Stop the Bleed Consensus

Juan Duchesne¹, Scott Ninokawa², Manuel S Terrazas³, Pablo R Ortiz⁴, Francisco de Salles Collet e Silva⁵, Terence O’Keefe⁶

ABSTRACT

Aim: To discuss important interventions and techniques to control hemorrhage in trauma patients.

Background: Although there have been dramatic advances in trauma care over the last two decades, there are still a significant number of patients each year who succumb to death from hemorrhagic shock. Hemorrhage due to trauma is the leading preventable cause of death in the military setting, accounting for up to 90% of potentially preventable deaths; in the civilian setting, hemorrhage is second only to neurologic injuries as a cause of death due to trauma. In April 2013, the American College of Surgeons released the Hartford Consensus, with recommendations to enhance survivability from mass casualty incidents and active shooter scenarios. One of the four reports recommended an improvement in the implementation of bleeding control to prevent death from hemorrhage in patients with traumatic injuries.

Review results: Advances in hemostatic resuscitation, antifibrinolytic medications, and more rapid transport times have all decreased mortality from hemorrhage. There has also been better bystander training through the more recent “Stop the Bleed” campaign, with its emphasis on early extremity hemorrhage control, including tourniquet use in the field. While previous studies have shown a decreased mortality in patients who were transported to the hospital quicker, decreasing the time to hemorrhage control remains one of the greatest barriers to improving patient mortality.

Conclusion: In this consensus, the methods of hemorrhage control are discussed for use in the prehospital setting and the emergency department. Additionally, surgical procedures are described that may enhance hemostatic control in the operating room and lead to better outcomes during and after damage control surgeries.

Keywords: Abdominal trauma, Consensus, Emergency medical services, Emergency medicine, Hemorrhage control, REBOA (Resuscitative endovascular balloon occlusion of the aorta), Thoracic trauma, Trauma, Trauma surgery care.

INTRODUCTION

Although there have been dramatic advances in trauma care over the last two decades, there are still a significant number of patients each year who succumb to death from hemorrhagic shock. Hemorrhage due to trauma is the leading preventable cause of death in the military setting, accounting for up to 90% of potentially preventable deaths; in the civilian setting, hemorrhage is second only to neurologic injuries as a cause of death due to trauma.

In April 2013, the American College of Surgeons released the Hartford Consensus, with recommendations to enhance survivability from mass casualty incidents and active shooter scenarios. One of the four reports recommended an improvement in the implementation of bleeding control to prevent death from hemorrhage in patients with traumatic injuries.
in the implementation of bleeding control to prevent death from hemorrhage in patients with traumatic injuries.³

Advances in hemostatic resuscitation, antifibrinolytic medications, and more rapid transport times have all decreased mortality from hemorrhage.⁴ There has also been better bystander training through the more recent “Stop the Bleed” campaign, with its emphasis on early extremity hemorrhage control, including tourniquet use in the field. While previous studies have shown a decreased mortality in patients who were transported to the hospital quicker, decreasing the time to hemorrhage control remains one of the greatest barriers to improving patient mortality.⁵

In this consensus, the methods of hemorrhage control are discussed for use in the prehospital setting and the emergency department. Additionally, surgical procedures are described that may enhance hemostatic control in the operating room and lead to better outcomes during and after damage control surgeries.

**Prehospital Opportunities**

A majority of civilian and combat-related deaths caused by traumatic bleeding occur before reaching hospital care.⁶ Life-compromising bleeding without appropriate and timely control may lead either to death or, in case of initial survival and subsequent massive transfusion, to possible sepsis and/or multiorgan failure.⁷ Therefore, prehospital interventions aiming for hemorrhage control have now awakened great interest as a survival improvement opportunity. For that goal, several interventions have been developed or are currently being assayed experimentally. Table 1 shows the current available treatment option to stop the bleeding in the prehospital setting.⁸

