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Operative Techniques in
General Surgery

The Control of Intraoperative Hemorrhage During Pelvic Operations

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The anatomy of the pelvis has few unusual variations. Although the tissue planes in which one performs dissection and mobilization of structures in the pelvis are readily identified in the normal state, prior surgery, malignancy, and longstanding inflammation may obscure them in disease. Urologists, gynecologists, vascular surgeons, orthopedists, and colorectal surgeons all operate within the pelvis, and sometimes with each other, as in the case of pelvic exenteration.[1] Familiarity with the normal anatomy is essential for all, and techniques developed in one specialty for pelvic hemorrhage control after pelvic fracture, obstetrical injury, cesarean delivery, or soft tissue trauma surgery may be adapted by another to control unexpected bleeding encountered in more elective circumstances.[2,3]

Patients submitted to pelvic operations should be queried preoperatively and appropriately evaluated for blood dyscrasia or bleeding disorders.[4] If found, clotting factors should be administered to normalize the coagulation milieu. A Cell Saver should be made available in cases in which there is a history of prior bleeding during surgical procedures and in cases in which von Willebrand's disease is present.

There are also subtle factors that alter coagulation and may impact intraoperative hemorrhage. A high alcohol intake on the part of the patient despite the presence of normal liver functions may lead to problems with subsequent bleeding. Herbal and natural remedies may exacerbate intraoperative coagulation difficulties; vitamin E, St. John's Wort, ginseng, garlic, ginkgo biloba, fish oil, and beta-carotene have been implicated in altering the coagulation cascade and should be discontinued for at least 7 days before surgery. Drugs such as Plavix alter platelet function and should be discontinued 2 weeks before surgery, if the underlying cardiovascular illness permits.

Although the most effective way to control bleeding is a direct occlusion of a visualized bleeding vessel, fibrin glue, Gelfoam, and surgicel are available to every surgeon and can be utilized when significant diffuse bleeding is encountered during pelvic surgery (Table 1). Platelet transfusions are an integral part of the resuscitative effort during transfusion of the bleeding patient; 10 to 20 units of platelets and supplemental calcium should be given after each blood volume replacement with transfused products. Factor VIII may also be administered in those patients even without a history of factor VIII deficiency because after massive transfusion, availability of factor VIII drops precipitously.[4,5]

Factors Impacting Blood Loss

Cornelius Sedgwick, of the Lahey Clinic, advocated the "Rule of Twos" for success in surgery; completion of the operation within 2 hours with blood loss of less than two units. Operating within such parameters exacts minimal physiologic toll on the patient. Major blood loss, however, defined as replacement transfusion of one total blood volume, can set up a cascade of physiologic derangements leading not only to hypothermia, coagulopathy, and hypoxia with acidosis (the lethal triad), but also myocardial dysfunction, arrhythmia and death. Hypothermia occurs because of a combination of blood loss and resuscitation efforts with cold fluids, combined with prolonged exposure of the open abdomen to the environment. If the body temperature goes below 36°C for greater than 4 hours, cardiac arrhythmia, decreased cardiac output, increased systemic vascular resistance, and a leftward shift of the oxygen hemoglobin dissociation curve may occur. Coagulopathy then occurs because of inhibition of the coagulation cascade; hemodilution and hypothermia have an additive effect, resulting in diminution of circulating coagulating factors and platelets. As hypoperfusion continues, anaerobic metabolism occurs, acidosis worsens and a vicious circle ensues that may lead to death if not reversed. The trauma literature suggests that with uninterrupted hypoperfusion and acidosis, an "irreversible shock" state is reached and survival becomes unlikely unless specific and expeditious measures are taken. The so-called bail-out or "damage control" approach championed in the trauma and emergent surgery literature clearly has application to elective pelvic operations in which exsanguinating hemorrhage has occurred.[2,3]

The Bail-Out Decision

In the majority of cases in which hemorrhage is encountered during pelvic operations, expeditious control can be undertaken by standard methods such as suture ligation or oversewing of injured blood vessels. Direct vascular repair of large

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Table 1 Topical Intraperitoneal Hemostatic Agents

