School Nurses on the Front Lines of Medicine

The Approach to a Student With Severe Traumatic Bleeding

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With the continued threat of mass casualty incidents in schools and surrounding communities, it is essential for school nurses to be knowledgeable regarding the recognition of hemorrhagic shock due to massive bleeding and the acute management of these victims. In the past decade, increased interest and research in acute bleeding control have led to published evidence-based guidelines to reduce morbidity and mortality for victims of violent acts. It is essential that healthcare providers, including nurses who are the first responders in schools, are aware of methods to assess and control massive bleeding. This article summarizes the most up-to-date recommendations for the management of children with traumatic bleeding.

Keywords: mass casualty events; hemorrhagic shock; bleeding control; tourniquets

Who Is the ER Pediatrician?

Dr. Robert Olympia, MD, is a pediatric emergency medicine physician with more than 20 years of experience, currently working in an emergency department in the Sweetest Place on Earth (Hershey, Pennsylvania). He is a professor in the Departments of Emergency Medicine and Pediatrics at the Penn State College of Medicine. His research interests include emergency and disaster preparedness for children in the setting of schools and school-based athletics, as well as in sports-related illness and injuries. He has presented his research both regionally and nationally and has lectured on a variety of topics pertaining to pediatric emergency medicine, such as fever and infectious diseases, trauma, sports-related injuries, and disaster preparedness.

Who Are Dr. Olympia's Coauthors?

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What Is the Purpose of the "School Nurses on the Front Lines of Medicine" Series?

The "School Nurses on the Front Lines of Medicine" series will present cases reflecting emergencies commonly encountered in the school setting, focusing on an evidence-based approach to the initial management, stabilization, and disposition of the ill or injured child. Topics to be covered in this series will include children presenting with the chief complaint of fever, vomiting/diarrhea/dehydration, shortness of breath, severe allergic reaction, lacerations/abrasions, sprains/strains/contusions, head injury/headaches, heat-related illness, acute mental status changes, seizures, cardiac arrest, chest pain, fainting, abdominal pain, and extremity fractures.

Special features unique to each article are extra credit points and report cards. Extra credit points are trivia questions or clinical pearls scattered throughout the article related to the topic at hand. Report cards are concise tables summarizing key points in each article that you can photocopy and laminate or photograph and keep on your smart device for easy access.

Case

You are summoned to the gymnasium and realize that the metal bleachers have collapsed under the weight of a group of children. You quickly discover that three of the children have sustained traumatic injuries, including lacerations associated with bleeding. The first child, Justin, is awake and alert with a 3-centimeter laceration to his right shoulder that is bleeding lightly. The second child, Mary, is screaming in pain but breathing fast with shallow breaths and has a 5-centimeter laceration to her lower

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abdomen that is bleeding moderately, but not enough to soak through her clothing. The third child, Alan, has a deep 10-centimeter laceration to his left thigh that is causing blood to soak through his clothing and pool on the ground around him. He is pale, sweaty, and confused; he tells you, "I feel like I'm going to pass out."

You immediately call 9-1-1 and emergency medical service (EMS) personnel are on the way. You ensure that the threat of further injury is not present. Now that you have had a moment to perform a primary assessment on each of the three children, what is the first step to managing each of them? Which of the three children would be a candidate for a tourniquet if one were available?

Extra Credit Point: What Is the Pediatric Assessment Triangle?

The Pediatric Assessment Triangle describes a method of performing an initial assessment of an acutely ill or injured patient utilizing three components: appearance, work of breathing, and circulation of the skin (Fernandez et al., 2017). Appearance reflects the adequacy of ventilation, oxygenation, brain perfusion, and central nervous system function and assesses the patient's tone, interactiveness, consolability, look/gaze, and speech/cry. Work of breathing, which assesses abnormal breath sounds, abnormal positioning (e.g., the tripod position for upper airway obstructions), retractions, and nasal flaring, is a more accurate indicator of oxygenation and ventilation compared with respiratory rate and lung auscultation. Circulation of the skin reflects cardiac output and perfusion of vital organs and assesses pallor, mottling, and cyanosis.

Utilization of the Pediatric Assessment Triangle is essential for determining disposition and for triaging when multiple patients are involved. A patient with no derangements of the three components of the Pediatric Assessment Triangle is often considered "sick," a patient with one derangement is often considered "sicker," and a patient with two or three derangements is often considered the "sickest."

