



Pre-peritoneal pelvic packing for the management of life-threatening pelvic fractures

Patrizio Petrone¹ · Martín Rodríguez-Perdomo¹ · Aida Pérez-Jiménez¹ · Fahd Ali¹ · Collin Everton Montgomery Brathwaite¹ · D'Andrea Krista Joseph¹

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Abstract

Background Pre-peritoneal pelvic packing (PPP) is a technique used for treating pelvic hemorrhage in patients with pelvic fractures and hemodynamic instability after a high-energy trauma representing a life-threatening situation. The aim of this study was to perform a comprehensive review of the literature.

Methods A review of the medical literature was performed, based on the following inclusion criteria: patients sustaining pelvic fractures with hemodynamic instability and the inclusion of PPP as a tool for hemorrhage control. Articles not involving human patients, review articles, surveys, pediatric patients, hemodynamic stability, case reports, and not directly related publications; such as angiography with or without embolization, and REBOA use for hemorrhage control as a primary outcome evaluation were excluded from this search.

Results Eleven articles out of seventy-seven identified publications between 2008 and 2018 met the inclusion criteria and were included in this review.

Conclusions PPP is a surgical approach used in life-threatening situations due to pelvic fracture with high risk of death for exsanguination. Performed expediently, good results can be obtained with a decrease in the need for blood products, improved systolic blood pressure, and a decrease in mortality rates overall. This makes PPP an important life-saving tool.

Keywords Pelvic fracture · Pre-peritoneal pelvic packing · Hemodynamic instability

Introduction

Pelvic fractures can be life-threatening and challenging to address. Hemodynamic instability is presented in up to 10% of this patient population with high-mortality rates [1]. One of the most significant presentations of pelvic fracture is of the open book variety where the patient typically presents with hemorrhagic shock, the most common cause of early death from an open pelvic disruption. Conversely, late deaths are produced by a multisystem organ failure [2–4]. Standardized treatment protocols based on the classification of pelvic fractures continues to be an ongoing debate with the best approach yet to be established [5, 6]. Treatment modalities

range from minimally invasive percutaneous techniques to open procedures [7]. During the last decade, angioembolization (AE) has gained favor in control of hemorrhage and is included in the algorithms in most of American trauma centers. Transfer of an unstable patient from the emergency department to the interventional radiology suite is less than desirable and can be fraught with risk and potential complication. In addition, AE only addresses arterial hemorrhage, and while this may decrease the blood supply to the bleeding site, AE cannot address the more prevalent venous or bony hemorrhage responsible for 85% of the pelvic fracture bleeding. The process of pre-peritoneal pelvic packing (PPP) plays an important role in hemorrhage control by increasing pressure within the retroperitoneal space [8]. The purpose of this article is to describe the PPP surgical technique according to the recent protocols and review the literature regarding the management of patients with pelvic fractures and hemodynamic instability and the use of this technique in treatment algorithms.

✉ Patrizio Petrone
patrizio.petrone@nyulangone.org;
patrizio.petrone@gmail.com

¹ Division of Trauma and Acute Care Surgery, Department of Surgery, NYU Winthrop Hospital, 222 Station Plaza North, Suite 603, Mineola, NY 11501, USA

Methods

A PubMed and SCOPUS databases' search was performed using the keywords pelvic fracture, pelvic packing, and extraperitoneal pelvic packing, used isolated or in combination. The search includes articles in English and Spanish languages published during the last 10 years from 2008 to 2018. Articles involving animals, review articles, surveys, pediatric patients, hemodynamically stable patients, case reports, and those not directly related to PPP such as publications using angiography with or without embolization, and the resuscitative balloon occlusion of the aorta (REBOA) for hemorrhage control as a primary outcome evaluation were also excluded (Fig. 1).

Results

Eleven out of seventy-seven articles met the inclusion criteria (Table 1). The articles excluded were those in which the outcomes did not assess the usefulness of the PPP, where the internal iliac artery was ligated in addition to PPP, where assessment of the focused abdominal sonography for trauma (FAST) in patients with pelvic fractures and hemodynamic stability was not recorded, and where full articles were not available.

