International Journal of Obstetric Anesthesia (2019) **38**, 37–45
0959-289X/$ - see front matter © 2018 Published by Elsevier Ltd.
https://doi.org/10.1016/j.ijoa.2018.10.004

ORIGINAL ARTICLE

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Massive hemorrhage protocol activation in obstetrics: a 5-year quality performance review

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ABSTRACT

Background: A structured approach to hemorrhagic emergencies in obstetrics has gained popularity with the implementation of massive hemorrhage protocols. The trauma literature suggests that routine quality reviews should be in place to improve patient outcomes. The aim of this study was to develop quality indicators and assess compliance by the clinical team.

Methods: A multidisciplinary team set the institutional quality indicators for the massive hemorrhage protocol review. A retrospective review of all obstetrical massive hemorrhage protocol activation events from September 2010 to January 2015 was performed. All protocol events occurred before the creation of the quality indicators. Data were retrieved from patient records.

Results: There were 17 (0.09%) protocol activations for 19 790 deliveries during the study period. All 17 (100%) patients received at least one unit of red blood cells. Overactivation, defined as the transfusion of <2 units of red blood cells, occurred in two cases (12%). Common causes of non-compliance were: 24% (4/17) temperature monitoring, 18% (3/17) lactate measurement, 41% (7/17) arterial blood gas sampling, and 18% (3/17) hemoglobin maintenance within the target range of 55–95 g/L. Admission to intensive care and peripartum hysterectomy occurred in 12 and 5 cases (71% and 29%), respectively.

Conclusions: Suboptimal compliance was found in multiple areas, which may be attributable to the low frequency of activation of our massive haemorrhage protocol in obstetrics. The quality targets identified in this report can act as a basis for other institutions developing quality indicators to evaluate performance.

Keywords: Massive hemorrhage protocol; Massive transfusion protocol; Pregnancy; Quality improvement; Postpartum hemorrhage; Blood transfusion

Introduction

Postpartum hemorrhage (PPH) is one of the leading causes of maternal morbidity and mortality worldwide.[1,2] Its rate is increasing in western countries, including the United Kingdom, Canada, the United States and Australia.[3–5] There is no uniform definition of severe PPH, with some investigators using only volume of blood loss[6] and others using criteria that select more severe hemorrhages (40 g/L drop in hemoglobin, four or more units of blood transfused, surgical intervention or death).[7] The incidence of severe PPH (PPH with either need for transfusion or surgical intervention) is 3/1000 deliveries[3] and maternal mortality from hemorrhage is 2/100 000 deliveries; the majority of deaths are thought to be avoidable.[8] Bleeding in PPH can be sudden and rapid. A structured approach to the management of a massive hemorrhage has recently gained popularity, primarily driven by the development of massive hemorrhage protocols (MHPs) in trauma patients.[9]

Accepted October 2018
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Massive hemorrhage protocols are used to manage massive hemorrhage in patients with major trauma or other types of major hemorrhage (gastrointestinal, surgical, obstetrics).[10–12] In retrospective reviews of MHP utilization, activations for obstetrical patients account for only 4% of MHPs.[13] The rapid mobilization of blood products and interventions to prevent and treat coagulopathy, acidosis and hypothermia are thought to be key to improving patient outcomes with an MHP.[14–16]

National guidelines have supported the implementation of a MHP as part of the management of PPH.[17,18] It is unclear from systematic reviews if the implementation of a MHP improves patient outcomes.[19] In obstetrics, the implementation of a systematic approach such as a MHP improves patient physiological markers (temperature, pH, and incidence of coagulopathy) without impacting on important clinical outcomes (length of stay and mortality).[20]

Quality performance targets for obstetrical MHPs are not defined in the literature and it is unclear if they need to be modified from metrics proposed for trauma hemorrhage. Previous studies have indicated variability in all aspects of the performance of MHPs for trauma patients.[21,22] This is likely to be exaggerated for MHPs in obstetrics due to their infrequency, and hence inability for healthcare personnel to maintain competence. Regular simulations for PPH to improve protocol compliance have been recommended,[23,24] since education through simulation is superior to non-simulation education for knowledge acquisition[25] and improving patient outcomes.[26]

The purpose of this study was to use quality indicators developed by a multidisciplinary team to illustrate areas for quality improvement over a five-year retrospective review of MHP events.