When Tragedy Strikes

Mass casualty events may occur in the school setting due to accidental or intentional events. Unfortunately, violent acts associated with terrorism, such as school shootings, occur far too often. The horrific events that occurred at Sandy Hook Elementary in 2012 prompted the meeting of a group of world-class government and healthcare leaders that would become known as the Hartford Consensus. The documents they produced outlined strategies, especially the application of bleeding control measures such as tourniquets, to increase survival in mass casualty events. Despite these strategies, more recent violent events, such as the deadly shootings at Santa Fe High School and Stoneman Douglas High School in 2018, continue to result in significant morbidity and mortality of students and school staff.

External hemorrhage remains the most significant preventable cause of death associated with mass casualty events due to terrorism (Jacobs & Joint Committee to Create a National Policy, 2015). School staff should be knowledgeable regarding the recognition of hemorrhagic shock due to massive bleeding and the acute management of these victims in order to reduce morbidity and mortality. The initial response to a mass casualty event, as outlined by the Hartford Consensus, is the acronym "THREAT", as shown in Table 1.

When Initial ABCs Are Not the Traditional ABCs

Managing a student with a significant bleeding injury can be a stressful and challenging task. Although the traditional ABCs ("Airway, Breathing, and Circulation") are essential to the acute management of an ill or injured student, "Alert, Bleeding, and Compression" are also important in the initial management of a patient with a significant acute hemorrhage (Pons & Jacobs, 2016):

Alert: Call 9-1-1. Emergency medical services must be notified immediately in order to transport the student with significant acute hemorrhage to the nearest emergency department.

Table 1. Report Card: Algorithm for Initial Response to a Mass Casualty Event ("THREAT")

1.	Threat suppression
2.	Hemorrhage control
3.	Rapid extrication to safety
4.	Assessment by medical providers
5.	Transport to definitive care

Source: Jacobs et al. (2013).

Bleeding: Find the bleeding injury. The source of any life-threatening bleeding must be quickly identified. Clothing around the injury site and objects in pockets that may interfere with tourniquet or gauze placement should be removed to allow full access to the bleeding site. Specific aspects of the injury such as the location and severity must be assessed before appropriate interventions can be applied.

Compression: Apply direct steady pressure and control bleeding. Direct pressure with either a towel, gauze pad, or a gloved hand, wound packing with either gauze pads or commercial hemostatic gauzes that contain agents that facilitate blood clotting, and tourniquets can be applied to compress the blood vessels, prevent ongoing bleeding, and reduce the likelihood of hemorrhagic shock.

Extra Credit Point: What Systolic Blood Pressure Values Define Hypotension in Children? What Heart Rate Values Define Tachycardia?

For children 1 to 10 years of age, the minimum healthy systolic blood pressure can be estimated using the following formula: 70 mmHg + (age in years × 2). For patients above the age of 10 years,

hypotension is defined as a systolic blood pressure below 90 mmHg.

For children 1 to 12 years of age, tachycardia is defined as a heart rate greater than 180 beats per minute. For patients over the age of 12, tachycardia is defined as a heart rate greater than 100 beats per minute (American Heart Association, American Academy of Pediatrics, 2016).

Hypotension and tachycardia in a patient who is acutely bleeding may indicate hypovolemic shock due to blood loss ("hemorrhagic shock").

Don't Fixate on All the Blood . . . Remember the Traditional ABCs

Although it is a natural tendency to fixate on any bleeding occurring before your eyes, it is important to remember that the initial assessment of a student who has sustained any trauma also involves the traditional ABCs.

Airway and Breathing

Is the student able to speak to you? What is his or her respiratory rate? What color is his or her lips? If he or she is able to speak, then his or her airway is open. If the student is unresponsive, unable to speak, and/or has signs of respiratory distress (fast or labored breathing, shallow breaths, absent chest rise, blueness of or around the lips, or evidence of airway obstruction [visualization of vomitus or excessive saliva in or around the mouth, gurgled upper airway sounds]), then you may have to position the head and neck with slight hyperextension (the "sniffing" position with a towel behind the shoulders) and proceed with rescue breaths. A student with a significant head injury or massive hemorrhage may have a depressed mental status, therefore affecting his or her ability to maintain an airway or breathe on their own. Tachypnea may be secondary to significant blood loss (respiratory alkalosis due to metabolic acidosis). If you have a stethoscope readily available, listen for breath sounds in all lung fields: There should be good aeration bilaterally without crackles or rales.