Table 1 Incidence by author, age, and ISS

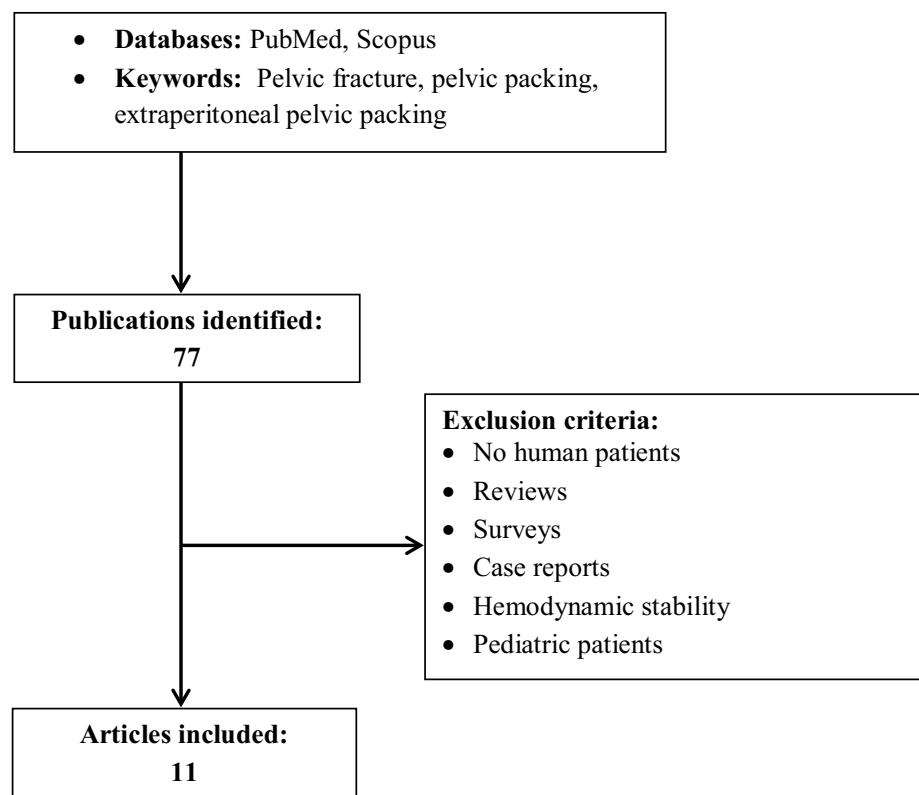
| Author (year) | N total/N PPP | Mean age | ISS |
|--------------------------|---------------|-------------|---------------|
| Osborn (2009) [9] | 40/20 | 37.9 ± 18.9 | 54.7 ± 12.7 |
| Burlew (2011) [8] | 1245/75 | 42 ± 2 | 52 ± 1.5 |
| Tai (2011) [10] | 24/11 | 51.2 ± 19.0 | 40 ± 12.5 |
| Lustenberger (2015) [11] | 173/12 | 44.7 ± 20.8 | 33.2 ± 18.1 |
| Ron (2015) [12] | 25/14 | 42.2 | 30.71 |
| Chiara (2016) [13] | 78/30 | 55.3 ± 21.8 | 44.93 ± 10.06 |
| Li (2016) [14] | 56/29 | 43 ± 13 | 48 ± 6 |
| Jang (2016) [15] | 30/14 | 59.7 ± 15 | 38.8 ± 8.3 |
| Hsu (2016) [16] | 24/14 | 49.9 ± 17.5 | 32 ± 6.7 |
| Burlew (2017) [17] | 2293/128 | 44 ± 2 | 48 ± 1.2 |
| Moskowitz (2018) [2] | NR/126 | 35 ± 4 | 46 ± 3 |

PPP pre-peritoneal pelvic packing, ISS Injury Severity Score, NR not recorded

Discussion

Pelvic fractures are produced by high-energy trauma. Most patients with unstable pelvic fractures are injured by blunt force trauma caused by either motor vehicle collisions, falls from a great height, or by compression [17]. The large amount of energy required to disrupt the pelvic ring also means that this energy is transferred to the rest of the body

Fig. 1 Flowchart of the literature search



[10], making the presence of associated injuries, the rule more than the exception [18]. Severe hemorrhage is presented in up to 50% of the cases and is associated with high Injury Severity Scores (ISS) in most series [19, 20]. Totterman et al. [21] found that 83% of patients have injuries to three or more organ systems with a mean ISS of 47, while Burlew's group [8] reported that 87% of patients underwent at least three procedures in addition to PPP, including long bone fixation, thoracotomy, laparotomy, vascular exploration, or neurosurgical procedures.