Agent	What It Is	How It Is Applied
Avitene ultrafoam	Absorbable collagen hemostat	Comes in powder; sprinkle on area
Fibrin glue Coseal Floseal Tisseal	Equal amounts of cryoprecipitate and thrombin	Spray on affected area with double-barrel syringe or device supplied by Baxter Healthcare
Gelfoam	Absorbable gelatin sponge	Cut in strips of appropriate size and apply to area
Surgicel	Oxidized regenerated cellulose	Cut in strips of appropriate size and apply to area

vessel injury or ligation of feeding vessels to a tumor may also be utilized. There are no hard and fast rules about when to consider the bail-out option during pelvic procedures; however, hypothermia of 34°C, a pH of 7.2 or less, a serum bicarbonate level of 15 mg/L, transfusions of greater than 4,000 mL of blood and blood products, and intraoperative volume replacement with greater than 10 liters of crystalloid are conditions that foster arrhythmia and acidosis and emphasize the preferability of a bail-out procedure to death from irreversible shock. Sometimes, an operative procedure may have to be abandoned at a stage where resection is not complete; the abdomen is packed and temporarily closed. The patient is returned, intubated, to the Intensive Care Unit for resuscitation. Hemoglobin and clotting factors are restored, and pH, intravascular volume and temperature as normalized to the extent possible. The interval between damage control and reoperation can be somewhat variable, but as longer intervals make septic complications more likely, reoperation should occur promptly after hemodynamic stability has been established and re-warming has occurred. Under most circumstances, this can be accomplished within 24 to 36 hours after the first surgery. During the resuscitative effort, as transfusion of blood and blood products seek to return oxygen delivery and clotting to normal, a predictor of success is the durability of the response of the platelet count. In surgical wounds bleeding after massive transfusion, platelet counts of greater than 100,000 are sought so that ongoing oozing and bleeding do not occur; multiple platelet transfusions may be necessary to accomplish this.

Anatomic Considerations

The relatively constant course of the ureter should be known and its dissection begun high on either side of the hollow of the pelvis and developed caudally to a point even with the tip of the coccyx. This approach should occur whether one is doing a low anterior or abdominoperineal resection.

There are in the normal state very few dramatic aberrations of pelvic vascular anatomy, but atherosclerotic disease and previous venous thrombosis do impact the ability to control pelvic bleeding. The most important aspects of pelvic operations are the avoidance of hemorrhage by a sound knowledge of the anatomy and those tissue planes in which dissection can be expeditious and safe. Prevention of venous bleeding demands that the surgeon know the points at which the major pelvic veins are adhesed to major structures. Distal to the bifurcation of the aorta, the iliac veins are frequently adherent to the common iliac arteries (Fig 1); likewise, the hypogastric artery needs to be carefully dissected away from both the common iliac and hypogastric veins in order not to injure them when the hypogastric artery must be ligated or divided. Such ligation should seriously be considered during gynecologic operations if hemorrhage control is ineffective by a direct approach to distal arterial branches or their venous drainage. There are numerous reports of successful bilateral hypogastric ligations and hemorrhage control in the gynecological literature; where possible, it should be avoided because of hypothetical concerns of infarction of pelvic organs.[6] The hypogastric artery itself divides into a superior and an inferior branch. The superior branch frequently requires ligation during gynecologic operations when hemorrhage from the area of the cervix and vaginal junction occurs. In mobilizing the rectum for resection, the surgeon should be aware that incision in the peritoneal reflection just above the sacrum can usually be made with little bleeding. That incision can be developed on either side of the rectum and extended in the direction of the pelvic floor and lower genitourinary tract. The areolar tissue in these areas can be gently swept away and the hollow of the sacrum can be readily entered with minimal blood loss. Only when one half of the circumference of the rectum is mobilized posteriorally are the so-called rectal stalks approached. Their dissection is begun anterior to the rectum in the space between the vagina or prostate and continued until either Denonvillier's fascia is reached in the male or the floor of the perineum is reached in the female. A rich cavernous plexus of veins also extends anteriorally near bone and prostatic tissue; unsecured, it can cause significant hemorrhage and require packing or direct suture. A dissection plane in this anterior area may be found that is free of any significant major blood vessel and should be identified before the stalks themselves are approached and controlled. There are numerous blood vessels within the stalks that are best dealt with by stretching the tissue between two fingers and creating a two-dimensional structure that can be clamped and divided all the way down to the perineal floor. The inferior hemorrhoidal arteries are encountered in a constant location and can be visualized, mobilized, and divided in a similar manner.