A Is Also Alignment

For any student who is unresponsive or complains of neck pain, and has a significant head, neck, or facial injury, it is of utmost importance to maintain cervical spine immobilization to minimize the risk of a possible spinal cord injury. Immobilization may be attained either with a cervical spine collar (if available) or with a staff member whose only responsibility is to hold the neck in midline positioning, avoiding any flexion, extension, or rotation.

Circulation

What is the student's heart rate and blood pressure? Are the student's extremities well perfused (strong and regular pulses, capillary refill less than 2 seconds, warm and pink skin)? Tachycardia and hypotension in a student who is acutely bleeding may indicate hypovolemic shock due to blood loss ("hemorrhagic shock").

Disability

What is the student's neurologic status? Is the student alert and oriented to person, place, and time? The focused neurologic exam of a student who recently sustained a head injury may include the following:

1. What is the student's overall neurologic status? The overall neurologic status of a student can be described quickly by either the mnemonic "AVPU" or by the Glasgow Coma Score (see Table 2). A depressed mental status may be secondary to hypoperfusion of the brain due to significant blood loss.
2. Are the pupils equal and responsive to light? Are they normal in size (2-4 millimeters)? Do the eyes move up and down, left and right on command?
3. Is there normal strength and sensation (to touch) of the bilateral arms and legs, and is the strength and sensation equal on both sides?

Head to Toe Examination

In any student who has sustained a traumatic event, it is important to perform a complete head to toe examination, including the head, face, neck, chest, abdomen, pelvis, back, and extremities. If life-threatening bleeding is occurring internally or is covered by clothing, it may not be initially apparent.

Indications for Tourniquets and Bleeding Control Measures

A tourniquet may be indicated in instances of life-threatening bleeding, as described in Table 3. During a mass casualty event, first responders will need to triage patients and determine which patients require immediate intervention based on the severity of their injuries.

The location of bleeding plays a large role in patient management. Standard commercial tourniquets can only be applied to arms and legs and cannot be applied to stop bleeding that occurs at the hip, shoulder, abdomen, torso, neck, or head. Penetrating abdomen and torso wounds cannot be managed effectively outside of the hospital because internal organs and blood vessels are likely damaged. Applying pressure to wounds of this nature does not effectively occlude the blood supply and bleeding often continues.

Types of Tourniquets

The limb tourniquets recommended by The Committee on Tactical Combat Casualty Care (CoTCCC) are the Combat Application Tourniquet (CAT), Special Operations Forces Tactical Tourniquet (SOFTT), and the Emergency Medical Tourniquet (EMT). While a multitude of other tourniquets, such as the Stretch Wrap and Tuck Tourniquet (SWAT-T) and the Rapid Application Tourniquet System are available for purchase, only the CAT, SOFTT, and EMT are recommended by the CoTCCC. Figure 1 shows a standard CAT tourniquet, commonly found in standard bleeding control kits.

Application of Tourniquets

For a tourniquet to be effective, it must be applied correctly. Criteria for effective tourniquet application includes prompt response, proper placement, and adequate tightness to stop blood flow to

Table 2. Report Card: General Assessment of Neurologic Status

1."AVPU":
Alert (A)
Responds to verbal stimulation (V)
Responds to painful stimulation (P)
Unresponsive (U)
2. *Glasgow Coma Score* (GCS; ranges from 3 to 15, assign a score for each of the following 3 assessments: eye opening, verbal response, and motor response):
Eye opening
Spontaneous (4 points)
Opens to verbal command or shout (3 points)
Opens to pain (2 points)
None (1 point)
Verbal response
Oriented (5 points)
Confused conversation, but able to answer questions (4 points)
Inappropriate responses, words discernable (3 points)
Incomprehensible speech (2 points)
None (1 point)
Motor response
Obeys commands for movement (6 points)
Purposeful movement to painful stimulus (5 points)
Withdraws from pain (4 points)
Abnormal (spastic) flexion, decorticate posture (3 points)
Extensor (rigid) response, decerebrate posture (2 points)
None (1 point)
Interpretation: Mild head injury (GCS 14-15)
Moderate head injury (GCS 9-13)
Severe head injury (GCS 3-8)

the affected extremity. To control life-threatening external bleeding of a limb, a tourniquet should be applied 2 to 3 inches above the wound, and it must be tightened enough to stop blood flow. If bleeding continues after placement of the first tourniquet, a second tourniquet can be applied above the current tourniquet without the removal of the first tourniquet (National Association of Emergency Medical Technicians, 2018). Figure 2 shows a practice CAT applied to a model. Proper application of a tourniquet can be viewed in the following instructional video from Gwinnett Medical (2017; see https://youtu.be/BVij7f6Brgo).

