Ontario MHP

Provincial Massive Hemorrhage Toolkit

ORBCoN

Ontario Regional Blood Coordinating Network

Inspiring and facilitating best transfusion practices in Ontario.

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1.0 PREFACE

The major cause of preventable death from trauma is catastrophic hemorrhage. A significant proportion of such deaths from exsanguination as a result of trauma are preventable by prompt arrest of blood loss combined with timely transfusion support. Maternal death from major hemorrhage should be preventable by timely aggressive hemostasis with transfusion support. The management of major gastrointestinal and operative surgical hemorrhage should also be governed by the same general therapeutic considerations.

While massive transfusion plays a significant part in the management of exsanguination from any cause, increasing experience, particularly in trauma care both civilian and military, has shown that it must be applied in conjunction with measures directed at "damage control" such as surgical and pharmacological hemostasis and mitigation of the adverse effects of massive transfusion of stored refrigerated blood components. Thus, massive transfusion forms only part of a larger plan, a massive hemorrhage protocol (MHP), which may be defined as a multidisciplinary practical framework for the coordinated delivery of hemorrhage control and planned blood replacement directed at improving patient survival and preparation for definitive treatment. Blood transfusion policy in this context may be seen as having a relationship to an MHP analogous to that between the clinical practice of elective transfusion and the concept of Patient Blood Management.

A recent survey of the preparedness of Ontario hospitals to support the management of a major hemorrhage event as evidenced by the documented establishment of a massive hemorrhage protocol revealed that 97 of 150 hospitals had documented policies addressing this issue. The information contained in those documents varied greatly from hospital to hospital in respect of title, content, recommended practices, criteria for decision-making and monitoring. 53 (35%) hospitals had no documented procedure for such situations. The current state of understanding of resuscitation practices and their delivery is such that it is possible to design an evidence-based protocol which can be quickly and consistently implemented to guide effective multidisciplinary resuscitation of exsanguinating patients if treated promptly. Thus, the current situation in Ontario justifies the establishment of a Province-wide MHP for all institutions which may receive patients with massive hemorrhage (e.g., local traumatic injury or gastrointestinal hemorrhage) or which perform procedures where hemorrhage may occur (e.g., routine obstetrical deliveries).

For the effective and efficient management of catastrophic hemorrhage from any cause, the complex processes involved cannot be optimally delivered in the absence of a well-understood and rehearsed coordinated response involving multiple disciplines and hospital services. For this reason, it is important for all hospitals to develop a clear, well documented, widely available MHP based on sound therapeutic principles and consistent with the resources available. Clearly the content of the MHP can only reflect the resources of individual institutions and "one size does not fit all". This document seeks to provide guidance to hospital management, medical staff and supporting services to assist in that development.

Specialties and services involved in forming the "team" will include some or all of the following (subject to availability within the resources of the institution): emergency room personnel, surgeons of various disciplines, anesthesiologists, critical care physicians, nursing (including charting support), laboratory personnel for transfusion management and urgent hematology and biochemical testing, "runners" for urgent blood and blood product product and test sample transport, hospital communications and social support for families (social work or spiritual care). There should be a mechanism in place whereby, for any given case, a member of the team, usually a surgeon or anesthesiologist, is identified for the critical role of team leader to direct the resuscitation (MHP) process. When the decision is made to initiate the MHP, there must be an effective rapid notification ("call") system to activate the immediate coordinated MHP "team" response appropriate to the circumstances of the individual institution.

Massive transfusion has traditionally been defined as "10 units of blood required within 24 hours" or massive blood loss as "one blood volume in 24 hours". Other definitions have included "transfusion of more than 4 units of red cells in 1 hour" or "replacement of 50% of blood volume within 3 hours". All these definitions, and other similar, may be of value in retrospective case identification and assessment, but are of less value when first faced with the exsanguinating patient about whom a decision to trigger the MHP is required. The MHP must include a prospective guide to reaching this decision based on the immediate clinical condition and a mechanism for activation of the transfusion aspects of the protocol.

It will also be necessary to determine and define the criteria to signal the termination of the need for the MHP and "stand down" the team. These criteria would include the death of the patient or the stabilization of the patient's condition. Such termination notice is required to cease the now unnecessary provision of blood components and products, and permit staff to resume normal duties.

Massive hemorrhage occurs in a variety of circumstances which may require particular accommodation in the MHP, including catastrophic obstetrical hemorrhage, surgical hemorrhage and gastro-intestinal bleeding. All of these share the need for hemorrhage control and blood replacement, but have the advantage that the source of hemorrhage is readily apparent. Another patient population for which specific advice on care is the pediatric patient who requires weight-based dosing and may be at greater risk of complications from massive transfusion (e.g., hyperkalemia).

To ensure that all necessary practical conditions of the MHP are being met, the protocol should include a check list of essential steps (refer to implementation checklist in Adult Appendix A) to guide the team and avoid omission of important elements (e.g., unique patient identification (ID) in place, temperature monitoring initiated, blood warmer in place and functional, tranexamic acid (TXA) given). The protocol should also contain a check list of required laboratory investigations and their timing, and a plan for the scheduled preparation and delivery of blood components and products in anticipation of, rather than in response to, need. There must be a statement of specific indications for specific critical interventions based on laboratory results as they become available (e.g., the prescribing of fibrinogen or prothrombin complex concentrate, reversal of anticoagulants, additional platelets for transfusion).

Mechanisms should be in place for recording (written or electronic) of patient information as the resuscitation proceeds to meet the needs of the patient record. A clear algorithm of the management plan should be developed and widely available in all locations directly or indirectly involved in the MHP response (See Adult Appendix B and Pediatric Appendix A).

Special provisions within the protocol and check lists will be required for particular situations such as early use of fibrinogen and aggressive local hemostasis in major obstetric hemorrhage or specific policies for children.

A system for the collection of "quality metrics" is required to monitor the effectiveness and quality of institutional performance in managing massive hemorrhagic events, and provide a basis for improvement if necessary, both in the performance within the provisions of the MHP and in the validity of the MHP itself. There should be a process for both local and Provincial oversight of quality assessment data.

Each hospital should establish specific conventional Standard Operating Procedures (SOPs) for each of its involved clinical or administrative services, laying out the details of their respective contributions to the functions of the MHP. The toolkit includes an implementation check list to ensure no component of the MHP is overlooked.

The various aspects of the content of an MHP Toolkit have been exhaustively reviewed by the panel of experts identified in the introduction to this toolkit and the recommended actions carefully assessed in the light of the information in the literature and their own respective experience in practice. The heterogeneous nature of Ontario's hospitals and the geographic distribution and dispersal of its population dictate that the MHP for many hospitals will be very much dependent on its size and location; in spite of these considerations, there is an obligation to provide the best possible management of the exsanguinating patient within the limitations they impose. The evidence-base for the management of the massively bleeding patient is constantly evolving; thus, this toolkit and the local MHP policies must be updated at least every three years so the care of these patients evolves in step with the available clinical trial evidence and the provincial MHP.

References

1. Callum JL, Yeh CH, Petrosoniak A, et al. A regional massive hemorrhage protocol developed through a modified Delphi technique. CMAJO 2019 Sep 3;7(3):E546-E561.
2. Cannon JW, Khan MA, Raja AS et al. Damage control resuscitation in patients with severe traumatic hemorrhage: a practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg 2017; 82: 605-617.
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2.0 INTRODUCTION

ORBCoN is funded by the Ontario Ministry of Health to provide an organized and integrated approach to blood management in Ontario through the engagement of hospitals and Canadian Blood Services. ORBCoN oversees transfusion use and audits of practice in the province and uses this data to provide hospitals with educational resources to improve patient safety and standardize best practices where needed. The goal of this project was to identify the key evidence-based principles required to develop a standardized provincial MHP and to develop quality indicators to encourage improvement in practice. Instituting an adaptable MHP for the province based on the local health care resource setting is needed to streamline the complex logistics of rapid delivery of blood components, facilitate rapid patient transfer where required and reduce the cognitive burden on bedside clinicians. Results of a baseline survey published in 2019 in Injury showed one third of Ontario hospitals did not have a formal MHP in place and those MHPs that were in place showed marked variability in all aspects of the protocol regardless of hospital size and services. There was marked variability in activation criteria, lab testing, resuscitation targets, temperature monitoring, reversal of anticoagulants and blood product usage. These core parts of an MHP were subjected to review by a modified Delphi exercise and the multidisciplinary panel voted on consensus statements in three rounds of iterative surveys. This unique approach resulted in 42 recommendations and 8 quality metrics which were published in CMAJ Open in 2019[1]. The 7Ts, which illustrates that 'transfusion' is just one element in a Massive Hemorrhage Protocol formed the basis of the provincial toolkit which is comprised of 12 sections, encompassing the 42 key recommendations.

7Ts:

1. Triggering
2. Team
3. Tranexamic Acid
4. Testing
5. Transfuse to Target
6. Temperature
7. Termination

We expect that, with the use of the toolkit, hospitals will achieve more consistent adoption of evidence-based care of the patient with massive hemorrhage, improved speed of delivery time of blood components and hemostatic adjuncts, and more diligent monitoring of clinical and laboratory parameters. There is also an opportunity to track patient outcomes in Ontario and to audit and understand the impact of this effort to standardize the care of these complex, high-acuity patients.

2.1 Background

A standardized, evidence-based, provincial MHP is key to achieving optimal care of the hemorrhaging patient. Through standardization we hope to achieve the following goals: (1) minimize underactivation that could result in a fatal outcome or prolonged time to hemorrhage control; (2) ensure red blood cells (RBCs) are delivered to the patient bedside within 10 minutes of protocol activation and post-transfusion hemoglobin is maintained between 60-110 g/L; (3) all patients without contraindication receive TXA as soon as IV access is obtained and optimally within 1 hour of injury/onset of hemorrhage*; (4) patients requiring transfer for definitive care have transport personnel mobilized promptly; (5) all patients have interventions to prevent hypothermia and achieve normothermia by the end of resuscitation (≥36°C); (6) use of universal donor components are minimized (O red cells and AB plasma); (7) blood component wastage is eliminated.

The modified Delphi exercise was restricted to adult patients with major hemorrhage from any cause; however, despite lack of pediatric trials, we thought it was important to provide advice and guidance on pediatric MHPs. Pediatric patients are more complex (requiring weight-based dosing), are less frequent (clinical teams have less practice and therefore the pediatric simulation exercise included in this toolkit will be especially helpful) and pediatric patients are more susceptible to complications of massive transfusion (electrolyte abnormalities, hypothermia, fluid overload).

*A single randomized controlled trial of tranexamic acid in patients with gastrointestinal bleed[2], which was published after the Delphi consensus statements were developed, has shown no benefit and increased risk of thrombosis. In view of these findings, universal administration of TXA in patients with gastrointestinal bleed cannot be recommended. Decision to use TXA in this clinical scenario should be made by the clinical team on a case by case basis.

References

1. Callum JL, Yeh CH, Petrosoniak A, et al. A regional massive hemorrhage protocol developed through a modified Delphi technique. CMAJO 2019 Sep 3;7(3):E546-E561.
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3.0 METHODS

A multi-disciplinary Steering Committee made up of community stakeholders, Canadian Blood Services (CBS) and ORBCoN was formed. The Steering Committee was tasked with selecting expert panelists, creating survey iterations, administering and analyzing results, organizing educational forums and overseeing the development of a provincial MHP toolkit (with the use of a modified Delphi exercise). Panel members were selected based on expertise and responsibilities administering MHPs across Ontario's diverse geographical network and were not financially remunerated. The expert voting panel consisted of 36 volunteer members and included a wide representation of all major stakeholder groups (trauma, critical care, emergency medicine, anesthetists, transfusion medicine, hematology and core laboratories, nursing, respiratory therapy, land and air emergency medicine services (EMS)/Ornge, hospital administration, blood supplier and patient representation) across all types of hospitals; academic, community, small/rural and pediatric.

The preliminary (key-principal) statement recommendations were generated by the members of the Steering Committee based on results of a baseline provincial survey, literature review and reflected the most up-to-date evidence in the area of massive hemorrhage management at the time. The panelists were provided with seminal papers to support and provide justification of the preliminary recommendations.

A Delphi method was used to achieve consensus among the voluntary multidisciplinary expert panel and to build the foundation of the proposed MHP. The Delphi technique is a systematic, interactive method that relies on a panel of experts to converge on consensus statements following a series of iterative surveys. This method allowed us to cost-effectively include a large number of participants spread across a large geographical area while eliminating biasing of opinions through anonymous voting. Each survey round was administered through an electronic web-based survey application (LimeSurvey) and conducted independently by each panel member via email link.

The Delphi method was modified to allow an open forum for discussion in round 1. The first round was completed one month in advance of a stakeholder MHP educational forum (to ensure the broadest range of expertise was captured in the consensus) as this meeting was dedicated to reviewing the relevant literature supporting the preliminary statements and open to panelists and delegates. This allowed the panelists to reflect on the presented evidence prior to completing a second survey round.

During all rounds, panelists were asked to score each statement using a 7-point Likert scale from "definitely should not" to "very important to" include. If a panelist had no expertise in one or more statements, he/she was instructed to select the option "unable to answer outside of my area of expertise".

A priori criteria for disposition of the items in round 1 were as follows:

1. Items receiving an average Likert score of at least 5.5 will be accepted as written and not subject to further rounds. These statements will be incorporated into a provincial MHP as written, unless a clear improvement in phrasing was suggested by any panelist.
2. Items scoring 2.6 to 5.4 will be discussed following educational forum with all the panelists. Following discussion, the items will be rewritten by the Steering Committee and sent out in the second round of Delphi.
3. Items with scores of 2.5 or less will be removed from any subsequent round unless strong opposition by the Steering Committee and will be openly discussed following educational forum. If on re-scoring, the ranking remains at 2.5 or less the statement will be removed from the list.

A priori criteria for disposition of the items in round 2 were as follows:

1. Items receiving an average Likert score of at least 5.5 will be accepted as written and not subject to further rounds. These statements will be incorporated into a provincial MHP.
2. Items scoring 5.4 or below will be rewritten on the basis of comments by the panelists and sent out in the third round.
3. Items scoring 2.4 or less will be removed from further rounds of scoring.

4. If all items score 5.5 or higher, there will be no third round.
5. Items scoring below 5.4 in the third round will not be included in the provincial MHP.

Intermediate items at the conclusion of three rounds were reviewed by the Steering Committee to determine the final disposition of the statement taking into account the range of the participant ratings.

The final statement list was sent to a wide range of external stakeholders for assessment of its content and ease of use.

References

1. Chin V, Cope S, Yeh CH, et al. Massive hemorrhage protocol survey: marked variability and absent in one-third of hospitals in Ontario, Canada. Injury 2019;50:46-53.
2. Callum JL, Yeh CH, Petrosoniak A, et al. A regional massive hemorrhage protocol developed through a modified Delphi technique. CMAJO 2019 Sep 3;7(3):E546-E561.

4.0 OVERARCHING STATEMENTS

Date of release: September 5, 2019

Note: At the time of the publication of the modified Delphi report in CMAJ Open[1] the FIBRES trial[2] was not published (randomized control trial (RCT) of cryoprecipitate vs. fibrinogen concentrate for bleeding after cardiac surgery). The FIBRES trial confirmed the hemostatic and safety equivalence of fibrinogen concentrate with cryoprecipitate. Given that fibrinogen concentrate is safer (pathogen reduced) and logistically less complex for hospitals to administer (no ABO group, not frozen, room temperature storage), cryoprecipitate has been removed from the toolkit and replaced with fibrinogen concentrate.

A prospective, double-blind, randomized trial of TXA dosing in patients with traumatic brain injury was published in 2020[3]. The trial compared a 2 gram bolus at the scene vs. 1 gram bolus at the scene and a 1 gram infusion on arrival to the hospital vs. placebo. Overall there was no difference in neurological outcomes or survival. When the results of this trial and the similar CRASH-3 trial (ref: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(19)32233-0/fulltext) were combined there was a statistically significant reduction in mortality (RR 0.89, 95% CI 0.80-0.99). In the former trial in subgroup analysis, patients who were determined while in the hospital to have had an intracranial hemorrhage, 28-day mortality was 18% in the bolus only group, 26% in the bolus maintenance group, and 27% in the placebo group (bolus maintenance vs placebo: adjusted difference, −0.8% [95% CI, −7.0% to 8.7%]; P = .84; bolus only vs placebo: adjusted difference, −8.2% [95% CI, −16.6% to −0.8%]; P = .03; bolus only vs bolus maintenance: adjusted difference, −9.0% [95% CI, −16.1% to −1.8%]; P = .01).

A definitive randomized controlled trial involving over 12,000 patients with gastrointestinal hemorrhage found that tranexamic acid does not reduce death from gastrointestinal bleeding and increases the risk of thromboembolic complications[4].

References

1. Callum JL, Yeh CH, Petrosoniak A, et al. A regional massive hemorrhage protocol developed through a modified Delphi technique. CMAJO 2019 Sep 3;7(3):E546-E561. (Note: A comprehensive list of references for the below overarching statements can be found within this paper)
2. Callum J, Farkouh ME, Scales DC, et al. Effect of Fibrinogen Concentrate vs Cryoprecipitate on Blood Component Transfusion After Cardiac Surgery: The FIBRES Randomized Clinical Trial. JAMA. 2019;322(20):1966–1976. doi:10.1001/jama.2019.17312
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Reference list for Delphi Statements can be found at the end of this publication.

Statement	Description
1	**All hospitals shall have a protocol to guide the management of a massively bleeding patient.** The panel concluded that an MHP is required to standardize the approach to the massively bleeding patient for all hospitals. For the purposes of the MHP, a hospital is defined as any organization that either maintains a red cell inventory or staffs an emergency department, urgent care centre, critical care unit, labour and delivery, or operating room. The panel recognized there are small clinic facilities where a bleeding patient may be encountered but where transfusion is currently not available and an MHP would not be appropriate. The panel concluded that a policy for rapid transport of patients with massive hemorrhage to a facility with an MHP would be required at such a facility.

2	**The protocol shall be developed by a multidisciplinary team and approved by the Hospital Transfusion Committee (or other relevant multidisciplinary committee).** The MHP requires support from multiple hospital services including, but not limited to: emergency, trauma, surgery, anesthesiology, critical care, blood transport personnel, communication services, and laboratory personnel.[10] The protocol should be reviewed and approved by the Hospital Transfusion Committee (or other relevant hospital committee) and the Medical Advisory Committee.
3	**The protocol shall incorporate the principles of damage control resuscitation, specifically giving highest priority to treating the source of hemorrhage.** Damage control resuscitation principles in traumatic injury include abbreviated surgical and/or endovascular interventions for hemorrhage control and management of intra-abdominal contamination, critical care support to correct deranged physiologic measures (hypothermia, acidosis, coagulopathy); with definitive surgical repair delayed until stabilization and hemostatic control have been achieved.[19] In the severely injured trauma population, damage control resuscitation is associated with reduced mortality, although the approach has never been tested in a randomized controlled trial.[14,20,21] Ongoing hemorrhage leads to worsening coagulopathy and other physiologic derangements.[22] Although the role of damage control resuscitation outside of traumatic injury is unknown, prompt hemorrhage control is likely to be an important component of care.[23,24]
4	**The protocol shall consider the available resources at the institution.** The hospital must consider the available resources of the institution when developing the local protocol. Centres caring for pediatric patients should ensure personnel are prepared for weight-based dosing and the use of size specific equipment (e.g., warming devices, intravenous infusion equipment). Smaller and more remote hospitals located at a distance from the blood supplier will need to make adjustments to streamline their MHP to compensate for the limited number of team members, blood component inventory and laboratory testing menus, and ability to provide definitive surgical or endovascular control of hemorrhage. The MHP will need to specify, if required, which and how patients should be transferred in a timely manner to other facilities for definitive treatment. Examples for simplification for smaller/remote sites include: (1) pre-labelled uncrossmatched red blood cell (RBC) units ready for immediate transfusion; (2) pre-prepared laboratory sample collection kits; (3) administration of a single bolus of tranexamic acid rather than an infusion; (4) administration of Prothrombin Complex Concentrates (PCC) and fibrinogen concentrate instead of plasma and cryoprecipitate; (5) use of point of care technology for laboratory testing; and (6) cross-training hospital personnel from other patient care areas.
5	**A single protocol for all patients is preferred in order to ensure compliance; there should be specific guidance provided for select patient populations (e.g., obstetrical patients should receive early fibrinogen replacement).** A survey from academic hospitals found that 60% of respondents have a single protocol for all patients.[25] Compliance with a single MHP is poor in published studies,[11,15,26] raising the concern that consistent care would be further compromised by multiple protocols for different bleeding scenarios. The panel recommended a single, standardized protocol in response to the massively bleeding patient with options to tailor the protocol for specific patient populations. Examples: In massive obstetrical hemorrhage, consideration should be given to measuring fibrinogen levels early and repeatedly, administering fibrinogen replacement if the level falls below 2.0 g/L,[27] and use of an intrauterine balloon device as a bridge to definitive bleeding control.[28] In gastrointestinal hemorrhage, consideration should be given for prompt endoscopic therapy for hemorrhage control.[29,30] In post-cardiac surgery hemorrhage, there is evidence to support the use of viscoelastic testing (as compared to standard laboratory tests) in reducing the risk of major bleeding.[31] Pediatric patients require weight-based dosing of blood components and hemostatic adjuncts, consideration for potentially higher transfusion triggers depending on co-morbidities and age, and provider awareness of increased risk for hyperkalemia and hypothermia.[32-35]
6	**The protocol should be reviewed at a minimum of every three years.** The science and clinical trial activity in the area of massive hemorrhage, coagulopathy, and MHPs is rapidly evolving. Each institutional MHP should be reviewed at a minimum of every three years to ensure alignment with the scientific evidence and the Provincial MHP. The protocol revision should be conducted by a multidisciplinary team as detailed in Statement 2, and approved by the Hospital Transfusion Committee and the Medical Advisory Committee.

7	**The protocol shall be called "The Massive Hemorrhage Protocol", and if activated as an overhead announcement, referred to as "Code Transfusion".** The existence of several different terms for the protocol across Ontario has created confusion and delays to activation (e.g., a trainee calling communications to activate the Code Omega protocol at a hospital that activates the protocol by calling the transfusion medicine laboratory to activate the "massive transfusion protocol"). The panel, after much deliberation, has chosen the protocol name of the **"Massive Hemorrhage Protocol"** for the following reasons: (1) Massive transfusion is most commonly defined in adults as a transfusion of 10 or more units of RBCs in a 24 hour period - however, some patients will not survive to receive 10 units and many patients between 4 and 10 units need additional therapies contained in an MHP; (2) The name highlights the importance of definitive hemorrhage control; and (3) An MHP is more than just a transfusion protocol and includes non-transfusion interventions (e.g., maintenance of normothermia, use of antifibrinolytics). The panel agreed that the method for MHP activation should be site-specific and clearly defined in the protocol, but that if a hospital-wide overhead announcement was implemented, a standard term should be used at all institutions. The consensus term chosen by the panel is "**Code Transfusion**" due to its clarity, ease of pronunciation, and lack of overlap phonetically with other "colour" codes (e.g., Code Bleed or Code Blood with Code Blue). The value of an overhead announcement is that it provides redundancy if the paging system fails and notifies all hospital employees that the laboratory is under acute pressure (and to refrain from calling for non-emergency blood products and non-urgent test results).
8	**Participating team members should have access to formal training and drills to increase awareness, adherence, and effective delivery of the MHP.** To achieve high levels of team performance and protocol adherence, team members require access to formal training material and exposure to multidisciplinary drills or simulations. This is particularly important for high-stress and rarely encountered massive hemorrhage scenarios. Simulations have been successfully employed for training in obstetrical hemorrhage,[36] pediatric hemorrhage,[37] and trauma.[38] A systematic review of 33 studies involving 1,203 resident and medical student participants found simulation was associated with improved provider behavior and patient outcomes.[39] In a systematic review of 13 studies of trauma team training, both non-technical skills and team-based performance improved.[40] Importantly, these improvements extend to patient outcomes as simulation-based training is associated with improved outcomes in trauma and cardiac arrest care.[41,42]
9	**The written MHP should be readily accessible as a reference tool for all team members.** To achieve high levels of protocol compliance among staff, ready access to the MHP is required. The local institution should develop resources (either in electronic or paper format) to assist clinicians with MHP compliance. The format and medium should be dictated by the local hospital circumstances.
10	**The transport service(s) should be promptly notified if the decision is made to transfer the patient to another hospital for definitive hemorrhage control. If required, the patient should be transferred as soon as and as safely as possible by appropriate staff and transport resources, to an institution where definitive hemorrhage control can be performed.** There are 150 hospitals in Ontario that have access to transfusion support. Due to Ontario's large geographic size and numerous remote regions, it would not be possible to have large stocks of blood components available at all hospitals without very high levels of wastage. Timely evacuation of massively bleeding patients from smaller centres to larger centres capable of definitive hemorrhage control is needed for two reasons: (1) small blood stocks held in remote hospitals (typically small number of RBCs, no platelet pools, and limited stocks of frozen plasma); and, (2) lack of access to definitive surgical or radiologic intervention to allow for hemorrhage control. There is little published on evacuation time targets within civilian settings. Rapid evacuation (<60 minutes) among military trauma patients with non- compressible torso injury and amputation injury is associated with reduced mortality.[43] Clinicians working with limited capacity to achieve surgical hemostasis should aim to transfer as soon and as safely as possible.

11	**The protocol shall have activation criteria.** Under-activation (i.e. delayed or no activation of MHP for patients who require hemorrhage control and blood components) could be catastrophic as it may result in otherwise preventable exsanguination. Retrospective studies suggest that delays in initial blood component administration is associated with worse outcomes (each 1 minute delay to the arrival of the first pack of blood components is associated with a 5% increase in the risk of death).[44] In contrast, over-activation (i.e., MHP activation that is ultimately not required) may lead to unnecessary transfusion, wastage of blood components, and diversion of human resources away from competing needs. Despite concern that appropriate and timely activation are critical, there are no criteria with both high sensitivity and specificity for predicting the need for massive transfusion. The two most commonly used scores validated in this setting are the Shock Index (blood pressure divided by heart rate or modified pediatric shock index[45]) and the ABC score (one point each for penetrating injury, blood pressure $\leq$90 mmHg, heart rate $\geq$120 and positive FAST (Focused Assessment with Sonography for Trauma on ultrasound), with the shock index performing slightly better in traumatic injury.[46] New data suggest that resuscitation intensity ($\geq$4 units of fluid in first 30 minutes with "1 unit" defined as any of 1 U RBC, 1 U plasma, 500 mL colloid, or 1L crystalloid) may represent an important alternative metric to identify patients who require MHP activation.[47] In pediatric patients, a retrospective study of combat injured children defined massive transfusion as requirement for ≥ 40 mL/kg of blood components transfused within 24 hours.[48] Given the current lack of evidence to support one set of activation criteria over another, the activation criteria should be set by the hospital to meet the needs of the local patient population.
12	**The protocol shall have termination criteria.** Termination of the protocol allows personnel to return unused blood components to regular inventory, cease ordering blood components from the blood supplier, cease thawing of frozen components, and divert resources to competing needs. In contrast, premature termination may lead to a reduction in the number of team members at the bedside, in the frequency of laboratory testing, and in the availability of blood components. Termination should be considered when bleeding source control has been attained, hemodynamic stability has been achieved, vasopressor requirements have diminished, and the transfusion rate has slowed such that additional transport personnel are no longer required. Typically when these features are present, transfusion decisions can be guided by laboratory test results.[49] As no explicit criteria have been validated, termination criteria should be determined at the local hospital level. The method to communicate the termination of the MHP should be specified in the local hospital protocol.
13	**The protocol shall specify the team members required to respond when the protocol is activated.** Executing all of the necessary tasks specified in an MHP, in addition to all the other clinical tasks required to achieve surgical control of blood loss, will require mobilization of an interdisciplinary team. The precise composition of the clinical team can be modified by the acuity of the hemorrhage, the location of the patient, the type of hemorrhage, and the institution's available resources. For example, the neonatal team will be required to attend postpartum hemorrhages to provide immediate care for the neonate, while in trauma MHPs managed in the trauma room where nursing to patient ratios are already high, additional nursing staff may not be required. Given the association between survival and the time arrival of the first cooler of blood components, a dedicated transport team for both blood samples and components is critical.

14	**The protocol should specify how the lead clinician at the bedside is designated.** How the lead clinician for the MHP is assigned should be specified in the local hospital protocol as it will be highly variable depending on the patient population served and the institutional resources. A broad range of physicians could serve as the team leader. In addition, in smaller organizations without on-site physicians, a nurse practitioner or midwife may be the most appropriate team leader. There may be a transition in leadership as the patient moves from one location to another. The process of handover from one leader to the next should be explicitly stated in the protocol. There must be training in non-technical skills for the team leads to promote high performance for communication, situational awareness, and decision-making skills. In simulation training, higher performance on non-technical skills by the team lead (situational awareness and decision making) correlates with critical task completion and improved team performance.[50] Simulation training for clinicians leading trauma resuscitation improves confidence and reduces anxiety.[51] Formal feedback of trauma team leaders in training by faculty is associated with improvement in leadership skills over time.[52]
15	**The protocol shall specify the team member(s) designated to be responsible for blood component and sample transport.** The protocol shall specify the team members designated to be responsible for both the transportation of blood components and patient blood samples for laboratory testing. Although the protocol specifies the use of a ratio-based resuscitation (standardized RBCs to plasma) to mitigate the risk of coagulopathy, this does not prevent over-transfusion or provide assurance that coagulation competence will be maintained.[53] Early and repeated laboratory testing (with rapid transportation of the samples to the laboratory) to confirm adequacy of transfusion resuscitation is required. It is also critical that blood components are rapidly supplied to the bedside and that empty coolers are returned to the transfusion medicine laboratory.
16	**The transfusion medicine laboratory and the core laboratory shall be notified of all MHP activations.** Early and prompt notification of the transfusion medicine laboratory will assist with timely blood component delivery, rapid transition to group specific blood, and designation of the transfusion medicine technologist team leader. A single individual on the clinical side should be the sole source of contact between the clinical team and the transfusion medicine technologist leader so as to reduce the risk of duplicate transfusion orders. Activation of the core laboratory technologists will ensure designation of the laboratory technologist team leader, rapid identification of MHP samples, prioritization of the testing, complete testing of all required tests for the MHP, and immediate communication of test results to the clinical team.
17	**All critical laboratory results and important coagulation parameters (hemoglobin, platelet count, INR, and fibrinogen) shall be communicated verbally to the clinical team as soon as they are available.** During MHP activation, the clinical team may not have ready access to the electronic health record due to patient acuity and clinical area layout. It is therefore required that all critical results (preliminary or complete, and as defined by the local laboratory) and important coagulation results (hemoglobin, platelet count, INR, and fibrinogen) be verbally communicated to the clinical team as soon as the results are available. This may mitigate the risks of under-transfusion or over-transfusion, and improve time to correction of other biochemical derangements (hyperkalemia, hypocalcemia, acidosis). The "push of information" is thought to be an important tool to improve team performance.[54] Consideration should be given to having dedicated mobile phones to mitigate the risk of communication failure between the laboratory and the clinical team due to rapid movement of the clinical team from one hospital location to another.
18	**The timing of protocol activation and termination shall be recorded in the patient's chart.** Documentation of the activation and termination times must be recorded in the patient chart in the format specified by the local institutional policy. This could be documented by hand or electronically in the nursing or physician notes or in the electronic computerized physician ordering system. These times are necessary during the review of the patient chart for the purposes of quality improvement.

19	**Patients and/or their Substitute Decision Maker for whom the massive hemorrhage protocol was activated should be informed. Actual (e.g., transfusion-associated circulatory overload, hyperkalemia, etc.) and potential adverse effects should be disclosed. Furthermore, women of childbearing potential should be informed of the risk of red blood cell alloimmunization.** At the earliest possible opportunity, the most responsible physician (or delegate) must have a conversation with the patient and/or their substitute decision maker regarding why the MHP was activated, the number and types of components transfused, the transfusion complications observed, and the potential long-term consequences of transfusion. Informed consent for transfusion should be obtained as per local hospital policy. Patients have variable perceptions related to transfusion risks[55] and accurate communication of the potential risks is important to achieve patient-centered care. Individuals of childbearing potential should be informed of the risk of red cell alloimmunization that may result in hemolytic disease of the fetus and newborn and should be counseled to undergo red blood cell antibody screening at 6 weeks and/or 6 months post-transfusion (many antibodies are evanescent and there is a brief window for detection).[56]
20	**The collection and testing of the group and screen sample shall be prioritized in the protocol to mitigate the impact on group O red blood cells and AB plasma stocks.** Both group O RBCs and AB plasma are in chronic short supply in Canada. The proportion of group O RBCs transfused to non-group O recipients is increasing, with trauma accounting for 10% of this pressure on group O blood stocks.[57] The vast majority of AB plasma units are transfused to non-AB recipients.[58] Given the pressure on AB plasma stocks, it has not been possible to provide male-only AB plasma for all recipients with resultant cases of transfusion-related acute lung injury from female AB plasma.[59] Hence, the draw of the group and screen sample, rapid transport of the sample to the laboratory, and testing of the sample should be prioritized.
21	**Laboratory testing should be done at baseline and at a minimum hourly until the protocol is terminated**. See rationale below for statement 22.
22	**The recommended minimum laboratory testing (where the test is available) at each blood draw should be: CBC, INR, activated partial thromboplastin time (aPTT; baseline only), fibrinogen, electrolytes, calcium (ionized), blood gas (pH and base excess) and lactate.** Baseline laboratory testing is prognostic,[60] identifies patients on oral anticoagulant medications in need of reversal, and directs immediate need for components in excess of the base ratio of RBCs to plasma. Although the proposed MHP includes the use of early ratio-based resuscitation for plasma prior to availability of laboratory test results of coagulation, this does not guarantee that coagulopathy will be prevented and raises the risk of over-transfusion of unnecessary blood components. Laboratory confirmation of adequate hemostatic resuscitation is required at least hourly. Current guidelines recommend early and repeated measures of hematology and coagulation parameters.[21] The measurement of the aPTT is only recommended at baseline to detect anticoagulant effect of certain anticoagulants (e.g., dabigatran) and preexisting bleeding disorders (e.g., hemophilia). If the baseline INR and aPTT are correlated then further aPTT measures are not indicated and may in fact delay release of the other coagulation test results.[61] The magnitude of the elevation of the PTT in postpartum hemorrhage is associated with worse outcomes; however, there is considerable overlap and minimal difference between outcome groups to be clinically useful.[27] Transitioning from blind ratio based component therapy to one based on either conventional laboratory testing or point of care viscoelastic testing has the potential to minimize unnecessary transfusions and allow for targeted component therapy.[31] Biochemical tests (e.g., potassium, calcium, and pH) may indicate potential complications from massive transfusion or inadequate resuscitation of hemorrhagic shock. Lactate measurements are also predictive of mortality, although the role of serial measurements in improving patient outcomes has not been confirmed in clinical trials.[62]

23	**The protocol should state the minimum laboratory protocol resuscitation targets for transfusion: (1) hemoglobin>80 g/L (RBC); (2) INR<1.8 (plasma or prothrombin complex concentrates); (3) Fibrinogen>1.5 g/L (cryoprecipitate or fibrinogen concentrates); (4) platelets > 50 x10^9/L; (5) ionized calcium >1.15 mmol/L. Relevant transfusion targets can also be used if viscoelastic testing is performed.** As there are no prospective studies evaluating laboratory resuscitation targets in the setting of massive bleeding, the suggested laboratory targets are based on the consensus opinion of the panelists and are concordant with the published literature.[21,63] These are minimum targets to be maintained throughout the resuscitation and are not meant to be overly prescriptive (i.e., restricting blood component issue based on the above values). Certain pediatric populations, such as neonates, patients with congenital heart disease, receiving extracorporeal life support, or in severe respiratory distress may require higher thresholds for RBC transfusion during an MHP.[33-35]
24	All massively bleeding patients should have a temperature measured within 15 minutes of arrival or **protocol activation and then at a minimum of every 30 minutes (or continuously where available) until the protocol is terminated.** See rationale below for statement 26.
25	**All patients should receive interventions to prevent hypothermia and achieve normothermia (≥36°C).** See rationale below for statement 26.
26	**All patients should receive warmed intravenous fluids, red blood cells and plasma to avoid hypothermia.** In both traumatic injury and postpartum hemorrhage, temperature monitoring is infrequently performed and when measured, hypothermia is common.[64,65] Hypothermia in traumatic injury is associated with worse outcomes,[66,67] although prospective trials have not confirmed whether aggressive warming protocols would alter outcomes.[68] Mild hypothermia is associated with a 22% increase in the risk of transfusion.[69] Warming of patients improves their comfort and therefore even in the absence of a confirmed survival benefit it should be a core part of every MHP.[70]
27	**Red blood cells should be delivered in a validated container to prevent wastage.** RBCs are a valuable resource requiring strategies to reduce wastage during transport to and storage at the patient bedside. Numerous investigators have validated that wastage can be mitigated with appropriate temperature controlled devices with resultant substantial cost savings.[71,72] At large academic centres with frequent MHP activation, all components should be transported in validated containers to mitigate component wastage.
28	**The MHP protocol should ensure there are processes in place to ensure an uninterrupted supply of blood components to the bedside.** The local MHP should include processes to ensure an uninterrupted supply of blood components to the bedside until termination. Specifically, the next cooler should be brought to the patient location before the previous cooler is empty. This will minimize the risk of lacking necessary blood components during the resuscitation. The person assigned to maintain the uninterrupted supply of blood components should be specified in the protocol. The procedure for requesting the next set of blood components should be stated in the protocol, easy to perform in the setting of massive hemorrhage, and designed with the intention of preventing wrong patient transfusion errors. The delivery of blood components to the bedside should not be equated with an order for transfusion.

