CHAPTER 19 ■ CONTROL OF PELVIC HEMORRHAGE

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DEFINITIONS

Autologous blood transfusion—A transfusion done with the patient's own blood. Blood is usually drawn 2–4 weeks before anticipated surgery and stored. It, or the components, can be transfused if the patient requires a blood transfusion during surgery. This minimizes the risk of a transfusion reaction.

Hemostatic clips—Small V-shaped clips of stainless steel, titanium, or plastic that can be applied on small vessels or tissue for hemostasis.

Homologous blood transfusion—Transfusion of blood or blood products from another human being.

Parachute pack—Sometimes called an umbrella pack. A towel or large sheet is inserted through the vagina into the pelvis, and it is then filled from below with gauze packing. The edges are twisted together, and the pack is pulled down against the pelvic floor to control deep pelvic bleeding after pelvic exenteration.

Peanut dissector—A long clamp with a small cotton bud placed in the tip of the jaws. It is a useful tool for blunt pressure dissection of small spaces.

Total blood volume—About 8% of total body weight or between 4.5 and 5.0 liters in the average woman. Acute blood loss of 25% of total blood volume (about 1,500 cc) produces symptoms of tachycardia, hypotension, and decreased urine output. Transfusion should be considered when operative blood loss exceeds 15% of total blood volume. This can be roughly calculated by multiplying the patient's weight in kilograms by 10 (750 cc for a 75-kg woman).

The prevention and control of bleeding are fundamental to the success of any operation. Preoperative, intraoperative, and postoperative hemorrhage are potential complications in every patient undergoing gynecologic surgery. Preoperative hemorrhage is encountered in a variety of circumstances, such as in women with intraperitoneal bleeding from a ruptured tubal pregnancy or in patients taking heparin who have intraperitoneal hemorrhage associated with ovulation. Intraoperative hemorrhage can result from vascular injury, and postoperative bleeding is often a carryover from failure to control bleeding during surgery that was not apparent when the abdomen was closed because of reflex vasoconstriction or hypotension.

A knowledge of the normal coagulation mechanism and potential abnormalities of this important system is important for every surgeon. Preoperative evaluation will minimize the risks of abnormal surgical bleeding. Surgical techniques and operations are designed to control bleeding and avoid hemorrhage; but, from time to time, every surgeon is confronted with heavy and uncontrolled bleeding during an operation. The surgeon who has the knowledge and experience in these difficult situations will not only have the skills required, but also will exhibit the leadership and confidence necessary to direct the whole operative team so that control of bleeding can be accomplished promptly and effectively.

Many benign gynecologic conditions are associated with an increase in menstrual blood loss (menorrhagia), an increase in the duration of menstrual flow (metrorrhagia), an increase in the frequency of menstrual periods (polymenorrhea), or combinations of all three. Repeated small menstrual hemorrhages, such as those that occur with menorrhagia, will reduce the iron stores in the body over time. The daily dietary intake of iron usually is sufficient to replace the iron lost with normal menstruation, but it is inadequate to replace the increased loss of iron associated with heavy menstruation. In gynecologic patients with a history of heavy or prolonged menstrual blood loss, it is a good idea to check the hematocrit or hemoglobin before setting a date for elective surgery. Preoperative iron supplementation is indicated in these women because a good hemoglobin level and adequate iron stores are the first step in managing perioperative hemorrhage. Transfusion before elective gynecologic surgery is rarely if ever indicated in women with chronic blood loss anemia. Menstrual blood loss may be controlled with hormonal therapy while surgery is delayed and iron supplementation given to enable the patient to replete her own hemoglobin stores.

The preoperative use of epoetin alfa (recombinant erythropoietin) for correction of preoperative anemia has been used successfully in orthopedics. Its application in gynecologic surgery remains unclear. It is probably most applicable in gynecologic patients with chronic renal failure, nonmyeloid (hematopoietic) leukemia, or human immunodeficiency virus (HIV). Occasionally, other forms of anemia will be encountered that require a more extensive evaluation and treatment before elective surgery. On the other hand, some women who present with acute blood loss from a ruptured ectopic pregnancy or malignancy may require urgent transfusion even as preparations are being made for surgical intervention.

FUNDAMENTAL CONCEPTS OF NORMAL COAGULATION

Every surgeon should understand at least the basic mechanisms of normal hemostasis that can be relied on when surgical injury to tissue is inflicted. Bleeding during gynecologic surgery usually results from cutting or lacerating small or large vessels, but occasionally it may result from or be complicated by some preexisting or intraoperative defect in the clotting mechanism. The surgeon should be able to recognize when normal hemostasis is interdicted so that available remedies to protect against or

remedy excessive bleeding can be found. Hemostasis is a complex, intricate, integrated, complementary, and countervailing system that maintains a delicate balance between normal coagulation and hypocoagulation or hypercoagulation. Unusual clinical situations can arise that require hematologic consultation for resolution. A specialist in coagulation disorders can provide invaluable assistance in the diagnosis and treatment of many rare disorders of coagulation.

The following is a discussion of the principles and concepts of normal hemostasis, abnormal hemostasis (congenital and acquired), and management techniques.

Effective hemostasis is the result of all aspects of the coagulation system functioning together to stop bleeding. Coagulation is the working interrelation of five aspects of a complex biochemical and vascular system that causes the formation and dissolution of the fibrin platelet plug. These five components are (a) vasculature, (b) platelets, (c) plasma clotting proteins, (d) fibrinolysis and clot inhibition, and (e) the hypercoagulable response. How these five components interrelate in the normal setting must be understood before one can appreciate how the five relate to bleeding or abnormal clotting in disease states.

Vasculature

The vasculature presents an endothelial-lined flexible conduit through which red cells, white cells, platelets, and all of the plasma proteins flow. At the interface between the flowing blood and vessel wall are several inhibitory biochemical systems that prevent the generation of the platelet–thrombin clot. The antiplatelet substance prostacyclin, produced in the vessel wall, inhibits platelet adhesion to the vessel wall. The surface antithrombin III–heparan sulfate complex inhibits deposition of thrombin and fibrin.

A tear in the vessel wall removes the endothelial cell layer, exposing the basement membrane, smooth muscle, collagen, and supporting adventitia. These substances are biochemical activators of platelets and have their own thromboplastic activity, which initiates fibrin generation and deposition. Therefore, the disruption in the vessel wall removes the protective covering of the endothelial cells, exposing platelet clumping and clot-initiating substances that produce a platelet–fibrin mass that will plug the tear in the vessel wall. A disease or medication that interferes with or intensifies this process can cause bleeding or inappropriate clotting. The vessel wall is diagrammed in Figure 19.1.

Congenital diseases associated with inadequate connective tissue and vascular dysfunction associated with bleeding are rare. The more frequently seen conditions are hereditary hemorrhagic telangiectasia, Ehlers-Danlos syndrome, and Marfan syndrome, which are characterized by defects in the quality of collagen. Defective collagen is responsible for poor clot formation and platelet activation at the injured site. No disease is known to be associated with excessive inappropriate clotting related to the vasculature as a structure. The congenital diseases closest to that definition are a predisposition to atherosclerosis owing to abnormalities in lipid metabolism, such as hypercholesterolemia, homocystinemia, and diabetes mellitus.

Acquired diseases of the vessel associated with bleeding include deficiencies in vitamin C; Cushing syndrome; acute and chronic inflammatory diseases, such as infectious vasculitis and immune vasculitis; pyrogenic purpura; embolic purpura; and anaphylactoid reactions from drugs. Myeloproliferative disorders, such as multiple myeloma and Waldenström macroglobulinemia, produce abnormal proteins that interfere with vascular function and therefore permit bleeding.

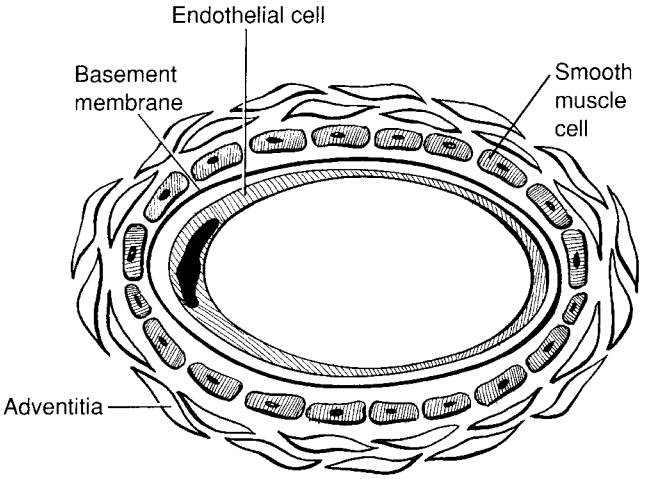

FIGURE 19.1. Vessel cross section.

Routine laboratory assessment of vascular function is extremely primitive. The capillary fragility test, the only routinely available test used to assess vascular function, has limited value. It is sensitive to only the severest vascular structure abnormalities. More in-depth studies include vascular biopsies and skin window testing procedures, which are research procedures. There are no routinely available methods for assessing increased vascular activity in the area of inappropriate clotting.

Platelet Function

Platelets are disk-shaped fragments of the large multinucleated megakaryocytes released from the bone marrow on a daily basis (normal count is 150×10^3/mL to 400×10^3/mL) (Fig. 19.2). Their life span is 8 to 10 days. These microscopic fragments have a well-defined substructure that can be directly correlated with platelet function.

The surface activation of the receptor sites on the platelet causes it to change first to a sphere and finally to a spiderlike structure, with pseudopods in all directions. This release reaction is the summation of biochemical and structural changes in the platelet, which are characterized as follows: The surface receptor sets up a biochemical chain reaction, resulting in the generation of thromboxane A_2. This causes contraction of the protein thrombosthenin, which causes the ejection of the platelet contents. Of great importance are the dense granules with nonmetabolic adenosine diphosphate (ADP). ADP is a potent platelet-aggregating agent that, in a dominolike sequence, stimulates more platelets, generating a large platelet plug.

The congenital diseases associated with poor platelet function are divided into four types of dysfunction: (a) adhesion to collagen, (b) adhesion to subendothelium, (c) release reaction defects, and (d) ADP aggregation defects. With the exception of von Willebrand disease, a defect in the adhesion to subendothelium, all the congenital defects are rare and not essential to this discussion. von Willebrand disease (Table 19.1) is a classically autosomal, dominantly inherited disorder resulting from absence, decreased production, or abnormal function of a large multimeric protein synthesized by megakaryocytes and vascular endothelium. This protein is responsible for the proper binding of platelets to the collagen surface exposed in

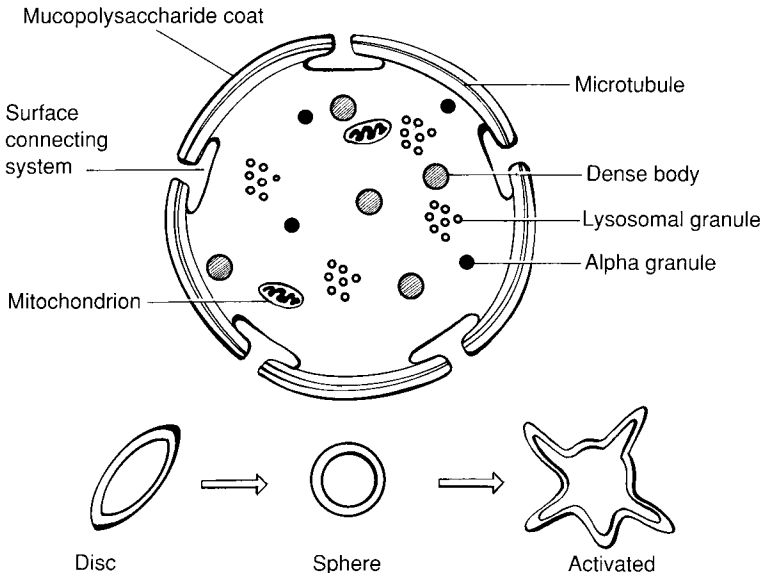

FIGURE 19.2. Platelet cross section.

vascular trauma. Its absence results in the failure of platelets to bind normally to disruptions in the vasculature, preventing formation of the platelet plug necessary for normal hemostasis. The condition remains undetected in most patients until some form of vascular trauma occurs or surgery is performed. In addition, such patients are particularly sensitive to aspirin or other antiplatelet medications and bleed excessively in surgery while taking this kind of medication. von Willebrand disease is the most common congenital platelet disorder and is the disease most likely to go undetected until surgery. This disorder is particularly dangerous because, in its milder forms, a history of bleeding in surgery is negative and the preoperative coagulation screen is normal. Acquired defects in platelet function are much more common and can be classified into two groups: (a) those that are the result or consequence of a disease, such as renal failure, myeloproliferative disorders (polycythemia vera, chronic myelogenous leukemia), and increased fibrin split products in consumptive coagulopathies; and (b) those that are iatrogenic, such as defects caused by medications (aspirin, nonsteroidal antiinflammatory drugs, antibiotics, antihistamines, tricyclic antidepressants, dextran) and cardiopulmonary bypass surgery.

Congenitally increased platelet function has not been described. Acquired disorders associated with increased platelet function, however, are common. The stress of routine surgery or trauma (fractured hip, femur, or pelvis) can create a hypercoagulable state with thrombocytosis and increased platelet activity.

The laboratory assessment of platelet function has been expanded from the research laboratory and is more readily available to the surgeon. The routine analysis of platelet function should begin with a platelet count and PFA-100. In special cases, platelet adhesion and platelet aggregation are useful in identifying the inadequate or overstimulated platelet. In addition, biochemical markers for increased platelet use or turnover can be demonstrated with platelet factor IV and β-thromboglobulin assays. Studies by Gewirtz and colleagues confirm previous studies that the bleeding time is not a good prediction of surgical bleeding.

TABLE 19.1

MORE COMMONLY SEEN RARE CONGENITAL CLOTTING DISORDERS

Name	Incidence (per million)	Treatment
Factor VIII (classic hemophilia A, sex-linked)	60–80	FVIII concentrate
Factor IX (classic hemophilia B, sex-linked)	15–20	FIX concentrate
von Willebrand disease (dominant; autosomal)	5–10	Cryoprecipitate (DDAVP), factor VIII concentrate with von Willebrand factor

DDAVP, Deamino-D-arginine vasopressin.
The remainder of the known congenital clotting factors are very rare and occur with such low frequency that their discussion, diagnosis, and management can be found elsewhere. (See Harker LA. *Hemostasis manual*, 2nd edition. Philadelphia: FA Davis;1974; Corriveau DM, Fritsma GA. *Hemostasis and thrombosis*. Philadelphia: JB Lippincott Co;1988; Triplett DA, ed. *Laboratory evaluation of coagulation*. Chicago: ASCP Press;1982.)

