

Understanding The Challenges In Extra-Peritoneal Packing For Pelvic Hemorrhage Control And Stabilization

Review

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Abstract: Pelvic injuries are a serious concern, often leading to high mortality rates, even with various bleeding control methods in place. This study looks into how Extra-peritoneal Pelvic Packing (EPP) and Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) can impact mortality rates and hemodynamic stability. Both EPP and REBOA have shown to be effective, improving stability and serving as logical first steps in a collaborative treatment approach. Particularly, Zone I REBOA could be beneficial for critically ill patients facing multiple torso hemorrhages. Damage control surgery (DCS) is a multi-step surgical strategy designed for the rapid management of life-threatening bleeding, followed by physiological stabilization and definitive repairs. Abdomino-pelvic packing (APP) inserting compressive materials into the abdomen and/or pelvis to control bleeding is a critical part of DCS. This review gathers existing research on DCS, focusing on APP, a technique initially developed for trauma and orthopedic surgery but applicable in gynecological and obstetric emergencies. We'll cover its historical development, physiological basis, and a systematic protocol for DCS tailored to specific situations, including postpartum hemorrhage, placenta accreta spectrum, uterine rupture, hepatic rupture in HELLP syndrome, and various oncological and non-cancerous surgeries. Modern adjuncts like early tranexamic acid administration, topical hemostatic agents, and coordinated multidisciplinary efforts have shifted packing from a last resort to a vital part of staged hemorrhage control. In obstetrics and gynecology, APP achieves effective hemostasis in 75 to 90 % of cases, leading to lower mortality rates compared to trauma surgeries. In conclusion, APP should be included in standardized protocols for handling hemorrhages in obstetrics and gynecology. Effective training, simulations, and adherence to guidelines are crucial, particularly in resource-limited settings where advanced treatments may not be available.

Keywords: damage control surgery; pelvic packing; obstetric hemorrhage; postpartum hemorrhage; placenta accreta spectrum; gynecologic surgery; massive hemorrhage; tranexamic acid; hemostatic-agents; surgical-emergencies.

I.Introduction

Dealing with traumatic pelvic fractures is one of the toughest challenges for trauma surgeons. The mortality rate remains alarmingly high for hemodynamically unstable patients after acute pelvic hemorrhage from trauma, sometimes exceeding 40% due to rapid blood loss. These days, a multimodal approach to treating pelvic injuries has become the norm. This includes early mechanical stabilization using pelvic binders, followed by surgical options like Extra-Peritoneal Packing (EPP) and endovascular techniques such as Angio-Embolization (AE) or REBOA, particularly in zone III. Every emergency treatment must consider the patient's hemodynamic status, the direction of the force, and the specific anatomy of the pelvic fractures, often using classifications like

‘Tile’ or ‘Young and Burgess.’ Numerous guidelines and clinical studies propose different treatment algorithms that hinge on the patient’s hemodynamic state.

Angiography and embolization can effectively manage between 80% and 100% of arterial bleeding linked to pelvic injuries, alongside mechanical stabilization. However, arterial hemorrhage is only seen in about 15-25% of cases.

Recently, EPP has emerged as a quick and effective surgical option for managing bleeding in patients with unstable pelvic conditions. Introduced in Germany in 1994, EPP has shown to be a potentially life-saving intervention, leading to lower mortality rates compared to other control measures. The key component of EPP is directly applying pressure to manage significant venous bleeding, which accounts for about 75 to 80 % of pelvic hemorrhaging. The EPP procedure can typically be done in under 20 minutes, whether in the operating room or the emergency-department.

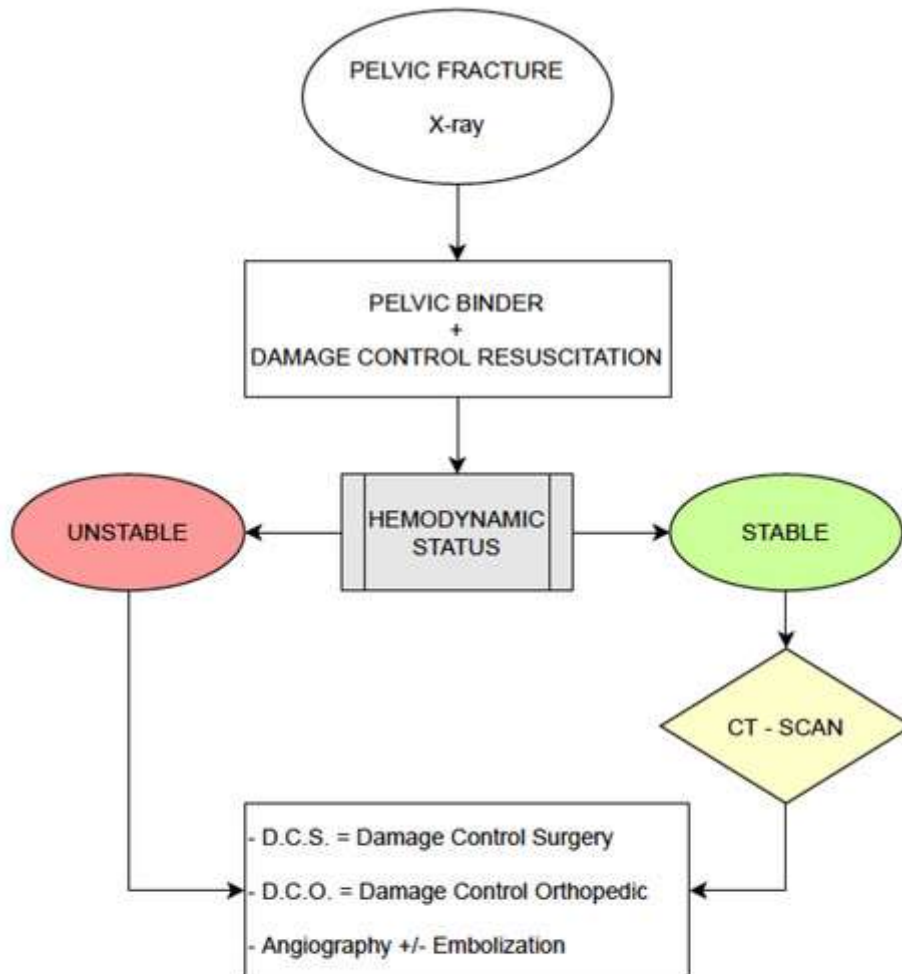
In recent developments, REBOA has gained recognition as a promising technique for controlling bleeding in patients facing hemorrhagic shock. When used in Zone 3, it could be a useful strategy for managing pelvic bleeding. Some studies suggest that REBOA may offer better survival rates in Zone 3 compared to Zone 1. However, the availability of the balloon isn't guaranteed, and further research indicates that REBOA can lead to severe complications like ischemia-reperfusion syndrome, acute kidney failure, limb amputations, and higher mortality rates. At present, multiple guidelines exist for the urgent management of pelvic bleeding due to severe traumatic injuries from various organizations. Our research aimed to evaluate and compare the effectiveness and outcomes of damage control techniques, expanding our previous analysis of EPP to include REBOA. Our primary goal was to look at mortality rates linked to both EPP and REBOA, while our secondary aim focused on the hemodynamic impacts of these interventions.

The mortality rate remains elevated among hemodynamically unstable individuals after acute pelvic hemorrhage resulting from trauma. This rate can exceed 40 % due to rapid blood loss. A multimodal therapy strategy for pelvic injuries has become the standard practice. This encompasses early mechanical stabilization utilizing a pelvic binder as needed, followed by both surgical management specifically, Extra-Peritoneal Packing (EPP) and endovascular strategies such as Angio-Embolization (AE) procedures or Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) positioned in zone III. All forms of emergency treatment must factor in the patient’s hemodynamic state, the direction of force, and the specific anatomy of the pelvic fractures, considering classifications like ‘Tile’ or ‘Young and Burgess.’ [1-5]. Numerous management guidelines and clinical studies have been released proposing varied treatment algorithms incorporating these interventions; the foundational element of all these algorithms hinges on the hemodynamic state of the patient. Angiography, along with embolization, can effectively manage between 80% and 100% of arterial bleeding associated with pelvic injuries, along with mechanical stabilization. Nevertheless, arterial hemorrhage is encountered in only 15 to 25% of cases [6,7]. Recently, Extraperitoneal Pelvic Packing (EPP) has emerged as a rapid and effective surgical option for managing bleeding in patients with unstable pelvic conditions [8,9]. This procedure was introduced in Germany in 1994.

Recent studies have highlighted EPP as a potentially life-saving intervention, resulting in lower mortality rates compared to those treated with alternative control measures. A fundamental aspect of EPP involves directly applying pressure to regulate significant venous bleeding, which accounts for approximately 75 to 80 % of pelvic hemorrhaging [10]. The EPP procedure can be executed in under 20 minutes, either safely in the operating room or in the emergency department. In recent times, Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) has been recognized as a promising method for managing bleeding in patients experiencing hemorrhagic shock [11,12]. When deployed in Zone 3, it has been proposed as a method to manage pelvic bleeding. Some research indicates that REBOA offers improved survival rates when applied in Zone 3 compared to Zone 1 for controlling pelvic arterial bleeding. [13]. However, the availability of the balloon is not guaranteed, and findings from additional research point to REBOA being linked to severe complications such as ischemia-reperfusion syndrome, acute kidney failure, limb amputations, and increased mortality rates. Currently, there are multiple guidelines for the urgent management of pelvic bleeding resulting from severe traumatic injuries from various associations and organizations.

1. Treatment Protocol

In our research, we identified three distinct treatment protocols based on the time period and the institution we were examining. To begin, we analyzed the treatment of patients at the ASST Niguarda Trauma Center up until 2009, adhering to the methodology outlined in our previous research. For patients with pelvic fractures who were hemodynamically unstable, a pelvic binder was applied, compressing at the area of the greater trochanters, while Damage Control Resuscitation, incorporating fluids and blood products, was initiated. If the Extended Focused Assessment with Sonography for Trauma (E-FAST) detected free fluid in the pelvis and the X-ray confirmed a pelvic fracture indicating an unstable condition, we would proceed directly to the operating room for laparotomy, arterial embolization, and external fixation of the fracture, if needed. **(Figure 1)**



(A)

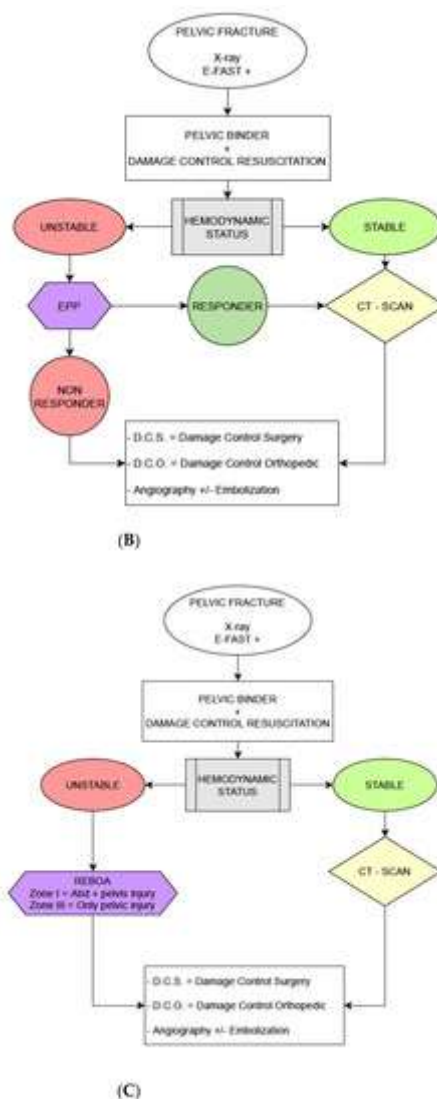


Figure 1. (A) Treatment protocol of No-EPP group, until 2009. (B) Treatment protocol of EPP group, 2009–2018. (C) Treatment protocol of REBOA group, 2014–2018.