A unique anatomic consideration in the pelvis relates to the location of the presacral venous plexuses beneath the fascia of the sacrum. This anatomic arrangement assures that the veins are kept open by bony attachments when they are injured. Thus, when they bleed, they tend to bleed massively. When one is posterior to the desired dissection plane and venous hemorrhage is encountered, for example, in the mobilization of the rectum, the unfavorable geometric apposition of a small pelvis and a big tumor may necessitate expeditious further mobilization and specimen removal before the bleeding site can be visualized and attempts at control can be undertaken. Some venous bleeders can be con-

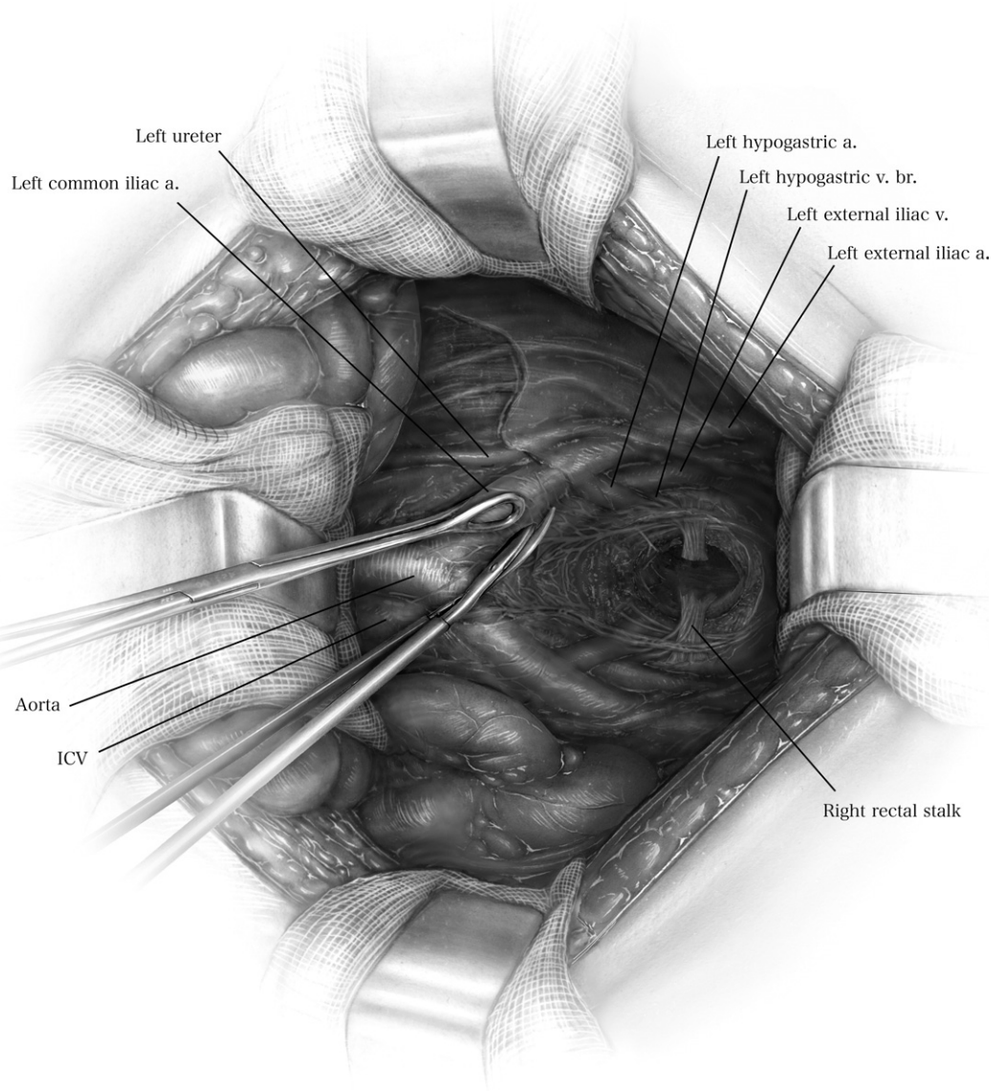

Figure 1 Dissection of the normally occurring adhesions between the branches of the iliac artery and the branches of the iliac veins distal to the aortic bifurcation, facilitating identification of the bleeding vessel in that region.