Plasma-Clotting Proteins

Plasma-clotting proteins are a group of serine proteases and cofactors that interact in a synergistic system to generate fibrin. The activation of the clotting system can be initiated in two ways: either by contact activation with factor XII or through thromboplastin activation of factor VII. The clotting cascade is diagrammed in Figure 19.3. As we will see later in the discussion of fibrinolysis and antithrombin systems, anticoagulation forces are initiated at the inception of clotting. The tear in the vessel wall, described earlier, begins the orderly activation of the plasma-clotting system. The fibrin contribution to the platelet–fibrin plug is initiated with the activation of factor XII by collagen and of factor VII by tissue juice (thromboplastin). Any congenital or acquired disorder of the clotting factors can lead to inadequate or no generation of fibrin. Each clotting factor has a different role and significance in the overall generation of fibrin. This also is true with abnormal increases in some clotting factors that are associated with inappropriate clotting.

The congenital-factor deficiencies associated with bleeding are either relatively common or rare. The relatively common group includes hemophilia A (factor VIII deficiency) and hemophilia B (factor IX deficiency). Both are seen in the male and rarely in the female disorders with sex-linked inheritance patterns. The rare group includes all the remaining factors that have an autosomal recessive inheritance pattern or a dominant pattern with variable penetrance.

The acquired factor deficiencies are common. Multiple deficiency is usually owing to iatrogenic vitamin K deficiency with loss of factors II, VII, IX, and X. This deficiency often is the result of multiple-antibiotic therapy, which kills the vitamin K–producing bacterial flora in the intestine, and the nothing-by-mouth status of many critically ill patients, which results in the loss of food sources of vitamin K. Other common acquired multifactor deficiencies are seen in acute and chronic liver disease, as in viral hepatitis and alcoholic cirrhosis; consumptive coagulopathies, as in sepsis and placenta abruptio; washout coagulopathies, as in multiple-transfusion patients after severe blood loss (such as from ruptured abdominal aneurysms); and major trauma, as from automobile accidents or gunshot wounds.

The laboratory assessment of the plasma clotting factors has traditionally begun with the prothrombin time (PT; factors V, VII, and X, prothrombin, and fibrinogen) and the activated partial thromboplastin time (APTT; factors VIII, IX, XI, and XII). Specific factor assays also can identify the exact deficiencies. One must remember that a factor deficiency as low as 30% can generate a normal PT and APTT. This relation is important in investigating minimal prolongations of the PT or APTT that appear insignificant but could be hiding a moderately severe deficiency. The tissue factor pathway inhibitor modulates activated factors X and VIII but is not apparently significant in disease.

The sensitivity of the PT and APTT reagents is essential to the appreciation of the proper use of these tests as preoperative

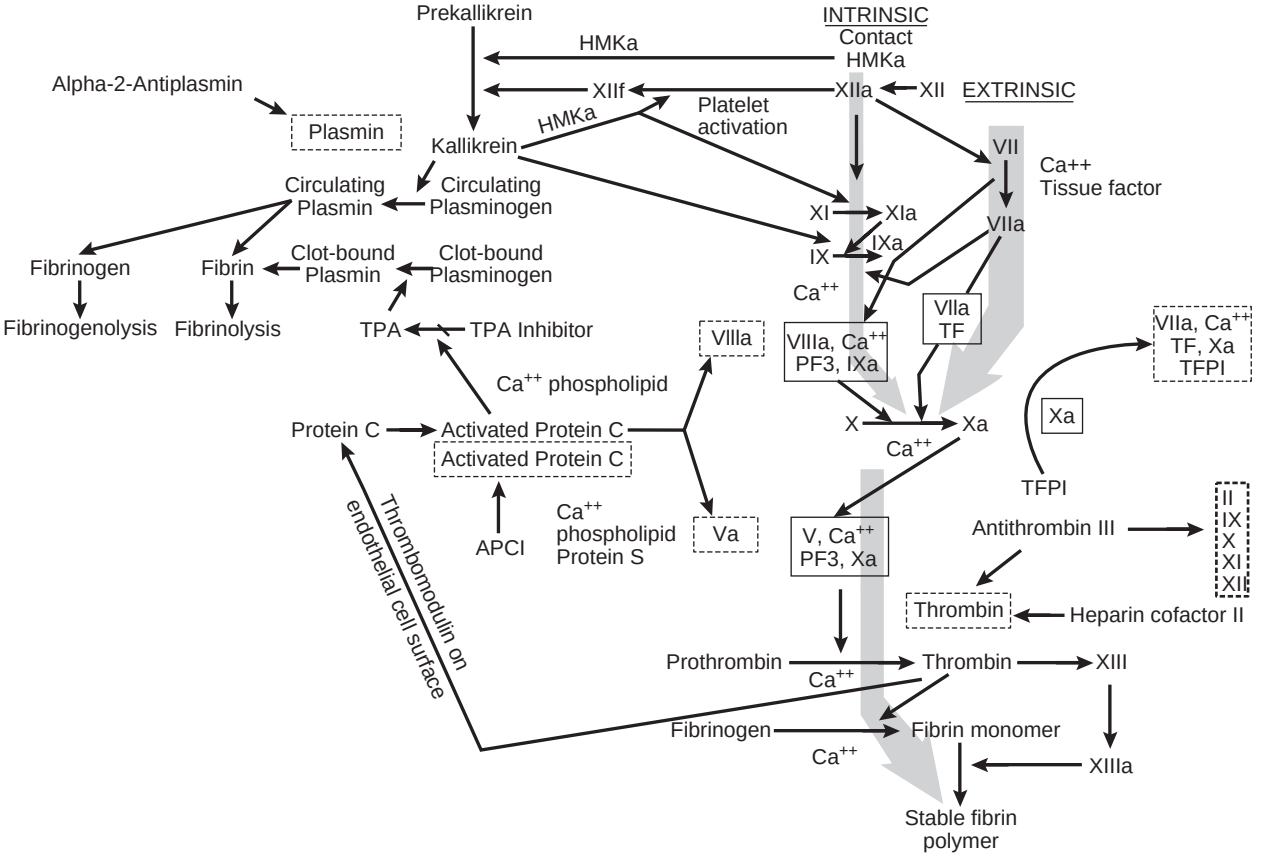

FIGURE 19.3. Coagulation system. Dashed boxes indicate destruction of factors. APC1, activated protein C1; HMKa, high-molecular-weight kininogen; PF3, platelet factor 3; TPA, tissue plasminogen activator; TF, tissue factor; TFPI, tissue factor pathway inhibitor.

TABLE 19.2

THERAPEUTIC RANGES FOR THE INTERNATIONAL NORMALIZED RATIOS

Condition	Therapeutic ranges
Prophylaxis for venous thromboembolism in high-risk surgery and in hip surgery	2.0–3.0
Treatment of venous thrombosis and pulmonary embolism	2.0–3.0
Prevention of systemic embolism	
Tissue heart valves	
Acute myocardial infarction	
Valvular heart disease	
Atrial fibrillation	
Bileaflet mechanical value in aortic position	
Treatment for mechanical prosthetic heart valves (high risk)	2.5–3.5
Prevention of recurrent systemic embolism	
Prevention of recurrent myocardial infarction	

From: Hirsh J, Dalen JE, Anderson DR, et al. Oral anticoagulants: mechanism of action, clinical effectiveness, and optimal therapeutic range. *Chest* 2002;119:8S.

screening tests or in monitoring warfarin and heparin anticoagulant therapy. Recent publications from Europe and the United States stress the importance of and need for a standardized prothrombin reagent system in the United States. The lack of sensitivity of the rabbit brain thromboplastin used in the United States has led to the overcoumarinization of some patients. The original value of 2.0 to 2.5 times the control was based on the more-sensitive human thromboplastin. Current recommendations have lower ratios (Table 19.2). These ratios are applicable only in stable, coumarinized patients. Studies of different APTT reagents have revealed a similar variability of sensitivity to heparin.

Fibrinolysis

The activation of the fibrinolytic system begins with the activation of the plasma substrate plasminogen. This substrate is converted by naturally occurring activators such as urokinase, kallikrein, and clot-activated proteases to the active enzyme plasmin. Plasmin is the active enzyme that if free or clot-bound lyses fibrin clots and destroys fibrinogen. This enzyme is modulated by α_2-antiplasmin and antitrypsin, which destroy the active enzyme plasmin.

This enzymatic conversion of fibrinolysis normally is initiated by clot formation or by a direct activator such as urokinase or tissue plasminogen activator (tPA). tPA released from the endothelium activates tissue plasminogen and is neutralized by plasminogen activator inhibitor-1 (PAI-1). Sometimes direct activation is seen in liver disease and during extracorporeal bypass. This activation also can be secondary to disease, as in a consumptive coagulopathy—such as bacterial sepsis—or a large abdominal aneurysm.

Hypercoagulable State

With physiologic stress, such as emotional stress and surgical stress, there is a response of fright or flight. This response to stress is evident in the coagulation system. The plasma-clotting proteins, such as fibrinogen and factor VIII, increase, and the platelet count and stickiness can increase as well. This normal response is important in ensuring hemostasis at the time of increased need. When this process is exaggerated, uncontrolled, or unmodulated, inappropriate clotting can occur, which produces venous and arterial clots and all their sequelae. In gynecologic surgery, the normal physical hypercoagulable state, as well as the inappropriate state, must be understood to appreciate the diagnosis, intervention, and management of postoperative vascular occlusive complications. Virchow, in 1845, was the first to conceptualize the triad of blood flow, vessel wall, and content of blood itself as a basis for inappropriate clotting. An understanding of the relation of the three parts is essential to explain what has occurred in the problem patient.

CONGENITAL CAUSES OF INAPPROPRIATE CLOTTING

The congenital etiology of inappropriate arterial and venous clotting has long been ill defined. Only recently has it been more completely elucidated (Tables 19.3 and 19.4). Procoagulants, when increased on a congenital basis, have been associated with a propensity to generate clots. These procoagulants include fibrinogen and factor VIII; however, they are not present frequently enough to warrant testing every suspect case. Naturally occurring inhibitors of clotting are defined as those factors that actively destroy clotting factors or substrates as they are formed. The more common of these rare deficiencies are antithrombin III, protein C, protein S, factor V Leiden (R506Q),

TABLE 19.3

RISK FACTORS FOR ARTERIAL THROMBOSIS

Inherited
Elevated cholesterol, triglycerides, lipoprotein (a), decreased high-density lipoprotein
Diabetes
FVII polymorphism
Hyperhomocysteinemia
Methylenetetrahydrofolate reductase mutation C677T
PLA_2 glycoprotein IIb/IIIa
Gender, male > female

Acquired
Antiphospholipid antibodies
Lupus anticoagulant
Hypertension
Diet with increased fat
Infection: chlamydia, cytomegalovirus
Heparin-induced thrombocytopenia
Social class, body mass index

Mixed hereditary/acquired
Factor VIII
Fibrinogen
FVII
Homocysteine
C-reactive protein
Von Willebrand factor

From: Triplett DA. Thrombophilia: laboratory evaluation. *ASCC Clinical Laboratory News* 2002;28:12.

TABLE 19.4

RISK FACTORS FOR VENOUS THROMBOSIS

Inherited
Common
Factor V Leiden (R506Q)
Factor II mutation (G21201A)
Factor VIII
Rare
Antithrombin III deficiency
Protein C deficiency
Protein S deficiency
PAI-1 polymorphism
Dysfibrinogenemia
Factor XII deficiency
Prekallikrein (Fletcher factor) deficiency
Plasminogen deficiency
Tissue plasminogen activator deficiency
Acquired
Surgery and trauma
Prolonged immobilization
Older age
Cancer
Myeloproliferative disorders
Previous venous thrombosis
Pregnancy/puerperium
Contraceptives/hormone replacement
Activated protein C resistance not due to FV Leiden
Antiphospholipid syndrome
Mild-to-moderate hyperhomocysteinemia
Obesity/metabolic syndrome

From: Seligsohn U, Lubetsky A. Genetic susceptibility to venous thrombosis. *N Engl J Med* 2001;344:1222.

factor II mutation (G21201A), PAI-1 polymorphisms 4G/5G, and methylenetetrahydrofolate reductase mutations (C677T, A1298C).

IMPAIRED FIBRINOLYSIS

A congenital decrease in the plasma substrate plasminogen results in inadequate fibrinolysis of thrombi. This deficiency can be qualitative and quantitative, with similar effects.

A congenital decrease in tPA that normally is released from the vascular endothelium is associated with impaired fibrinolysis. An abnormal increase in plasminogen activator inhibitor also will reduce the level of tPA, resulting in inappropriate clotting, elevated PAI-1 secondary to obesity, metabolic syndrome, or acute phase reactions.

The decrease or absence of Fletcher factor (prekallikrein) and factor XII also can result in impaired fibrinolysis because of a decrease in activation of circulating plasminogen at the time of clot activation.

ACQUIRED CAUSES OF INAPPROPRIATE CLOTTING

The number of acquired causes of inappropriate clotting is much greater than the number of congenital causes and is expanding every day because the same chemistry found in the congenital mechanism can be identified as a deficiency in an ongoing disease process. These include such risk factors as an elevated factor VIIIc, fibrinogen, metastatic cancer, myeloproliferative disorders, and diabetes/metabolic syndrome.

Iatrogenic causes of inappropriate clotting are common findings in the hospital setting and generate great concern. Such causes include the postsurgical state, medication, vascular prosthetic devices, and immobilization for any reason.

As a physiologic acute-phase response to surgical stress, an exaggerated outpouring of clotting factors and platelets in combination with a decrease in physiologic inhibitors can result in clot formation. This often occurs in deep leg veins, particularly in association with venous stasis.

Prosthetic devices such as grafts, shunts, and artificial heart valves can provide a clottable surface that will form a nidus for initial thrombosis quickly followed by further clot formation, resulting in obstruction or embolization.