In 2009, the implementation of early Extra-Peritoneal Packing (EPP) became part of the treatment regimen at Niguarda. For individuals exhibiting a positive E-FAST and an X-ray that verified a pelvic fracture, if they continued to show hypotension after the application of a pelvic binder and the urgent transfusion of at least two units of O-negative packed red blood cells (PRBCs), they underwent immediate EPP. Following the intervention, if there was an indication of improved hemodynamics, a contrast-enhanced computed tomography (CT scan) was conducted. Should the CT contrast leakage and verify it as arterial, angiography would take place followed by embolization. If EPP did not lead to a stable condition and the patient remained unstable, it was essential to proceed directly to the operating room (OR) for surgical, endovascular, or orthopedic interventions as needed. Extra-Peritoneal Packing was also conducted in the Emergency Department/Trauma Bay if the patient's condition was too critical for safe transport to the OR. In the latter segment of the study, we partnered with the R Adams Cowley Trauma Center in Baltimore, where the REBOA protocol utilized from 2013 to 2018 for patients with unstable pelvic injuries. For hypotensive patients with a positive E-FAST and, if applicable, an X-ray showing a pelvic fracture, REBOA was administered in Zone I if there was a suspected

abdominal-pelvic injury or in Zone III for suspected isolated pelvic injuries. Once the REBOA was positioned and the balloon inflated, imaging could either take place before accessing the OR or not, depending on the patient's hemodynamic status.

2. Hemorrhage during perioperative and peripartum periods

Hemorrhage occurring during the perioperative and peripartum phases continues to be significant sources of morbidity and mortality in gynecology and obstetrics (OB/GYN) [14-16]. Clinically important blood loss is often characterized as a loss of ≥ 1000 mL, a necessity for a transfusion, or a reduction of $\geq 25\%$ in circulating volume; a depletion of 30–40% usually leads to cardiovascular instability, and a loss exceeding 40% poses a threat to life [17,18]. Substantial bleeding can appear unexpectedly within various aspects of gynecologic and obstetric practice, from routine, low-risk surgeries like cesarean sections and hysterectomies [17,19,20] to intricate oncologic surgeries, including pelvic exenteration and cytoreductive procedures for advanced ovarian or cervical cancer [19-23]. In laparoscopy, which is currently the predominant access method in gynecology, critical hemorrhaging can arise right from the initial step: complications due to entry are responsible for 60–80% of serious vascular injuries, and severe incidents have been documented even during fundamental surgical tasks [24,26]. Severe intra-abdominal bleeding coupled with hemorrhagic shock has been noted following coital injuries [27-29]. The experience of the provider and the facility also play a crucial role: increased surgeon and hospital case volumes are associated with reduced hospital mortality rates after ovarian cancer operations [30]. Conversely, mortality due to exsanguination remains rare in skilled hands, even in high-difficulty surgeries like pelvic exenteration [31,32]. Damage control surgery (DCS), which was first proposed by Rotondo et al. in 1993 for both military and civilian trauma [33], is a staged surgical approach that emphasizes quick hemorrhage control and physiological stabilization rather than immediate definitive repairs for critically unstable patients [34-37]. The essential elements concise procedures, immediate management of bleeding and infection, intensive care resuscitation, and scheduled reoperation can be adapted for obstetrics and gynecology, though direct application of trauma protocols must consider the unique differences in specialties [23,38-41]. Frequent contributors to substantial bleeding in OB/GYN include, but are not limited to, placenta accreta spectrum causing pelvic sidewall bleeding, unmanageable uterine atony or traumatic postpartum bleeding (such as uterine rupture), severe injuries during childbirth, persistent pelvic oozing in patients with coagulation disorders, vascular injuries or atypical neovascularization damage during oncologic surgeries, trocar-entry injuries in laparoscopic procedures, presacral hemorrhage in sacrocolpopexy, and bleeding from retroperitoneal vessels due to deep-infiltrating endometriosis [37-43].

Abdomino-pelvic packing (APP) the insertion of sterile, radiopaque, flexible materials into the abdomen and/or pelvis to control bleeding against anatomical structures when traditional methods are insufficient continues to be a fundamental part of damage control surgery (DCS) in specific situations [44-47]. While it has been formally addressed and extensively researched within trauma and visceral surgery groups (for instance, in cases of unstable pelvic fractures or liver ruptures), APP was initially documented in the field of gynecologic oncology as a solution for severe pelvic bleeding [23] and clearly has significant relevance in various urgent obstetric and gynecological situations [19,20,48-54]. Frequently used materials include laparotomy pads or specially designed packs; in certain cases, other sterile space-filling devices, such as balloons or prosthetic sizers, have been employed based on the same concept, although standard procedures typically adhere to pads or specialized packs. [48,50,53,55-58]. Many of the early methods were created at a time when modern topical hemostatic techniques were unavailable, and when the use of anatomical aids and imaging technology was more limited. Notably, neither studies from the 1990s [23] nor more recent investigations consistently outline the preparatory steps that should occur before APP, such as enhancing systemic hemostasis, utilizing local hemostatic substances, administering aggressive early uterotonics, employing balloon tamponade, applying uterine compression sutures, performing arterial ligation, and undertaking selective arterial embolization. [15,59-61]. These encompass strategies for managing blood loss, prompt administration of tranexamic acid (TXA) [62-65], a wide array of hemostatic products [16,57,65,66-69], and vascular control techniques, ranging from ligating the internal iliac artery [70-72] to performing selective endovascular embolization or using balloon occlusion [73,74]. Although these approaches can reduce the need for invasive surgical interventions and minimize tissue trauma, severe bleeding can still occur, even with procedures generally considered low-risk. Therefore, gynecologic and obstetric surgeons must maintain their skills in the essential techniques of DCS, including the prompt use of APP [15,40,50]. Recognizing that APP can be critical for survival, this narrative review discusses its history, fundamental concepts, techniques, as well as potential risks and complications, integrating APP as part of DCS adapted for contemporary OB/GYN practice.

3. History of Abdomino-Pelvic Packing

The APP technique for controlling hemorrhage was first introduced by James Hogarth Pringle in 1908, who treated significant liver bleeding through perihepatic packing along with temporary cessation of hepatic blood flow the latter being referred to as the Pringle manoeuvre [75]. In the field of gynecology, Logothetopoulos presented an innovative method in 1926 for addressing pelvic bleeding after hysterectomy by placing a sterile bag filled with gauze inside the pelvic space and pulling it through the vaginal canal to compress the bleeding areas [76]. This approach, later known as Logothetopoulos packing, has undergone a variety of alterations and was sometimes called the “mushroom,” “parachute,” or “umbrella” pack due to its shape when deployed [48]. Despite its creative design, there were significant barriers to clinical use because of high infection rates, with some reports indicating infectious complications occurring in as many as 81.8% of cases [48-51,56]. During World War II and the Vietnam War, abdomino-pelvic packing was not widely embraced by U.S. military surgeons owing to concerns regarding infections and potential delayed complications. Nevertheless, civilian surgeons persisted in utilizing packing as a lifesaving intervention, particularly for liver injuries, and ongoing clinical experiences reinforced its effectiveness. [35,36,29,77]. Later, this method popped up toward the end of the 1900s when Stone and team reported better outcomes for trauma patients bleeding heavily due to clotting issues who got quick pack techniques. Instead of full surgery, they jammed 4 to 17 surgical sponges into the abdomen to stop internal bleeding; then stitched it shut tightly, no tubes or openings left behind [78].

4. Physiological Basis and Key Concepts of DCS in Obstetrics and Gynecology

DCS (Damage Control Surgery), is a phased surgical approach aimed at critically unstable patients that emphasizes swift control of bleeding and infection management, followed by intensive care unit resuscitation and scheduled reoperation for comprehensive repair [33]. The primary aim is to halt the self-reinforcing cycle leading to the “lethal triad” of hypothermia, acidosis, and coagulopathy, conditions that significantly elevate mortality rates in patients experiencing severe blood loss [79]. Previously, Kashuk and associates illustrated the related issue of the “bloody vicious cycle,” where hemorrhage, cellular shock, and tissue damage interact negatively, intensifying the bleeding [80].

Every element of the triad exacerbates the others and increases continuous blood loss: • Hypothermia (typically below 35 °C) compromises tissue oxygen delivery by lowering heart performance, altering the oxyhemoglobin dissociation curve to the left, and impairing platelet function and coagulation enzyme activity [81-83].

- Lactate buildup and tissue hypoperfusion cause acidosis ($\text{pH} < 7.2$ or base deficit > 8 mEq/L), which directly inhibits several coagulation cascade steps and impairs myocardial function [37,84].

- Coagulopathy is usually non-mechanical and widespread, leaking from venous plexuses and bare surfaces [78].

Coagulopathy is mostly diagnosed clinically by looking for widespread, non-surgical bleeding from wounds, vascular access points, and other sources. In critically injured individuals, laboratory testing does not always confirm coagulopathy. Even though the diagnosis can be supported by abnormalities in standard labs (such as prolonged PT/aPTT, thrombocytopenia, and hypofibrinogenemia), clinical judgment is still crucial because conventional tests might not be available right away and might not reveal real-time or clinically significant coagulopathy in critically injured patients [48,79,84,85]. When a patient's physiology and surgical trajectory suggest that a lengthy definitive treatment is dangerous, DCS is taken into consideration in practice [48,50,55,79,82,86]. Typical red flags in physiology and resuscitation include:

- High transfusion needs, such as ≥ 10 PRBC or ≥ 5000 mL of blood products in a 24hour period;
- Continued hypotension in spite of aggressive resuscitation ($\text{SBP} < 90$ mmHg);
- A significant metabolic disturbance ($\text{pH} < 7.2$, base deficit > 8 mEq/L, etc.).
- Clinical coagulopathy (diffuse bleeding) and hypothermia (less than 35 °C).
- Glasgow Coma Scale decrease, a worldwide indicator of hypoperfusion in hemorrhagic shock, is one example of a depressed sensorium. Red flags for operations and injury patterns that frequently lead to a shortened approach include [37,48,82]:

- Long operating times in unstable patients (e.g., > 90 minutes without obvious hemostatic control).
- Excessive intraoperative fluid/blood product replacement (e.g., >12,000 mL crystalloids/blood products).
- High injury score (ISS) or combination injuries (severe visceral and abdominal vascular injuries). **Table (1)**
- major vascular involvement in pelvic trauma.
- Temporary closure is required because edema and packing prevent tension-free primary fascial closure.

Following the DCS decision, the operational plan is divided into four phases [33,48,79]:

1. Short laparotomy with an exclusive hemostasis focus (e.g., APP, fast vascular control).
2. Temporary closure to permit further investigation.
3. Resuscitation in the intensive care unit (ICU) to reverse coagulopathy, acidosis, and hypothermia.
4. After physiological stability is attained, a planned reoperation for pack removal and final repair is made.

5. Topographic Classification of Packings in OB/GYN

A geospatial categorization of APP methods offers a useful guideline for surgical choices and has educational significance in the fields of obstetrics and gynecology. By organizing packing techniques based on the specific anatomical area being treated, surgeons can customize their approaches to address the likely origin of bleeding. The main categories are as follows:

• Vaginal packing

This method is mainly employed for ongoing vaginal or cervical bleeding, such as from tears, episiotomy sites, or lacerations that occur during delivery or following surgery. This approach continues to be significant as an initial mechanical method for targeting localized bleeding and is included in the recommended practices for managing postpartum hemorrhage (PPH) (60). Vaginal packing is not advised in PPH cases caused by uterine atony (15).

• Uterovaginal packing

This approach is typically utilized for addressing PPH resulting from uterine atony when medical treatments and other primary methods are ineffective. Although traditional gauze packing was once standard, it is increasingly being replaced or supplemented by intrauterine balloon tamponade devices, such as the Bakri balloon or condom catheter, which provide more precise and measurable pressure while minimizing risks of infection and displacement (60). Recent analyses emphasize the effectiveness of these devices in lessening the need for surgical intervention (52).