Hemodynamic instability is defined by systolic blood pressure (SBP) persistent below 90 mmHg in the initial resuscitation period despite transfusion of two units of packed red blood cells (PRBC) or after receiving 2 L of intravenous crystalloid [10, 17]. In a hemodynamically unstable patient, mortality rates range from 10 to 60% depending on the association and severity of the other injuries [3, 17, 21]. Of note, this mortality range is based on analyses of dissimilar cohorts and, in particular, upon variable definitions of what constitutes an unstable patient with pelvic fracture [22]. There are groups working to assess result scores using the Young–Burgees or Tile pelvic fracture classification and ISS.

Major trauma is commonly defined as an ISS threshold of 15 or above [2, 4, 23–25]. The Young–Burgees system is a mechanism-based classification that groups fractures as lateral or anteroposterior compressions, vertical shear, or a combination thereof and a further classification with levels of injury based on the degree of disruption of the ligamentous and bony stabilizers of the pelvis. The Tile classification system is based on the integrity of the posterior sacro-iliac ligaments of the pelvis and associated mechanical instability. The description is as follows: Tile A, stable; Tile B, rotationally unstable; Tile C, rotationally and vertically unstable [26].

Historical perspective and surgical technique

Initial stabilization of the pelvic fracture involves the placement of a pelvic binder and appropriate resuscitation until definitive treatment is performed. These provisional means are often successful but remain futile in major hemodynamic instability. Angiography is utilized as part of the algorithm of pelvic trauma, but not all centers can produce this in a timely fashion. Moreover, major instability requires more expeditious management. The main source of bleeding in pelvic trauma is typically venous, so angiography may not be useful in many instances [2, 4, 27, 28]. The need for a more immediate intervention is paramount.

Pelvic packing was first described by the gynecologist Logothetopoulos in 1926, as a surgical technique management of a bleeding uterus. It was first used as a life-saving procedure for pelvic fractures with hemodynamic

instability in the 1960s [10]. The original procedure was a trans-abdominal approach performed after an exploratory laparotomy. However, the results were poor and felt to be related to the lack of pressure for tamponade once the pelvic hematoma was released. In fact, bleeding seemed to worsen as did the increase in the rate of pelvic infection. As a result, this technique was abandoned [10].

Since the first description of “damage control” in 1993 by Rotondo and Schwab [29] with the focus of using temporizing life-saving surgical techniques, PPP has gained support as one of the said techniques. It was then modified by Pohlemann et al. [30] in 1995 as a retroperitoneum packing for hemorrhage control, and again recently described by the Denver group, Burlew et al. [8] in 2004, and Totterman et al. [21] in 2007. Since then, the technique has sustained a few modifications depending on the trauma center, surgeon's preferences, and capabilities, although the core principles remain the same. With the described modifications, this technique has obtained the good results by decreasing mortality rates in patients with major hemorrhage in pelvic due to fracture patterns, as shown in Table 2. Pre-peritoneal packing has been included in many level I trauma centers as part of the management of pelvic fracture algorithms [2, 5, 17].

The PPP technique consists of an infra-umbilical mid-line incision of about 6–8 cm or a Pfannenstiel incision. Subcutaneous tissue is dissected until the fascia is carefully opened taking care not to violate the peritoneal cavity. Often this plane is already dissected by the pelvic hematoma. The dissection is completed bluntly with the bladder retracted superiorly and with the limit of posterior dissection being the sacro-iliac joint. Once the entirety of the pelvic ring is dissected and the hematoma evacuated, three or four large

Table 2 Mortality compared PPP versus no PPP

| Author (year) | PPP/no PPP |
|-----------------------------|------------------------|
| Osborn (2009) [9] | 20/30 ^a |
| Tai (2011) [10] | 36.3/69.2 ^a |
| Lustenberger (2015) [11] | NR/12.7 ^b |
| Ron (2015) [12] | 27.2/NA |
| Chiara (2016) [13] | 20/52 ^a |
| Li (2016) [14] | 13.8/18.5 ^a |
| Jang (2016) [15] | 14.3/37.5 ^a |
| Hsu (2016) [16] | 7.1/30 ^b |
| Burlew (2011, 2017) [8, 17] | 21/8 ^b |
| Moskowitz (2018) [2] | 0/7 ^b |

Values are expressed in %

PPP pre-peritoneal pelvic packing, NA not applicable, NR not recorded

^aAngio group

^bOverall mortality

lap pads, depending on the patient size, are placed from bottom to top. The same procedure is then executed on the opposite side. The fascia is closed with a running suture and the skin with staples. No drains are left in the pelvic cavity. This procedure is complementary to a pelvic fixation as the unstable pelvic rings can increase the hemorrhage. Once the PPP is done, other interventions can be performed, as an AE or laparotomy and preferably through a separate incision avoiding disruption of the pelvic tamponade. Ideally, the packing from PPP should be removed within 24–48 h and repacking performed for any ongoing bleed. This, however, carries an increased risk of infection [3, 31, 32].

