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Intensive Care Management after Major Postpartum Hemorrhage

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INTRODUCTION

The admission of obstetric patients to the intensive care unit (ICU) is relatively infrequent. Critically ill patients who have sustained postpartum hemorrhage (PPH) are more likely to be sent for after care which involves continuation of resuscitation measures, repetitive and intensive monitoring, and appropriate organ support. Management of this subgroup of obstetric patients must take into account normal physiological changes that occur during pregnancy, the aim being to ensure adequate oxygen delivery and tissue perfusion.

ADMISSION TO INTENSIVE CARE UNIT

Patients should be admitted to ICU before their condition reaches a point from which recovery is impossible. The early detection of the severe physiological changes which may occur in patients with PPH remains a challenge because of the relative rarity of such events and the normal changes in physiology associated with pregnancy and childbirth. The early warning score (EWS)[1] is a tool for bedside evaluation based on physiological parameters. The modified early obstetric warning score (MEOWS) (of the type described in Chapter 10) is another specific tool for bedside evaluation of the obstetric patient based on physiological parameters. The routine use of such charts in patients with PPH assists the prompt and appropriate recognition of the acutely ill woman requiring urgent medical review, thereby preventing further deterioration which can be catastrophic. Patients who trigger a specific score on the MEOWS chart should be referred to intensive care outreach team and intensive care team. The use of MEOWS was recommended in the CEMACH report *Saving Mothers' Lives* (2007)[2]. This is also supported by National Institute for Health and Clinical Excellence (NICE) guidelines for the acutely ill patient[3] and the National Patient Safety Agency (NPSA)[4]. In the ward if there is any concern about the patient's condition, she is admitted to ICU for appropriate organ support. If PPH is diagnosed in the operating theater, then the patient is kept asleep (if already intubated), ventilated and admitted to ICU.

MANAGEMENT

An initial assessment of the patient's condition is made and resuscitation is begun in the labor ward or operating room when the diagnosis of PPH is made. The approach to such an acutely unwell patient is immediate management of airway, breathing and circulation (ABC) with a main aim of supporting the patient's vital functions. At some time after the initial resuscitative and therapeutic efforts have taken place, when the patient is considered to be in a stable or relatively stable condition, the patient is transferred to the ICU with its appropriately trained staff, high intensity nursing and prolonged monitoring capability. These factors act together to prevent further deterioration.

Airway management

The airway is most easily maintained with the patient in the left lateral (recovery) position, thus allowing the tongue, soft palate and any oropharyngeal fluid to move away from the laryngeal inlet. In the supine position, the patent airway is maintained with the head tilt and jaw thrust maneuver. Airway adjuncts such as the oropharyngeal (Guedel) airway also can be used. Any fluid, including vomitus, from the oropharynx must be suctioned. Endotracheal intubation may be indicated to provide airway protection and to institute mechanical ventilation and oxygenation. Rapid sequence induction (RSI) with application of cricoid pressure is necessary to avoid gastroesophageal reflux and aspiration.

Breathing management

Respiratory efforts are assessed for signs of hypoxia by inspecting the patient's color especially around lips, tongue and hands. A dusky, bluish hue may suggest hypoxia. The chest is examined for adequate air entry. Tachypnea may indicate hypovolemia, hypoxia, acidosis or pain. Pulse oximetry is a useful non-invasive method of monitoring the patient's oxygenation. Supplementary high flow oxygen up to 10–15 l/min should be administered to seriously ill patients. Patients may not require mechanical ventilation, but those who do require that their ventilation need be

identified as early as possible before they deteriorate further.

Invasive ventilation

Mechanical ventilation is instituted via endotracheal tube when the patient's spontaneous ventilation is inadequate or there is imminent respiratory failure leading to poor gas exchange in the lungs. The underlying condition for respiratory failure (PPH and its complications) should be corrected while the patient is ventilated. Once the underlying condition is treated and the patient is able to support her own ventilation and oxygenation, the ventilatory support is gradually withdrawn (weaning).

Non-invasive ventilation

Non-invasive ventilation (NIV) refers to the provision of ventilatory support through the patient's upper airway using a mask or similar device[5]. Application of non-invasive positive airway pressure may be helpful in some selected patients by both preventing atelectasis and improving oxygenation.