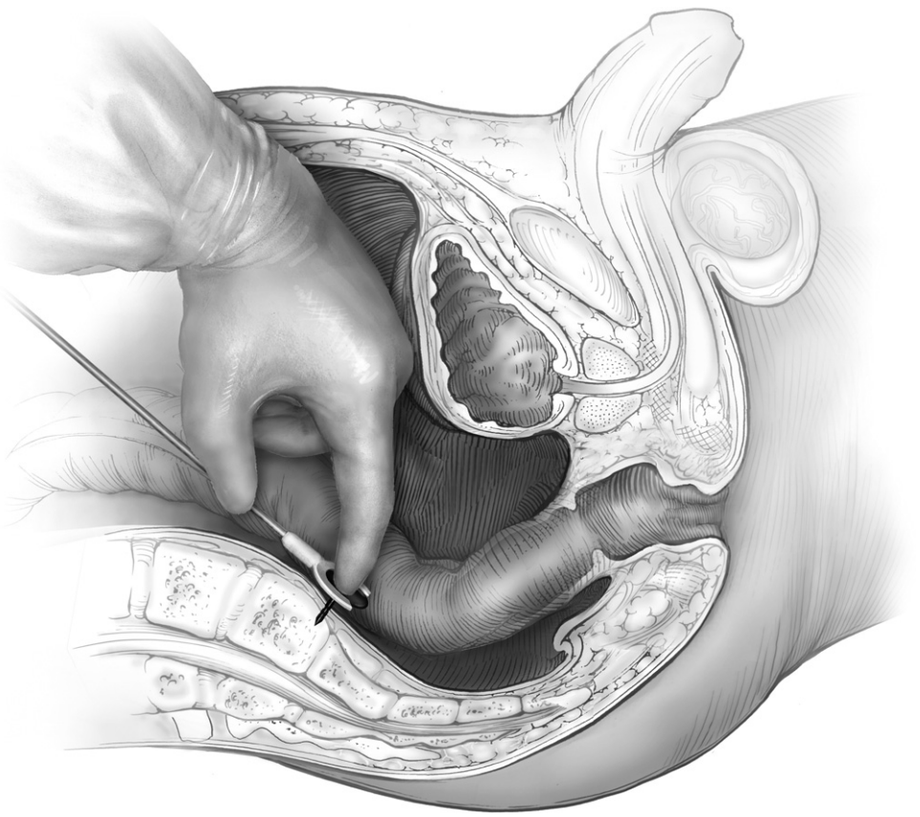

Figure 2 A thumbtack placed directly into the cortex of the sacral bone occludes venous bleeding from the subfascial sacral venous plexus.

Figure 3 "Tacks and packs": Plain abdominal radiograph showing several thumbtacks in the sacrum and marked Mikulicz pads. The patient was transported to the surgical intensive care unit, where fluid resuscitation, administration of blood products, correction of clotting abnormalities, and warming of the patient continued. Packs were removed at a subsequent laparatomy. (Photo courtesty of Russell J. Nauta, MD.)

