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Maternal special care unit in the delivery suite: experience from Prince of Wales Hospital

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This article summarises the history of the establishment of the first maternal special care (MSC) unit in Hong Kong. The authors highlight the use of obstetric early warning system, the levels of care for critically ill mothers, the equipment used in MSC, and the midwifery training in maternal critical care. The authors also present the statistics of MSC admissions at Prince of Wales Hospital from 2018 to 2020.

Keywords: Critical care; Maternal mortality; Midwifery

Background

The maternal mortality ratio in Hong Kong is <5 per 100 000 registered live births, which is among the lowest in the world[1]. However, the number of maternal mortalities may be under-reported,[2,3] as Hong Kong does not have confidential enquiries into maternal deaths or obstetric surveillance programme for severe and near-miss maternal morbidities[4,5]. In addition, the median age for first childbirth among Hong Kong women is consistently rising. In the latest census report, the number of live births born by younger women has reduced by half, whereas that by women of advanced maternal age has doubled[6]. The ageing maternity population is associated with higher rates of co-existing medical diseases and obstetrics complications[7-9]. According to the World Health Organization, the top three causes for maternal deaths are obstetric haemorrhage, sepsis, and hypertensive disorders, accounting for 50% of all maternal mortalities[10]. Other common causes are venous thromboembolism and amniotic fluid embolism. The disease pattern of maternal death in Hong Kong is similar, based on data of intensive care unit (ICU) admissions for obstetric patients[11-13] and maternal mortalities[2,3,14,15]. Maternal critical care comes into play, as management of these deathly obstetric conditions often involves intensive care.

Introduction of maternal critical care

In the confidential enquiries into maternal deaths report in 1985 to 1987 in the UK, delay and difficulty in recognising critical illness in mothers has been identified as a recurring problem leading to maternal mortality[16,17]. This prompted the establishment of proper facilities for mothers in need[18,19]. Since then, centralised high dependency care with appropriately trained staff and monitoring equipment and techniques has been promoted across UK. In 2011, the Maternal Critical Care Working Group in the UK published the first document specifically for maternal critical care provision[20].

In the United States, with the rising maternal morbidity and mortality secondary to increasing medically complex obstetric population, critical care in obstetrics is considered the key strategy to address the issue[21]. In 2009, the American College of Obstetricians and Gynecologists published the first clinical management guideline for critical care in pregnancy. The latest version was updated in 2019[22]. Although the service models of maternal critical care vary widely among different healthcare systems with no globally agreed standard, it is now recognised as an important tool to reduce maternal morbidity and mortality[21,23-25].

Establishment of maternal special care unit

In 2013/14, a proposal of setting up a high dependency unit in the delivery suite was submitted to the Hospital Authority New Territories East Cluster annual planning exercise by the Prince of Wales Hospital, which has the highest birth rates among all birth units. A service gap was identified as the number of high-risk pregnancies was increasing, and the service need was reviewed at the Service Management Meeting. In 2015/16, a proposal further expanded to include all birth units was submitted to the Clinical Coordinating Committee. It was agreed that

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the service gap was big for all birth units as there were significant manpower shortage, lack of staff training, lack of modernised monitoring equipment, and lack of resources allocated. The proposal obtained full support, with funding to improve obstetric care by setting up maternal special care beds with modern equipment and trained staff.

The Prince of Wales Hospital was one of the pilot hospitals to kick off this project. Two additional nurses were allocated, and funding was provided to procure equipment and to train doctors and midwives. In May 2018, the first maternal special care (MSC) bed was set up within the delivery suite. It serves as an intermediary unit between the ICU and the general ward to help to reduce the number of admissions to ICU and shorten the duration of ICU stay. Patient safety is enhanced by intensive monitoring of high-risk cases, prompt recognition of deteriorated cases, early consultation to ICU, and emergency care before transferring to ICU. Placing MSC within the delivery suite enables optimal management of specific obstetric conditions and reduction of mother-baby separation. MSC is managed by a multidisciplinary team of maternal medicine specialists, obstetricians, obstetric anaesthetists, and midwives with critical care training. Owing to high utilisation rate in the first year, more funding was given to expand MSC to two beds.