A study of laypersons with no prior tourniquet training found only 16.9% correct application of the CAT and 10.6% correct application of the SWAT-T. The cause of incorrect application was inadequate tightness in 74.1% of cases, improper placement technique in 44.4% of cases, and incorrect positioning in 16.7% of cases (Ross et al., 2018). Clearly, proper training is required before bystanders are capable of successfully applying tourniquets. Table 4 shows common mistakes made regarding tourniquet application as outlined by the Hartford Consensus.

Are Tourniquets Safe and Effective?

Bystanders are often hesitant to apply tourniquets because they are afraid of cutting off circulation and damaging the limb with the tourniquet itself. Historically, tourniquets were discouraged based on fear of ischemic damage, but these recommendations were not evidence-based. Claims of the dangers of tourniquets have propagated into modern society, but years of military research have proved these notions to be false. An influential military study showed that, when used appropriately, tourniquets improve prehospital survival and do not result in ischemic damage (Kragh et al., 2009). Even if the tourniquet is applied for too long, the risk of ischemic damage is preferable to the risk of severe hemorrhage and death due to shock.

Recently, tourniquets have been proven to be effective in the civilian sector. A large, multicenter study showed that tourniquet application was associated with a sixfold reduction in mortality (Teixeira et al., 2018). Current recommendations for bleeding control include more frequent use of tourniquets in the prehospital setting for patients with severe extremity bleeding.

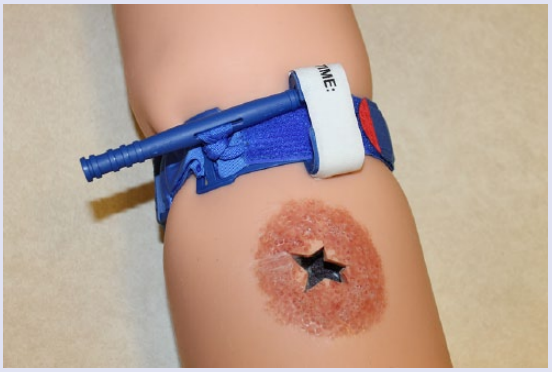
Table 3. Report Card: Signs of Life-threatening Bleeding

• There is pulsatile or steady bleeding from the wound.
• Blood is pooling on the ground.
• The overlying clothes are soaked with blood.
• Bandages or makeshift bandages used to cover the wound are ineffective and steadily becoming soaked with blood.
• There is a traumatic amputation of the arm or leg.
• There was prior bleeding, and the patient is now in shock (unconscious, confused, pale).

Source: Holcomb, Butler, and Rhee (2015).

Figure 1. Combat Application Tourniquet (CAT)

Figure 2. Practice Combat Application Tourniquet (CAT) Applied to a Practice Model



Extra Credit Point: How Long Can a Tourniquet Be Applied Before It Causes Permanent Damage?

Ischemic damage is rare if the tourniquet is used for less than 2 hours, and surgeons often apply tourniquets continuously for even longer in the operation suite without causing ischemic injury.

Tourniquets for Pediatric Patients

Although data regarding the use of tourniquets in pediatric patients is limited, the Pediatric Trauma Society supports the use of tourniquets in the prehospital setting for severe extremity hemorrhage (Cunningham, Auerbach, Cicero, & Jafri, 2018). The Pediatric Trauma Society recommends direct steady pressure as the initial intervention for significant hemorrhage, but this technique becomes problematic if the provider must care for multiple patients concurrently. A successfully placed tourniquet would allow the provider to move on to care for other patients in the event of a mass casualty event.

The CAT, SOFTT, and EMT are recommended for all ages, but critics claim that they may not be effective for application on the arms or legs of very small school children. If recommended tourniquets do not control hemorrhage due to small limb size, other bleeding control measures, such as direct steady pressure, must be applied.

Extra Credit Point: Would My Belt Work as a Tourniquet?

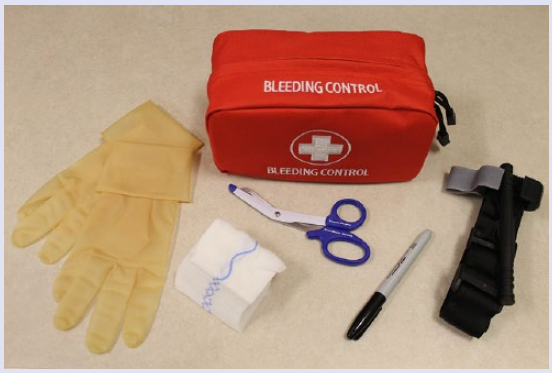
Current literature and training programs do not fully support the use of improvised tourniquets, such as belts and ropes. Improvised tourniquets may waste time, break, or fail to achieve adequate tightness. Applying constant pressure to the wound by hand is likely equally effective, if not more effective, than makeshift tourniquets.