29	**If the blood group is unknown, O Rh D-negative red blood cells should only be used for female patients of childbearing potential (age<45).** O Rh D-negative stocks are insufficient to allow all patients of unknown blood group to be supported with O Rh D-negative RBCs until the blood group is resulted in the laboratory information system. The risk of alloimmunization in an Rh D-negative patient after exposure to Rh D-positive RBCs in the setting of major bleeding is 20%.[73,74] Immunization to the D-antigen is only relevant for females who wish to have future pregnancies. Over 99% of births occur in women under the age of 45 years,[75] and hospital MHPs should restrict the use of O Rh D-negative RBCs for women under this age. For conscious women, efforts should be made to determine their age early in the course of care so that the transfusion medicine service can be instructed to supply the optimal Rh D-type of blood. The risk of immunization from Rh D-positive platelets is 1% and therefore Rh-immunoglobulin should only be provided to Rh D-negative women under the age of 45 (after transfer to the intensive care unit but within 72 hours of the Rh D-incompatible platelet transfusion).[76]
30	**Uncrossmatched red blood cells shall be available at the bedside within 10 minutes of MHP activation.** See rationale below for statement 31.
31	**In bleeding patients in need of red blood cell transfusion, uncrossmatched red blood cells should be transfused until crossmatch compatible red blood cells are available.** In retrospective analyses in trauma resuscitation, faster time to delivery of the first pack of RBCs is associated with superior survival (every 1 minute delay to the first pack was associated with a 5% increase in the odds of mortality).[44] Collection of the group and screen sample, transport of the sample to the laboratory, centrifugation of the sample, testing and result release into the laboratory information system require approximately 70-90 minutes. Therefore, following MHP activation, it is not appropriate to wait for crossmatch-compatible RBCs. The transfusion laboratory must have a protocol and process for the immediate release of uncrossmatched RBCs. In severe traumatic injury, where communication from the pre-hospital emergency services suggests the patient will need immediate transfusion due to hemodynamic instability and severe injury, it is appropriate to order RBCs to the emergency department in advance of patient arrival.
32	**There is no threshold of units of group O red blood cells above which a switch to group specific red blood cells is prohibited. The switch to group specific red blood cells and plasma should be done as soon as possible.** Each unit of RBCs in Canada is produced with a minimal amount of residual plasma (less than 30 mL per unit) and therefore even after 10 to 20 units of group O RBCs the amount of incompatible plasma is trivial and does not preclude a transition to group specific RBCs.
33	**The protocol shall state the reversal strategy for commonly used oral anticoagulants.** The MHP protocol shall include a table with all approved anticoagulant therapies and their appropriate reversal strategy, including the dosage(s) of the therapies to be administered.

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The initial management of the rapidly bleeding patient that precludes the use of laboratory-guided transfusion should begin with immediate red blood cell (RBC) transfusion and then transfusions at a RBC:plasma ratio of 2:1. Two prospective randomized trials have failed to confirm a survival benefit of a RBC: plasma ratio of 1:1 (compared to 2:1).[77,78] A large retrospective review of experience before and after implementation of 1:1 resuscitation failed to find a mortality benefit.[79] The Canadian consensus conference on massive transfusion recommended a ratio of 2:1 (RBC:plasma) followed by transition to laboratory-guided blood component administration as soon as possible.[80] The standard approach outlined below, and based on expert consensus, is applicable to most large adult hospitals. No blood components should be transfused without a clear order and specified infusion rate from the team leader or delegate. Simplified options are provided for institutions that do not stock plasma, platelets and/or cryoprecipitate (or are unable to provide the components in a rapid manner due to limited numbers of personnel or lack of thawing devices), or that cannot provide definitive surgical or radiological care, and the goal is to stabilize in preparation for transport out by land or air ambulance. Pediatric institutions should develop age and weight based MHP component protocols to ensure that blood components and fractionated coagulation factors are delivered in appropriate ratios. In institutions that care for pediatric patients, the transfusion boxes must come with clear instructions for the clinical team to mitigate the risk of over- or under-transfusion.

Standard approach	Simplified options for smaller organizations
Box 1 should contain 4 RBC.	No modification required.
Box 2 should contain 4 RBC, 4 plasma.	Box 2 (where plasma **not** stocked in hospital transfusion laboratory) should contain 4 RBC, 2000 IU PCC, and 4 grams Fibrinogen Concentrate. Efforts should be made to transfer the bleeding patient to a centre capable of definitive hemorrhage control.
Box 3* should contain 4 RBC, 2 plasma, and fibrinogen replacement (10 units Cryoprecipitate or 4 grams Fibrinogen concentrate).	As above.
Platelets, when stocked in the hospital transfusion laboratory, should be transfused based on the platelet count.	Platelets, when **not** stocked in the hospital transfusion laboratory, should be ordered in for transfusion (if patient cannot be promptly transferred out). If patient is transferred before platelets transfused, this should be communicated to the receiving hospital.

* Few patients will require more than 12 RBCs due to an acute hemorrhage. By 12 units of RBCs, transfusion decisions for plasma and fibrinogen replacement should be made based on the hourly measurement of the INR and the fibrinogen levels and orders communicated promptly to the blood bank.

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Recombinant factor VIIa (rVIIa) should only be considered when massive hemorrhage is refractory to surgical hemostasis, medical optimization of coagulation parameters, acidosis, and hypocalcemia, and used in consultation with an expert in the management of coagulopathy in the massively bleeding patient. Recombinant activated factor VIIa (rVIIa) has not been shown to improve mortality in prospective, randomized controlled trials. [81,82] In contrast, rVIIa is associated with an increase in thromboembolic complications.[82] Given the concerns regarding lack of efficacy and potential risks, all other lower risk hemostatic therapies should be exhausted and it should only be used in consultation with an expert in the management of coagulopathy of the massively bleeding patient.

36	**Fibrinogen concentrate 4 grams (equivalent to approximately 10 U of cryoprecipitate) can be used as a reasonable alternative to cryoprecipitate for fibrinogen replacement.** Cryoprecipitate in Canada is provided as individual units that must be thawed, reconstituted with saline and then pooled. This takes approximately 30-45 minutes of technologist's time and may compete with their ability to perform laboratory testing or prepare other components. The product can only be kept for one year after donation. It must be transported frozen at all times. Once thawed and pooled it expires after 4 hours. Given the time intensive preparation requirements and limited shelf-life, it is reasonable for some hospitals to transition to pathogen-reduced fibrinogen concentrates. There are no large randomized controlled trials of cryoprecipitate and fibrinogen concentrates to determine equivalence, although a large trial in cardiac surgery related hemorrhage is ongoing (FIBRES Study, NCT03037424).[83] For pediatric patients a dose of approximately 50 mg/kg of fibrinogen concentrate up to a maximum of 4 grams is suggested.[84]
37	**At institutions lacking sufficient resources to issue plasma (e.g., no thawing device or no plasma stocked in inventory), Prothrombin Complex Concentrates (PCC) 2000 IU can be substituted for coagulation factor replacement. Fibrinogen replacement should be given concurrently with PCCs unless the fibrinogen level is known to be ≥1.5g/L.** Similar to the challenges with cryoprecipitate, some smaller organizations may have challenges in providing plasma during an MHP (no thawing device or not stocked in the laboratory due to rarity of use). In these situations, a reasonable option is to transfuse PCCs and fibrinogen concentrates. This is a common strategy employed in many European countries and outcomes appear to be similar to a plasma resuscitation strategy in trauma, usually guided by viscoelastic point-of-care testing.[85] This strategy should be seen as a bridge prior to transport to an institution capable of definitive surgical management and more complete transfusion support. For pediatric patients a dose of 25 IU/kg of PCCs (rounded to the closest 500 IU) up to a maximum of 2000 units is suggested.[86,87]
38	**Patient and product identification pre-transfusion bedside check shall be performed prior to transfusion of any component to avoid mistransfusion.** Transfusion-related errors remain common in the emergency department.[88,89] Under no circumstances can the patient and product identification pre-transfusion bedside check be aborted, especially in mass casualty scenarios where there may be multiple patients receiving blood components simultaneously.
39	**Patient demographics shall not be updated/changed until after termination of the protocol. Once MHP is terminated, patient demographics should be updated as soon as possible.** Patients admitted during major hemorrhage or after traumatic injury are frequently registered with a temporary name and number (e.g., Unidentified, Andrew) or with an incomplete registration (e.g., no date of birth). Modifications to key identifiers during active resuscitation may delay the issue of blood components from the transfusion service or may result in an erroneous incompatibility detected at the pre-transfusion bedside check. The update of the patient identification should be delayed until the patient has stabilized and with coordination between the nursing team and the transfusion medicine laboratory to ensure no gaps in release of laboratory test results or transfusion support.

40	**Tranexamic acid should be administered as soon as intravenous or intraosseous access is achieved but within 3-hours from time of injury or within 3-hours from MHP activation in all other patients.** Tranexamic acid improves mortality in the setting of trauma[90] and postpartum hemorrhage.[91] It is most effective when given immediately, with the survival benefit decreasing by 10% for every 15 minute delay in administration and with no benefit after 3 hours from injury/onset of bleeding.[92] There is no increased risk of venous or arterial thromboembolic complications.[93] Dosages and infusion rates vary depending on the study protocol (1 gram bolus plus 1 gram infusion over 8 hours,[90] 1 gram bolus and 1 gram bolus repeated at 1 hour,[94] 1 gram bolus and repeated if ongoing bleeding at 30 minutes or greater[91], 2 gram bolus at the scene of the injury [Rowell SE, et al, 2020]). Dosage and infusion rate should be determined by the local institution. Simplification may be needed in more resource-challenged locations and a single 2 gram bolus may be preferred. Evidence for tranexamic acid is currently limited in pediatric trauma, but it is accepted practice for use in pediatric trauma patients requiring transfusion within the same time parameters as adults. For pediatric patients the initial bolus of tranexamic acid can be dosed at 15 mg/kg up to a maximum of 1 gram and additional doses/infusion based on local policy.[95,96] The role of tranexamic acid in gastrointestinal bleeding has not been confirmed; a large multicenter trial is underway (HALT-IT Trial Collaborators, 2020) to determine if tranexamic acid assists with hemostasis and reduces transfusion or mortality rates.[97] Tranexamic acid should be readily available in clinical areas where massive hemorrhage is common to prevent delays in administration.
41	**MHP activations should be reviewed by a multidisciplinary committee for quality assurance.** Compliance with MHPs is poor during the resuscitation of a critically ill patient who has multiple competing priorities.[11,15] Implementation of an MHP is just the first step to improving the care of massively bleeding patients; training, simulations, check-lists, audit and feedback are needed to achieve high levels of performance. At a minimum, the quality metrics listed in statement 42 should be tracked on consecutive MHP activations by a multidisciplinary team with feedback to the frontline staff at regular intervals.
42	The following quality metrics should be tracked on all activations of the protocol and the data reviewed quarterly at the hospital transfusion committee and the Medical Advisory Committee:

	Quality metric	Local Reporting	Provincial Reporting
Q1	The proportion of patients receiving tranexamic acid within 1 hour of protocol activation.	X	X
Q2	The proportion of patients in whom RBC transfusion is initiated within 15 minutes of protocol activation.	X	X
Q3	The proportion of patients (of patients requiring transfer for definitive care) with initiation of call for transfer within 60 minutes of protocol activation.	X	
Q4	The proportion of patients achieving a temperature >35°C at termination of the protocol.	X	
Q5	The proportion of patients with hemoglobin levels maintained between 60-110 g/L during protocol activation, excluding certain pediatric populations (e.g., neonates) that may require higher hemoglobin values.	X	
Q6	The proportion of patients transitioned to group specific RBCs and plasma within 90 minutes of arrival/onset of hemorrhage.	X	X
Q7	The proportion of patients with appropriate activation (>6 RBC units in first 24 hours; >40 ml/kg/24 hours of RBCs in pediatric patients) or before this level in patients dying due to hemorrhage within 24 hours.	X	
Q8	The proportion of patients without any blood component wastage (including plasma that is thawed and not used within the 5 day limit on another patient).	X	

5.0 PATIENT TRANSPORT

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The Patient Transport section will address the following recommendation statement: The transport service(s) should be promptly notified if the decision is made to transfer the patient to another hospital for definitive hemorrhage control. If required, the patient should be transferred as soon as and as safely as possible by appropriate staff and transport resources, to an institution where definitive hemorrhage control can be performed (Statement number 10).

This section will include additional information regarding: (1) Facilitation of Early Transfer (2) Patient Information Needed for Safe Handover (3) Patient Preparation (4) Transfusion Medicine.

5.1 Facilitation of Early Transfer

The transport medicine environment is challenging. To carry out the transport safely, the patient may need interventions prior to transport that would not be performed if the patient was not transported out to another hospital.

Can the patient receive definitive hemorrhage control in current facility?

If not:

1. Consider need for immediate transfer to definitive care setting
2. If transfer required, initiate request for transfer (CritiCall 1-800-668-4357). Refer to Adult Appendix H.

To minimize the time the transport crew needs to prepare the patient for transport, please consider the following before the crew arrives:

1. Patient information
2. Patient preparation
3. Will blood components / products be necessary during patient transport?

If yes, contact the Transfusion Medicine Laboratory (TML) of sending facility immediately to have the blood components / products prepared.

Note: a dedicated transport team or transport personnel may not always be available to transport the patient.

5.2 Patient information

Have clinician available to communicate pertinent details to the dispatcher, transport physician or crew and answer further questions as required.

Physician to physician communication is often helpful, and Ornge has Transport Medicine Physician (TMP) for this purpose (if being transported by Ornge).

Communication by the sending physician:

- Determine care required in transport
- Communicate directly with receiving physician
- Ensure patient is optimized for transfer
- Make copies of all documentation for the transport crew to bring to the receiving hospital.

Communication with the receiving physician:

- Accept patient, ensure receiving facility can accommodate patient
- Provide advice if requested or necessary
- Notify relevant services - Admitting, Emergency Department (ED), Operating Room (OR), Diagnostic Imaging (DI), Intensive Care Unit (ICU), TML of patient's anticipated time of arrival.

Refer to MHP Checklist/Handover tool in Adult Appendix C and Pediatric Appendix E.

Note: there are space limitations in the transport vehicle that may preclude taking more than one box of blood

5.3 Patient Preparation

To minimize the time the transport crew spends preparing the patient for transport, a number of things can be done prior to the crew's arrival.

Consider the following as you prepare your patient for transport:

- Secure airway if compromised oxygenation / ventilation, or altered level of consciousness
- Recent arterial blood gas if mechanically ventilated
- Good intravenous access (≥2 large bore peripheral IVs)
- Consider a central and / or arterial line
- Insert urinary catheter and / or gastric tube if indicated
- Adequate supply of blood and blood products packaged for transport
- Spinal motion restrictions if concerned
- Splint extremity fractures if present
- Prevent inadvertent hypothermia: monitor temperature q30minutes
- Warm blankets, change q30minutes and immediately before handover to Emergency Medical Services (EMS)

5.4 Transfusion Medicine Laboratory

The TML of the sending hospital should notify TML of the Receiving hospital of the MHP and any pertinent patient information. If blood components / products are necessary during patient transport ensure they are packaged and documented properly to ensure continuation of traceability.

Shipment of Blood Components/Products Accompanying a Patient

Interhospital Transfer Form - Blood Components/Products Accompanying a Patient

Pediatric

Any pediatric MHP activation or risk of activation in a non-definitive hospital care setting requires contact with specialized services (e.g., CritiCall in the province of Ontario) to provide care guidance and facilitate transfer to a pediatric definitive hospital care setting as soon as possible. For more information please refer to pediatric section 15.0 and associated learning aids (CritiCall "Cheat Sheet" and inter-hospital patient handover tool) located in the Adult appendices.

PREPARING THE MHP PATIENT FOR TRANSPORT

To carry out transport safely, the patient may require interventions prior to transport. To minimize time the transport crew needs to prepare the patient for transport, please consider preparing or carrying out the following items before the crew arrives:

Pre-Transport Checklist

Action	Initials
Patient information	
☐ Incident history and relevant past medical history	
☐ Medications and allergies	
☐ Treatment and response to treatment	
☐ Equipment, ongoing infusions and therapies required during transport	
☐ Recent vital signs and pertinent physical findings	
☐ 12-lead ECGs (when pertinent)	
☐ Lab test results	
☐ Diagnostic imaging results – crew may wish to view images	
☐ Resuscitation status: DNR or advanced directives	
☐ Complete and copy documentation for products transfused and accompanying patient ☐ TXA _____ grams ☐ Number of blood components transfused ___ RBCs ___ FP ___ Plts ___ Grams of Fibrinogen concentrate ___ IU of PCC ☐ Total IV crystalloid and/or colloid and urine output ☐ Temperature * refer to MHP Checklist/Handover Tool in appendices ** Note: space limitations in the transport vehicle may preclude taking more than one box of blood	
Patient Preparation	
☐ Secure airway if compromised oxygenation / ventilation, or altered level of consciousness	
☐ Recent arterial blood gas if mechanically ventilated	
☐ Good intravenous access (≥2 large bore peripheral IVs)	
☐ Consider a central and / or arterial line	
☐ Insert urinary catheter and / or gastric tube if indicated	
☐ Adequate supply of blood products packaged for transport	
☐ Spinal motion restrictions if concerned	
☐ Splint extremity fractures if present	
☐ Prevent inadvertent hypothermia: monitor temperature q30 minutes Warm blankets change q30 and immediately before handover to EMS	

MHP Patient Transport

Pre-hospital, Pre-activation

- Consider notifying Transfusion Service of need for blood components if patient meets MHP activation criteria

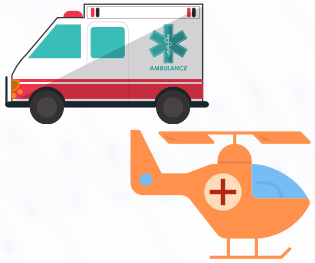
MHP Activation

- Follow algorithm for hospital size to activate MHP
- Can definitive hemorrhage control be achieved at current hospital site?
- If not, consider need for immediate transfer to definitive care setting
- Initiate call for transfer

Initiate request CritiCall Ontario

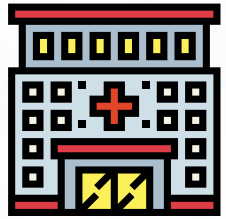
1-800-668-4357 (HELP)

- CritiCall will gather information and connect sending facility staff with appropriate transport agency
- Inform Transfusion Service to package blood components for transport



Transport Patient

- Transport by land or air may involve local paramedic/ambulance service or Ornge
- Continue MHP during transport if within the scope of practice of the transport team
- Maintain original packaging of blood components to avoid wastage



Definitive care hospital setting

- Transfusion Service of sending hospital should communicate with Transfusion Service of receiving hospital - pertinent patient information
- Return unused blood components to Transfusion Service at receiving hospital

WHEN TO TRANSFER THE MASSIVELY BLEEDING PATIENT

Patient experiencing or at high risk of massive hemorrhage

1. Poor BP response to fluids
2. Obvious bleeding
3. Hypotension

Or use local activation criteria

CAN YOUR FACILITY ACHIEVE HEMOSTASIS ?

ACHIEVE SOURCE CONTROL

By any of the following:

- Caesarean Deliveries
- Laparotomy
- Treatment of Open Fractures
- Vascular Emergencies
- Esophageal, Gastric, Uterine and Aortic Balloon Tamponade
- Tourniquets and Pelvic Binders
- Hemostatic Gauze

STOCK REQUIRED BLOOD AND BLOOD PRODUCTS

Know your blood and blood product inventory

Consumption of blood products outpaces ability to restock inventory (from nearby hospital or CBS)

LABORATORY TESTING TO MONITOR HEMOSTASIS

Does your facility routinely test for:

CBC
INR
aPTT *(at baseline only)*
Fibrinogen,
Electrolytes,
Calcium *(ionized)*,
Arterial or Venous blood gas *(pH and base excess)*
Lactate

If No Then:

TRANSFER PATIENT IMMEDIATELY TO A FACILITY THAT CAN

IF TIMELY TRANSFER NOT AVAILABLE THEN CONTACT YOUR LABORATORY TO ORDER BLOOD AND BLOOD PRODUCTS FROM NEARBY HOSPITAL OR CBS (WHICHEVER IS QUICKER) UNTIL TRANSFER AVAILABLE

6.0 DAMAGE CONTROL RESUSCITATION

Andrew Beckett (Chair), Neill Adhikari, Rohan D'Souza, Luis Da Luz, Avery Nathens, Troy Thompson

The damage control resuscitation (DCR) section will address the following recommendation statement: The Protocol shall incorporate the principles of damage control resuscitation, specifically giving highest priority to treating the source of hemorrhage (Statement number 3).

6.1 DCR Definition

DCR principles in traumatic injury include abbreviated surgical and/or endovascular interventions for hemorrhage control and management of intra-abdominal contamination, with definitive surgical repair delayed until stabilization and hemostatic control have been achieved.

- In addition, DCR includes critical care support to correct deranged physiologic measures (hypothermia, acidosis, and coagulopathy).
- Furthermore**,** DCR is generally accepted as a complementary strategy usually accompanying Damage Control Surgery (DCS). DCS focuses on surgical interventions to address life-threatening hemorrhage and delays all other surgical care until metabolic and physiologic derangements have been treated.[1]

6.2 DCR Goals

The principal goal of DCR is to restore hemostasis, prevent or mitigate the development of tissue hypoxia, oxygen debt and burden of shock, as well as coagulopathy. More specifically, DCR prevents 'blood failure', with a goal of restoring blood functionality (improving oxygen delivery and tissue perfusion, reducing acidosis, preventing fibrinolysis, reducing coagulopathy, protecting the endothelium, and reducing platelet dysfunction).[2]

6.3 DCR Components

DCR consists of the following elements:

1. Compressible hemorrhage control (tourniquets, dressings, and closure of scalp wounds);
2. Early administration of anti-fibrinolytic therapy (TXA);
3. Rapid surgical or angiographic control of non-compressible (torso) or junctional (neck, axilla, or groin) hemorrhage;
4. Avoidance of the overuse of crystalloid and colloids;
5. Prevention or correction of acidosis, hypothermia, and hypocalcemia; and
6. Hemostatic resuscitation (early blood and blood products) with minimum ratio of 2:1 of RBC:plasma.

6.4 Patient Selection

The two most commonly used scores validated in the trauma setting, used to predict massive transfusion, and help the clinician decision on activation of the MHP are the Shock Index (SI) (blood pressure divided by heart rate) and the ABC (Assessment of Blood Consumption) score (one point each for penetrating injury, blood pressure <90 mmHg, heart rate >120 and a positive FAST [Focused Assessment with Sonography for Trauma]), with the shock index performing slightly better in trauma. New data suggest that resuscitation intensity of >4 units of fluid within the first 30 minutes may represent an important alternative metric to identify patients who require MHP activation (1 unit of fluid is defined as any of 1 U RBC, 1 U FP, 500 mL colloid, or 1L crystalloid). In addition, retrospective studies suggest that delays in initial blood component administration is associated with worse outcomes (each 1 minute delay to the arrival of the first pack of blood components is associated with a 5% increase in the risk of death). In contrast, over-activation (i.e., MHP activation that is ultimately not required) may lead to unnecessary transfusion, wastage of blood components, and

diversion of human resources away from competing needs. Despite concern that appropriate and timely activation are critical, there are no criteria with both high sensitivity and specificity for predicting the need for massive transfusion.

6.5 Ratio-Driven Component Resuscitation

The initial management of the rapidly bleeding patient that precludes the use of laboratory-guided transfusion should begin with immediate RBC transfusion and then transfusions at a RBC:plasma ratio of 2:1.

- Two prospective randomized trials have failed to confirm a survival benefit of a higher ratio of 1:1 (compared to 2:1).[3, 4]
- A large retrospective review of experience before and after implementation of 1:1 resuscitation failed to find a mortality benefit.[5]
- The Canadian consensus conference on massive transfusion recommended a ratio of 2:1 followed by transition to laboratory-guided blood component administration as soon as possible.[6]
- No blood components should be transfused without a clear order and specified infusion rate from the team leader or delegate.

6.6 Importance of Early Hemorrhage Control

The highest priority should be given to controlling the source of hemorrhage. Ongoing hemorrhage leads to worsening coagulopathy and other physiologic derangements. Although the role of DCR outside of traumatic injury is unknown, prompt hemorrhage control is likely to be an important component of care.

6.7 Importance of Preventing and Correcting Hypothermia

All massively bleeding patients should have a temperature measured within 15 minutes of arrival or protocol activation and then at a minimum of every 30 minutes (or continuously where available) until the protocol is terminated.

- All patients should receive interventions to prevent hypothermia and achieve normothermia.
- All patients should receive warmed intravenous fluids and blood to avoid hypothermia. In both traumatic injury and postpartum hemorrhage, temperature monitoring is infrequently performed and when measured, hypothermia is common.

Hypothermia in traumatic injury is associated with worse outcomes, although prospective trials have not confirmed whether aggressive warming protocols would alter outcomes. Mild hypothermia (1°C drop in temperature) is associated with a 22% increase in the risk of transfusion. Warming of patients improves their comfort and therefore even in the absence of a confirmed survival benefit it should be a core part of every MHP.

6.8 Adjuncts to Damage Control Resuscitation

Prevent further hemorrhage with direct pressure, topical hemostatic dressings, and/or tourniquets, if possible, to minimize the risk of shock. Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) can be highly effective if rapidly implemented by skilled and designated teams. Another important adjunct to treat hyperfibrinolysis in severely bleeding patients is TXA, which should be administered as soon as intravenous or intraosseous access is achieved but always within 3 hours from the time of injury or within 3 hours from MHP activation in all other patients.

TXA improves mortality in the setting of trauma and postpartum hemorrhage. It is most effective when given immediately, with the survival benefit decreasing by 10% for every 15 minute delay in administration and with no benefit after 3 hours from injury onset of bleeding. There is no increased risk of venous or arterial thromboembolic complications. Dosages and infusion rates vary depending on the study protocol (1 gram bolus plus 1 gram infusion over

8 hours,1 gram bolus and 1 gram bolus repeated at 1 hour, 1 gram bolus and repeated if ongoing bleeding at 30 minutes or greater, 2 gram bolus at the scene of the injury).[4] Due to lack of benefit and potential evidence of harm, universal TXA administration to patients with massive gastrointestinal bleeding cannot be recommended[7]. In these cases, decision to give TXA should be made by the clinical team on a case by case basis, after careful consideration of risks and benefits.

6.9 Damage Control Surgery (DCS)

DCS can be defined as abbreviated surgery for hemorrhage and contamination control. DCS, which aims to restore homeostasis by the rapid control of hemorrhage and contamination, should be conducted emergently in patients who are undergoing DCR. Definitive repair is deferred until the patient is euthermic and coagulopathy has been corrected.[2]

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6. Dzik WH, Blajchman MA, Fergusson D, et al. (2011) Clinical review: Canadian National Advisory Committee on Blood and Blood Products — Massive Transfusion Consensus Conference 2011: report of the panel. Crit Care 15:242.
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7.0 MULTI-DISCIPLINARY STAFF TEAM

Josée Theriault (Chair), Suzanne Beno, Kevin Berger, Denise Evanovitch, Renée Fillier, T. Dorien Ruijs, Rardi Van Heest, Margaret Zurke

The Teams section will address the following recommendation statements: 2,4,8,13-15,17 and 38 with emphasis on statement #13 that states the protocol shall specify the team members required to respond when the protocol is activated.

7.1 Team Members and Roles

7.1.1 Team Leader (Lead Clinician)

The team leader may vary according to the institution's resources and population served.

Team leader oversees resuscitation efforts during the MHP. The team Leader is the person most experienced with MHP and may not be directly involved in the patient's care prior to MHP initiation. To improve team performance, team leader may delegate specific MHP tasks to another qualified individual.

Examples include Trauma Team Leader (TTL), ED Physician, Surgeon, Intensivist, Pediatrician, Nurse Practitioner, Fellow

7.1.2 Nurse Leader

A nurse with the most experience in managing critically ill patients, not necessarily a nurse assigned to that patient. Tasks include: communicates results of laboratory tests hourly, ensures a continuous supply of blood at the bedside, informs team leader what components/products have been transfused, instructs designated porter when to pick up components/products, ensures patients temperature is measured every 30 minutes and ensures appropriate charting is done.

Examples include Intensive Care Unit (ICU), Critical Care Response Team (CCRT), Operating Room (OR) or Emergency Department (ED) trained nurse who has received additional training on the local MHP.

7.1.3 Other Nurses

Dedicated to the MHP patient, with designated roles (such as charting - recording medications, interventions), according to the level of resources available. Tasks include: Checking of blood and blood products pre-transfusion, draws blood for testing, obtains IV access, sets up and operates level 1 infuser, administers medications and IV fluids, monitors patient including vitals, urinary output etc.

7.1.4 Porter

Designated person for the entire duration of the MHP. The designated porter should report to Laboratory Lead and Nurse Leader or Team Leader.

Tasks include: Transport of blood samples from the patient to the laboratory (or delivery service e.g., OPP). Transport of blood components/products from the laboratory to the patient or delivery service (e.g., OPP). Retrieve warm blankets/ equipment to keep patient warm. Return of all unused blood components/products to laboratory.

7.1.5 Respiratory Therapist

Where a Respiratory Therapist is available, they may help with Point of Care Testing (POCT) and/or arterial line insertion and blood draw. They may also assist with verifying patient information and blood component/product identification

as per hospital policy when the patient is being transfused and assist with managing airway, setting up and adjusting ventilator, setting up rapid infusers and administering blood and blood products.

7.1.6 Communication / Switchboard

Receives the call to activate Code Transfusion / MHP. Provides dedicated paging and/or phone calls to designated MHP Team members and/or overhead announcements to trigger an internal Code Transfusion response. Must have system in place to notify laboratories of MHP activation.

7.1.7 Transfusion Medicine Laboratory / Core Laboratory

Dedicated laboratory person(s) will be identified as leaders to ensure:

a. TML will conduct compatibility testing, prepare, pack into appropriate containers and issue blood products/ components.
    - The Transfusion Leader is dedicated to communicating with the Team or Nurse Leader. Any transfusion challenges will be promptly communicated (e.g., blood or component shortages or positive antibody screening test results). Dedicated communication tools such as specific extensions or cell/portable phones are useful in critical communication.

b. Core Laboratory prioritizes hematology and biochemistry testing for MHP patients, performs tests and communicates all results to the MHP team promptly.

7.1.8 Family Advisor/Chaplain/Spiritual Leader

Dedicated person to assist and provide information and support to the family during the on-going resuscitation.

7.1.9 Security

When the institution feels that a security team member is warranted. For example, difficult cases, pediatrics, distressed family members, assist with transport-elevators, doors, codes and ID scans.

7.1.10 Crisis Plan, Criticall and Transport Services

Where a patient would need urgent transport to a centre for definitive hemorrhage control, a designated person should be assigned for that specific role at the initiation of the protocol. This person should have medical knowledge in order to answer Criticall, Ornge, and/or receiving physician's questions. Establishing contact with Regional Virtual Critical Care services where available is recommended. In some institutions, senior administrators may be involved with calling in extra staff and granting physician privileges, in extenuating circumstances.

7.1.11 IT support (for development, implementation and troubleshooting)

Where IT support is available, they should be part of the team and participate in the creation and implementation of the electronic order sets/documents of the MHP. They should also participate in other electronic aspects and most importantly, streamline all electronic communication between departments to avoid unnecessary order entry and delays.

7.2 Handover between Leaders

When a change in Leader is necessary, there should be a formal handover between Leaders in order to ensure continued protocol adherence.

7.2.1

Patients being cared for in a non-definitive care hospital setting, particularly in small hospitals/rural communities, should initiate early transfer using an MHP-associated standardized handover tool to facilitate patient care and transfer to a definitive care setting. Refer to MHP Checklist / Handover Tools in Adult Appendix E and Pediatric Appendix E to ensure necessary steps taken.

7.3 Team Training

Participating team members should receive formal MHP training and periodic simulation exercises. This training is essential to improve protocol adherence, team communication, leadership, therefore enhancing care delivery and patient outcomes. Training, such as high-fidelity simulation for Crisis Resource Managements skills (e.g., Team communication, situational awareness, leadership, defining roles) and task training (e.g., arterial-line insertion and blood draws, temperature probe insertion, Level 1 infuser, fluid warmer, blood product verification, the protocol algorithm/ check lists) will help to develop a cohesive team leading to patient-centered care, and ultimately improving patient outcomes. Refer to Education section for additional resources on training and simulation exercises.