Circulatory management

Acute and continued blood loss leads to hypovolemic shock. The onset of shock is usually secondary to hypovolemia and represents a failure of tissue perfusion. The body responds to an acute hemorrhage by activating various physiological systems. The cardiovascular system responds with tachycardia and compensatory vasoconstriction. In such circumstances, an initially normal blood pressure does not exclude shock, as the blood pressure may be maintained because of vasoconstriction.

The principles of management are to aim for normal tissue oxygen delivery. This is done by adjusting the preload, increasing cardiac contractility and optimizing systemic vascular resistance. The preload is adjusted first to ensure an adequate circulating volume with fluids and then, if necessary, vasoactive drugs are commenced. Increasing the hemoglobin with blood transfusion and good oxygenation optimizes the oxygen content of the blood. The treatment should be aggressive and directed by the response to therapy.

Fluids and bloods

Initially fluids should be infused to compensate for blood loss. However, adequate blood transfusion therapy must be instituted sooner rather than later as discussed elsewhere in this book (see Chapter 4).

Electrolytes

Serum electrolytes such as sodium, potassium, magnesium, calcium and phosphate play important roles in cellular metabolism and regulation of cellular membrane potentials. These should be regularly measured and corrected accordingly.

Monitoring

Physical examination will show the signs and symptoms of hypovolemic shock. Apart from continuous electrocardiogram (ECG), pulse oximetry saturation (SpO$_2$) and non-invasive blood pressure monitoring, the invasive monitoring should be instituted as soon as possible to guide the therapy.

Invasive blood pressure

Non-invasive blood pressure measurements may not be reliable because of factors such as shock and/or patient restlessness. Arterial cannulation is required for monitoring arterial pressure, arterial blood gas analysis and for frequent blood sampling.

Central venous pressure

A central venous pressure line should be secured at the earliest opportunity and used to guide volume replacement and infusion of vasoactive drugs.

Cardiac output

The measurement of cardiac output constitutes a vital part in the management of critically ill patients. Invasive methods such as the thermodilution technique using a pulmonary artery (Swan–Ganz) catheter are the clinical standard[6]. Despite this, minimally invasive techniques are gaining popularity, as they allow continuous cardiac output monitoring while avoiding the risks associated with invasive procedures[7]. In addition, minimally invasive hemodynamic monitoring provides easier, quicker, cheaper, safer, continuous, on-line, real-time display of the hemodynamics of acutely ill patients compared with invasive monitoring[8]. The minimally invasive cardiac output measurement techniques include esophageal Doppler, arterial pulse contour analysis (LiDCO plus) and thoracic bioimpedance.

Esophageal Doppler The esophageal Doppler technique is based on measurement of blood flow velocity in the descending aorta by means of a Doppler transducer (4 MHz continuous or 5 MHz pulsed wave). In a mechanically ventilated patient, the probe is introduced orally and advanced gently until the tip is located at approximately the mid-thoracic level; it is then rotated so that the transducer faces the aorta and a characteristic aortic velocity signal is obtained. When combined with aortic cross-sectional area, this allows hemodynamic variables including stroke volume and cardiac output to be obtained from interpretation of the size and shape of the waveform (Figures 1 and 2). Probe position is optimized by slow rotation in the long axis and alteration of the depth of insertion to generate a clear signal with the highest possible peak velocity. Gain setting is adjusted to obtain the best outline of the aortic velocity waveform.

The esophageal Doppler cardiac output monitor has undergone significant technological advancement and clinical evaluation[9]. There is good correlation

between measures of cardiac output made simultaneously with the esophageal Doppler monitor and conventional thermodilution. Esophageal Doppler ultrasonography has been used for intravascular volume optimization in both the perioperative period and the critical care setting. Its use in cardiac, general and orthopedic surgery has been associated with a reduction in morbidity and hospital stay[10–12].

Arterial pulse contour analysis Arterial pulse contour analysis (PiCCO and LiDCO plus) estimates the left ventricular stroke volume and therefore cardiac output from arterial pulse pressure waveform on a beat to beat basis. This may have advantages over the existing technologies, as the majority of critically ill patients already have the arterial pressure traces transduced, making this technique minimally invasive and providing the ability to monitor changes in stroke volume and cardiac output[13].