The main issue to consider in implementing any set of interventions to control hemorrhage in the prehospital arena is the training level of the ambulance crew. In developing a system of prehospital care, it is essential to proactively establish the knowledge and skills that will be required of providers working at different levels in the system. National efforts to implement prehospital trauma care must not be hindered or sidetracked by well-intentioned but ill-advised schemes to emulate emergency care systems in developed countries. The implementation of costly advanced life support interventions may be counterproductive if it siphons scarce resources away from the core elements of prehospital care.⁹ Another aspect to consider regarding paramedic training and skills is communication with receiving hospitals. During the prehospital phase, it is crucial to identify those patients at risk of severe hemorrhage to quickly activate a specific intrahospital standardized hemorrhage control response, connecting the multispecialty trauma team, blood bank, transfusion protocols, interventional radiology, and surgical team.¹⁰ Prehospital medical doctors are also an option when the local context allows timely arrival of the emergency vehicle to the spot.

The prehospital setting remains an important window of opportunity to achieve a reduction in global trauma mortality. Currently, successful strategies used in the military setting must continue to be translated to the civilian prehospital setting. The extreme variability in training and material resources among prehospital trauma care providers remains an obstacle in most of the low- and middle-income countries as well as in the rural zones of the high-income countries for the implementation of new interventions for acute bleeding; therefore, improvement strategies are mandatory. Data collection remains a priority as the prehospital setting in low- and middle-income countries remains poorly characterized.

### Table 1: Prehospital methods of hemorrhage control

| Prehospital therapeutic options* | Advantages | Disadvantages | Physician presence needed |
|----------------------------------|------------|---------------|--------------------------|
| Injectable hemostatic sponges     | Easy, designed for penetrating wounds | Only junctional, removal of sponges | No |
| Intra-abdominal gas insufflation  | Minor invasive, less risk at pressure necrosis than foam | Abdominal compartment syndrome, risk of air embolisms, experimental | No |
| Intra-abdominal self-expanding foam | Tamponade of abdominal compartment, less invasive than REBOA | Pressure necrosis, abdominal compartment syndrome, needs surgical removal, experimental | No |
| Junctional tourniquets            | Axillary, inguinal, and truncal application. External compression of the abdominal aorta | Easily broken, uncomfortable in truncal application, limited application maximum time in truncal bleeding | No |
| Pelvic sheet                      | Low cost, widely available | Inadequate application, dislodgement | No |
| Pelvic stabilizer                 | Easy applicable, wide experience, enables REBOA | Insufficient if hemorrhage is arterial | No |
| REBOA                             | Proximal control, raises central aortic pressure | Invasive, risk of (spinal) ischemia, challenging, time-consuming | Yes |
| Resuscitative thoracotomy         | Very proximal control, raises central aortic pressure | Invasive, risk at infection | Yes |
| Tranexamic acid                   | Very easy topical application | Risk of thromboembolic event unknown | No |
| Wound clamps                      | Very easy, any location | Only superficial seal, hematoma | No |

*The most common therapeutic options for hemorrhage control that may be available in the prehospital setting REBOA, resuscitative endovascular balloon occlusion of the aorta

**Novel Techniques in Abdominal Hemorrhage Control**

Noncompressible torso hemorrhage remains an area where control of bleeding has proven to be difficult to improve outside of the
confines of a major trauma center. Newer hemostatic agents and technologies are starting to move out of the laboratory and proof-of-concept phases and into the clinical setting. As the research landscape is continually changing, it remains to be seen which solutions will be the most effective; however, we will address some of the newer topical hemostatic agents and discuss other possible techniques for hemorrhage control in this section.

**Topical Hemostatic Agents**

**QuickClot Control Plus**

With Food and Drug Administration (FDA) approval for both internal and external use, QuickClot Control Plus has quickly become one of the top choices of hemostatic gauze for both the prehospital and hospital settings. Like its previous iterations, it is impregnated with kaolin, which serves as a catalyst for the activation of factor XI, thereby activating the intrinsic pathway of the clotting cascade. It comes in multiple different sizes and formulations of products that allow for its use in both deep external wounds and the abdominal cavity. While it has been difficult to truly ascertain whether this product has major advantages over standard gauze products, it has been widely adopted and used in damage control laparotomy, obstetrics–gynecology surgery, and Mohs operations.11–13

**ResQFoam**

This new and experimental product functions on a principle similar to the “Fix-a-Flat” foam product for repairing punctures in car tires, in that it is a rapid expanding polymerized foam. Once it has been placed into the patient, it is designed to put pressure on bleeding structures and/or organs, thereby temporarily controlling bleeding until definitive surgical control can be obtained. A number of animal studies have been performed with good results, as well as cadaver work in freshly deceased patients.14,15 One pitfall that has been discovered thus far is a tendency of the high intra-abdominal pressure of the foam to cause bowel damage, which has necessitated careful inspection and occasional bowel resection prior to definitive closure of the abdomen.

