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Medical emergency team may reduce obstetric intensive care unit admissions

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Abstract

Aim: Some recent studies have reported that early intervention by a medical emergency team (MET) for clinical deterioration before intensive care unit (ICU) admission was associated with a survival benefit in critically ill cancer patients. We hypothesized that early MET intervention for an obstetric crisis in the general wards would be related to favorable outcomes in critically ill obstetric patients.

Methods: Data of obstetric patients who were managed by a MET were collected retrospectively from 1 March 2008 to 30 April 2015. A total of 69 obstetric patients were enrolled. Among them, 48 (69.6%) were treated successfully in the general wards and 21 (30.4%) were transferred to the ICU.

Results: Major causes of MET activation were pulmonary edema (n = 23, 33.3%), hypovolemic shock (n = 19, 27.5%), and septic shock (n = 8, 11.6%). Compared with the patients treated in the general ward, the patients transferred to the ICU had significantly higher severity of illness score. Sequential Organ Failure Assessment score was the most useful for prediction of ICU admission of obstetric patients (AUC, 0.810, $P < 0.001$), and the ideal cut-off was 4 (sensitivity, 81%; specificity, 60%). During the study period, in-hospital mortality of the obstetric patients was 2.9% (2/69).

Conclusion: After MET activation many obstetric patients could be successfully treated in the general wards without mortality. Therefore, MET may reduce ICU admissions in critically ill obstetric patients.

Key words: critical illness, hospital rapid response team, intensive care unit, obstetrics.

Introduction

The major roles of the rapid response system (RRS) are early recognition and rapid intervention for in-hospital patients at risk in order to prevent adverse outcome.[1,2] RRS is gradually spreading throughout the world because this system is associated with a decrease in unplanned, intensive care unit (ICU) admissions and mortality in general ward patients.[3]

A previous study suggested that surgical patients (e.g. obstetrics/gynecology, orthopedic etc.) with early detection of deterioration would have a better outcome than medical patients.[4] Among the patients who triggered medical emergency team (MET) activation, obstetric patients are unique in that they are relatively young and usually do not have a chronic illness. Therefore, they could have better outcome as a result of intervention.

Mortality or morbidity in pregnant and post-partum women is an important public health problem as well as a problem for their family members. It is well known that the level of maternal mortality in a particular country is related to the quality of obstetric care.[5] But, given that maternal mortality is rare, ICU admission is considered a marker of severe maternal morbidity,[6–8] which is

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why many studies have been carried out on the epidemiology, outcome or factors of obstetric ICU admission.[6,8–12] To date, however, there have been only a few articles on MET early intervention before obstetric ICU admission.[13,14] There have also been no reports on whether a MET could decrease the rate of obstetric ICU admission.

Some recent studies have reported that early intervention of a MET for clinical deterioration before ICU admission was associated with survival benefit in critically ill cancer patients.[15,16] Similarly, we hypothesized that early intervention of a MET for an obstetric crisis in the general wards would be related to favorable outcome in critically ill obstetric patients.

The aim of this study was therefore to evaluate whether a MET could reduce ICU admission in critically ill obstetric patients, and to analyze the differences between the patients transferred to the ICU and the patients treated in the general wards, in obstetric patients triggering MET activation.

Methods

The Institutional Review Board of Asan Medical Center approved the review and publication of the information obtained from the patient records. Informed consent was waived due to the retrospective nature of the study.

Subjects and Study Design

This was a retrospective cohort study conducted by a MET of Asan Medical Center, a 2715-bed, university-affiliated, tertiary referral hospital in Seoul, Korea, and which is available for approximately 100 000 admissions per year. The MET recognized and treated hospitalized patients at early risk beginning in March 2008. Details of the present MET characteristics and implementation are described in a previous study.[4] To identify whether a MET could reduce unplanned ICU admissions in obstetric patients, we collected and analyzed clinical data regarding obstetric patients who triggered MET activation in general wards between 1 March 2008 and 30 April 2015. During the study period, MET activation was triggered on 11 951 occasions for patients hospital-wide, and there was a total of 17 367 deliveries.

Data Collection

The following data of obstetric patients triggering MET activity were retrieved from the MET registry and the electronic medical records and included patient age, obstetric history such as gestational age, body mass index, gravidity, parity and previous cesarean section (C-section), origination of hospitalization (via the emergency room or outpatient department), delivery method for index birth, twin pregnancy, cause of the MET activation, comorbidities, and critical care interventions including endotracheal intubation, central venous catheterization, arterial catheterization, renal replacement therapy, extracorporeal membrane oxygenation (ECMO), vasopressors, transfusion, and diuretics.