• Vagino-pelvic packing

This technique is indicated for managing significant pelvic bleeding following hysterectomy, particularly when retroperitoneal bleeding or hemorrhage from the vaginal cuff is suspected. Commonly known as Logothetopoulos packing, a term stemming from its first description in 1926, it involves inserting sterile packs through the vaginal canal into the pelvic area to achieve tamponade of deeper blood vessels or areas with widespread oozing (51,76).

• Pelvic packing

This is executed directly within the pelvic cavity through laparotomy to manage widespread venous oozing, arterial bleeding stemming from parametrial dissection, or damage to branches of the internal iliac vein. Techniques such as the “Mikulicz method” involve stacking laparotomy pads in layers to enhance compression against the pelvic bones and fascial layers (22-24). This technique is recorded in case studies related to gynecologic oncology surgeries, where immediate control of hemorrhage is vital (22).

• Abdominal packing

This is implemented for managing severe bleeding originating from the upper or middle abdomen, such as due to liver or splenic injury, major blood vessel issues, or widespread peritoneal bleeding during significant cancer surgeries. Although less commonly needed in strictly gynecological procedures, it has been noted in the context of complex cytoreductive or exenterative surgeries (50,52). It's crucial to understand that these classifications may overlap; actual clinical scenarios often require their simultaneous application, depending on the degree and location of the bleeding. For example, concurrent vaginal and pelvic packing might be required after a radical hysterectomy complicated by simultaneous hemorrhage from the vaginal cuff and retroperitoneal areas (22). Moreover, advancements in hemostatic techniques have prompted adaptations of traditional methods. The use of balloon tamponade in uterovaginal management marks a trend towards less invasive, monitored, and reversible procedures, which decreases the dependence on classical gauze packing (60). Even within the scope of minimally invasive surgery, localized laparoscopic packing, which includes the use of hemostatic sponges introduced through a 10 mm trocar port, has been noted for its effectiveness in managing localized hemorrhage, especially during laparoscopic procedures addressing ectopic pregnancies or adhesiolysis (58). Although these methods face limitations due to access issues and challenges in retrieval, they exemplify how damage control principles can be adapted to contemporary surgical practices. Irrespective of the type, any packs placed in the abdominal or pelvic cavity must be counted with precision, distinctly labelled (for instance, with radiopaque markers and external tags), and scheduled for removal within a timeframe of 24 to 48 hours to reduce the likelihood of infection, compartment syndrome, or any retained foreign objects (33).

6. Decision-Making,

Indications, and Contraindications for DCS in OB/GYN The concepts underlying damage control surgery (DCS) stem from trauma surgery; however, their utilization in this field is shaped by specific physiological conditions, such as the heightened circulatory dynamics of pregnancy or disruptions in coagulation associated with cancer, as well as procedural intricacies, such as oncological dissection or urgent obstetrical situations. Both the pregnant and recently pregnant uterus present a distinctive anatomical situation characterized by increased blood flow and altered tissue structures. Physiological changes during pregnancy include a blood volume increase of 30-50%, higher cardiac output, and a tendency toward hypercoagulability (87). These elements lead to the need for adjusted resuscitation goals and new thresholds for interventions. Furthermore, bleeding patterns in obstetrics and gynecology often differ from those seen in trauma: injuries typically involve lower energy levels, frequently comprise smaller blood vessels, and the surgical fields may be influenced by pregnancy or tumor structures, presenting unique challenges.

6.1. Obstetric Indications

In obstetrics, severe hemorrhage can result from placental complications, uterine atony, or trauma, particularly when associated with coagulopathy or delayed identification. The most frequently encountered situations include:

- Placenta accreta spectrum (PAS) involving the pelvic sidewall or bladder; significant bleeding occurring during or post-delivery or hysterectomy (19,53,54,73,89).
- Surgical intervention for persistent uterine atony following the unsuccessful use of uterotonics, balloon tamponade, or compression sutures, along with developing coagulopathy (30,75).
- Traumatic obstetric hemorrhage (such as uterine rupture or cervical/vaginal lacerations) that arises after vaginal delivery, especially when there is a delay in diagnosis or transfer (30,35,55,72).
- Rupture of the liver (either subcapsular or intrahepatic) linked to HELLP syndrome in patients with instability (89,90).
- Coagulopathy following substantial transfusions leading to the development of broad-ligament or retroperitoneal hematomas after cesarean sections (22,41).
- Settings with limited resources that are unable to provide blood products or access to interventional radiology (17).

6.2. Gynecological Indications

In the realm of gynecology, DCS is most commonly taken into account during intricate oncological surgeries or reoperative interventions, where anatomical distortions and the density of blood vessels elevate the risk of bleeding, as well as during routine procedures that could result in severe injuries to major blood vessels. Notable scenarios encompass:

- Cytoreductive surgery for ovarian cancer with extensive pelvic or upper abdominal dissection, or in the presence of prior coagulopathy (22,43).
- Pelvic exenteration carrying a risk of injury to the presacral venous plexus or internal iliac branches (24,31,33,91).
- Bleeding from retroperitoneal or presacral areas occurring during lymphadenectomy, which is a typical part of many cancer surgeries (39,92,93).
- Hemorrhage caused by tumor-associated neovascularization, characterized by fragile and unpredictably located vessels or anatomical variations (92,93).
- Complex pelvic reconstructive procedures (such as Sacro colpopexy, mesh revision, or fistula repair) in areas with scar tissue or changed anatomical layers (25,45).
- Vascular injuries incurred during laparoscopic entry (involving iliac or inferior epigastric vessels), with a reported incidence of 0.04-0.5% (25).
- Vascular damage or widespread bleeding in a “frozen pelvis” due to endometriosis, infection, or previous operations (42).
- Severe hemorrhage resulting from a burst ovarian cyst or tumor (94).
- Pregnancy outside the uterus that has ruptured, particularly when diagnosis is late or in uncommon cases (such as abdominal presentations) (67,68,95).

6.3. Clinical Decision-Making and Reasons Against DCS and APP

Making a quick choice about DCS and APP is crucial and must take into account the surgeon's personal expertise (like internal iliac artery ligation) as well as the availability of urgent non-surgical options (such as endovascular embolization) (17,71,73). Possible contraindications, whether absolute or relative for DCS and packing include:

- Injuries that cannot be survived, such as severe traumatic brain injury or metastatic cancer with excessive bleeding, alongside patient-specific elements like advance directives that prefer comfort care. It's vital to understand that DCS is intended to save lives, not to replace meaningful discussions about patient care goals.
- Unmanageable bleeding from significant central vessels, such as the abdominal aorta or inferior vena cava, when effective pressure cannot be maintained through packing alone.
- Uncontrolled infections present in the surgical area, such as a perforated organ with pus contamination, which could prevent temporary closure and increased the risk of sepsis.
- Abdominal compartment syndrome occurring without a method for pressure relief, as packing may worsen intra-abdominal pressure.

7. Evidence-Based DCS Protocol in OB/GYN In obstetrics and gynecology,

Damage control surgery (DCS) should adhere to a systematic, multi-phase strategy, focusing on stabilizing physiological function rather than anatomical reconstruction. Initially proposed by Rotondo and colleagues as a three-phase approach—starting with an abbreviated laparotomy (Phase I), ICU resuscitation (Phase II), and re-laparotomy for comprehensive repair (Phase III)—the model has since included preoperative resuscitation (Phase 0/Ground Zero) and a specific phase for closing the abdominal wall, highlighting improvements in critical care and management of open abdomens (33,36,38). This revised protocol—derived from

trauma surgery yet tailored for specific specialties, consists of four interconnected phases: preoperative resuscitation (Phase 0/Ground Zero), abbreviated surgical control (Phase I), ICU-based resuscitation (Phase II), and scheduled re-laparotomy for final reconstruction (Phase III). Each phase is crucial and relies on timely execution and collaboration among various disciplines.

7.1. Phase 0/Ground Zero:

Preoperative Resuscitation and Team Activation Effective damage control surgery (DCS) initiates even before entering the operating room. Taking prompt actions in the emergency or surgical area is vital for reducing the fatal triad and setting up for surgical intervention.

7.1.1. Multidisciplinary Team Assembly

The efficiency of DCS is improved through a unified, interdisciplinary strategy. In well-equipped environments, especially for complicated scenarios like placenta accreta spectrum (PAS), having a team that includes a gynecologic oncologist (who specializes in retroperitoneal issues), an interventional radiologist, an anesthesiologist experienced in large volume transfusions, and a blood bank liaison leads to better results (37,41,53,96). It is also preferable to have a urologist or colorectal surgeon available if there's a risk of injury to the urinary tract or intestines, and a hepatobiliary surgeon could be enlisted if there's a chance of liver rupture due to pre-eclampsia (81). However, in numerous healthcare environments particularly those outside major centers such specialists might not be readily accessible. In these instances, knowledge of the fundamental concepts of DCS is paramount: swift control of bleeding, concise surgical interventions, and stabilization of the patient's condition. Early implementation of non-surgical methods for hemostasis like TXA, topical agents, and systematic blood product resuscitation can be crucial until definitive treatment can be administered. For gynecological oncology situations, the team is frequently gathered during the surgery itself, given that DCS is usually not planned and occurs in the face of unexpected blood loss (97).

7.2. Hemostatic Optimization

The prompt use of TXA—1 g IV over 10 minutes, ideally given within an hour, but no later than 3 hours after the onset of bleeding is highly recommended by the WOMAN trial. Simultaneously activating a massive transfusion protocol (MTP) with a ratio of 1:1:1 for packed red blood cells (pRBC), fresh frozen plasma (FFP), and platelets is vital to prevent coagulopathy (43,99). Additionally, administering 1 g of calcium chloride IV (or approximately 3 g of calcium gluconate) during or right after the first blood product unit and after every 4 units thereafter, along with monitoring ionized calcium levels to avoid complications related to low calcium levels and coagulation issues is essential (88-100).

7.3. Volume and Pressure Management

Initial resuscitation increasingly adopts a limited fluid strategy to strike a balance between adequate blood flow and proper hemostasis; small amounts of crystalloids serve as a temporary measure before blood products are given, reducing the chances of dilutional coagulopathy, swelling, and disruption of clots (72,101). Permissive hypotension keeping blood pressure below standard levels until hemostasis is achieved is often described as aiming for a systolic blood pressure (SBP) of approximately 80–90 mmHg or a mean arterial pressure (MAP) in the 50–60 mmHg range in patients actively losing blood who do not have traumatic brain injury (TBI), although the research supporting this is varied and tailored to individual cases (101). This method is not advisable for suspected or confirmed TBI cases, which necessitate higher pressures; current guidelines suggest maintaining SBP at 100–110 mmHg (depending on age) and MAP at 80 mmHg or above to ensure adequate blood flow to the brain (82). If fluid and blood product targets aren't achieved (67), norepinephrine is often utilized to maintain MAP as hemostasis is being managed. Use of supplemental oxygen and tracking lactate/base deficit and urine output assists in evaluating how well perfusion is maintained during this controlled resuscitation phase (82,101).

7.4. Temperature Management

Immediate steps should be taken to warm patients (using forced-air blankets), to heat intravenous fluids and irrigants, and to control room temperature, as hypothermia (81) Core temperature must be monitored continuously through methods such as esophageal, bladder, or pulmonary artery probes. These practices conform to current guidelines for trauma and bleeding, along with

perioperative studies that indicate even slight hypothermia can heighten blood loss and the necessity for transfusions, making the maintenance of normal body temperature essential (82,83).

7.5. Laboratory and Point-of-Care Monitoring

The initial evaluation ought to incorporate a complete blood count, basic metabolic panel, coagulation tests (including PT/INR and aPTT), fibrinogen measurement, and type and crossmatch to ensure there is sufficient pRBC availability. When feasible, viscoelastic tests (such as TEG/ROTEM) offer immediate assessment of clotting and can inform targeted hemostatic interventions (like fibrinogen, PCC, or platelets) in situations of significant bleeding, such as postpartum hemorrhage. If these tests are unavailable, medical staff should depend on clinical progression and begin early empirical treatments while awaiting standard laboratory results (82,102,103).