A clinical trial in human patients has been approved by the FDA with enrollment starting in late 2018, which has been treating patients with severe, intra-abdominal bleeding, who are not expected to survive before surgery. The goal of this study is to significantly decrease the amount of time that it takes to secure hemorrhage control, as outlined in Figure 1. Given the appeal of this product to the military, further investigation is needed to better understand if this device can be successfully deployed without causing serious side effects such as organ or intestinal damage.

**Trauma Gel**

This product was initially developed from algae-based polymers while the inventor was still an undergraduate student. The product is currently approved as an adjunct to decrease bleeding in animals undergoing veterinary procedures (where it is marketed and sold as “Vetigel”), and it is currently under investigation for potential human use as a hemostatic agent. Although not necessarily designed for internal use, the benign nature of the components and the lack of an exothermic reaction might make it an ideal adjunct for the control of nonsurgical abdominal hemorrhage. It can also be easily washed off, based on the company’s promotional materials.17

![Fig. 1: ResQFoam has the potential to decrease the amount of time from patient injury to hemorrhage control. This expanding foam can be used to obtain hemorrhage control in the emergency department and possibly in the prehospital setting.](image)

**Abdominal Interventions**

**Abdominal Insufflation**

The concept of increasing intra-abdominal pressure to “tamponade” abdominal hemorrhage is not a new one, but with the advent of laparoscopic technology, the ability to achieve these increased pressures has become much easier using trocars or Veress needles. Some early experiments using insufflation have shown that it can reduce the degree of intra-abdominal hemorrhage without obvious side effects.18,19 This technique requires a full operating room which may limit its applicability, as it cannot offer hemostatic control in the emergency department or prehospital setting. At this point, there are no human clinical data to support this technique. Nevertheless, abdominal insufflation may make significant progress in the next few years and move into the clinical arena.

**Direct Peritoneal Resuscitation**

Although not strictly hemorrhage “control,” there is good evidence that adding specific solutes to fluids instilled into the peritoneal cavity following abdominal hemorrhagic shock can lead to improved outcomes.20,21 In this technique, peritoneal dialysis fluid is instilled directly into the abdominal cavity following trauma or an abdominal catastrophe.22 Based on multiple animal studies, positive results include improved splanchnic perfusion, beneficial osmotic effects, and improved immune modulation. There have been human studies in patients undergoing damage control procedures, where there was improvement in the ability to achieve fascial closure and an overall reduction in complications23 (Fig. 2). Given that these patients are undergoing surgical procedures, it is conceivable that placing a catheter to allow for direct peritoneal resuscitation (DPR) would not increase operative times and could have significant clinical benefit. Like insufflation, this has not been widely adopted in the clinical arena.

**Resuscitative Endovascular Balloon Occlusion of the Aorta**

There are several life-saving procedures in trauma and vascular surgery, such as tourniquets for extremity bleeding, which have reduced prehospital mortality to 10%. However, for truncal and junctional regions, prehospital mortality remains around 90%. The implementation of massive transfusion protocol and damage control surgery has reduced the mortality associated with trauma, but truncal and junctional hemorrhage still remains challenging for trauma surgeons.
Some critical maneuvers used in hemorrhage control, such as descending aorta occlusion through anterolateral thoracotomy, are associated with poor results. With advances in endovascular procedures and the new endovascular catheter, the use of an endovascular balloon to occlude the aorta is an option for catastrophic, uncontrolled hemorrhage of trunk and junctional regions. It is thought that obstruction of the distal aorta increases cardiac afterload, and the additional pressure in the proximal aorta enhances myocardial and cerebral perfusion. The use of endovascular aorta occlusion is not a new idea, with the first instance in 1954 by Hughes during the Korean War. However, this initial method was abandoned because of the high incidence of complications. It was only renewed in the early 2000s with new models of catheters and enhancements of resuscitation techniques.