The vascular component of acquired thrombotic disease has only recently been described in detail. It appears that decreased blood flow through a vein can decrease the contact between thrombin and thrombomodulin, diminishing the contact with protein C and predisposing the vein to thrombosis. However, the arterial side with high blood flow rates has a rich capillary bed with greater contact with protein C, lysing clots more efficiently. Local thrombus formation can be generated by direct mechanical disruption of the vascular endothelium, traumatic damage to the vessel wall, infectious or chemical damage to the vessel wall, and vasculitis.

PREOPERATIVE COAGULATION ASSESSMENT FOR SURGICAL PATIENTS

For the preoperative evaluation, gynecologic patients must of necessity be divided into two categories: those having routine or elective surgery and those having emergency surgery.

Elective Surgery

The elective gynecologic surgical patient must be evaluated in two ways: general medical history and specific nature of the surgery. The medical history taken at bedside, with review of the medical chart when available, is an excellent place to begin. Table 19.5 highlights the most important positive and negative findings to be identified.

Preoperative coagulation screening is of limited value without complete knowledge of the patient's past and current

TABLE 19.5

PERTINENT MEDICAL HISTORY TO SCREEN FOR COAGULATION PROBLEMS

History of spontaneous bruising or bleeding
History of unusual bruising or excessive bleeding after surgery
Family history of bruising or bleeding after surgery
Medication associated with bruising or bleeding
Current medication within past week
Previous coagulation testing
Current coagulation testing

TABLE 19.6

TESTS TO INDICATE COAGULATION STATUS

Test	Reference range[a]	Level of alarm	Significance
Hematocrit (%)	37–47	25	Tissue anoxia
White cell count (mL)	4×10^3–12×10^3	3×10^3–25×10^3	Susceptibility to infection, leukemia
Platelet count (mL)	140×10^3–400×10^3	100×10^3–700×10^3	Bleeding, myeloproliferative disorder
Fibrinogen (mg/dL)	150–400	100	Bleeding, liver disease, intravascular consumption
Prothrombin time (s)	10–13	14	Bleeding factor deficiency
Activated partial thromboplastin time (s)	28–38	40	Bleeding factor deficiency, inhibitor
PFA-100	Collagen–epinephrine	Prolonged closure time	Screen for medication effect
Bleeding time (will not predict surgical bleeding)			

[a]Reference ranges may vary in each laboratory, reflecting method, instrumentation, and reagents.

history. It does not replace a good history and physical examination. One should not expect this screening to reveal the estimated blood loss in a routine surgical procedure. It is essential, however, for resolving and eliminating risk factors that can affect postoperative bleeding (Tables 19.6 and 19.7).

Risk factors such as unknown history or known history in an emergency surgical procedure; positive personal or family history of bleeding or bleeding with or without surgery; and known history of taking medications that can affect coagulation, such as antiplatelet medication, acquired vitamin K deficiency (nothing-by-mouth status with long use of antibiotics), and fibrinolytic therapy (decreased fibrinogen), are assessed by preoperative screening.

A preoperative coagulation screen is not usually indicated unless the medical history and physical examination reveal suspicious or explained findings that suggest a risk of surgical bleeding. These findings might include a history of unexplained surgical bleeding, family history of bleeding, bleeding after medication, or evidence of bruising or bleeding on examination, to mention only a few.

The risk of blood-borne infections and adverse reactions is always present, but the documented need for blood as a lifesaving substance will validate the decision. When blood is transfused when indicated but is not justified in writing, this lifesaving substance becomes a liability to all who use it. The routine preoperative orders for blood require knowledge of the specific needs of the patient and the surgeon's usual transfusion requirements for a specific surgical procedure. For the routine gynecologic procedure, such as simple hysterectomy in an otherwise healthy woman, a type and antibody screen are appropriate. With the type and antibody screen, the patient's blood is screened for unexpected antibodies. No specific blood units are set aside, but blood is available from the general inventory in an emergency. If an unexpected antibody is identified, the blood bank should notify the ordering physician and set aside 2 U of antigen-negative cross-matched compatible blood for use in an emergency situation.

In an emergency, the blood bank can release blood immediately (with a type and match to follow) with a 99.99% safety factor when the previous screen for unexpected antibodies was negative. Additionally, when the surgeon can wait 10 to 15 minutes, an immediate spin cross match can be performed to further verify ABO compatibility between donor and recipient. The value of the type and antibody screen is in monetary savings for the patient, and there is no undue or unnecessary risk to the patient.

In more complex procedures, such as pelvic exenteration for cancer, where there usually is significant blood loss, a type and cross match for the average number of units used is appropriate. With extremely difficult procedures or other complicating diseases, additional blood, fresh-frozen plasma, and platelets may be required during the procedure and should be requested preoperatively.

Ideal or time-proven guidelines are difficult to establish for every operative case. Each surgical experience will benefit the surgeon, and over time he or she will establish usual transfusion requirements for both type and antibody screen, as well as type and cross match. The hospital quality assurance program, in planning with the transfusion service or blood bank and transfusion committee, should establish guidelines to assist the surgeon in identifying the usual blood transfusion needs. The use of either Guidelines for Transfusion Therapy (Boral) or Maximal Surgical Blood Order Schedule (Judd) is helpful in developing hospital guidelines.

TABLE 19.7

COAGULATION PROFILES

Brief coagulation profile	Complete coagulation profile
CBC (includes WBC differential)	CBC (includes WBC differential)
Platelet count	Platelet count
Prothrombin time	Prothrombin time
Partial activated Thromboplastin time	Partial activated Thromboplastin time
	Fibrinogen
	PSA-100

CBC, complete blood count; WBC, white blood cell.

Emergency Surgery

As the emergency procedure is begun, decisions regarding blood replacement must be made. A direct approach to blood

replacement therapy and the complications of such therapy depends on a clear understanding of the following concepts.

1. As bank blood replacement with just packed red cells corrects the blood loss problem, it may create an acquired bleeding disorder, thrombocytopenic hemophilia. Platelets and fresh-frozen plasma may be indicated.
2. The patient's bleeding potential is dynamic and will change rapidly and frequently with the loss of blood and replacement therapy.
3. Direct monitoring before, during, and after surgery offers the best chance to diagnose and manage the bleeding. Direct monitoring also allows formulation of plans and adjustment of the replacement therapy program.

COMPONENT THERAPY FOR REPLACEMENT BEFORE SURGERY

With surgery planned, the preoperative data can be evaluated. Assuming the patient does not have hemophilia, von Willebrand disease, severe liver disease, or liver failure, a prolonged PT and APTT may suggest a less common acquired or congenital bleeding disorder. (The blood sample must be properly drawn and mixed well and must not be taken from an A-line containing heparin or from an infusion site.) Assistance from a clinical pathologist or hematologist should be requested if an intrinsic bleeding disorder is suspected.

COMPONENT THERAPY FOR REPLACEMENT DURING SURGERY

According to Schifman and Steinbronn, when intraoperative blood loss exceeds 15% of the patient's estimated blood volume, the surgeon should consider red blood cell transfusion to replace the acute blood loss. As a general rule, 15% of an adult's blood volume equals the patient's weight (in kilograms) times 10. For example, for a 50-kg woman (110 lb), 15% of blood volume is (50 × 10) 500 mL; for a 75-kg woman (165 lb), 15% of blood volume is (75 × 10) 750 mL; for a 100-kg woman (220 lb), 15% of blood volume is (100 × 10) 1,000 mL. The patient's estimated blood volume, the estimated intraoperative blood loss, the anticipation of additional blood loss, the presence of preoperative anemia, and the risk of hypoxic complications must all be taken into consideration when deciding whether to transfuse.

When massive blood replacement therapy is under way, intraoperative monitoring of coagulation at 2-hour intervals, or after every 10 U of blood transfused, usually is sufficient. One should remember that a patient bleeding during a surgical procedure has a higher demand for clotting factors and platelets than does a patient at bed rest. In many oncology cases in which the patient is undergoing chemotherapy, a platelet count of 50,000/mL is adequate; in a surgical case in which the patient is bleeding, a 50,000/mL platelet count is not adequate to achieve a good platelet plug. The use of blood and blood components in the management of massive bleeding that is due to a major vessel rupture has the following objectives:

1. To maintain sufficient blood volume and circulating red cells to sustain life
2. To replace blood sufficiently to achieve adequate coagulation and hemostasis, assuming there was extensive loss of plasma-clotting factors and platelets
3. To avoid falling so far behind in replacement that management involves not only bleeding from a vascular tear but also bleeding at the microvascular level because of insufficient clotting factors and platelets

Each of these objectives requires repeated assessment of the patient throughout the surgical procedure. Careful monitoring by established routine policies often is the best way to handle a crisis situation created by massive bleeding.

Formulas for blood transfusion that are applied ritualistically without the benefit of laboratory data may resolve the need to treat but do not answer the needs of the patient. The formulas described below are designed to initiate the marshaling of blood bank resources. They do not replace the thoughtful analysis of laboratory data coupled with the selection of a specific blood component to correct a specific deficit. The following guidelines are recommended for component therapy in clinical situations requiring massive blood replacement to maintain normal hemostasis.

For every 6 to 8 U of packed red blood cells, 2 U (500 mL) of fresh-frozen plasma should be given. The size and age of the patient affect blood replacement. If the patient's blood volume can accommodate an additional 500 mL of fresh-frozen plasma, this amount should be transfused and the PT and APTT monitored.

Platelets should be given when the platelet count falls below 100,000/mL in massive hemorrhage. (Measurement error of a platelet count can be as high as 62,000/mL in a bleeding patient.) When a long surgical procedure is anticipated, or when more than 6 U of blood are given, 6 U of platelets in a volume of 300 mL should be given toward the end of the surgical procedure or when surgical hemostasis is achieved. This amount should be administered once to provide a maximum bolus effect. Because platelets are often difficult to obtain, their use should be reserved until near the end of the procedure. Otherwise, they may be lost and therefore unavailable when needed because of continued blood loss and replacement during extensive surgical repair. Pooling and transporting the platelets can take up to an hour, so the blood bank should be given sufficient notice to have them available in surgery when needed. In assessing the patient's coagulation status, it should be remembered that clotting factors are constantly changing. Six units of platelets will achieve maximum bolus effect in an average patient (3 U in a child or small adult) and will also enable evaluation of platelet use. A platelet count of 40,000 to 60,000/mL should be expected in a 70-kg person after transfusion of 6 U of platelets. Monitoring the platelet count after transfusion and for the next several hours will reveal the success of replacement, consumption, and life of the platelets.

When the PT and APTT are prolonged (more than 14 seconds and 40 seconds, respectively) after replacement therapy, intrinsic disease must be considered initially, if only to be ruled out later. A borderline hemophiliac or patient with liver disease may manifest excessive bleeding after stress, trauma, or blood replacement because of the increased coagulation needs. A mild hemophilia or liver disease is rare as an unknown, but it is possible. Therefore, administration of fresh-frozen plasma in these 2-U (500-mL) doses should begin to correct the deficiencies caused by massive red blood cell replacement. If oozing continues despite the rapid transfusion of 6 U of fresh-frozen plasma, a clotting problem or other ongoing bleeding disorder should be suspected and additional support sought.

When the fibrinogen level falls below 100 mg/dL, transfusion of 20 U of cryoprecipitate will provide about 150 mg/dL fibrinogen in a 70-kg person. A low fibrinogen level is rare because fibrinogen is stable and present in fresh-frozen plasma. Liver disease or intravascular consumption must be suspected if the fibrinogen level is initially less than 100 mg/dL and remains low throughout surgery and recovery. The 20 U of cryoprecipitate will achieve therapeutic levels quickly and permit monitoring over several hours.

The goals of intraoperative monitoring are as follows:

- To assess changes in the coagulation mechanism resulting from blood loss and replacement therapy
- To identify the coagulation components affected and determine the correct components to initiate therapy
- To determine the success of replacement component therapy in an extensive operative procedure
- To enable selection of components to achieve the following values: PT less than 14 seconds, APTT less than 40 seconds, fibrinogen more than 100 mg/dL, and platelets more than 80×10^3/mL. If surgical hemostasis appears to have been achieved from a technical viewpoint and bleeding is present but mild, one can "wait to see" for 2 hours. If bleeding is profuse and worsening, 2 to 4 U of fresh-frozen plasma and a 6- to 10-U dose of platelets are given, and then packed red cells are given as needed. The patient is monitored when the transfusion is completed. Laboratory monitoring is repeated after 1 to 2 hours, whether the patient is bleeding or not, to determine the success of replacement.

COMPONENT THERAPY FOR POSTOPERATIVE REPLACEMENT

The presurgical and intrasurgical alarm levels for hematocrit, platelet count, PT, APTT, fibrinogen, and clot retraction also apply postoperatively, and a comparison of these values provides an accurate assessment of the bleeding patient. Significant clinical bleeding with good postoperative coagulation values suggests surgical bleeding. When laboratory values are abnormal, however, further surgery can be delayed until an attempt at aggressive specific component therapy is made. We have found that when abnormal coagulation studies exist, the following causes predominate, in order of frequency (most frequent first):

1. Low platelet count owing to transfusion of only packed red cells or fresh-frozen plasma
2. Prolonged PT and APTT owing to replacement with packed red cells without fresh-frozen plasma. In administering aggressive replacement therapy, it should be remembered that some patients have a meager blood volume. Careful monitoring of venous and arterial pressure, as well as cardiac output, should be considered in blood component therapy. Often a slower rate of administration can achieve hemostasis without cardiovascular overload. In rare cases, phlebotomy may be required to create needed space for transfusion. If nearly normal coagulation values are achieved but bleeding continues, surgical causes for bleeding should be considered.
3. Low fibrinogen level owing to dilution with plasma expanders or concurrent development of a disseminated intravascular coagulation

The goals of postoperative monitoring are as follows:

- To determine whether a coagulopathy was created by blood replacement and to determine current status
- To determine the success of specific component therapy and identify the need for additional components
- To enable the surgeon to distinguish surgical from nonsurgical bleeding

The routine use of postoperative monitoring, whether the patient is bleeding or not, will achieve these goals. As the surgeon reviews the results of each case, he or she will develop a valuable assessment of the patient's usual postoperative coagulation states. With this knowledge, the unexpected is recognized and resolved in a more timely manner.

RISKS OF BLOOD TRANSFUSION

Transfusions of whole blood were given sporadically before 1900, usually to treat specific diseases rather than to replace lost blood volume. Indeed, heavy bleeding was thought to be beneficial and therapeutic for many diseases. Even as late as World War I, the importance of blood loss and replacement was not recognized, because shock was thought to be owing to toxins released from traumatized tissue. It was the work of Cannon and Bayliss in 1919 and of Blalock in 1930 that proved that the important factors in shock were the loss of circulating blood volume and the decreased return of venous blood to the right heart.