7.6. Phase I:

Abbreviated Surgical Control and Packing Phase I focuses on quickly controlling bleeding with the least physiological disruption, postponing definitive repairs.

7.6.1. Surgical Access and Exploration

A vertical midline laparotomy, extending from the pubic region to above the umbilicus and reaching the xiphoid process, if necessary, is the conventional method, irrespective of existing incisions. This approach allows optimal entry to the pelvis and facilitates packing. A swift exploration of all quadrants is conducted to locate sources of hemorrhage. Visible injuries are managed using clamps, sutures, or vessel loops (50).

7.6.2. Infection Control In trauma

Injuries to hollow organs need to be managed through straightforward suture repairs or stapling; creating anastomoses or stomas is postponed. However, visceral contamination is infrequent in cases of obstetric and gynecological damage control surgery (DCS), where the primary issue is bleeding rather than organ perforation (33).

7.6.3. Decision to Pack vs. Repair The usual indications for packing include:

- Numerous or widespread bleeding locations (such as the presacral venous plexus or parametrial oozing).
- Instability in hemodynamics that makes prolonged surgery difficult.
- Coagulation issues that hinder surgical control of bleeding.
- Anatomically difficult areas of bleeding (like the retroperitoneum or deep pelvis).
- Ongoing hemorrhage after a hysterectomy or ligation of the internal iliac artery.
- Liver laceration when suturing does not succeed (in conjunction with the Pringle manoeuvre) (89,90).

7.6.4. Modern Packing Technique

- Material selection: Employ large, radiopaque laparotomy pads (at least 7–10, ideally 10–12). Smaller pads are more likely to be misplaced when removed, especially after 48 hours.
- Pad preparation: Pads can be rolled prior to placement to apply targeted pressure. These can also be pre-soaked in TXA (at a concentration of 100 mg/mL) or treated with a hemostatic agent to improve local hemostasis (15,40,57,69).
- Placement technique: Begin packing from the deepest area towards the surface, applying steady manual pressure for a minimum of 5 minutes. Ensure pads are overlapped tightly to eliminate "dead spaces," as these gaps can weaken the tamponade effect (33,50).
- Accountability: Pads need to be tied together and carefully counted to confirm complete retrieval.

- Visceral protection: Use bowel bags placed between packing materials and the organs to avoid adhesion; if feasible, consider placing omentum over exposed areas. Ureters should be recognized or treated as though they are likely present in high-risk areas (42).

7.6.5. Short-Term Abdominal Closure

Fascial closure is purposely avoided during the initial phase of damage control surgery to reduce tension in the abdominal wall and to prevent abdominal compartment syndrome from developing. A technique known as temporary abdominal closure (TAC) is used to hold the internal organs in place, reduce fluid and heat loss, permit future surgeries, and aid in the recovery of physiological functions. The selection of TAC should be influenced by the patient's stability, potential needs for re-laparotomy, the risk of infections, and the availability of resources. The TAC methods outlined in [104] include the following:

- Close the skin using clips or sutures: This method is quick, low-cost, and easily accessible but has a high likelihood of causing evisceration, infections, recurrent intra-abdominal hypertension, and less favourable outcomes. Due to these high rates of complications and mortality, this approach is now less preferred.
- Closure using mesh and dynamic retention sutures: Utilizing meshes (either absorbable or non-absorbable) offers a barrier that allows for gradual fascial closure but comes with risks of hernia, infections, and adhesions. Dynamic retention sutures help maintain fascial positioning for delayed closure, yet they are technically challenging and come with a significant hernia risk.
- Wittmann Patch (Artificial Burr): This adhesive patch allows for a gradual, staged closure of the abdomen, achieving a high rate of primary fascial closure (75–90%). It supports multiple re-entries while maintaining space, making it particularly useful for patients requiring several surgical interventions. However, it is expensive and does not effectively remove peritoneal fluid.
- Bogota Bag: This low-cost method can be quickly set up using a sterile irrigation bag sewn onto the fascia or skin. It acts as a “non-traction” technique suited for settings with limited resources. However, it may allow fascial retraction and loss of domain, increases the likelihood of infections and fistulas, and is linked to lower rates of closure.
- Barker Vacuum Pack: This approach entails covering the internal organs with a polyethylene sheet, followed by towels and an adhesive drape, and employing a suction drain to create negative pressure. It is straightforward and cost-effective. Although still utilized in resource-limited environments, it has largely been replaced by commercial negative pressure therapy systems due to subpar closure rates and complications.
- Commercial Negative Pressure Therapy (NPT) Systems: Devices like 3M™ AbThera™ Therapy are specially crafted for managing open abdomens. These systems deliver continuous negative pressure, assist in fluid elimination, maintain abdominal space, and encourage fascial approximation. They boast superior closure rates, lower mortality, and improved clinical outcomes; therefore, they are preferred according to most guidelines when accessible, although cost and access may pose challenges [104]. The placement of abdominal drains is a topic of debate some support monitoring the output, while others caution against the heightened risk of compartment syndrome [33,40,48].

7.7. phase II:

Vital Care Resuscitation Postoperative management in the ICU focuses on reversing physiological derangement

7.7.1. primary Resuscitation goals

- Temperature: maintaining core $> 36^{\circ}\text{C}$ with lively warming.
- Acid–base balance: concentrated on $\text{pH} > 7.25$ and base deficit $< 4 \text{ mEq/L}$. Avoidance of recurring bicarbonate use except $\text{pH} < 7.1$.
- Coagulation: Target values for fibrinogen are $> \text{two hundred mg/dL}$ (complement with fibrinogen concentrate if $< \text{one hundred fifty mg/dL}$), $\text{PT/PTT} < 1.5 \times \text{normal}$, and platelets $> 75,000/\mu\text{L}$ [85].
- Continuation of TXA: 1 g every 8 h have to be persevered in ongoing bleeding [62-65].

7.7.2. Monitoring and Complication Prevention

- Abdominal compartment syndrome (ACS): display intra-belly strain (IAP) via bladder catheter. Thresholds: <15 mmHg in non-pregnant, <25 mmHg in peripartum patients [107,108]. Clinical signs and symptoms consist of oliguria, hypotension, and accelerated height airway pressures.
- Drain output: must decrease to < 200 mL/hour after coagulopathy correction. Re-laparotomy can be indicated if output exceeds 400 mL/hour in a coagulopathic patient [38].
- Neurological and ache management: adequate sedation and analgesia are integral, especially in prolonged ICU remains.
- Enteral feeding: Early enteral nutrition (EN) is related to fewer infections and higher fascial closure rates [107]. Parenteral nutrients should be initiated started right away while EN is not viable. As soon as hemodynamic resuscitation is largely complete and intestinal viability is showed, EN have to be initiated. A relative contraindication to EN is a possible bowel remnant < 75 cm [108].
- Thromboprophylaxis: Mechanical prophylaxis during coagulopathy; pharmacological after correction [85].
- Antibiotic prophylaxis: In trauma, broad-spectrum antibiotics are standard due to hollow viscus injury. In OB/GYN, an optimal antibiotic prophylaxis is debatable. Usually, second-generation cephalosporins +/- metronidazole are recommended until definitive repair; aminoglycosides should be avoided due to nephrotoxicity and ototoxicity [40].

7.8. Phase II: Definitive Reconstruction

Timely return to the operating theatre is essential to minimize infection risk while ensuring physiological readiness.

7.8.1. Timing of Re-Laparotomy

- Obstetric cases: 24–48 h, as bleeding is typically venous or capillary and stabilizes earlier [20].
- Oncologic or trauma cases: 48–72 h, allowing time for resuscitation and resolution of coagulopathy [33,91].
- The timeframe of 72 h should never be exceeded, as infection risk increases exponentially beyond this point.

7.8.2. Readiness Criteria

Definitive repair should be proceeded when ALL (or the great majority) of the following are satisfied and trending towards normalization:

- Temperature: core temperature $\geq 36^{\circ}\text{C}$ (normothermia achieved). Earlier recommendation for at least >6 h at $>36^{\circ}\text{C}$ appears arbitrary; fashion and balance matter extra than time box [109].
- Acid–base and perfusion: lactate falling (preferably towards < 2–3 mmol/L or clear downward trend) and base deficit improving (e.g., > -6 to -5 and rising toward 0) [82,110].
- Coagulation: INR ≤ 1.5 , platelets $\geq 100 \times 10^9/\text{L}$, fibrinogen adequate (many centers target $\geq 2.0 \text{ g/L}$), and not using an energetic diffuse coagulopathic oozing [72].
- Hemodynamics: solid MAP with minimum or no vasopressor support and sufficient urine output ($\geq 0.5 \text{ mL/kg/h}$), indicating restored give up-organ perfusion. IAP < 15 mmHg is a reasonable safety boundary for closure (IAH is $\geq 12 \text{ mmHg}$; ACS is $>20 \text{ mmHg}$ with new organ disorder) but ought to be mixed with usual stomach compliance/closure feasibility [72].
- Abdominal domain/compliance: abdomen amenable to safe closure besides upsetting intra-belly hypertension (IAP kept < 12–15 mmHg) OR an open-abdomen diagram is in place (NPWT with planned staged closure) [105,108,111].
- Transfusion trajectory: no ongoing huge transfusion requirement and blood product use virtually decelerating (many groups use “ ≤ 2 units over 4–6 h” pragmatically, though not officially tenet-mandated) [72].

- there may be no demonstrated abdominal drain-output threshold, that's congruent with universal weak evidence for routine drainage in surgical procedure. a few resources advocate doing away with drains while output is < 200 mL/h, but the individual threshold should be seen in context of injury pattern, TAC technique, patient hemodynamics, and feasibility of safe closure instead [91,108].

7.8.3. Pack Removal and Definitive Hemostasis

- Preparation: Full surgical team, anesthesia with muscle relaxation, blood products at bedside, and setup for re-packing if needed.
- Technique: Irrigate the field with warm saline before removal. Remove packs slowly and systematically, applying counter-pressure. Inspect each anatomical zone for residual bleeding.
- Definitive control: Address active bleeding with sutures, clips, or vessel ligation. Use hemostatic agents as adjuncts.
- Closure: After copious irrigation, attempt primary fascial closure if possible—achieved in 60–80% of cases. If not, use NPT or planned skin grafting.

8. Complications and Outcomes of DCS in OB/GYN

DCS with pelvic packing is a life-saving intervention, but it carries significant risks arising from the physiological stress of hemorrhage, the surgical technique itself, and prolonged critical illness [40]. Understanding these risks and implementing preventive strategies is essential for optimizing outcomes in obstetric and gynecologic patients.