Table 4. Report Card: Common Mistakes Made Regarding Tourniquets

• Not having an effective commercial tourniquet available
• Not using a tourniquet when one should be used
• Using a tourniquet for minimal or minor bleeding when one should not be used
• Putting the tourniquet on too proximally
• Not making the tourniquet tight enough to effectively stop bleeding
• Not using a second tourniquet if needed
• Waiting too long to put the tourniquet on
• Not reevaluating the tourniquets effectiveness
• Periodically loosening the tourniquet to allow blood flow to injured extremity

Source: Holcomb et al. (2015).

Figure 3. Contents of a Standard Bleeding Control Kit: Gloves, Hemostatic Gauze, Trauma Shears, Permanent Marker, and a Combat Application Tourniquet



Stop the Bleed: Bleeding Control Training Programs

Individuals must be trained in bleeding control before they can successfully utilize these techniques. Simply understanding the concepts outlined in this article does not qualify an individual to control bleeding; a hands-on, certified training program, such as the Stop the Bleed program, is often suggested. Stop the Bleed is a nationwide initiative of the American College of Surgeons Committee on Trauma and the Hartford Consensus that trains bystanders, school staff and nurses, healthcare providers, first-responders, and members of a community through a basic bleeding control course. The course is taught by a certified healthcare provider and includes the opportunity to practice tourniquet application and other bleeding control techniques. A study has shown that the Stop the Bleed course gives trainees the confidence and knowledge to assist in the prevention of unnecessary hemorrhagic death (Lei et al., 2018). More information can be found on their website, www.bleedingcontrol.org.

Individuals cannot effectively apply bleeding control measures if they do not have access to the proper equipment. After training, members of the community or school systems should ensure that they have access to bleeding control kits (Figure 3) so that they can respond quickly in a bleeding emergency. Professionals and civilians alike are capable of controlling external hemorrhage, but only if they are both well-trained and well-equipped (Holcomb et al., 2015). Bleeding control kits come at a relatively low cost but with a huge life-saving potential.

Case Resolution

Using the Pediatric Assessment Triangle, you triage Justin as "sick", Mary as "sicker," and Alan as the "sickest." You feel confident in your ability to manage acute hemorrhage because you recently completed a community Stop the Bleed course. You quickly call 911 and retrieve the bleeding control kit located in the hallway outside the gymnasium.

Alan is experiencing hemorrhagic shock, as indicated by changes in his mental status, signs of hypoperfusion, and significant blood loss. He is a candidate for tourniquet application due to the severity of his bleeding and the location of the deep laceration on his thigh. You are able to utilize your hemorrhage control training to effectively apply a tourniquet to Alan's thigh to stop the bleeding.

While Mary's abdominal laceration does not appear to be bleeding profusely, the possibility of significant, life-threatening intra-abdominal injury makes her assessment difficult. The location of her injury makes her ineligible for a tourniquet. While applying direct steady pressure to her superficial abdominal laceration with gauze pads may control further external hemorrhage, application of pressure would be relatively ineffective in controlling intra-abdominal injury and bleeding. Although her vital signs, mental status, respiratory status, and perfusion are stable, she requires transport to the local emergency department for observation and possible operative treatment.

Justin is the student with the least life-threatening hemorrhage. His

shoulder laceration is not exhibiting any of the signs of life-threatening hemorrhage. Application of direct steady pressure with gauze pads may be enough to stop his bleeding.

EMS arrives, and all three children are transported to the nearest emergency department for stabilization and further management. Your tourniquet saved Alan's life, and he recovers fully without loss of leg function.

In the event of a mass casualty incident at school, it is essential for school nurses to be knowledgeable regarding the recognition of hemorrhagic shock due to massive bleeding and the acute management of these victims. Therefore, it is paramount that first responders, including school nurses and school staff, are trained in bleeding control skills and have access to proper bleeding control equipment.

Contact Dr. Olympia

If you have a clinical question, send your question to Dr. Olympia (rolympia@hmc.psu.edu). Questions will be selected and discussed as part of the "School Nurses on the Front Lines of Medicine" series. ■

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