The LiDCO plus is based on the lithium bolus indicator dilution method of measuring cardiac output. A small dose of lithium chloride is injected via a central or peripheral venous line; the resulting arterial lithium concentration–time curve is recorded by withdrawing blood past a lithium sensor attached to the patient's existing arterial line. This value is then used to calibrate the LiDCO as well as to give continuous cardiac output and derived variables from arterial waveform analysis. This facilitates patient management by allowing assessment of the immediate response to a fluid challenge, drugs or other therapeutic interventions. In terms of accuracy, clinical studies over a wide range of cardiac outputs demonstrate that the LiDCO method is at least as accurate as thermodilution even in patients with varying cardiac outputs[14]. Having said this, several factors affect the accuracy of cardiac output measurements based on the analysis of arterial waveforms, including damped waveforms and inadequate pulse detection (e.g. severe arrhythmias, catheter dislodgement)[15].

Inotropes and vasopressors

Pharmacologic agents that increase the blood pressure by increasing cardiac contractility are called inotropes, and agents that increase blood pressure by arteriole vasoconstriction are called vasopressors. This group of drugs is useful for resuscitation of seriously ill patients. Inotropes include the catecholamines or phosphodiesterase inhibitors. The catecholamines increase intracellular cAMP levels via adenylate cyclase stimulation; cAMP increases intracellular calcium ion mobilization and force of contraction[16].

These drugs all act directly or indirectly on the sympathetic nervous system, but the effect of each drug varies depending on the sympathetic receptor (Table 1) for which the drug possesses greatest affinity. Direct acting drugs act by stimulating the sympathetic nervous system receptors, whereas indirect acting drugs cause the release of noradrenaline from the receptor which then produces the effect. Some drugs have a mixed effect. Commonly used inotropes

(dopamine, dobutamine and adrenaline) and vasopressors (phenylephrine, noradrenaline and vasopressin) are shown in Table 2.

Dopamine Dopamine acts on D1, D2, β1 and α1 receptors, in a dose dependent manner. At low doses, dopamine causes dopamine receptor (D1, D2) mediated renal and mesenteric vasodilatation and results in diuresis. At an intermediate dose, dopamine increases
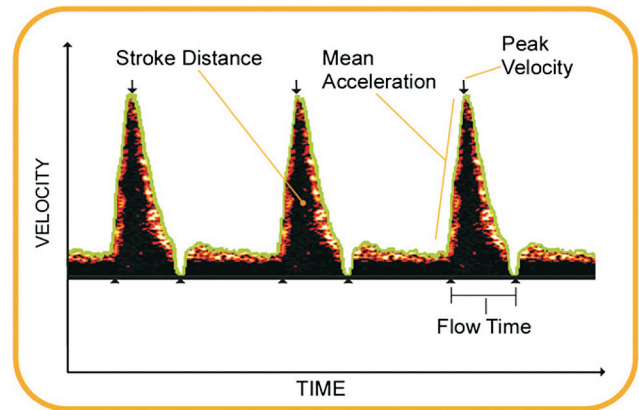

Figure 1 Interpretation of aortic Doppler waveform changes. Image reproduced with kind permission of Deltex Medical© 2012
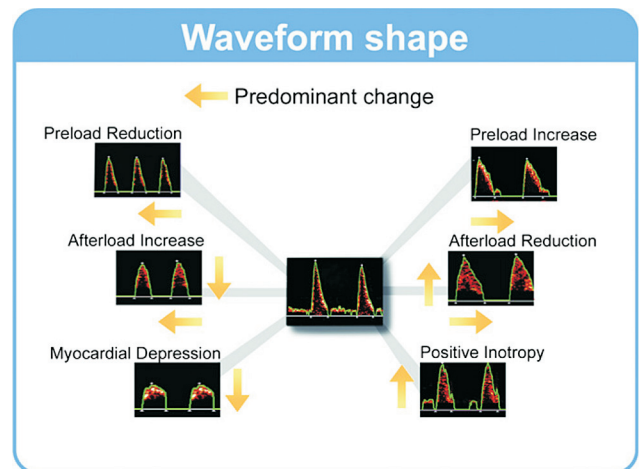

Figure 2 Predictable changes in the shape of the esophageal Doppler waveform occur during changes in the hemodynamic state of an individual. The most common abnormality seen during targeted fluid administration is hypovolemia, which is represented by the narrow triangular waveform 'preload reduction'. Image reproduced with kind permission of Deltex Medical© 2012