8.1. Abdominal Compartment Syndrome (ACS)

Abdominal compartment syndrome (ACS) is the most serious specific complication of damage control surgery (DCS), occurring in 10–40% of patients who undergo the procedure [105,112]. ACS is a life-threatening condition in critically injured patients caused by increased intra-abdominal pressure (IAP), which can lead to multiorgan failure. Elevated IAP compromises perfusion to vital organs, resulting in cardiovascular, respiratory, renal, and neurological dysfunction, which may culminate in left ventricular failure. Normal intra-abdominal pressure ranges from 5 to 7 mmHg and may rise to 10–11 mmHg in critically ill, non-pregnant patients [105]. According to the World Society of the Abdominal Compartment Syndrome (WSACS), intra-abdominal hypertension (IAH) is defined as a sustained IAP ≥ 12 mmHg, while ACS is diagnosed when IAP exceeds 20 mmHg with new-onset organ dysfunction [105]. However, in pregnancy, baseline IAP is physiologically elevated due to the expanding uterus, amniotic fluid, and placenta. During the third trimester, median IAP ranges from 15 to 29 mmHg, and it decreases to approximately 16 mmHg within 24 h postpartum [106,111,113,114]. Pregnant women adapt to this increase (as a result of growing fetus/es, amniotic fluid and placenta) by developing greater abdominal wall compliance [111,112,114]. Therefore, as pregnant or postpartum patients have an elevated baseline IAP, diagnostic thresholds derived from non-pregnant populations are not directly applicable to obstetric and postpartum patients. Clinical signs—such as hypotension, oliguria, abdominal distension, and elevated peak airway pressures—should be integrated with IAP measurements for accurate diagnosis [40,111,114]. Additional conditions in pregnancy—such as pre-eclampsia, eclampsia, and HELLP syndrome—can further elevate IAP [111]. In the context of an open abdomen, excessive or tightly packing may also contribute to ACS, particularly when combined with fluid overload or bowel distension. Gynecologic conditions associated with increased IAP include large retroperitoneal hematomas, ovarian hyperstimulation syndrome, malignant ascites, and prolonged laparoscopy with high insufflation pressures, among others [111]. Typical ACS symptoms include hypotension, oliguria, abdominal distension, and elevated ventilator peak pressures. Diagnosis of IAP is most reliably assessed via bladder pressure measurement, the gold standard recommended by WSACS. A Foley catheter is used to instill 25 mL of sterile saline, and pressure is measured at the mid-axillary line using a manometer. In older literature, gastric pressure via a nasogastric (Ryle's) tube connected to a water manometer was considered an alternative [36,40,105]. Treatment depends on severity and clinical stability:

- Non-surgical measures: nasogastric or rectal decompression, gastrointestinal prokinetics, diuretics, and neuromuscular blockade to reduce intra-abdominal volume and abdominal wall tone.
- Surgical decompression: indicated when medical management fails and organ dysfunction persists; may involve opening a closed fascia, loosening or removing packs (with potential risk of re-bleeding), or extending the abdominal incision [40].

8.2. Infectious Complications

A significant proportion of patients undergoing APP develop febrile morbidity. The most common non-specific infectious complications are intra-abdominal (pelvic, subphrenic, intramesenteric) abscesses and sepsis. In trauma surgery, the incidence of intra-abdominal abscesses is consistently reported as high, due to a combination of contaminated operative fields, the presence of foreign material in the abdominal cavity, shock, and immunocompromised patients [35]. For OB/GYN DCS, data on septic-related morbidity after APP are conflicting. While some authors report “near-universal febrile morbidity” [49], others report lower rates of infection-related complications. In OB/GYN series comparing APP with no APP for intractable hemorrhage, infection rates were similar, while bleeding control was significantly higher with APP [22,54]. Given the variable infection rates reported with APP, broad-spectrum antibiotic prophylaxis is recommended [54]. Prolonged packing (>72 h) stays a main danger aspect for infectious morbidity [45]; therefore, early elimination of packing materials 24–48 h in obstetric cases and 48–72 h in oncologic cases is obligatory [20,45,54].

8.3. Urological complications

The ureters are most at risk of compression at 2 anatomical sites: the pelvic brim wherein they omit below the uterine artery and the ureterovesical junction close to the bladder [42,115]. Medical symptoms of ureteral compromise generally emerge 24–48 h postoperatively and include oliguria, rising serum creatinine, and hydronephrosis on imaging [25]. In prolonged compression associated with extraperitoneal pelvic packing, renal pelvicalyceal rupture has been stated [116]. When ureteral damage or obstruction is suspected, control requires prompt decompression, e.g., through loosening or repositioning packs or ureteral stenting, or if stenting fails percutaneous nephrostomy to maintain renal feature and save you everlasting damage [25].

8.4. Vascular complications

Vascular complications get up in the main from compression of main pelvic vessels during packing, leading to deep vein thrombosis and ability limb ischemia [54,117]. Among trauma patients with isolated severe pelvic fractures, the ones handled with preperitoneal pelvic packing had considerably better venous thromboembolism rates and worse survival than matched patients controlled besides packing [118]. Inadvertent ligation or damage of main vessels throughout pre-packing manoeuvres can bring about big-territory ischemia (e.g., limb hypoperfusion, mesenteric/colonic ischemia) or excessive venous outflow obstruction [117,119,120]. Hence, designated knowledge of pelvic vascular anatomy and common variations is critical for preventing and dealing with extreme pelvic bleeding [71,92,93]. This anatomic familiarity is especially essential in complicated oncologic operations and emergencies, wherein rapid orientation is necessary for powerful, atraumatic pack placement [56]. As soon as hemostasis is completed and bleeding risk declines, pharmacologic thromboprophylaxis ought to be initiated directly to prevent thromboembolic occasions. non-stop limb-perfusion monitoring (pulses/Doppler, capillary fill up, limb temperature) is crucial. If vascular compromise is suspected, urgent vascular surgery session is warranted to prevent irreversible ischemic injury or limb loss [117,120,121].

8.5. Effects of APP/DCS

8.5.1. Short-Time Period Results

Modern series show favourable results while DCS is correctly applied in obstetric and gynecologic emergencies. Hemostasis is executed in 62–90 % of patients, with reviews of significantly decrease mortality versus conservative management [18,20,22,29]. Whilst done within appropriate timeframes, standard survival exceeds 80 %, and primary fascial closure is done at re-laparotomy in 60–80% of instances [20,22,40]. In the largest multicenter take a look at of abdomen packing after unsuccessful peripartum hysterectomy, Deffieux et al. stated a 62% fulfilment rate (33/53) for hemorrhage control besides additional tactics; median percent stay was 39.5 h (IQR 24–48), and no packing-related infectious headaches had been stated [20]. Kumar et al. [22] said an 87.5% success rate, and Yoong et al. [48] said 100% manipulate of intractable venous hemorrhage with abdomino-pelvic packing in a small collection.

8.5.2. Long-Time Period Effects

OB/GYN-specific long-term records after APP/DCS stay sparse, so evidence extrapolated from trauma cohorts must be interpreted with caution. In trauma sufferers, early fascial closure (≤ 7 days) is associated with higher long-time quality of existence and a higher return-to-work rate (54% vs. 10%) as compared with delayed closure [107]. Sufferers managed with damage control strategies have multiplied risks of past due complications together with ventral hernia, enterocutaneous fistula, intra-abdominal adhesions, bowel obstruction, and reduced SF-36 scores—on lengthy-term comply with-up [123,124]. persistent ache and psychological sequelae also are common after primary trauma; meta-analytic statistics in ICU/trauma survivors display PTSD and depressive signs in 20–30% at 6–365 days [125]. In obstetrics, a current systematic review highlights lengthy-term physical, mental, and social effects after peripartum hysterectomy, which includes PTSD, depression, tension, and grief; when DCS is required as a salvage measure after failed peripartum hysterectomy, a similar or extra psychological burden is workable, underscoring the need for habitual psychological screening and early referral to aid services [126].

8.5.3. Key Elements for Superior Outcomes

- Early intervention before the deadly triad (hypothermia, acidosis, coagulopathy) becomes set up.
- suitable patient selection.
- Multidisciplinary crew experience (gynecology/obstetrics, anesthesia/imperative care, interventional radiology, vascular/urology).
- Integration of cutting-edge hemostatic techniques (TXA, topical hemostats, embolization).
- Strict aseptic approach.
- Well timed pack removal (24–48 h, obstetric; 48–72 h, oncologic).
- Comprehensive postoperative monitoring and help (contamination surveillance, DVT prophylaxis whilst secure, nutrients/physiotherapy, mental support).

8.6. Special Considerations in Gynecologic Oncology

In gynecologic malignancy, DCS/APP intersects with risk elements that impair healing cachexia, anemia, hypoalbuminemia, and current chemotherapy which worsen wound restoration and infection risk [31,32]. Early targets are hemostasis, source manipulate, and nutritional/hematologic optimization, followed through well timed DVT prophylaxis once bleeding risk lets in. Multidisciplinary making plans have to outline criteria and timing to renew chemotherapy (after pack removal and stable wound healing) to avoid compromising oncologic manage [22,40]. This focused technique preserves the hemostatic blessings of DCS whilst minimizing delays in adjuvant therapy.

9. Discussion

The roots of APP in the DCS framework lie in late 20th century trauma surgical procedure, when speedy tamponade of exsanguinating pelvic or retroperitoneal hemorrhage was once often the sole temporizing choice [23]. Even though many procedurals derive from the trauma literature, direct transposition to modern OB/GYN practice is restricted by means of anatomic, physiologic, and situational variations [40,86,111]. Trauma sufferers generally present with complex pelvic fractures, excessive-strength blunt injuries, and multisystem harm. In contrast, obstetric eventualities greater frequently contain iatrogenic vessel injury in otherwise healthy patients or hemorrhage from gravid or currently gravid uteri. Physiologic diversifications of pregnancy which include multiplied blood extent, cardiac output, and baseline intra-abdominal pressure affect both presentation and resuscitation targets in hemorrhagic surprise [111], necessitating modified thresholds for intervention. In gynecologic oncology, cytoreductive surgical operation, e.g., for advanced ovarian cancer, entails huge-volume resections, hard-to-get access to areas, and retroperitoneal and upper abdominal dissections, with dangers of important vessel injury and huge raw surfaces prone to diffuse oozing [22-24,127,128]. Tumor-related coagulopathy, large surgical trauma, and compromised nutritional state in addition complicate hemostasis [28,94]. In benign gynecology, packing may be life-saving in rare however necessary scenarios along with vascular

injury during laparoscopic trocar insertion or excessive bleeding from pelvic vessels for the duration of adhesiolysis or deep endometriosis surgical operation [25,42,69]. Catastrophic intra-abdominal bleeding also can be precipitated with the aid of apparently atraumatic situations like consensual intercourse [27-29]. The threat gain profile of pelvic packing in OB/GYN remains incompletely described because of a paucity of big, managed research. Available data recommend excessive immediate hemostatic 389fulfilment (75–90%), tempered by way of dangers of infection, organ compression, and thrombosis [39]. Meticulous technique, anatomic familiarity, suitable material selection, and strict timelines for pack removal (24–48 h for obstetric instances; 48–72 h for oncologic cases) are central to minimizing those dangers [91]. Each time viable, APP length ought to no longer exceed these limits. Appreciation pelvic vascular anatomy and recognizing tough-to-get access to areas are critical for stopping and dealing with primary pelvic hemorrhage [92,93]. This understanding is especially essential in the course of complex oncologic techniques, where version vascular patterns are not unusual, and in emergencies, in which fast orientation is critical for powerful, atraumatic pack placement [127,128]. Advances in adjunctive measures have shifted pelvic packing from a last resort to an incorporated factor of staged hemostatic control. Early TXA presents survival advantage in trauma (CRASH-2) and postpartum hemorrhage (WOMAWN) [62-65,129] and is an increasing number of followed in most important gynecologic surgery. Maternal mortality disproportionately affects low- and middle-income nations, in which blood products, ICU ability, and specialized expertise may be confined [14,129,130]. TXA's heat-stable, low-price profile is valuable in such settings and may lessen reliance on resource extensive interventions [129]. Topical hemostats which include flowable gelatin thrombin matrices, fibrin sealants, oxidized regenerated cellulose, and chitosan-based dressings provide focused manipulate of parenchymal or tough-to-get entry to bleeding [43,57,58,69]. In oncologic surgical procedure, early application can prevent progression to out of control hemorrhage and reduce the need for packing or reoperation [16]. Use of agents containing coagulation components (fibrin, thrombin) reduces operative time, blood loss, and transfusion wishes even in sufferers with disturbed coagulation potentially decreasing the need for DCS [28]. Past pre-APP use, hemostatic marketers had been implemented to soak/coat packing substances [15]. More than one reviews guide APP/DCS in OB/GYN. In placenta accreta spectrum, pelvic packing controlled continual bleeding after peripartum hysterectomy without postoperative headaches in a small series [68]. A changed "pelvic strain packing" using a Foley-condom saline device (eliminated at 48–72 h) executed definitive hemostasis in 11 obstetric/gynecologic instances without a morbidity or mortality [14]. APP also managed big bleeding after placental removal in abdominal pregnant [69]. In the most important multicenter cohort of packing after unsuccessful peripartum hysterectomy, the 389fulfilment rate was 62%, with a normal mortality of 24%, reflecting infection severity as opposed to the packing itself [18]. A 6-affected person collection of "Karateke packing" (near-warm sponges wrapped round a Bakri balloon, 500–a 1000 mL, vaginal traction) carried out hemostasis in 5/6; 1 affected person with placenta percreta died from rupture and hypovolemic shock; no packing-associated headaches had been mentioned amongst survivors [74]. In gynecologic oncology, mixed intra-abdominal/intrapelvic packing during cytoreductive surgical treatment for advanced ovarian cancer showed 12.5% operative mortality (2/16) and no extra morbidity versus controls [17]. After failure of internal iliac ligation, a ribbon-gauze/Penrose drain pack arrested bleeding in 4 extra instances (one postpartum, 3 oncologic) [15]. Despite its life-saving ability, APP's effectiveness relies upon on group readiness and institutional preparedness. Because its use is infrequent, competency have to be maintained through based packages simulation-based structured programs, and mentorship in high-quantity centers [131]. In aid restrained settings where embolization is unavailable, packing stays a low cost, excessive effect option. Emphasis should be positioned on early TXA, fundamental packing techniques with available substances, and everyday education [131,132]. Publications in Scandinavia established that formal training will increase each frequency and accuracy of packing, confirming that the skill is teachable and sustainable [134]. For OB/GYN, integrating DCS concepts into residency curricula and medical institution large hemorrhage protocols is essential, keeping in idea that intractable hemorrhage can arise at any time and in any placing, in particular in obstetric departments. Despite the fact that preceding PPH, pre-present anemia, chorioamnionitis, fetal macrosomia, multiple gestation, pre-eclampsia, big uterine myomas, previous uterine surgical operation, or obesity are well-known chance elements for PPH related to the "4 Ts" trauma of the birth canal, (intrauterine) tissue retention, atony, and thrombin alterations (coagulopathy) in maximum instances (ca. 60%), PPH occurs barring sizable chance elements [130]. In the close to destiny, AI-supported training systems must enhance education in DCS and emergency protocols, through consisting of real-time "unpredictable" situations and reflecting the pace and uncertainty of actual emergencies. High-fidelity digital truth/augmented truth simulation and tele mentoring can rehearse uncommon bleeding styles, device screw ups, and human element stressors underneath time pressure, with objective metrics and debriefs [133,134]. In this review, we analyzed the quasi "linear" maturation of DCS,