For the purpose of the outcome prediction, the following severity scores were calculated based on the available data on the occasion of MET activation: Acute Physiology and Chronic Health Evaluation II (APACHE II) score; Simplified Acute Physiology Score II (SAPS II); Sequential Organ Failure Assessment (SOFA) score; and Modified Early Warning Score (MEWS).

The primary outcome was the number of obstetric patients treated in the general wards and not in the ICU after MET activation. The secondary outcomes included the differences in in-hospital mortality, hospital length of stay (LOS), and the ICU LOS between the ICU and general ward patients.

Statistical Analysis

Data are given as median (IQR) or mean ± SD for continuous variables, and as number (%) for categorical variables. Statistical analysis was performed using Student's t-test or Mann–Whitney U-test for continuous variables, and the chi-squared test or Fisher's exact test for categorical variables, as appropriate. The area under the receiver operating characteristic (ROC) curve (AUC) for the ICU predicting models was calculated in order to measure the diagnostic accuracy. $P < 0.05$ was considered statistically significant. All data were analyzed using IBM SPSS statistics for Windows, version 21.0 (IBM, Armonk, NY, USA).

Results

During the study period, a total of 69 obstetric patients were enrolled. Among them, 48 (69.6%) were treated successfully in the general ward and 21 (30.4%) were transferred to the ICU. The baseline clinical characteristics and outcomes of critically ill obstetric patients who triggered MET activation are listed in Table 1. The majority of the critically ill obstetric patients were aged >30 (n = 56, 81.2%) and approximately half of the

Table 1 Baseline characteristics and outcomes for obstetric patients triggering MET activation

Variables	Patient data (n = 69) Mean ± SD, median (IQR) or n (%)
Age (years)	33.6 ± 4.3
20–29	13 (18.8)
30–39	47 (68.1)
40–49	9 (13.1)
BMI (kg/m^2)	25.6 ± 4.0
DIC	23 (33.3)
Gestational age (weeks)	35.5 (25.8–38.0)†
Gravidity	
Single	29 (42.0)
Multiple	40 (58.0)
Parity	
Nullipara	12 (17.4)
Primipara	33 (47.8)
Multipara	24 (34.8)
Twin pregnancy	10 (14.5)
Hospitalization via the emergency room	42 (60.9)
Previous cesarean section	16 (23.2)
Delivery method for index birth	
Stillbirth or no delivery	17 (24.6)
Vaginal	17 (24.6)
Cesarean section	35 (50.8)
Comorbidity	15 (21.7)
Major causes of obstetric MET activation	
Pulmonary edema	23 (33.3)
Hypovolemic shock	19 (27.5)
Severe sepsis/Septic shock	8 (11.6)
Pulmonary thromboembolism	3 (4.3)
Cardiomyopathy	3 (4.3)
Diabetic ketoacidosis	2 (2.9)
Others‡	11 (15.9)
Interventions	
Endotracheal intubation	16 (23.2)
Central venous catheterization	34 (49.3)
Arterial catheterization	24 (34.8)
Renal replacement therapy	6 (8.7)
ECMO	3 (4.3)
Vasopressors	15 (21.7)
Transfusion	48 (69.6)
Diuretics	52 (75.4)
Severity of illness	
APACHE II	10.39 ± 6.43§
SAPS II	18.55 ± 12.67
SOFA score	4.14 ± 3.56¶
MEWS	4.14 ± 2.59
Outcomes	
No. patients treated on obstetric wards	48 (69.6)
In-hospital mortality	2 (2.9)
Hospital LOS	8 (6–13)

‡Respiratory distress related to drug use, anaphylaxis, arrhythmia, electrolyte imbalance, requested procedure or health-care provider concern. Missing data: †3, §8, ¶3. APACHE II, Acute Physiology and Chronic Health Evaluation II; BMI, body mass index; DIC, disseminated intravascular coagulation; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; LOS, length of stay; MET, medical emergency team; MEWS, Modified Early Warning Score; SAPS II, Simplified Acute Physiology Score II; SOFA, Sequential Organ Failure Assessment.

patients (n = 35, 50.8%) had C-section deliveries. At the time of the MET activation, 58 (84.1%) of these patients were in the post-delivery status (either vaginal or cesarean) and with dilation and curettage (D&C). Major causes of MET activation were pulmonary edema (n = 23, 33.3%), hypovolemic shock (n = 19, 27.5%), and septic shock (n = 8, 11.6%). Diuretics and blood products, including packed red blood cells, platelet concentrate, and fresh frozen plasma were used in three-quarters of the obstetric patients. For the purpose of hemostasis, angiographic embolization was performed in 25 patients (36.2%), and 14 (20.3%) had undergone surgery. During the study period, there were two maternal deaths (2.9%), and one case of hypoxic brain damage. One patient died from uncontrolled post-partum bleeding, and the other patient died due to progression of gastric cancer.