Landsteiner discovered the four major blood groups in 1900. Banking and storage of donated blood became possible with refrigeration and the addition of sugar and later sodium citrate as an anticoagulant. In World War II, a remarkable program was organized to collect and store large quantities of type O (so-called universal donor) blood for shipment to U.S. military hospitals throughout the world. Many lives were saved by the use of this banked blood to treat the shock associated with battle casualties. This experience firmly established the need for blood banks and the importance of blood transfusions in combatting hypovolemic shock from hemorrhage before, during, and after surgery.

To be safe, homologous blood must be collected from carefully selected volunteer donors and properly matched to the potential recipient. Although many lives have been saved by properly administered transfusions, gynecologic surgeons must be aware of the potential hazards of perioperative transfusions. The risks of red blood cell transfusion were reviewed by a National Institutes of Health and Food and Drug Administration Consensus Development Conference on Perioperative Red Cell Transfusion and published in 1988. The following excerpt is taken directly from their report.

In deciding whether to use red blood cell transfusion in the perioperative period, the need for possibly improved oxygenation must be weighed against the risks of adverse consequences, both short term and long term. The disadvantages are of two general types: transmission of infection and adverse effects attributable to immune mechanisms.

Any infectious agent that is present in the blood of a donor at the time of donation is potentially transmissible to a susceptible recipient. The consequence may be seen as clinical morbidity and mortality after an incubation period characteristic of the agent or recognized only by serological or other types of laboratory testing. If the agent produces chronic infection, clinical mortality may not be seen until years after the transfusion (Table 19.8).

TABLE 19.8

BLOOD TRANSFUSION RISKS

Disease or situation	Risk
Viral infection	
HIV	1:1.9 million
HTLV	1:250,000–1:2.0 million
Hepatitis B	1:180,000
Hepatitis C	1:1.6 million
Bacterial contamination	
Platelet packs (stored at room temperature)	1:12,000
Packed or whole red blood cells	1:5 million
Fatal red-cell hemolytic reaction	1:250,000–1:1.1 million
Delayed red-cell hemolytic reaction	1:1,000–1:1,500
TRALI	1:5,000
Febrile red-cell nonhemolytic reaction	1:100
Allergic (urticarial reaction)	1:100
Anaphylactic reaction	1:150,000

HIV, human immunodeficiency virus; HTLV, human t-cell lymphotrophic virus; TRALI, transfusion-related acute lung injury. From: Zoon KC. Ten years after: what has been achieved by Consent Decrees: the FDA view. Paper presented at: Fifth Annual FDA and the Changing Paradigm for Blood Regulation; January 16–18, 2002; New Orleans, LA; Schreiber GB, Busch MP, Kleinman SH, et al. The risk of transfusion-transmitted viral infections: the retrovirus epidemiology donor study. *N Engl J Med* 1996;334:1685; Dziecxkowski JS, Anderson KC. Transfusion biology and therapy. In: Fauci AS, Martin JB, Braunwald E, et al., eds. *Harrison's principles of internal medicine.* 14th edition. New York: McGraw-Hill;1998:718; Goodnough LT, Breacher ME, Kanter MH, et al. Transfusion medicine: first of two parts—blood transfusion. *N Engl J Med* 1999:340;438.

In modern blood banking practice, bacterial contamination of red blood cell units is rare. For practical purposes, the transmissible agents of greatest concern are viruses.

- Cytomegalovirus infection occurs with moderate frequency among those recipients without prior infection. Most of these infections are asymptomatic, except among immunocompromised people. The use of the newer leukocyte reduction filters ($<5 \times 10^6$) is under extensive clinical study and application as an alternative to cytomegalovirus-negative blood.
- Human T-cell lymphotropic viruses occur with low but not negligible frequency among donor populations in the United States. It is not known whether transfusion-transmitted infection with these viruses among adults results in T-cell leukemia/lymphoma and/or neurological disease several to many years later.
- On rare occasions, other microbial agents—including paroviruses, malaria, *Toxoplasma,* Epstein-Barr virus, and *Babesia*—cause infection and disease.

It is known for the human hepatitis viruses that the incidence of infection in recipients increases with the number of donor exposures. This relationship is probably true for other transfusion-transmitted infections. If homologous transfusion is to be used, therefore, the number of units administered should be kept to a minimum.

HIV, about which there is the greatest public concern, presently poses only a remote hazard because of donor selection and laboratory screening procedures. The consequences of HIV infection are rarely seen until 2 or many more years have elapsed, but ultimately morbidity and mortality are extremely high.

Immunologic consequences also complicate homologous red blood cell transfusion. Hemolytic and nonhemolytic reactions are largely caused by alloimmunization to red blood cell and leukocyte antigens. Compatibility testing virtually has eliminated immediate hemolytic transfusion reactions; when they occur, they are largely owing to human error. Nonhemolytic febrile reactions occur in 1% to 2% of recipients owing to sensitization to leukocyte antigens. This may be reduced by the use of leukocyte reduction filters ($<5 \times 10^6$).

Although blood transfusions are and will remain an essential component of perioperative gynecologic care, an awareness of their associated risks is important in every patient before electing their use. There is every reason to carefully consider the risk:benefit ratio of giving "just one bottle of blood." Indeed, it is the rare clinical situation in which this action can be justified.

The growing public concern about transfusion-associated infections should make gynecologic surgeons aware of the importance of being selective in their use of transfusion therapy. The public has been greatly sensitized by the transfusion-associated transfer of acquired immunodeficiency syndrome (AIDS). The most common transfusion-related viral infection, however, is non-A, non-B hepatitis, which accounts for 90% to 95% of cases of previous transfusion-acquired hepatitis and possibly as many as 3,000 deaths per year in the United States. Ultimately, on further testing, many of these cases will be found to have hepatitis C. When mortality or significant morbidity occurs with blood transfusion, the gynecologic surgeon must be able to show that the transfusion was indicated.

There are alternatives to blood and blood component transfusion that may be considered in critically ill patients such as those with sepsis and deseminated intravascular coagulation. The drug activated protein C, drotrecogin alfa (Xigris), is recombinant human activated protein C (drotrecogin alfa, activated). It is used in replacement therapy in sepsis and holds a great promise in the management and survival in sepsis. By replacing this essential naturally occurring anticoagulant, there is reversal of the bleeding and thrombosis seen with sepsis. Its specific application in septic gynecological surgical patients has not been reported in any large study.

Recombinant activated FVII (NovoSeven) has been clinically demonstrated to successfully manage patients with FVIII and FIX inhibitors. It has also been used in management of bleeding in cardiovascular surgery, liver failure, and Coumadin overdose, and disseminated intravascular coagulation. It has significantly reduced the use of blood components in these disorders, and although expensive, it has the potential to greatly improve the outcomes with these disorders.

By reducing the need for blood and blood components with the use of activated protein C, drotrecogin alfa, and recombinant activated FVII, one can reduce the infectious disease exposure of blood, as well as the generation of allogenic antibodies. Not only may there be improved survival, but also there should be a substantial reduction of blood and blood components used in the treatment of similar complications in gynecological surgery.

According to Friedman and colleagues, in every age range the mean hematocrit of men is higher than that of women. Women adapt to this relative state of anemia physiologically by a variety of mechanisms. Their red blood cells have a greater capacity than those of men to release oxygen. The erythrocyte oxygen dissociation curve of women is right-shifted when compared with that of men. Levels of 2,3,-diphosphoglycerate, adenosine triphosphate (ATP), and glucose-6-phosphate are higher in the red blood cells of women than in those of men. Because of these physiologic adaptations, Friedman and colleagues suggest that a lower hematocrit support level to govern the blood transfusion of female surgical patients be considered.

There are a variety of methods to support circulating volume, but there is no available material to support oxygen transport. Future research may be successful in developing modified hemoglobin solutions and perfluorochemical emulsions for oxygen transport, but there currently is no substitute for red blood cells for this purpose.

In a comprehensive discussion of perioperative interventions to decrease transfusion of allogeneic blood products, Ereth and associates suggest that an increased awareness of transfusion-related morbidity from allogeneic blood products has resulted in increased development and application of alternatives to allogeneic transfusion. As an indication of what can be accomplished, a program instituted by the Transfusion Committee of the Methodist Hospital of Indianapolis modified transfusion practice in the hospital by establishing new transfusion guidelines based on national standards rather than on local practices and by implementing educational and monitoring systems. As reported by Rosen and colleagues, over a 3-year period, the total decrease in donor exposures for patients was 42,072. Overall savings amounted to $1,627,348. This program was able to effect substantial cost and patient risk reductions, even though hospital services involving blood transfusion increased. A comprehensive update titled "Transfusion Medicine in Obstetrics and Gynecology" was published recently by Santoso and associates.

AUTOLOGOUS BLOOD TRANSFUSION

Blood collected from a patient for retransfusion at a later time into the same patient is called autologous blood. Autologous blood transfusions have been endorsed by the Council on Scientific Affairs of the American Medical Association and by the Committee on Hospital Transfusion Practice of the American Association of Blood Banks. If established guidelines are followed, autologous blood is the safest type of blood for transfusion. It does not eliminate all risks associated with red blood cell transfusion, because there is still the possibility of a hemolytic reaction caused by the rare clerical error or bacterial contamination. It does eliminate the risk of alloimmunization and the risk of transferring such infections as hepatitis, malaria, cytomegalovirus, and AIDS. In patients with rare blood types who have antibodies to common blood antigens, it may be the only blood available for transfusion. Autologous blood transfusion is acceptable to most Jehovah's Witnesses who have a religious objection to transfusion with homologous blood or blood products. The use of autologous blood decreases the need for banked blood, which may then be reserved for other purposes. Given the improved safety of allogeneic transfusions today, the increased protection afforded by donating autologous blood is limited and may not justify the increased cost. This choice may be presented to the patient who has concerns about blood transfusion.

Intraoperative Autologous Transfusion

The frequency of autologous transfusion has increased appreciably in the past decade, especially for cardiovascular operations. Keeling and colleagues reported on the use of the Haemonetics Cell Saver for autologous intraoperative transfusion in 725 consecutive general hospital patients. Seventy-five percent were cardiovascular patients, but a variety of other patients, including gynecology/obstetric patients, were represented.

A general subject review of intraoperative autologous transfusion was published by Popovsky and associates in 1985. These investigators stated that although the technology of the earlier experiences was comparatively crude and associated with technical problems and complications, better methods have been developed in recent years to eliminate problems in the operation and maintenance of the machinery and to make intraoperative autologous transfusion safe. Our experience in gynecologic surgery reported by Shapiro and Toledo, although limited at this point to a series of 25 myomectomy operations, has demonstrated to our satisfaction that intraoperative autologous transfusion is convenient to use and does not in any way interfere with the performance of the procedure.

The Haemonetics Cell Saver operates by retrieving blood from the operative site by suctioning it into a double-lumen catheter, in which it is immediately anticoagulated with heparin. It is then collected in a cardiotomy reservoir, where a filter removes gross debris. The blood is then pumped to a spinning centrifuge bowl, where the red blood cells are separated, washed with normal saline solution, and then concentrated to a hematocrit of about 50%. The supernatant waste that is subsequently collected contains saline, anticoagulant, activated coagulation factors, platelets, leukocytes, free hemoglobin, and other small debris. The washed packed red blood cells are pumped into a reinfusion bag. The blood is then directly transfused to the patient through a filter. The reagents and the collecting system are sterile and disposable. The entire process takes 8 to 10 minutes to process about 250 mL of packed cells. The machine is maintained and operated by a trained technician.

At least until additional data are available to the contrary, intraoperative autologous transfusion is contraindicated in patients with malignant disease and in patients with bacterial contamination of blood in the operative field. Although the addition of antibiotic agents to the cell-washing system can reduce or eliminate contaminating bacteria, some bacteria with the potential of causing systemic infection if retransfused may remain. There is a theoretical concern that malignant cells contained in retransfused blood may be responsible for generalized seeding of the malignant process. Although there are no data to support or deny this position—for medicolegal reasons at least—intraoperative autologous transfusion should be considered contraindicated in a patient with cancer unless the need is desperate. It is difficult to distinguish the hematologic changes induced by intraoperative autologous transfusion from the changes induced by hemorrhage and massive transfusion with homologous blood. Guidelines for the use of component therapy are the same for both groups.

Merrill and colleagues reported the use of intraoperative autotransfusion in 38 patients with ruptured ectopic pregnancy. Transfusion-related morbidity occurred in six patients; two patients developed clinical coagulopathy, two patients developed pulmonary edema, and two patients developed minor transfusion reactions from concomitantly used bank blood. The total amount of retransfused blood was 49,475 mL, or 59% of the total amount of blood administered. This saved about 90 U of banked blood.

It must be remembered that both autologous (intraoperative) and homologous blood are essentially packed red blood cells. One risk with autologous blood transfusions is forgetting that only the patient's packed cells are transfused. The patient still will need fresh-frozen plasma and platelets when massive transfusion of autologous blood is used.

Predeposit Autologous Blood Transfusion

Because blood transfusion is so rarely required in gynecologic surgery for benign disease, predeposit of autologous blood for intraoperative transfusion is rarely indicated. However, certain patients may strongly desire this approach if there is any possibility of requiring a transfusion; in some patients with malignant disease or other extensive surgery, the risk of transfusion may be significant. Experience has shown that autologous blood can be collected and stored as whole blood, red blood cells, plasma, or platelets for retransfusion into the same patient during surgery if needed or at some other time. Donation can be scheduled at weekly intervals up to 3 days before surgery. Oral iron therapy is administered, and the hematocrit and hemoglobin levels must not be low. The American Association of Blood Banks' standards for elective preoperative autologous blood donation include the following guidelines:

- A hemoglobin of no less than 11 g/dL or a packed cell volume of no less than 34%
- Phlebotomy no more frequently than every 3 days and not within 72 hours of surgery

If a patient's condition is stable enough to allow elective surgery, then preoperative donation for autologous transfusion is not contraindicated. Mann and associates studied the safety of autologous blood donation before elective surgery for a variety of potentially high-risk patients. Of 300 patients in the study, 46 were at least 70 years old. Four percent of patients experienced a minor reaction to blood donation. This method of providing autologous blood should have applicability in gynecologic surgery. Experience suggests that it should be encouraged when practical.