Methods

An MHP was implemented at our hospital in July 2004 with the help of a multidisciplinary working group, and has undergone several revisions since initial release. No substantive updates were made to the MHP during the study period (policy updates performed in January 2010, May 2015 and February 2018; current protocol overview included as Supplemental Fig. 1).

Activation criteria for the MHP obstetrics are: life-threatening bleeding requiring mobilization of blood bank, laboratory and clinical resources; anticipated need for at least four units of red blood cells (RBCs) immediately; and marked ongoing blood loss. The protocol, activated with an overhead announcement which specifies either non-obstetric or obstetric patients, mobilizes clinical, laboratory, transfusion medicine and transport personnel. Activation is at the direction of a staff physician and is not based solely on blood loss. In addition to the MHP, the institution has a separate PPH policy for management of less severe PPH. Additional personnel (rapid response intensive care team, neonatal intensive care, obstetrical service and anesthesia service) are activated for an obstetric MPH. Blood is immediately provided to the bedside by a designated porter and is never delayed awaiting crossmatch results. During the study period blood was provided in a 1:1:1 ratio (RBCs; plasma: platelet units). Cryoprecipitate (10 U) is prepared for all obstetrical activations and is transfused if the fibrinogen level is less than 2.0 g/L or the clinical condition is deemed too severe to wait for laboratory test results.

Blood samples are taken at baseline and repeated hourly, temperature monitoring is at a minimum of every 15–60 min or continuously, and tranexamic acid is recommended for all patients (either 1 g bolus followed by 125 mg/h for 8 h, or 1 g followed by a 1 g bolus one hour later). The blood transfusion laboratory is notified that the MHP has ceased when hemostasis has been achieved.

Education of nurses, obstetricians and anesthesiologists is ongoing. After each MHP, formal debriefing occurs and the forms are reviewed annually by a working group to identify common failures that require system changes, education or protocol modification. Annual obstetric drills were performed to assess protocol performance and identify weaknesses.

A multidisciplinary team consisting of a transfusion medicine specialist, obstetrician, anesthesiologist, trauma surgeon, intensive care physician, advanced practice nurse and blood bank manager developed quality indicators. All indicators were derived after our study period from the items specified in the massive hemorrhage protocol, and were chosen by consensus. Timeframes based on transport and analytic turnaround times for laboratory tests or blood product preparation were established. Laboratory measurement targets to assess adequate resuscitation were achieved by consensus.

Sunnybrook Health Sciences Centre is a facility with high acuity neonatal intensive care, trauma, critical care units, and obstetric service with approximately 4500 deliveries per annum. After obtaining Research Ethics Board approval and patient consent waiver, all MHP activations between September 2010 and January 2015 were obtained from the hospital communications department, and the subset of activations for obstetric patients was identified through the electronic patient record review. Identified records were retrospectively reviewed to collect demographic and obstetrical data, tranexamic acid usage, transfusion volumes and patient outcomes (hysterectomy, mechanical ventilation, length of stay in intensive care and hospital, sepsis, acute renal failure, multiple organ failure and mortality). Transfusion volumes were verified for accuracy with the blood bank information system (HCLL, Mediware, Lenexa,

Kansas). Data for all obstetric patients who were transfused six or more RBC units in a 24-h period were also extracted from the blood bank information system, in order to detect underactivation of the MHP.

Laboratory data (where performed) were extracted from the patient chart at activation and at protocol termination.

Data were analyzed using descriptive statistics in Excel (Microsoft®, Redman, Washington, USA). Compliance with the MHP was calculated as a percentage of all activations. Correlation between the volume of blood transfused (units of RBCs) and estimated blood loss was determined by R^2 coefficient of determination. Estimated blood loss was determined by the obstetrician through estimation considering suction volume, blood in the drapes and number of soaked sponges.

Results

The indicators detailed in Fig. 1 were deemed essential for patient outcomes by the multidisciplinary team during the obstetric activation of the MHP. Indicators were developed to allow for evaluation of activation, initiation of protocol, maintenance and termination phases. Where applicable, appropriate time to completion and/or frequency were detailed.