Table 1 Noradrenergic receptors and main actions of each receptor subtypes

Receptor	Action
α1	Peripheral arterial vasoconstriction, increases systemic vascular resistance
β1	Increased heart rate, increased atrioventricular conduction velocity, increased ventricular contractility
β2	Vasodilation in skeletal muscle, brochodilatation
DA	Increased renal blood flow

DA, dopaminergic receptors

Table 2 Commonly used inotropes and vasopressors

Drug	Dose range	α1	β1	β2	Other	Major side-effects
Dopamine	2.0–20 μg/kg/min	++	+		DA +++	Ventricular arrhythmias
Dobutamine	2.0–20 μg/kg/min		+++	++	0	Peripheral vasodilator, tachycardia at higher doses
Adrenaline (epinephrine)	0.01–0.1 μg/kg/min	+++	+++	++	0	Ventricular arrhythmias, severe hypertension
Phenylephrine	100 μg/ml at a rate of 30 ml/h	+++			0	Bradycardia, peripheral ischemia
Noradrenaline (norepinephrine)	0.01–3 μg/kg/min	+++	++	+	0	Bradycardia, peripheral ischemia
Vasopressin	0.01–0.1 U/min				V1 +++	Severe peripheral ischemia

DA, dopamine receptors

cardiac output via the β1 receptor. At higher doses, this agent leads to α1 receptor mediated vasoconstriction.

Dobutamine Dobutamine is mainly a β1 receptor agonist with weak β2 receptor agonist properties. It is a potent inotrope with a weaker chronotropic and peripheral vasodilatory effect.

Adrenaline (epinephrine) Adrenaline is a potent β receptor agonist which also has α receptor agonist activity. Adrenaline is useful during resuscitation and maintaining cardiac output during initial stages; however, tachycardia, increased myocardial oxygen demand and arrhythmias are limiting factors in its use.

Phenylephrine Phenylephrine has potent α receptor agonist activity, but virtually no affinity for the β receptor. Phenylephrine is given as a bolus or infusion to increase the mean arterial pressure in the presence of peripheral vasodilatation. It is started as an infusion of 100 μg/ml at a rate of 30 ml/h, but is titrated to keep the blood pressure within 20% of the patient's baseline for as long as it is needed.

Noradrenaline (norephenephrine) Noradrenaline is a potent α1 receptor agonist with some β1 receptor activity leading to potent vasoconstriction, raised blood pressure and compensatory bradycardia. Myocardial oxygen demand is increased markedly after its administration.

Vasopressin Vasopressin or antidiuretic hormone (ADH) has a potent vasoconstriction effect through V1 receptors in the vascular smooth muscle; it causes water retention by the kidney via increased adenylate cyclase activity and cAMP levels. Pressor effects of vasopressin are relatively well-preserved during hypoxic and acidotic conditions, which commonly develop during shock of any origin.

Neurological management

Rapid assessment of global neurological function is achieved using the Glasgow coma scale (GCS). The original GCS[17] has been modified with a maximum score of 15. It is an objective, reliable and accepted

Table 3 The modified Glasgow coma scale (GCS)

	Score
Eye opening response (E)	
Spontaneously	4
To speech	3
To pain	2
None	1
Best verbal response (V)	
Oriented	5
Confused	4
Inappropriate speech	3
Incomprehensible speech	2
None	1
Best motor response (M)	
Obeys command	6
Localizes to painful stimulus	5
Withdrawal to painful stimulus	4
Abnormal flexion to painful stimulus	3
Extension to painful stimulus	2
None	1
Total	15

way of assessing global neurological function. Modification was achieved by adding three components, namely the eye opening response (E, with a maximum score of 4), best verbal response (V, with a maximum score of 5) and best motor response (M, with a maximum score of 6) as shown in Table 3. Although the modified GCS was initially used to assess consciousness level after head trauma, it is a relatively simple and easy to follow neurological assessment tool for most patients, including those who have sustained catastrophic PPH.