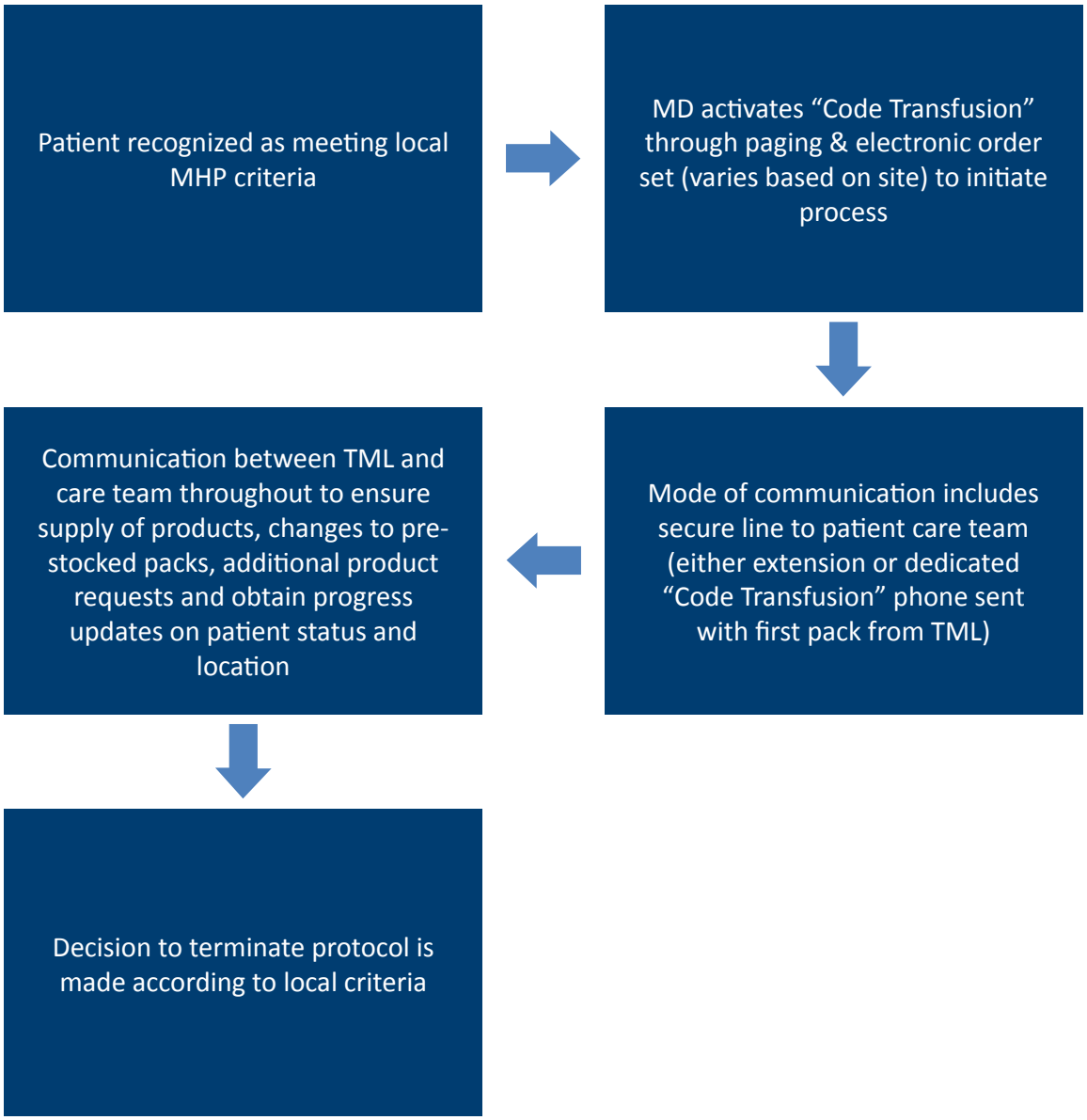
Pediatric

With a few exceptions, considerations for attending interdisciplinary team composition and team lead clinician designation are similar in a pediatric MHP setting compared with the adult population. In a non-definitive care hospital setting the attendance, where possible, of team members with pediatric experience (e.g., consulting pediatrician) and associated technical skill sets (e.g., intravenous/osseous access) who are comfortable with mg or ml/kg medication/blood product dosing is ideal. Early consultation with specialized services is recommended.

8.0 COMMUNICATIONS

Michelle Zeller (Chair), Jancinthe Lampron, Jennifer Lovering, Sarah Magwood, Sheena Scheuermann, Robert Skeate, Susan White

To mitigate confusion and delays in MHP activation due to the existence of several terms across Ontario hospitals, the protocol shall be called "Massive Hemorrhage Protocol (MHP)" and if activated as an overhead page "Code Transfusion". This section outlines the importance of prompt notification of all activations (and terminations) to the Transfusion Medicine and Core Laboratories, prompt notification of all critical laboratory results and coagulation parameters to the clinical team specifically addressing the following recommendation statements: 7, 16-18 and 39.



8.1 Activation

The MHP must be activated by the Team Leader/Lead Clinician

- Call Paging (or switchboard or communication) at extension XXXX
- State: Activate MHP and if overhead announcement "CODE TRANSFUSION"

- Paging (or switchboard or communications) patches through to TML and stays on the line
- Clinical team state patient sex, approximate age (if pediatric, approximate weight) and if patient is on anti-coagulants or antiplatelets
- Clinical team states location

Switchboard personnel will automatically page the Code Transfusion team as a result of the code activation with information on location, sex +/- age [the individuals paged will vary based on each hospital]. Refer to Teams section for complete information.

8.2 Mode of Communication

Notification for TML and the core lab will vary at different hospitals:

- May require electronic order entry, paper or downtime requisition to generate initial blood order set (e.g., Stat Group & Screen, CBC, INR, PTT, Fibrinogen, Electrolytes, Blood Gas, ionized Ca, & Lactate)
- May require electronic order entry, paper or downtime requisition to initiate blood product preparation/delivery
- Mode of communication between lab and clinical side requires secure line to patient care team (either extension or dedicated "Code Transfusion Phone" sent with first pack from TML)
- Porter, if part of the team, will await cooler #1 (and deliver dedicated "Code Transfusion Phone to Nurse" with cooler #1; phone will travel with patient; or communication designate provides extension).

8.3 Content of Communication

- Communication will include reporting of critical laboratory results and important coagulation parameters (hemoglobin, platelet count, INR, fibrinogen) whether critical or not, to enable modification of blood orders as needed.
  - » If a dedicated phone or extension is not available then a direct/accessible means of communication between laboratory and clinical team looking after the patient must be established at onset of code. Communication surrounding blood ordering will differ depending on each hospital setting (electronic vs. paper vs. verbal orders).
- After each cooler the clinical team should reassess if the patient requires additional blood and blood product preparation and delivery and if MHP can be de-activated due to stabilization of the patient.
  - » Empty coolers should be returned to TML as soon as possible. There may be 3 or more coolers in circulation depending on proximity to the TML and local practice. It is advisable to ensure return of empty coolers, and no more than 2 coolers distributed at a given time to prevent full coolers piling up at the bedside and potential for wastage.
- Laboratory investigation is recommended at a minimum of every 60 minutes and the modes of ordering will vary based on hospital (electronic orderset, paper-based orderset).

8.4 Communication Loop

Communication within the team during the code should be via a designated individual (e.g., Clinical Leader, Nurse Leader, nurse recorder, assigned transfusion nurse etc.)

- Identify appropriate individual and notify TML of who that individual is
- Ensure access to phone/dedicated extension
- Individual has knowledge and access to patient status, blood product utilization and is able to communicate critical lab results to the rest of the clinical team

TML to contact TM physician on call/physician covering TM service at a pre-decided threshold of products utilized/ inventory status for advice on Rh-group switching, and for obtaining further product. Make sure the TML assesses need to bring in additional back-up if insufficient staffing to meet patient needs.

TML should contact the clinical side for a status update if no empty coolers have been returned for ~45 minutes to determine if the MHP can be terminated.

Communication to other hospital sites (if transfer needed) and involve sub-specialties, such as interventional radiology (IR).

Communication between TML and CBS is required to:

1. Make sure CBS Distribution is notified in the event of a mass casualty event (multiple traumas) at CBS.
2. TML technologist is required to look at inventory levels (how low can they safely go before needing to bring in inventory?) Green, amber and red phase levels for inventory could be used as a guideline on when to order from CBS and replenish inventory as needed (communication to CBS should indicate MHP ongoing as applicable)
3. Ensure that after MHP termination that the backfilling occurs in an expeditious manner for "replenishment"

8.5 Timing

Communication should occur when there is significant change in patient's status or goals of care, when patient location changes and when MHP is terminated.

8.6 Termination

Decision to de-activate Code Transfusion is made by the Team Leader or delegate:

- By calling XXXX and stating "Code Transfusion and location- cancel as per local policy"
- Switchboard may notify through paging/text that the code is terminated to individuals initially notified of activation.
- All unused blood components/products and shipping containers to be returned to TML as per hospital cooler validation timeline/policy.
- Return of discarded blood product bags and tags as per local policy.
- Refer to section on Patient and Family Support regarding notification of exposure to blood components/products.

Pediatric

Pediatric patient weight and sex should be communicated to the transfusion medicine laboratory as soon as possible after MHP activation. Reported weight determines blood product (RBC and FP) cooler unit content and guides platelet, and factor concentrate dosing. A pediatric ml/kg dosing chart for blood products and factor concentrates will accompany each cooler to avoid inadvertent product under or overdose (see Pediatric Appendix B: pediatric drug and blood product dosing table and Appendix F: Pediatric blood product dosing cooler box labels).

9.0 LABORATORY TESTS

Luis Da Luz (Chair), Sarah Hall, Hina Hanif, Laurie MacLeod, Shuoyan Ning, Rita Selby, Michelle Zeller

The laboratory tests section will address the following recommendation statements: 5, 17, 20 -23.

9.1 Minimum recommended laboratory testing

CBC, INR, activated partial thromboplastin time (aPTT, at baseline only), fibrinogen, electrolytes, calcium (ionized), arterial or venous blood gas (pH and base excess) and lactate, are the minimum recommended tests to be performed **(Statement 22)**.

- Attention needs to be given to specific characteristics of each facility, such as size (tertiary care vs. small vs. community hospitals) and test availability and its turnaround time.
- Smaller hospitals should establish in their site specific MHPs the changes to the above minimum tests, depending on their test availability. For example, fibrinogen may not be available on-site at all Ontario hospitals.
- Clinicians may choose to alter the testing panel depending on the clinical scenario, giving greater importance to specific tests in place of others for different patient populations. For example, in a massive variceal bleed in a patient with end-stage liver failure the clinical team may also order liver function testing.

9.2 Minimum laboratory protocol resuscitation targets

The panel recommends minimum resuscitation targets for transfusion **(Statement 23)**, as follows: (a) hemoglobin>80 g/L (RBC); (b) INR<1.8 (plasma or prothrombin complex concentrates); (c) Fibrinogen>1.5g/L (replaced preferably with fibrinogen concentrate); (d) platelets > 50 $x10^9$/L; (e) ionized calcium >1.15 mmol/L.

- In facilities that use viscoelastic testing, relevant transfusion targets currently published in clinical practice guidelines should be used.
- In neonates on extracorporeal life support or in severe respiratory distress higher thresholds for RBC transfusion may be required if severely bleeding.
- Patients with post-partum hemorrhage or post cardiac surgery may benefit from higher fibrinogen targets (>2.0 g/L).

9.3 Processes for blood sample collection

Facilities should have their sample tubes in situ, pre-organized in bundles, ready for baseline blood testing. It is also recommended that for the subsequent time points (hourly testing), tubes are, again, pre-organized in bundles, properly identified, and easily dispensed, to increase awareness for the next blood withdrawals.

- Each facility should have a process for replacement of sample tubes and management of their inventory. A logical process is to attach sample tube kits to each MHP pack/cooler.

9.4 Minimum frequency of testing

Laboratory testing should be done at baseline and then at minimum hourly until the termination of the protocol, as recommended by the panel **(Statement 21)**.

- Smaller community hospitals where the patient is promptly transferred to a facility for definitive bleeding control may only have baseline blood work performed.
- In addition, different clinical scenarios may require different approaches, such as in Jehovah`s witnesses or anticoagulated patients, for example.

- Clinicians may also decide to do specific testing more frequently than others depending on previous results, rapidity of transfusion, and patient response to the resuscitation process.

9.5 Expected turnaround times

Laboratories are expected to have processes in place to prioritize performing and releasing tests in an MHP scenario. However, other factors in the pre-laboratory period may add to the turnaround time of the MHP panel, such as the time for the blood samples to reach the laboratory. Hospitals should minimize this pre-laboratory time with having dedicated staff to transport blood samples from bedside to the laboratory. A turnaround time of 20 minutes would be ideal for the completion of all tests once the samples arrive in the laboratory. However, each facility will determine their local turnaround time, according to local characteristics such as test menu and staffing levels. Turnaround times should be a focus of quality assurance.

9.6 Communication of results to the treating clinician

Critical laboratory values and all transfusion-related targets (hemoglobin, platelet count, INR, and fibrinogen) should be communicated verbally to the treating clinician as soon as they are available **(Statement 17)**. The release of abnormal results to the clinical team should not be delayed while completing confirmatory testing (e.g., repeats and dilutions for the Clauss fibrinogen). This may impact clinical decisions, which may cause further complications in a patient already experiencing a life-threatening condition. Furthermore, this may mitigate the risks of under- or over-transfusion, and improve time to correction of other coagulation, electrolytic, or metabolic abnormalities.

- Laboratories should release results with a verbal disclaimer that the test result is pending confirmation.
- For patients transferred from smaller facilities for definitive care in larger facilities, baseline test results should be sent with the patient, to the receiving clinical team.

9.7 Prioritization of tests

Group and screen sample testing should be prioritized as recommended by the panel **(Statement 20)** to minimize impact on group O red blood cell and AB plasma stocks. Characteristics of each facility or laboratory, such as staffing or availability of kits, may also influence prioritization of blood sample collection. Furthermore, different clinical scenarios may require specific tests more importantly than others. In these situations, prioritization will be the decision of the treating clinician. The recommendations for MHP state that patients should be switched to ABO group specific red cells as soon as is feasible in order to conserve group O red cells. A second sample must be obtained to confirm the patient's ABO group before non-group O ABO compatible red cells can be issued (CSA Z902 Standard 10.6.1.3).

9.8 Use of viscoelastic testing

Goal-directed therapy based on viscoelastic testing such as thromboelastography (TEG®) and rotational thrombelastometry (ROTEM®) has been used to guide resuscitation of severely bleeding patients, especially in trauma[1,2], cardiac surgery[1-3], post-partum hemorrhage[1-4], and liver transplant[1-5]. In Canada, few large centres use viscoelastic testing to guide transfusion due to logistics and costs. Additionally, transfusion parameters are hard to define and have not been validated in large randomized controlled trials. If capable, facilities should establish their own protocols for using these methods, including their thresholds for transfusion based on current published clinical practice guidelines in viscoelastic testing.

9.9 Special patient populations

As recommended by the panel, a single protocol for all patient populations is preferred to optimize compliance **(Statement 5)**. However, the protocol may be tailored for specific settings for transfusion thresholds and weight-based dosing. For laboratory testing, the following particularities should be considered:

a. **Cardiac surgery patients:** Currently in post-cardiac surgery hemorrhage, there is evidence to support the use of viscoelastic testing as compared to standard laboratory tests in reducing the risk of major bleeding. In this clinical setting, viscoelastic tests should be used if available. Samples should be collected as per each facility guideline on these methods.

b. **Massive obstetrical hemorrhage associated to trauma:** A sample for fibrinogen level testing should be prioritized and collected early in the resuscitation process and repeated at least hourly.

Pediatric

(1) Prioritization of collection of CBC and group/screen testing if there is limitation, with a reminder that they can be performed with capillary samples (microcontainer samples); (2) Each facility should be aware of what types of testing can be bundled up to decrease the volume of blood collected, depending on their devices; (3) A blood glucose test should be added as blood glucose levels are important predictors of outcome in the pediatric population with brain injury. In addition, a magnesium level measure should also be performed, as abnormal results are more common in this population and may exacerbate hypocalcemia; (4) Physicians should be aware of pre-analytical issues with microcontainers and avoid using them for platelet counts. However, for hemoglobin level these samples are usually concordant with vacutainer results; (5) The minimum volume of testing will depend on the type of analyzers and systems at each facility. For neonates a 500µL sample of whole blood, using the gel methodology is the minimum volume required for group and screen. However, other methodologies may require more volume; (6) Avoid intra osseous samples for the pediatric population. If access is an issue, consider capillary samples instead. Of note, intra osseous samples can be used for group and screen.

BLOOD DRAW TOOL

MHP Blood Draw and Testing Protocol									
Lab tests[1]		**Adult**	**Pediatric**	**Baseline**	**#1**	**#2**	**#3**	**#4**	**#5**
INR, aPTT (baseline only), Fibrinogen	Sodium Citrate (Blue)	2.7mL	1.8 mL	x	x	x	x	x	x
ROTEM/TEG	Sodium Citrate (Blue)	2.7 mL	1.8 mL	x	x	x	x	x	x
Na, K, Cl, Mg, Urea	Serum (Red/Gold)	4.5 mL	2.0 mL	x	x	x	x	x	x
Glucose (baseline only)	Serum (Red/Gold)	NA		x	NA	NA	NA	NA	NA
Ionized Calcium[2]	Serum (Gold)	4.5 mL	2.0 mL	x	x	x	x	x	x
Venous Lactate[2]	Lithium Heparin (Green)	4.5 mL	2.0 mL	x	x	x	x	x	x
G&S (baseline only)[3]	EDTA (Pink)	6.0 mL	1.0 mL[4]	x	NA	NA	NA	NA	NA
CBC	EDTA (Lavender)	4.0 mL	1.0 mL	x	x	x	x	x	x
Venous Lactate	Lithium Heparin (Syringe)	-	-	x	x	x	x	x	x
Arterial Lactate	Lithium Heparin (Syringe)	-	-	x	x	x	x	x	x
Blood gas (pH and base excess)	Lithium Heparin (Syringe)	-	-	x	x	x	x	x	x
Ionized Calcium	Lithium Heparin (Syringe)	-	-	x	x	x	x	x	x
Na, K, Cl	Lithium Heparin (Syringe)	-	-	x	x	x	x	x	x

[1]Lab draws appear in appropriate draw order - Sodium Citrate should always be draw n first.

[2]Can be bundled up (i.e., done together with a blood gas sample, if device/analyzer is available).

[3]Follow facility specific policies regarding ABO confirmation and requirement for second specimen.

[4]500uL for neonates

Prioritize samples as per MHP lead and as available at your facility - vacutainer/microtainers may differ depending on facility and patient population.

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10.0 TEMPERATURE CONTROL

Bourke Tillmann (Chair), Asim Alam, Jennifer Lovering, Pablo Perez D'Empaire, Troy Thompson

Accurate temperature monitoring and management is an essential component of a massive hemorrhage protocol. An increase in the core temperature of a hypothermic patient by 1°C is associated with a 10% reduction in red blood cell transfusion requirement.[1] Likewise, hypothermia is associated with increased blood loss and transfusion requirements and is an independent predictor of mortality.[2,3] Moreover, as blood components are stored at temperatures between 2°C and 6°C, massive transfusion of these components can worsen hypothermia.[4] The following section provides details on how to manage the temperature of the actively hemorrhaging patient addressing recommendation statement numbers 24-26 divided into three parts: (1) how to accurately monitor a patient's temperature, (2) techniques to maintain or increase a patient's temperature, and (3) practical tips and the application of these techniques.

10.1 Monitoring

- The gold standard for temperature monitoring is the thermistor of an intravascular pulmonary artery catheter.[5] However, given the technical skills required to place a pulmonary artery catheter and the potential complications associated with its use, we **do not recommend the pulmonary artery catheter** as the standard tool for temperature measurement during massive hemorrhage resuscitation.[6,7]
- We **recommend that patient temperature is measured using either an esophageal, rectal, or bladder thermometer**.[5,7,8,9] The choice of measurement modality should be based on the available hospital resources and clinician familiarity. However, given the discomfort associated with placement of an esophageal probe, it is recommended for use primarily in the intubated patient.
- Peripheral thermometers (including tympanic membrane, temporal artery, axillary, and oral) do not have acceptable accuracy and at extremes of temperature can report measurements up to 2°C higher or lower than actual core temperature.[8-10]
- If one uses a peripheral thermometer, we recommend the use of a tympanic membrane thermometer.[11-14] If a tympanic thermometer is to be used, the ear should be cleaned of wax and the tympanic membrane should be intact to allow for optimal measurement.[10-11]
- It is recommended that devices used to measure temperature be routinely calibrated as per vendor instructions.[5,8]
- Many thermometers are inaccurate at temperatures less than 34°C. Given the concern for hypothermia, a thermometer capable of reading low temperatures should be used to measure core temperature during massive hemorrhage resuscitation.[15]
- There is limited evidence regarding the frequency that temperature should be checked during resuscitation. However, during active warming temperature can change by greater than 3°C per hour.[16] As such it is reasonable to monitor temperature continuously. If continuous monitoring is not possible, we recommend that the patient's temperature be measured within 15 minutes of patient arrival or protocol activation and then at a minimum of every 30 minutes.

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10.2 Methods for patient warming

- We recommend hypothermia prevention and rewarming with multiple methods that include passive external warming, active external rewarming, and active internal rewarming.[1] Prevention of heat loss is essential given the challenges of rewarming patients that are already hypothermic.
- Passive rewarming strategies such as removing wet clothing, increasing room temperature, and applying warm blankets should be used to avoid heat loss. However, none of these interventions are effective in isolation to manage significant hypothermia.[2]
- The use of active rewarming with resistive heating devices can increase thermal comfort and keep stable core temperature in situations in which physical and logistical challenges limit warming methods, including out of hospital and intra-hospital transport.[3,4,5]
- We **recommend the use of forced-air warmers** as one of the active external rewarming methods;[6] the larger the area the blanket covers, the more effective it is. The use of forced-air warmers should be continued in the operating room. Forced-air warmers are safe and easy to use, they limit further heat loss and provide heat to the body.[7] The use of conductive warmer systems is less effective and has higher risk for burns and pressure ulcers.[7]
- We **recommend the routine use of intravenous fluid warmers** to avoid worsening of hypothermia from cold blood and fluid resuscitation. The ideal fluid warmer should be capable of safely delivering components at normothermia at both low and high flow rates.[8] The temperature should be set ideally at 41.5°C to effectively avoid hypothermia[3] but not higher than 43°C to avoid the risk of hemolysis and air embolism.[9]
- Patients that require intubation and induction of anesthesia have a higher risk for hypothermia.[10,11] Heat loss from the airway is a small but additive factor. We recommend that in addition to the previously mentioned strategies, heat and moisture exchange (HME) filters are utilized to reduce evaporative heat loss from the airways.[2]
- Patients with temperatures below 32°C have impaired thermogenesis such that the aforementioned therapies will likely be insufficient to increase their core temperature. If a patient's temperature is below 32°C clinicians should

refer to local guidelines for treatments of severe hypothermia. This degree of hypothermia should prompt the clinician to identify alternative causes aside from massive hemorrhage or transfusion.

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10.3 Practical strategies to apply rewarming techniques

10.3.1 Passive rewarming:

- As soon as is safe remove wet clothing, linens, dressings, and dry the patient thoroughly.[1] Shears can be utilized to cut away clothing.
- Cover the patient with warm blankets.[1,2] Locations in which patients are commonly resuscitated, such as the emergency department or operating room, should have easy access to a warmer in which blankets can be kept.
- When able the patient's head should also be covered (warm towel) to prevent additional heat loss.[1,2]

10.3.2 Active rewarming:

- Healthcare providers who are expected to be involved in acute resuscitations should ensure they are familiar with the location and utilization of the forced-air warmer.[1] Common challenges in using a forced-air warmer include limited access to the patient's core after application, and challenges to ensure the warming blanket stays on the patient.
- Ensure the warming blanket used with the forced air-warmer is in direct contact with the patient.[3]
- Ensure the blanket is placed as per the manufacturer's instructions, this includes ensuring that the perforated side is facing in the correct direction (towards the patient), and the blanket is secured to avoid it blowing off the patient as it inflates.

- When using a forced-air warmer ensure that the hose carrying the warm air from the heater to the patient does not come in direct contact with the patient's skin.[3] Likewise, **do not use the hose to blow warm air directly at the patient**, a practice referred to as "hosing".
- If a fluid circulating blanket is used for patient rewarming place a sheet between the patient and circulating water blanket. [2,4]
- Blood transfusions should be warmed using blood warmer.[2] Given the speed and volume of fluids transfused, if resources allow have two healthcare providers operating the fluid warming device.

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Pediatric

Please refer to section 15.0 and Appendix D regarding specific pediatric considerations and tips for temperature management in children, respectively.

11.0 TRANSFUSION MEDICINE / COAGULATION LABORATORY

Michelle Sholzberg (Chair), Tracy Cameron, Hina Hanif, Menaka Pai, Jacob Pendergrast, Jami-Lynn Viverios

The Transfusion Medicine and Coagulation laboratory section will address the following recommendation statements: 27-37.

The MHP will ensure immediate notification to laboratories of an MHP activation. Uncrossmatched red blood cells shall be available at the bedside not more than 10 minutes after MHP activation and used until group-specific red blood cells are available. There shall be an uninterrupted supply of blood components to the bedside and the components shall be supplied in a validated container. The MHP will define the proportionate issue of blood components, blood products and the management of anticoagulant agent reversal.

11.1 Transfusion Medicine Responsibilities During MHP

TML should initiate internal protocols in consultation with the physician on call. The lab will follow internal blood selection, crossmatching and emergency release policies as they pertain to the MHP.

- Uncrossmatched red blood cells shall be available at the bedside within 10 minutes of MHP activation and be transfused until crossmatch compatible red blood cells are available.
- Laboratory staff will prepare all required products on a “STAT” basis to support patient clinical condition and to maintain product level ordered and dispensed.
- Communication between the TML and the MHP Team/Nurse Leader is paramount. The TML will notify the MHP Leader when blood products and components are ready, so the dedicated porter can be dispatched. They should also communicate MHP status updates to the other laboratory staff as needed to assess workload and inventory needs.
- TML should work to identify MHP patient identity as soon as possible to check for current specimens and confirm patient crossmatch history, including blood group, to support the MHP.
- The TML will continually “stay ahead” by preparing additional products so that the next pack of products is always ready.
- MHP remains in effect until deactivation has been initiated. Reassessment of need to continue with MHP should be done after each pack by the clinical team.

Preparing Blood and Components for Issue
Standard approach (Larger Community and Teaching Hospitals)

Table 1: Transfusion Packs for Adults with Massive Hemorrhage: Standard Approach

	**Pack 1:** 4 Red Blood Cells (RBCs). If the MHP patient is any aged male or female not of childbearing potential (<45), O Positive RBCs should be issued.
	**Pack 2:** 4 RBCs, 4 Frozen Plasma (FP).
	**Pack 3:** 4 RBCs, 2 FP and 4g of Fibrinogen Concentrates (FCs).
	**Pack 4 and beyond:** includes 4 units of RBC and 2 units of FP. Lab values should now be used to guide transfusion at this point.

Platelets: when stocked in the hospital transfusion laboratory, should be transfused based on the platelet count.

Fibrinogen Concentrates: transfuse 4g if Fibrinogen is <1.5g/L
*Less than 2.0g/L for postpartum hemorrhage.

Modified approach for smaller hospitals without the ability to provide plasma

Physicians should consider transferring the patient to a hospital capable of definitive hemorrhage control first. Then follow the transfusion protocol below:

Table 2: Transfusion Packs for Adults with Massive Hemorrhage: Modified Approach for TMLs that can't provide plasma

	**Pack 1:** 4 Red Blood Cells (RBCs). If the MHP patient is any aged male or female not of childbearing potential (<45), O Positive RBCs should be issued.
	**Pack 2:** 4 RBCs, 2000 IU Prothrombin Complex Concentrates (PCCs), 4g of Fibrinogen Concentrates (FCs).

If transfer is not possible then continue with the following:

	**Pack 3:** 4 RBCs, 2000 IU PCCs and 4g of FC.

Platelets: when not stocked in the hospital transfusion laboratory, should be ordered in for transfusion only if patient cannot be transferred out and will be used. If the patient is transferred out before platelets transfused, this should be communicated to the receiving hospital.

11.1.2 Inventory Management

The recommendations for the MHP state that patients should be switched to ABO group specific red blood cells as soon as is feasible to conserve group O red blood cells. A second sample must be obtained to confirm the patient's ABO group before ABO group specific red cells can be issued[1].

Communication should be maintained between the TML and the Team Leader to determine the extent of products needed (dependent upon patient condition) throughout the MHP transfusion event. The TML will execute defined protocols to obtain additional blood products from nearby area hospitals and/or CBS if stocks fall below minimum inventory level. When platelets are ordered in for patients but not transfused before patient transfer, then consider sending platelets with the patient.

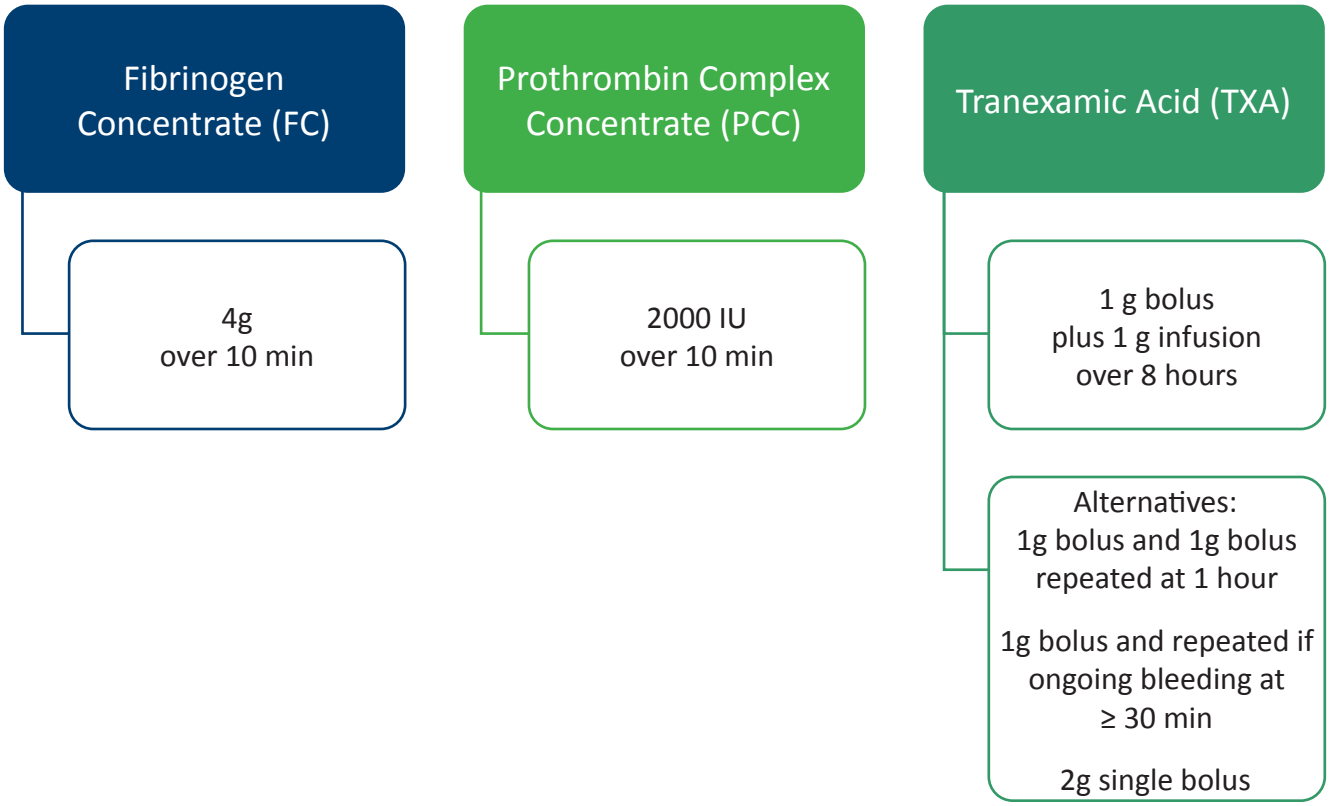
11.2 Coagulation

Patients who present with or are at risk of massively bleeding may be on anticoagulants that need to be reversed immediately. Refer to table 3 for reversal agents.

Managing Coagulopathy in the Massively Hemorrhaging Patient

Management of coagulopathy in the massively hemorrhaging patient is multifactorial and includes blood product support, administration of hemostatic agents (e.g., TXA), temperature control, acid-base management, and reversal of anticoagulant and antiplatelet agents.

Figure 1: Hemostatic Agent Dosing



Anticoagulant Reversal in the Massively Bleeding Patient

Table 3: Anticoagulant and Antiplatelet Agent Dosing

Anticoagulant	Recommended Reversal
Warfarin	Prothrombin complex concentrate PCC (Octaplex® or Beriplex®) 2000 units IV over 10 min Vitamin K 10 mg IV over 10 min
Dabigatran (Pradaxa®)	Idarucizumab (Praxbind®) 2.5g IV twice (total = 5g) over 10 min
Rivaroxaban (Xarelto®) Apixaban (Eliquis®) Edoxaban (Lixiana®)	Prothrombin complex concentrates (Octaplex ®or Beriplex®) 2000 units IV over 10 min Repeat at 1 hour if still bleeding
Heparin	**Unfractionated Heparin (UFH)** Protamine 1 mg per 100 units of UFH administered within past 4 hours 25mg IV of Protamine will reverse heparin infusions running at a rate of approx. 1,500 units/hour **Low Molecular Weight Heparin (LMWH)** If administered within 8 hours: 1 mg of protamine per 100 units anti-Xa or 1mg per 1mg of enoxaparin If administered more than 8 hours ago: 0.5 mg of protamine per 100 units anti-Xa or 0.5 mg per 1mg of enoxaparin

When antiplatelet agents (including aspirin, $P2Y_{12}$ inhibitors, and GPIIb/IIIa antagonists) are present in the setting of a massive hemorrhage, it is unclear if empiric platelet transfusions are consistently beneficial and potentially may be harmful.

The antiplatelet effects of aspirin and clopidogrel can be at least partially reversed with platelet transfusions. Meanwhile, platelet transfusions appear less effective for ticagrelor reversal, as the drug and its active metabolite have a longer half life.

The decision to transfuse platelets in these patients should be individualized according to specific patient factors and the judgment of the treating clinician.

CAUTION:

A. Factor VIIa is not recommended in the case of patients with hypothermia, arterial pH less than 7, or known history of prior venous or arterial thrombotic event. In addition, strong evidence of efficacy of Factor VIIa in off-label use is lacking.

B. Prothrombin Complex Concentrate - No contraindications listed. Risk of thrombosis and DIC. No documented efficacy in the absence of pre-existing coagulopathy or INR values less than 1.5

C. TXA - contraindications include acquired defective color vision, patients with subarachnoid hemorrhage, patients with active intravascular clotting and patients with hypersensitivity to TXA or any of the ingredients.

For centers that don't normally stock idarucizumab or PCCs, the best option for a bleeding patient on anticoagulants is early transfer.

More information can be found at Thrombosis Canada at https://thrombosiscanada.ca/clinicalguides.

11.3 Approaching Patients with Bleeding Disorders with Massive Hemorrhage

Physicians should suspect that the bleeding patient may have a bleeding disorder when

- Bleeding is not in keeping with severity of injury
- Patient is not on antithrombotic therapy
- There is a history of abnormal bleeding

Healthcare professionals should look for a medical alert bracelet/tag and/or a bleeding disorder card. If a bleeding disorder is suspected, they should immediately contact the nearest Hemophilia treatment centre (HTC).

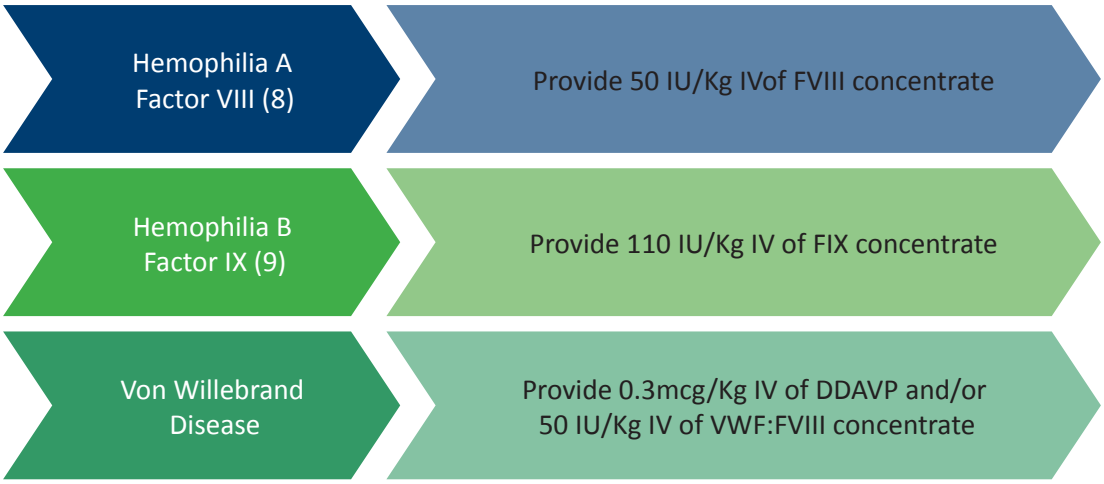
Pediatric

Please refer to Pediatric appendices for pediatric MHP blood product, factor concentrate and associated drug dosing including TXA. As current administration of non-vitamin K antagonist direct oral anticoagulants (DOACs) in children is rare, only reversal strategies for warfarin and heparin are provided. Similar to adult bleeding patients in need of red blood cell transfusion, children can be transfused group O uncrossmatched red blood cells until group specific crossmatch compatible blood cells are available. There is no threshold volume of group O red cells above which a switch to group specific red blood cells is prohibited.