Comparison of clinical characteristics and outcome for the patients treated in the obstetric wards and transferred to the ICU after MET activation is given in Table 2. Obstetric patients treated in the general wards were 3 years younger than the patients transferred to the ICU. In addition, interventions, including endotracheal intubation, central venous catheterization, arterial catheterization, renal replacement therapy, ECMO, and infusion of vasopressors differed significantly. Diabetes mellitus and hypertension were the most common morbidities of critically ill obstetric patients (Table 3).

The severity scores for the outcome prediction (obstetric ICU admission after MET activation) were significantly different, except for SAPS II. The SOFA score was the most useful to predict ICU admission of critically ill obstetric patients. On ROC analysis of obstetric ICU admission, AUC for SOFA score was 0.81 (95%CI: 0.69–0.93; Fig. 1). At the time of MET activation, the ideal cut-offs for obstetric ICU admission were as follows: SOFA score = 4 (sensitivity, 81%; specificity, 60%); MEWS = 4 (sensitivity, 81%; specificity, 60%); and APACHE II score = 9 (sensitivity, 76%; specificity, 60%).

Discussion

In this study, we confirmed that critically ill obstetric patients could be safely managed by a MET and that many of these patients were treated in the general wards, not in the ICU. To ensure this, a well-designed, institution-specific RRS is crucial. Also the severity of illness scores, including APACHE II and SOFA score, and MEWS would be necessary in order to decide whether critically ill obstetric patients should be transferred to the ICU.

Previously obstetric-specific MET were implemented to respond to obstetric crises at Magee-Women's Hospital and the New York Hospital Medical Center of Queens.[13,14] Each medical center optimized the team size and composition based on the hospital capability, provided education to the medical staff regarding various emergency scenarios, and implemented a multidisciplinary team approach for obstetric patient safety. Obstetric MET with expertise specifically targeted at maternal and fetal crisis was added to pre-existing RRS for medical crises at Magee-Women's Hospital. Meanwhile, at the New York Hospital Medical Center of Queens, an obstetric-specific, rapid response team was formed primarily to respond to major obstetric hemorrhage. They found that maternal deaths or obstetric adverse events decreased after implementing obstetric MET. The present MET was different from the aforementioned obstetric-specific teams in that we covered all in-hospital patients, not only obstetric patients. The team, physician led, consisted of nine nurses (senior critical care qualified nurse), two ICU residents (internal medicine third grade), four ICU fellows, and three ICU staff (intensivist). During the day an intensivist, a fellow, a resident and two nurses were on call. At night the team consisted of two nurses and a fellow. In particular, this team was designed to increase the early detection of deterioration through screen triggering and call triggering.[4] After MET activation, prompt resuscitation including airway management, early goal-directed therapy and cardiopulmonary resuscitation was performed by the MET. At the same time, an obstetrician decided whether or not the patient required surgery. If the cause of MET activation was a medical problem such as pulmonary edema or septic shock, ICU admission was discussed with the obstetrician. The MET used a portable ultrasound machine to distinguish pulmonary edema from cardiogenic pulmonary edema.[17] The patients kept in the obstetric wards were monitored and treated by the MET until their condition stabilized.

In this way, we successfully treated 48 (69.6%) of the 69 obstetric patients in the general ward. The ICU admission rate of obstetric patients was relatively lower than that in the other countries and was 1.2 per 1000 deliveries.[8] In common with obstetric MET, maternal deaths and morbidity were lower after the introduction of MET.

A recent study reported that two-thirds of ICU beds are occupied at any time, and that the occupancy in academic hospitals is approximately 80%.[18] This high rate of ICU occupancy causes bottlenecks in critical care. Therefore, some patients would have to wait for many hours before being admitted to the ICU. Delayed ICU admission is associated with increased requirement and longer duration of invasive mechanical ventilation.[19] Moreover, ICU resources are limited and expensive. The USA pays $108bn per year for critical care illness, and critical care medicine accounted for 13.2% of the hospital costs and 0.74% of the US gross domestic product in 2010.[20] In this

Table 2 Clinical characteristics and outcome after MET activation vs ICU transfer