Obstetric early warning system

The early warning system to detect early symptoms or/and signs of maternal deterioration is highly accurate in predicting death among critically ill obstetric patients[26]. As obstetric patients have altered physiological parameters secondary to pregnancy, several different early warning systems have been modified for this special group of patients[27]. The aim is to raise clinical awareness of potential serious events and to trigger urgent patient evaluation and hence timely diagnosis and prompt intervention so as to reduce maternal morbidity and mortality.

We referenced several different early warning systems[27-29] and generated our own system that is applicable to all obstetric patients in our unit. A colour-coded (yellow or red) observation chart is used to guide the escalation of care (Table 1). It is important to note that the respiratory rate is an early indicator of patient deterioration[30]. Despite its clinical importance, the respiratory rate is the least accurately measured vital sign. Its assessment is often neglected or inaccurately performed owing to a lack of training or knowledge or a lack of time under heavy workload[31]. Therefore, highlighting assessment of the respiratory rate is important in nursing education, particularly critical care training. However, the early warning system has limitations. It cannot replace proper attainment of the vital signs, prompt reaction to escalation, effective communication, accurate clinical judgment, and prompt management[32]. In addition, the early warning system only provides a snapshot of a patient's current vital signs; any insidious changes over time may be missed if the situation awareness is low[33]. Although obstetric patients are mostly young and fit with a good compensatory capacity, failure to identify these subtle changes may result in a point of no return when the patient decompensates and enters a catastrophic stage.

Three levels of care for critically ill mothers

In August 2018, the Royal College and Obstetricians and Gynaecologists, the Royal College of Midwives, The Royal College of Anaesthetists and the Faculty of Intensive Care Medicine jointly published a guideline titled Care of the Critically Ill Woman in Childbirth: Enhanced Maternal Care. Collaboration among maternity units, critical care units, and other specialities' is important to provide appropriate levels of care in a timely manner[34]. The levels of competency and the role required by midwives are clearly defined, which include management of the central venous access and the arterial line.

Table 1. Obstetric early warning system in Prince of Wales Hospital

Parameter	Yellow (if any one parameter occurs, then inform case nurse or house officer)	Red (if any one parameter occurs, then inform nurse in charge and medical officer)
Level of consciousness	-	Response only to voice/pain/unresponsive
Blood pressure, mmHg	Systolic ≥140 or diastolic≥90	Systolic ≤90 or ≥160 or diastolic ≤50 or ≥100
Heart rate, beats per minute	≤50 or ≥110	≤40 or ≥120
Temperature, °C	≥37.5	≤35 or ≥38
Respiratory rate, breaths per minute	9-11 or 21-24	≤8 or ≥25
Oxygen saturation, %	-	≤94

MSC provides level 1 care to patients at risk of deterioration who require enhanced monitoring or need additional clinical interventions, clinical input or advice, and/or as a stepping down of care from a higher level (Table 2). Level 2 care is provided to patients with greater illness severity, at higher risk of deterioration, and requiring closer or invasive monitoring. It also includes single organ support, preoperative optimisation, extended postoperative care, and/or stepping down from higher levels of care. Patients at level 2 care may decompensate rapidly, and therefore caretakers should be alert and proactively monitor for any deterioration. Additional input from the critical care team should be promptly sought to facilitate early transferal to the ICU. Level 3 care is intensive care provided in the ICU for patients requiring ≥2 organs support or advanced respiratory support such as mechanical ventilation. The staff-to-patient ratio is one critical care nurse per patient, and active management is led by intensivists.

Experience of Prince of Wales Hospital from 2018 to 2020

From May 2018 to December 2020, 815 obstetric patients (mean age, 35 years) received MSC (a mean of 25 cases per month), accounting for 5.66% of the total deliveries (Table 3). The mean length of stay in MSC was 23.8 hours. Of them, 503 (61.7%) required level 1 care and 312 (38.3%) required level 2 care. 55 women were admitted to ICU or cardiac care unit, accounting for 0.38% of the total deliveries. 430 (52.8%) women were of advanced maternal age (≥35 years). 760 (93.3%) women were booked cases in our unit. For non-booked cases, most had antenatal care in other hospitals or from mainland China. 162 (19.9%) women with gestation of <32 weeks on admission. The mean gestational age at delivery was 35 weeks. The earliest gestation on admission to MSC was 16 weeks and 3 days owing to maternal sepsis.