During the study period there were 19 790 deliveries and 17 obstetrical MHP activations, representing 0.09% (95% CI 0.05 to 0.13) of all deliveries. Demographics of the MHP patients are shown in Table 1. The majority of patients were delivering their first infant at term and were 20–34 years old. Half the deliveries were by cesarean section, and four patients were at risk of PPH due to abnormal placentation (see Fig. 2).

The etiology of hemorrhage is shown in Table 2. The majority of cases were attributable to uterine atony. Table 3 depicts the number of units of RBCs, plasma, platelets and cryoprecipitate transfused to each of the 17 patients. All patients received at least one unit of RBCs and 12/17 (71%) patients received more than four units. At least one unit of plasma, platelets or cryoprecipitate was transfused in 12/17 patients (71%). A correlation was found between the estimated volume of blood loss and the number of RBCs transfused in the 24 hours after activation (R^2 linear = 0.75).

Quality		Item	Time
Activation	Overactivation	< 2 units RBC transfused	First 24 hrs after delivery
	Underactivation	≥ 6 units transfused	In a 24 hr after delivery period
Initiation	Initial Blood Work	CBC	Within 30 minutes of activation; unless drawn up to one hour before
		INR/PTT	
		Fibrinogen	
		Lactate	
		Artterial blood gas	
		Group/Screen	
	Time arrival lab to system	CBC (≤ 10 min)	Initial: sample arrival in laboratory Final: result released in computer
		INR/PTT (≤ 15 min)	
		Fibrinogen (≤ 20 min)	
	Resuscitation	Two large bore intravenous access in place	Within 30 minutes of activation
		Temperature measurement	
		Body warmer	
		Fluid warmer	
		Arterial line	
		Tranexamic acid	
		At least 2 uterotonics in addition to oxytocin (ergotamine, carboprost, misoprostol)	
	Porter	Package 1a (4 RBC) ≤ 15 min	Time to deliver package 1a after activation
	Obstetrician	Intrauterine balloon	Yes or No
Maintenance	Blood work	CBC	Every hour
		INR/PTT	
		Fibrinogen	
		Lactate	
		ABG	
	Resuscitation and transfusion	Temperature measurement	Consistently
		Temp > 36	
		pH ≥ 7.2	
		Lactate ≥ 4.99	
		55g/L ≤ Hb ≤ 95g/L	
		Platelet ≥ 30,000	
Termination	Waste	Yes or No	Total
	Debrief	Debrief	In 72 hrs

Fig. 1 Massive haemorrhage protocol in obstetrics performance improvement indicators

Table 1 Patient demographic and obstetrical data (n=17)

Maternal age (y)	
Less than 20	1 (5.9%)
20–34	9 (52.9%)
35–39	5 (29.4%)
40 or more	2 (11.8%)
Ethnicity	
Caucasian	4 (23.5%)
Asian	8 (47.1%)
Hispanic	2 (11.8%)
Black	1 (5.9%)
Other or not documented	2 (11.8%)
Body mass index (kg/m^2) at delivery (n=12)	28.3 [26.0–30.9]
Parity	
Nullipara	11 (64.7%)
Multipara	6 (35.3%)
Gestational age (weeks)	38 [32–40]
Mode of delivery	
Caesarean[1]	9 (52.9%)
Vaginal	8 (47.1%)
Multiple gestation	0
Medical induction of labour	6 (35.3%)

Data are number (%) or median [interquartile range].
[1]Only one cesarean section was an elective procedure.