from its first definitions and conceptualizations to innovative enrichment with pharmacologic adjuncts (e.g., TXA, topical hemostats) and standardized blood-control protocols. We hypothesize that the following decade could be pushed with the aid of AI- and robot-supported protocols, which could synchronize early analysis and protocolized laboratory and imaging u/s. with automated multidisciplinary activation within mins. Nowadays, we have a look at an emerging shift from “robot-assisted” to “robotic-guided” surgical operation, as artificial Genius facilitates fuse augmented reality and multimodal inputs (imaging, radiomics, molecular diagnostics) into a visually and informationally better field [135]. Ideally, personalized DCS should start before the incision. AI can fuse patient-unique profiles comorbidities, anticoagulants, coagulation phenotype, previous hemorrhage, or even genetic markers to stratify bleeding chance, pre-position sources, and lower the edge for an abbreviated, packing-first method while the threat of damage extension is excessive [136]. Intraoperatively, robot strategies may be paired with 3-D reconstructions, AR overlays, fluorescence imaging, and AI selection-assist, imparting actual-time signals (e.g., impending hypotension) and guiding strategies (e.g., packing vs. definitive restore), highlighting anatomic risk zones, and documenting fundamental steps, whilst postoperatively enabling chance-stratified tracking for rebleeding, ACS, or infection [136,137].

II. Conclusion

APP within a DCS approach is a doubtlessly life-saving alternative for “near miss” patients with persistent, uncontrollable bleeding. In post-hysterectomy pelvic hemorrhage and decided on obstetric and oncologic emergencies, stated fulfilment costs are high, with applicable morbidity. Therefore, DCS concepts need to be embedded in obstetric hemorrhage recommendations and institutional large bleeding protocols, with APP retained a defined step for refractory bleeding. education obstetricians and gynecologists through simulation and fingers on courses can reduce delays and improve effects. In aid-limited settings, where interventional radiology (arterial embolization) may be unavailable, APP offers a realistic, effective bridge to resuscitation and definitive care.

Abbreviations

- **REBOA: (Resuscitative Endovascular Balloon Occlusion of the Aorta)**

involves three anatomical zones for balloon occlusion:

Zone I: Extends from the left subclavian artery to the celiac artery (approximately 20 cm long).

Zone II: Extends from the celiac artery to the most caudal renal artery.

Zone III: Extends from the most caudal renal artery to the aortic bifurcation (just above the level of the umbilicus). These zones are critical for targeting the site of hemorrhage during the REBOA procedure.

- **ISS: Injury severity score Table (1)**

Injury Severity Score; ISS			
Region	Injury Description	AIS	Square Top Three
Head & Neck	No injury	0	0
Face	No Injury	0	0
Chest	Flail Chest	4	16
Abdomen	No injury	0	0
Extremity	Fractured femur	3	9
External	Contusion	1	1
Injury Severity Score:			26

AIS Score	Injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Survivable

ISS	
1-8	Minor
9-15	Moderate
16-24	Serious
25-49	Severe
50-74	Critical
75	Maximum

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- The WOMAN trial: investigated the effects of tranexamic acid on death and morbidity in women with post-partum haemorrhage (PPH) in developing countries (16 Jul 2020) ·
- Pringle manoeuvre: refers to a manual or vascular clamp occlusion of the hepatoduodenal ligament to interrupt blood flow into the liver, including the hepatic artery and portal vein.
- IAP: Intra-abdominal pressure.
- IAH: Intra-abdominal hypertension.
- ACS: acute coronary syndrome.
- SF score: refers to the Short Form Health Survey, which is a questionnaire designed to assess general health quality of life.
- PTSD: Post-traumatic stress disorder.
- (CRASH-2): The 2010 Clinical Randomization of an Antifibrinolytic in Significant Hemorrhage 2.

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References

- [1] - Tran, Thai Lan N., et al. "Western Trauma Association Critical Decisions in Trauma: Management of pelvic fracture with hemodynamic instability—2016 updates." *Journal of Trauma and Acute Care Surgery* 81.6 (2016): 1171-1174.
- [2]- Costantini, Todd W., et al. "Pelvic fracture pattern predicts the need for hemorrhage control intervention—results of an AAST multi-institutional study." *Journal of Trauma and Acute Care Surgery* 82.6 (2017): 1030-1038.
- [3]- Tosounidis, Theodoros I., and Peter V. Giannoudis. "Pelvic fractures presenting with haemodynamic instability: treatment options and outcomes." *The Surgeon* 11.6 (2013): 344-351.
- [4]- Croce, Martin A., et al. "Emergent pelvic fixation in patients with exsanguinating pelvic fractures." *Journal of the American College of Surgeons* 204.5 (2007): 935-939.
- [5]- Scaglione, Michelangelo, et al. "External fixation in pelvic fractures." *Musculoskeletal surgery* 94.2 (2010): 63-70.
- [6]- Tesoriero, Ronald Brian, et al. "Angiographic embolization for hemorrhage following pelvic fracture: Is it “time” for a paradigm shift?" *Journal of Trauma and Acute Care Surgery* 82.1 (2017): 18-26.
- [7]- Osborn, Patrick M., et al. "Direct retroperitoneal pelvic packing versus pelvic angiography: a comparison of two management protocols for haemodynamically unstable pelvic fractures." *Injury* 40.1 (2009): 54-60.
- [8]- Cothren, C. Clay, et al. "Preperitoneal pelvic packing for hemodynamically unstable pelvic fractures: a paradigm shift." *Journal of Trauma and Acute Care Surgery* 62.4 (2007): 834-842.
- [9]- Chiara, Osvaldo, et al. "Efficacy of extra-peritoneal pelvic packing in hemodynamically unstable pelvic fractures, a Propensity Score Analysis." *World journal of emergency surgery* 11.1 (2016): 22.
- [10]- Burlew, Clay Cothren, et al. "Preperitoneal pelvic packing reduces mortality in patients with life-threatening hemorrhage due to unstable pelvic fractures." *Journal of Trauma and Acute Care Surgery* 82.2 (2017): 233-242.
- [11]- Brenner, Megan, et al. "Use of resuscitative endovascular balloon occlusion of the aorta for proximal aortic control in patients with severe hemorrhage and arrest." *JAMA surgery* 153.2 (2018): 130-135.
- [12]- Morrison, Jonathan J., et al. "Aortic balloon occlusion is effective in controlling pelvic hemorrhage." *journal of surgical research* 177.2 (2012): 341-347.
- [13]- Do, Woo S., et al. "Preperitoneal balloon tamponade and resuscitative endovascular balloon occlusion of the aorta: alternatives to open packing for pelvic fracture-associated hemorrhage." *Journal of Trauma and Acute Care Surgery* 87.1 (2019): 18-26.
- [14]- Cresswell, Jenny A., et al. "Global and regional causes of maternal deaths 2009–20: a WHO systematic analysis." *The Lancet Global Health* 13.4 (2025): e626-e634.
- [15]- Escobar, Maria Fernanda, et al. "FIGO recommendations on the management of postpartum hemorrhage 2022." *International Journal of Gynecology & Obstetrics* 157 (2022): 3-50.
- [16]- Wright, Jason D., et al. "Patterns of use of hemostatic agents in patients undergoing major surgery." *journal of surgical research* 186.1 (2014): 458-466.
- [17]- Bhosale A, Kavya HS, Nandanwar YS, Ansari A. Pelvic pressure packing for intractable obstetric and gynaecological hemorrhage in a tertiary care hospital. *Int J Reprod Contracept Obstet Gynecol* 2018; 7:4956-9.
- [18]- YU, STEVE P. MD*; COHEN, JOSHUA G. MD*; PARKER, WILLIAM H. MD*. Management of Hemorrhage During Gynecologic Surgery. *Clinical Obstetrics and Gynecology* 58(4): p 718-731, December 2015.
- [19]- David, Liji, Anuja Abraham, and Annie Regi. "Clinical perspective: caesarean hysterectomy for placenta accreta spectrum and role of pelvic packing." *Int J Reprod Contracept Obstet Gynecol* 8 (2019): 4107-4110.

