Control of Bleeding

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Techniques for Achieving Hemostasis

Hemostat and Ligature

A hemostat of the proper length and design is a suitable instrument for occluding most bleeding vessels, followed by a ligature of a size compatible with the diameter of the vessel. As demanded by the situation, hemostats the size of a Halsted, Crile, Adson, Kelly, or Mixter may be indicated (see Chap. 11).

Polyglycolic (PG) ties are useful for most routine ligatures. Silk provides greater security when tying major vessels, such as the left gastric or inferior mesenteric artery. When the mesentery of the sigmoid colon is being divided during treatment of perforated diverticulitis, use 2-0 PG to ligate the vessels. If the splenic artery is being divided and ligated during resection of a pseudocyst of the pancreas, use a 2-0 ligature of Prolene.

Tying "In Continuity" with a Ligature Passer

When ligating large vessels such as the inferior mesenteric, ileocolic, or left gastric artery, it is convenient to pass a blunt-tipped right-angle Mixter clamp behind the vessel. The blunt tip of the clamp separates the adventitia of the artery from the surrounding tissue. Preferably, at least 1.5 cm of vessel is dissected free. When this has been done, use a ligature passer, which consists of a long hemostat holding the 2-0 silk ligature, to feed the thread into the jaws of the open Mixter clamp. Then draw the ligature behind the vessel and tie it. Pass the Mixter clamp behind the vessel again, feed a second ligature into its jaws, and ligate the distal portion of the vessel. Divide the vessel, leaving a 1 cm stump distal to the proximal tie and about 0.5 cm on the specimen side. Leaving a long stump of vessel distal to a single tie of 2-0 silk prevents the ligature from slipping off, even when it is subjected to the continuous pounding of arterial pulse waves. This type of ligation is sometimes called "tying in continuity" because the ties are placed before the vessel is divided.

Suture Ligature

Two simple ligatures of 2-0 silk placed about 3 mm apart, with a free 1 cm stump distal to the ligatures, ensure hemostasis when ligating the large arteries encountered during gastrointestinal surgery. If there is not a sufficient length of artery to meet these conditions, a 2-0 silk ligature supplemented by insertion of a transfixion suture ligature that pierces the wall of the artery 3 mm distal to the simple ligature is almost as good as a free 1 cm arterial stump. Pass the suture part of the way through the vessel wall rather than completely transfixing it. This maneuver avoids bleeding through the needle hole.

Another type of suture ligature is used in tissue into which a vessel has retracted. This problem may occur on the surface of the pancreas, where attempts to grasp a retracted vessel with hemostats can be much more traumatic than a small figure-of-eight suture of atraumatic 4-0 silk. The same figure-of-eight suture-ligature technique is valuable when a vessel has retracted into a mesentery thickened by obesity or Crohn's disease. Take care when using this technique to ensure that the vessel is actually secured; reinspect the region for hematoma formation (which would indicate that the vessel has continued to bleed and is not secured properly).

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Hemostatic Clips

Metallic hemostatic clips offer a secure, expedient method for obtaining hemostasis, provided the technique is properly applied. These clips are useful *only* when the *entire circumference* of a vessel is visible, preferably *before* the vessel has been lacerated. Applying a clip inaccurately often results in incomplete occlusion of the vessel and continued bleeding, following which the presence of the metal clip obstructs any hemostat or suture ligature in the same area. Attempts to remove the clip from a thin-walled vein may increase the rate of bleeding.

When clips are applied in an area where subsequent steps in the operation require blunt dissection or vigorous retraction, such as when performing a Kocher maneuver, the subsequent surgical maneuvers often dislodge the clips and lacerate the vessels, producing annoying hemorrhage. Hemostatic clips may similarly interfere with application of a stapling device.

It is futile to apply multiple clips in the general area from which blood is oozing in the hope it will somehow catch the bleeder. Again it must be emphasized that applying a clip is counterproductive unless a bleeding vessel can be clearly visualized.

In the absence of these contraindications, hemostatic clips speed dissection and allow secure control of bleeding vessels. An example is in the mediastinum during esophageal dissection or in the retroperitoneal area during colon resection.

Staplers

Laparoscopic surgeons are familiar with use of staplers, loaded with "vascular cartridges," for control of vessels too large to securely clip or ligate. These staplers are gradually making their way into common use during open surgery as well. They deposit three staggered rows of 2.5 mm staples and cut between, thus securing and dividing the vessels. They appear particularly useful for large diameter veins such as the adrenal vein during adrenalectomy or the splenic vein during splenectomy. As with any stapling device, it is essential that the surgeon be familiar with the particular stapler being used and that no clips are contained in the tissue to be stapled.