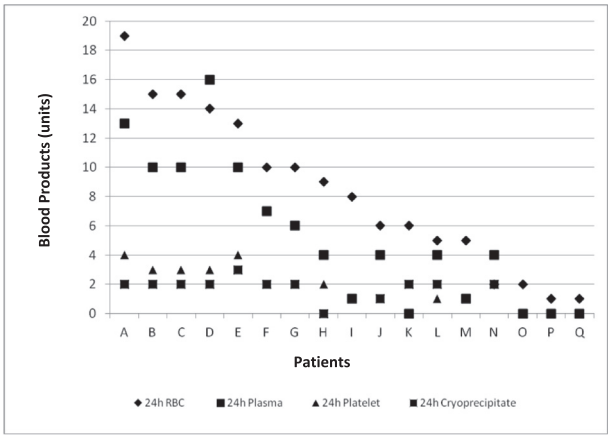

Fig. 2 Number of blood products received per patient ordered by the number of red blood cells transfused

Two obstetrical patients were transfused six units or more RBCs within 24 hours after delivery, but did not have the MHP activated (one patient received seven units and one eight units). Neither patient underwent a hysterectomy or transfer to the intensive care unit. No reason for failure to activate the MHP was documented. No further data were collected for these patients.

The quality parameters compliance rates are listed in Table 4. Patient physiologic and coagulation measures before and after MHP activation are shown in Table 5. There was no documentation of debriefing in any of the cases. There were no deaths. Intensive care admission and peripartum hysterectomy occurred in 12 and 5 of 17 cases (71% and 29%), respectively. Sepsis, acute renal failure or multi-organ failure did not occur. Five patients were mechanically ventilated for more than 10 hours. The median (IQR) hospital length of stay after delivery was 6 (IQR 4–7.5) days.

Discussion

While MHP activations in obstetrics are uncommon, they play a role in standardizing care, ensuring delivery of critical therapies, and ensuring rapid access to blood products. The quality indicators selected by our multidisciplinary team permitted a determination of institutional compliance with the MHP. The audit focused on severe PPH with MHP activation, although the value of reviewing all blood loss exceeding 1500 mL is acknowledged.[27]

The review found several examples of excellent compliance, but low compliance was found in timely blood gas sampling, monitoring of fibrinogen and lactate levels, and monitoring and management of hypothermia. Documentation was missing for the time of delivery of blood products and for debriefing following the termination of the MHP.

Temperature monitoring was performed in only 24% (4/17) of patients, and fewer than half the patients received interventions to prevent hypothermia. Hypothermia contributes to the coagulopathy of massive hemorrhage and transfusion in trauma,[28] and a review of prevention and management strategies has been published by our group.[29] An arterial cannula

Table 2 Etiology of hemorrhage (n=17)

Uterine atony	13 (76.5%)
Placenta accreta	3 (17.6%)
Placenta previa	4 (23.5%)
Placenta accreta and previa	2 (11.8%)
Retained placenta	2 (11.8%)
Placental abruption	2 (11.8%)
Uterine inversion	1 (5.9%)
Acute fatty liver	1 (5.9%)
Vaginal laceration	3 (17.6%)
Cervical laceration	2 (11.8%)
Uterine artery injury	1 (5.9%)
Laceration external iliac vein	1 (5.9%)

Data are number (%). Patients could have more than one factor.

Table 3 Number of units of blood received by the patient in first 24 hours after delivery (ordered by the number of red blood cells transfused)

Patient	Red blood cells	Plasma	Platelet pool (4 units per pool)	Cryoprecipitate (10 units per pool)
A	19	13	4	2
B	15	10	3	2
C	15	10	3	2
D	14	16	3	2
E	13	10	4	3
F	10	7	2	2
G	10	6	2	2
H	9	4	2	0
I	8	1	1	1
J	6	4	1	1
K	6	0	0	2
L	5	4	1	2
M	5	1	1	1
N	2	4	2	2
O	2	0	0	0
P	1	0	0	0
Q	1	0	0	0

was inserted in most patients, but arterial blood gas samples were taken within the first 30 minutes in fewer than half the patients. Since acidosis is implicated in the development of hemorrhagic coagulopathy, monitoring is vital.[30] We have modified our blood packs to include sample tubes, blood gas syringes and completed laboratory requisition slips, to aid compliance.

Only three patients (18%) maintained a hemoglobin level within the target range (55–95 g/L); five (29%) had at least one instance of a hemoglobin level below 55 g/L and 12 patients (71%) had at least one value above 95 g/L. While both over- and under-transfusion occurred, over-transfusion was more frequent. It is now recommended that, after transfusion of 2–4 units of RBCs, patients undergo clinical and laboratory assessment of the need for additional units,[15] and that all blood results (not just critical values) are now notified to the treating team.