Outcomes and complications

Hemorrhagic shock is the main cause of death among trauma patients during the first 24 h with most deaths occurring within the first 3 h of admission. Multisystem organ failure and infections are responsible for the later deaths [22, 24, 33, 34]. In addition, risk factors such as advanced age or the presence of co-morbidities were identified as independent risk factors that can increase mortality [22]. One of the most important sites of bleeding in pelvic fractures is the presacral venous plexus and bony sites fractures, accounting for about 80–85%, and arterial bleeding in 10–15% of cases increasing the challenge of hemostatic control [1].

Although AE and PPP show a decreased need for transfusions with improvement of SBP after packing, PPP unlike AE shows no early deaths. In some groups, there was no difference in mortality rates between AE and PPP [9, 14]. However, Chiara et al. [13] showed a decrease in mortality in the packing group (49% vs. 33%) and a better hemodynamic response after PPP as compared to other methods, suggesting this as a fast and safe technique to decrease mortality [9].

External fixation in addition to PPP is indicated as the optimal management for life-threatening bleeding from unstable pelvic fracture; PPP by itself is suboptimal [17]. The Eastern Association for the Surgery of Trauma (EAST) guidelines [6] propose as a level III recommendation the use of PPP as an effective tool in hemorrhage control with the need for future comparative studies to define the best strategy.

Some centers limit the use of AE to cases where there is evidence of contrast extravasation seen by CT, or in cases of persistently low SBP after PPP was performed. However, angiography is highly recommended by some authors as an early procedure in patient suspected of having pelvic hemorrhage as a first attempt to hemorrhage control, with mortality rates as high as 50% when hemodynamic instability is present.

The use of REBOA has recently been included in the therapeutic algorithms in some trauma centers, although this remains controversial due to the difficulty in establishing

randomized studies to compare techniques. In addition, comparing different hemorrhage control procedures is difficult secondary to associated injuries that can significantly increase mortality, such as traumatic brain injury. Some authors support the inclusion of PPP in algorithms and its use as a salvage technique, while others have been changing their trauma-level I center protocols to adopt PPP as an option in patients with pelvic fracture and hemodynamic instability, with or without complementary AE [2, 10, 17, 21]. Conversely, some large series encourage the use of PPP because of its ability to decrease the need for blood transfusion, improvement in blood pressure, short time of execution, and decreased mortality rates. The utility of PPP is also useful in patients in extremis, and where the transfer to an angiography room is not possible due to instability and high possibility of death from exsanguination. Pre-peritoneal packing thus offers the possibility of achieving the hemodynamic control allowing for the performance of other tests or procedures as needed [2, 9, 10, 17].

The main complication of PPP is infection, especially in the presence of associated organ injury as in bowel or bladder trauma or in the case of open fractures. Infection rates have been reported to be as high as 12–28% in a large series which increased in repacked groups to about 47%. However, no other serious complications have been reported [32].

Conclusions

Patients with pelvic fractures and hemodynamic instability are a challenge and require a multidisciplinary team approach. An expeditious-and-thorough evaluation must be performed following the advanced trauma life support (ATLS®) protocols to identify immediate life-threatening injuries and the potential sites of bleeding that may endanger the patient's life.

Based on several large series and The First Italian Consensus, statement recommends PPP for patients arriving at the emergency department with pelvic fracture and hemodynamic instability as a means of establishing accurate and rapid bleeding control [5, 6, 17]. Subsequently, if an arterial injury is detected by CT scan or angiography, a selective embolization of pelvic vessels can be performed to optimize the pelvic hemorrhage control. The use of a multidisciplinary team approach is the best way to maximize outcome in those with complicated pelvic injury and other organ systems that are life-threatening.