Hemophilia Treatment Centres in Ontario	
Hamilton Health Sciences	Health Sciences North (Sudbury)
London Health Sciences	St. Michael's Hospital (Toronto)
Thunder Bay Regional Health Sciences Centre	Sick Kids (Toronto)
Kingston Health Sciences Centre	The Ottawa Hospital
Children's Hospital of Eastern Ontario (Ottawa)	

It is recommended that replacement therapy be given immediately for obvious or suspected bleeding or major trauma. Treat first and then investigate.

Figure 2: Replacement Therapy for the Bleeding Disorder Patients with a Massive Hemorrhage



More information can be found at www.hemophilia.ca.

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12.0 EDUCATION

Ziad Sohl (Chair), Stephanie Cope, Andrew McDonald, Kimmo Murto, Andrew Petrosoniak, Samantha Slomer, Jordan Tarshis

Aiding hospitals in the implementation of a provincial MHP: Barriers and facilitators to knowledge translation

The successful adoption, implementation and sustainability of an MHP in a clinical setting can be a complex undertaking. It requires a staged change management process (described elsewhere in the toolkit) developed based on a site-specific assessment of anticipated barriers to implementation followed by a multi-faceted (e.g., rounds, simulation and feedback) and multi-level (e.g., lab and bed-side clinicians) implementation strategy. The following section provides guidance on how to achieve protocol adherence and to increase team awareness and effective delivery of an MHP. This section will address recommendation statements 8 and 41.

12.1 Barriers

Barriers to the uptake and implementation of practice guidelines are generally attributed to issues related to knowledge, attitudes and behaviour.[1] Specific to patient blood management guidelines, barriers include:

- knowledge and beliefs about the intervention
- access to knowledge
- information and resistance to clinical practice change.[2]

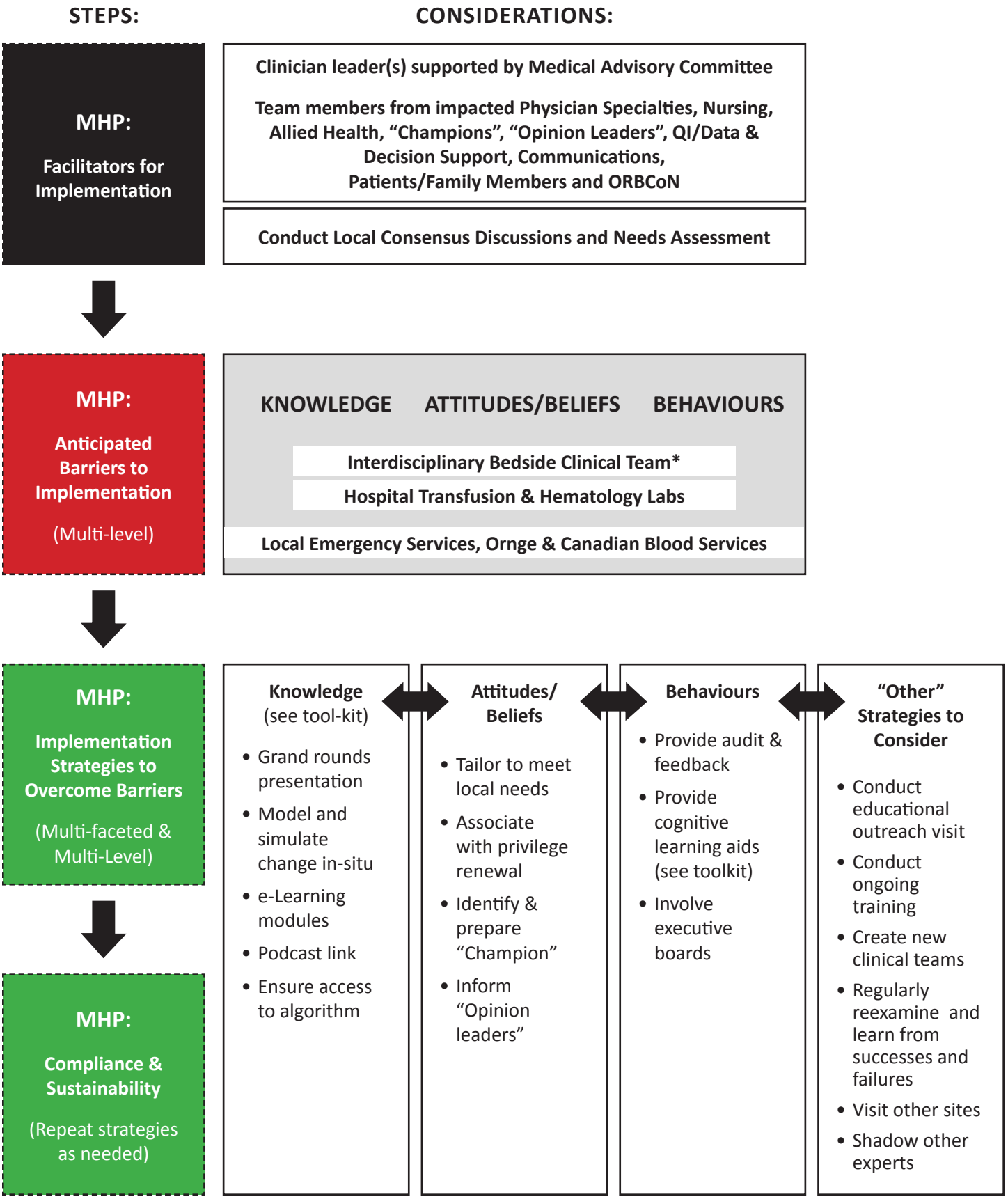
The successful implementation of an MHP has to consider barriers specific to various environmental contexts and match them to implementation strategies.

Guideline implementation strategies to overcome these barriers, include:

- conducting educational meetings
- auditing and providing feedback
- developing educational materials
- local consensus discussions to formally establish a need for a guideline and should include a staged change management process.[2,3]

Examples of MHP implementation in adult and pediatric clinical settings[4,5,6] reveal they can be lengthy (up to 12 months), usually initiated by a multi-disciplinary team and provide some reference to clinician education (e.g., "structured and directed educational conferences") and access to related knowledge/materials. While there is no reported evidence-based approach for successful MHP implementation in a clinical care setting,[7] the reader is referred to a number of available published tools to identify barriers and generate related implementation strategies for guideline adoption[7,8,9,10,11,12]. Organizations may also benefit from incorporating an Ontario Health-endorsed staged quality improvement (QI) process or consultation with a guideline implementation expert.[3] The goal of effective MHP education and local consensus building is guideline adoption, successful implementation and sustained utilization.

Figure 1: Educational strategies to facilitate implementation of a massive hemorrhage protocol in a clinical setting



*Composition of interdisciplinary team will vary according to contextual local needs (e.g., obstetrics, pediatrics etc.)

Figure 1 represents an example of an approach to incorporate educational strategies to address anticipated barriers to MHP implementation in any clinical setting, which at the local level is ideally supported by the Medical Advisory Committee and an executive sponsor. Leadership is crucial and the designated lead during MHP development and eventual activation must be clear. For successful implementation, a multi-disciplinary team that includes specialty specific clinicians and lab personnel associated with MHP activation must be identified. Opinion leaders should be engaged by this group. Consultation with the patient and family advisory committee to understand their experiences of care is recommended. At the local level, barriers to implementation must be identified through discussion with key stakeholders, which may include engagement of resource personnel outside of the hospital. Implementation strategies should be multi-faceted and go beyond simple audit and feedback and include e-learning and in-situ simulation, cognitive learning aids and involve local champions. The MHP toolkit provides resources for training and simulation drills on the operation of the MHP and for review of activations to ensure reinforcement, training, maintenance of competency and process improvement.

- A series of five training modules developed for key hospital personnel (Porters, MLTs, Nurses, Physicians) and communication /hospital administration MHP elearning modules
- Simulation Exercise: Three tabletop scenarios are presented in paper appendices and video forms. An observational tool is provided, in appendix to support the debrief and prompt further discussion.
- A generic PowerPoint slide deck created to be used by hospitals to present (MAC/Grand Rounds) elements of the provincial MHP (MHP slide deck).
- Emergency Medicine Cases - A podcast on the 7T's of Massive Hemorrhage Protocols. February, 2021.
- The reader is encouraged to refer to a publication by Powell et al. for a list of "Other" implementation strategies.[8]

Finally, a willingness and commitment to regular MHP re-evaluation and quality improvement will improve protocol compliance and sustainability. MHP activations should be reviewed, at least quarterly, by a multidisciplinary committee (Transfusion Committee / Medical Advisory Committee) for quality assurance purposes. The toolkit also provides a generic MHP algorithm for both non-definitive and definitive-care settings (adult and pediatric specific) as well as a patient handover tool.

Refer to the Quality Section 14.0 for guidance on provincial reporting and what MHP quality metrics to track.

Pediatric

Please refer to related pediatric considerations in section 15.0 and appendices for pediatric MHP cognitive aids (algorithm, dosing table, cooler dosing guides, equipment examples and infographic for heat loss reduction).

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13.0 FACILITATING COMMUNICATION BETWEEN HEALTH CARE PROFESSIONALS AND MHP PATIENTS AND THEIR FAMILIES

Neill Adhikari, Joel Aguirre, Denise Evanovitch, Joe Hacket, Amanda McFarlen, Ellen Valleau

13.1 Introduction

The content of this section will address recommendation statement 19: Patients and/or their Substitute Decision Maker for whom the massive hemorrhage protocol was activated should be informed. Actual (e.g., transfusion-associated circulatory overload, hyperkalemia, etc.) and potential adverse effects should be disclosed. Furthermore, patients of childbearing potential should be informed of the risk of red blood cell alloimmunization that may complicate future pregnancies.

The purpose of this section is to supply tips and tools for the MHP healthcare team to share with the patient and their family to keep them informed and advised on what happened during the MHP resuscitation and what complications from transfusion they might expect in the future. A template patient information form has also been included. It is recommended that the TML initiates the process with this form with the number of units transfused during the first 24 hours of treatment, once the initial critical phase has passed and hemostasis has been achieved (e.g., the day after MHP activation).

The tables included in this section of the toolkit model the information to be completed on the MHP Patient Form that will be given to the patient once stabilized. Therefore the tables in the toolkit are provided for a reference only; they are not intended to be completed. The tables provided in the MHP Patient Form will be completed, discussed and given to the patient.

13.2 Initial Patient & Family Contact and Discussion

The healthcare provider tasked with communicating with the family member (or patient once stable) should open the discussion as soon as possible and may want to use the MHP Patient Form as a guide. The person communicating with the patient may be the most responsible physician, another senior physician, or a nurse with expertise in massive hemorrhage. The MHP Patient Form will provide the patient and family with a written resource during a stressful time. Spiritual Care Practitioners are available to address any psychosocial spiritual concerns arising before, during, or after the massive hemorrhage protocol. This includes supporting families through crisis, providing spiritual and emotional support, and addressing values, beliefs, and religious needs of patients and families as they pertain to an MHP. The following items should be communicated with the patient (and patient's family) to describe things that may have occurred during treatment despite or as a consequence of the treatment.

13.3 Problems a massively bleeding patient may experience in the first 24 hours

Check a "Yes" or "No" box for each problem

Yes/No	Problem	How this was controlled or treated	How the patient may feel or appear
☐ Yes ☐ No	Uncontrolled bleeding	Pressure on the wound, balloon devices, endoscopy, surgery	Pressure, anesthesia
☐ Yes ☐ No	Low body temperature	Warm IV fluids, warm blankets where possible	Cold, shivering
☐ Yes ☐ No	Low body pH (acidity)	IV fluids, red blood cell (RBC) transfusion, medication to raise pH	Confusion, rapid shallow breathing

Yes/No	Problem	How this was controlled or treated	How the patient may feel or appear
☐ Yes ☐ No	Not clotting properly	IV calcium, regular laboratory testing, transfusion of plasma, platelets or other blood products, other pro-clotting medications	Wounds not clotting
☐ Yes ☐ No	Anemia and low blood pressure	Red blood cell (RBC) transfusion	Weak, short of breath, dizzy, pale
☐ Yes ☐ No	Electrolyte imbalance	IV medication	Tingling, trouble breathing, chest pain, nausea
☐ Yes ☐ No	Increased fluid in tissues	Diruetics (water reducing medication), reduce IV fluids, chest Xray	Difficulty breathing, general swelling throughout the body
☐ Yes ☐ No	Allergic reactions (including anaphylaxis)	Antihistamine medication	Itchy, hives, puffy eyes, difficulty swallowing and breathing
☐ Yes ☐ No	Fever from the blood products	Tylenol (acetaminophen)	Fever and chills
☐ Yes ☐ No	Lung injury	Oxygen, respiratory support (e.g., with intubation and ventilation), diuretics, chest X-ray for diagnosis	Difficulty breathing, chest pain

13.4 Problems that may affect a massively transfused patient in the future

Problem	How this was controlled or treated	How the patient may feel or appear
Develop red blood cell antibodies that can complicate future transfusions: 1 in 13 patients	It can't be prevented but the transfusion laboratory will ensure they find compatible blood for you if you need another transfusion. You should have a blood test 6 weeks to 6 months after transfusion to see if you have produced any red cell antibodies.	Back pain, weakness, dizziness, and yellow skin/ eyes up to 28 days after transfusion
For female patients with child bearing potential/ capabilities, may cause Hemolytic Disease of the Fetus and Newborn	Will be managed during pregnancy with extra testing, monitoring, and rarely, fetal and neonatal transfusions	Patient's fetus/baby may have anemia. Baby may be jaundiced (yellow).
Blood borne disease: less than 1/1,000,000	Testing and donor screening	No symptoms or disease related (fever, jaundice, etc.)

The reactions experienced and possibility of transfusion reactions in the future should be discussed with the patient or family members once the patient is stabilized. If the patient has child bearing potential and received red blood cells or platelets, the risk of developing Hemolytic Disease of the Fetus and Newborn (HDFN) must be discussed. Where possible, the patient should be tested at 6 weeks to 6 months after transfusion with a group and screen to detect the antibodies (they can be transient and there is a narrow window to detect their presence). Using the MHP Patient Form, list any reactions/events the patient experienced. Explain why they occurred and how they were mitigated when discussing the MHP experience with the patient/family.

13.5 Informing the Patient and Family of all the Blood and Blood Products they Received

Patients want to know the numbers and types of blood components and products they received. Complete this section of the MHP Patient Form and discuss why these transfusions were required. Perform this task with the family members if they wish, even when the patient does not survive.

13.6 Informed Consent

As soon as the patient (or substitute decision maker) is able to make treatment decisions and has the ability to give 'informed' consent, it must be obtained and documented in the patient's chart.

13.7 Explain Who the Patient or Family can Call with Further Questions

Complete this section of the MHP Patient Form with the department name, telephone number of the health care area to answer any further questions the patient or family may have about their MHP treatment. Consider using the same telephone number as included in the routine post transfusion notification letter/notice. Some examples of contact persons include: transfusion safety officer, trauma surgeon, midwife, obstetrician, or any other contact person provided at that particular hospital.

Pediatric

Family presence/inclusion is a core value in pediatric care, and the option to include family members within the resuscitation of a child, while providing designated personnel to support them, has been adopted as a care-standard across pediatric institutions globally. Literature suggests the presence of a family member provides positive psychological benefits for both the child and their guardians while also assisting the clinical team in the assessment and management of an injured child to reduce fear and anxiety, and enhance communication.[99] It is reported that 30% of children suffer from post-traumatic stress disorder (PTSD) after a motor vehicle collision, and in the setting of a critically ill or injured child, evidence thus far demonstrates improved psychosocial outcomes for family, with a greater sense of closure when the resuscitation is unfortunately unsuccessful.[124,174]

for patients and their families

Massive Hemorrhage Protocol
Letter for MHP Patients and their Families

Patient Name: _____ (can apply patient label here)

DOB: _ _ _/_ _ /_ _

Patient #: _____

1. Purpose

The purpose of this letter is to try and answer some of the questions you and your family may have about your transfusion support during your major bleed. The letter can also act as a guide to the discussion with your health care team to ensure you have a chance to hear about your treatment. The health care team members speaking to you could include your primary physician, another physician, a nurse, a social worker or a spiritual care practitioner.

This document provides you with a permanent record of the summary of your transfusion treatments. We have also included a contact at the bottom of the pamphlet, so you can ask any follow up questions you may have at a future date. Please feel free to ask any further questions.

2. How Much Blood was Transfused (so far)?

_____ Red Blood Cells (RBCs)

_____ Platelet Doses

_____ Plasma

_____ Other blood derived products. List _____

3. Problems I experienced during my massive bleed in the first 24 hours

Yes/No	Problem	How this was controlled or treated	How I may feel or appear
☐ Yes ☐ No	Uncontrolled bleeding	Pressure on the wound, balloon devices, endoscopy, surgery	Pressure, anesthesia
☐ Yes ☐ No	Low body temperature	Warm IV fluids, warm blankets where possible	Cold, shivering
☐ Yes ☐ No	Low body pH (acidity)	IV fluids, red blood cell transfusion, medication to raise pH	Confusion, rapid shallow breathing
☐ Yes ☐ No	Not clotting properly	IV calcium, regular laboratory testing, transfusion of plasma, platelets or other blood products, other pro-clotting medications	Wounds not clotting
☐ Yes ☐ No	Anemia and low blood pressure	Red blood cell (RBC) transfusion	Weak, short of breath, dizzy, pale
☐ Yes ☐ No	Electrolyte imbalance	IV medication	Tingling, trouble breathing, chest pain, nausea
☐ Yes ☐ No	Increased fluid in tissues	Diruetics (water reducing medication), reduced IV fluids	Difficulty breathing, general swelling throughout the body
☐ Yes ☐ No	Allergic reactions to blood products (including anaphylaxis)	Antihistamine medication, steroids	Itchy, hives, puffy eyes, difficulty swallowing and breathing
☐ Yes ☐ No	Fever from blood products	Tylenol (acetaminophen)	Fever and chills
☐ Yes ☐ No	Lung injury from blood products	Oxygen, respiratory support (e.g., with intubation and ventilation), diuretics, chext X-ray for diagnosis	Difficulty breathing, chest pain

4. Hospital Contact for any Further Questions

If you think of any further questions, here is someone you can email or speak with by telephone:

Department/Name: _____

Email: _____

Telephone: _____

14.0 QUALITY

Amanda McFarlan (Chair), Allison Collins, Avery Nathens, Troy Thompson

Continuous quality improvement activities in healthcare are an essential part of improving patient experiences and outcomes. Standardized quality metrics have been developed for the Provincial MHP to help assess and improve specific activities over time at individual hospitals and will allow for peer benchmarking. This section will address recommendation statements 41 and 42. There are 8 quality metrics recommended for reporting in order to assess the MHP process at your institution.

- The proportion of patients receiving tranexamic acid within 1 hour of protocol activation.
- The proportion of patients in whom RBC transfusion is initiated within 15 minutes of protocol activation.
- The proportion of patients (of patients requiring transfer for definitive care) with initiation of call for transfer within 60 minutes of protocol activation.
- The proportion of patients achieving a temperature >35^{o}C at termination of the protocol.
- The proportion of patients with hemoglobin levels maintained between 60-110 g/L during protocol activation, excluding certain pediatric populations (e.g., neonates) that may require higher hemoglobin values.
- The proportion of patients transitioned to group specific RBCs and plasma within 90 minutes of arrival/onset of hemorrhage.
- The proportion of patients with appropriate activation (>6 RBC units in first 24 hours; >40 ml/kg/24 hours of RBCs in pediatric patients) or before this level in patients dying due to hemorrhage within 24 hours.
- The proportion of patients without any blood component wastage (including plasma that is thawed and not used within the 5 day limit on another patient).

Quality Metrics Reporting

A Quality Metrics reporting portal has been developed using the REDCap software platform in order to capture all 8 MHP quality metrics. The Quality Metrics reporting portal is a validated and free tool that will assist with evaluating compliance. The reporting of MHP metrics is voluntary and the reporting portal will be linked to a "dashboard" which will provide both local (hospital specific) and provincial (aggregate) data in order to monitor quality metrics over time.

(Please note- the MHP Quality Metrics portal and associated dashboard are in the development stages at time of toolkit release and more information will be provided in the future)

Hospitals can enter each MHP activation (one per patient) on a per patient basis or monthly into the MHP Quality metrics portal.

Instructions for Entering MHP Metrics

MHP Quality Metrics Portal link: https://is.gd/mhp_survey

MHP - Quality Metrics Working Instructions

Quality Metrics	Metric Reporting	Considerations
1. The proportion of patients receiving tranexamic acid (TXA) within 1 hour of protocol activation.	Did patient receive TXA within 1 hour of activation? ☐ Yes ☐ No ☐ N/A – Patient expired before 1 hr ☐ N/A – Given by referring hospital ☐ N/A – Given by EMS/Ornge ☐ N/A – TXA contraindicated ☐ N/A – TXA ineffective (i.e., gastrointestinal hemorrhage, bleeding secondary to thrombocytopenia)	• need to consider pre-hospital infusions • exclude patients dying within first hour • receiving at least 1 gram for adult patients • need to consider dosing for pediatrics (the initial bolus -15 mg/kg up to a maximum of 1 g) • received or initiated 1 gram infusion within the first hour • look for information on the nursing drug administration area on documentation sheet or on Ornge/EMS call sheet • info could be in physician or nursing documentation
2. The proportion of patients in whom RBC transfusion is initiated within 15 minutes of protocol activation.	Was RBC transfusion initiated within 15 minutes of protocol activation? ☐ Yes ☐ No ☐ Yes – Start time of first unit not documented but first unit Issued from BB/TM before or within 10 minutes of activation ☐ N/A – first RBC given at referring hospital ☐ N/A – first RBC given by EMS/ Ornge ☐ N/A – MHP over-activation and no RBC units required ☐ N/A – patient expired before 15 minutes	• red cells issued from blood bank within 10 minutes of activation[1] – every 1 minute delay associated with a 5% increase in mortality • MHP activated when call to blood bank or through communications, time-stamped emails or call log from communication or documentation time in nursing documentation in the chart • need to consider pre-hospital initiation of MHP • transfusion initiation very difficult to obtain and therefore issue time from blood bank to be used as a surrogate where required • Each hospital to record metrics (ie. patient may have metrics entered at 2 hospitals – sending and receiving) • include box “initiated at sending hospital” if applicable • need to consider Ornge/ambulance initiated treatment

3. The proportion of patients (of patients requiring transfer for definitive care) with initiation of call for transfer within 60 minutes of protocol activation.	Was the initiation for patient transfer within 60 minutes of protocol activation? ☐ Yes ☐ No ☐ N/A – Patient expired before 60 minutes ☐ N/A – no transfer/definitive care provided	• small site- have N/A; definitive care provided at supporting hospital categories • time of activation-time of the call for transfer • can get data from Criticall for call of transfer • Ornge/EMS call transfer sheet has time of call- can be used for surrogate marker • Ambulance call report usually scanned into Medical Health records
4. The proportion of patients achieving a temperature >35°C at termination of the protocol.	Was the patient's temperature >35°C at termination of protocol? (30 minutes prior to/6 hours after termination) ☐ Yes ☐ No ☐ No – no temperature documented within 6 hours of termination ☐ N/A – patient died before termination	• N/A patient died before termination • If termination not documented use temperature at arrival time at destination (ICU, Recovery room) • temperature at last red cell transfusion post resuscitation • If MHP not formally terminated or time not documented • temperature can be accepted 30 min prior or 6 hours after protocol termination/arrival at destination/at time of last RBC
5. The proportion of patients with hemoglobin levels maintained between 60-110 g/L during protocol activation, excluding certain pediatric populations (e.g., neonates) that may require higher hemoglobin values.	Was the patient's Hb maintained over 60 g/L in the first 24 hours? ☐ Yes* ☐ No ☐ Unknown – patient died before post-transfusion blood work drawn *After 1st RBC unit to 24 hours after activation – no Hb value was <60g/L Was the patient's Hb below 110 g/L at 24 hours? ☐ Yes* ☐ No ☐ Unknown – patient died before post-transfusion blood work drawn *After 1st RBC unit to 24 hours after activation - no Hb value was >110g/L	• Exclude any Hb before initiation of transfusion • Hb at 24 hours after resuscitation as surrogate (fluid shifts complete) for over transfusion • important to be able to capture under resuscitation and over-transfusion • recording if hemoglobin <60 g/L at any point in first 24 hours excluding "opening" Hb before transfusion • Hb levels only at reporting centre –if arrival hemoglobin from another hospital is <60 or >110 g/L, only record post-transfusion levels • Referring hospitals should review hemoglobin levels in Connecting Ontario to ensure complete capture of over and under-transfusion events, based on care directed by the referring hospital

6. The proportion of patients transitioned to group specific RBCs and plasma within 90 minutes of arrival/ onset of hemorrhage.	Was the patient transitioned to group specific RBC/Plasma within 90 minutes of arrival/onset of hemorrhage? ☐ Yes ☐ No ☐ N/A – unable to transition due to mix-field discrepancy unresolved at 90 minutes ☐ N/A – no blood issued after 90 minutes ☐ N/A – patient group O	• red cell provided after 90 minutes is group specific- yes or no or N/A • time is the issue time from the blood bank for the first group-specific unit
7. The proportion of patients with appropriate activation (>6 RBC units in first 24 hours; >40 ml/ kg/24 hours of RBCs in pediatric patients) or before this level in patients dying due to hemorrhage within 24 hours.	Was the MHP activation appropriate for this patient? ☐ Yes (>6 RBC in 1st 24 hours; >40 ml/kg/24 hours of RBCs in pediatric patients) ☐ Yes – death of bleeding before unit 6 ☐ No (Does not meet above criteria) ☐ N/A – transferred out before unit 6	
8. The proportion of patients without any blood component wastage (including plasma that is thawed and not used within the 5 day limit on another patient).	Were any blood/blood products wasted during this MHP activation? ☐ Yes Which products? ☐ RBC – # of units? ☐ Plasma – # of units ☐ Platelets – # of units ☐ Prothrombin Complex Concentrate – IU ☐ Fibrinogen Concentrate – grams ☐ No	• blood that comes with patient and not appropriately packaged and are wasted should be counted in the sending hospital metrics • any blood products received should be recorded by sending hospital (including EMS/Ornge issues) • standardized packing configuration in the protocol may need to be considered if wastage rate is high • plasma thawed and not transfused to another patient, coded as wasted

Additional information regarding the MHP Quality Metrics dashboard will be provided at a later date.

References

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15.0 PEDIATRIC CONSIDERATIONS

Kimmo Murto (Chair), Vicky Breakey, Suzanne Beno, Peter Hayes, Elaine Leung, Lani Lieberman, Mark McVey, Neil Merritt, Wendy Owens, Lindsey Rae, Lois Shepherd, Teresa Skelton

Introduction

Care provided to children experiencing massive hemorrhage needs to be standardized. While 70% of North American Hospitals that provide pediatric healthcare services have a dedicated MHP, there is a significant amount of variability including activation criteria and products administered[1] and many Ontario community/small hospitals lack a hospital approved MHP, particularly pediatric specific protocols.[2] The lack of pediatric specific MHPs is concerning as more than half of these hospitals receive critically injured infants, children and adolescents. As a result, the majority of these patients are transferred from peripheral hospitals to pediatric tertiary care centers rather than being admitted directly through the emergency department.[3] The event rate of large volume transfusions account for approximately 3% of children treated for trauma in a pediatric tertiary care emergency department setting.[3,4,5] For the most part, the epidemiology of massive hemorrhage is similar in adults and children and it is a leading cause of preventable death in both trauma (i.e. motor vehicle collisions, non-accidental physical trauma, falls, homicide and suicide) and elective surgical settings (i.e.. solid organ transplant, tumor resection, congenital heart disease, craniosynostosis and scoliosis repair).[6,7,8] Trauma is the leading cause of death in children > 1 years of age and attributed primarily to traumatic brain injury (TBI), however hemorrhage is the leading cause of preventable death. In the operating room, massive hemorrhage is the leading cause for cardiac arrest in children.[9] Finally, approximately 6 per 10,000 live births result in an emergency blood product request for a neonate experiencing massive hemorrhage in utero or during birth from placental abruption/placenta previa with a mortality rate of 35%.[10] Limited availability/access to a standardized pediatric MHP appears to be an obvious gap in care.

Given the above, the lack of evidence-based guidelines for transfusion during MHP activation in children is concerning.[11] Fortunately, massive hemorrhage is an uncommon event. The current definition is 40 ml/kg of blood products administered over 24 hours,[12] but it does not include the young child in hemorrhagic shock who receives 35 ml/kg of RBCs over an hour in the trauma bay or consider hemostatic resuscitation information within the first three hours of injury, when the majority of deaths occur.[13] Most treatment guidance is based on observational data or extrapolated from the adult literature. Compared to adults, a child's immature body habitus raises issues of scale related to blood product administration (ml/kg vs. units), contributes to mechanistic differences in traumatic injury (higher prevalence of TBI, blunt > penetrating trauma and less exsanguination) and a predisposition to hypothermia. In children, higher "transfusion triggers" may be required that depend on comorbidities (e.g., cyanotic heart disease), age (e.g., premature infant) and the presence of coagulopathy (e.g., after cardiopulmonary bypass for congenital heart disease repair). All of these factors should be accounted for in a pediatric MHP. When utilized in pediatric trauma settings, MHPs have demonstrated improved system resource utilization, speed of blood product delivery to the bedside and decreased patient exposure to blood products,[14,15,16,17,18] however, evidence for outcome benefits in pediatric trauma or surgical settings remain elusive.

The contents of this section of the MHP Toolkit are dedicated to key pediatric MHP domains specific guidance for pediatrics includes MHP activation/termination criteria, damage control resuscitation, laboratory testing, resuscitation targets, hypothermia, hyperkalemia, TXA, fibrinogen and prothrombin complex concentrates, transport and handover and continuing education. Pediatric transfusion literature is less robust compared with similar adult literature. Much of the chapter content is either extrapolated from the adult literature or primarily based on single-center pediatric studies of retrospective or observational design, with varying definitions of massive hemorrhage, non-random treatment allocation and high potential for confounding. Outcomes are clouded by associated traumatic brain injury, inconsistent adherence to transfusion protocols and varying age groups. Massive hemorrhage literature associated with elective surgery is under represented. Please refer to the associated learning aids contained within the appendices (Pediatric Appendices A-G).

15.1 Activation and termination

Recognizing significant blood loss in children can be deceiving even for experienced clinicians.[19] Blood volume varies from the premature (90-100 ml/kg) to the older (> 3 months) term infant (70 ml/kg) and in the obese child (65 ml/kg).[20] Adult massive hemorrhage predictions scores are available, but they have limited application in children.[21] Children have robust cardiovascular compensatory responses that delay diagnosis of 30-40% blood volume loss. Subtle changes in the heart rate and extremity perfusion may signal impending cardiorespiratory failure.[22] Hypotension is considered a late finding in pediatric hypovolemic shock and an independent predictor of death when related to trauma.[23] As such, a shock index that is pediatric age-adjusted (SIPA=heart rate/systolic blood pressure) may more expeditiously identify the child at increased risk for emergent intervention[24,25,26] A SIPA > 1 may indicate a need for blood transfusion in children 1-12 years old.[27] Pediatric massive transfusion has been arbitrarily defined in terms of circulating blood volume lost (or blood products transfused) including 50% of total blood volume in 3 hours or 100% of total blood volume in 24 hours.[28] The threshold of 40 mL/kg total blood products administered within a 24 hr time-interval most reliably identify pediatric patients at risk for early or in hospital mortality[12] and has been widely adopted as a pediatric massive transfusion definition. This definition is limited in its ability to trigger activation of the MHP, as both adult[29] and pediatric data suggest that most bleeding requiring MHP activation is intense and occurs in a short time frame (< 3 hours).[23,30] Also, guidelines are now advocating for less aggressive crystalloid resuscitation to avoid a dilutional coagulopathy.

In the absence of defined pediatric MHP triggers, some combination of the following parameters would imply the potential for significant hemorrhage:

- Shock Index Pediatric Age Adjusted (SIPA) 1-12 yrs > 1[25,27]
- Continued hemodynamic instability after two 10 ml/kg boluses of crystalloid[27]
- Continued hemodynamic instability after 20 ml/kg RBC
- Estimated need for more than 40 ml/kg RBC in 3 hours[12,31]
- Penetrating injury[21]
- Glasgow coma scale ≤ 12
- SBP <80 mmHg ≤ 5yrs and <90 mmHg 6-12 yrs

It should be noted that in contrast to adults, it is unknown if the presence of a TBI in children impairs the above shock index performance to classify hypovolemic shock or predict need for blood products.[32] Hemodynamic parameters and the SIPA may not apply in an elective surgical setting. MHP termination criteria may include:[33]

- Bleeding source control has been attained,
- Hemodynamic stability has been achieved,
- Vasopressor requirements have diminished,
- Transfusion rate has slowed such that additional transport personnel are no longer required.

15.2 Damage Control Resuscitation

While the tenents of DCR described previously also apply to children, they have unique MHP considerations in terms of body habitus and physiology which influence the type of injuries experienced and treatment decisions including their consequences, as detailed below.[39,40]

Anatomy and physiology considerations:

Compared with adults, children have less fat, more elastic connective tissue, and a pliable skeleton protecting tightly packed and proportionally larger solid intra-abdominal, abdominal organs and thoracic structures. Similar to adults, large amounts of blood may be lost internally secondary to a long bone fracture, retro-peritoneal bleeding or blunt abdominal trauma. Children suffer relatively more solid organ injury from both blunt and penetrating mechanisms,[22] Intra-abdominal internal organ injury is associated with 30% of major traumas in children, associated skeletal injury is

uncommon and is the most common cause of unrecognized fatal injury in children.[41] However, children have greater hemostasis associated with blunt solid organ injuries; non-operative management is common.[41] When bleeding does occur, children arrest suddenly without hypotensive decline as is seen in adults.[22] A proportionately larger head with reduced cervical muscle control is associated with a higher frequency of traumatic brain injury (TBI), the leading cause of death in pediatric trauma patients. In addition, pediatric head injury predisposes to a proportionately increased blood loss from the scalp or into the cranium, particularly in infants. Finally, children are predisposed to hypothermia during and after massive bleeding.

