

Hemorrhage Control

Lessons Learned From the Battlefield

Use of Hemostatic Agents That Can Be Applied in a Hospital Setting

Herman A. Allison, FNP-C, MSN, RN, CCEMT-Paramedic, PNCCT

Uncontrolled blood loss is a major cause of preventable death worldwide. A severe injury can occur anywhere at any time. Controlling blood loss is an important issue for patient care in the hospital setting. Through the casualties of war, the lifesaving value of quick interventions was developed. Since 2001, new hemostatic agents have advanced the benefits of controlling blood loss. There are unforgettable lessons learned in the preventable deaths of many soldiers and should be passed on to the next generation of health care providers, to include all hospitals up to level I trauma hospitals. This article covers the current hemostatic agents that have been used for more than 17 years on the battlefield and are slowly making their way into the hospital settings. The hemostatic agents covered include QuikClot Combat Gauze, QuikClot Control+, WoundClot Hemostatic Gauze, HemCon Nasal Plug, and RevMedx's XSTAT hemostatic device. The standard of care should not be affected by the location of a patient, whether that patient is in a remote village overseas, on the battlefield, a rural farm, or at a major metropolitan hospital here in the United States. **Key words:** *critical care, ED, hemorrhage/bleeding control, hemostatic agents, liver lacerations, military, nosebleeds, postcardiac catheterization, postpartum hemorrhage, trauma*

THERE is an old Latin saying *Need taught him wit*. This became the old English proverb “necessity is the mother of invention.” Across many cultures, throughout his-

tory there were setbacks, defeats, and challenges that required a creative solution. These areas include improvements in science, technology, medicine, and the military. We, as humans, learn from our mistakes and setbacks with a mindset of learning and growing to come back and do better.¹

The US Military learned from previous wars. Causality survival rates from gunshot wounds and explosive fragments have improved. During World War II the survival rate was 80%, and 84% in the Korean War. Since 2001, the survivability rate is now at 90%.^{2,3} During the Vietnam War, one Army Medical Corps officer used his experience to improve medical care. Quote from Spurgeon Neel, Colonel, Medical Corps, US Army⁴:

It is appropriate that experience during unavoidable “epidemics of trauma” be exploited in improving our national capability to provide better surgical and medical care for citizens.

Author Affiliation: SR-AHEC Family Practice Clinic, Fayetteville, North Carolina.

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I would like to dedicate this article to all the Americans who have died supporting the War on Terror all over the world since September 11, 2001.

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Correspondence: Herman A. Allison, FNP-C, MSN, RN, CCEMT-Paramedic, PNCCT, SR-AHEC Family Practice Clinic, 1601 Owen Dr, Fayetteville, NC 28304 (RNMedic1@botmail.com).

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REAL LIFE STORY

As an army soldier in a combat zone, I needed to stop the bleeding of a fellow soldier that was shot by the Russian assault weapon—Avtomat Kalashnikova (AK-47), during an ambush at a remote location. Blood was pumping out with each heartbeat, but all I had was a small gauze dressing in my first-aid pouch. I did all that I could with what I had, but he still bled out and died. Years later, I was again at a remote location, with a wounded casualty bleeding out from the devastating effects of an AK-47 round. This time with the newest hemostatic agent, tourniquets, predeployment hands-on training, and the confidence to use these products, I was able to stop the bleeding and save his life.

Lessons learned from the recent war on terror should be passed on to the civilian medical communities and hospital systems. Some areas of military trauma care are years ahead of civilian medicine.⁵ Seeking out new medical procedures and devices from other sources that could be used to provide the highest quality of care for our patients should be the goal of every medical professional.

DISCUSSION

Uncontrolled hemorrhage is a leading cause of prehospital mortality in military trauma and the second leading cause after civilian trauma.⁶⁻¹⁰ A severe injury can occur anywhere at any time. Controlling blood loss is an important issue for patient care in both prehospital and in the hospital. We have learned from previous wars the value of quick, easy-to-use interventions that save lives. There are unforgettable lessons learned in the preventable deaths of many soldiers. An example cited by Bellamy⁶ states that, in Vietnam, 2500 soldiers lost their lives due to lack of hemorrhage control from extremity injuries. Since 2001, we have learned the advantages of new hemostatic agents and the benefits of controlling blood loss.¹¹⁻¹⁴ These vital discoveries should be passed on to the next generation of health care providers in a

hospital setting. This article discusses the current hemostatic agents that have been used for more than 17 years on the battlefield and are slowly making their way into the civilian sector. Examples will include its uses in the emergency department (ED) trauma room, a cardiac care unit (CCU), the labor and delivery unit, and general surgery. The standard of care should not be affected by the location of a patient, whether that patient is in a remote village overseas, on the battlefield, a rural farm, or a metropolitan hospital in the United States.