Table 2. Conditions equivalent to level-1 and level-2 care

Conditions equivalent to level-1 care
1-2 L oxygen supplement via nasal cannula or face mask to maintain oxygen saturation
Severe pre-eclampsia on magnesium sulphate prophylaxis with or without oral anti-hypertensive
Magnesium sulphate infusion for neuroprotection in preterm labour <32 weeks gestation
Postpartum haemorrhage at risk of further bleeding, requiring additional monitoring or additional medical treatment (transamine or haemabate)
Cardiac diseases requiring cardiac monitoring
Diabetes mellitus requiring insulin infusion
Sepsis requiring close monitoring (early consultation to intensive care unit [ICU] if patient is not responding to initial treatment or showing signs of deterioration despite treatment)
Morbidly obese women who received general anaesthesia
Other medical conditions requiring close monitoring as requested by obstetrician/anaesthetist
Stepping down from higher level of care for monitoring eg ICU
Conditions equivalent to level-2 care
Invasive monitoring by arterial line or central venous catheter line
>2L oxygen supplement via nasal cannula or face mask to maintain oxygen saturation
Use of AirVO2 to maintain oxygen saturation (early consultation to ICU if escalating respiratory support)
Pulmonary oedema/ fluid overload requiring intravenous furosemide
Severe hypertension or pre-eclampsia requiring intravenous anti-hypertensive
Eclampsia requiring magnesium sulphate infusion to control seizure (not prophylaxis)
Cardiac conditions requiring use of intravenous anti-arrhythmic drug eg ATP, verapamil
Monitoring for acute renal or hepatic failure eg HELLP syndrome or acute fatty liver
Major postpartum haemorrhage requiring additional surgical management eg compression sutures/Bakri balloon/uterine artery embolisation/hysterectomy
Severe sepsis or septic shock (interim while consulting ICU)
Other medical conditions requiring close monitoring as requested by obstetrician/anaesthetist
Stepping down from higher level of care for monitoring eg ICU

Table 3. Maternal special care unit admissions in Prince of Wales Hospital, 2018-2020

	May to December 2018*	2019*	2020*
Total deliveries	3954	5871	4583
Intensive care unit admission	15 (0.38)	22 (0.37)	18 (0.39)
Maternal special care unit admission	177 (4.5)	362 (6.2)	276 (6)
No. per month	22.1	30.2	23
Level 1 care	97 (55)	235 (65)	171 (62)
Level 2 care	80 (45)	127 (35)	105 (38)
Duration of stay, hours	25.8 (1.4-144.5)	24.1 (0.4-120)	21.7 (0.1-117.9)
Stay for ≥72 hours	2 (1.1)	6 (1.7)	4 (1.4)
Maternal age, y	35 (18-48)	34 (19-48)	35 (21-46)
Advanced maternal age (≥35 y)	96 (54)	184 (51)	150 (54)
Non-booked cases	13 (7.3)	27 (7.5)	15 (5.4)
Gestation on admission, weeks	16+6 to 41+3	16+3 to 41+5	19+2 to 41+3

* Data are presented as No. (%) of patients

Table 4. Patient distribution in terms of levels of care and conditions

Condition	Level 1 care*	Level 2 care*
Pre-eclampsia/eclampsia	220 (59.6)	149 (40.4)
Massive haemorrhage	62 (35.6)	112 (64.4)
Preterm labour <32 weeks	108 (94.7)	6 (5.3)
Sepsis	21 (61.8)	13 (38.2)
Endocrine conditions	43 (100)	0
Cardiac diseases	21 (63.6)	12 (36.4)
Respiratory diseases	9 (29)	22 (71)
Acute fatty liver / HELLP syndrome	0	20 (100)
Others	17 (38.6)	27 (61.4)