Coagulopathy:

Children are vulnerable to trauma-induced coagulopathy (TIC) defined as INR prolongation (>1.8) and increased base deficit (>6). They reflect extensive tissue injury and significant hemorrhagic shock, respectively. It is associated with increased morbidity and an elevated mortality rate.[57,58,59] Acidosis and hypothermia associated with major trauma or surgery impair pro-coagulant factors as well as platelets. Platelet numbers decrease earlier in massive hemorrhage related to trauma compared with major elective surgery (e.g., scoliosis) in children.[28] Typically, during massive hemorrhage, fibrinogen levels drop before all other coagulation factors are depleted.[60] Fibrinogen concentrate is an effective treatment for acquired fibrinogen deficiency in children.[61,62,63,64]

In children, a clear definition of TIC (comprised of acute traumatic coagulopathy [ATC] and iatrogenic coagulopathy [IC]) is lacking[133] and a similar mechanism of ATC has not been fully elucidated.[134,135] In the presence of severe TBI children may experience fibrinolytic dysregulation leading to either hyper-fibrinolysis or associated fibrinolysis shut-down.[51,52,53,83,136] Early or premature platelet and plasma administration may exacerbate the latter condition.[48,50,53] In pediatric literature there is clinical equipoise regarding the mortality benefit of high plasma to RBC ratios in pediatric trauma[14,42,43,137,138,139,175] and increased morbidity and mortality have been associated with plasma transfusions in critically ill children.[53,140] Similar to adults,[35,36,37] mortality benefit from platelets has not been reported in pediatric combat and civilian trauma treated for massive hemorrhage[42,43,138,139] and prophylactic platelet transfusion has been associated with increased major bleeding events and mortality with higher compared with lower transfusion thresholds in neonates.[47] A 2% increase in mortality for every additional standard dose of platelets (10 ml/kg) administered has been reported in a pediatric critical care setting.[141]

Avoiding secondary injury:

Damage control surgery

In order to manage pediatric patients with massive injuries associated with severe bleeding, damage control resuscitation often involves surgical intervention. The goal is to prevent secondary injuries and damage control surgeries such as a damage control laparotomy (DCL) is implemented quickly to attain hemostasis. DCL is relatively understudied in children.[65,66] It has an incidence of approximately 12% in children with abdominal trauma and is associated with hypothermia and multi-system trauma.[41] Perioperative transfusion is often encountered and intra-abdominal hypertension and abdominal compartment syndrome are associated with excessive fluid resuscitation, shock[67] and a high mortality rate,[65] but are under recognized despite their common occurrence (0.6-13% incidence). Liver hypo-perfusion (e.g., aortic cross-clamp above hepatic artery to maintain blood pressure) may result in citrate toxicity, causing life-threatening hypocalcemia and progressive coagulopathy or ischemia leading to hyperkalemia.[39,68] Massive transfusion related electrolyte disturbances including hypomagnesemia are relatively common and thus close monitoring is required.[15]

Fluid management

There are negative consequences of fluid over resuscitation in children. Both morbidity and mortality are directly related to increasing volumes of crystalloid, which should be limited to 20 ml/kg in the hemorrhaging pediatric patient prior to moving to blood, as recommended by the 10th edition of the Advanced Trauma Life Support (ATLS) manual.[40,69] Large volume resuscitation has been linked to increased intensive care unit length of stay, ascites, pleural effusions, and sequential organ failure.[15,40] Permissive hypotension to a low targeted blood pressure has not gained wide traction in pediatric trauma due to a high prevalence of associated TBI, a contraindication to permissive hypotension.[39,70] Prolonged transport times in the Canadian pediatric trauma population are not conducive to extended periods of permissive

hypotension and should be limited to the adolescent population with exclusively penetrating trauma and short transport times. It should only be viewed as a temporary strategy to allow for definitive surgical management of bleeding.[45,71] Information regarding recommended BP targets and the appropriate use crystalloids or vasopressors in children experiencing massive hemorrhage is limited.

Traumatic brain injury

Care delivery in the massively bleeding pediatric trauma patient is complicated by the presence of a TBI. There is a higher incidence of blunt trauma and associated TBI in children compared with adults. In TBI, permissive hypotension is contraindicated. Vigilant hemodynamic control is required and a cerebral perfusion pressure (Mean arterial minus the greater of either intracranial or central venous pressure) target between 40 (infants) and 50 (adolescents) mm Hg is recommended; and an intracranial pressure < 20 mm Hg is suggested.[72] Excessive crystalloid may exacerbate cerebral edema and associated mortality with TBI.[73,74] Severity and duration of hyperglycemia after TBI is associated with worse outcomes,[75,76] however, there is no benefit to target glucose concentrations lower than 8.3-10 mmol/L (150-180 mg/dl) in critically ill children.[77,78] Therapeutic hypothermia has not been shown to improve outcomes in pediatric patients with TBI.[79,77] Patients with blunt injury including TBI are at increased risk of trauma induced coagulopathy (TIC) thus making active warming to 36°C a priority.[58,57] Coagulopathy is commonly reported in children with isolated TBI as a dysregulation of fibrinolysis with aspects of disseminated intravascular coagulation.[80,81,82] It should be noted that the clinical presentation of TIC can be complicated when TBI is combined with poly-trauma.[52,53,59,83] The role of TXA in pediatric TBI is unclear and is reviewed in the associated section.

15.3 Laboratory tests

There are unique considerations in the drawing, processing and type of blood samples required in pediatric patients, which should be grouped together when possible to simplify collection and minimize the volume and number of samples. Intraosseous blood sampling for laboratory testing, with exception of blood group typing, is not recommended in children or adults if other access can be obtained.[84]

Typically, sites with smaller red blood cell inventories will be able to manage an MHP activation in young children with their on-site Group O units; however, any delay in switching to group specific RBCs in older children/adolescents can quickly deplete the O unit inventory. Beyond the more common blood gas, electrolytes and biochemistry testing, blood glucose is recommended as an additional minimum lab test to be measured early on in an MHP activation, and monitored closely throughout. Both hypo- and hyperglycemia can occur in pediatric trauma patients and is of particular concern in the presence of severe TBI. Magnesium deficiency should be anticipated in the child who has lost 1.5-2 blood volumes, particularly in the setting of arrhythmias refractory to calcium supplementation.[28]

15.4 Resuscitation Targets

As there is a significant risk of over transfusion in the pediatric patient, they must be transfused based on per kg dosing for blood products, fibrinogen concentrate and PCCs as outlined in Appendix B. Total volume of RBCs and plasma transfused need to be tracked in order to maintain an appropriate ratio of product administered. While ideally blood product transfusion should be laboratory-guided, rapid exsanguination may require a formula-based approach (10-20: 10 ml/kg RBC to plasma ratio). Inadequate platelet counts can also be expected earlier in the resuscitation of a trauma compared with an elective surgical patient.[20,28] Importantly, pediatric patients who are adult-sized (> 40 kg) and > 12 years of age should be managed using the adult-directed algorithm.

Thresholds for blood product administration in children should consider developmental changes in the hematologic and coagulation systems throughout childhood. The hemoglobin concentration approaches adult levels by 12 weeks of age. In children, the medical literature recommends hemoglobin should be maintained between 70-100 g/L.[86,87,88,89] A hemoglobin transfusion threshold of 80 g/L accounts for unpredictable blood loss and hemodynamic instability during massive hemorrhage. Certain pediatric populations, such as neonates, patients with congenital heart disease, those receiving extracorporeal life support, or are in severe respiratory distress, may, however, require higher thresholds for RBC transfusion.

Unlike RBCs, the coagulation system undergoes significant changes during childhood, most marked in the first six months of life. Although platelet numbers are equivalent to adults at birth, platelet function and both pro-coagulants (with the exception of fibrinogen and factors V and VIII) and most of the natural anticoagulants (e.g., protein C) concentrations are reduced.[90,91,92] Most anticoagulant concentrations achieve adult levels by the age of 5 years, however, coagulation factor level concentrations vary through childhood and adolescence, achieving adult levels in the mid-teens. Only the upper limit of the reference value for PTT in infants is higher than in older children and adults.[93,94] Age-appropriate reference intervals should be applied when evaluating laboratory coagulation data, particularly in neonates.

There is limited data to suggest laboratory investigations of coagulation are useful to diagnose a clinical coagulopathy or guide hemostatic therapy during MHP activation.[55,83,95] A threshold platelet count of 50 x 10^9/L requiring treatment is not evidenced based, but is routinely recommended.[35,43,46] There is growing interest in the pediatric surgical and trauma literature to use viscoelastic technology; however, it has yet been proven to improve outcomes and its role in hemostatic resuscitation remains unclear.[15,96,97,98] In Ontario, viscoelastic goal-directed management of coagulopathy is uncommon in children, even when available to providers.[96]

15.5 Hypothermia

Pediatric patients have physiological differences from adults (e.g., less body fat, higher body surface area to volume ratio) which increase their susceptibility to hypothermia.[99] Hypothermia is an independent risk factor for coagulopathy, arrhythmias, acidosis, transfusion and mortality in pediatric trauma.[100,101,102] Considering the morbidity and mortality associated with hypothermia in massively bleeding children, all patients should receive interventions aimed to prevent hypothermia (goal >36°C).[103] Heat loss occurs through conduction, convection, radiant and evaporative mechanisms.[103] Multiple passive and active warming strategies targeting the patient and environment should be utilized simultaneously to prevent and/or treat hypothermia. These include warming the external environment, removal of wet clothing/blankets, applying a clear plastic cover sheet or attaching a heat and moisture exchanger to an endotracheal tube.[104] Active rewarming using convective air blankets (e.g., Bair Hugger™ designed for over or under patient placement), overhead radiant heaters or hospital-grade exothermic chemical pads placed under the child should be initiated with a core temperature of <36°C. Intravenous fluids can be warmed in-line or placed in a warming cupboard prior to administration. Multiple modalities are available to measure temperature (e.g., esophageal, nasopharyngeal and bladder); rectal temperature has been shown to have high correlation to brain temperature in children with TBI in the normal temperature range.[105] Please refer to appendices C and D for pediatric MHP approaches to blood product administration and temperature preservation, respectively.

15.6 Hyperkalemia

Hyperkalemia due to red blood cell transfusion is second only to hypovolemia from blood loss as the most common causes of cardiac arrest in the pediatric perioperative environment.[9] Ease of rapid administration of RBCs into a volume contracted and acidotic small child are key risk factors. Non-irradiated red cell units should be provided, especially in younger children who are at higher risk of fatal hyperkalemia.[106] To reduce the risk, vigilant hemodynamic management, avoidance of transfusion through central lines, use larger bore (>23G) and shorter peripheral IV catheters (to reduce red cell shear/hemolysis), as well as frequently monitoring for ECG and electrolyte abnormalities frequently (e.g., hypocalcemia and acidosis) including vigilant ECG monitoring is recommended.

15.7 Tranexamic Acid

TXA administration is not yet standard practice for use in pediatric trauma patients, but is often used in children and adolescents requiring transfusion within the same time parameters as adults. Prospective evidence of benefit or harm is not yet available for TXA in children with trauma, but clinical trials are in progress and an on-going pediatric civilian trauma study (Tic-Toc trial) is evaluating TXA both in thoraco-abdominal and TBI hemorrhage as a feasibility study in preparation for a definitive large multi-center prospective trial.[108,109] In pediatric combat casualties, TXA has been shown to be independently associated with decreased mortality and improved discharge neurologic status.[110] For pediatric

patients the initial bolus of TXA can be dosed at 15 mg/kg up to a maximum of 1 gram and additional doses/infusion based on local policy with empiric dosing at 2-5 mg/kg/hr until the bleeding stops. Pharmacokinetic simulation data suggest initial doses between 10-30 mg/kg and infusion rates of 5-10 mg/kg/hr may be most effective.[111] Reports suggest a reduction in blood loss and transfusion requirements in children receiving TXA for cardiac surgery, craniosynostosis surgery and spinal fusion for scoliosis repair.[111,112] Administration should be over 10 minutes either in 100 ml of fluid or as a slow IV push. While TXA may be associated with seizures particularly with high bolus doses (100 mg/kg) or in susceptible surgical populations (e.g., cardiac or trauma)[113], TXA is not currently contraindicated in children with an underlying seizure disorder.[111] However, renal impairment/dysfunction requires a dose adjustment because of the increased risk of drug accumulation.[111] A recent report of survivor benefit in adults with isolated mild to moderate TBI receiving TXA, has not been extrapolated to adopt its routine use in Canadian children with similar clinical findings.[114]

15.8 Fibrinogen and Prothrombin Complex Concentrates

In Canada, fibrinogen concentrate is indicated for coagulation support in children. In adults it has been shown that early use of fibrinogen concentrates can increase survival, reduce bleeding and transfusion requirements.[142,143,144] However, the best approach to incorporate fibrinogen concentrate in hemostatic resuscitation in children and adults is unknown. Although the use of fibrinogen concentrates appears to be safe and effective in the treatment of acute bleeding, there is a paucity of evidence directly supporting the use of fibrinogen concentrates in pediatric massive hemorrhage protocols.[145,146] Nonetheless, the perceived risk of thromboembolic events is low and reports in adult and pediatric surgical patients suggest no difference in thromboembolic complications when fibrinogen concentrate was compared with placebo/comparator.[147,148] Considering the effectiveness and safety reported in adults to treat bleeding and emerging evidence of off-label use in children and neonates we recommend the administration of fibrinogen concentrates as part of our massive hemorrhage protocol.[63,97,145,149,150] We recommend administering a dose of 50 mg/kg (maximum single dose 4 gms, 2 gms if < 30 kg) to maintain fibrinogen level > 1.5 g/L (> 2 g/L may be required with critical bleeding) or as guided by viscoelastic point of care testing. For sites that do not stock frozen plasma or cryoprecipitate, fibrinogen concentrate should be used as a fibrinogen substitute. For sites that have the option to carry either frozen plasma or cryoprecipitate, fibrinogen should be considered as first line for fibrinogen replacement. If fibrinogen concentrate is unavailable, cryoprecipitate 5 ml/kg should be considered an equivalent dose for fibrinogen replacement.

Similar to fibrinogen concentrates, prothrombin complex concentrates (PCCs) are indicated for coagulation support in Canadian children. However, they should be considered as a third line hemostatic treatment in massive hemorrhage where coagulopathy is a contributing factor because pediatric trial-related efficacy, dosing and safety data are unavailable.[31,151] In contrast to early depletion of fibrinogen during massive hemorrhage, in adults thrombin generation in the early stages of trauma-related bleeding is often increased suggesting reduced thrombin generation is a late finding in massive hemorrhage related to trauma or surgery.[133,152,153,154,155] It is unclear if a similar pattern of a delayed reduction in thrombin generation during trauma or surgery occurs in children.[134,156] Evidence of early reduced thrombin generation is associated with increased mortality.[152,155] PCC can be considered a “plasma substitute”, and it benefits from many of the same advantages as fibrinogen concentrate (e.g. low risk of pathogen transmission and transfusion reactions) and most importantly, the volume administered is inconsequential. Concerns about TACO and worsening of coagulopathy through plasma-related dilution of RBCs, platelets and coagulation factors are avoided with the use of PCCs, but there is a theoretical increased risk for venous thromboembolic (VTE) events up to 3-4 days after administration.[155]

Pediatric PCC data is relegated to case reports in severely injured children or case series of neonates to adolescents utilizing 4-factor PCCs to treat perioperative bleeding or provide rapid VKA reversal in a cardiac surgery setting.[31,157,158] Reported complications were rare (limited to a single DVT) and children may have a lower risk for VTE, in part due to their quantitative and qualitative differences in hemostasis and reported lower thrombin generation (reduced by as much as 26%) in older children[90,134,159] and appears to be reflected in a lower incidence of VTE in children (0.02-1.2%) compared with adults (20-58%) in the absence of thrombo-prophylaxis.[135,160] It is possible VTE incidence is under reported in children.[160,161] Nonetheless, VTE risk continues to be perceived as low in children as routine VTE prophylaxis is not recommended for age <12 years old, unless there is a history of VTE or presence of a femoral central venous line.[162,163,164] Also, only four-factor PCCs (compared to 3-factor) are licensed in Canada and are associated with fewer thromboembolic events[165] and do not increase the thromboembolic risk over plasma for VKA reversal in

adults.[166,167,168,169,170] In addition, increased thromboembolic events have been reported in animal studies at higher PCC doses (>34 IU/kg).[171,172] Considering the data available, we recommend PCCs combined with vitamin K as described in the associated dosing table to rapidly reverse VKAs with the goal to reduce the INR<1.8.[157] We also recommend a moderate dose of PCC (25 IU/kg) as a third line treatment after tranexamic acid and fibrinogen concentrate, but it should only be administered with ongoing massive bleeding where coagulopathy is a contributing factor despite treatment for other causes (e.g. hyper-fibrinolysis, low fibrinogen or platelets or platelet dysfunction).[173] A low risk of a thrombotic complication should be weighed against the need for rapid and effective correction of a potentially fatal coagulopathy. For sites that do not carry frozen plasma or cryoprecipitate, PCC should be used as a frozen plasma substitute, while sites that carry frozen plasma or cryoprecipitate, frozen plasma should be considered first line for coagulation factor replacement. No recommendation can currently be provided on the need for thromboprophylactic measures in children treated with PCC.

15.9 Transport and handover

Infants and children (< 13 years old) subject to or are at risk of MHP activation should be cared for in a pediatric definitive-care hospital setting to receive specialized care.[115,116] Children cared for in a non-definitive care hospital setting, particularly in rural communities, should trigger early/urgent consultation with a specialized service using an MHP-associated standardized hand-over tool to facilitate patient care and transfer to a pediatric definitive care setting (see Pediatric Appendix E for an example of a patient hand-over tool).

15.10 Education

Care of children undergoing an MHP needs to be incorporated in training materials and simulations/drills. Steps for MHP adoption, implementation and compliance in a clinical setting are described elsewhere. A pediatric MHP has the added challenge of being a rare event with several unique considerations compared with adults as previously discussed. As such, annual review of a pediatric specific MHP using in-situ simulation (see Appendix G for script).[117,118,119,120,121,122] Please refer to Appendices (A-G) for examples of pediatric cognitive aids including an MHP algorithm, medication dosing table and related infographics. A pediatric MHP bag or cart containing equipment and drugs with attached cognitive aids in a location known to all providers is a simple first step to reduce provider anxiety and variability in pediatric care. Expired equipment can be used for training scenarios.[123]

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Pediatric Appendix

NEED A MASSIVE HEMORRHAGE PROTOCOL? PEDIATRIC USE (AGE <13 YEARS OLD)

NO
NOT YET

1. TRANSFUSE UP TO 20 ML/KG UNCROSSMATCHED RBC
2. REASSESS NEED FOR MHP

YES
NEED IT NOW

1. POOR BP RESPONSE TO FLUIDS
2. OBVIOUS BLEEDING
3. HYPOTENSION

Or use local activation criteria

MHP COOLER DELIVERY SEQUENCE				
Weight	**Cooler 1**	**Cooler 2**	**Cooler 3**	**Cooler 4+**
>40 Kg	4 U RBC*	4 U RBC 4 U FP	4 U RBC 2 U FP 4 g FBGN	4 U RBC 2 U FP
31-40 Kg	3U RBC*	3 U RBC 3 U FP	3 U RBC 2 U FP 2 g FBGN	3 U RBC 2 U FP
10-30 Kg	2 U RBC*	2 U RBC 2 U FP	2 U RBC 1 U FP 2 g FBGN	2 U RBC 1 U FP
<10 Kg	1 U RBC*	1 U RBC 1 U FP	1 U RBC 1 U FP 1 g FBGN	1 U RBC 1 U FP

• For Coolers 2+ adjust RBC: FP ratio 1-2:1 (weight-based dosing) as needed UNTIL lab directed dosing possible
• Transfuse PLATELETS (Plts) if < 50 x 10^9/L
***Administer O Negative for females, otherwise O Positive RBC**
Note: RBC=Red Blood Cell, FP=Frozen Plasma, FBGN=Fibrinogen

ANTICOAGULATION REVERSAL	
Warfarin	Vitamin K 1- 10 mg (neonate to adolescent) IV over 10 min & PCC 15 IU/kg for INR < 3 (or unknown) & 30 IU/kg if INR ≥ 3
Thrombin/Factor Xa inhibitors or Heparins	Consult with hematologist and/or call pharmacy for dosing

LABORATORY TRANSFUSION THRESHOLDS

Value	Transfuse
Hgb <80 g/L	RBC 20 ml/kg per dose
INR ≥ 1.8	Frozen plasma 10-20 ml/Kg per dose
Fibrinogen <1.5 g/L	Fibrinogen concentrate 50 mg/kg max 4 g (max 2 g if <30 kg)
Platelets <50 x10^9/L	Platelets 10 ml/kg per dose

PATIENT NO LONGER NEEDS MHP

1. Deactivate as per local policy
2. Ensure coolers and unused MHP components returned to Transfusion Medicine Lab ASAP
3. Complete documentation and hand-over

CALL XXXX: INITIATE CODE TRANSFUSION

1. Identify source and attempt local control of hemorrhage
2. Obtain IV/IO access
3. Consider tranexamic acid 30 mg/kg (max 2 g) and infusion of 10 mg/kg/hr IV/IO
4. Infuse all of "Cooler 1" RBCs (20 ml/Kg per dose) BEFORE "Cooler 2" products, UNLESS lab results direct otherwise
5. Limit use of crystalloids
6. Administer calcium chloride ($CaCl_2$) 20 mg/Kg (max 1 g) or calcium gluconate 60 mg/Kg IV (max 3 g)
7. Keep patient core temperature above 36°C
8. Collect blood samples including blood glucose
9. Reverse anticoagulation if applicable
10. Transfer for definitive bleeding control

EVERY 30-60 MINUTES REASSESS

1. **Can MHP be turned off?**
   Can patient be switched to lab directed transfusion?
   Consider: bleeding controlled?
   Hemodynamics stable?
2. Is patient's core temperature >36°C
3. Are blood samples collected q30-60 mins?
   Transfusion of products adjusted?
4. $CaCl_2$ 20 mg/Kg (max 1 g) or gluconate 60 mg/Kg IV (max 3 g) after each RBC equivalent of one cooler transfused or ionized calcium <1.15 mmol/L
5. Monitor for complications (ex. hyperkalemia, hypothermia and volume overload)
6. Is resuscitation adequate? (ex. hemodynamics, lactate, base deficit, account for traumatic brain injury)
7. Switch to group specific blood products when able

NEED A MASSIVE HEMORRHAGE PROTOCOL? PEDIATRIC USE (AGE <13 YEARS OLD)

NO
NOT YET

1. TRANSFUSE UP TO 20 ML/KG UNCROSSMATCHED RBC
2. REASSESS NEED FOR MHP

YES
NEED IT NOW

1. POOR BP RESPONSE TO FLUIDS
2. OBVIOUS BLEEDING
3. HYPOTENSION

Or use local activation criteria

CALL FOR EARLY TRANSFER TO PEDIATRIC TRAUMA CENTER

CALL XXXX: INITIATE CODE TRANSFUSION

1. Identify source and attempt local control of hemorrhage
2. Obtain IV/IO access
3. Consider tranexamic acid 30 mg/kg (max 2 g) IV/IO
4. Transfuse all of "Cooler 1" RBCs (20 ml/Kg per dose) BEFORE "Cooler 2" products
5. Limit use of crystalloids
6. Administer calcium chloride ($CaCl_2$) 20 mg/Kg (max 1 g) or calcium gluconate 60 mg/Kg IV (max 3 g)
7. Keep patient's core temperature above 36°C
8. Collect blood samples including blood glucose
9. Reverse anticoagulation if applicable
10. Transfer for definitive bleeding control

EVERY 30-60 MINUTES REASSESS

1. **Can MHP be turned off?**
   Can patient be switched to lab directed transfusion?
   Consider: bleeding controlled?
   Hemodynamics stable?
2. Is patient's core temperature >36°C
3. Are blood samples collected q30-60 mins?
   Transfusion of products adjusted?
4. $CaCl_2$ 20 mg/Kg (max 1 g) or gluconate 60 mg/Kg IV (max 3 g) after each RBC equivalent of one cooler transfused or ionized calcium <1.15 mmol/L
5. Monitor for complications (ex. hyperkalemia, hypothermia and volume overload)
6. Is resuscitation adequate? (ex. hemodynamics, lactate, base deficit, account for traumatic brain injury)
7. Switch to group specific blood products when able

MHP COOLER DELIVERY SEQUENCE		
Weight	**Cooler 1**	**Cooler 2+**
>40 Kg	4 U RBC*	4 U RBC, 2000 IU PCC & 4g FBGN
31-40 Kg	3U RBC*	3 U RBC, 1000 IU PCC & 2g FBGN
10-30 Kg	2 U RBC*	2 U RBC, 1000 IU PCC & 2 FBGN
<10 Kg	1 U RBC*	1 U RBC, 500 IU PCC & 1g FBGN

• Transfuse PLATELETS (Plts) if < 50 x 10^9/L
***Administer O Negative for females, otherwise O Positive RBC**
Note: U=unit, IU=international unit, RBC=Red Blood Cell, PCC= Prothrombin complex concentrate, FBGN=Fibrinogen concentrate

ANTICOAGULATION REVERSAL	
Warfarin	Vitamin K 1 to 10 mg (neonate to adolescent) IV over 10 min and PCC 15 IU/kg for INR < 3 and 30 IU/kg if INR > 3 (or unknown)
Thrombin/Factor Xa inhibitors or Heparins	Consult with hematologist and/or call pharmacy for dosing

LABORATORY TRANSFUSION THRESHOLDS

Value	Transfuse
Hgb <80 g/L	RBC 20 ml/kg per dose
INR ≥ 1.8	PCCs 25 IU/kg (rounded to closest 500 IU) max 2000 IU
Fibrinogen <1.5 g/L	Fibrinogen concentrate 50 mg/kg max 4 g (max 2 g if <30 kg)
Platelets <50 x10^9/L	Platelets 10 ml/kg per dose

PATIENT NO LONGER NEEDS MHP

1. Deactivate as per local policy
2. Ensure coolers and unused MHP components returned to Transfusion Medicine Lab ASAP
3. Complete documentation and hand-over

PEDIATRIC DOSING TABLE FOR BLOOD AND PRODUCTS

Pediatric massive hemorrhage dosing table for blood products, factor concentrates, drugs and antidotes

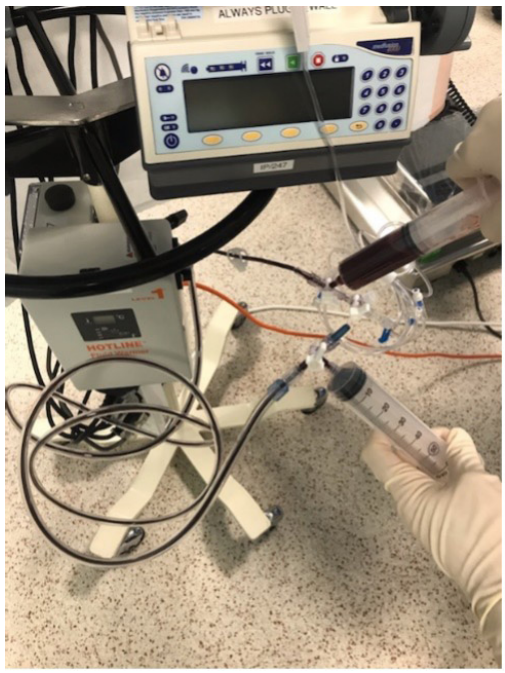
Product/Drug	Dose	Target	Additional Notes
Red Blood Cells (RBCs)	10-20 mL/kg up to a maximum single dose of 4 units (3 units if 30-40 kg, 2 units if 10-30 kg and 0.5-1 unit if < 10 kg) Note: 5-10 mL/kg will increase Hgb by 10 g/L and Hct by 3%, depends on rate of blood loss	Hemoglobin > 80 g/L	Certain populations (neonates, those with congenital heart or lung disease, receiving extracorporeal life support) may require higher thresholds for RBC transfusion.[28,125,126,127] Older RBC and irradiated units increase risk of hyperkalemia (especially infants< 2 years old).[128] Where possible use fresher units to avoid hyperkalemia.
Frozen Plasma (FP)	10-20 mL/kg up to a maximum single dose of 4 units (3 units if 30-40 kg, 2 units if 10-30 kg and 0.5-1 unit if < 10 kg). [129]	INR < 1.8	Consider calcium gluconate 3 mg/ml of FP administered for associated hypocalcemia.
Prothrombin Complex Concentrate (PCC-Octaplex™ or Beriplex™)	25 IU/kg of PCCs (rounded to the closest 500 IU) maximum 2000 IU. **For warfarin reversal:** 15 IU/kg for INR < 3 (or unknown) and 30 IU/kg if INR > 3	INR < 1.8	A substitute for coagulation factor replacement when FP is unavailable. Provide fibrinogen replacement if level <1.5 g/L. Maximum 2 doses of PCC. For warfarin reversal co-administer with IV vitamin K (see dose below).
Platelets (PLTs)	10-20 mL/kg up to a maximum single dose of one apheresis unit or pooled unit (0.5 apheresis unit or pooled unit in children < 20 Kg)[129] Note: 5-10 ml/kg will increase count by approximately 50 – 100 x 10^9/L	PLTs > 50 x 10^9/L	Stored and transported at room temperature.
Fibrinogen Concentrate	50 mg/kg up to a maximum single dose of 4 grams (maximum 2 grams in children < 30 Kg)	Fibrinogen > 1.5 g/L	Fibrinogen Concentrate 4g equivalent to approximately 10 units of cryoprecipitate. Children who have undergone cardiopulmonary bypass may require higher fibrinogen levels (> 2 g/L).
Cryoprecipitate	1 unit/10 kg (5-10 mL/kg)[129] up to a maximum single dose of 10 units (5 units in children<20 kg).	Fibrinogen > 1.5 g/L	Typically ordered in units and neonatal dose is 1 unit.

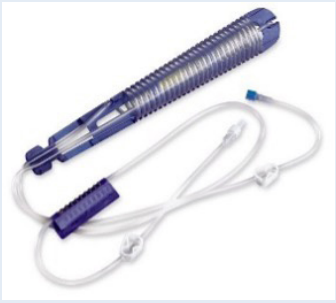
Product/Drug	Dose	Target	Additional Notes
Sodium Bicarbonate	2-3 meq (mmol)/kg	pH > 7.2	Administration is controversial in MHP. Excessive dosing may cause hypernatremia; rapid administration may cause intraventricular hemorrhage in neonates.
Tranexamic acid	Regular bleeding: 10-15 mg/kg bolus load to 1 gram max followed by: <13 years 5 mg/kg/hr infusion. >/= 13 years 1 gm over 8 hours **If bleeding is catastrophic:** < 13 years 30 mg/kg load to 2 gram max followed by 10 mg/kg/hr infusion. >/= 13 years 15 mg/kg (max 1g) bolus and 15 mg/kg (max 1g) bolus repeated at 1 hour, 15 mg/kg (max 1g) bolus and repeated if ongoing bleeding at ≥ 30 min or 30 mg/kg (max 2g) single bolus.	Ensure fibrinogen > 1.5 g/L and dose within 3 hours of trauma or initiation of hemorrhage	Efficacy and safety in pediatrics in the presence of TBI is unclear.
Undiluted Calcium Chloride ($CaCl_2$) or Calcium gluconate	15-20 mg/kg[28] IV "push" 45-60 mg/kg IV over 5-10 mins.	Ionized calcium > 1.15 mmol/L	Bolus either in setting of MHP and unstable hemodynamics and/or hyperkalemia related arrhythmia. $CaCl_2$ extravasation can cause tissue necrosis (prefer CVL access or use larger peripheral IV catheter in a more proximal site, ensure line function prior to administration). $CaCl_2$ preferable with hemodynamic instability.
Magnesium (Mg)	25-50 mg/kg over 20 mins. followed by infusion 30-60 mg/kg/24 hr	Mg > 2 mmol/L	Rapid administration may cause hypotension. Typically, hypomagnesemia is encountered after 1.5-2 blood volume loss and responsible for calcium refractory cardiac arrhythmias in children.[28]
Vasoactive and Inotropic agents	Unknown	Unknown	The early administration of vasopressors to maintain blood pressure and limit crystalloid use in this setting is controversial.[130]
Vitamin K (only for warfarin reversal)	1 to 10 mg (neonate to adolescent) IV over 10-20 minutes	INR<1.8	Coadminister with PCC for warfarin reversal. Requires 6-8 hrs to work.

Product/Drug	Dose	Target	Additional Notes
Protamine	Call pharmacy for dosing	PTT or ACT	Administer for heparin reversal. May cause acute hypotension and/or pulmonary hypertension.
Reversal agents for DOACs: Idarucizumab (for dabigatran) Alternative nonspecific agents (FP & PCC) can counteract DOACs when specific reversal agents are unavailable.[131]	Consultation with a hematologist is recommended	DOAC dependent[132]	Current available DOACs are either a direct thrombin inhibitor (dabigatran etexilate) or specific inhibitors of factor Xa (apixaban, betrixaban, edoxaban and rivaroxaban).

Note: ACT=activated clotting time, CVL=central venous line, DOACs= direct oral anticoagulants, DIC=disseminated intravascular coagulation, FP=frozen plasma, Hgb=hemoglobin, Hct=hematocrit, hr=hour, INR=international normalized ratio, IU = international unit, IV=intravenous, kg=kilogram, mg=milligram, ml=milliliter, meq=millequivalents, mmol=millimole, µ = micro; M = molar, prn=as required, PCC=prothrombin complex concentrate, PTT=partial thromboplastin time, RBC=red blood cell, TBI=traumatic brain injury.