FUNCTIONALITY OF HEMOSTATIC AGENTS

QuikClot Combat Gauze

Each dressing is a multiple-ply rayon/polyester construction coated with kaolin, aluminum silicate clay, which is a potent coagulation initiator. Dressings come in several forms, which can be tailored for usage. Since kaolin is an inert mineral that does not contain animal or human proteins, no allergic reaction at the site of application was reported. Contact between kaolin and blood triggers electrostatic rearrangement of factor XII, making factor XII to become activated and initiate intrinsic coagulation pathway. QuikClot Combat Gauze (QCG) accelerates the clotting cascade while creating a stronger and faster clot on a single sheet.^{11,12} (See the Appendix.)

QuikClot Control+

This is the first and only hemostatic dressing indicated for temporary control of internal organ space bleeding for patients displaying class III or class IV bleeding, as in damage control surgery—a new option that can be delivered quickly, easily, and reliably to offer effective, safe, and efficient performance in the worst bleeds. It is available in various sizes, ranging from 5- to 12-inch squares.

WoundClot Hemostatic Gauze

WoundClot Hemostatic Gauze is a Food and Drug Administration (FDA)-cleared,

next-generation hemostatic gauze made from cellulose, which is engineered to be effective in the management of mild, moderate, and severe bleeding. It is FDA approved for intraoperative use. WoundClot is also effective in the temporary management of severe bleeding during surgical procedures as well as postoperative and donor-site bleeding. It works by absorbing up to 3500% its size and weight in fluid and remains actively absorbent for up to 36 hours. This new product has multiple uses; the smaller size 2-×2-inch can be used for postprocedure wound oozing, rhinoplasty, scalp/facial lacerations, fingertip avulsions, nosebleeds, abrasions and skin tears, oozing lines, ports, and tubes. The 3-× 8-inch size can be used for gunshot and stab wounds, blunt and penetrating trauma, lacerations and avulsions, moderate to severe venous and arterial bleeding, postpartum bleeding, and vaginal tears. For the renal dialysis patient, the gauze can be used for arteriovenous shunt site bleeding.

HemCon Nasal Plug (m.doc)

The m.doc Nasal Plugs are a polyvinyl acetate sponge with Tricol's proprietary formulation of microdispersed oxidized cellulose (m.doc). The Nasal Plug expands and softens to fit the nasal cavity while it absorbs blood to control anterior nose bleeding fast. Nasal plugs offer patients an easy-to-use, quick, comfortable, and reliable solution to stop nasal bleeding without any side effects.

RevMedx's XSTAT

XSTAT is a hemostatic device control for severe, life-threatening bleeding from junctional wounds in the groin or axillary, and bleeding from narrow entrance extremity wounds in the arms or legs not amendable by tourniquet application in adults and adolescents.

The XSTAT device is designed to seal gunshot wounds in the pelvis or shoulder area in about 15 seconds. It works like a syringe that injects tablet-sized sponges into the wound that then expand and provide the necessary hemostasis while the patient is transported.

The XSTAT device works by providing mechanical direct internal pressure inside the wound. There are no hemostatic agents of any kind. Once they come in contact with liquid, they quickly expand and create an internal compression. The sponges provide a surface on which blood can begin to clot. The sponges will need to be removed, and each has a tiny radiopaque marker so that any remaining in the body can be spotted on x-ray.

GENERAL GUIDELINES

Hemostatic agents work in different ways to stop bleeding. Their proper use requires education on how they work with hands-on training so that they can be used correctly. All hemostatic agents were designed to be used with direct pressure at the site of the wound, even deep inside the wound, if needed.

Drew et al¹⁵ discuss the decade-long advances of battlefield medicine for the treatment of severe hemorrhage that have led to a significant reduction in mortality. The authors looked into the older methods of direct pressure, pressure points, and elevation that are no longer recommended, and recommend the use of both hemostatic agents and tourniquets for hemorrhage control that can be used by any provider in any setting. They emphasize the evidence-based advances on tourniquets for extremity injuries that occurred in battle trauma medicine since 2001. They state that these tourniquets had a profound effect on saving lives.

Product alert

Hemostatic agents should not be used on the eyes, airway, chest, or head injuries where there is exposed brain tissue.

Hemostatic agent use in a hospital setting: Emergency department

If the local emergency medical services do not carry hemostatic agents, then the ED trauma team should be able to quickly and correctly apply the tourniquet and/or hemostatic agents to gain hemostasis for penetrating trauma, gunshot, or stabbing wounds.