Compliance with ethical standards

Conflict of interest Patrizio Petrone, Martín Rodríguez-Perdomo, Aida Pérez-Jiménez, Fahd Ali, Collin Everton Montgomery Brathwaite, and D'Andrea Krista Joseph declare that they have not conflict of interest.

References

- Burlew CC. Preperitoneal pelvic packing for exsanguinating pelvic fractures. *Int Orthop*. 2017;41(9):1825–9.
- Moskowitz EE, Burlew CC, Moore EE, Pieracci FM, Fox CJ, Champion EM, et al. Preperitoneal pelvic packing is effective for hemorrhage control in open pelvic fractures. *Am J Surg*. 2018;215(4):675–7.
- Filiberto DM, Fox AD. Preperitoneal pelvic packing: Technique and outcomes. *Int J Surg*. 2016;33(9):222–4.
- Smith W, Williams A, Agudelo J, Shannon M, Morgan S, Stahel P, et al. Early predictors of mortality in hemodynamically unstable pelvis fractures. *J Orthop Trauma*. 2007;21(1):31–7.
- Magnone S, Coccolini F, Manfredi R, Piazzalunga D, Agazzi R, Arici C, et al. Management of hemodynamically unstable pelvic trauma: results of the first Italian consensus conference (cooperative guidelines of the Italian Society of Surgery, the Italian Association of Hospital Surgeons, the Multi-specialist Italian Society of Young Surgeons, the Italian Society of Emergency Surgery and Trauma, the Italian Society of Anesthesia, Analgesia, Resuscitation and Intensive Care, the Italian Society of Orthopaedics and Traumatology, the Italian Society of Emergency Medicine, the Italian Society of Medical Radiology—Section of Vascular and Interventional Radiology—and the World Society of Emergency Surgery). *World J Emerg Surg* 2014;9(1):18.
- Cullinane DC, Schiller HJ, Zielinski MD, Bilaniuk JW, Collier BR, Como J, et al. Eastern Association for the Surgery of Trauma practice management guidelines for hemorrhage in pelvic fracture—update and systematic review. *J Trauma*. 2011;71(6):1850–68.
- Smith WR, Moore EE, Osborn P, Agudelo JF, Morgan SJ, Parekh AA, et al. Retroperitoneal packing as a resuscitation technique for hemodynamically unstable patients with pelvic fractures: report of two representative cases and a description of technique. *J Trauma*. 2005;59(6):1510–4.
- Burlew CC, Moore EE, Smith WR, Johnson JL, Biffl WL, Barnett CC, et al. Preperitoneal pelvic packing/external fixation with secondary angioembolization: optimal care for life-threatening hemorrhage from unstable pelvic fractures. *J Am Coll Surg*. 2011;212(4):628–37.
- Osborn PM, Smith WR, Moore EE, Cothren CC, Morgan SJ, Williams AE, et al. Direct retroperitoneal pelvic packing versus pelvic angiography: a comparison of two management protocols for haemodynamically unstable pelvic fractures. *Injury*. 2009;40(1):54–60.
- Tai DK, Li WH, Lee KY, Cheng M, Lee KB, Tang LF, et al. Retroperitoneal pelvic packing in the management of hemodynamically unstable pelvic fractures: a level I trauma center experience. *J Trauma*. 2011;71(4):E79–86.
- Lustenberger T, Wutzler S, Stormann P, Laurer H, Marzi I. The role of angio-embolization in the acute treatment concept of severe pelvic ring injuries. *Injury*. 2015;46(Suppl 4):33–8.
- Ron G, Epstein D, Ben-Galim P, Klein Y, Kaban A, Sagiv S. Extra-peritoneal pressure packing without external pelvic fixation: a life-saving stand-alone surgical treatment. *J Emerg Trauma Shock*. 2015;8(4):181–7.
- Chiara O, di Fratta E, Mariani A, Michaela B, Prestini L, Sammartano F, et al. Efficacy of extra-peritoneal pelvic packing in hemodynamically unstable pelvic fractures, a Propensity Score analysis. *World J Emerg Surg*. 2016;11:22.