Electrocautery

With electrocautery a locally high current density is passed through the target tissues to achieve rapid tissue heating. Monopolar cautery devices allow the surgeon to cut or cauterize with a bladelike tip. The return current path is through a large grounding electrode placed on the patient's thigh or back. Two types of current are supplied by most electrocautery generators: cutting and coagulating. Cutting current is continuous-wave, high-frequency, relatively low-voltage current. It produces rapid tissue heating, which allows the blade of the cautery to cut through tissue like a scalpel. There is minimal hemostatic effect. Coagulating current is pulsed-waveform, low-frequency, high-voltage current that heats tissues slowly. The resulting protein coagulation seals small vessels.

Cautery is most effectively employed by grasping the bleeding vessel with forceps or a hemostat, elevating it slightly above surrounding tissue, and then touching the cautery blade to the instrument. The resulting coaptive coagulation seals the front and back wall of the collapsed vessel together. Small punctate bleeders may be secured by touching them directly with the tip of the cautery.

Bipolar cautery units generally have a forcepslike configuration that facilitates use of coaptive coagulation. It is less useful, however, for cutting.

Electrocautery is a valuable, rapid means to achieve hemostasis, provided certain contraindications are observed. Vessels that have an external diameter of more than 2–3 mm should not be secured with cautery. As with hemostatic clips, any tissue that will subsequently be subjected to blunt dissection or retraction may not be suitable for electrocautery, as the friction often wipes away the coagulum, causing bleeding to resume. Fat does not conduct electricity well, and extensive use of cautery in fatty tissues may result in excessive tissue destruction. Similarly, when many subcutaneous bleeding points are subjected to electrocoagulation, the extensive tissue insult may contribute to wound infection.

Ultrasonic Shears

Ultrasonic shears were initially introduced for minimal access surgery but are now available with shorter shanks for use during open surgery. These devices use ultrasound to heat and coagulate tissue in a coapted position. The tissue is then cut with the device or with scissors. Slightly larger vessels (e.g., short gastric vessels or vessels in the lateral rectal pedicles) may be secured with this device rather than with coaptive coagulation using electrocautery.

Physicochemical Methods

Gauze Pack

Physical application of a large, moist gauze pad has been employed for decades to control diffuse venous oozing. It enhances the clotting mechanism because pressure slows down the loss of blood, and the interstices of the gauze help form a framework for the deposition of fibrin. Unfortunately, after the gauze pack is removed, bleeding sometimes resumes. Packing has been lifesaving after major hepatic trauma or for persistent pelvic bleeding during abdominoperineal resection, particularly when the patient has become cold or developed a coagulopathy. Packs may be left in and removed after 24 h when the patient is stable and all hemostatic parameters have returned to normal (see Chap. 8).

Topical Hemostatic Agents

A variety of topical hemostatic agents are available in powder, sheet, and woven form. They vary in chemical formulation, but most are collagen or cellulose derivatives and act as a matrix and stimulant for clot formation; thus, the patient must be able to form clot for these agents to work. It is wise to remember the old axiom that *topical agents work best in a dry field*. In other words, these agents are adjuncts that help stop oozing but do not substitute for definitive hemostasis of individual bleeding vessels. References at the end give further details on specific agents.

Topical agents may be applied in a thin layer to an oozing surface, such as liver or spleen from which the capsule has been avulsed. An overlying gauze pad is then placed and pressure applied. When the pack is removed 10–15 min later, the topical hemostatic agent remains adherent to the surface, preventing disruption of the coagulum that is forming underneath. Choice of an agent is dictated in part by the physical geometry of the bleeding site (powders are best for irregular surfaces), availability, and surgeon preference.

Avitene (microfibrillar collagen) comes in powdered form to be sprinkled on a bleeding surface, or it can be applied with clean, dry forceps. Any moisture on instruments or gloves that come into contact with Avitene causes the Avitene to stick to the moist instrument rather than to the bleeding surface. If blood oozes through the layer of Avitene, another layer should be applied and pressure exerted over it. When flat surfaces of a denuded spleen or gallbladder bed are oozing, oxidized cellulose seems to be as effective as Avitene at one-twentieth the cost. Avitene is better for irregular surfaces because it is a powder. Microfibrillar collagen and oxidized cellulose are valuable when some portion of the splenic capsule has been avulsed during a vagotomy or splenic flexure mobilization.

Fibrin Sealant

Fibrin sealant is a hemostatic agent that mimics the final stage of blood coagulation. Fibrinogen and thrombin are combined at the bleeding site in the presence of calcium and in appropriate concentrations to produce an artificial coagulum. There is no current consensus on the usefulness of this agent in general surgical practice, although it is an area of active investigation. See references at the end for further information on these adjuncts.