ED trauma case

In a trauma patient with multiple gunshot wounds who becomes hypothermic and hemodiluted, Johnson et al¹⁶ found that QCG was more effective in achieving hemostasis than standard gauze (84.6% QCG vs 30.8%, standard gauze). The QCG reduced blood loss by an average of 92.5% in a hemodiluted and hypothermic porcine model. This is easy to use; the gauze goes directly into the wound and direct pressure to the site held for at least 2 to 3 minutes until the bleeding stops.

Common occurrence: Nosebleeds

A 7-year-old boy comes to the ED with a severe nosebleed due to his hemophilia. At home, his mom did all the standard treatment of direct pressure, but the bleeding did not stop. Te Grotenhuis et al¹⁷ studied the effectiveness of HemCon Nasal Plugs in the treatment of severe epistaxis in the prehospital setting. During June 2012 to December 2014, a total of 33 patients were treated with HemCon Nasal Plugs. Twenty-four patients were taking anticoagulants or suffered from a clotting disorder. The study concluded that HemCon Nasal Plugs were effective adjuncts to use in severe uncontrolled epistaxis.

ED to cardiac catheterization suite, CCU hospital case

A 56-year-old man with the complaint of chest pain, shortness of breath, and nausea arrives via emergency medical services to the local ED. The ED staff meets the patient for quick assessment and up he goes to the catheterization laboratory. Due to previous catheters and scar tissue, they were unable to gain femoral access. The radial approach is used and postcardiac catheter hemorrhage control is done by QuikClot radial pad with the Trans-Radial (TR) compression device band in place.

Postcardiac catheterization procedure CCU case

In the cardiac care/chest pain unit, the same patient is now undergoing postcar-

diac catheterization with a hemorrhage at the catheter insertion site. Whether this is the femoral or radial site, the standard treatment of direct pressure, occlusive dressing, pelvic binder, or TR band is unsuccessful. The critical care nurse would be able to use a proven hemostatic agent to stop the bleeding. Roberts and Niu¹⁸ reported the use of a hemostatic agent to achieve patient hemostasis of both the radial and ulnar arteries at the completion of the diagnostic and coronary interventional procedures.¹⁹ The hemostatic used was QuikClot radial hemostasis pad and the TR band. In the study, Roberts and Niu¹⁸ had 30 patients went through transradial access (TRA) coronary angiography and/or percutaneous coronary intervention were randomized into 3 cohorts post-TRA: 10 patients received mechanical compression with the TR band, 10 patients received 30 minutes of compression with the QuikClot radial pad, and 10 patients received 60 minutes of compression with the QuikClot radial pad. Times to hemostasis and access-site complications were recorded. Successful hemostasis was achieved in 100% of patients, with both the 30- and 60-minute compression groups using the QuikClot pad. Hemostasis failure occurred in 50% of patients when the TR band was initially weaned at the protocol-driven time (40 minutes after sheath removal). The study concluded that the use of the QuikClot radial pad significantly shortened hemostasis times when compared with the TR band, with no increased complications noted.

The study by Trabattoni et al²⁰ was the first European clinical trial sought to evaluate the safety and efficacy of the QuikClot interventional hemostatic bandage used for closures after diagnostic and interventional procedures. During this study, 40 consecutive patients undergoing diagnostic angiographic 62% or percutaneous coronary intervention 38% by femoral approach, using a 6 (90%) or 7 (10%) French size introducer, received arterial sheath removal with the QuikClot interventional gauze used to

control postprocedure bleeding. Only one hemostasis failure occurred requiring prolonged mechanical compression. The study found that neither major bleeding, re-bleeding, nor hematoma occurred after early ambulation.

Obstetrics

Labor and delivery case

A postcesarean section patient had a bilateral tubal ligation. The patient continued to bleed after standard treatment of fundal massage, IV Pitocin, Cytotec (misoprostol), and Hemabate (carboprost tromethamine) a form of prostaglandin used to treat severe bleeding after childbirth. Despite using current standard postpartum hemorrhage medical treatments, according to Evensen et al,²¹ the young woman continued to bleed out for more than 4 hours. She required 2 units of packed cells, and the attending physician took her back to the operating room.

Patel et al²² demonstrated the first case of QCG used to control vaginal hemorrhage 6 years earlier in 2012. If any hemostatic agent had been used during the early stages of her postpartum hemorrhage, it most likely would have been controlled, and the surgery may not have been needed. Schmid et al^{23,24} used a chitosan-covered gauze that was developed for combat trauma to gain hemostasis of postpartum hemorrhage and avoided a hysterectomy.

General surgery

Liver laceration case

In the operating room controlling bleeding can be a major issue for a patient with a liver laceration. The vascular liver can bleed profusely. Baker et al²⁵ compared hemostatic agents in an animal study for their possible use in arterial bleeding and liver lacerations. The study included 31 animals and included the monitoring of vital signs, hemodynamics, and fluid resuscitation for 4 hours. The study found the hemostatic agents were

superior to the standard of care in controlling the bleeding of organ surface and soft tissue.²⁵

LESSONS LEARNED

We have come a long way from using only a gauze and direct pressure in the management of hemorrhage control. These small, simple-to-use products save lives. More evidence-based outcomes are listed about the benefits of these agents.