Variables	Treated in the general wards (*n* = 48) Mean ± SD, median (IQR) or n (%).	Transferred to ICU (*n* = 21) Mean ± SD, median (IQR) or n (%)	*P*-value
Age (years)	32.9 ± 4.4	35.2 ± 4.0	0.038
20–29	12 (25.0)	1 (4.8)	0.052
30–39	32 (66.7)	15 (71.4)	
40–49	4 (8.3)	5 (23.8)	
BMI (kg/m^2)	25.3 ± 3.9	26.5 ± 4.3	0.261
DIC	14 (29.2)	9 (42.9)	0.267
Gestational age (weeks)	37.0 (25.0–38.0)†	34.0 (26.0–37.0)‡	0.286
Gravidity			0.134
Single	23 (47.9)	6 (28.6)	
Multiple	25 (52.1)	15 (71.4)	
Parity			0.264
Nullipara	10 (20.8)	2 (9.5)	
Primipara	24 (50.0)	9 (42.9)	
Multipara	14 (29.2)	10 (47.6)	
Twin pregnancy	6 (12.5)	4 (19.0)	0.477
Hospitalization via the emergency room	30 (62.5)	12 (57.1)	0.675
Previous cesarean section	9 (18.8)	7 (33.3)	0.187
Delivery method for index birth			0.356
Stillbirth or no delivery	12 (25.0)	5 (23.8)	
Vaginal	14 (29.2)	3 (14.3)	
Cesarean section	22 (45.8)	13 (61.9)	
Comorbidity	9 (20.8)	5 (23.8)	0.783
Interventions			
Endotracheal intubation	2 (4.2)	14 (66.7)	< 0.001
Central venous catheterization	18 (37.5)	16 (76.2)	0.003
Arterial catheterization	6 (12.5)	18 (85.7)	< 0.001
Renal replacement therapy	0 (0)	6 (28.6)	< 0.001
ECMO	0 (0)	3 (14.3)	0.007
Vasopressors	3 (6.3)	12 (57.1)	< 0.001
Transfusion	34 (70.8)	14 (66.7)	0.729
Diuretics	36 (75.0)	16 (76.2)	0.916
Severity of illness			
APACHE II	8.33 ± 3.96 §	14.33 ± 8.29	0.004
SAPS II	18.90 ± 12.10	17.76 ± 14.20	0.735
SOFA score	2.89 ± 2.20 ¶	6.81 ± 3.87	< 0.001
MEWS	3.42 ± 1.98	5.81 ± 3.08	0.003
Outcomes			
Hospital LOS	7 (5–10)	13 (8.50–21.50)	0.002
ICU LOS	0	5 (2.50–11.50)	

Missing data: †1, ‡2, §8, ¶3. APACHE II, Acute Physiology and Chronic Health Evaluation II; BMI, body mass index; DIC, disseminated intravascular coagulation; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; LOS, length of stay; MET, medical emergency team; MEWS, Modified Early Warning Score; SAPS II, Simplified Acute Physiology Score II; SOFA, Sequential Organ Failure Assessment.

context, the intensivists must decide appropriately whether or not patients should be transferred to the ICU. ICU triage decision, however, is difficult for the intensivists.[21] Several factors are associated with the decision to admit a patient to the ICU, such as the severity of the illness, the need for mechanical ventilation, and the ICU beds availability.[22] In this study, obstetric ICU admission is considered for older patients who need interventions including endotracheal intubation, central venous catheterization, arterial catheterization, renal replacement therapy, ECMO, and infusion of vasopressors.

The scoring systems used to predict the risk of mortality are inaccurate for use with obstetric ICU patients because of the physiological alterations related to pregnancy in women.[11,12,23,24] In this study, we used these scoring systems, as well as MEWS, in order to predict the risk of maternal ICU admission using the available data on MET activation in the general wards. We determined that the scores (SOFA score >4, MEWS >4,

Table 3 Comorbidity and causes of MET activation vs ICU transfer

Variables	Treated in the general wards (*n* = 48) n (%)	Transferred to the ICU (*n* = 21) n (%)
Comorbidity		
Diabetes mellitus	3 (6.3)	3 (14.3)
Hypertension	2 (4.2)	1 (4.8)
Asthma	2 (4.2)	0 (0)
Chronic kidney disease	1 (2.1)	0 (0)
Hypothyroidism	2 (4.2)	0 (0)
SLE	1 (2.1)	0 (0)
Immune thrombocytopenia	1 (2.1)	0 (0)
Anti-phospholipid syndrome	0 (0)	1 (4.8)
Gastric cancer	0 (0)	1 (4.8)
Major causes of obstetric MET activation		
Pulmonary edema	16 (33.3)	7 (33.3)
Hypovolemic shock	15 (31.3)	4 (19.0)
Severe sepsis/Septic shock	4 (8.3)	4 (19.0)
Pulmonary thromboembolism	1 (2.1)	2 (9.5)
Cardiomyopathy	1 (2.1)	2 (9.5)
Diabetic ketoacidosis	1 (2.1)	1 (4.8)
Others†	10 (20.8)	1 (4.7)

†Respiratory distress related to drug use, anaphylaxis, arrhythmia, electrolyte imbalance, requested procedure or health-care provider concern. ICU, intensive care unit; MET, medical emergency team; SLE, systemic lupus erythematosus.