Below, we outline the major steps involved in deploying REBOA. The steps to insertion of the endovascular aorta balloon are as follows:

- **Step 1:** arterial access—dissection of femoral artery using a 12-Fr catheter or a Seldinger puncture techniques using a 7-Fr catheter.
- **Step 2:** balloon position in the aorta: zone 1—between left subclavian artery and celiac trunk, zone 2—between celiac trunk and superior mesenteric artery, and zone 3—below superior mesenteric artery. Please note that it is important to confirm the position of the catheter by radiographic imaging.
- **Step 3:** balloon insufflation—occlusion of the distal aortic flow while avoiding over-dilatation of aorta.
- **Step 4:** management—during balloon occlusion, stabilize the catheter to avoid balloon dislocation.
- **Step 5:** balloon deflation—monitor the hemodynamic and metabolic parameters to avoid reperfusion problems—the duration of the aorta occlusion must be the least possible amount of time required to control the hemorrhage (usually at zone 1, 30 minutes maximum; and zone 3: 60 minutes, avoid the use in zone 2).
- **Step 6:** catheter removal and post-resuscitation care—sometimes the femoral artery must be repaired and clots must be removed.

Most of the potential complications of aortic balloon occlusion are associated with the steps of the catheter insertion. There is currently much discussion concerning where and when to insert the catheter. Some are exploring the possibility of insertion in the prehospital setting, while others are questioning whether catheter insertion should occur in the emergency room or the operating room. Typically, aseptic technique is used to insert the catheter in the hospital; however, a 7-Fr catheter can be inserted.
Endovascular balloon occlusion of the aorta has been used in trauma patients, and ruptured aortic aneurysm patients have been associated with improvements of hemodynamic parameters and outcomes for several decades. There are currently a series of case studies, a prospective study, and some meta-analysis studies on the use of REBOA. In 2018, Borger van der Burg performed a meta-analysis of the use of REBOA in the management of major exsanguination (ruptured aortic aneurism and trauma), which included 1,436 patients in hemodynamic shock with an overall mortality of 49.2%. This study found that the use of the balloon increased systolic mean pressure almost 50 mm Hg. A formal, prospective study is warranted to clarify the role of this technique in all hemodynamically unstable patients. In a 2017 meta-analysis study, Nunez et al. compared aortic cross-clamping with aortic endovascular balloon occlusion for bleeding control in trauma patients. Of the 1,276 patients in the study, the 873 patients who received REBOA had lower odds of mortality compared with the 403 patients who received aortic cross-clamping. Overall, this study suggests a positive effect of REBOA on mortality among noncompressible torso hemorrhage patients. However, these results warrant further investigation.

Operative Techniques for Damage Control Surgery

After traumatic injury, more than 80% of deaths in the operating room are due to exsanguination or coagulopathy. Thus, it is extremely important to understand the many available surgical techniques for emergent hemostatic control. The following operative techniques will be categorized by thorax or abdomen, depending on the region where the technique is most commonly applicable.

Surgical and endovascular options to control hemorrhage of the thorax:

- Pulmonary tractotomy. This technique consists of opening the pulmonary parenchyma along the tract of injury or laceration and individually ligating each bleeding vessel.
- The pulmonary hilum twist is a technique used to rotate the entire lung after dissection of the inferior pulmonary ligament. This is done by placing one hand on the anterior aspect of the upper pulmonary lobe and the other on the posterior aspect of the lower lobe. The lower lobe is rotated anteriorly, and the upper lobe is rotated posteriorly 180°; thus the apex of the lung is moved adjacent to the diaphragm. The twisting of the hilum during this maneuver can help control bleeding from the lung.
- Thoracic endovascular aortic repair. A recent study by the American Association for the Surgery of Trauma demonstrated that the use of endovascular stent grafts in thoracic aorta injuries led to a decrease in mortality compared with standard operative repair.
- Aortic cross-clamping. An aortic cross-clamp can be used to control hemorrhage from an aortic injury to a distal segment, or it can be used to restrict blood flow to distal regions to allow time for definitive surgical repair.
- Vascular shunt. A shunt can be placed inside the ends of a vessel, such as the aorta. This can be a chest tube or any tube with similar caliber. Similarly, a Foley catheter can be placed anywhere in the aorta to obtain control of that segment.
- Cardiac staples can be used to correct cardiac lacerations. Placing a Foley catheter in the lesion is another temporary way to obtain hemostatic control prior to definitive repair of a cardiac injury (Fig. 3). Prior to repairing any cardiac injury, a vascular clamp can be placed in the right atrium (Fig. 4).
- A vascular clamp can be stapled or placed at the hilum of the lung to control active bleeding prior to definition intervention to pulmonary injury (Fig. 5). Similarly, the hilum can be occluded by manual compression for short periods of time.
- Packing a bleeding chest. Even though it is not traditionally encouraged because of the increased thoracic pressure, restriction of cardiac filling, compromise of cardiac ejection fraction, and restriction of lung expansion, there are data showing that packing a nonsurgical bleeding chest is safe and that it has controlled bleeding in patients with life-threatening hemorrhage.

Surgical and endovascular options to control hemorrhage of the abdomen and pelvis:

Fig. 3: Cardiac hemorrhage control with a Foley catheter. This is one of the many methods to obtain hemostatic control in the operating room when there is significant trauma damage to cardiac tissue

Fig. 4: Vascular clamp at right atrium. A vascular clamp can be placed in the right atrium prior to performing hemostatic interventions on the heart
Pelvic packing and binders. Direct preperitoneal packing in conjunction with a pelvic binder can be used to control hemorrhage from pelvic ring disruptions and has been reported to be superior to transabdominal pelvic packing. This technique utilizes a midline suprapubic incision into the space of Retzius and allows for hematic control until definitive fixation of the pelvic ring is appropriate.33

Transcatheter arterial embolization. Endovascular interventions have been proven to be an extension of damage control surgery. It is most useful in patients with solid organ injuries with areas of extravasation or areas with high potential for bleeding. An appropriate catheter and embolization agent are then selected based on the location and severity of injury. This technique is generally used to control abdominal bleeding from the pelvis and abdominal organs, such as the liver, spleen, or kidneys. When deciding on appropriate use of embolization, care should be taken to only embolize non-vital vessels, as to reduce ischemic injury to extremities and end organs.34

Vessel ligation. Target blood vessels can be ligated using metal clips, plastic clips, or surgical ties. When vessel ligation is indicated, one should also consider primary surgical repair or endovascular options.35

Temporarily closing with a plastic equivalent to the Bogota bag and making the final skin closure when the patient returns for definitive surgery.

In special situations, and under fluoroscope or direct palpation, REBOA could be placed in zone 1 or 3 proximal to the aortic lesion to control hemorrhage, as previously mentioned.

**Conclusion**

Hemorrhage remains as a significant cause of mortality in both military and civilian trauma patients. Currently, the therapies most likely to improve survival are injury prevention and decreasing transport times to major trauma centers with the surgical expertise to care for these patients.

With further investigation of hemostatic equipment and bleeding control techniques, we may be able to practically eliminate unnecessary death due to hemorrhage after trauma.

This will require advances in prehospital structure and training, early hemostatic control in the hospital setting, and better surgical options for damage control. Likewise, injury prevention appears to be another feasible target for reducing deaths from hemorrhagic shock after trauma.

**References**

1. Eastridge BJ, Ward M, Cantrell J, et al. Died of wounds on the battlefield: causation and implications for improving combat casualty care. J Trauma 2011;71(1 Suppl):S4–S8. DOI: 10.1097/TA.0b013e318221147b.

2. Kauvar DS, Lefering R, Wade CE. Impact of hemorrhage on trauma outcome: an overview of epidemiology, clinical presentations, and therapeutic considerations. J Trauma 2006;60(6 Suppl):S3–S11. DOI: 10.1097/01.ta.0000199961.02677.19.