Thus GCS = E + V + M

GCS = 15, fully alert and conscious
GCS = 13–14, mild state of unconsciousness
GCS = 9–12, moderate state of unconsciousness
GCS = 3–8, deep state of unconsciousness. The patient needs tracheal intubation and ventilation

Renal management

Acute renal failure (ARF) presenting as oliguria or anurea is one of the commonest complications of

acute hypovolemic shock and PPH. Hypovolemia leads to reduced glomerular perfusion, acute tubular necrosis and ultimately renal failure. Patients with pregnancy induced hypertension are more susceptible to ARF following PPH because of decreased intra-vascular volume and increased vascular response to catecholamines[18,19].

The urinary bladder must be catheterized in all patients with PPH. Hourly recording of urine output provides an early indication of ARF. Management should be aimed at maintaining adequate intravascular volume, supportive care and avoiding nephrotoxic drugs like non-steroidal anti-inflammatory drugs (NSAIDs). Prompt recognition, aggressive resuscitation and intervention may prevent ARF. Traditionally low dose dopamine infusion has been shown to increase renal blood flow; however, current evidence suggests that this does not affect the clinical outcome.

Renal replacement therapy (RRT) in the form of peritoneal dialysis (PD), continuous venovenous hemofiltration (CVVH) or continuous venovenous hemodifiltration (CVVHDF) may be indicated if there is established ARF, not responding to volume replace-ment and diuretics (Table 4).

Gastrointestinal management

Protein energy malnutrition is a major problem in severely ill hypercatabolic patients in the ICU[21]. Early initiation of enteral nutrition is beneficial, with signifi-cant positive effects on septic complications, and improved outcome compared with parenteral nutri-tion. Enteral nutrition guarantees the preservation of gut mass and prevents increased gut permeability to bacteria and toxins[22].

Hematological management

Blood products and hematological management are discussed in various other chapters of this book (see Chapter 4–6).

Sepsis management

Sepsis is a leading cause of death in critically ill patients despite the aggressive management and use of specific antibiotics. The septic response is an extremely com-plex chain of events involving both inflammatory and anti-inflammatory processes[23]. Early diagnosis and stratification of the severity of sepsis is very important, thereby increasing the possibility of starting timely and specific treatment[24].

Table 4 Indications for renal replacement therapy in ICU (adapted from Ronco et al.[20])

Oliguria (urine output <0.5 ml/kg/h)
Uncompensated metabolic acidosis (pH <7.1)
Blood urea >30 mmol/l (84 mg/dl)
Serum creatinine >300 μmol/l (3.4 mg/dl)
Serum potassium >6.5 mmol/l or rapidly rising

The Surviving Sepsis Campaign (SSC)[25] is a high profile initiative of the European Society of Intensive Care Medicine, the International Sepsis Forum and the Society of Critical Care Medicine. It was proposed to improve the management, diagnosis and treatment of sepsis. The SSC aims to reduce mortality from sepsis via a multipoint strategy, primarily by:

- Building awareness of sepsis
- Improving diagnosis
- Increasing the use of appropriate treatment
- Educating health-care professionals
- Improving post–ICU care
- Developing guidelines of care
- Facilitating data collection for the purposes of audit and feedback.

Pain relief and sedation

Critical illness can be a frightening experience for the awake and alert patient, and adequate sedation may reduce this. The ideal sedative agent should have minimal cardiovascular effect with rapid onset and offset actions. Commonly used sedatives include benzodiazepines in the form of a midazolam infusion. Midazolam has three metabolites; one of these (1-hydroxymidazolam) can accumulate in the critically ill. The normal elimination half-life is 2 hours, but can be as long as a few days in the long-term sedated, criti-cally ill individual. Shorter acting drugs like propofol infusion can also be used with caution, because it can cause cardiovascular depression in the hypovolemic and septic patient.

Pain is common and may be worsened by invasive and unpleasant procedures that can lead to respiratory and cardiac complications as a result of increased sym-pathetic activity. Assessment of pain is a vital element in effective pain management. Opioids are the main-stay of treatment and possess sedative, hypnotic effects besides their obvious analgesic effects. They work at the level of the opioid receptors. Morphine sulfate is the most commonly used opioid. Morphine is metabolized primarily in the liver into two main products, morphine-3-glucuronide and morphine-6-glucuronide. Both are excreted renally and accumulate in circumstances of renal dysfunction. Other short act-ing opioids such as fentanyl or alfentanil infusions can also be used.