The number of centers providing autologous blood transfusion programs will probably continue to increase as a result of AIDS and public knowledge of the possibility of spread of this disease by homologous blood transfusion, even though rare. Programs encouraging selected patients to donate their own blood before surgery are becoming increasingly popular, despite the numerous logistical problems that must be solved. Only 2% of the blood collected in the United States is for predeposit autologous transfusion.

Much of gynecologic surgery is elective, and many patients are comparatively healthy. Elective gynecologic surgery often is scheduled 3 to 4 weeks in the future. During this time, many patients can have blood predeposited for use during operation. Only about 2% of patients undergoing elective hysterectomy require blood transfusion, depending on the skill of the operator and the extent and nature of the gynecologic pathology. Routine predeposit of autologous blood is not recommended for hysterectomy for benign disease.

Goodnough and colleagues have found that the administration of recombinant human erythropoietin increases the amount of autologous blood that can be collected before surgery. The volume of red cells donated by patients treated with erythropoietin during the study was 41% greater than that donated by patients given placebo.

BASIC SURGICAL PRINCIPLES TO AVOID EXCESSIVE BLEEDING IN PELVIC SURGERY

It is easier to stay out of trouble than to get out of trouble! A good knowledge of the surgical anatomy is the basis for avoiding hemorrhage. A well-planned surgical procedure with good exposure, precise placement of the clamps, skillful dissection technique, and careful suture placement are all important. In addition to good technical ability, surgical judgment is a key ingredient to a consistently excellent surgical outcome. Should the densely adherent bladder be dissected a little more before clamping across the vagina? Should the endometriosis in the posterior cul-de-sac be dissected free from the sigmoid colon or just cauterized? These decisions occur constantly during any operation, and the surgeon who knows the patient, the disease entity being treated, the technical details of the planned surgical procedure, and his or her own technical abilities can confidently make these judgments that will result in a successful surgical outcome and avoid complications such as intraoperative hemorrhage.

Among the many contributions to surgery made by William S. Halsted, first chief of surgery at Johns Hopkins Hospital, was a surgical technique that emphasized meticulousness in dissection, gentleness in the handling of tissues, accuracy in hemostasis, precision in wound approximation, and absolute asepsis. This meticulous technique has become widely known in the United States as the Halstedian technique. It promotes good tissue healing by reducing tissue damage and wound infection. The accuracy of dissection, hemostasis, and tissue approximation is emphasized rather than speed, but wasting time with unnecessary hesitation, indefiniteness, and indecision can increase blood loss and the risk of infection. The experienced surgeon will be able to finish the operative procedures in a deliberate, purposeful, timely, and precise manner. The speed with which the dissection is performed should be varied from one phase of the operation to the other, but the operation should progress in an orderly manner. For example, the incision can be fashioned with some haste, but dissection around deep pelvic veins must be performed with great caution to avoid injury and bleeding. Although shorter operative procedures are generally associated with less blood loss and lower rates of infection, the pace of the procedure should be governed by the difficulty of the surgery and the skill and experience of the surgeon. Too much haste will sooner or later result in excessive blood loss or injury to adjacent organs or structures, which will ultimately prolong the operation. Technical aspects of surgical technique, including good exposure, gentle handling of tissues, accurate clamp placement, and good suture technique—which includes secure knot tying—are all important characteristics that will minimize blood loss and contribute to a successful and well-executed operative procedure.

It is impossible to place too much emphasis on the need for **optimum exposure** to limit blood loss. During vaginal operations, a contracted pelvic outlet will limit exposure for vaginal

hysterectomy. A leiomyomatous uterus may require morcellation to allow sufficient exposure for safe vaginal removal. A Schuchardt incision may be required to improve exposure during vaginal operations. If exposure is inadequate, bleeding from vessels in the upper broad ligament may not be controllable from below, and an abdominal incision may be necessary to achieve final hemostasis from above. When hemorrhage is a problem during vaginal or laparoscopic surgery, the question always arises, "When should the operation be converted to an open abdominal procedure so that improved exposure and better access can be used to control the bleeding?" The answer to this question will vary depending on a variety of circumstances, but good exposure will go a long way toward solving many surgical difficulties. During abdominal operations, the exposure achieved will depend on the choice of incision, the method of retracting, the placement and intensity of the lights, and the presence of willing and skilled assistants. *Suction should be available* to keep the field as free of blood as possible and is preferred over sponges for two reasons. First, sponges can cause damage to delicate serosal surfaces. Second, a determination of the amount of blood lost can be more accurate if the largest percentage has actually been suctioned into a calibrated bottle and measured. One can then add to this exact amount an estimate of the amount of blood lost on the drapes, sponges, and lap packs. The record of the amount of blood lost should be as accurate as possible and can be of great value in making correct decisions subsequently about the patient's care, especially regarding the need for blood replacement in case there is a suspicion of hypovolemia. Good lighting of the surgical field is important. In addition to the standard surgical lights, we have found that a *headlight* worn by the surgeon and/or the assistants is very useful in providing excellent lighting deep in the pelvis. There are also *lighted retractors,* which may be helpful in some vaginal surgery.

For pelvic laparotomy, the patient usually is placed in a modest Trendelenburg position. In this position, the packs required to keep the intestines displaced in the upper abdomen tend to stay in place better, thereby enhancing exposure. An anesthetic or muscle relaxant is needed to keep the patient from pushing her bowels into the operative field, especially when the dissection is tedious, and good exposure is mandatory for safe performance of the operation. A retractor with an upper blade or blades to retract the intestines out of the pelvis is very useful and reduces the requirement for Trendelenburg positioning and anesthetic muscle relaxation.

It usually is possible, and always desirable, to keep the number of clamps in the operative field to an absolute minimum. If the field is cluttered with clamps, the operators cannot see as well to operate. The length of the instruments must vary, depending on the thickness of the abdominal wall, the depth of the pelvis, and other variables. Pedicle clamps, tissue forceps, dissecting scissors, needle holders, and all other instruments must be longer for operations on obese patients and for extensive operations in a deep pelvis. The handles of the instruments must come all the way out and above the level of the incision so as not to interfere with the operator's view of the pelvis. There is an unfortunate tendency for gynecologic surgeons to use instruments that are too short. The operator must stand high enough to see down into the pelvis. The patient's abdominal wall should be at about the level of the operator's umbilicus, not too high or too low.

Cushing, a neurosurgeon, introduced the *hemostatic silver metal clip* in 1911 to occlude cranial vessels inaccessible to ligation. More recently, clips have been made of stainless steel, tantalum, and the new synthetic absorbable nonopaque polydioxanone polymer. The latter has the advantage of not causing the streaked artifact of metal clips when subsequent computed tomography (CT) of the pelvis is performed. Clips cause little tissue reaction, usually are easily and rapidly applied, and provide secure control of bleeding vessels in relatively inaccessible places in the pelvis where ligation would be more difficult. A small vessel can be quickly occluded with a clip even before the vessel is cut, thus keeping the field dry and the tissues to be dissected free of blood staining. Clips are especially useful in retroperitoneal dissections. They are available in several sizes. Disposable applicators loaded with multiple clips are available, obviating the need for reloading and facilitating rapid use. If appropriately used, clips can reduce blood loss, facilitate dissection, and reduce operating time.

Working with Bovie, Cushing also pioneered the use of *electrosurgery* for hemostasis. Modern electrosurgical units are radiofrequency generators that supply 500,000 to 2 million Hz of alternating current to the tip of the electrode. The best techniques for use of electrosurgical equipment and important safety information are well discussed in Chapter 15, but several points should be emphasized. An electrosurgical instrument can be used to coagulate small vessels or to cut through fat or muscle. If a "blend" cut is used, small vessels will be coagulated as the instrument divides the tissue.

The needlepoint electrode can be used for precise incisions with minimal tissue injury from collateral thermal effect. Superficial coagulation of small vessels can be achieved by holding the electrode close to the tissue, pressing the "coagulation" button, and allowing the sparks to jump to the tissue surface. The blood should not be allowed to pool. Dry surfaces are much more effectively coagulated with the electrosurgical instrument. If bleeding is brisk, the vessel is grasped with a fine-pointed clamp or forceps, and hemostasis can be achieved by touching the metal clamp with the tip of the electrosurgical instrument and apply the "cutting" current. This may seem paradoxical, but the "cutting" current actually results in a deeper tissue effect in these circumstances, leading to better sealing of large vessels. Bipolar electrodes built into tissue forceps are also very effective for coagulating smaller vessels during tedious dissections. Experience in the use of electrosurgery will result in maximum efficiency with minimum tissue damage and a shorter operating time.

With a thorough knowledge of pelvic anatomy, the surgeon should emphasize the **development of pelvic planes and spaces**. This will avoid unnecessary bleeding and allow more accurate placement of clamps on vessels. Certain parts of the dissection can be delayed until later, especially if they are not needed now and blood loss is likely to be increased. For example, when abdominal hysterectomy is performed, dissection of the bladder away from the cervix and vagina may be associated with blood loss and should not be performed at the beginning of the operation. Exposure of the anterior lower uterine segment and cervix is not required until the uterine vessels and broad ligament need to be clamped. Until then, there is no need to start this potentially bloody dissection.

In the early days of abdominal pelvic surgery, postoperative hemorrhage was common because an effective technique of hemostasis was not known. The usual method of performing abdominal hysterectomy involved use of a ligature en masse around the lower uterus. This mass ligature saved time and was used to occlude both uterine and ovarian vessels simultaneously. The uterine corpus with adnexa attached was simply amputated above the ligature. The stump thus formed was such a large mass of tissue that it could not be safely returned to the peritoneal cavity because of the danger of intraperitoneal bleeding. Therefore, sometimes the stump was fixed extraperitoneally in the incision so that it was available for hemostatic

clamping if the need arose. It was not until 1889 that Stimson published a technique for secure individual ligation of the uterine and ovarian vessels that was responsible for significantly reducing the incidence of postoperative hemorrhage. Kelly published a similar technique with illustrations in 1891. The technique of ligating large tissue pedicles with large sutures has been suggested for some types of total laparoscopic hysterectomy in recent years. In our opinion, mass ligation of such large pedicles is a step backward that will, sooner or later, lead to significant hemorrhage.

In abdominal operations today, all major vascular pedicles should be individually ligated, twice if technically feasible. Delayed-absorbable sutures should be used and the knots firmly tied. Vascular pedicles should be small and the vessels skeletonized as much as possible so that a secure ligature with little extraneous tissue can be accomplished. A vascular pedicle where the tip of the clamp is free, such as the infundibulopelvic ligament, should always be ligated first with a free tie to occlude the vessels. The pedicle is then secured with a transfixion suture ligature placed between the previous free tie and the clamp. This technique avoids hematoma formation and the rare occurrence of a traumatic arteriovenous fistula. If a suture ligature is to be held long for traction or later identification, there is a danger that it will become loosened or be pulled off, with a resulting hematoma or bleeding. Sutures used to ligate vessels should usually be cut and rarely held for traction for that reason. During vaginal hysterectomy, the upper broad ligament containing the uteroovarian ligament and the fallopian tube should be doubly clamped. The lateralmost clamp is replaced by a free tie completely around the pedicle. Tied tightly, this ligature compresses the vessels in the pedicle so that the most medial clamp (the one closest to the uterus) can then be replaced with a suture ligature placed through the pedicle, passed around the tip of the clamp both ways, and tied tightly around the pedicle. This is one vascular ligature that can be held long for identification and traction with minimal risk of bleeding.

"The finer the suture, the finer the surgeon" is an aphorism that is associated with meticulous surgical technique. The aphorism is good advice, up to a point. The newer delayed-absorbable sutures are strong, and smaller-gauge sutures are strong enough to ligate vessels. However, it is dangerous to use fine suture to ligate large pedicles. The suture may break or cut through the tissue if there is too much tension on the pedicle. Fine needles with small sutures are useful for controlling localized venous or arterial bleeding, but larger suture with bigger bites are less likely to pull through infected or malignant tissue. Proper suture selection for the specific technique and patient is an important part of obtaining the best result from any given surgical procedure.

INTRAOPERATIVE MEASURES TO CONTROL PELVIC HEMORRHAGE

Despite adequate technical skills and careful dissection, serious hemorrhage can suddenly complicate almost any operative procedure. These occasions call for a maximum use of a surgeon's knowledge, technical ability, and leadership to produce a happy outcome. The first task is to control the hemorrhage. *A finger should immediately be placed on the bleeding point for prompt, atraumatic control with pressure.* When the blood has been suctioned out and the fingertip exposed, it may be gently rolled off the bleeding point while a fine-tipped clamp of adequate length is poised to clamp the bleeding vessel and suction is ready to provide exposure. In most instances, this will adequately control the hemorrhage, although it is often necessary to place another clamp, clip, or suture adjacent to the first clamp to control the other side of the lacerated vessel or other nearby bleeders. It is most important to avoid placing too many clamps in the area because this will obscure the bleeding site and cause additional trauma to the vessels. Multiple sutures and/or clips may also cause more bleeding and can injure adjacent structures, such as the ureter, bladder, pelvic vessels, and nerves. Cautery should not be used to attempt to control significant bleeding. It will only cause increased bleeding and more tissue injury.

If an immediate attempt to control the hemorrhage by simple means is unsuccessful, the *bleeding should be controlled again with pressure*, either with a fingertip, a sponge forceps, or occasionally by packing. The surgeon should step back, take a deep breath, and carefully consider the situation. *The anesthesiologist should be made aware of the hemorrhage and consulted* about the patient's stability, blood loss up to this point, availability of blood for transfusion, intravenous lines, and so forth. The anesthesiologist will play an important role in fluid and blood replacement, monitoring coagulation factors and ensuring perfusion of vital organs. Therefore, it is important that he or she be fully aware of the situation and an active participant in such decisions as how long to safely continue surgery. The anticipated difficulty in controlling the hemorrhage must be honestly evaluated, and the patient's overall condition and the planned operative procedures should be considered and discussed with the surgical team. If *additional suction or instruments* are needed, they should be requested. If *additional or more experienced assistants* or additional scrub and/or circulating nurses are needed, they should be requested. Would it be helpful to have your partner, a gynecologic oncologist, a urologist, a general surgeon, or a vascular surgeon scrub in? They are probably not immediately available, so it is important to request their help sooner rather than later.