3. Jacobs LM. The Hartford Consensus III: implementation of bleeding control. Conn Med 2015;79(7):431–435.

4. Ker K, Roberts I, Sharuk H, et al. Antifibrinolytic drugs for acute traumatic injury. Cochrane Database Syst Rev 2015;5:CD004896. DOI: 10.1002/14651858.CD004896.pub4.

5. Alarhayem AQ, Myers JG, Dent D, et al. Time is the enemy: Mortality in trauma patients with hemorrhage from torso injury occurs long before the “golden hour”. Am J Surg 2016;212(6):1101–1105. DOI: 10.1016/j.amjsurg.2016.08.018.

6. Kragh JF, Walters TJ, Baer DG, et al. Survival with emergency tourniquet use to stop bleeding in major limb trauma. Ann Surg 2009;249(1):1–7. DOI: 10.1097/SLA.0b013e318188446a.

7. Malone DL, Dunne J, Tracy JK, et al. Blood transfusion, independent of shock severity, is associated with worse outcome in trauma. J Trauma 2003;54(5):989–905. DOI: 10.1097/01.TA.0000060261.10597.SC.

8. van Oostendorp SE, Tan ECTH, Geeraedts Jr LMG. Prehospital control of life-threatening truncal and junctional hemorrhage is the ultimate challenge in optimizing trauma care; a review of treatment options and their applicability in the civilian trauma setting. Scand J Trauma Resusc Emerg Med 2016;24(1):110. DOI: 10.1186/s13049-016-0301-9.

9. Sasser S, Varghese M, Kellermann A, et al. Prehospital trauma care systems. Geneva: World Health Organization; 2005.

10. Hamada SR, Rosa A, Guass T, et al. Development and validation of a prehospital “Red Flag” alert for activation of intra-hospital haemorrhage control response in blunt trauma. Crit Care 2018;22(1):113. DOI: 10.1186/s13054-018-2026-9.

11. Choron RL, Hazeltin JP, Hunter K, et al. Intra-abdominal packing with laparotomy pads and QuikClot during damage control laparotomy: a safety analysis. Injury 2017;48(1):158–164. DOI: 10.1016/j.injury.2016.07.033.

12. Villardo N, Feinberg J, Black J, et al. The use of QuikClot combat gauze in cervical and vaginal hemorrhage. Gynecol Oncol Rep 2017;21:114–116. DOI: 10.1016/j.gore.2017.07.012.

13. Shiu VF, Keller R. The use of QuikClot combat gauze during Mohs stages for intra-operative hemorrhage. J Am Acad Dermatol 2018;80(5):e117–e118. DOI: 10.1016/j.jaad.2018.06.020.

14. Rago AP, Larentzakis A, Marinj J, et al. Efficacy of a prehospital self-expanding polyurethane foam for noncompressible hemorrhage under extreme operational conditions. J Trauma Acute Care Surg 2015;78(2):324–329. DOI: 10.1097/TA.0000000000000507.

15. Rago A, Duggan MJ, Marinj J, et al. Self-expanding foam improves survival following a lethal, exsanguinating iliac artery injury. J Trauma Acute Care Surg 2014;77(1):73–77. DOI: 10.1097/TA.0000000000000263.

16. Chang JC, Holloway BC, Zamisch M, et al. ResQFoam for the treatment of non-compressible hemorrhage on the front line. Mil Med 2015;180(9):932–933. DOI: 10.7205/MILMED-D-15-00049.

17. TRAUMAGEL™ Hemostatic Gel. (2019, April 15). Retrieved from https://creslion.com/traumagel/.

18. Velmahos GC, Spaniolas K, Tabbara M, et al. Abdominal insufflation decreases blood loss without worsening the inflammatory response.
implications for prehospital control of internal bleeding. Am Surg 2008;74(4):297–301.

19. Velmahos GC, Spaniolas K, Duggan M, et al. Abdominal insufflation for control of bleeding after severe splenic injury. J Trauma 2007;63(2):285–288; discussion 288–290. DOI: 10.1097/TA.0b013e3180d0a6ea.