Balanced analgesia (multimodal approach) is the method of choice for moderate pain control wherever possible by using other analgesic techniques such as paracetamol, NSAIDs and regional techniques (e.g. epidural infusions for postoperative patients).

General management

General management includes deep vein thrombosis (DVT) prophylaxis, stress ulcer prevention,

prevention of nosocomial pneumonia, line sepsis care and skin care to prevent decubitus ulcerations.

Care bundle

The 'care bundle' is a relatively new concept in intensive care practice. It appears that when several evidence based interventions are grouped together in a single protocol, they result in substantially greater improvement in patient outcome. This concept was developed in the USA by Berenholtz and Pronovost *et al.*[26,27] to eliminate catheter related blood stream infections in the ICU. The care bundle is being promoted by National Health Service Modernisation Agency in UK[28] as it provides a method for establishing best evidence based clinical practice (Table 5).

Various care bundles have been developed all of which can be grouped together under ventilator care bundle. FAST HUG is a mnemonic proposed 5 years ago by Jean-Louis Vincent[29] as a way of assisting health-care workers looking after critically ill patients. The FAST HUG mnemonic has seven basic components (Table 6) that should be considered for every intensive care patient at least once a day: feeding, analgesia, sedation, thromboembolic prophylaxis, head-of-bed elevation, stress ulcer prevention and glucose control. Although all of these elements may not require action as to particular patients each day, it is suggested that considering each of these elements will minimize mistakes, reduce complications and improve positive outcomes and quality of life for ICU patients.

Whenever possible and, if appropriate, the mother should be informed about the baby's health and progress. It is important not to forget that the intensive care patient is not just a series of diseased organs, but a human being with physical, psychological and spiritual needs. Intensive care admission is a stressful event for the patient and her family, and patients recovering from critical illness are at risk of developing post-traumatic stress disorder (PTSD). The provision of an ICU diary is associated with a reduction in the incidence of new-onset PTSD[30]. While the patient is in ICU, the health-care staff and family write about the daily progress of the patient along with photographs in a diary. This diary explains what happened to the patient in the ICU, thus helping fill in significant gaps they have in their memories and putting any delusional memories into context. These efforts aid psychological recovery.

Discharge and follow-up

Once discharged from the ICU, MEOWS charts can be continued in these patients when they return to a step-down unit at which time the intensive care outreach team should provide follow-up on the ward. The intensive care outreach team is a multidisciplinary team comprising senior nurses with a background in intensive care and intensivists. The team works closely with the ICUs. The primary aim is to ensure that these patients receive appropriate and timely treatment after their discharge from the ICU and prevent any readmission.

SUMMARY

The care of the acutely ill PPH patient in the critical care unit is challenging and often requires a multidisciplinary approach. Early recognition and prompt treatment of such patients can help prevent irreversible organ dysfunction.

PRACTICE POINTS

- Management of the PPH patient in the ICU should take into account the normal physiological changes during pregnancy.

- The main aim is to support the patient's vital functions, ensure adequate oxygen delivery and tissue perfusion, thus preventing irreversible organ dysfunction.

- The 'FAST HUG' approach should be considered for every intensive care patient at least once a day.

- Sepsis is a leading cause of death in critically ill patients despite the aggressive management and use of specific antibiotics. The early diagnosis and stratification of the severity of sepsis is important.

Table 5   Central line care bundle[27]

Hand hygiene
Maximum barrier precautions
Chlorhexidine skin antisepsis
Optimal catheter site selection
Daily review of line necessity and prompt removal

Table 6   The seven components of the FAST HUG approach. Reproduced from Vincent, 2005[29], with permission

Component	Consideration for intensive care unit (ICU) team
Feeding	Can the patient be fed orally, if not enterally? If not, should we start parenteral feeding?
Analgesia	The patient should not suffer pain, but excessive analgesia should be avoided
Sedation	The patient should not experience discomfort, but excessive sedation should be avoided; 'calm, comfortable, collaborative'
Thromboembolic prevention	Should we give low-molecular-weight heparin or use mechanical adjuncts?
Head of the bed elevated	Optimally, 30–45°, unless contraindications (e.g. threatened cerebral perfusion pressure)
Stress **U**lcer prophylaxis	Usually H2 antagonists; sometimes proton pump inhibitors
Glucose control	Within limits defined in each ICU

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