- Li Q, Dong J, Yang Y, Wang G, Wang Y, Liu P, et al. Retroperitoneal packing or angioembolization for haemorrhage control of pelvic fractures—quasi-randomized clinical trial of 56 hemodynamically unstable patients with Injury Severity Score \geq 33. *Injury*. 2016;47(2):395–401.
- Jang JY, Shim H, Jung PY, Kim S, Bae KS. Preperitoneal pelvic packing in patients with hemodynamic instability due to severe pelvic fracture: early experience in a Korean trauma center. *Scand J Trauma Resusc Emerg Med*. 2016;24:3.
- Hsu JM, Yadev S, Faraj S. Controlling hemorrhage in exsanguinating pelvic fractures: utility of extraperitoneal pelvic packing as a damage control procedure. *Int J Crit Illn Inj Sci*. 2016;6(3):148–52.
- Burlew CC, Moore EE, Stahel PF, Geddes AE, Wagenaar AE, Pieracci FM, et al. Preperitoneal pelvic packing reduces mortality in patients with life-threatening hemorrhage due to unstable pelvic fractures. *J Trauma Acute Care Surg*. 2017;82(2):233–42.
- Papadopoulos IN, Kanakaris N, Bonovas S, Triantafyllidis A, Garnavos C, Voros D, et al. Auditing 655 fatalities with pelvic fractures by autopsy as a basis to evaluate trauma care. *J Am Coll Surg*. 2006;203(1):30–43.
- Hornez E, Maurin O, Bourgouin S, Cotte J, Monchal T, de Roulhac J, et al. Management of exsanguinating pelvic trauma: do we still need the radiologist? *J Visc Surg*. 2011;148(5):379.
- Yoshihara H, Yoneoka D. Demographic epidemiology of unstable pelvic fracture in the United States from 2000 to 2009: trends and in-hospital mortality. *J Trauma Acute Care Surg*. 2014;76(2):380–5.
- Totterman A, Madsen JE, Skaga NO, Roise O. Extraperitoneal pelvic packing: a salvage procedure to control massive traumatic pelvic hemorrhage. *J Trauma*. 2007;62(4):843–52.
- Correa WO, Batista VGR, Cavalcante EFJ, Fernandes MP, Fortes R, Ruiz GZL, et al. Mortality predictors in patients with pelvic fractures from blunt trauma. *Rev Col Bras Cir*. 2017;44(3):222–30.
- Durkin A, Sagi HC, Durham R, Flint L. Contemporary management of pelvic fractures. *Am J Surg*. 2006;192(2):211–23.
- Croce MA, Magnotti LJ, Savage SA, Wood GW 2nd, Fabian TC. Emergent pelvic fixation in patients with exsanguinating pelvic fractures. *J Am Coll Surg*. 2007;204(5):935–42.
- Dente CJ, Feliciano DV, Rozycki GS, Wyrzykowski AD, Nicholas JM, Salomone JP, et al. The outcome of open pelvic fractures in the modern era. *Am J Surg*. 2005;190(6):830–5.
- Skitch S, Engels PT. Acute management of the traumatically injured pelvis. *Emerg Med Clin North Am*. 2018;36(1):161–79.
- Tesoriero RB, Bruns BR, Narayan M, Dubose J, Guliani SS, Brenner ML, et al. Angiographic embolization for hemorrhage following pelvic fracture: Is it “time” for a paradigm shift? *J Trauma Acute Care Surg*. 2017;82(1):18–26.
- Cho J, Benjamin E, Inaba K, Lam L, Demetriades D. Severe bleeding in pelvic fractures: considerations in planning damage control. *Am Surg*. 2018;84(2):267–72.
- Rotondo MF, Schwab CW, McGonigal MD, Phillips GR 3rd, Fruchterman TM, Kauder DR, et al. ‘Damage control’: an approach for improved survival in exsanguinating penetrating abdominal injury. *J Trauma*. 1993;35(3):375–83.
- Pohlemann T, Gansslen A, Bosch U, Tscherne H. The technique of packing for control of hemorrhage in complex pelvic fractures. *Tech Orthop*. 1995;9:267–70.
- Monchal T, Hornez E, Coisy M, Bourgouin S, de Roulhac J, Balandraud P. Preperitoneal pelvic packing. *J Visc Surg*. 2017;154(Suppl 1):57–60.
- Glass NE, Burlew CC. Preperitoneal pelvic packing: how and when. *Curr Trauma Rep*. 2015;1(1):1–7.
- Sugrue M, D’Amours SK, Joshipura M. Damage control surgery and the abdomen. *Injury*. 2004;35(7):642–8.
- Sihler KC, Napolitano LM. Complications of massive transfusion. *Chest*. 2010;137(1):209–20.