20. Zakaria el R, Garrison RN, Spain DA, et al. Intraperitoneal resuscitation improves intestinal blood flow following hemorrhagic shock. Ann Surg 2003;237(5):704–711; discussion 711–713. DOI: 10.1097/01.SLA.0000064660.10461.9D.

21. Garrison RN, Conn AA, Harris PD, et al. Direct peritoneal resuscitation as adjunct to conventional resuscitation from hemorrhagic shock: a better outcome. Surgery 2004;136(4):900–908. DOI: 10.1016/j.surg.2004.06.027.

22. Smith JW, Neal Garrison R, Matheson PJ, et al. Adjunctive treatment of abdominal catastrophes and sepsis with direct peritoneal resuscitation: indications for use in acute care surgery. J Trauma Acute Care Surg 2014;77(3):393–398; discussion 398–399. DOI: 10.1097/TA.0000000000000393.

23. Smith JW, Garrison RN, Matheson PJ, et al. Direct peritoneal resuscitation accelerates primary abdominal wall closure after damage control surgery. J Am Coll Surg 2010;210(5):658–664, 664–667. DOI: 10.1016/j.jamcollsurg.2010.01.014.

24. Hughes CW. Use of an intra-aortic balloon catheter tamponade for controlling intra-abdominal hemorrhage in man. Surgery 1954;36(1):65–68.

25. Davidson AJ, Russo RM, Reva VA, et al. The pitfalls of resuscitative endovascular balloon occlusion of the aorta: risk facatores and mitigation strategies. J Trauma Acute Care Surg 2018;84(1):192–202. DOI: 10.1097/TA.0000000000001711.

26. Borger van der Burg BLS, van Dongen TTCF, Morrison JJ, et al. A systematic review and meta-analysis of the use of resuscitative endovascular balloon occlusion of the aorta in the management of major exsanguination. Eur J Trauma Emerg Surg 2018;44(4):535–550. DOI: 10.1007/s00068-018-0959-y.

27. Nunez RM, Naranjo MP, Foianini E, et al. A meta-analysis of resuscitative endovascular balloon occlusion of the aorta (REBOA) or open aortic cross-clamping by resuscitative thoracotomy in non-compressible torso hemorrhage patients. World J Emerg Surg 2017;12:30. DOI: 10.1186/s13017-017-0142-5.

28. Hoyt D, Bulger EM, Knudson MM, et al. Death in the operating room: an analysis of a multi-center experience. J Trauma 1994;37(3):426–432. DOI: 10.1097/00005373-199409000-00016.

29. Wall Jr MJ, Villacencio RT, Miller 3rd CC, et al. Pulmonary tractotomy as an abbreviated thoracotomy technique. J Trauma 1998;45(6):1015–1023. DOI: 10.1097/00005373-199812000-00008.

30. Wilson A, Wall Jr MJ, Maxson R, et al. The pulmonary hilum twist as a thoracic damage procedure. Am J Surg 2003;186(1):49–52. DOI: 10.1016/S0002-9610(03)00102-8.

31. Demetriades D, Velmahos GC, Scalea TM, et al. Blunt traumatic thoracic aortic injuries: early or delayed repair–results of an American Association for the Surgery of Trauma prospective study. J Trauma 2009;66(4):967–973. DOI: 10.1097/TA.0b013e31817dc483.

32. Phelan HA, Patterson SG, Hassan MO, et al. Thoracic damage control operation, principles, techniques and definitive repair. J Am Coll Surg 2006;203(6):933–941. DOI: 10.1016/j.jamcollsurg.2006.08.016.

33. Aseni P, Carlis L, Mazzola A, et al. Operative Techniques and Recent Advances in Acute Care and Emergency Surgery. Springer International Publishing AG; 2019.

34. Glass NE, Burlaw CC. Preperitoneal pelvic packing: how and when. Curr Trauma Rep 2015;1(1):1–7. DOI: 10.1007/s40719-014-0001-8.

35. Lim CS, Jang JY, Lee SE, et al. Comparison of various methods of vessel ligation: what is the safest method? Surg Endosc 2013;27(9):3129–3138. DOI: 10.1007/s00464-013-2866-y.