Travers et al²⁶ in a European journal cited the use of QCG in civil prehospital practice. Zietlow et al²⁷ cite that both hemostatic bandages and tourniquets are effective use of translation from military experience to implementation in civilian trauma. Rowell²⁸ asks whether civilian trauma units should change how they manage injuries that involve massive loss of blood.

QCG is now the hemostatic dressing of choice for all military personnel deploying as per the updated 2018 Committee on Tactical Combat Casualty Care.²⁹ The selection of QuikClot is intended for common combat injuries. There are many new hemostatic agents, each with their own pros and cons based on the type of injury, procedure done, and location on the body. Each should be reviewed for the specific value added for patient care.

CONCLUSION

The use of specific hemostatic agents and tourniquets should be considered in both the prehospital and in hospital settings to stop bleeding not controlled with standard treatment. It is important to keep in mind that each type of hemostatic agent should be used as designed. Formal education and skills training need to be completed as with other clinical devices used in patient care. No matter the severity of wounds or the location of the patient, whether they are in a remote village or at a metropolitan medical center, the goal is better patient survivability outcomes.

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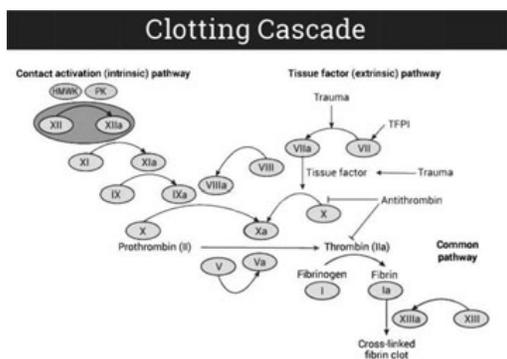
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APPENDIX

Diagrams and Illustrations



QuikClot Science: <https://www.z-medica.com/Products#Science>

This reaction leads to the transformation of factor XII to its activated form XIIa, which instigates the rest of the coagulation cascade.

Dee KC, Puleo DA, Bizios R. *Tissue-Biomaterial Interactions*. Hoboken: Wiley & Sons; 2002.

(Photo and product information used with permission)

QuikClot Combat Gauze



Product information from web site:

QuikClot hemostatic bandages are absorbent nonwoven rayon/polyester-coated gauze, approved by the Food and Drug Administration for external use to control bleeding.

Z-Medica-LLC QuikClot Product Information. Available from: <http://www.quikclot.com> [Accessed on July 1, 2018].

(Photo and product information used with permission)

QuikClot Control+



Product information from web site:

QuikClot Control+ is the first and only hemostatic dressing indicated for temporary control of internal organ space bleeding for patients displaying class III or class IV bleeding.

Z-Medica-LLC QuikClot Product Information. Available from: <https://quikclotcontrolplus.com/QuikClot-Control-Plus#about> [Accessed on Sept 20, 2018]

(Photo and product information used with permission)

WoundClot Hemostatic Gauze



Product information from web site: www.woundclot.com

WoundClot is made from cellulose, a natural product. WoundClot is the only Non-Oxidized Regenerated Cellulose (NORC) Product in world. On contact with blood, WoundClot rapidly converts to a thick tenacious gel that expands, creating internal pressure and effectively adheres to wound surfaces. WoundClot is highly absorbent (up to 3500% its size and weight in fluid), highly

adherent to wound surfaces—even in high-pressure bleeding and is actively hemostatic for up to 48 hours in the wound. Product information current as of Oct 16, 2018.

(Photo and product information used with permission)

HemCon Nasal Plug (m.doc)



Product web site: <https://tricolbiomedical.com/product/hemcon-nasal-plug/>

For Information: info@tricolbiomedical.com

The Nasal Plug expands and softens to fit the nasal cavity while it absorbs blood to control anterior nose bleeding fast. Nasal plugs

offer patients an easy-to-use, quick, comfortable, and reliable solution to stop nasal bleeding without any side effects. (Add your reference)

(Photo and product information used with permission)

RevMedx's XSTAT



Product information from web site: <https://www.revmedx.com/xstat/>

RevMedx has developed the XSTAT device that works by providing mechanical direct internal pressure inside the wound. There are no hemostatic agents of any kind. It comes in 2 sizes: the XSTA and the XSAT12 for larger wounds.

In 2017, XSTAT was recommended by the Tactical Combat Casualty Care (TCCC) and the Joint Trauma System for massive hemorrhage.

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