If the patient is stable and any necessary equipment—such as a second suction, deeper retractors, or hemoclips—has been readied, it is reasonable to reconsider the anatomy, obtain good exposure, and have another try at controlling the bleeding. If you are lucky, the 10 minutes or so that the hemorrhage has been controlled by pressure will result in a substantial reduction in the bleeding. Perhaps the vessel or bleeding site can be more clearly seen and controlled with a clamp and a few small sutures or a clip or two. Arterial bleeding in the pelvis usually is easily controlled. The vessels have thick walls and are not easily torn further. Blood spurting from the vessel leads to its easy identification. If the artery can be clamped, it usually can be ligated, a clip can be applied, or both. If an artery has mostly retracted from view with only one small edge still visible, that edge may be grasped with a clamp and gently twisted, thus decreasing the amount of bleeding sufficiently to allow clipping or ligation. *Venous hemorrhage in the pelvis may be a much more difficult problem.* Such bleeding can vary in magnitude from a trivial ooze to life-threatening hemorrhage. Pelvic veins can be fragile, tortuous, hidden from view, and distended. Blood returning through the lacerated vein can come from multiple deeper sources that are unavailable for ligation. Placing clamps and sutures blindly is dangerous and can even make the problem worse. Electrocoagulation of a laceration in a large vein should not be attempted because it will inevitably result in a larger hole that will be even more difficult to secure. Sometimes the best procedure is to hold a finger or a pack against the bleeding site for a minimum of 5 minutes, after which the bleeding may stop or decrease so that the bleeding vessel can be identified and controlled with a clip or a suture. Digital

pressure to control venous bleeding takes advantage of the fact that the pressure in pelvic veins is very low. The initial use of digital pressure also is less likely to cause further tearing and trauma to the vein. Sometimes additional careful dissection in the area is required to free the vessel above and below, to allow more precise ligation or clipping. A long, finely pointed instrument is used to clamp the vessel, and clips are placed on each side. If the vessel can be sufficiently liberated, another instrument is gently slipped beneath the first one so that its point is free. Then a fine ligature is placed around the clamp. If necessary, clips can also be placed on each side of the tie.

If the bleeding has still not been controlled at this point or if bleeding cannot be controlled by pressure on the bleeding site, consultation should be requested to get additional help or expertise. By this time, the surgeon may feel frustrated, and it is important to maintain control of the operation and the surgical team. Blood and clotting factors should be replaced as discussed earlier in this chapter, the patient kept warm, and the whole situation reevaluated with input from all members of the team. The surgeon must maintain a positive outlook and exert good judgment and leadership. Good leadership involves using the skills and ideas of each member of the surgical team. Good judgment involves knowing which ideas to use, when to use them, and when to ask for help.

Special Techniques

Diffuse venous oozing, which may be associated with malignancy, inflammation, or extensive lysis of adhesions, can usually be controlled by electrosurgery (sometimes on the "spray" mode) or packing for 5 to 15 minutes. When these techniques are not effective, various **hemostatic agents** may be considered. Most of the studies on these agents have been done on animals, and there is very little literature comparing these agents with each other in human subjects.

Older agents such as *oxidized, regenerated cellulose* come in a thin, pliable, woven sheet (Surgicel NuKnit®, Johnson & Johnson, USA) or a soft, multiple-layered, fuzzy pad that can be separated into thin sheets or used as a pliable pad (Surgicel Fibrillar®, Johnson & Johnson, USA). *Absorbable, gelatin foam* pads (Gelfoam®, Pharmacia and Upjohn, USA) are also available in several sizes, and can be cut to fit. These stiff sponges are about 4 mm thick and can be applied dry or moistened with saline to make them pliable. Both of these sheets or pads can be applied to an oozing surface and covered with a pressure pack for 5 minutes or so, during which time clot formation will, it is hoped, form on the cellulose or gelatin matrix. The patient must have normal clotting factors for these products to work.

Microfibrillar collagen "flour" (Avitene®, Davol, USA or InStat®, Johnson & Johnson, USA) is a soft, granular material that can be placed on a semidry surface or into a small crevice for hemostasis. This bovine collagen material can be applied directly and compressed against an area of a small bleeding vessel. It acts as a fibrin nidus to accelerate thrombus formation on the surface of the vessel. It will only control bleeding from a small arteriole or venule. Caution must be exercised in the use of this material because it can produce secondary fibrosis in the pelvis and even a persistent palpable mass. There have been reports of retroperitoneal fibrosis and ureteral obstruction secondary to the use of this material.

In one case of severe bleeding from deep pelvic veins, we were successful in finally controlling the bleeding with multiple layers (sandwiches) of Gelfoam and Avitene cut to appropriate size from sheets and stacked one on top of the other. If coagulation factors have been depleted because of multiple transfusions, the Gelfoam can be soaked in thrombin. When the material is applied, the field should be as dry as possible. Constant pressure can be applied by placing sutures that can be tied on top of the sandwiches. There is a new commercial product made of absorbable collagen sponge coated with human coagulation factor and thrombin that sounds very good, but it is not yet U.S. Food and Drug Adminstration (FDA) approved for use in the United States (TachoSil®, Nycomed, Denmark).

Malviya and Deppe have reported the successful use of *fibrin glue*, a biodegradable tissue adhesive and sealant and topical hemostatic agent, to control life-threatening hemorrhage in one obstetric and two gynecologic patients. The fibrin glue (Tisseal®, Baxter Pharma, USA or Crosseal®, Ethicon, USA) is prepared from equal amounts of cryoprecipitate (highly concentrated human fibrinogen) and bovine thrombin. It imitates the last stages of physiologic coagulation at the local site. It is available as a spray applicator or in a dual syringe set. This technique has been used successfully in microvascular, cardiovascular, and thoracic surgical procedures and has recently been reported in controlling hemorrhage in liver transplantation. Schwartz and colleagues compared spray on fibrin sealant to standard techniques for hemostasis in 121 patients undergoing liver resection. Time to achieve hemostasis and postoperative complications were significantly less in the patients randomized to fibrin sealant. This technique should be helpful in extensive pelvic dissections for gynecologic cancer, especially to control low-pressure pelvic vein bleeding that is not controllable by other standard measures.

Gynecologic surgeons usually do not have the luxury of using *tourniquets* to control bleeding. There are, however, two special procedures in which tourniquets have been used to advantage. These are myomectomy and uterine unification operations. The tourniquet is fashioned in the manner used by vascular, thoracic, and trauma surgeons to occlude major vessels. A vesiloop or a small Silastic pediatric catheter can be used for this purpose. A tourniquet loop can be placed around the uterine isthmus through a small hole made in the broad ligament just lateral to the uterine vessels. Loops also can be placed around both infundibulopelvic ligaments through the same hole in the broad ligament. When these are snugged down tightly and held with a Kelly clamp, the entire circulation to the uterus can be occluded. A sterile Doppler probe can be used to ensure that arterial pulsations have disappeared completely. This technique can reduce blood loss to a minimum in these two procedures. Similarly, vessel loops or "bull dog" vascular clips can be used above and below the defect when repairing a sizable hole in the wall of a large vein or artery that cannot be sacrificed.

Unnecessary bleeding in the area of dissection stains tissues, obscures visibility, restricts technical freedom, and gradually adds up to a significant amount of blood loss that may require replacement. Reducing the circulation to the operative field by deliberate induction of hypotension is a safe and effective anesthetic technique in properly selected patients. *Hypotensive anesthesia* is not recommended for most routine gynecologic surgery. The technique requires planning and cooperation between the surgeon and the anesthesiologist. It has been used for radical pelvic surgery in the past, but is rarely used today.

Hypogastric Artery Ligation

One of the methods of controlling severe pelvic hemorrhage is ligation of both hypogastric arteries. In 1893 at the Johns Hopkins Hospital, Howard Kelly performed bilateral hypogastric artery ligation to control hemorrhage during hysterectomy

for uterine cancer. Hypogastric artery ligation was later introduced by Mengert and colleagues and was then extensively investigated by Burchell. Burchell demonstrated that the pulse pressure in the artery just distal to the point of ligation was decreased significantly (77%) on the same side. If both hypogastric arteries are ligated, the pulse pressure is decreased by 85%. This reduction in pulse pressure presumably allows blood clots to form at the site of bleeding from damaged vessels. Blood flow in vessels distal to the point of ligation is decreased by only 48%.

Because it is important to preserve some of the collateral circulation to the pelvis—including the lumbar, iliolumbar, middle sacral, lateral sacral, superior and middle hemorrhoidal, and gluteal arteries—it is important to ligate the anterior division of the hypogastric artery distal to the posterior parietal branch, as demonstrated in Figure 19.4. In ligating the hypogastric artery, the peritoneum is opened over the external iliac artery from the round ligament to the infundibulopelvic ligament. The ureter is left attached to the medial peritoneal reflection to avoid disturbing its blood supply. The hypogastric artery is gently cleaned off with a fingertip or the tip of the suction. The hypogastric vein is also identified on the pelvic sidewall, if possible; but as long as the artery is well visualized and separated from the sidewall, it is not necessary to dig around risking more bleeding to isolate the hypogastric vein. The posterior branch of the hypogastric artery must be clearly identified before double ligation of the anterior division is performed. Nonabsorbable suture is passed around the artery with a right-angle clamp and tied. A second free-tie suture is placed distal to the initial ligature to avoid recanalization. Transfixion or division of the vessel is not recommended in this procedure. The hypogastric arteries should be ligated bilaterally, if possible, to obtain the best results. When possible, we believe that the arterial branch closest to the bleeding point should be ligated. Because the uterine artery is the first visceral branch of the hypogastric artery, it may be feasible to identify this artery and ligate it separately if the bleeding is from the uterus. This may be a somewhat more difficult procedure than ligating the entire anterior division of the hypogastric artery and should not be attempted in the face of massive pelvic bleeding, distorted pelvic anatomy, or shock.

When massive bleeding is present but the uterus has not been removed (as may occur in certain obstetric operations), it is important to ligate both ovarian arteries also. This procedure is easily accomplished by extending the lateral peritoneal incision up to the infundibulopelvic ligaments. The ureter must be identified. The artery should be ligated with a single, permanent ligature, but the artery should not be cut. This avoids the need for multiple ligatures and the risk of retraction and retroperitoneal bleeding of the vessel. A single hemoclip also can be placed on each ovarian artery as a quicker and easier method of occlusion. Care should be taken to avoid injury to the ovarian vein. If there is difficulty in distinguishing the artery from the ovarian vein, ligation of both the ovarian artery and vein within the infundibulopelvic ligament is acceptable. Even though ligating both the arterial and venous circulation to the ovary leads to a high incidence of postoperative cystic enlargement of the ovary, this complication is preferable to the risk of recurrent pelvic bleeding when the ovarian arteries are not ligated.

As an alternative to ligating the ovarian artery in the infundibulopelvic ligament, Cruikshank and Stoelk have described a technique of ligating this artery at the point of its anastomosis with the uterine artery in the medial mesosalpinx. This point of ligation allows maintenance of the blood flow to the tube and ovary but occludes the ovarian artery

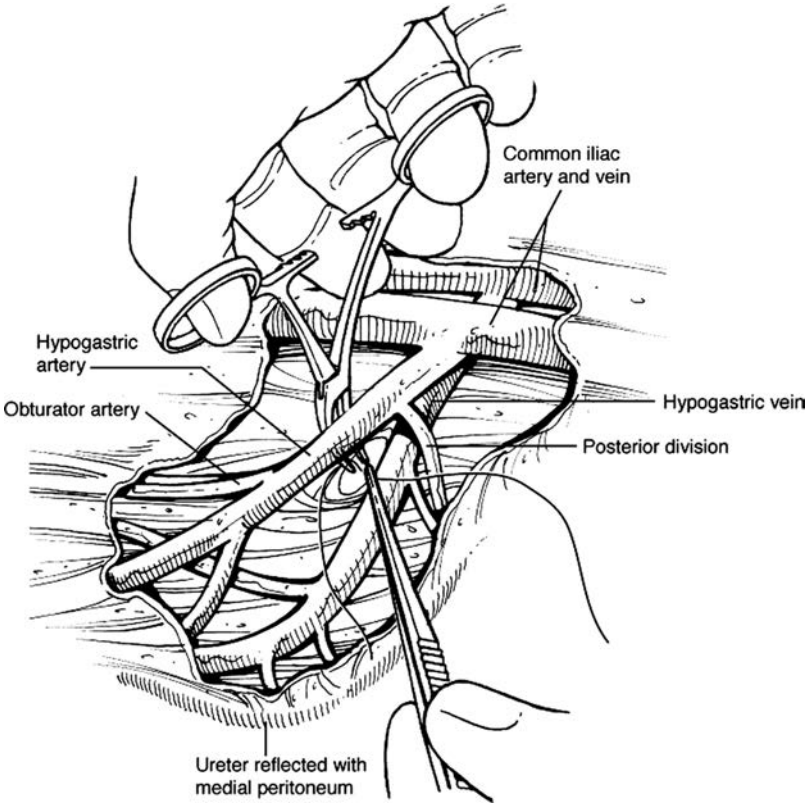

FIGURE 19.4. Ligation of the right hypogastric artery. The clamp is passed laterally to medial and the ligature is placed around the anterior division of the hypogastric artery. Note the ureter is attached to the peritoneum, which is reflected medially.

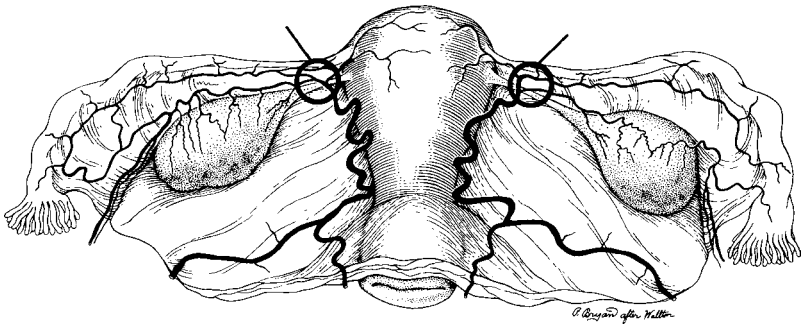

FIGURE 19.5. In addition to ligation of the anterior division of the hypogastric artery, the blood flow to the uterus through the ovarian artery can be ligated in the medial mesosalpinx without interfering with the blood flow to the tube and ovary.

blood flow to the uterus (Fig. 19.5). Because this technique allows uninterrupted blood supply to the ovaries, it is probably preferable.