TIPS FOR ADMINISTERING FLUIDS AND BLOOD PRODUCTS IN CHILDREN

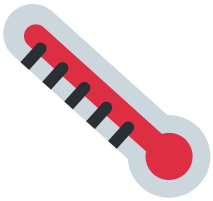
<table>
<tr><th>TOPIC</th><th>EXAMPLE</th><th>FIGURE or LINK</th></tr>
<tr><td>Rapid volume resuscitation:</td><td>Infusion pump, level I or pressure bag</td><td>TIPS FOR VOLUME RESUSCITATING PEDIATRIC PATIENTS
Warm fluids
Monitor for electrolyte imbalances
Prevent air embolism
HD stable: Use infusion pump
Transfuse blood products at 2-5 mL/kg/hr
Hemodynamic instability or major bleeding requiring rapid fluid delivery with IV size ≥ 18 g
Use rapid infuser when available
Hemodynamic instability or major bleeding with IV size ≤ 18 g
Use warmed fluids or a fluid warming device
Use a pressure bag at 300 mmHG or hand held syringes</td></tr>
<tr><td rowspan="2">Warming fluids:</td><td>Use stop-cock to push blood through proximal end of Hotline™ with distal end either:
a. Connected to patient iv
or
b. Connected to syringe to receive warmed blood (see figure)</td><td>  </td></tr>
<tr><td>Ranger™ (Pediatric Cassette)</td><td>  </td></tr>
</table>

TOPIC	EXAMPLE	FIGURE or LINK
	Bair hugger™ pediatric sized blanket with temperature settings and placed under the patient. A clear plastic sheet can be placed over the patient.	
	Bair hugger™ fluid warming set	
	Warming cabinets: approved for safe warming of iv fluids (NOT BLOOD)	
Intraosseous Access:	Insertion devices and techniques (land marking)	https://www.youtube.com/watch?v=v7A8b1GQA08 Intraosseous needle insertion video (NEJM)
Fluid boluses:	Push/pull method: a. Figure provides example of 40-micron filter and dispensing pin used to draw blood from RBC unit; link provides example of fluid bolus in children	 https://www.youtube.com/watch?v=UpUW_Nh9T1s

TOPIC	EXAMPLE	FIGURE or LINK
	b. Infusion pumps: typically, back pressure manufacturer default alarm set at 6 psi (300 mmHg), consider lowering to 2 psi (100 mmHg) to alert for interstitial extravasation of fluid.	Canadian Agency for Drugs and Technologies in Health HTA Health Technology Inquiry Service (HTIS) CADTH_Guidelines for Infusion pumps in pediatrics August 2009 CADTH Infusion pump pressure settings and guidelines October 2015
Administering blood products:	Pediatric Vascular Access	Link for IV insertion video in pediatric patients https://academic.oup.com/bjaed/article/15/4/199/305980
	Vascular access using ultrasound	
	Filtration	A standard blood administration set with a 170-260-micron filter or equivalent efficacy approved by Health Canada must be used for infusion of fresh blood components (RBC, plasma, platelets, cryoprecipitate). Transfusion may occur as fast as tolerated but must be completed within 4 hours. https://blood.ca/en/hospital-services/products/component-types/circular-information
Vein finders:	Vein Viewers	 

TIPS TO REDUCE HEAT LOSS IN PEDIATRIC PATIENTS

Pediatric patients are more susceptible to heat loss and should receive interventions to avoid hypothermia



WARM THE ENVIRONMENT

- Use radiant heaters
- Raise the temperature of the room

WARM THE PATIENT

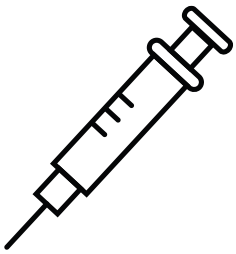
- Apply warming convective air blankets under and over the patient
- Use chemical warming pads
- Use heat and moisture exchanger on endotracheal tube

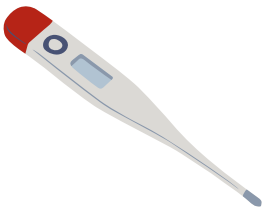
RETAIN PATIENT'S OWN WARMTH

- Remove any wet or damp clothing or blankets
- Use plastic to wrap patient
- Use hat to cover patient's head

WARM ALL FLUIDS PRIOR TO INFUSION

- Warm syringes under warming blanket
- Use pediatric blood and fluid warming devices





MONITOR TEMPERATURE FREQUENTLY/ CONTINUOUSLY (GOAL >36˚C)

Note: Therapeutic hypothermia has **NOT** been shown to improve outcomes in pediatric patients with traumatic brain injury

PEDIATRIC PATIENTS, DEFINITIVE CARE AT HOSPITAL

To be repeated on each page

MASSIVE HEMORRHAGE PROTOCOL (MHP) CHECKLIST

TIME & PACK	ACTION	☐ INITIALS
ACTIVATION & PACK 1 (date dd _ _ / mo_ _ _ / yr_ _ time _ _ /_ _)		
	MHP Lead RN: _____	
	Call to hospital locating (ext. - - - -) to activate **CODE TRANSFUSION**	☐
	Provide patient number, name, sex, age, body weight in kg (if < 13 years of age), location, and information regarding patient use of antiplatelet or anticoagulants to blood bank at ext. - - - - Anti-platelets ☐ Yes; Anticoagulant ☐ Yes, drug name:_____	
	☐ Ensure identification band is affixed to patient	
	☐ Obtain group and screen sample	
	☐ Obtain baseline blood work	
	<u>Tranexamic acid</u>: Consider administering 30 mg/kg iv bolus tranexamic acid (maximum dose 2 g) over 20 minutes and an iv/io infusion of 10 mg/kg/hour *Hold if: more than 3 hours from injury/onset of hemorrhage or given pre-hospital or pre-activation or patient has a gastrointestinal hemorrhage*	☐
	<u>Hypothermia prevention</u>: ☐ Measure and document patient temperature ☐ Obtain blood warmer for all infusions ☐ If patient temperature less than 36^{o}C start active warming	
	<u>Definitive hemorrhage control:</u> Notify if required: ☐ Operating Room ☐ Interventional Radiology ☐ Gastroenterology	☐
	<u>Obtain 1st MHP pack (if not obtained before activation):</u> Pack arrival time (_ _/_ _) ☐☐☐☐ 1 - 4 units Red Cells (RBCs) [# units dependent on the patient's body weight (kg); 20 ml/Kg per dose, unless laboratory results direct otherwise)] *Use Rh-negative blood only for females* *Avoid additional boluses or infusions of crystalloid except on physician order*	☐
	☐ **<u>Platelets:</u>** If platelet count below 50 x10^{9}/L or patient on an antiplatelet drug, transfuse 10 mL/kg of pooled platelets	☐
	☐ **<u>Fibrinogen:</u>** if fibrinogen less than 1.5 g/L, administer 50 mg/kg fibrinogen concentrate (max dose 4 g if > 30 kg; max dose 2 g if < 30 kg) over 5 min by iv push	☐
	☐ **<u>Calcium:</u>** 20 mg/kg (maximum 1 g) Calcium Chloride or 60 mg/kg (maximum 3 g) Calcium Gluconate iv push after pack 1 or ionized calcium <1.15 mmol/L	☐
	<u>Anticoagulant reversal:</u> ☐If Warfarin: PCC 15 IU/kg (for INR <3 or if INR unknown) or PCC 30 IU/kg (for INR > 3) iv over 10 minutes AND Vitamin K 1- 10 mg (neonate to adolescent) iv over 10 min ☐If Xa inhibitors (e.g., apixaban, rivaroxaban), Dabigatran, or Heparins: consultation with hematologist recommended	☐ ☐

PACK 2 (Arrival time _ _ /_ _)

	☐ Obtain hour one blood work	
	☐ Review last set of blood work to ensure at target: Hemoglobin greater than 80 g/L, INR less than 1.8, fibrinogen greater than 1.5 g/L, platelets greater than $50x10^9$/L, blood glucose > 4 mmol/L , ionized calcium ≥ 1.15 mmol/L & potassium < 5.8 mmol/L	☐
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C start active warming	
	Obtain 2nd MHP pack (if needed): Transfusions based on laboratory measures where feasible ☐☐☐☐ 1 - 4 units Red Cells (RBCs) [# units dependent on the patient's body weight (kg); 20 ml/Kg per dose, unless laboratory results direct otherwise)] ☐☐☐☐ 1 - 4 units Frozen plasma [# units dependent on the patient's body weight (kg); 10-20 ml/Kg per dose, unless laboratory results direct otherwise)]	☐ ☐
	☐ **Platelets:** if platelet count below $50 x10^9$/L, 10 mL/kg of pooled platelets	☐
	☐ **Fibrinogen:** if fibrinogen less than 1.5 g/L, administer 50 mg/kg fibrinogen concentrate (max dose 4 g if > 30 kg else max 2 g if < 30 kg) over 5 min by iv push	☐
	Anticoagulant reversal (only if ongoing hemorrhage): ☐ If Xa inhibitors (second dose): consultation with hematologist recommended	☐
	☐ **Calcium:** 20 mg/kg (max 1 g) Calcium Chloride or 60 mg/kg (max 3 g) Calcium Gluconate iv push after pack 2 or ionized calcium <1.15 mmol/L	☐

PACK 3 (Arrival time _ _ /_ _)

	☐ Obtain hour 2 blood work	
	☐ Review last set of blood work to ensure at target including blood glucose > 4 mmol/L , ionized calcium ≥ 1.15 mmol/L & potassium < 5.8 mmol/L	☐
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C start active warming	
	Obtain 3rd MHP pack (if needed) Transfusions based on laboratory measures where feasible ☐☐☐☐ 1 - 4 units Red Cells (RBCs) [# units dependent on the patient's body weight (kg); 20 ml/Kg per dose, unless laboratory results direct otherwise)] ☐☐ 1 - 2 units Frozen plasma [# units dependent on the patient's body weight (kg); 10 ml/Kg per dose, unless laboratory results direct otherwise)] ☐ 50 mg/kg fibrinogen concentrate (max dose 4 g if > 30 kg; max 2 g if < 30 kg) over 5 min by iv push	☐ ☐ ☐
	☐ **Platelets:** if platelet count below $50 x10^9$/L, 10 mL/kg of pooled platelets	☐
	☐ **Calcium:** 20 mg/kg (max 1 g) Calcium Chloride or 60 mg/kg (max 3 g) Calcium Gluconate iv push after pack 3 or ionized calcium <1.15 mmol/L	☐

PACK 4 (Arrival time _ _ /_ _)		
	☐ Obtain hour 3 blood work	
	☐ Review last set of blood work to ensure at target including blood glucose > 4 mmol/L ionized calcium ≥ 1.15 mmol/L, potassium < 5.8 mmol/L & magnesium ≥ 0.70 mmol/L	☐
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C start active warming	
	Obtain 4th pack (if needed) Transfusions based on laboratory measures where feasible ☐☐☐☐ 1 - 4 units Red Cells (RBCs) [# units dependent on the patient's body weight (kg); 20 ml/Kg per dose, unless laboratory results direct otherwise)] ☐☐ 1 - 2 units Frozen plasma [# units dependent on the patient's body weight (kg); 10 ml/Kg per dose, unless laboratory results direct otherwise)]	☐ ☐
	☐ **Platelets:** if platelet count below 50 x10^9/L, 10 mL/kg of pooled platelets	☐
	☐ **Fibrinogen:** if fibrinogen less than 1.5 g/L, administer 50 mg/kg fibrinogen concentrate (max dose 4 g if > 30 kg; maxi 2 g if < 30 kg) over 5 min by iv push	☐
	☐ **Calcium:** 20 mg/kg (max 1 g) Calcium Chloride or 60 mg/kg (max 3 g) Calcium Gluconate iv push after pack 4 or ionized calcium <1.15 mmol/L	☐
PACK 5 (Arrival time _ _ /_ _)		
	☐ Obtain hour 4 or greater blood work	
	☐ Review last set of blood work to ensure at target including blood glucose > 4 mmol/L ionized calcium ≥ 1.15 mmol/L, potassium < 5.8 mmol/L & magnesium ≥ 0.70 mmol/L	☐
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C commence active warming	
	Obtain 5th (if needed) Transfusions based on laboratory measures where feasible ☐☐☐☐ 1 - 4 units Red Cells (RBCs) [# units dependent on the patient's body weight (kg); 20 ml/Kg per dose, unless laboratory results direct otherwise)] ☐☐ 1 - 2 units Frozen plasma [# units dependent on the patient's body weight (kg); 10 ml/Kg per dose, unless laboratory results direct otherwise)]	☐ ☐
	☐ **Platelets:** if platelet count below 50 x10^9/L, 10 mL/kg of pooled platelets	☐
	☐ **Fibrinogen:** if fibrinogen less than 1.5 g/L, administer 50 mg/kg fibrinogen concentrate (max dose 4 g if > 30 kg; max 2 g if < 30 kg) over 5 min by iv push	☐
	☐ **Calcium:** 20 mg/kg (max 1 g) Calcium Chloride or 60 mg/kg (max 3 g) Calcium Gluconate iv push after each pack or ionized calcium <1.15 mmol/L	☐
TERMINATION (time _ _ /_ _)		
	Once hemorrhage control is obtained and patient is hemodynamically stable call blood bank and the hematology laboratories to terminate the protocol	☐
	☐ Measure and document patient temperature	
	☐ Return all unused blood products in appropriate storage containers	
	☐ Complete this form and place in patient chart	
	☐ Complete handover SBAR tool below with receiving team	

HANDOVER SBAR TOOL FOR HANDOVER TO THE CRITICAL CARE TEAM

(Time _ _ /_ _)

S: SITUATION (Relay the following)	HANDOVER NOTES
☐ Patient age, sex, weight ☐ Patient estimated blood volume (70 ml/kg) _____L	
☐ Context (trauma ± TBI, surgery, or other)	
B: BACKGROUND (Relay the following)	
☐ TXA administration _____ g	
☐ Total volume (mL-unless specified) of blood products _____ RBC _____ Plasma _____ PLTs _____ g Fibrinogen _____ IU PCC	
☐ Total (L) crystalloid and/or colloid and urine output _____ L of non-blood product fluid; _____ L of urine output	
☐ IV / IO access and need for vasopressors	
☐ For trauma, external/internal bleeding ± TBI management	
☐ Consultant(s) involved (e.g., surgery, radiology or gastroenterology)	
☐ Complications (hypothermia, coagulopathy, acidosis or arrhythmias)	
A: ASSESSMENT (Relay the following)	
☐ Hemodynamic status (stable or unstable, vitals and temperature)	
☐ Definitive hemorrhage control achieved? YES / NO	
☐ Critical labs (specify) and latest blood work results Hgb _____ PLT _____ INR _____ Fibrinogen _____ Lactate _____ Calcium _____	
☐ Availability of blood products from blood bank/coolers at bedside	
R: RECOMMENDATION (Consider the following)	
☐ Consider need for additional blood products since last set of labs	
☐ Consider need for further consultation, tests and drug re-dosing	

PEDIATRIC PATIENTS, NON-DEFINITIVE CARE AT HOSPITAL
NO PLASMA AVAILABLE ON SITE
PATIENT TO BE TRANSFERRED TO TERTIARY CENTRE

To be repeated on each page

MASSIVE HEMORRHAGE
PROTOCOL (MHP) CHECKLIST

TIME & PACK	ACTION	☐ INITIALS
ACTIVATION & PACK 1 (date dd _ _ / mo _ _ _ / yr _ _ time _ _ /_ _)		
	MHP Lead RN: _____	
	Call to hospital locating (ext. - - - -) to activate **CODE TRANSFUSION**	☐
	Provide patient number, name, sex, age, body weight in kg (if < 13 years of age), location, and information regarding patient use of antiplatelet or anticoagulants to blood bank at ext. - - - - Anti-platelets ☐ Yes; Anticoagulant ☐ Yes, drug name:_____	
	☐ Ensure identification band is affixed to patient	
	☐ Obtain group and screen sample	
	☐ Obtain baseline blood work	
	Tranexamic acid: Consider administering 30 mg/kg iv bolus tranexamic acid (maximum dose 2 g) over 20 minutes and an iv/io infusion of 10 mg/kg/hour *Hold if: more than 3 hours from injury/onset of hemorrhage or given pre-hospital or pre-activation or patient has a gastrointestinal hemorrhage*	☐
	Hypothermia prevention: ☐ Measure and document patient temperature ☐ Obtain blood warmer for all infusions ☐ If patient temperature less than 36°C start active warming	
	Initiate transfer out: Notify if required: ☐ CritiCall - 1-800-668-4357 ☐ EMS ☐ Ornge	☐
	Obtain 1st MHP pack (if not obtained before activation): Pack arrival time (_ _/_ _) ☐ ☐ ☐ ☐ 4 units Red Cells (RBCs) [# units dependent on the patient's body weight (kg); 20 ml/Kg per dose, unless laboratory results direct otherwise)] *Use Rh-negative blood only for females* *Avoid additional boluses or infusions of crystalloid except on physician order*	☐
	☐ **Platelets (if available):** If platelet count below 50 x10^9/L or patient on an antiplatelet drug, transfuse 10 mL/kg of pooled platelets	☐
	☐ **Fibrinogen:** if fibrinogen less than 1.5 g/L, administer 50 mg/kg fibrinogen concentrate (max dose 4 g if > 30 kg; max dose 2 g if < 30 kg) over 5 min by iv push	☐
	☐ **Calcium:** 20 mg/kg (maximum 1 g) Calcium Chloride or 60 mg/kg (maximum 3 g) Calcium Gluconate iv push after pack 1 or ionized calcium <1.15 mmol/L	☐
	Anticoagulant reversal: ☐If Warfarin: PCC 15 IU/kg (for INR <3 or if INR unknown) or PCC 30 IU/kg (for INR > 3) iv over 10 minutes AND Vitamin K 1- 10 mg (neonate to adolescent) iv over 10 min	☐ ☐

	☐ If Xa inhibitors (e.g., apixaban, rivaroxaban), Dabigatran, or Heparins: consultation with hematologist recommended	
PACK 2 (Arrival time _ _ /_ _)		
	☐ Obtain hour one blood work	
	☐ Review last set of blood work to ensure at target: Hemoglobin greater than 80 g/L, INR less than 1.8, fibrinogen greater than 1.5 g/L, platelets greater than $50x10^9$/L, blood glucose > 4 mmol/L , ionized calcium ≥ 1.15 mmol/L & potassium < 5.8 mmol/L	☐
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C start active warming	
	<u>Obtain 2nd MHP pack (if needed):</u> Transfusions based on laboratory measures where feasible ☐☐☐☐ 4 units Red Blood Cells [# units dependent on the patient's body weight (kg); 20 ml/Kg per dose, unless laboratory results direct otherwise)]	☐
	☐ Prothrombin Complex Concentrate 25 IU/kg (round to closest 500 IU) max 2000 IU	☐
	☐ Fibrinogen concentrate 50 mg/kg (max dose 4 g if > 30 kg; max dose 2 g if < 30 kg) over 5 min by iv push	☐
	☐ **<u>Platelets (if available):</u>** if platelet count < $50 x10^9$/L, 10 mL/kg of pooled platelets	☐
	<u>Anticoagulant reversal (only if ongoing hemorrhage):</u> ☐ If Xa inhibitors (second dose): consultation with hematologist recommended	☐
	☐ **<u>Calcium:</u>** 20 mg/kg (max 1 g) Calcium Chloride or 60 mg/kg (max 3 g) Calcium Gluconate iv push after pack 2 or ionized calcium <1.15 mmol/L	☐
PACK 3 (Arrival time _ _ /_ _)		
	☐ Obtain hour 2 blood work	
	☐ Review last set of blood work to ensure at target including blood glucose > 4 mmol/L , ionized calcium ≥ 1.15 mmol/L & potassium < 5.8 mmol/L	☐
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C start active warming	
	<u>Obtain 3rd MHP pack (if needed)</u> Transfusions based on laboratory measures where feasible ☐☐☐☐ 4 Units Red Blood Cells [# units dependent on the patient's body weight (kg); 20 ml/Kg per dose, unless laboratory results direct otherwise)]	☐
	☐ Prothrombin Complex Concentrate 25 IU/kg (round to closest 500 IU) max 2000 IU	☐
	☐ Fibrinogen concentrate 50 mg/kg (max dose 4 g if > 30 kg; max dose 2 g if < 30 kg) over 5 min by iv push	☐
	☐ **<u>Platelets (if available):</u>** if platelet count < $50 x10^9$/L, 10 mL/kg of pooled platelets	☐
	☐ **<u>Calcium:</u>** 20 mg/kg (max 1 g) Calcium Chloride or 60 mg/kg (max 3 g) Calcium Gluconate iv push after pack 3 or ionized calcium <1.15 mmol/L	☐

PEDIATRIC PATIENTS, NON-DEFINITIVE CARE AT HOSPITAL
NO PLASMA AVAILABLE ON SITE
PATIENT TO BE TRANSFERRED TO TERTIARY CENTRE

TERMINATION (time _ _ /_ _)		
	Once <u>either</u> hemorrhage control is obtained and patient is hemodynamically stable call blood bank and the hematology laboratories to terminate the protocol <u>or</u> patient has been transferred to tertiary centre for definitive hemorrhage control	☐
	☐ Measure and document patient temperature	
	☐ Return all unused blood products in appropriate storage containers	
	☐ Complete this form and place in patient chart	
	☐ Complete handover SBAR tool below with transport team	

HANDOVER SBAR TOOL FOR HANDOVER TO THE TRANSPORT TEAM
(Time _ _ /_ _)

S: SITUATION (Relay the following)	HANDOVER NOTES
☐ Patient age, sex, weight ☐ Patient estimated blood volume (70 ml/kg) _____L	
☐ Context (trauma ± TBI, surgery, or other)	
B: BACKGROUND (Relay the following)	
☐ TXA administration ____ grams	
☐ Total volume (ml-unless specified) of blood products ____ RBC ____ PLTs ____ g Fibrinogen _____ IU PCC	
☐ Total (L) crystalloid and/or colloid and urine output _____ L of non-blood product fluid; ____ L of urine output	
☐ IV / IO access and need for vasopressors	
☐ For trauma, external/internal bleeding ± TBI management	
☐ Consultant(s) involved (e.g., surgery, radiology or gastroenterology)	
☐ Complications (hypothermia, coagulopathy, acidosis or arrhythmias)	
A: ASSESSMENT (Relay the following)	
☐ Hemodynamic status (stable or unstable, vitals and temperature)	
☐ Blood products prepared for transport	
☐ Critical labs (specify) and latest blood work results Hgb ____ PLT ____ INR ____ Fibrinogen ____ Lactate ____ Calcium ____	
R: RECOMMENDATION (Consider the following)	
☐ Consider need for additional blood products during transport	
☐ Consider need for drug re-dosing during transport	

PEDIATRIC HOSPITAL BLOOD PRODUCT DOSING COOLER/PACK LABEL REMINDER TO ACCOMPANY ALL COOLERS

CAUTION! PEDIATRIC USE (age < 13 years old)

DOSE BY WEIGHT & LIMIT CRYSTALLOIDS

"CODE TRANSFUSION" Cooler #1

Weight	Content of Cooler #1 Units (U)	RBC Dose	Goals
>40 Kg	4 U RBC	20 mL/Kg per dose	Hgb > 80 g/L INR < 1.8 PLTs>50 x 10^9/L Fibrinogen> 1.5 g/L
31-40 Kg	3 U RBC		
10-30 Kg	2 U RBC		
< 10 Kg	1 U RBC		

Note: Infuse all of "Cooler #1" RBCs **BEFORE** starting "Cooler # 2" products, **UNLESS** lab results guide otherwise.

CAUTION! PEDIATRIC USE (age < 13 years old)

DOSE BY WEIGHT & LIMIT CRYSTALLOIDS

"CODE TRANSFUSION" Cooler #2

Weight	Content of Cooler #2 Units (U)	RBC : FP Dose	Goals
>40 Kg	4 U RBC & 4 U FP	20 mL : 10-20 mL per Kg/dose	Hgb > 80 g/L INR < 1.8 PLTs>50 x 10^9/L Fibrinogen> 1.5 g/L
31-40 Kg	3 U RBC & 3 U FP		
10-30 Kg	2 U RBC & 2 U FP		
< 10 Kg	1 U RBC & 1 U FP		

Note: Adjust RBC:FP ratio 1-2:1 as needed **UNTIL** lab guided dosing possible; platelets 10 ml/Kg/dose

CAUTION! PEDIATRIC USE (age < 13 years old)

DOSE BY WEIGHT & LIMIT CRYSTALLOIDS

"CODE TRANSFUSION" Cooler #3

Weight	Content of Cooler #3 Units (U)	RBC : FP & Fibrinogen Dose	Goals
>40 Kg	4 U RBC & 2 U FP 4 g Fibrinogen	20 mL : 10 mL per Kg/dose Fibrinogen 50 mg per Kg	Hgb > 80 g/L INR < 1.8 PLTs>50 x 10^9/L Fibrinogen> 1.5 g/L
31-40 Kg	3 U RBC & 2 U FP 2 g Fibrinogen		
10-30 Kg	2 U RBC & 1 U FP 2 g Fibrinogen		
< 10 Kg	1 U RBC & 1 U FP 1 g Fibrinogen		

Note: Adjust RBC:FP ratio 1-2:1 as needed **UNTIL** lab guided dosing possible; consider platelets (10 ml/Kg/dose) if delayed platelet count results

PEDIATRIC HOSPITAL BLOOD PRODUCT DOSING COOLER/PACK LABEL REMINDER TO ACCOMPANY ALL COOLERS

CAUTION! PEDIATRIC USE (age < 13 years old)

DOSE BY WEIGHT & LIMIT CRYSTALLOIDS

CODE TRANSFUSION" Cooler #4+

Weight	Content of Cooler #4 Units (U)	RBC : FP Dose	Goals
>40 Kg	4 U RBC & 2 U FP	20 mL : 10 mL per Kg/dose	Hgb > 80 g/L INR < 1.8 PLTs>50 x 10^9/L Fibrinogen> 1.5 g/L
31-40 Kg	3 U RBC & 2 U FP		
10-30 Kg	2 U RBC & 1 U FP		
< 10 Kg	1 U RBC & 1 U FP		

Note: Adjust RBC:FP ratio 1-2:1 as needed **UNTIL** lab guided dosing possible; platelets 10 ml/Kg/dose

COMMUNITY HOSPITAL (WHERE PLASMA NOT AVAILABLE) PEDIATRIC BLOOD PRODUCT DOSING COOLER/PACK LABEL REMINDER TO ACCOMPANY ALL COOLERS

CAUTION! PEDIATRIC USE (age < 13 years old)

DOSE BY WEIGHT & LIMIT CRYSTALLOIDS

CODE TRANSFUSION" Cooler #1

Weight	Content of Cooler #1 Units (U)	RBC Dose	Goals
>40 Kg	4 U RBCs	20 mL/Kg per dose	Hgb > 80 g/L INR < 1.8 PLTs>50 x 10^9/L Fibrinogen> 1.5 g/L
31-40 Kg	3 U RBCs		
10-30 Kg	2 U RBCs		
< 10 Kg	1 U RBCs		

Note: Infuse all of "Cooler #1" RBCs BEFORE starting "Cooler # 2" products, UNLESS lab results guide otherwise.

COMMUNITY HOSPITAL (WHERE PLASMA NOT AVAILABLE) PEDIATRIC BLOOD PRODUCT DOSING COOLER/PACK LABEL REMINDER TO ACCOMPANY ALL COOLERS

CAUTION! PEDIATRIC USE (age < 13 years old)

DOSE BY WEIGHT & LIMIT CRYSTALLOIDS

CODE TRANSFUSION" Cooler #2+

Weight	Content of Cooler #2+	RBC, PCC & Fibrinogen Dose	Goals
>40 kg	4 U RBC, 2000 IU PCC & 4 g FBGN	RBC 20 mL/Kg per dose PCC 25 IU/Kg (rounded to closest 500 IU) maximum 2000 IU Fibrinogen 50 mg per Kg	Hgb > 80 g/L INR < 1.8 PLTs>50 x 10^9/L Fibrinogen> 1.5 g/L
31-40 kg	3 U RBC, 1000 IU PCC & 2 g FBGN		
10-30 kg	2 U RBC, 1000 IU PCC & 2 g FBGN		
< 10 kg	1 U RBC, 500 IU PCC & 1 g FBGN		

Note: platelets 10 ml/Kg/dose

SIMULATION EXERCISE

Curriculum Topic/Title:	Massive Hemorrhage Protocol: PEDIATRIC MHP
Developed by:	Devin Singh, J Pirie, Natasha Collia, Suzanne Beno (MPH Pediatric WG), Teresa Skelton (MPH Pediatric WG), Heather O'Reilly (Department of Anesthesiology and Pain Medicine, CHEO)
Creation/Modification Date:	March 2020; mod: 2020-Jun-18

Learning Objectives:

1. Demonstrate how to transfuse blood products and administer medications including tranexamic acid and calcium on a per kg basis;
2. Organize and initiate a timely patient transfer procedure to a tertiary care pediatric center; and
3. Recognize and treat key complications (hyperkalemia and hypothermia)

References / Review Articles:

Callum JL, Yeh CH, Petrosoniak A et al. A regional massive hemorrhage protocol developed through a modified Delphi technique. CMAJ Open 2019; 7:E546–E561.

PATIENT & SCENARIO INFORMATION FOR FACILITATORS

Patient Name: EDWARD CHAN

Patient Info: PMH, current problem/procedure, meds, allergies:

7-year-old male being brought in by emergency medical services (EMS). Found lying on ground, 10 feet away from an ATV, moaning in pain. EMS patches in Glasgow Coma Scale (GCS) score of 13 and extreme tachycardia and pallor. Estimated time-to-arrival (ETA) to resuscitation room is 10 minutes. Parents not available to provide remaining information.

Location / Setting: Emergency Department

EQUIPMENT FOR EXERCISE:

Comments:

- This exercise does NOT require a high fidelity mannequin, but could be used with one
- A method to communicate vital signs is required. Options include:
  - » Whiteboard or paper-based technique
  - » Tablet-based technique using app based software (example SimMon on and iPad)
  - » Software from high-fidelity mannequin

Monitors required:

Available	On patient		Available	On patient	
☐	☒	NIBP	☒	☐	ECG
☒	☐	Arterial line	☒	☐	Temperature
☒	☐	CVP	☒	☒	Pulse oximeter
☐	☐	PA Catheter	☒	☐	Capnograph
☐	☐	Fetal heart monitor	☒	☐	IV (primary)
☐	☐	Urinary catheter	☒	☐	Secondary IV
☐	☒	Oxygen mask	☒	☒	Interosseous (IO) line

Other equipment required:

- Equipment that would normally be available in this clinical area per institutional protocols should be available for this simulation.

Simulation Video
A video based on this exercise script is also available for training purposes. Available at this link:
https://transfusionontario.org/en/category/massive-hemorrhage-protocol/simulation-videos/

Supporting Files (assessment, labs, imaging, etc):

1. Q30-60 minute labwork
2. Observational tool
3. Participant evaluation form available at:

Scenario Content:

Information for Learner:

(place on a separate page as we often give them this 'stem' to read, along with the anesthetic record / supporting documents if appropriate)

7-year-old male being brought in by EMS. Found lying on ground 10 feet from an ATV moaning in pain. EMS patches in GCS of 13 and extreme tachycardia and pallor. ETA to resuscitation room is 10 minutes. Parents not available to provide remaining information.

EMS arrival and handover: IO access (distal tibia) x1 established. One 20 ml/kg normal saline bolus pushing currently. GCS 12. Vital signs HR 150-160 bpm, BP 90/68 mmHg, RR 28, SpO2 92% on 100% O2 via facemask.

Scenario Content:

Additional Information for Instructor only, including:
Roles of confederates or other participants
Type of HELP available:

Instructor / Leader of this exercise will pre-determine the number and nature of respondents corresponding to realistic local resouce availability

Simulator Setup and Programming Notes:

One facilitator (not the leader) should be assigned to dissemination of current vital signs throughout the simulation. This individual should have sufficient medical knowledge to be able to alter the vital signs in a realistic fashion in response to events as they occur during the simulation.

Baseline Simulator Physiologic State (leave blank if not relevant):

HR: ***155*** BP: ***85/52*** RR: ***26*** SpO_2: ***95%***

Weight: ***25 kg***

Neuro (LOC, orientation etc.): ***GCS 12***

Respiratory: ***tachypneic, no chest wall trauma, equal bilateral breath sounds***

Progress During Scenario: ***Standard trauma management, including IV access, spine precautions, primary survey, which demonstrates a postitive FAST and a fractured femur, with concern for intraabdominal injury as source of blood loss. . Patient responds appropriately to MHP and fluids. If high functioning team and scenario lasts long enough, labs will demonstrate hyperkalemia (K 5.9) which requires treatment.***

Laboratory, Radiology, or other relevant information, available initially or as the scenario progresses:

need image of pediatric femur fracture

Key Processes During MHP Simulation

T7 Framework

- Triggering
- Team
- Testing
- Tranexamic Acid
- Temperature
- Transfusion
- Termination

Discussion and Teaching Points for Debriefing:

- Minimum of 2 facilitators required, preferably interprofessional
- Notes should be taken during the scenario to identify processes well done and areas of improvement
- Team debriefing is required, with focus on system improvement and not individual performances

Post Simulation Activities:

- One or more individuals must, a priori, be tasked with compiling a summary from each simulation including areas for system improvement, individual(s) responsible for addressing the issues identified during the simulation
- This process should become part of the routine quality and safety processes at the institutional level
- Follow up, and repeat simulations are mandatory, as a single intervention without follow up will not lead to any improvement in patient care

B. Blood work results for simulation

Lab work	On arrival	30 minutes	60 minutes	90 minutes
Hemoglobin (g/L)	85	75	78	95
Platelets (x10^9/L)	350	300	225	180
INR	1.9	1.6	1.5	1.5
Fibrinogen (g/L)	1.5	1.5	1.3	1.9
Sodium (mmol/L)	140	142	145	145
Potassium (mmol/L)	4.8	5.9	5.4	5.0
Ionized calcium(mmol/L)	1.30	1.05	1.4	1.25
Glucose (mmol/L)	8	9	10	12
Lactate	1.4	2.2	2.8	3.5
Arterial blood gas				
PH	7.25		7.35	
PO2 (mmHg)	250		175	
PCO2 (mmHg)	35		38	
HCO3 (mmol/L)	15		20	
Base Deficit	Minus 11		Minus 4	
FIO2 (%)	100		50	
Blood products and drugs ideally administered	RBC 20 ml/kg & FP 10-20 ml/kg; TXA load 15 mg/kg and infusion 5 mg/kg/hr	RBC 20 ml/kg; $CaCl_2$ 15 mg/kg or Calcium gluconate 45 mg/kg	RBC 20 ml/kg	TXA infusion 5 mg/kg/hr
Vital signs	Reflect 40% blood volume loss	Reflect on going 20% blood volume loss	Reflect slowing of blood volume loss (<20%)	Vitals stabilized

Adapted with permission from a Sick Kids Simulation Program Scenario.

ADVANCED SIMULATION EXERCISE

Title: Pediatric Massive Hemorrhage Protocol

Creation date: March 2020

Contributors: Suzanne Beno (MPH Pediatric WG), Teresa Skelton (MPH Pediatric WG), Heather O'Reilly (Department of Anesthesiology and Pain Medicine, CHEO)

Original Scenario: Devin Singh, J Pirie, Natasha Collia

References: Pediatric MHP toolkit, CMAJ modified Delphi article

Learning Objectives:

1. Demonstrate safe and proficient management of a pediatric patient with blunt abdominal trauma and significant bleeding.
2. Recognize need for massive hemorrhage protocol (MHP) and demonstrate ability to activate an institutional protocol.
3. Organize safe and proficient transfer of pediatric trauma patient receiving blood products.
4. Demonstrate efficient teamwork and effective communication skills in a simulated setting.

Role/Competency	Objective
Medical Expert	Recognize importance of early activation of massive hemorrhage protocol (MHP) in trauma when hemorrhagic shock is suspected
Medical Expert	Demonstrate ability to accurately use weight-based dosing for blood products and medication
Medical Expert	Recognize and manage potential unique complications of massive transfusion in children, including hypothermia and hyperkalemia
Communication	Demonstrate clear closed-loop communication and coordination of blood product orders pertaining to MHP
Collaborator	Demonstrate ability to effectively work with Laboratory, Blood Bank, Allied Health and Support personnel to efficiently and accurately activate and execute the MHP at your center
Manager	Demonstrate ability to use / delegate use of MHP Cognitive Aid
Manager	Demonstrate effective situational awareness and prioritization of management goals
Manager	Recognize need for early initiation of CritiCall and transfer protocols.

Patient Scenario Information

Patient Information: Age, past medical history, current problem, medications, allergies:

7-year-old male being brought in by emergency medical services (EMS). Found lying on ground, 10 feet away from an ATV, moaning in pain. EMS patches in Glasgow Coma Scale (GCS) score of 13 and extreme tachycardia and pallor. Estimated time-to-arrival (ETA) to resuscitation room is 10 minutes. Parents not available to provide remaining information.

Location/setting: Resuscitation room / Emergency

Monitors required:

Available	On patient		Available	On patient	
☐	☒	NIBP	☒	☐	ECG
☒	☐	Vascular access	☒	☐	Temperature
☐	☒	Intra-osseous (IO) line	☐	☒	Pulse oximeter
☒	☐	Arterial line	☒	☐	Capnograph
☒	☐	Urinary catheter	☐	☒	100% O2 Non-Rebreather

Other equipment required:

☒	Infusion Pumps	☒	ICU ventilator
☒	Defibrillator	☒	Warming blanket
☒	Fluid warmer	☒	Ultrasound
☒	Glide scope	☒	FAST
☒	Crash cart	☒	EZ IO
☒	ETT	☒	Chest tube and tray
☒	LMA	☒	**MHP Coolers**
☒	Laryngoscope	☒	IV tubing and fluids

Supporting Files and information:

iSTAT or other available point-of-care-testing (POCT)
Lab values
Ultrasound findings
Chest x-ray

Time duration (minutes):

Setup	
Simulation	
Debrief	

Scenario Content (provided to learner as stem at beginning and by EMS on arrival):

7-year-old male being brought in by EMS. Found lying on ground 10 feet from an ATV moaning in pain. EMS patches in GCS of 13 and extreme tachycardia and pallor. ETA to resuscitation room is 10 minutes. Parents not available to provide remaining information.

EMS arrival and handover: IO access (distal tibia) x1 established. one normal saline bolus pushing currently. GCS 12. Vital signs HR 150-160 bpm, BP 90/68 mmHg, RR 28, SpO2 92% on 100% O2 via facemask.

Simulator setup and programming notes:

Simulator and moulage: Sim junior, bruising to abdomen.

Medications: Epinephrine (1:10,000), Normal Saline, Fentanyl, Rocuronium, Ketamine, RBCs, FP, Platelets, TXA, Calcium Gluconate or Calcium Chloride, D10W, Insulin, Sodium Bicarbonate, Ventolin, Vasopressors.