* Data are presented as No. (%) of patients

The most common indication for MSC was pre-eclampsia/eclampsia (n=369, 45%), followed by massive haemorrhage (n=174, 21%), preterm labour before 32 weeks requiring magnesium sulphate for neuroprotection (n=114, 14%), endocrine conditions (most frequently diabetes mellitus requiring dextrose-potassium-insulin infusion) (n=43, 5%), cardiac diseases requiring continuous cardiac monitoring (eg, hypertrophic obstructive cardiomyopathy, severe supraventricular tachycardia, Wenckebach heart block, Barlow's disease, cardiomegaly, Wolff-Parkinson-White syndrome, transposition of the great arteries, non-specific chest pain) (n=33, 4%), severe sepsis (n=31, 4%), respiratory diseases (n=31, 4%), acute fatty liver or HELLP (haemolysis, elevated liver enzymes, low platelets) syndrome (n=20, 2%), and others (such as malignancies, acute pancreatitis) (n=44, 5%). Some women had more than one indication; the most common co-existing indication was severe pre-eclampsia complicated by massive postpartum haemorrhage secondary to uterine atony. All women with endocrine conditions required level 1 care only. About 40% of women with hypertensive disorders, sepsis, or cardiac diseases required level 2 care. Women with massive haemorrhage, respiratory diseases, or other less common conditions required more intensive monitoring and interventions such as arterial line and central venous line monitoring (Table 4).

Of 55 (0.38%) ICU admissions, 44 (80%) were during the postpartum period and 11 (20%) were during antenatal period. The most common mode of delivery was Caesarean section (n=39, 88.6%), followed by vacuum extraction (n=2), normal vaginal birth (n=2), and assisted breech delivery (n=1). The most common indication for ICU admission was sepsis or septic shock (n=13, 23.6%), followed by severe pre-eclampsia/eclampsia (n=11, 20%), massive haemorrhage (n=10, 18.2%), respiratory disease (n=8, 14.5%), others (n=8, 14.5%), and cardiac disease (n=5). The mean duration of ICU stay was 38.6 (range, 4.7-410.8) hours; four (7.3%) women stayed in ICU for >3 days. The mean blood loss secondary to massive postpartum haemorrhage was 5.3 L. Postpartum haemorrhage was mainly caused by placenta accreta spectrum (n=2) or uterine atony (n=8) and was controlled by compression sutures (n=8), insertion of a Bakri Balloon (n=6), or hysterectomy (n=3). One patient had cardiac arrest secondary to severe haemorrhage and was revived after cardiopulmonary resuscitation for 4 minutes. The total estimated blood loss was 8 L.

Of 11 women admitted to ICU for severe preeclampsia, two had concomitant eclampsia and three had concomitant HELLP syndrome. Other complications included acute pulmonary oedema and deranged renal function. Of 13 women admitted to ICU for sepsis or septic shock, one developed septic shock after medical termination of pregnancy and the remaining 12 were for non-obstetric reasons such as pyelonephritis and urosepsis. Five of the 12 patients had cardiovascular problems (pulmonary hypertension, moderate to severe mitral regurgitation, moderate to severe mitral stenosis, moderate ventricular septal defect, and infective endocarditis). The most common respiratory problem was asthmatic attacks. Other problems include acute pancreatitis, stomach cancer, and brain cavernoma.

There was one maternal death among the 14 408 deliveries. The woman had multiple obstetric complications including massive postpartum haemorrhage, severe pre-eclampsia, and severe sepsis. She was initially stabilised in ICU and transferred back to MSC unit for close monitoring after postpartum day 1. She deteriorated on day 3 and was transferred back to ICU. She developed asystole arrest that did not respond to cardiopulmonary resuscitation. Autopsy confirmed the cause of death was severe sepsis.

Equipment in maternal special care unit

The high-flow nasal cannula system is used for respiratory support. It enhances comfort with humidification and efficiency with ventilation by washout of nasopharyngeal dead space and provision of a small positive airway pressure effect[35]. In patients with hypoxaemic respiratory failure, it improves oxygenation and decreases the need for intubation[36,37]. It is commonly used in the emergency department and ICU.

Blood gas analyser (RAPIDPoint 500e blood gas analyser, Siemens Healthineers) is used for measurements of pH, partial pressure of carbon dioxide, partial pressure of oxygen, electrolytes (ionised sodium, potassium, calcium), and lactate levels in the blood[38]. It has a short turnaround time and is particularly useful for severe sepsis[39].