Control of Hemorrhage

Temporary Control

During the course of operating, the equanimity of the surgeon is jarred occasionally by a sudden hemorrhage caused by inadvertent laceration of a large blood vessel. One should have in mind a sequence of steps to execute in such an event, aimed at temporary control of the bleeding in preparation for definitive steps later. The sequence should go something like the following:

1. *Finger pressure*. The simplest step, especially useful for controlling bleeding from an artery, is simple application of a fingertip to the bleeding point. In the case of a large vein, such as the axillary vein or vena cava, pinching the laceration between the thumb and index finger is sometimes effective. Notify the anesthesiologist that you are dealing with bleeding. Ascertain that the patient is fully resuscitated, that large-bore intravenous catheters are in place, and that blood and blood products are available. In the trauma situation, the use of defined protocols for blood product replacement has significantly helped avoid iatrogenic coagulopathy (see references at end).
2. *Elevation of the structure by placing the hand behind it*. If step 1 is not applicable, sometimes the left hand can be placed behind a structure such as the hepatoduodenal ligament to control bleeding from the cystic artery or the pancreas or behind the portal vein for bleeding in that area. This maneuver may bring temporary control.
3. *Compression by hand pressure or gauze-pad pressure*. Large lacerations of the liver may be temporarily controlled by compressing the liver between two hands while the patient is being resuscitated. Massive venous bleeding from the presacral space can be controlled by applying a large gauze pad.
4. *Satinsky clamp*. When direct pressure is not effective, a partially occluding Satinsky-type vascular clamp may be used to control the laceration of a large vessel.
5. *Proximal and distal control*. Sometimes even temporary control of hemorrhage is impossible without proximal and distal occlusion of the vessel, in some cases involving the aorta or vena cava. Preferably, vascular clamps are used; but in their absence, umbilical tape is a satisfactory temporary substitute. The aorta may even be clamped or occluded by pressure in a suprarenal position for 15–20 min if no other means of hemostasis is effective. This safe period may be lengthened if iced sterile saline is poured over the kidneys to reduce their metabolic requirements.

Definitive Control

Once hemorrhage has been temporarily controlled, the surgeon reassesses the strategic situation. The field is cleared of all instruments and hemostats not relevant to the major problem at hand. If additional exposure is needed, plans are outlined immediately to accomplish this by extending the incision or repositioning gauze pads or retractors. Optimal light and suction lines are put in place, and arrangements are made with the blood bank for adequate support of the patient. Additional personnel are recruited as necessary.

Assign someone to be "bookkeeper." This individual's only duty is to keep track of the volume of blood lost and the rate at which it is replaced, reporting this information to the operating surgeon at frequent intervals. Otherwise, the surgeon and anesthesiologist may become so involved with the task at hand they make inadequate provision for resuscitating the patient.

After all these steps have been completed and the patient's condition has stabilized, the surgeon can convert the measures for temporary control of hemorrhage to maneuvers to ensure permanent control. This step generally involves applying a partially occluding Satinsky-type clamp to the vessel or achieving proximal and distal control with vascular clamps, so the laceration can be sutured in a definitive fashion with a continuous suture of atraumatic Tevdek or Prolene. No surgeon should undertake to perform major surgery unless trained and experienced in suturing large arteries and veins.

Further Reading

Chambers LA, Chow SJ, Shaffer LE. Frequency and characteristics of coagulopathy in trauma patients treated with a low- or high-plasma-content massive transfusion protocol. Am J Clin Pathol. 2011;136:364.

Harrell AG, Kercher KW, Heniford BT. Energy sources in laparoscopy. Semin Laparosc Surg. 2004;11:201.

Holcomb JB, Pusateri AE, Hess JR, et al. Implications of new dry fibrin sealant technology for trauma surgery. Surg Clin North Am. 1997;77:943.

Jackson MR, Alving BM. Fibrin sealant in preclinical and clinical studies. Curr Opin Hematol. 1999;6:415.

Lier H, Bottiger BW, Hinkelbein J, Krep H, Bernhard M. Coagulation management in multiple trauma: a systematic review. Intensive Care Med. 2011;37:572.

Newcomb WL, Hope WW, Schmelzer TM, et al. Comparison of blood vessel sealing among new electrosurgical and ultrasonic devices. Surg Endosc. 2009;23:90.

Trus TL. Chapter 10. Laparoscopic hemostasis: hemostatic products and adjuncts. In: Soper NJ, Scott-Conner CEH, editors. The SAGES manual, vol. I. 3rd ed. New York: Springer Science + Business Media; 2012.