IV access/fluids in place: IO access x 1 with normal saline push ongoing

Anesthesia or ventilation settings: 100% O2 via non-breather facemask

Scenario flow:

Vital Sign Changes	Expected Actions and Transitions	Unexpected Actions & Complications	Facilitator Notes
HR: 155 bpm BP: 85/52 mmHg RR: 26 O2 Sats: 95% on 100% non-Rebreather	Attach monitors Receive handover Begin ATLS Primary Assessment beginning with <C>ABC (catastrophic hemorrhage, airway, breathing, circulation) assessment		Estimated weight 25 kg
Stage 1 **Assessment & Diagnosis** **Diagnose Shock, Suspect Hemorrhagic** **0-5 min**			
VS: HR 160, RR 26, BP 80/51, SpO2 95% with 100% O2 **<C>:** no active external bleeding **A:** Patent, moaning in pain **B:** Tachypneic. Equal and bilateral breath sounds. No chest wall trauma. **C:** Cap refill 4 seconds, pale lips. Abdomen distended. Pelvis stable. Deformed right thigh with apparent closed right femur fracture.	**A:** Continue 100 % oxygen, ensure C spine immobilization. **B:** No intervention at this time, team may prepare for intubation and ventilation in event of patient decompensation. **C:** Establish vascular access(x2) IV access successful x 1 (AC) Consider second IO.	Recognize need for potential analgesia Recognize hemorrhagic shock and need to assess for source of bleeding; bind pelvis if child remains unstable. Begin fluid resuscitation and call for blood or activate MHP. If no recognition of need for transfusion: • Increase tachycardia • Decreased BP • Decrease GCS	iStat or POCT pending Bedside glucose 7.2 mmol/L EFAST: + fluid RUQ/pelvis, normal lung sliding

Vital Sign Changes	Expected Actions and Transitions	Unexpected Actions & Complications	Facilitator Notes
D: Pupil 4 mm, equal & reactive GCS 12 M – 5, E – 4, V - 3 R forearm deformed at wrist. Pulse present. **E:** Temp 36.1°C. Log Roll reveals extensive abrasions and bruising along R flank.	Order 2U uncrossmatched RBC Consider need to activate MHP Fluid bolus: RL or 0.9% NS up to total 20 ml/kg rapid bolus. Assess need for pelvic binder iStat or POCT and emergent lab work, cross-match (most important) + trauma labs (consider fem arterial stick to obtain blood) **D:** Maintain spinal motion restriction **E:** Warm Room, warm blankets, remove clothes and safely remove from spine board. Consider IV 1 mcg/kg fentanyl (or low dose ketamine) for analgesia Call Criticall for Pediatric TTL and initiate transfer.	Reduce and immobilize right leg. If no warmed blankets or fluids, temp starts to drop to 35.0°C	CXR, pelvis Xray, R femur and +/- lateral neck to be completed after primary survey and simultaneously with ongoing interventions. Team members wear lead to facilitate no delays.
Stage 2 **Recognize abdomen and potentially pelvis as sources of concealed bleeding.** **Activate MHP and Initiate Communication with Criticall.** **5-10 min**	Include role of Lab and Blood Bank preparing MHP Coolers. Include role of Porter to transport Coolers.	**Intubation Medications:** Resuscitate child in shock with fluid and/or blood prior to giving induction medications. **Induction:** Fentanyl 1 mcg/kg (PRN – not recommended if hemodynamics unstable) Ketamine 1-2 mg/kg IV (decrease dose to 0.5-1 mg/kg in unstable patient) **Paralysis:** Rocuronium: 1-1.2 mg/kg IV (onset 1min, lasts 20-45min, consider 1.2 mg/kg if induction agent dose lowered)	

Vital Sign Changes	Expected Actions and Transitions	Unexpected Actions & Complications	Facilitator Notes
VS: HR 165, RR 26, BP 82/50, SpO2 92 with O2 100% non-rebreather **A:** Patient continues to moan **B:** Shallow tachypneic breaths. Equal bilaterally and no adventitia. **C:** Cap refill 4 sec. Cool skin. **D:** 4mm, equal & reactive GCS 8 M – 4, E – 2, V - 2 **E:** Temp 35.0C	**A:** Patent but now unprotected due to GCS 8, will require intubation. **B**: Shallow but equal. **C:** Rapid transfusion of PRBC 2 units of uncrossed PRBCs available while MHP protocol being activated. Warm fluids. Multiple IVs established (2nd large bore AC). Consider Prox humeral IO if needed. **E:** Warmed blankets and warm room	Recognize need for intubation due to decreasing GCS. If no recognition of need for intubation: • Increase tachypnea • Decrease SpO2 • Decrease GCS Recognize need to activate MHP and transfuse blood. Activate local MHP If no recognition of need for transfusion: • Increase tachycardia • Decrease BP • Progress to PEA If no warmed blankets or fluids, temp starts to drop to 34.5	Initial iStat: Hb 80 Na 135 K 4.8 Pre-intubation VBG: pH 7.28 / PCO2 60 / pO2 70/ HCO3 16 (mixed metabolic and respiratory acidosis Glucose 7.2 Team may consider central line access, if peripheral access inadequate (stress large bore peripheral access better for rapid transfusion)
Stage 3 **Hypovolemic Shock – Utilization of MHP & Intubation (if not done already)** **10-15 min**		**Intubation Medications:** Resuscitate child in shock with fluid and/or blood prior to giving induction medications. Fentanyl 1 mcg/kg (PRN – not recommended if hemodynamics unstable) Ketamine 1-2 mg/kg IV (decrease dose to 0.5-1 mg/kg in unstable patient) **Paralysis:** Rocuronium: 1-1.2 mg/kg IV (onset 1min, lasts 20-45min, consider 1.2 mg/kg if induction agent dose lowered) **Vasopressors:** **Phenylephrine:** 0.5-1 mcg/kg IV/IO **Epinephrine:** 0.5-1 mcg/kg/IV/IO *** pressors if used must be in conjunction with fluid delivery; not used when permissive hypotensive strategy employed	

Vital Sign Changes	Expected Actions and Transitions	Unexpected Actions & Complications	Facilitator Notes
VS: HR 160, RR 20, BP 78/46, Intubated: SpO2 93% Intubated and ventilated via BVM/ETT on 100% 02 *Not Intubated: SpO2 85% on 100% non-rebreather, or SpO2 90% if BMV* **A:** Intubated, patent. (If not yet intubated, patient becomes obtunded) **B:** BVM/ETT or ventilator. SpO2 93% **C:** HR 160, BP 78/46. Peripherally cold to touch. Cap refill 4 sec. Abdomen becoming more distended. **D:** If intubated, patient should be sedated. If not intubated then patient becomes unresponsive. **E:** Temp 35.9C (If warming blanket and fluid warmer used) Temp 34.5C if no warming devices used.	**A:** Intubated – Clear. *Non intubated, airway becomes obstructed, improves with BMV.* **B:** BVM/ETT or ventilator. Equal bilaterally. No Adventitia. **C:** MHP • Cooler 1(2U RBC) - 20ml/kg given • Cooler 2 (2U RBC + 2U FP) –20 ml/kg of each infusing now • Check Plt count; order Plts if <50; anticipate ordering plt if ongoing active hemorrhage • TXA 30 mg/kg (max 2g) over 10 min if not yet given; order infusion (10 mg/kg/hr) • Calcium gluconate 60 mg/kg slow IV push • Cooler 3 (2U RBC + 1U FP + 2g fibrinogen) – on the way **D:** Warmed blankets. Insert foley. Criticall – Ornge dispatched and will be 20 min.	Cooler 2: 2U RBC + 2U FP Transfuse 20ml/kg each If no use of hotline warmer or rapid transfuser body temperature will decrease to 34.5C	Bloodwork Results: INR: 2.2 PTT: 50 Fibrinogen: 0.75 PLT: 210 K: 5.8
Stage 4 **Manage Hyperkalemia and Prep for Transport** **15-20 min**			

Vital Sign Changes	Expected Actions and Transitions	Unexpected Actions & Complications	Facilitator Notes
VS: HR 150, RR bagged, BP 88/44, SpO2 96% A: Bagging via ETT B: Equal and bilateral, no adventitia C: Cap refill 4. Repeat POCUS – no pericardial effusion; + FAST Central pulses: palpable peripheral pulses: thready and weak, cooler extremities ECG showing Peaked T waves and intermittent PVCs D: If already intubated: GCS 3 Pupils 3-4mm sluggishly reactive. No fixed pupils. E: Temp 36.0C (If warming fluids and warming blanket) remains 34.5C if no warming measures.	**A:** Continue bagging; capnography; secure tube. Prep airway equipment and medications for transfer. **B:** Continue bagging vs. ventilator if intubated. Prep O2 tank. **C:** Recognize potential for Hyperkalemia, Repeat iStat and treat. Planning for ongoing 1-2:1 RBC: FP transfusion ratio during transport and anticipate further product needs while en route including PCC and/or fibrinogen. Start Cooler 3 if ongoing instability; otherwise have ready for transport. **Plan to bring rescue meds:** Epinephrine Rescue Dose for Cardiac Arrest (ie CODE DOSE): Epi: 0.01mg/kg IV/IO (0.1cc/kg of 1:10,000) *** Follow traumatic arrest algorithm to reverse reversible causes as a priority should patient lose VS. ALS measures such as epi are simultaneous but not priority.** Epinephrine for Pressor Support: Epi: 0.5-1 mcg/kg or 0.005-0.01 cc/kg of 1:10,000) **D:** Plan to bring sedation/paralytic medications. **Do not forget to sedate a paralyzed patient.** **E:** Warm blankets	Treat Hyperkalemia: **Goal 1: Stabilize cardiac membrane.** Calcium gluconate 60 mg/kg slow IV Push or Calcium chloride 20mg/kg IV if central or large bore peripheral access without concern for extravasation **Goal 2: Shift K intracellularly** • Ventolin (through ETT) • Insulin 0.1 U/kg/dose in Dextrose 5 ml/kg/dose over 30 minutes • Bicarbonate (8.4%) 1-2 ml/kg/dose IV -Hyperventilate **Goal 3: Enhance elimination** • Lasix 1mg/kg IV (max 10 mg) • Kayexalate 1g/kg/dose pr (if able) **Be prepared for malignant arrythmia / prepare crash cart** Consider things that can go wrong on Transport: • Dislodged tube • Continued blood loss • Electrolyte abnormalities • ATC (acute traumatic coagulopathy) secondary to severe trauma • Progressive hypotension and Loss of Vitals (PEA/ Vtach/Vfib/asystole) Prepare for Arrival of Ornge • Review Transport Checklist • Have documents and chart ready to go. Images scanned on CD • Ensure tubes secure • Ensure medications ready • Ensure access adequate • Notify receiving hospital when patient leaves • Handover bedside and provide all records to Ornge using MHP handover SBAR tool (see included)	K: 6.8

POCT # 1

VBG pH 7.28 / PCO2 60 / pO2 70/ HCO3 16

Hb 80

Na 135

K 4.8

Glucose 7.2

Labs

WBC 11,000

HGB 78

PLT: 210

INR: 2.2

PTT: 50

Fibrinogen: 0.75

K: 5.8

ALT 44

POCT # 2

VBG pH 7.31 / PCO2 40 / pO2 88/ HCO3 17

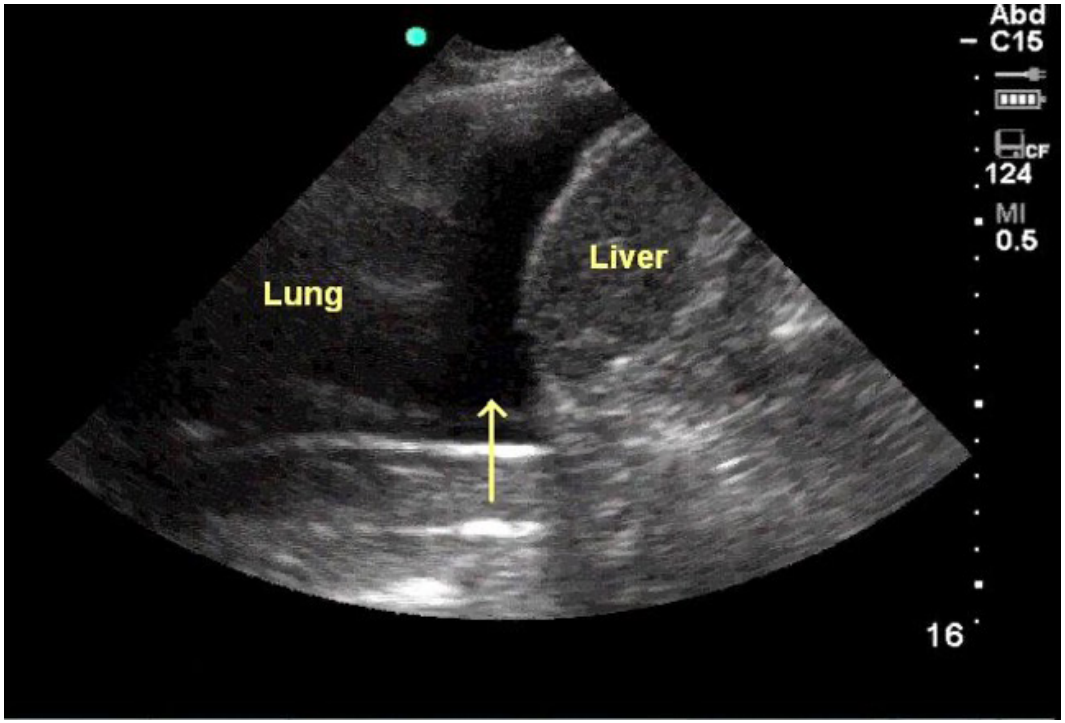
Hb 88

Na 135

K 6.8

Glucose 7.2

Imaging



PEDIATRIC MASSIVE HEMMORHAGE PROTOCOL OBSERVATION TOOL

1	2	3	4	5
Poor	**Marginal**	**Acceptable**	**Good**	**Not Observed**
Performance endangered or potentially endangered patient safety	Performance indicated cause for concern, considerable improvement needed	Performance was of satisfactory standard but could be improved	Performance was of a consistently high standard, enhancing patient safety	

Objectives	Questions	Comments	Rating (consider Likert)
Triggering	Were there any errors in the method of activation? Did the patient meet the activation criteria? Were there any delays in triggering the MHP or the arrival of pack 1 (<15 minutes)?		
Team	Was the appropriate team mobilized (appropriate type and number of personnel)? Did the team leader manage the team well? Was the team functioning well as a unit to complete the appropriate steps needed during the MHP?		
Testing	Was a timely Group & Screen collected and sent both at baseline and as a second verification sample? Were appropriate labs collected (at baseline then at least hourly) and managed appropriately?		
TXA	Was TXA administered within 1 hour of MHP activation? Was the proper dose by weight used?		

Objectives	Questions	Comments	Rating (consider Likert)
Temperature	Was the temperature checked at baseline? Was it checked frequently enough and kept at or over 36°C? Where warming measures required and if so, were they applied appropriately?		
Transfusion	Were uncross-matched RBCs available at the bedside within 10 minutes of activation? Were appropriate and timely blood products ordered and made available? Were blood products administered using weight based dosing? Did the patient receive appropriate ratio based resuscitation at a minimum of 2RBC:1Plasma? Note: plasma and platelets may be unavailable in a community setting.		
Termination	Was the MHP terminated in the appropriate manner? Was MHP termination communicated well? Were the remaining blood products returned in the appropriate storage containers? Were any blood products wasted?		

Adult Appendix

CHECKLIST FOR ONTARIO HOSPITALS TO GUIDE MASSIVE HEMORRHAGE PROTOCOL IMPLEMENTATION

Element	Date Completed	Name & Signature
Review Ontario MHP toolkit and checklist		
Identify gaps between current hospital MHP (if exists) and Ontario MHP toolkit and checklist		
Meet with MHP hospital steering committee (or hospital transfusion committee) to discuss gaps and eliminate gaps or development of a new draft hospital MHP		
Draft of revised/new hospital MHP protocol reviewed by the Transfusion Committee for compliance within the hospital's capabilities		
Circulate draft MHP protocol to hospital stakeholders for consultation		
MHP approved by Transfusion Committee (or equivalent) as conforming with provincial MHP within the hospital's capabilities		
MHP approved by Medical Advisory Committee (and/or other committees as required by hospital policy)		
Identify items required for implementation of the MHP (e.g., coolers, phones)		
Identify any validations required for implementation (e.g., coolers, platelet bags, electronic order sets)		
Set up "Code Transfusion" with hospital administration, communications/switchboard (this may include editing of lanyard cards and other lists of Codes)		
Communicate existence and content of MHP with local land and air Emergency Medical Services (EMS) provider and dispatch centres, clarify their role		

Element	Date Completed	Name & Signature
Prepare training materials for ☐ hospital administration ☐ medical staff ☐ nursing staff ☐ laboratory staff (core lab, chemistry, hematology, transfusion medicine) ☐ respiratory therapists (RTs) ☐ porters or other transport personnel ☐ switchboard/communications (These may include handouts, slide decks, talking points for in-person training/rounds, post-training quiz)		
Publication of MHP e.g., on hospital Intranet, in relevant Policy and Procedure Manuals		
Communicate existence of MHP and how to access training material with ☐ hospital administration ☐ medical staff ☐ nursing staff ☐ laboratory staff (core lab, chemistry, hematology, transfusion medicine) ☐ respiratory therapists (RTs) ☐ porters or other transport personnel ☐ switchboard/communications (e.g. by email, newsletters, hospital Intranet, screen savers, nursing huddles, etc.)		

Element	Date Completed	Name & Signature
Deliver training to ☐ hospital administration ☐ medical staff ☐ nursing staff ☐ laboratory staff (core lab, chemistry, hematology, transfusion medicine) ☐ respiratory therapists (RTs) ☐ porters or other transport personnel ☐ switchboard/communications (e.g., review of slide decks, handouts, rounds, nursing huddles) (Confirm an effective sign-off system to ensure that relevant staff have reviewed/completed training material and/or completed post-training quiz)		
Plan simulation exercise(s), generic or service-specific e.g., obstetrics, emergency department, other		
Run simulation exercise, with de-brief		
Plan MHP steering committee meetings every 3 to 6 months to review successes, performance issues and quality metrics		

NEED A MASSIVE HEMORRHAGE PROTOCOL?

NO
NOT YET

1. ORDER 4 UNCROSSMATCHED RBC
2. REASSESS NEED FOR MHP

YES
NEED IT NOW

1. MASSIVE BLOOD LOSS
2. HYPOTENSION
3. LIKELY NEED PLASMA

Or based on hospital activation criteria

ANTICOAGULATION REVERSAL	
Warfarin	PCC 2000 units IV over 10 min Vitamin K 10mg IV over 10 min
Dabigatran (Pradaxa)	Idarucizumab 5g IV over 10 min
Apixaban (Eliquis) Rivaroxaban (Xarelto) Edoxaban (Lixiana)	PCC 2000 units IV over 10 min Repeat in 1 hour if bleeding continues
Heparins	Call pharmacy for dosing of protamine

MHP COOLER DELIVERY SEQUENCE	
Cooler 1	4 units ONeg RBC for women < 45 *All others receive OPos*
Cooler 2	4 units RBC 4 plasma
Cooler 3	4 units RBC 2 plasma 4g fibrinogen concentrate
Cooler 4+	4 units RBC 2 plasma

PLATELETS order if <50 or on antiplatelets
FIBRINOGEN CONCENTRATE order 4g IV if <1.5

PATIENT STABLE AND HEMORRHAGE CONTROLLED

1. Deactivate as per local policy
2. Perform bedside termination checklist
3. Inform family member and SDM of needing MHP
4. Return unused MHP components to blood bank

CALL XXXX:
INITIATE CODE TRANSFUSION

1. Control rapidly bleeding site (tourniquet)
2. IV/IO access
3. Tranexamic acid total dose of 2g IV / IO
4. 4U RBCs with rapid infuser
5. Limit use of crystalloids
6. Calcium chloride 1g IV
7. Keep patient temperature above 36°C
8. Obtain MHP blood work
9. Reverse anticoagulation
10. Call for definitive bleeding control (OR, angio, endoscopy)

EVERY HOUR REASSESS

1. **Can MHP be turned off?**
   Can laboratory guided transfusion be used instead?
   Is bleeding controlled?
   Stable hemodynamics?
2. Do we need to call for the next cooler?
3. Patient temperature >36°C
4. Collect q1h blood work
5. $CaCl_2$ 1g IV for every 4 RBC or ionized calcium < 1.15
6. Monitor for complications (hyperkalemia, volume overload)
7. Is resuscitation adequate? (hemodynamics, lactate, VBG)
8. Switch to group specific blood products, when able

Laboratory transfusion triggers
(once results available or rate of bleeding controlled)

Value	Transfuse
Hgb < 80	RBCs
INR ≥ 1.8	Plasma 4 units
Fibrinogen < 1.5 *Less than 2.0 for postpartum hemorrhage	Fibrinogen concentrate 4g
Platelets < 50	Platelets 1 adult dose
Ionized calcium < 1.15	$CaCl_2$ 1g

If available, ROTEM triggers

Value	Transfuse
EXTEM CT > 80	Plasma 4 units
EXTEM A10 < 35	Platelets 1 adult dose
FIBTEM A10 < 8-10	Fibrinogen concentrate 4g

NEED A MASSIVE HEMORRHAGE PROTOCOL?

NO
NOT YET

1. ORDER 4 UNCROSSMATCHED RBC
2. REASSESS NEED FOR MHP

YES
NEED IT NOW

1. MASSIVE BLOOD LOSS
2. HYPOTENSION
3. LIKELY NEED PLASMA

Or based on hospital activation criteria

ANTICOAGULATION REVERSAL	
Warfarin	PCC 2000 units IV over 10 min Vitamin K 10mg IV over 10 min
Dabigatran (Pradaxa)	Idarucizumab 5g IV over 10 min
Apixaban (Eliquis) Rivaroxaban (Xarelto) Edoxaban (Lixiana)	PCC 2000 units IV over 10 min Repeat in 1 hour if bleeding continues
Heparins	Call pharmacy for dosing

MHP COOLER DELIVERY SEQUENCE	
Cooler 1	4 units ONeg RBC for women < 45 *All others receive OPos*
Cooler 2+	4 units RBC 2000 IU PCC 4 g fibrinogen concentrate

PLATELETS order if <50 or on antiplatelets
FIBRINOGEN CONCENTRATE order 4g IV if <1.5

Laboratory transfusion targets
(once results available and rate of bleeding controlled)

Value	Transfuse
Hgb < 80	RBC 2 units
INR ≥ 1.8	Plasma 4 units
Fibrinogen < 1.5 *Less than 2.0 for postpartum hemorrhage	Fibrinogen concentrate 4g
Platelets < 50	Platelets
Ionized calcium < 1.15	$CaCl_2$ 1g

PATIENT STABLE AND HEMORRHAGE CONTROLLED

1. Deactivate as per local policy
2. Perform bedside termination checklist
3. Inform family member and SDM of needing MHP
4. Return unused MHP components to blood bank

CALL FOR EARLY TRANSFER TO TERTIARY CARE CENTER

CALL XXXX:
INITIATE CODE TRANSFUSION

1. Control rapidly bleeding site (tourniquet?)
2. IV/IO access
3. Tranexamic acid total dose of 2g IV / IO
4. 4U RBCs with rapid infuser
5. Limit use of crystalloids
6. Calcium chloride 1g IV
7. Keep patient temperature above 36°C
8. Obtain trauma blood work
9. Reverse anticoagulation
10. Transfer patient via EMS/Ornge for definitive bleeding control

EVERY HOUR REASSESS

1. **Can MHP be turned off for lab directed transfusion?**
   Is bleeding controlled?
   Stable hemodynamics?
2. Do we need to call for the next cooler?
3. Is patient temperature >36°C
4. Is q1h blood work being collected?
5. $CaCl_2$ 1g IV for every 4 RBC or if ionized calcium < 1.15
6. Monitor for complications (hyperkalemia, volume overload)
7. Is resuscitation adequate (hemodynamics, lactate, VBG)
8. Switch to group specific blood products, when able

ADULT PATIENTS, DEFINITIVE CARE AT HOSPITAL

To be repeated on each page

MASSIVE HEMORRHAGE PROTOCOL (MHP) CHECKLIST

TIME	ACTION	INITIALS
ACTIVATION & PACK 1 (date _ _ / _ _ _ / _ _ time _ _ /_ _)		
	MHP Lead RN: _____	
	Call to hospital locating (ext. - - - -) to activate **CODE TRANSFUSION**	
	Provide patient number, name, sex, age, location, and information regarding patient use of antiplatelet or anticoagulants to blood bank at ext. - - - - Antiplatelets □ Yes; Anticoagulant □ Yes, drug name:_____	
	□ Ensure identification band is affixed to patient	
	□ Obtain group and screen sample	
	□ Obtain baseline blood work	
	Tranexamic acid: Administer 2 gram iv bolus in 100 mL over 20 minutes. *Hold if: more than 3 hours from injury/onset of hemorrhage or given pre-hospital or pre-activation or patient has a gastrointestinal hemorrhage*	
	Hypothermia prevention: □ Measure and document patient temperature □ Obtain blood warmer for all infusions □ If patient temperature less than 36^{o}C start active warming	
	Definitive hemorrhage control: Notify if required: □ Operating Room □ Interventional Radiology □ Gastroenterology	
	Obtain 1st MHP pack (if not obtained before activation): Pack arrival time (_ _/_ _) □ □ □ □ 4 units Red Cells (RBCs) *Use Rh-negative blood only for females under 45 years* *Avoid additional boluses or infusions of crystalloid except on physician order*	
	□ **Platelets:** If platelet count below 50 x10^{9}/L or patient on an antiplatelet drug, transfuse 1 pool of platelets	
	□ **Fibrinogen:** if fibrinogen less than 1.5 g/L, 4 grams of fibrinogen concentrate over 5 min by iv push	
	□ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 1	
	Anticoagulant reversal: □ If Warfarin: PCC 2000 IU iv over 10 minutes AND □ Vitamin K 10 mg iv □ If Xa inhibitors (e.g., apixaban, rivaroxaban): PCC 2000 IU iv over 10 minutes □ If Dabigatran: Idarucizumab 5 grams iv over 10 minutes □ If Heparins: consult Pharmacy for protamine dosing	
PACK 2 (time _ _ /_ _)		
	□ Obtain hour one blood work	
	□ Review last set of blood work to ensure at target: Hemoglobin greater than 80 g/L, INR less than 1.8, fibrinogen greater than 1.5 g/L, platelets greater than 50x10^{9}/L	
	□ Measure and document patient temperature □ If patient temperature less than 36^{o}C start active warming	
	Obtain 2nd MHP pack (if needed): Transfusions based on laboratory measures where feasible	

	☐☐☐☐ 4 units Red Blood Cells ☐☐☐☐ 4 units of Frozen Plasma	
	☐ **Platelets:** if platelet count below 50 x10^9/L, 1 pool of platelets	
	☐ **Fibrinogen:** if fibrinogen less than 1.5 g/L, 4 grams of fibrinogen concentrate over 5 min	
	Anticoagulant reversal (only if ongoing hemorrhage): ☐ If Xa inhibitors (second dose): PCC 2000 IU iv over 10 minutes	
	☐ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 2	
PACK 3 (time _ _ /_ _)		
	☐ Obtain hour 2 blood work	
	☐ Review last set of blood work to ensure at target	
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C start active warming	
	Obtain 3rd MHP pack (if needed) Transfusions based on laboratory measures where feasible ☐☐☐☐ 4 Units Red Blood Cells ☐☐ 2 Units of Frozen Plasma ☐ 4 grams of fibrinogen concentrate over 5 min	
	☐ **Platelets:** if platelet count below 50 x10^9/L, 1 pool of platelets	
	☐ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 3	
PACK 4 (time _ _ /_ _)		
	☐ Obtain hour 3 blood work	
	☐ Review last set of blood work to ensure at target	
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C start active warming	
	Obtain 4th pack (if needed) Transfusions based on laboratory measures where feasible ☐☐☐☐ 4 units of Red Blood Cells ☐☐ 2 units of Frozen Plasma	
	☐ **Platelets:** if platelet count below 50 x10^9/L, 1 pool of platelets	
	☐ **Fibrinogen:** if fibrinogen less than 1.5 g/L, 4 grams of fibrinogen concentrate over 5 min	
	☐ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 4	
PACK 5 (time _ _ /_ _)		
	☐ Obtain hour 4 or greater blood work	
	☐ Review last set of blood work to ensure at target	
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C commence active warming	
	Obtain 5th (if needed) Transfusions based on laboratory measures where feasible ☐☐☐☐ 4 units of Red Blood Cells per pack (RBCs) ☐☐ 2 units of Frozen Plasma	
	☐ **Platelets:** if platelet count below 50 x10^9/L, 1 pool of platelets	
	☐ **Fibrinogen:** if fibrinogen less than 1.5 g/L, 4 grams of fibrinogen concentrate over 5 min	

	☐ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after each pack	
TERMINATION (time _ _ /_ _)		
	Once hemorrhage control is obtained and patient is hemodynamically stable call blood bank and the hematology laboratories to terminate the protocol	
	☐ Measure and document patient temperature	
	☐ Return all unused blood products in appropriate storage containers	
	☐ Complete this form and place in patient chart	
	☐ Complete handover SBAR tool below with receiving team	

HANDOVER SBAR TOOL FOR HANDOVER TO THE CRITICAL CARE TEAM
(Time _ _ /_ _)

S: SITUATION (Relay the following)	HANDOVER NOTES
☐ Patient age, sex, weight	
☐ Context (trauma ± TBI, surgery, or other)	
B: BACKGROUND (Relay the following)	
☐ TXA administration _____ grams	
☐ Total numbers of blood products _____ RBC _____ Plasma _____ PLTs _____ g Fibrinogen _____ IU PCC	
☐ Total (L) crystalloid and/or colloid and urine output _____ L of non-blood product fluid	
☐ IV access and need for vasopressors	
☐ For trauma, external/internal bleeding ± TBI management	
☐ Consultant(s) involved (e.g., surgery, radiology or gastroenterology)	
☐ Complications (hypothermia, coagulopathy, acidosis or arrhythmias)	
A: ASSESSMENT (Relay the following)	
☐ Hemodynamic status (stable or unstable, vitals and temperature)	
☐ Definitive hemorrhage control achieved? YES / NO	
☐ Critical labs (specify) and latest blood work results Hb _____ PLT _____ INR _____ fibrinogen _____ lactate _____ Calcium _____	
☐ Availability of blood products from blood bank/coolers at bedside	
R: RECOMMENDATION (Consider the following)	
☐ Consider need for additional blood products since last set of labs	
☐ Consider need for further consultation, tests and drug re-dosing	

ADULT PATIENTS, NON-DEFINITIVE CARE AT HOSPITAL
NO PLASMA AVAILABLE ON SITE
PATIENT TO BE TRANSFERRED TO TERTIARY CENTRE

To be repeated on each page

MASSIVE HEMORRHAGE
PROTOCOL (MHP) CHECKLIST

TIME	ACTION	INITIALS
ACTIVATION & PACK 1 (date _ _ / _ _ _ / _ _ time _ _ /_ _)		
	MHP Lead RN: _____	
	Call to hospital locating (ext. - - - -) to activate **CODE TRANSFUSION**	
	Provide patient number, name, sex, age, location, and information regarding patient use of antiplatelet or anticoagulants to blood bank at ext. - - - - Antiplatelets □ Yes; Anticoagulant □ Yes, drug name:_____	
	□ Ensure identification band is affixed to patient	
	□ Obtain group and screen sample	
	□ Obtain baseline blood work	
	Tranexamic acid: Administer 2 gram iv bolus in 100 mL over 20 minutes. *Hold if: more than 3 hours from injury/onset of hemorrhage or given pre-hospital or pre-activation or patient has a gastrointestinal hemorrhage*	
	Hypothermia prevention: □ Measure and document patient temperature □ Obtain blood warmer for all infusions □ If patient temperature less than 36^{o}C start active warming	
	Initiate transfer out: Notify if required: □ CritiCall - 1-800-668-4357 □ EMS □ Ornge	
	Obtain 1st MHP pack (if not obtained before activation): Pack arrival time (_ _/_ _) □ □ □ □ 4 units Red Cells (RBCs) *Use Rh-negative blood only for females under 45 years* *Avoid additional boluses or infusions of crystalloid except on physician order*	
	□ **Platelets (if available):** If platelet count below 50 x10^{9}/L or patient on an antiplatelet drug, transfuse 1 pool of platelets	
	□ **Fibrinogen:** if fibrinogen less than 1.5 g/L, 4 grams of fibrinogen concentrate over 5 min by iv push;	
	□ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 1	
	Anticoagulant reversal: □ If Warfarin: PCC 2000 IU iv over 10 minutes AND □ Vitamin K 10 mg iv □ If Xa inhibitors (e.g., apixaban, rivaroxaban): PCC 2000 IU iv over 10 minutes □ If Dabigatran: Idarucizumab 5 grams iv over 10 minutes □ If Heparins: consult Pharmacy for protamine dosing	
PACK 2 (time _ _ /_ _)		
	□ Obtain hour one blood work	
	□ Review last set of blood work to ensure at target: Hemoglobin greater than 80 g/L, INR less than 1.8, fibrinogen greater than 1.5 g/L, platelets greater than 50x10^{9}/L	
	□ Measure and document patient temperature □ If patient temperature less than 36^{o}C start active warming	

ADULT PATIENTS, NON-DEFINITIVE CARE AT HOSPITAL
NO PLASMA AVAILABLE ON SITE
PATIENT TO BE TRANSFERRED TO TERTIARY CENTRE

	Obtain 2nd MHP pack (if needed): Transfusions based on laboratory measures where feasible ☐☐☐☐ 4 units Red Blood Cells ☐ 2000 IU of Prothrombin Complex Concentrates ☐ 4 grams of fibrinogen concentrate over 5 min by iv push	
	☐ **Platelets (if available):** if platelet count below 50 x10^9/L, 1 pool of platelets	
	Anticoagulant reversal (only if ongoing hemorrhage): ☐ If Xa inhibitors (second dose): PCC 2000 IU iv over 10 minutes	
	☐ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 2	
PACK 3 (time _ _ /_ _)		
	☐ Obtain hour 2 blood work	
	☐ Review last set of blood work to ensure at target	
	☐ Measure and document patient temperature ☐ If patient temperature less than 36°C start active warming	
	Obtain 3rd MHP pack (if needed) Transfusions based on laboratory measures where feasible ☐☐☐☐ 4 Units Red Blood Cells ☐ 2000 IU of Prothrombin Complex Concentrate ☐ 4 grams of fibrinogen concentrate over 5 min	
	☐ **Platelets (if available):** if platelet count below 50 x10^9/L, 1 pool of platelets	
	☐ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 3	
TERMINATION (time _ _ /_ _)		
	Once either hemorrhage control is obtained and patient is hemodynamically stable call blood bank and the hematology laboratories to terminate the protocol or patient has been transferred to tertiary centre for definitive hemorrhage control	
	☐ Measure and document patient temperature	
	☐ Return all unused blood products in appropriate storage containers	
	☐ Complete this form and place in patient chart	
	☐ Complete handover SBAR tool below with transport team	

HANDOVER SBAR TOOL FOR HANDOVER TO THE TRANSPORT TEAM
(Time _ _ /_ _)

S: SITUATION (Relay the following)	HANDOVER NOTES
☐ Patient age, sex, weight	
☐ Context (trauma ± TBI, surgery, or other)	
B: BACKGROUND (Relay the following)	
☐ TXA administration ____ grams	
☐ Total numbers of blood products ____ RBC ____ PLTs ____ g Fibrinogen _____ IU PCC	
☐ Total (L) crystalloid and/or colloid and urine output	

ADULT PATIENTS, NON-DEFINITIVE CARE AT HOSPITAL
NO PLASMA AVAILABLE ON SITE
PATIENT TO BE TRANSFERRED TO TERTIARY CENTRE

____ L of non-blood product fluid	
☐ IV access and need for vasopressors	
☐ For trauma, external/internal bleeding ± TBI management	
☐ Consultant(s) involved (e.g., surgery, radiology or gastroenterology)	
☐ Complications (hypothermia, coagulopathy, acidosis or arrhythmias)	
A: ASSESSMENT (Relay the following)	
☐ Hemodynamic status (stable or unstable, vitals and temperature)	
☐ Blood products prepared for transport	
☐ Critical labs (specify) and latest blood work results Hb ____ PLT ____ INR ____ fibrinogen ____ lactate ____ Calcium ____	
R: RECOMMENDATION (Consider the following)	
☐ Consider need for additional blood products during transport	
☐ Consider need for drug re-dosing during transport	