For post–cesarean delivery hemorrhage, Fehrman has recommended bilateral ligation of the uterine arteries as primary treatment. When this method was used in 66 patients, only 6 required hysterectomy to achieve hemostasis. If bilateral uterine ligation is not effective in controlling the uterine bleeding, Fehrman recommends supplementary ligation of the round ligaments and the ovarian ligaments at their junction with the uterine corpus. He also believes that bilateral uterine artery ligation is a more effective treatment for life-threatening uterine hemorrhage than is bilateral hypogastric artery ligation.

The vaginal artery can originate as a separate branch from the hypogastric artery. Uncontrollable bleeding from the vagina may not be stopped by hysterectomy or by ligation of the uterine arteries. Hypogastric artery ligation is required.

Pregnancy after Hypogastric Artery Ligation. Amazingly, there are many reports of full-term deliveries after bilateral hypogastric artery ligation with and without bilateral ovarian artery ligation. This is ample testimony to the abundant collateral blood supply to the uterus that can develop over time. According to Burchell, the blood flow to the pelvis is reduced by as much as 50%, and yet there remains an adequate reserve to nourish a future term pregnancy. Ischemic necrosis of pelvic tissues does not occur unless additional collateral pathways are destroyed.

The collateral circulation of the female pelvis is extensive and provides a variety of intercommunicating sources of arterial blood from various sites along the arterial tree. These collateral vessels anastomose with the hypogastric artery and the blood supply to the uterus through a number of circuitous arterial pathways in the pelvis. During a difficult hysterectomy, the collateral circulation can create problems in achieving adequate hemostasis. Therefore, it is important to have a clear understanding of the various extrapelvic arteries that communicate with the pelvic circulation.

Packing Techniques

In rare cases, standard techniques of pressure, clipping, ligation, or application of hemostatic agents is unsuccessful for controlling bleeding. Several techniques may be considered in these cases. Trauma surgeons will occasionally pack persistent venous bleeding and close the abdomen when the procedure has been prolonged and/or the patient is unstable. The patient is then reoperated on in 24 to 48 hours when coagulation factors and blood volume have been normalized and everyone is refreshed. In some cases, the packing can be brought out through a large, hollow, soft rubber drain placed in a separate incision in the abdominal walls. The packing can then be removed through the drain in 48 hours under a light general anesthesia without opening the abdomen. If bleeding persists, it can sometimes be controlled by vascular embolization by the interventional radiologist.

Some surgeons have found the *parachute pack*, or umbrella pack, to be useful as a last-ditch effort to control persistent venous bleeding from the pelvic floor muscles after pelvic exenteration. This area is very deep in the pelvis, and exposure may be unsatisfactory from either above or below. This technique involves the formation of a large pack of loose gauze within an outstretched, opened piece of gauze or plastic sheet. The center of the sheet is inserted through the vagina and positioned in the pelvic cavity from above. The pack is then stuffed from below with one or more gauze packing rolls or "fluffs" (Fig. 19.6A). When an adequate volume has been obtained, the corners of the sheet are twisted together, and the stuffed ball of packing is pulled down against the pelvic floor, compressing the vessels of the pelvic floor muscles and paravaginal tissues (Fig.19.6B). Downward traction is maintained by clamping the twisted sheet at the vaginal introitus with several sturdy clamps. These are padded with gauze or foam rubber as they rest tightly against the perineum. The handles should be taped shut, but may be reclamped from time to time to maintain pressure on the towel as it stretches. The pack can be left in place with perineal traction for 24 to 48 hours until the bleeding has ceased. It is removed vaginally by first withdrawing the internal gauze and then the outside bags, sheet, or towel.

Potentially Troublesome Anatomic Locations

Iliac Vessels

One of the most dangerous places in the pelvis to dissect is in the region of the bifurcation of the common iliac artery and vein. This is the "axilla" of the pelvis, where many lymph nodes that drain the cervix are found. The hypogastric vein and its branches are at risk of injury when dissecting between the distal common iliac artery and the psoas muscle and deeper in the area of lumbosacral nerve trunks. When the surgeon pulls on surrounding areolar tissue, a relatively loose and thin-walled vein may inadvertently be torn or pulled into the dissecting scissors. The vein wall may not be distinct, especially when the tissue is bloodstained. One is wise to proceed cautiously. Furious hemorrhage threatening exsanguination can result from laceration of either the external iliac vein or the hypogastric vein where they join together, or from laceration of their major branches in the area. On the medial side of these veins, the lateral sacral veins disappear into the sacral foramina. Fatal hemorrhage can result from laceration of these vessels. If they are torn where they enter the foramina, they cannot be

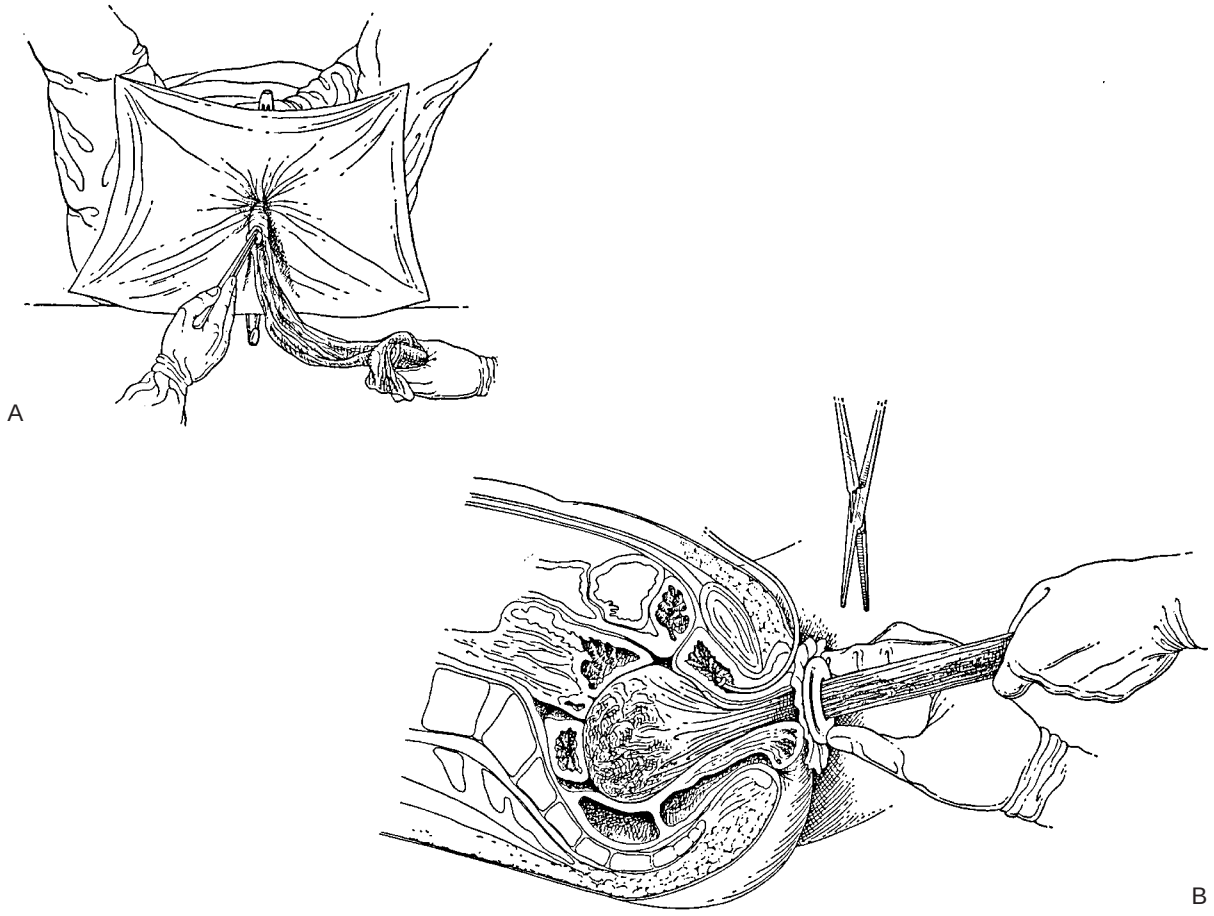

FIGURE 19.6. **A** and **B:** The parachute pack can be used to control bleeding from the deep pelvic veins after pelvic exenteration. A plastic sheet or towel is packed with gauze rolls through the vaginal or perineal opening. The ball of gauze packing is then pulled down to exert pressure against the vessels of the pelvic floor.

clamped and ligated. They cannot be clipped. They are kept open by their attachment to the walls of the foramina. Extreme measures may be required to control such bleeding. One can try to pack the foramen with bone wax, but this usually is not successful. Alternatively, multiple layers (sandwiches) of absorbable gelatin sponge (Gelfoam) and microfibrillar collagen (Avitene) can be held in place with a strong pressure pack for 20 minutes and, perhaps, ultimately the packing can be fixed with sutures. This area deserves its reputation as the "corona mortis" of the pelvis.

Obturator Fossa

Numerous variations in the branches of the hypogastric artery and vein are encountered in dissecting the obturator fossa, especially in the floor of the fossa. The "web" of paracervical tissue separating the paravesical and pararectal spaces contains branches of the hypogastric artery and vein. These vessels must be carefully ligated with clips or sutures during a radical hysterectomy. The dissection can be carried to the depths of the paravesical space and pararectal space by carefully ligating or clipping each vessel encountered. The obturator artery and vein are usually found just below the obturator nerve. In a radical hysterectomy or even a pelvic exenteration, these vessels are usually not disturbed. If injured, they may be ligated or clipped. If these vessels are allowed to retract through the obturator foramen into the upper thigh without being ligated, bleeding into the thigh may be a significant problem.

Pararectal Space

When dissecting in the pelvis, one should avoid making a deep, narrow hole with a bottom that cannot be exposed in case a deep vein might be lacerated. For example, development of the pararectal space must be done carefully because of the danger of injuring the internal iliac veins against the pelvic sidewall. The space is developed between the ureter and the hypogastric artery. The dissection is directed posteriorly at first but soon changes to a more caudal direction. Failure to make this directional change can result in laceration and bleeding from veins in the bottom of the space. If development of the pararectal space is difficult, such as after pelvic radiation therapy, the paravesical space should be opened, then the cardinal ligament or "web" can be taken down bit by bit, starting with the uterine vessels at their origin or insertion into the internal iliac vessels. As clips or small clamps are used to take down the cardinal ligament, the pararectal space gradually is opened inferiorly, with the ureter identified medially and the iliac veins visualized laterally. The pararectal space can be expanded with sharp dissection or with pressure from a small cotton bud in the tip of a long clamp (we call it a "peanut dissector" because the

cotton bud is about the size of a small peanut). It should not be forced.

Aortic Area

The removal of lymph nodes around the aorta and vena cava can result in serious hemorrhage from either vessel if not done carefully and with adequate exposure. An abdominal incision that provides sufficient exposure for a routine pelvic operation is not ordinarily sufficient for dissection around the aorta and vena cava unless the incision is extended. A laceration in the aorta must be repaired. The aorta cannot be ligated without serious consequences. Although the vena cava usually can be ligated without serious problems, a laceration in the vena cava should be repaired. Bleeding is controlled by placing a finger over the laceration and gaining the necessary exposure by retraction and suctioning. Continuous no. 5–0 Prolene suture on a small vascular needle is used to close the laceration from side to side as the finger is slowly withdrawn. The same technique can be used to repair lacerations in other large veins, such as the common and external iliac veins. These two veins usually can be ligated with no untoward results, but we prefer to repair the laceration if possible, and it usually is possible. Lacerations of the common and external iliac arteries must always be repaired. These vessels cannot be ligated without serious consequences. If the laceration is not repairable, the artery should be replaced.

Presacral Space

In the presacral region, bleeding usually can be avoided by choosing a plane of dissection that is superficial to the anterior sacral artery and vein. The retrorectal space is easily entered and developed inferiorly to the tip and lateral margins of the sacrum without appreciable bleeding, provided the dissection is carefully made with the hand and in the correct plane superficial to the presacral fascia and the vessels that overlie the periosteum of the sacrum. Timmons and colleagues and Khan and associates have recommended using metal thumbtacks to control presacral hemorrhage when the usual methods fail. Sterilized metal thumbtacks are placed directly over the bleeding point in the presacral fascia and pushed all the way into the sacrum with the thumb. We have used a combination of bone wax and thumbtacks with success. Bleeding from the veins can be aggravated by imprecise use of clips, ligatures, or cautery. Packs, hemostatic agents, and thumbtacks may be preferable in controlling the bleeding in this area.

POSTOPERATIVE BLEEDING

With normal hemostasis and proper surgical technique, postoperative hemorrhage is a rare occurrence. Every patient, however, should be carefully monitored postoperatively for signs of occult bleeding. The intensity and duration of the monitoring will depend on the type of surgery and the medical condition of the patient. In addition to measuring the vital signs such as pulse, blood pressure, and urine output, the abdominal incision and/or the perineum should be inspected for bleeding. Any sign of restlessness in the patient may be an indication of blood loss. A hematocrit can be checked if there is a suspicion of postoperative bleeding or anemia. Because the risk of postoperative hemorrhage is so low in routine, uncomplicated gynecologic surgery, many experts do not recommend routinely checking the hematocrit or hemoglobin postoperatively; but a hematocrit 8 to 12 hours postop may be helpful for radical surgery, patients with intraoperative hemorrhage, or patients who were not "dusty dry" when the abdomen was closed.

Occult intraperitoneal bleeding is one of the most serious postoperative complications after abdominal or vaginal surgery. It may not become evident in the recovery room. There may be no vaginal bleeding, the patient's vital signs may be stable for 12 to 18 hours after the operation is completed, and then suddenly severe hypotension, tachycardia, tachypnea, restlessness, and abdominal distention lead to a diagnosis of intraperitoneal hemorrhage that has actually been developing slowly since surgery. In most cases, a small vessel has been slowly bleeding. Only after a significant blood loss has occurred do changes in the vital signs or symptoms of abdominal distention alert the clinician to a problem. In retrospect, subtle signs of hypovolemia usually have been present. Persistent low blood pressure, low urine output, and a restless, uncomfortable patient will alert the vigilant recovery room or ward staff that a problem is present; the surgeon should be notified. Once again, a surgeon with good leadership and team-building skills should educate nurses and other caregivers responsible for the postoperative care of the patient to be observant for these findings, and they should be encouraged to call too soon rather than too late with any concerns about the patient's postoperative course.