The trauma literature suggests that quality and compliance for MHPs includes process-driven targets (such as blood availability times), intervention targets (such as blood-to-blood product ratios) and physiological targets (such as lactate, pH, fibrinogen).[9,31] Key critical MHPs components have been identified: transfusion assistance, temperature control, activation, termination and quality assurance.[32] Some parameters, goals and turnaround times may be institution specific.

Our institutional rate of MHP activation (0.09%) was double the incidence of severe PPH reported in a United States of America population sample (4.2 per 1000, 0.042%)[3] in which PPH was defined as requiring blood transfusion, peripartum hysterectomy or surgical repair of the uterus. Skupski et al. reported a 0.53% major hemorrhage rate (greater than 1500 mL blood loss) in an institution with a MHP, although activations were not recorded (median transfusion volume was 500 mL or two units for their cohort).[20] The Scottish Reproductive Health Programme reported a major hemorrhage rate of 0.6%, and 80% of patients required transfusion.[6] Massive hemorrhage protocol activation rates of 0.26%

Table 4 Massive hemorrhage protocol quality and performance indicators and compliance rate (n=17)

Phase 1. Activation	
Under-activation[1]	2 (0.01%)
Over-activation (<2 units of red blood cells)	2 (11.8%)
Phase 2. Initiation (within 30 min)	
Group and screen	17 (100%)
Complete blood count	17 (100%)
INR (International Normalization Ratio)	15 (88.2%)
Fibrinogen	12 (70.6%)
Lactate	3 (17.6%)
Arterial blood gas	7 (41.2%)
Two IV cannulae in place of 18-gauge or wider	17 (100%)
Temperature measurement	4 (23.5%)
Body warmer installed	8 (47.1%)
Fluid warmer installed	7 (41.2%)
Arterial line inserted	16 (94.1%)
Tranexamic acid administered	12 (70.6%)
Two uterotonics as well as oxytocin	12 (70.6%)
Porter arrival	no documentation
Issue time of red blood cells $\leq$15 min	15 (88.2%)
Phase 3. Maintenance	
Complete blood count (hourly)	12 (70.6%)
INR (hourly)	11 (64.7%)
Fibrinogen (hourly)	9 (52.9%)
Lactate (hourly)	4 (23.5%)
Arterial blood gas(hourly)	8 (47.1%)
Temp $\geq$36 °C; *n=4*	2 (50%)
pH $\geq$7.2; *n=16*	13 (81.3%)
Lactate $\leq$4.99; *n=12*	7 (58.3%)
55 g/L $\leq$ Hb $\leq$ 95 g/L[2]	3 (17.6%)
Platelet $\geq 30 \times 10^9$/L	17 (100%)
Phase 4. Termination	
Waste of blood products	1 (5.9%)
Debrief documented within 72 h	0

Patients presented with at least one value above 95 g/L.; Data are number (percentage). IV:intravenous.
[1]Denominator of 19 790 deliveries.
[2]Five patients presented with at least one Hb value below 55 g/L and 12.

Table 5 Baseline and post-resuscitation laboratory parameters (N=17)

	Baseline	Post-resuscitation
Hemoglobin (g/L)	120.1 (12.5)	100.4 (19.1)
Platelets ($\times 10^9$/L)	199.6 (48.9)	106.1 (46.4)
INR	0.9 (0.1); *n=4*	1.1 (5.1)
PTT (s)	31 (4.2); *n=4*	29.5 (5.4)
Fibrinogen (g/L)	5.2 (1.2); *n=2*	2.5 (0.9); *n=15*
pH	No data	7.3 (0.1); *n=15*
Base deficit	No data	5.8 (2.9); *n=15*

Data are mean (SD): post-resuscitation blood work was defined as the blood parameters after definitive hemorrhage control and cessation of red blood cell transfusion. INR: International Normalized Ratio. PTT: partial thromboplastin time.

have been independently reported in two institutions.[33,34]

Variability in institutional rates is anticipated due to different patient populations and the definitions used for case selection. Our high-risk tertiary facility would be expected to have more obstetrical complications compared to a low-risk facility; however, only patients where the clinical team activated the MHP were included, which is expected to be a subset of all patients with PPH. Variability in rates may be due to differences

in protocol activation criteria, such as blood loss and hemodynamic instability, or after a defined number of red cell units transfused.