Thromboelastography (TEG®6s, Haemonetics, Braintree, MA, USA) is used as the point-of-care coagulation test to identify any coagulopathy at an early stage of postpartum haemorrhage[40]. In obstetric patients, fibrinogen plays a major role in postpartum haemorrhage and is an early predictor of coagulopathy[41,42]. It enables real-time assessment of fibrinogen and platelet functions, which may guide early intervention[43]. Current guidelines recommend maintaining a fibrinogen concentration of at least 1.5 g/L[44]. Starting from December 2020, fibrinogen concentrates are stocked in the labour ward for urgent use. Fibrinogen concentrates are superior to cryoprecipitate in terms of administration speed, as they are stored in the labour ward and transportation time is minimal. Conventional blood products such as fresh frozen plasma or cryoprecipitate take about 20 minutes to defrost in addition to time for compatibility testing and transportation[45]. In cases of massive obstetric haemorrhage or suspected amniotic fluid embolism, the combination of real-time assessment of clotting abnormalities and administration of fibrinogen concentrates is the optimum approach[46,47].

Midwifery training in maternal critical care

Patients admitted to MSC unit are cared for by midwives specialised in maternal critical care. In 2018, an overseas visit was organised for midwife leaders to learn setting up an MSC unit. They visited the Liverpool Women's Hospital, Queen Charlotte's Hospital, and St Thomas' Hospital. These hospitals have a maternal high dependency unit within the delivery suite. In 2019, the second overseas training was co-organised by The Hong Kong College of Midwives and Department of Obstetrics and Gynaecology, The Chinese University of Hong Kong. The aim was to strengthen the knowledge in caring critically ill obstetric women. The team also visited the Texas Children's Hospital Pavilion for Women in Houston, USA, and attended the Fundamental of Critical Care in Obstetrics course organised by the Society of Critical Care Medicine.

Local trainings are available to enhance the competence of midwives in critical care. The Institute of Advanced Nursing Studies provides different levels of intensive care nursing programme: (1) Enhancement Program on High Dependency Obstetric Care (4-full-days lectures and 4 weeks clinical attachment to the adult ICU), (2) Elementary Course in Adult Intensive Care Nursing (3 days of lectures and 2 weeks clinical attachment to the adult ICU), (3) Fundamental Course in Intensive Care Nursing (3-day theory course), and (4) High Dependency Obstetrics Care (1-day seminar). Professional Training Course in Critical Care in Obstetrics is a course within the Advanced Midwifery Practice Series of Master in Obstetric and Midwifery Care organised by the Department of Obstetrics and Gynaecology, The Chinese University of Hong Kong. This 22-hour course is designed to enhance the advanced clinical and decision-making skills in caring for women with complicated obstetric related problems.

Table 5. In-house training at Prince of Wales Hospital

In-house training	Topic	Frequency
Case review	Risk watch in obstetrics (~5 cases/month)	Monthly
Audit	Postpartum haemorrhage	Yearly
Drills	Massive transfusion protocol for obstetrics: transfer of critically ill patients, desaturation, postpartum haemorrhage, pre-eclampsia and eclampsia, maternal cardiac arrest, sepsis in pregnancy and childbirth	Half-yearly to yearly
Workshops	High dependency monitoring for obstetrics: Safe Obstetric Practice in High risk and Emergency, crew resource management	Yearly

The BASIC for Nurses course is an entry course organised by the Department of Anaesthesia and Intensive Care Faculty of Medicine, The Chinese University of Hong Kong. It is a 2-day introductory course for novice ICU and high dependency unit nurses. The Certificate Course on Essential Critical Care Nursing is organised by the Hong Kong Tuberculosis, Chest and Heart Disease Association. It is a 4-half-day course to strengthen, update, and enhance the knowledge on critical care nursing. In addition, in-house training is essential for continuous learning. Meetings, drills, workshops, and special equipment demonstrations are regularly arranged (Table 5). All aim to strengthen frontline midwives' skills and techniques to manage critically ill women and emergencies.

Contributors

All authors designed the study, acquired the data, analysed the data, drafted the manuscript, and critically revised the manuscript for important intellectual content. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have disclosed no conflicts of interest.

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Data availability

All data generated or analysed during the present study are available from the corresponding author on reasonable request.

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