- [20] - Deffieux, Xavier, et al. "Maternal outcome after abdominal packing for uncontrolled postpartum hemorrhage despite peripartum hysterectomy." *PLoS One* 12.6 (2017): e0177092.
- [21]- Buras, Andrea L., et al. "Major vascular injury during gynecologic cancer surgery." *Gynecologic Oncology Reports* 37 (2021): 100815.
- [22]- Kumar, Sunesh, et al. "Combined intra-abdominal pelvic packing during cytoreductive surgery in advanced epithelial ovarian cancer: a case series." *Archives of gynecology and obstetrics* 285.4 (2012): 1125-1132.
- [23]- Finan, Michael A., et al. "Massive pelvic hemorrhage during gynecologic cancer surgery:” pack and go back”." *Gynecologic oncology* 62.3 (1996): 390-395.
- [24]- Wydra, D., et al. "Surgical pelvic packing as a means of controlling massive intraoperative bleeding during pelvic posterior exenteration—a case report and review of the literature." *International Journal of Gynecological Cancer* 14.5 (2004): 1050-1054.
- [25]- Watrowski, Rafał, Stoyan Kostov, and Ibrahim Alkatout. "Complications in laparoscopic and robotic-assisted surgery: definitions, classifications, incidence and risk factors—an up-to-date review." *Video surgery and Other Mini invasive Techniques* 16.3 (2021): 501-525.
- [26]- Edwards, William R. "Hysterectomy, massive transfusion and packing to control haemorrhage from pelvic veins in the course of bilateral oophorectomy." *Australian and New Zealand journal of obstetrics and gynaecology* 36.1 (1996): 82-84.
- [27]- Sivalingam, N., and D. Rajesvaran. "Coital injury requiring internal iliac artery ligation." *Singapore medical journal* 37 (1996): 547-548.
- [28]- Jeng, Cherng-Jye, and Lih-Rong Wang. "Vaginal laceration and hemorrhagic shock during consensual sexual intercourse." *Journal of Sex & Marital Therapy* 33.3 (2007): 249-253.
- [29]- Fletcher, Horace, Ian Bambury, and Michelle Williams. "Post-coital posterior fornix perforation with peritonitis and haemoperitoneum." *International Journal of Surgery Case Reports* 4.2 (2013): 153-155.
- [30]- Bristow, Robert E., et al. "Impact of surgeon and hospital ovarian cancer surgical case volume on in-hospital mortality and related short-term outcomes." *Gynecologic oncology* 115.3 (2009): 334-338.
- [31]- Tortorella, L., et al. "Prediction of short-term surgical complications in women undergoing pelvic exenteration for gynecological malignancies." *Gynecologic oncology* 152.1 (2019): 151-156.
- [32]- Tortorella, Lucia, et al. "Predictive factors of surgical complications after pelvic exenteration for gynecological malignancies: a large single-institution experience." *Journal of Gynecologic Oncology* 35.1 (2023): e4.
- [33]- Rotondo, Michael F., et al. "'Damage control': an approach for improved survival in exsanguinating penetrating abdominal injury." *Journal of Trauma and Acute Care Surgery* 35.3 (1993): 375-383.
- [34]- Sharp, KENNETH W., and RICHARD J. Locicero. "Abdominal packing for surgically uncontrollable hemorrhage." *Annals of surgery* 215.5 (1992): 467.
- [35]- Johnson, Jon W., et al. "Evolution in damage control for exsanguinating penetrating abdominal injury." *Journal of Trauma and Acute Care Surgery* 51.2 (2001): 261-271.
- [36]- Jaunoo, S.S.; Harji, D.P. Damage Control Surgery. *Int. J. Surg.* 2009, 7, 110–113.
- [37]- Pikoulis, Emmanouil, et al. "Damage control for vascular trauma from the prehospital to the operating room setting." *Frontiers in Surgery* 4 (2017): 73.
- [38]- Waibel, Brett H., and Michael MF Rotondo. "Damage control surgery: it's evolution over the last 20 years." *Revista do Colegio Brasileiro de Cirurgioes* 39 (2012): 314-321.

- [39]- Awonuga, A. O., Z. O. Merhi, and N. Khulpateea. "Abdominal packing for intractable obstetrical and gynecologic hemorrhage." *International Journal of Gynecology & Obstetrics* 93.2 (2006): 160-163.
- [40]- Pacheco, Luis D., et al. "Damage-control surgery for obstetric hemorrhage." *Obstetrics & Gynecology* 132.2 (2018): 423-427.
- [41]- Carvajal, Javier A., et al. "Damage-control resuscitation in obstetrics." *The Journal of Maternal-Fetal & Neonatal Medicine* 35.4 (2022): 785-798.
- [42]- Gingold, Julian A., and Tommaso Falcone. "Retroperitoneal anatomy during excision of pelvic side wall endometriosis." *Journal of endometriosis and pelvic pain disorders* 8.2 (2016): 62-66.
- [43]- Watrowski, Rafał, Christoph Jaeger, and Johannes Forster. "Improvement of perioperative outcomes in major gynecological and gynecologic–oncological surgery with hemostatic gelatin–thrombin matrix." *in vivo* 31.2 (2017): 251-258.
- [44]- FELICIANO, DAVID V., et al. "Packing for control of hepatic hemorrhage." *Journal of Trauma and Acute Care Surgery* 26.8 (1986): 738-743.
- [45]- Ordoñez, Carlos, et al. "The 1–2–3 approach to abdominal packing." *World journal of surgery* 36.12 (2012): 2761-2766.
- [46]-Eastman, Alexander L., and April Miller. "Managing severe (and open) pelvic disruption." *Trauma Surgery & Acute Care Open* 10. Suppl 1 (2025).
- [47]- Lin, Shi-Shui, et al. "The effect of preperitoneal pelvic packing for hemodynamically unstable patients with pelvic fractures." *Chinese Journal of Traumatology* 24.02 (2021): 100-103.
- [48]- Howard, Rebecca J., et al. "Pelvic umbrella pack for refractory obstetric hemorrhage secondary to posterior uterine rupture." *Obstetrics & Gynecology* 100.5 Part 2 (2002): 1061-1063.
- [49]- Dildy, Gary A., et al. "An effective pressure pack for severe pelvic hemorrhage." *Obstetrics & Gynecology* 108.5 (2006): 1222-1226.
- [50]- Yoong, Wai, et al. "Abdomino-pelvic packing revisited: An often-forgotten technique for managing intractable venous obstetric haemorrhage." *Australian and New Zealand Journal of Obstetrics and Gynaecology* 59.2 (2019): 201-207.
- [51]- Naranjo-Gutiérrez, Leonardo A., et al. "Pelvic packing with vaginal traction for the management of intractable hemorrhage." *International Journal of Gynecology & Obstetrics* 127.1 (2014): 21-24.
- [52]- Winata, I. Gde Sastra, and Alit Darma Asmara. "Abdominal packing for obstetric surgical uncontrollable hemorrhage." *European Journal of Medical and Health Sciences* 4.4 (2022): 70-74.
- [53]- Touhami, Omar, et al. "Pelvic packing for intractable obstetric hemorrhage after emergency peripartum hysterectomy: a review." *Obstetrical & gynecological survey* 73.2 (2018): 110-115.
- [54]- Touhami, Omar, et al. "Efficacy and safety of pelvic packing after emergency peripartum hysterectomy (EPH) in postpartum hemorrhage (PPH) setting." *European Journal of Obstetrics & Gynecology and Reproductive Biology* 202 (2016): 32-35.
- [55]- Braley, Scott C., et al. "Controlled tamponade of severe presacral venous hemorrhage: use of a breast implant sizer." *Diseases of the colon & rectum* 45.1 (2002): 140-142.
- [56]- Kılıççı, Çetin, et al. "Modified abdominal packing method in “near miss” patients with postpartum hemorrhages." *Turkish Journal of Obstetrics and Gynecology* 15.3 (2018): 159.
- [57]- Dueckelmann, Anna M., et al. "Safety and efficacy of the chitosan covered tamponade for the management of lower genital tract trauma during childbirth." *The Journal of Maternal-Fetal & Neonatal Medicine* 38.1 (2025): 2511092.
- [58]- Thomas, Mathew A., Sam B. Bhayani, and Louis R. Kavoussi. "Laparoscopic temporary packing for hemostasis." *Urology* 66.4 (2005): 880-e3.

- [59]- Shah, Monjri, and Jason D. Wright. "Surgical intervention in the management of postpartum hemorrhage." *Seminars in perinatology*. Vol. 33. No. 2. WB Saunders, 2009.
- [60]- Cochrane Pregnancy and Childbirth Group, et al. "Mechanical and surgical interventions for treating primary postpartum haemorrhage." *Cochrane Database of Systematic Reviews* 2020.7 (1996).
- [61]- Behrens, Adam M., Michael J. Sikorski, and Peter Kofinas. "Hemostatic strategies for traumatic and surgical bleeding." *Journal of Biomedical Materials Research Part A* 102.11 (2014): 4182-4194.
- [62]- Shakur, Haleema, et al. "Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN): an international, randomised, double-blind, placebo-controlled trial." *The Lancet* 389.10084 (2017): 2105-2116.
- [63]- Brenner, Amy, et al. "The impact of early outcome events on the effect of tranexamic acid in post-partum haemorrhage: an exploratory subgroup analysis of the WOMAN trial." *BMC pregnancy and childbirth* 18.1 (2018): 215.
- [64]- Ker, Katharine, et al. "Tranexamic acid for postpartum bleeding: a systematic review and individual patient data meta-analysis of randomised controlled trials." *The Lancet* 404.10463 (2024): 1657-1667.
- [65]- Shakur, H., et al. "CRASH-2 trial collaborators. Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial." *Lancet* 376.9734 (2010): 23-32.
- [66]- Brown, Kilian GM, and Michael J. Solomon. "Topical haemostatic agents in surgery." *British Journal of Surgery* 111.1 (2024): znad361.
- [67]- Watrowski, Rafał. "Hemostatic gelatine–thrombin matrix (FloSeal®) facilitates hemostasis and organ preservation in laparoscopic treatment of tubal pregnancy." *Archives of gynecology and obstetrics* 290.3 (2014): 411-415.
- [68]- Watrowski, Rafał, Annabel Lange, and Jochen Möckel. "Primary omental pregnancy with secondary implantation into posterior cul-de-sac: laparoscopic treatment using hemostatic matrix." *Journal of minimally invasive gynecology* 22.3 (2015): 501-503.
- [69]- Watrowski, Rafał. "Unifying local hemostasis and adhesion prevention during gynaecologic laparoscopies: Experiences with a novel, plant-based agent." *Journal of Obstetrics and Gynaecology* 40.4 (2020): 586-588.
- [70]- Esmer, Ahmet Rıza, et al. "External iliac artery thrombosis after hypogastric artery ligation and pelvic packing for placenta previa percreta." *Turkish Journal of Obstetrics and Gynecology* 15.2 (2018): 130.
- [71]- Kostov, Stoyan, et al. "Internal iliac artery ligation in obstetrics and gynecology: surgical anatomy and surgical considerations." *Clinics and practice* 14.1 (2023): 32-51.
- [72]- Papathanasiou, K.; Tolikas, A.; Dovas, D.; Fragkedakis, N.; Koutsos, J.; Giannoylis, C.; Tzafettas, J. Ligation of Internal Iliac Artery for Severe Obstetric and Pelvic Haemorrhage: 10 Year Experience with 11 Cases in a University Hospital. *J. Obstet. Gynaecol.* 2008, 28, 183–184.
- [73]- Shahin, Yousef, and Chun Lap Pang. "Endovascular interventional modalities for haemorrhage control in abnormal placental implantation deliveries: a systematic review and meta-analysis." *European Radiology* 28.7 (2018): 2713-2726.
- [74]- Fan, Yao, et al. "A prospective observational study evaluating the efficacy of prophylactic internal iliac artery balloon catheterization in the management of placenta previa–accreta: A STROBE compliant article." *Medicine* 96.45 (2017): e8276.
- [75]- PRINGLE, J. HOGARTH F.R.C.S., OF GLASGOW. NOTES ON THE ARREST OF HEPATIC HEMORRHAGE DUE TO TRAUMA. *Annals of Surgery* 48(4): p 541-549, October 1908.