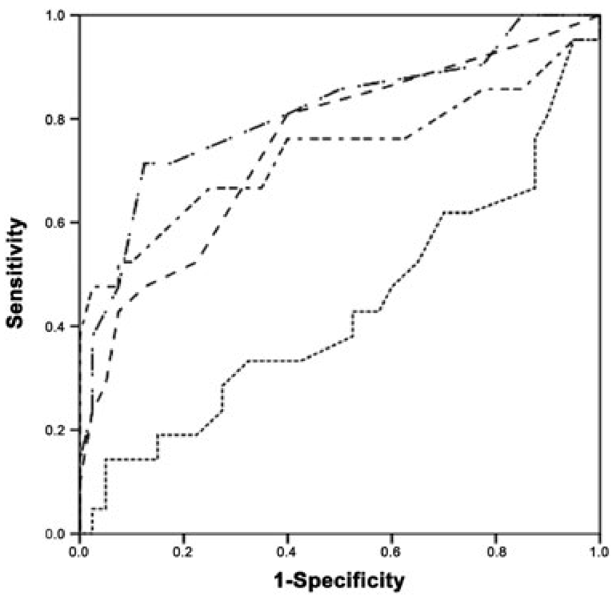

Figure 1 Area under the receiver operating characteristic curve (AUC) for prediction of intensive care unit admission. (– –) Acute Physiology and Chronic Health Evaluation II score, AUC = 0.74 (95%CI: 0.58–0.89; P = 0.003); (- - -) Simplified Acute Physiology Score II, AUC = 0.43 (95%CI: 0.27–0.59; P = 0.4); (–·) Sequential Organ Failure Assessment score, AUC = 0.81 (95%CI: 0.69–0.93; $P <$ 0.001); (– -) Modified Early Warning Score, AUC = 0.75 (95%CI: 0.61–0.88; P = 0.002).

and APACHE II score >9) would be helpful for deciding on ICU transfer for a patient in obstetric crisis. SOFA score was the most useful model for determining obstetric ICU admission, given that MEWS is used usually in surgical patients.[25] As noted, the decision regarding ICU triage is complex. The intensivists should therefore assess severity of illness as well as the requirement and availability of the ICU resources during MET activation.

The major causes of obstetric ICU admission are hypertensive disorder during pregnancy and obstetric hemorrhage.[6,8–10,13,23] In the present study the leading cause of obstetric ICU admission was respiratory distress resulting from pulmonary edema and hypovolemic shock, both of which were associated with obstetric hemorrhage and transfusion. The other causes of obstetric ICU admission were septic shock, pulmonary thromboembolism, and cardiomyopathy. These results were consistent with those of previous studies.[6,10] In contrast, hypertensive disorders of pregnancy, such as eclampsia or hemolysis elevated liver enzymes and low platelets (HELLP) syndrome, were not significant in the present study because they are mainly antepartum diagnoses. At the time of MET activation, 58 patients (84.1%) were in the post-partum stage or had had D&C; and the hospital LOS of obstetric ICU patients was 6 days longer than that of ward patients.

Most of the literature related to critically ill obstetric patients has been focused on the incidence and characteristics of pregnant and post-partum women requiring admission to the ICU.[8,9] The present study, however, was conducted to identify whether early MET intervention could reduce obstetric ICU admission in a tertiary referral hospital, and to investigate severity scores for prediction of obstetric ICU admission.

The major limitations of this study include its retrospective design, single-center site, the inability to calculate severity scores for some patients, and that the number of obstetric patients who triggered MET activation was small. Therefore, the main results may not be applied to all obstetric patients with clinical deterioration. Large multicenter studies are required to confirm whether MET could reduce obstetric ICU admission.

In conclusion, a large proportion of obstetric patients could be successfully treated in the general wards without mortality after MET activation. SOFA score and MEWS are helpful to decide whether critically ill obstetric patients should be transferred to the ICU. Institution-specific MET may reduce ICU admission in critically ill obstetric patients.

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Disclosure

The authors declare no conflicts of interest.

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