OBSTETRICAL PATIENTS

To be repeated on each page

MASSIVE HEMORRHAGE PROTOCOL (MHP) CHECKLIST

TIME	ACTION	INITIALS
ACTIVATION & PACK 1 (date _ _ / _ _ _ / _ _ time _ _ /_ _)		
	MHP Lead RN: _____	
	Call to hospital locating (ext. - - - -) to activate **CODE TRANSFUSION**	
	Provide patient number, name, location, and information regarding patient use of antiplatelet or anticoagulants to blood bank at ext. - - - - Antiplatelets □ Yes; Anticoagulant □ Yes, drug name:_____	
	□ Ensure identification band is affixed to patient	
	□ Obtain group and screen sample	
	□ Obtain baseline blood work	
	Tranexamic acid: Administer 1 gram iv bolus in 100 mL over 10 minutes *Hold if: more than 3 hours from onset of hemorrhage or given pre-activation*	
	Hypothermia prevention: □ Measure and document patient temperature □ Obtain blood warmer for all infusions □ If patient temperature less than 36^{o}C start active warming	
	Definitive hemorrhage control: Notify if required: □ Operating Room □ Interventional Radiology	
	Obtain 1st MHP pack (if not obtained before activation): Pack arrival time (_ _/_ _) □ □ □ □ 4 units Red Cells (RBCs) *Use Rh-negative blood until Rh-blood group confirmed* *Avoid additional boluses or infusions of crystalloid except on physician order*	
	□ **Platelets:** If platelet count below 50 x10^{9}/L or patient on an antiplatelet drug, transfuse 1 pool of platelets	
	□ **Fibrinogen:** if fibrinogen less than 2.0 g/L, 4 grams of fibrinogen concentrate over 5 min by iv push	
	□ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 1	
	Anticoagulant reversal: □ If Warfarin: PCC 2000 IU iv over 10 minutes AND □ Vitamin K 10 mg iv □ If Xa inhibitors (e.g., apixaban, rivaroxaban): PCC 2000 IU iv over 10 minutes □ If Dabigatran: Idarucizumab 5 grams iv over 10 minutes □ If Heparins: consult Pharmacy for protamine dosing	
PACK 2 (time _ _ /_ _)		
	□ Obtain hour one blood work	
	□ Review last set of blood work to ensure at target: Hemoglobin greater than 80 g/L, INR less than 1.8, fibrinogen greater than 2.0 g/L, platelets greater than 50x10^{9}/L	
	□ Measure and document patient temperature □ If patient temperature less than 36^{o}C start active warming	
	Obtain 2nd MHP pack (if needed): Transfusions based on laboratory measures where feasible □ □ □ □ 4 units Red Blood Cells	

OBSTETRICAL PATIENTS

	□ □ □ □ 4 units of Frozen Plasma	
	□ **Platelets:** if platelet count below 50 x10^9/L, 1 pool of platelets	
	□ **Fibrinogen:** if fibrinogen less than 2.0 g/L, 4 grams of fibrinogen concentrate over 5 min	
	Anticoagulant reversal (only if ongoing hemorrhage): □ If Xa inhibitors (second dose): PCC 2000 IU iv over 10 minutes	
	□ **Tranexamic acid**: Administer 1 gram iv bolus in 100 mL over 10 minutes if hemorrhage continues (maximum dose 2 grams total)	
	□ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 2	
PACK 3 (time _ _ /_ _)		
	□ Obtain hour 2 blood work	
	□ Review last set of blood work to ensure at target	
	□ Measure and document patient temperature □ If patient temperature less than 36°C start active warming	
	Obtain 3rd MHP pack (if needed) Transfusions based on laboratory measures where feasible □ □ □ □ 4 Units Red Blood Cells □ □ 2 Units of Frozen Plasma □ 4 grams of fibrinogen concentrate over 5 min	
	□ **Platelets:** if platelet count below 50 x10^9/L, 1 pool of platelets	
	□ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 3	
PACK 4 (time _ _ /_ _)		
	□ Obtain hour 3 blood work	
	□ Review last set of blood work to ensure at target	
	□ Measure and document patient temperature □ If patient temperature less than 36°C start active warming	
	Obtain 4th pack (if needed) Transfusions based on laboratory measures where feasible □ □ □ □ 4 units of Red Blood Cells □ □ 2 units of Frozen Plasma	
	□ **Platelets:** if platelet count below 50 x10^9/L, 1 pool of platelets	
	□ **Fibrinogen:** if fibrinogen less than 2.0 g/L, 4 grams of fibrinogen concentrate over 5 min	
	□ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after pack 4	
PACK 5 (time _ _ /_ _)		
	□ Obtain hour 4 or greater blood work	
	□ Review last set of blood work to ensure at target	
	□ Measure and document patient temperature □ If patient temperature less than 36°C commence active warming	
	Obtain 5th (if needed) Transfusions based on laboratory measures where feasible □ □ □ □ 4 units of Red Blood Cells per pack (RBCs) □ □ 2 units of Frozen Plasma	
	□ **Platelets:** if platelet count below 50 x10^9/L, 1 pool of platelets	

	☐ **Fibrinogen:** if fibrinogen less than 2.0 g/L, 4 grams of fibrinogen concentrate over 5 min	
	☐ **Calcium:** 1g Calcium Chloride or 3g Calcium Gluconate iv push after each pack	
TERMINATION (time _ _ /_ _)		
	Once hemorrhage control is obtained and patient is hemodynamically stable call blood bank and the hematology laboratories to terminate the protocol	
	☐ Measure and document patient temperature	
	☐ Return all unused blood products in appropriate storage containers	
	☐ Complete this form and place in patient chart	
	☐ Complete handover SBAR tool below with receiving team	

HANDOVER SBAR TOOL FOR HANDOVER TO THE CRITICAL CARE TEAM
(Time _ _ /_ _)

S: SITUATION (Relay the following)	HANDOVER NOTES
☐ Patient age, weight	
☐ Context (cause of hemorrhage, prior bleeding history)	
B: BACKGROUND (Relay the following)	
☐ TXA administration ____ grams	
☐ Total numbers of blood products ____ RBC ____ Plasma ____ PLTs ____ g Fibrinogen _____ IU PCC	
☐ Total (L) crystalloid and/or colloid and urine output ____ L of non-blood product fluid	
☐ IV access and need for vasopressors	
☐ Consultant(s) involved (e.g., surgery, interventional radiology)	
☐ Complications (hypothermia, coagulopathy, acidosis or arrhythmias)	
A: ASSESSMENT (Relay the following)	
☐ Hemodynamic status (stable or unstable, vitals and temperature)	
☐ Definitive hemorrhage control achieved? YES / NO	
☐ Critical labs (specify) and latest blood work results Hb ____ PLT ____ INR ____ fibrinogen ____ lactate ____ Calcium ____	
☐ Availability of blood products from blood bank/coolers at bedside	
R: RECOMMENDATION (Consider the following)	
☐ Consider need for additional blood products since last set of labs	
☐ Consider need for further consultation, tests and drug re-dosing	

Transfusion Packs for Adults with Massive Hemorrhage

BIG HOSPITAL

Pack 1	4 units O negative RBC (women < 45 years) 4 units O positive RBC (all others)
Pack 2	4 units RBC 4 units FP
Pack 3	4 units RBC 2 units FP 4 g FC
Pack 4 and beyond	4 units RBC 2 units FP

GIVE PLATELETS AS NEEDED

Once available, use lab values to guide transfusion

SMALL HOSPITAL
(Do Not Carry Plasma)

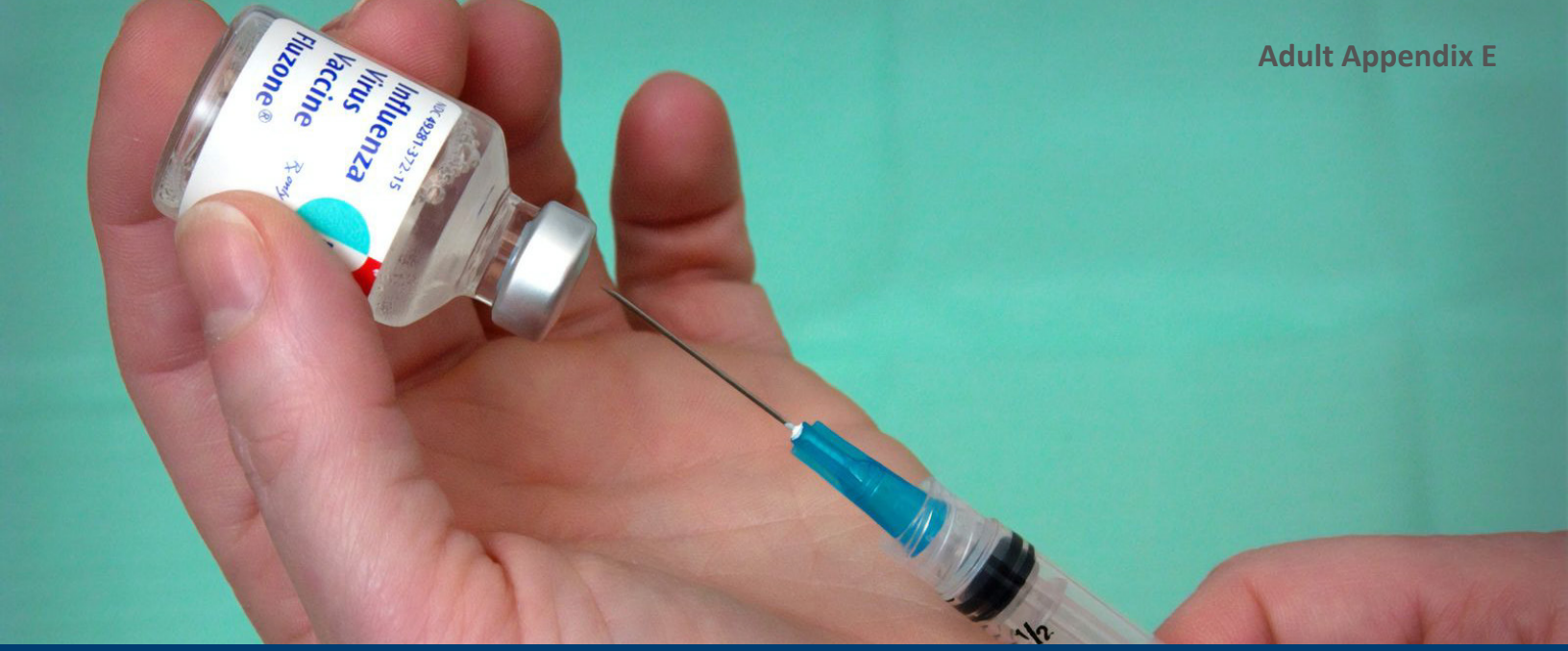
Transfer patient to a hospital capable of definitive hemorrhage control

Pack 1	4 units O negative RBC *if in stock* (women < 45 years) 4 units O positive RBC (all others)
Pack 2	4 units RBC 2000 IU PCC 4 g FC

If transfer is not possible...proceed to Pack 3

Pack 3 and beyond	4 units RBC 2000 IU PCC 4 g FC

IF PLATELETS NOT STOCKED, AND PATIENT CANNOT PROMPTLY BE TRANSFERRED OUT, ORDER PLATELETS



Adult Patients with Massive Hemorrhage: Tips for Product Dosing

Fibrinogen Concentrate (FC)	4 g over 10 minutes
Prothrombin Complex Concentrate (PCC)	2000 IU over 10 minutes
Tranexamic Acid (TXA)	1 g bolus plus 1 g infusion over 8 hours

Alternatives

1 g bolus and 1 g bolus repeated at 1 hour

1 g bolus and repeated if ongoing bleeding at ≥ 30 minutes

2 g single bolus

Adult Patients with Massive Hemorrhage: Tips for Anticoagulant Reversal

Warfarin	Prothrombin complex concentrate (Octaplex® or Beriplex®) 2000 units IV over 10 min Vitamin K 10 mg IV over 10 min
Dabigatran (Pradaxa®)	Idarucizumab (Praxbind®) 2.5 g IV twice (total 5 g) over 10 min
Rivaroxaban (Xarelto®) Apixaban (Eliquis®) Edoxaban (Lixiana®)	Prothrombin complex concentrate (Octaplex® or Beriplex®) 2000 units IV over 10 min Repeat at 1 hour if still bleeding
Heparin	<u>Unfractionated Heparin (UFH)</u> • 1 mg per 100 units of UFH administered within past 4 hours • 25 mg IV will reverse heparin infusions running at a rate of approx. 1,500 units/hour <u>Low Molecular Weight Heparin(LMWH</u> • If administered within 8 hours: 1 mg of protamine per 100 units anti- Xa or 1 mg per 1 mg of enoxaparin • If administered more than 8 hours ago: 0.5 mg of protamine per 100 units anti-Xa or 0.5 mg per 1 mg of enoxaparin

Thrombosis Canada
Thrombose Canada

https://thrombosiscanada.ca

Approach to Patients with Bleeding Disorders with Massive Hemorrhage

Suspect a bleeding disorder when:

- Bleeding is out of keeping with severity of injury
- Patient is not on antithrombotic therapy
- History of abnormal bleeding

Look for medical alert bracelet and/or bleeding disorder card

Connect with a Hemophilia Treatment Center (HTC) STAT

Give replacement therapy immediately for obvious or suspected bleeding or major trauma. Treat first, and then investigate.

Bleeding Disorder

- Hemophilia A Factor VIII (8) → Provide 50 U/Kg IV of FVIII Concentrate
- Hemophilia B Factor IX (9) → Provide 100 U/Kg IV of FIX concentrate
- Von Willebrand Disease → Provide 0.3 mcg/kg IV of DDAVP and/or 50 U/Kg IV of VWF:FVIII concentrate

Ideally, transfer patient to Lead Trauma Hospital affiliated with an HTC

Hamilton Health Sciences	Health Sciences North (Sudbury)
London Health Sciences	St. Michael's Hospital
Thunder Bay Regional Health Sciences Centre	Sick Kids/CHEO
Kingston Health Sciences Centre	The Ottawa Hospital

CRITICALL ONTARIO

Connecting physicians, resources and care 1-800-668-HELP

Help Sheet

CritiCall Ontario Guidelines for Physicians and Hospitals

When to Call CritiCall Ontario

- If your hospital has an urgent or emergent patient who requires care beyond your hospital's resources, call CritiCall Ontario at 1-800-668- 4357 (HELP)

A CritiCall Ontario Call Agent Will:

- Collect basic patient information from the **physician or a designate** (**Note:** the physician or designate must clearly express **the urgency of the case, including whether it is Life or Limb)**

- Use the Provincial Hospital Resource System (PHRS) inventory to determine where the required resources are available and to contact a physician specialist to provide a consultation **(Note:** consultations are provided by on-call specialists working in Ontario hospitals and are not employed by CritiCall Ontario)

- Facilitate a physician-to-physician telephone consultation so the physicians can work together to make clinical decisions about the patient's care (**Note:** Call Agents do not relay clinical information between physicians)

- Effective December 9, 2015, assist with transport coordination **for Confirmed "Life or Limb" cases only**

Case Type/ Issue	CritiCall Ontario Contact Guidelines and General Support
Life or Limb Cases **MOHLTC/LHIN Requirements**	**Contact CritiCall Ontario first if:** • the patient requires emergent care within 4 hours (Life or Limb); or • MoHLTC or LHIN required use of CritiCall Ontario
Urgent Cases	**Contact CritiCall Ontario if:** • the patient needs urgent care within 24 hours and the physician is unable to make arrangements outside of CritiCall Ontario for the patient's care
Non-Urgent Cases/On-Call Coverage	**Use existing agreements and contact partner hospitals directly for:** • **non-urgent or non-emergent issues** (e.g. closed extremity fractures)
Transport	**CritiCall Ontario will facilitate transport coordination for:** • **Confirmed "Life or Limb" cases only** (CritiCall Ontario will collect additional information from the physician or designate and contact ORNGE or CACC directly) • **For all other/Non Confirmed Life or Limb cases:** the sending physician is responsible for arranging transport by directly contacting the transport provider(s)
CritiCall Ontario Medical Associates	• CritiCall Ontario Medical Associates are employed by CritiCall Ontario to provide assistance with case facilitation. They do not generally provide clinical consultations.

For more information, please visit our website www.criticall.org or contact the CritiCall Ontario Client Relations Manager for your region.

CritiCall Ontario is funded by the Government of Ontario

Remember… FactorFirst

PROMPT INFUSION will halt bleeding, minimize long-term complications and can save life. If bleeding persists, follow the guidelines for life or limb-threatening bleeds and call the:

Hemophilia Treatment Centre

Physician: _____

Nurse: _____

Day Phone: _____

Night Phone: _____

Delay in the restoration of hemostasis to the patient with hemophilia or von Willebrand disease may be life or limb-threatening.

- **PROMPT TRIAGE AND ASSESSMENT.**
- Determine the severity of the bleed.
- Recognize that bleeding in the head, spine, abdomen or pelvis may initially be occult and potentially life-threatening.
- **TREAT FIRST AND INVESTIGATE LATER – "FACTOR FIRST".**
- Avoid invasive procedures such as arterial punctures unless the patient has factor replacement.
- **NO** IM injections and **NO** ASA.
- The patient or guardian may be your most important resource, so do ask about specific treatment protocols.
- Contact the patient's Hemophilia Treatment Centre where a hematologist is always on call.
- Provide clear discharge instructions and arrange a follow-up plan or admit to hospital if necessary.

Use Universal Precautions

Patient Information:

Name: _____

Date of Birth: _____

Diagnosis: _____

Severity: _____ Level: _____

Response to desmopressin (DDAVP): ❑ no ❑ yes to _____ %

Inhibitors: ❑ no ❑ yes

Other Medical Information: _____

Date of Recommendation: ____/____/____

Signature of Physician _____

Recommended Treatment:

Product and Dose/kg for Life or Limb-threatening Bleeds:

Product and Dose/kg for Moderate/Minor Bleeds:

GUIDELINES FOR EMERGENCY MANAGEMENT OF HEMOPHILIA AND VON WILLEBRAND DISEASE

LIFE OR LIMB-THREATENING BLEEDS

- Head (intracranial) and neck
- Chest, abdomen, pelvis, spine
- Iliopsoas muscle and hip
- Massive vaginal hemorrhage
- Extremity muscle compartments
- Fractures or dislocations
- Any deep laceration
- Any uncontrolled bleeding

MODERATE/MINOR BLEEDS

- Nose (epistaxis)
- Mouth (including gums)
- Joints (hemarthroses)
- Menorrhagia
- Abrasions and superficial lacerations

TREATMENT FOR LIFE OR LIMB-THREATENING BLEEDS

PATIENT MUST RECEIVE PRODUCT URGENTLY

Hemophilia A: (all severities)
Recombinant factor VIII concentrate 40-50 units/kg

Hemophilia B: (all severities)
Recombinant factor IX concentrate 100-120 units/kg >15 yrs
Recombinant factor IX concentrate 135-160 units/kg <15 yrs
The dosage for recombinant factor IX is substantially higher because of its lower recovery, particularly in children.

Von Willebrand Disease:
A VW factor concentrate containing factor VIII such as Humate-P 60-80 Ristocetin cofactor units/kg

It is critical to raise the factor level to 80-100% urgently for all life or limb-threatening bleeds.

TREATMENT FOR MODERATE/MINOR BLEEDS

PATIENT MUST RECEIVE PRODUCT WITHIN 30 MINUTES WHENEVER POSSIBLE

Hemophilia A: (severe/moderate)
Recombinant factor VIII concentrate 20-30 units/kg

Hemophilia A: (mild)
Desmopressin (Octostim/DDAVP) 0.3 mcg/kg (max. 20 mcg) –SC/IV

Hemophilia B: (severe/moderate/mild)
Recombinant factor IX concentrate 35-50 units/kg >15 yrs
Recombinant factor IX concentrate 50-70 units/kg <15 yrs
The dosage for recombinant factor IX is substantially higher because of its lower recovery, particularly in children.

Von Willebrand Disease:
Type 1 and Type 2A or 2B known to have used desmopressin safely and effectively – (Octostim/DDAVP) 0.3 mcg/kg (max. 20 mcg) –SC/IV

For patients not responding to desmopressin (such as Type 3 or Type 2B) use a VW factor concentrate containing factor VIII such as Humate-P 60-80 Ristocetin cofactor units/kg

For mucosal bleeds in all above add:
Tranexamic Acid (Cyklokapron) 25 mg/kg po tid 1-7 days (contraindicated if hematuria)

Dosages are patient specific – these are general guidelines only. Round doses up to the nearest vial. If the products listed are not available, please call the nearest Canadian Blood Services or Héma-Québec Centre.

FactorFirst

Canadian Hemophilia Society
Help Stop the Bleeding

AHCDC Association of Hemophilia Clinic Directors of Canada

www.hemophilia.ca/emergency

SIMULATION EXERCISE

Curriculum Topic/Title: Massive Hemorrhage Protocol case #1: TRAUMA
Developed by: Drs. Jordan Tarshis and Jeannie Callum
Creation/Modification Date: 2020-Mar-26 / Mod 2020-Jun-18

Learning Objectives:

1. Demonstrate safe and proficient management of an adult patient with injury and significant bleeding.
2. Recognize need for massive hemorrhage protocol (MHP) and demonstrate ability to activate an institutional protocol
3. Achieve high performance in situational awareness, teamwork and communication in a simulated setting.
4. Identify areas of improvement and develop a plan.

References / Review Articles:

Callum JL, Yeh CH, Petrosoniak A et al. A regional massive hemorrhage protocol developed through a modified Delphi technique. CMAJ Open 2019; 7:E546–E561.

PATIENT & SCENARIO INFORMATION

Patient Name: JOHN WILLIAMS

Patient Info: DOB, PMH, current problem/procedure, meds, allergies:

DOB: 1944-04-13
Past medical history only significant for atrial fibrillation for which his is on warfarin. Past surgical history is significant for remote cholecystectomy. No allergies

Location / Setting: Emergency Department

EQUIPMENT FOR EXERCISE:

Comments:

- This exercise does NOT require a high fidelity mannequin, but could be used with one
- A method to communicate vital signs is required. Options include:
  - » Whiteboard or paper-based technique
  - » Tablet-based technique using app based software (example SimMon on and iPad)
  - » Software from high-fidelity mannequin

Monitors required:

Available	On patient		Available	On patient	
☐	☒	NIBP	☐	☒	ECG
☒	☐	Arterial line	☐	☒	Temperature
☒	☐	CVP	☐	☒	Pulse oximeter
☐	☐	PA Catheter	☐	☐	Capnograph
☐	☐	Fetal heart monitor	☐	☐	End-Tidal Agent Concentration
☐	☒	Urinary catheter	☐	☐	Train of four

Other equipment required:

- Equipment that would normally be available in this clinical area per institutional protocols should be available for this simulation.

Simulation Video
A video based on this exercise script is also available for training purposes. Available at this link:
https://transfusionontario.org/en/category/massive-hemorrhage-protocol/simulation-videos/

Supporting Files (assessment, labs, imaging, etc):

1. q1h lab results
2. Observational tool
3. Participant evaluation form available at:

Scenario Content:

Information for Learner:

(place on a separate page as we often give them this 'stem' to read, along with the anesthetic record / supporting documents if appropriate)

A 56 year old man with atrial fibrillation is brought by ambulance to the emergency department after falling off a ladder while cleaning his second floor eavestroughs. He is on warfarin – dose has been stable for 6 months without dose adjustment. Initial assessment shows a broken left femur, a stable, undisplaced pelvic fracture and fractured left ribs 4-7. He is hypotensive (systolic 85 mmHg) and tachycardic (127 bpm). He has received 2 L of saline en route to the ER (no RBCs) without hemodynamic response.

Scenario Content:

Additional Information for Instructor only, including:
Roles of confederates or other participants
Type of HELP available:

Instructor / Leader of this exercise will pre-determine the number and nature of respondents corresponding to realistic local resouce availability

Simulator Setup and Programming Notes:

One facilitator (not the leader) should be assigned to dissemination of current vital signs throughout the simulation. This individual should have sufficient medical knowledge to be able to alter the vital signs in a realistic fashion in response to events and medical decisions as they occur during the simulation.

Baseline Simulator Physiologic State (leave blank if not relevant):

HR: ***127*** BP: ***85*** RR: ***17*** SpO_2: ***99***

Weight: ***88 kg*** BMI: ***31***

Neuro (LOC, orientation etc.): ***GCS 14, in pain***

Respiratory: ***decreased breath sounds left side***

Laboratory, Radiology, or other relevant information, available initially or as the scenario progresses:

Key Processes During MHP Simulation

T7 Framework

- Triggering
- Team
- Testing
- Tranexamic Acid
- Temperature
- Transfusion
- Termination

1. q1h lab results from simulation #1

Lab work	On arrival	60 minutes
Hemoglobin (g/L)	120	90
Platelets (x10^9/L)	210	135
INR	2.4	1.6
Fibrinogen (g/L)	3.0	1.4
Sodium (mmol/L)	131	140
Potassium (mmol/L)	3.5	4.1
Ionized calcium(mmol/L)	1.4	1.0
Glucose (mmol/L)	10	15
Lactate	3.5	2.5
Arterial blood gas		
PH	7.29	7.34
PO2 (mmHg)	150	160
PCO2 (mmHg)	34	38
HCO3 (mmol/L)	16	20
Base Deficit	- 7	- 3
FIO2 (%)	Non-rebreather	Non-rebreather
Blood products and drugs ideally to be administered	RBC 4 units + FFP 2 units or PCC; TXA 2 mg over 15 min	Fibrinogen concentrate
Vital signs	Reflect 25-30% blood volume loss	Reflect slowing of blood volume loss (<15%)

Discussion and Teaching Points for Debriefing:

- Minimum of 2 facilitators required, preferably interprofessional
- Notes should be taken during the scenario to identify processes well done and areas of improvement
- Team debriefing is required, with focus on system improvement and not individual performances

Post Simulation Activities:

- One or more individuals must, a priori, be tasked with compiling a summary from each simulation including areas for system improvement, individual(s) responsible for addressing the issues identified during the simulation
- This process should become part of the routine quality and safety processes at the institutional level
- Follow up, and repeat simulations are mandatory, as a single intervention without follow up will not lead to any improvement in patient care

SIMULATION EXERCISE

Curriculum Topic/Title: Massive Hemorrhage Protocol case #2: GI BLEED
Developed by: Dr. Jordan Tarshis
Creation/Modification Date: 2020-Jun-18

Learning Objectives:

1. Demonstrate safe and proficient management of an adult patient with injury and significant bleeding.
2. Recognize need for massive hemorrhage protocol (MHP) and demonstrate ability to activate an institutional protocol
3. Achieve high performance in situational awareness, teamwork and communication in a simulated setting.
4. Identify areas of improvement and develop a plan.

References / Review Articles:

Callum JL, Yeh CH, Petrosoniak A et al. A regional massive hemorrhage protocol developed through a modified Delphi technique. CMAJ Open 2019; 7:E546–E561.

PATIENT & SCENARIO INFORMATION FOR FACILITATORS

Patient Name: VANESSA TYRONE

Patient Info: PMH, current problem/procedure, meds, allergies:

64 y.o. woman admitted with pancreatitis secondary to EtOH. Known liver cirrhosis (moderate, Child-Pugh B). Not on any regular medications, no allergies.

Location / Setting: Acute care inpatient unit appropriate for site

EQUIPMENT FOR EXERCISE:

Comments:

- This exercise does NOT require a high fidelity mannequin, but could be used with one
- A method to communicate vital signs is required. Options include:
  - » Whiteboard or paper-based technique
  - » Tablet-based technique using app based software (example SimMon on and iPad)
  - » Software from high-fidelity mannequin

Monitors required:

Available	On patient		Available	On patient	
☐	☒	NIBP	☒	☐	ECG
☒	☐	Arterial line	☒	☐	Temperature
☒	☐	CVP	☐	☒	Pulse oximeter
☐	☐	PA Catheter	☐	☐	Capnograph
☐	☐	Fetal heart monitor	☐	☒	IV (primary)
☒	☐	Urinary catheter	☒	☐	Secondary IV

Other equipment required:

- Equipment that would normally be available in this clinical area per institutional protocols should be available for this simulation.

Simulation Video

A video based on this exercise script is also available for training purposes. Available at this link: https://transfusionontario.org/en/category/massive-hemorrhage-protocol/simulation-videos/

Supporting Files (assessment, labs, imaging, etc):

1. Q1h lab results
2. Observational tool
3. Debrief guide
4. Participant evaluation form available at:

Scenario Content:

Information for Learner:

(place on a separate page as we often give them this 'stem' to read, along with the anesthetic record / supporting documents if appropriate)

A 64 y.o. woman was admitted 2 days ago with pancreatitis secondary to ethanol. She has known alcohol use disorder and had moderate liver cirrhosis. She has known varices for which she was prescribed beta-blocker (but she has been non-compliant). Her INR on admission was 1.8 on admission and platelet count 78. She does not take any regular medications at home, and has no allergies. She is being treated now with IV fluid for hydration, hydromorphone IM for analgesia and supportive care. Her last CBC taken on admission showed a macrocytic anemia with a Hb of 97.

30 minutes ago she vomited a large amount of fresh red blood. Her vital signs are currently BP 82/45, HR 125 sinus, SpO2 98% on room air, GCS is 15. As you arrive by the bedside she vomits up an additional large amount of fresh red blood.

Scenario Content:

Additional Information for Instructor only, including:
Roles of confederates or other participants
Type of HELP available:

Instructor / Leader of this exercise will pre-determine the number and nature of respondents corresponding to realistic local resouce availability

Simulator Setup and Programming Notes:

One facilitator (not the leader) should be assigned to dissemination of current vital signs throughout the simulation. This individual should have sufficient medical knowledge to be able to alter the vital signs in a realistic fashion in response to events as they occur during the simulation.

Baseline Simulator Physiologic State (leave blank if not relevant):

HR: ***125*** BP: ***82/45*** RR: ***24*** SpO_2: ***98***

Weight: ***45 kg*** BMI: ***18***

Neuro (LOC, orientation etc.): ***GCS 15***

Respiratory: ***spontaneous respirations***

Progress During Scenario: ***Patient becomes more tachycardic and hypotensive, but responds to fluids and blood products in a realistic fashion***

Laboratory, Radiology, or other relevant information, available initially or as the scenario progresses:

Key Processes During MHP Simulation

T7 Framework

- Triggering
- Team
- Testing
- Tranexamic Acid
- Temperature
- Transfusion
- Termination

Discussion and Teaching Points for Debriefing:

- Minimum of 2 facilitators required, preferably interprofessional
- Notes should be taken during the scenario to identify processes well done and areas of improvement
- Team debriefing is required, with focus on system improvement and not individual performances

Post Simulation Activities:

- One or more individuals must, a priori, be tasked with compiling a summary from each simulation including areas for system improvement, individual(s) responsible for addressing the issues identified during the simulation
- This process should become part of the routine quality and safety processes at the institutional level
- Follow up, and repeat simulations are mandatory, as a single intervention without follow up will not lead to any improvement in patient care

1. q1h lab results from simulation #2

VERSION 1		
Lab work	**On arrival**	**60 minutes**
Hemoglobin (g/L)	97	72
Platelets (x10^9/L)	78	58
INR	1.8	2.2
Fibrinogen (g/L)		1.6
Lactate		3.0
PH		7.34
Blood products administered	1 unit RBC	1 unit RBC 1 pool platelets 2 units FFP
Vital signs BP Temperature	 81/43 Not measured	 84/47 Not measured

VERSION 2		
Lab work	**On arrival**	**60 minutes**
Hemoglobin (g/L)	97	65
Platelets (x10^9/L)	78	58
INR	1.7	2.3
Fibrinogen (g/L)		1.0
Lactate		3.0
PH		7.34
Blood products administered	4 units RBC + 1 pool platelets (based on low count) 2 units FFP	1 pool platelets 4g Fibrinogen Concentrate
Vital signs BP Temperature	 84/47 36.5	 93/52 36.5

MASSIVE HEMORRHAGE PROTOCOL DEBRIEFING GUIDE – GI BLEED SCENARIO

Learning Objectives:

1. Demonstrate safe and proficient management of an adult patient with injury and significant bleeding.
2. Recognize need for massive hemorrhage protocol (MHP) and demonstrate ability to activate an institutional protocol
3. Achieve high performance in situational awareness, teamwork and communication in a simulated setting.
4. Identify areas of improvement and develop a plan.

Notes:

- The intent is to display this video to the intended audience as a group. A facilitator with content expertise will be present to lead the discussion after the video is viewed.
- The facilitator should inform the audience that the people in the video have consented to be observed, and that their performance in the video was scripted and does not reflect how they would perform with a real patient.
- This teaching session could be done in person or virtually. It is intended to be done with synchronous learning, and the facilitator should endeavour to provide an interactive session with audience participation.
- This video contains 2 versions: version 1 is managed with intentional gaps in quality of care, and allows the group to discuss how the management shown here could be improved. Version 2 is the same scenario managed better.
- Version 1 should be watched first and the video stopped after this scenario. A discussion will ensue. After this discussion, the video can be re-started and version 2 watched and discussed.
- The audience should have the observation tool in front of them as they watch the video. They should be encouraged to make notes and observations and be prepared to discuss the scenario after watching.
- Evaluation forms of this session should be completed by all participants at the end of the session.

A comment on TXA

While TXA is a component of an MHP, the use for patients with gastrointestinal bleeding is controversial. The HALT-IT trial, published in 2020 (Reference: Lancet 2020;395:1927-36) is a large international randomized placebo-controlled trial that enrolled 12,000 subjects with a GI bleed. The treatment group received 1 g TXA over 10 minutes followed by 3g TXA over the next 24 hours.

There was no difference in the outcome of death due to bleeding within 24 hours, 5 days or 28 days. There was no difference in the risk of arterial thromboembolic events, but there was a significant difference in the risk of venous thromboembolic events (RR 2.11, 95% CI 1.25-3.59), with a suggestion of higher risk in those with suspected variceal bleeding or liver disease.

Recognizing that this is a single trial, that the dose of TXA used was high, and that the patient in this scenario has advanced liver disease, it was decided not to administer TXA in this scenario. The usage and dosing of TXA for an MHP in a GI bleed remains at the discretion of the treating health care team. These comments are intended to guide discussions around this topic and not to dictate management nor standard of care.

MASSIVE HEMMORHAGE PROTOCOL SIMULATION OBSERVATION TOOL

1	2	3	4	5
Poor	**Marginal**	**Acceptable**	**Good**	**Not Observed**
Performance endangered or potentially endangered patient safety	Performance indicated cause for concern, considerable improvement needed	Performance was of satisfactory standard but could be improved	Performance was of a consistently high standard, enhancing patient safety	

Objectives	Questions	Comments	Rating (1-4)
Triggering	Were there any errors in the method of activation? Did the patient meet the activation criteria? Were there any delays in triggering MHP?		
Team	Was the appropriate team mobilized (appropriate type and number of personnel)? Did the team leader manage the team well? Was the team functioning well as a unit to complete the appropriate steps needed during the MHP?		
Testing	Were appropriate labs drawn at baseline then at least hourly? Was Group & Screen drawn immediately?		
TXA	Was TXA administered within 1 hour of MHP activation? Was an appropriate dose used?		
Temperature	WWas the temperature checked at baseline? Was the temperature kept at or over 36C? Were warming measures used if temperature below 36C?		

Objectives	Questions	Comments	Rating (1-4)
Transfusion	Did the patient receive appropriate ratio based resuscitation at a minimum of 2RBC:1Plasma? Were uncrossmatched RBCs available at the bedside within 10 minutes of activation? Did the lead physician communicate clearly to the nursing staff what products to administer?		
Termination	Was the MHP terminated in the appropriate manner? Were the remaining blood products returned in the appropriate storage containers? Was all blood not wasted?		