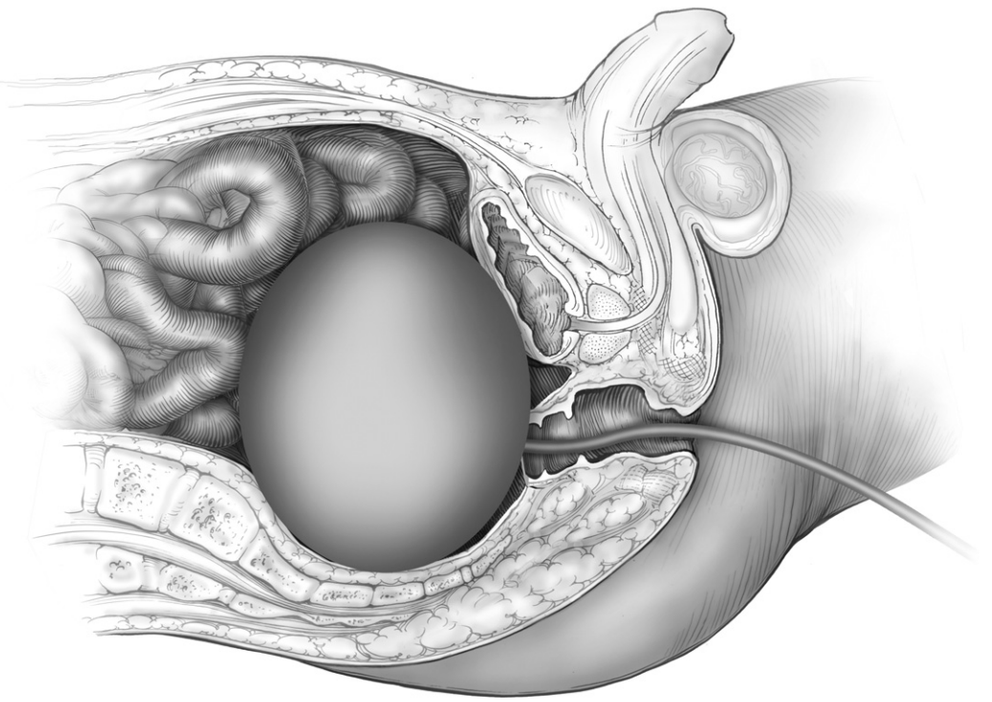

Figure 4 The Bakri balloon is introduced through the transected rectal stump after removal of the proximal rectum and it is inflated to apply direct pressure to adjacent bleeding points. Alternatively, as the clinical situation permits, it could be placed through an open vaginal cuff to control posthysterectomy bleeding.

trolled by a combination of digital pressure and subsequent suture ligation with a stout needle and a Gelfoam or Surgicel pack. More advanced techniques may be required if these maneuvers fails.

An ingenious device for control of hemorrhage from the presacral space and sacral foramina has been developed by Wortrich and consists of a long handle into which a thumbtack is placed to facilitate its placement into the sacrum with an unobstructed view.[7-9] It is tapped into place by the surgeon with a small mallet or secured with digital pressure (Fig 2). Other methods for controlling and tamponading hemorrhage within the pelvis have been advocated, including the use of expandable breast prostheses, tissue expanders, or tissue expander sizers placed into the pelvis, which can then be inflated and secured in place. Packs made of Surgicel, Bonewax, Gelfoam, and gauze have also been employed (Fig 3).[10,11] Direct injection of fibrin glue into or near the bleeding venous branches near the hollow of the sacrum has also been advocated.[12] Suffice it to say whatever has been imagined to be able to provide effective compression or to facilitate closure has been attempted.[13]

The Bakri balloon, an obstetrics device that is inserted into the atonic bleeding postpartum uterus transcervically and then inflated to control hemorrhage, can be analogously used to tamponade hemorrhage in the pelvis by introducing it through an open vaginal cuff or rectal stump and then inflating it (Fig 4). Traction may be utilized to put pressure on the pelvic sidewalls to stop bleeding.[14-17]

Once hemostasis is obtained by whatever method, the decision needs to be made whether to continue to attempt to achieve the original goals of the operation or whether to accept that damage control has been achieved, but at a physiologic cost. In some circumstances it may be appropriate to wait in the operating room for 10 or 15 minutes with packs in place and all bleeding controlled to catch up on the blood loss and fluid requirements of the patient and then to decide to go ahead and systematically remove the hemostatic packs or pressure balloons. Under these circumstances, the operation should be continued only if it is possible to do so safely, quickly, and with minimum further blood loss. When a huge amount of blood loss has already occurred and when hypothermia and acidosis are established, damage control may be the most prudent approach, with a return trip to the operating room planned within 24 to 36 hours. The surgeon may avail himself of further adjuncts to packing and transfusion of blood products in the SICU or the interventional radiology suite. Effective control of posttraumatic pelvic bleeding in cases of fractures and other injuries has been achieved by interventional radiologic methods including vessel occlusion, Gelfoam embolization of arterial bleeding, balloon occlusion, and deployment of covered stents.[18-20] The intraoperative environment does not readily lend itself to the application of these methods. However, once packs are in place and the patient is stabilized in the Intensive Care Unit, they should be considered as part of the resuscitative effort before return to the operating room. As with approaches to gastrointestinal bleeding, sheaths placed into the iliac vessels for angiography may be left in place for easier access in case subsequent bleeding suggests that a transluminal approach would be helpful.

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