- [76]- Logothetopoulos, K. "Eine absolut sichere Blutstillungsmethode bei vaginalen und abdominalen gynäkologischen operationen." *Zentralbl Gynäkol* 50 (1926): 3202.
- [77]- LUCAS, CHARLES E., and ANNA M. LEDGERWOOD. "Prospective evaluation of hemostatic techniques for liver injuries." *Journal of Trauma and Acute Care Surgery* 16.6 (1976): 442-451.
- [78]- Stone, H. Harlan, Priscilla R. Strom, and Richard J. Mullins. "Management of the major coagulopathy with onset during laparotomy." *Annals of surgery* 197.5 (1983): 532-535.
- [79]- BURCH, JON M., et al. "Abbreviated laparotomy and planned reoperation for critically injured patients." *Annals of surgery* 215.5 (1992): 476-484.
- [80]- Kashuk, Jeffry L., et al. "Major abdominal vascular trauma—a unified approach." *Journal of Trauma and Acute Care Surgery* 22.8 (1982): 672-679.
- [81]- Jurkovich, Gregory J., et al. "Hypothermia in trauma victims: an ominous predictor of survival." *50 Landmark Papers every Trauma Surgeon Should Know*. CRC Press, 2019. 43-48.
- [82]- Rossaint, Rolf, et al. "The European guideline on management of major bleeding and coagulopathy following trauma." *Critical Care* 27.1 (2023): 80.
- [83]- Rajagopalan, Suman, et al. "The effects of mild perioperative hypothermia on blood loss and transfusion requirement." *Database of Abstracts of Reviews of Effects (DARE): Quality-assessed Reviews [Internet]*. Centre for Reviews and Dissemination (UK), 2008.
- [84]- Corwin, Gregory S., et al. "Characterization of acidosis in trauma patient." *Journal of Emergencies, Trauma, and Shock* 13.3 (2020): 213-218.
- [85]- Maier, Cheryl L., et al. "Contemporary management of major haemorrhage in critical care." *Intensive Care Medicine* 50.3 (2024): 319-331.
- [86]- Villalobos Rodríguez, Alejandro Lenin. "The obstetrician attached to the obstetric emergency." *Colombia Médica* 55.3 (2024).
- [87]- Soma-Pillay, Priya, et al. "Physiological changes in pregnancy: review articles." *Cardiovascular journal of Africa* 27.2 (2016): 89-94.
- [88]- Rouzi, Abdulrahim A., and Mohammed Sulaimani. "Damage-Control Surgery for Maternal Near-Miss Cases of Placenta Previa and Placenta Accreta Spectrum." *International Journal of Women's Health* (2021): 1161-1165.
- [89]- Chawanpaiboon, Saifon, et al. "Managing Life-Threatening Spontaneous Liver Rupture in Pregnancy: A Case Study." *The American Journal of Case Reports* 26 (2025): e946909.
- [90]- Dubey, Sunita, and Jyotsna Rani. "Hepatic rupture in preeclampsia and HELLP syndrome: A catastrophic presentation." *Taiwanese Journal of Obstetrics and Gynecology* 59.5 (2020): 643-651.
- [91]- Fotopoulou, Christina, et al. "European Society of Gynaecological Oncology guidelines for the peri-operative management of advanced ovarian cancer patients undergoing debulking surgery." *International Journal of Gynecological Cancer* 31.9 (2021): 1199-1206.
- [92]- Kostov, Stoyan, et al. "Paraortic Lymphadenectomy in Gynecologic Oncology—Significance of Vessels Variations." *Journal of Clinical Medicine* 11.4 (2022): 953.
- [93]- Kostov, Stoyan, et al. "Pelvic lymphadenectomy in gynecologic oncology—Significance of anatomical variations." *Diagnostics* 11.1 (2021): 89.

- [94]- Watrowski, Rafał. "Pregnancy-Preserving laparoscopic treatment of acute hemoperitoneum following lutein cyst rupture in early gestation." *Zeitschrift Für Geburtshilfe Und Neonatologie* 223.02 (2019): 109-112.
- [95]- Kunwar, Shipra, Khan Tamkin, and Kumkumrani Srivastava. "Abdominal pregnancy: methods of hemorrhage control." *Intractable & rare diseases research* 4.2 (2015): 105-107.
- [96]- Touhami, Omar, et al. "Placenta accreta spectrum: a non-oncologic challenge for gynecologic oncologists." *International Journal of Gynecological Cancer* 32.6 (2022): 788-798.
- [97]- Jamal, Leila, et al. "Emerging approaches to pre-hospital hemorrhage control: a narrative review." *Annals of translational medicine* 9.14 (2021): 1192.
- [98]- Giancarelli, Amanda, et al. "Hypocalcemia in trauma patients receiving massive transfusion." *Journal of Surgical Research* 202.1 (2016): 182-187.
- [99]- Latif, Rana K., et al. "Traumatic hemorrhage and chain of survival." *Scandinavian journal of trauma, resuscitation and emergency medicine* 31.1 (2023): 25.
- [100]- Potestio, Christopher P., et al. "The incidence, degree, and timing of hypocalcemia from massive transfusion: a retrospective review." *Cureus* 14.2 (2022).
- [101]- Kudo, Daisuke, Yoshitaro Yoshida, and Shigeki Kushimoto. "Permissive hypotension/hypotensive resuscitation and restricted/controlled resuscitation in patients with severe trauma." *Journal of Intensive Care* 5.1 (2017): 11.
- [102]- Butwick, Alexander J., and Lawrence T. Goodnough. "Transfusion and coagulation management in major obstetric hemorrhage." *Current Opinion in Anesthesiology* 28.3 (2015): 275-284.
- [103]- Jokinen, Samuli, et al. "Thromboelastometry-guided treatment algorithm in postpartum haemorrhage: a randomised, controlled pilot trial." *British Journal of Anaesthesia* 130.2 (2023): 165-174.
- [104]- Afsar, Levent, et al. "Narrative Review of Open Abdomen Management and Comparison of Different Temporary Abdominal Closure Techniques." *Journal of Abdominal Wall Surgery* 4 (2025): 14119.
- [105]- Kirkpatrick, Andrew W., et al. "Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome." *Intensive care medicine* 39.7 (2013): 1190-1206.
- [106]- Chun, Rosaleen, and Andrew W. Kirkpatrick. "Intra-abdominal pressure, intra-abdominal hypertension, and pregnancy: a review." *Annals of intensive care* 2. Suppl 1 (2012): S5.
- [107]- Dissanaik, Sharmila, et al. "Effect of immediate enteral feeding on trauma patients with an open abdomen: protection from nosocomial infections." *Journal of the American College of Surgeons* 207.5 (2008): 690-697.
- [108]- Coccolini, Federico, et al. "The open abdomen in trauma and non-trauma patients: WSES guidelines." *World journal of emergency surgery* 13.1 (2018): 7.
- [109]- C. M. Lamb, P. MacGoey, A. P. Navarro, A. J. Brooks, Damage control surgery in the era of damage control resuscitation, *BJA: British Journal of Anaesthesia*, Volume 113, Issue 2, August 2014, Pages 242–249
- [110]- Mizobata, Yasumitsu. "Damage control resuscitation: a practical approach for severely hemorrhagic patients and its effects on trauma surgery." *Journal of Intensive Care* 5.1 (2017): 4.
- [111]- Lozada, M. James, et al. "Management of peripartum intra-abdominal hypertension and abdominal compartment syndrome." *Acta obstetrica et gynecologica Scandinavica* 98.11 (2019): 1386-1397.

- [112]- Burch, J.M.; Moore, E.E.; Moore, F.A.; Franciose, R. The Abdominal Compartment Syndrome. *Surg. Clin. N. Am.* 1996, 76, 833–842.
- [113]- Fuchs, Florent, et al. "Are standard intra-abdominal pressure values different during pregnancy?" *PLoS One* 8.10 (2013): e77324.
- [114]- Staelens, Anneleen SE, et al. "Intra-abdominal pressure measurements in term pregnancy and postpartum: an observational study." *PLoS One* 9.8 (2014): e104782.
- [115]- Chatroux, Louisa R., and Jon I. Einarsson. "Keep your attention closer to the ureters: Ureterolysis in deep endometriosis surgery." *Best Practice & Research Clinical Obstetrics & Gynaecology* 95 (2024): 102494.
- [116]- Mansbridge, Margaret Mary, et al. "Renal pelvicalyceal rupture secondary to extraperitoneal pelvic packing (EPP) in the unstable trauma patient." *Case Reports* 2018 (2018): bcr-2018.
- [117]- Selloua, Maria, et al. "Acute limb ischemia due to a common iliac artery thrombosis following total pelvic exenteration with pelvic sidewall resection: A case report." *Gynecologic Oncology Reports* (2025): 101750.
- [118]- Kolitsas, Apostolos, et al. "Preperitoneal pelvic packing in isolated severe pelvic fractures is associated with higher mortality and venous thromboembolism: a matched-cohort study." *The American Journal of Surgery* 236 (2024): 115828.
- [119]- Gupta, Sachin, and Deeksha S. Tomar. "Ischemic gut in critically ill (mesenteric ischemia and nonocclusive mesenteric ischemia)." *Indian Journal of Critical Care Medicine: Peer-reviewed, Official Publication of Indian Society of Critical Care Medicine* 24. Suppl 4 (2020): S157.
- [120]- Heelan, Alicia A., et al. "Worth looking! venous thromboembolism in patients who undergo preperitoneal pelvic packing warrants screening duplex." *The American Journal of Surgery* 220.6 (2020): 1395-1399.
- [121]- Jongkind, Vincent, et al. "Editor's Choice—Update of the European Society for Vascular Surgery (ESVS) 2020 clinical practice guidelines on the management of acute limb ischaemia in light of the COVID-19 pandemic, based on a scoping review of the literature." *European Journal of Vascular and Endovascular Surgery* 63.1 (2022): 80-89.
- [122]- Fox, Nicole, et al. "Early abdominal closure improves long-term outcomes after damage-control laparotomy." *Journal of Trauma and Acute Care Surgery* 75.5 (2013): 854-858.
- [123]- Brenner, Megan, et al. "Long-term impact of damage control laparotomy: a prospective study." *Archives of surgery* 146.4 (2011): 395-399.
- [124]- Theodorou, Alexis, et al. "Long term outcome after open abdomen treatment: function and quality of life." *Frontiers in surgery* 8 (2021): 590245.
- [125]- Righy, Cassia, et al. "Prevalence of post-traumatic stress disorder symptoms in adult critical care survivors: a systematic review and meta-analysis." *Critical care* 23.1 (2019): 213.
- [126]- Jayawardane, I. A., et al. "Long-term morbidity of peripartum hysterectomy: A systematic review." *International Journal of Gynecology & Obstetrics* (2025).
- [127]- Kostov, Stoyan, et al. "Surgical and Anatomical Basics of Pelvic Debulking Surgery for Advanced Ovarian Cancer—The “Hudson Procedure” as a Cornerstone of Complete Cytoreduction." *Chirurgia* 118 (2023): 187-201.
- [128]- Kostov, Stoyan, et al. "Neglected anatomical areas in ovarian cancer: Significance for optimal debulking surgery." *Cancers* 16.2 (2024): 285.
- [129]- Roberts, Ian, Amy Brenner, and Haleema Shakur-Still. "Tranexamic acid for bleeding: much more than a treatment for postpartum hemorrhage." *American Journal of Obstetrics & Gynecology MFM* 5.2 (2023): 100722.

- [130]- Surbek, Daniel, et al. "Patient blood management (PBM) in pregnancy and childbirth: literature review and expert opinion." *Archives of gynecology and obstetrics* 301.2 (2020): 627-641.
- [131]- Helmer, Philipp, et al. "Postpartale Hämorrhagie." *Der Anaesthetist* 71.3 (2022): 181-189.
- [132]- Bach, Allan, et al. "Retroperitoneal packing as part of damage control surgery in a Danish trauma centre—fast, effective, and cost-effective." *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 16.1 (2008): 4.
- [133]- Leal, Jaime Andrés MD, MHPE. Artificial Intelligence in Orthopaedic and Trauma Surgery Education: Applications, Ethics, and Future Perspectives. *JAAOS: Global Research and Reviews* 9(9): e25.00174, September 2025.
- [134]- Aurello, Paolo, et al. "Enhancing Surgical Education Through Artificial Intelligence in the Era of Digital Surgery." *The American Surgeon™* (2025): 00031348251346539.
- [135]- Watrowski, Rafał, and Radmila Sparić. "Changing backgrounds and groundbreaking changes: gynecological surgery in the third decade of the 21st century volume II." *Frontiers in Surgery* 12 (2025): 1587048.
- [136]- Pavone, Matteo, et al. "Unveiling the real benefits of robot-assisted surgery in gynaecology: from telesurgery to image-guided surgery and artificial intelligence." *Facts, Views & Vision in ObGyn* 17.1 (2025): 50.
- [137]- Mascagni, P.; Alapatt, D.; Sestini, L.; Yu, T.; Alfieri, S.; Morales-Conde, S.; Padoy, N.; Perretta, S. Applications of Artificial Intelligence in Surgery: Clinical, Technical, and Governance Considerations. *Cir. Esp. (Engl. Ed.)* 2024, 102 (Suppl. 1), S66–S71.