACE-UK critical care chapter- writing group (2016). Messages for critical care. In: Knight M, Nour M, Tuffnell D, Kenyon S, Shakespear J, Brocklehurst P, Kurinczuk JJ (eds.) on behalf of

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Revision #1
Created 2026-01-22 16:38:11 UTC by Omar Ayman
Updated 2026-01-22 16:38:11 UTC by Omar Ayman