The causes of hemorrhage were consistent with published trends.[3] Uterine atony was present in most patients (13/17; 77%) followed by abnormal placentation (9/17; 53%) (Table 2). Uterine atony is the most common cause of PPH worldwide;[35] prompt administration of uterotonics was a quality and compliance indicator in the MHP audit where administration of two uterotonics within 30 minutes was achieved in 71% of activations.

Low fibrinogen levels are associated with an increased severity of PPH and are a predictor of progression to severe hemorrhage.[36] A recent trial in patients with PPH comparing the effect of fibrinogen concentrate (2 g) versus placebo found no difference in outcomes,[37] although written informed consent was required from each patient and those with massive hemorrhage and low fibrinogen levels were not included. A small, randomized control trial of 55 patients with PPH who received either fibrinogen or placebo, demonstrated no reduction in blood loss from fibrinogen given to women with a rotational thromboelastometry FIBTEM of <12 mm.[39] In our study, fibrinogen was measured in 12 out of 17 patients (71%) within 30 minutes of MHP activation and was measured hourly in 9/17 (53%).

The WOMAN trial found that administration of tranexamic acid had a positive impact on maternal deaths from hemorrhage, especially if given early after the onset of hemorrhage.[40] Administration of tranexamic acid is a core component of our MHP. Twelve of seventeen patients received tranexamic acid within 30 minutes of MHP activation.

Due to the small number of MHP activations, it is difficult to comment on the morbidity impact in this group, but just over half the patients required intensive care unit admission and just under one-third required hysterectomy, so the morbidity associated with massive obstetric hemorrhage is not trivial. Peripartum hysterectomies are associated with abnormal placentation and cesarean section, and their incidence is increasing in high-income countries.[41]

Results of the MHP survey have prompted system changes at our institution. Records of MHP activations, arrival times of clinical team members, product issue times from the blood bank and delivery times of blood products are now collected, so this may improve subsequent performance assessment.[42] No debriefs after MHP activation were documented in the patient record. Debriefing after adverse events in simulated and clinical settings is an educational opportunity, beneficial for staff's psychological welfare and directly improves performance in future scenarios.[43] Guidance on how to improve debriefing is available.[44] Improvements to the MHP performance center on dissemination, education and inter-professional involvement. The results of this study have been presented locally to departmental stakeholders, and real-time MHP simulations have been implemented to improve protocol compliance.[20,27] Simulations of PPH management with MHP have highlighted common failures, including late activation, failure to collect samples for laboratory testing and failure to discuss the management plan.[23]

The study has multiple limitations. First, the size of the cohort was small and lacked a comparator from an institution without an MHP. Second, due to the lack of published literature, the list of performance indicators was arbitrarily created by a local inter-professional team. Third, the retrospective review of MHP quality indicators does not identify the personnel present, nor does it examine their roles in the context of the MHP. As such, the success and compliance of the MHP may vary depending on the team members present, time of day and other activities occurring on the labor and delivery unit or the blood bank. A prospective review of quality indicators may identify human factors and system issues, as is advocated in the trauma literature.[9] Lastly, our threshold for under-activation was chosen as six or more RBCs for a PPH for which the team believed a MHP should have been activated; it is possible that patients with 3–5 RBC transfusions may have warranted activation.

This 5-year quality review of activations of MHP for obstetrical patients found poor compliance rates for documentation, monitoring for hypothermia, performance of regular tests of coagulation, maintenance of hemoglobin level within the specified target range and performance of post-resuscitation debriefings. Future research in the area of MHPs in obstetrics should focus on prospective real-time observational studies, investigating the impact of quality compliance on outcomes, and evaluating the role of simulations in improving compliance. Multicenter studies would also provide benchmarking data to permit comparisons between institutions.

Declarations of interest

None.

Role of the funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijoa.2018.10.004.