The diagnosis of intraperitoneal bleeding in the postoperative patient can be difficult. Peritoneal signs are subtle and can be masked by incisional pain and analgesic medications. Unfortunately, the initial examination of the abdomen may be quite benign. The peritoneal cavity has an enormous capacity for occult blood loss without appreciable abdominal distention. As much as 3,000 mL of blood (about 65% of the total blood volume of a 70-kg person) can be hidden in the peritoneal cavity, with only a 1-cm increase in the radius of the abdomen. Occult intraperitoneal hemorrhage is even more serious when one considers that the postoperative patient may not have had replacement of all the blood that was lost at the initial operation and may already be hypovolemic when she reaches the recovery room. *Abdominal ultrasound* is a rapid, noninvasive, readily available method of confirming the diagnosis of intraperitoneal bleeding. A rapid, low-tech method of testing for intraperitoneal blood is to insert a long 18-gauge spinal needle into the abdominal cavity in one of the lower quadrants under local anesthesia. This is definitely not a "noninvasive" technique and may not demonstrate intraperitoneal bleeding unless the abdomen is grossly distended. If a patient has experienced an unexpected drop in hematocrit postoperatively but is very stable, an abdominal and pelvic CT scan is another good way to identify (or rule out) intraabdominal hemorrhage or a hematoma (Fig. 19.7).

Sometimes it is difficult for the surgeon who performed the original operation to convince himself or herself that bleeding is persistent and intervention is urgently needed. A consult with a colleague is often helpful. There may be a temptation to blame the coagulation system and look for some defect in clotting factors. A routine coagulation profile, ordered at the first suspicion, or even simple observation of clot formation in a tube of blood at the bedside will eliminate this possibility. However, the experienced surgeon knows that the most common reason for intraperitoneal blood and postoperative shock is loss of surgical hemostasis—a vessel has become disligated. The question now becomes: Should the patient be immediately operated on again to identify and control the bleeding or taken to the radiology suite in an attempt to control the bleeding by embolization? Both techniques are highly effective, and we have generally used the stability of the patient as a guide. For instance, if the patient is unstable with a rapid pulse, falling

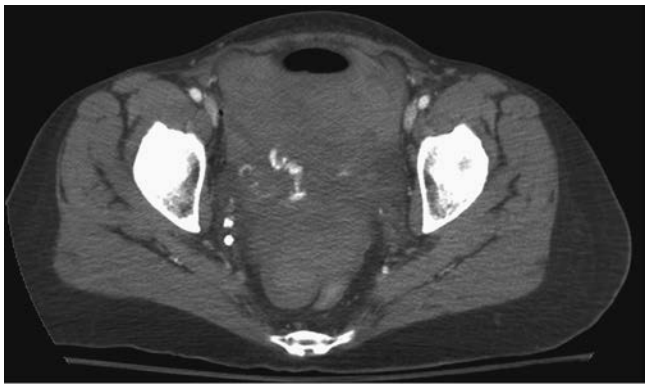

FIGURE 19.7. Axial CT image of the pelvis in a 52-year-old woman who is 5 hours postop from a vaginal hysterectomy. Note the extravasation of contrast from an arterial injection into the right internal iliac artery.

blood pressure, and/or low urine output, or if the interval since surgery is short, suggesting fairly rapid hemorrhage, we would prefer to quickly return to the operating room where we have a team of anesthesiologists and other personnel to monitor the patient, assist with blood replacement, and treat hemorrhagic shock. On the other hand, if the patient is reasonably stable and bleeding does not appear too brisk based on time from surgery and the volume of blood in the abdomen or retroperitoneal space by ultrasound estimate, then it is reasonable to try to identify the bleeding artery and embolize it by transcatheter interventional radiological techniques.

Whichever plan is selected, one or more large-bore intravenous lines should be started, and fluid replacement should begin with packed red blood cells ordered and started as indicated and available. A Foley catheter should be inserted and urine output monitored. Broad-spectrum antibiotics should be started. If the patient is not in the recovery room, she should be transferred there or to a monitored bed with easy access to the operating room. Preop labs should be obtained, and the operating room and anesthesia service should be notified, as well as the interventional radiology team if appropriate.

Arterial Embolization

In 1969, Nusbaum and colleagues described arterial embolization to control bleeding from esophageal varices by selectively cannulating the superior mesenteric artery and infusing small doses of vasopressin into terminal vessels. The subsequent use of particulate matter to achieve hemostasis within bleeding viscera developed rapidly. Selective angiographic arterial embolization has been used to control hemorrhage after abdominal and vaginal hysterectomy and other gynecologic operations, hemorrhage from cervical cancer and gestational trophoblastic disease, postpartum hemorrhage, hemorrhage from abdominal pregnancy, and retroperitoneal hemorrhage. Experience has shown that selective pelvic artery embolization is a comparatively simple and safe procedure. Dramatic results can be seen. Clinical success rates of more than 90% are routinely reported when embolization is used for postsurgical and posttraumatic hemorrhage. Therefore, embolization rather than surgical ligation is appropriately selected as the primary procedure to control bleeding in patients who are stable or who cannot tolerate another operation.

The method of intravascular embolization is quite simple, although it requires the expertise of a skilled interventional radiologist. Percutaneous catheterization of the femoral artery under local anesthesia provides direct access in a retrograde manner to the hypogastric artery (Fig. 19.8). The brachial artery can also be used for access to the vascular system. If prior hypogastric artery ligation has obstructed this pathway, arteriography of the pelvic vasculature through one of the collateral arteries usually localizes the specific bleeding vessel or vessels, although with greater difficulty. The site of bleeding can be accurately identified with angiography and fluoroscopy if the rate of bleeding is 2 to 3 mL per minute or more. The hypogastric artery or the specific collateral vessel is cannulated for injection (Fig. 19.9A–C). A variety of materials can be used for embolization, including small pieces of Gelfoam, metal coils, small Silastic spheres, autologous clot, subcutaneous tissue, and other hemostatic materials. Gelfoam is one of the most practical and easily injected materials. It is sterile, is nonantigenic, remains in the vessel for 20 to 50 days, and forms a fibrin mesh framework on which blood clots can develop. Its immediate effect is to obstruct the distal artery or arteriole and reduce pulse pressure in the bleeding vessel, thereby permitting clot formation and cessation of bleeding. Material is injected under angiographic observation. When it becomes evident by repeat angiography that the bleeding vessel has been occluded, the catheter is removed and the patient is carefully monitored for evidence of further bleeding.

After embolization, patients usually have no complications or evidence of the effects of local ischemia. Those who have not had a hysterectomy will resume normal menstruation. Some patients will exhibit evidence of a mild postembolization syndrome, including pain, fever, leukocytosis resulting from

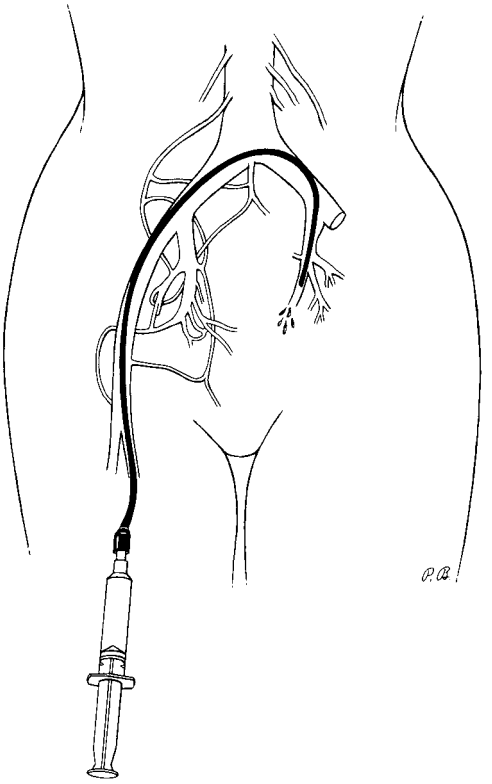

FIGURE 19.8. The femoral artery can be catheterized under local anesthesia to provide access to the hypogastric artery and its branches.

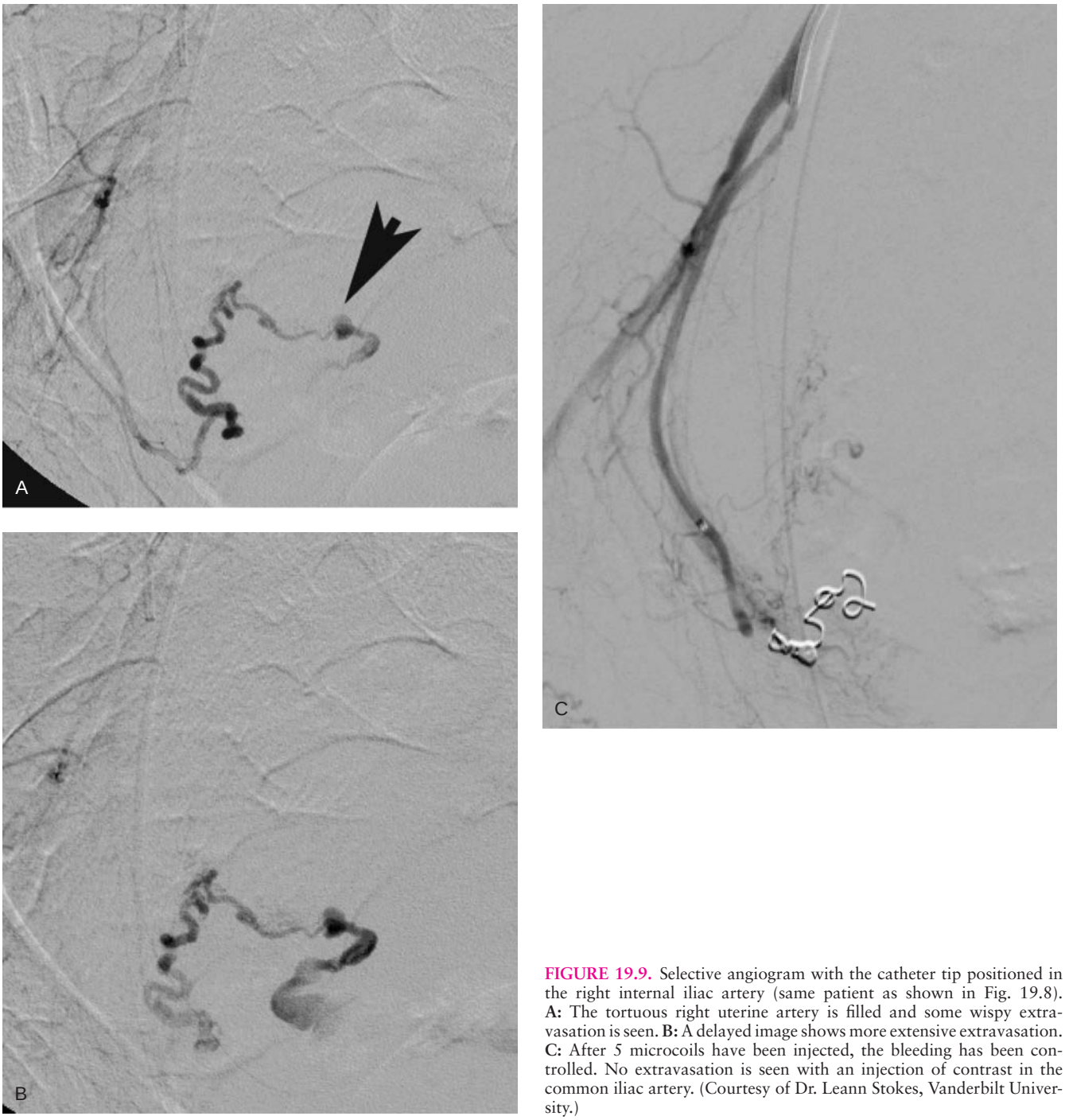

FIGURE 19.9. Selective angiogram with the catheter tip positioned in the right internal iliac artery (same patient as shown in Fig. 19.8). **A:** The tortuous right uterine artery is filled and some wispy extravasation is seen. **B:** A delayed image shows more extensive extravasation. **C:** After 5 microcoils have been injected, the bleeding has been controlled. No extravasation is seen with an injection of contrast in the common iliac artery. (Courtesy of Dr. Leann Stokes, Vanderbilt University.)

vascular thrombosis, and tissue necrosis. A few isolated cases of more serious problems have been reported, including bladder necrosis, vesicovaginal fistula, neuropathies, and renal toxicity from the contrast medium. The overall complication rate should be less than 10%.

Reoperation

If reoperation is selected, the patient should be as stable as possible, with blood running or at least available in the room. Two suctions should be ready and an adequate staff and assistants involved. If the patient has previously had an abdominal operation, the incision should be reopened. A preoperative ultrasound or CT scan should have identified the bleeding as intraperitoneal or retroperitoneal. The previous procedure should be mentally reviewed to identify any possible ligatures that were tentative or any troublesome bleeding sites that may have continued to bleed. When the abdomen is opened, the clots should be evacuated and a search instituted for the bleeding sites, starting with the most likely locations. Care should be taken when removing clots from the pelvic area.

Bleeding sites should be carefully ligated, sutured, or clipped. It is not unusual to reopen the abdomen and find no active bleeding sites. This is somewhat disconcerting because of the concern that the problem will repeat itself after the abdomen is again closed. Every attempt should be made to get the pelvis and abdomen completely dry before closing a second time.

During reoperation, patients are at increased risk of ureteral injury. In addition to exercising care in clamping and ligating bloodstained tissue with distorted anatomy, it may be wise to prove ureteral integrity at the end of the operation. This can be done by injecting 5 mL of indigo carmine dye intravenously and observing efflux of dye from each ureteral orifice through the cystoscope or by opening the bladder dome (see Chapter 38). After reoperation, patients are also at increased risk of developing postoperative complications such as pulmonary atelectasis, abdominal distention from ileus, postoperative infection, incisional complications, and coagulation disorders from multiple transfusions. The anticipation of these complications allows the adoption of measures to prevent or manage them correctly should they occur.

Postoperative hemorrhage from the vaginal vault usually comes from the vaginal artery in the lateral vaginal fornix or from one of its branches. Most often, the lateral vaginal angle, including the vaginal artery, is not properly secured or becomes disligated. To prevent such bleeding, the lateral vaginal angle stitch should be anchored in tissue lateral to the angle so that the angle cannot slip out. This stitch should not be held because traction will loosen it. Excessive vaginal bleeding may be noted in the recovery room or after the patient has returned to her room. Every attempt should be made to establish an objective measurement of the amount of blood lost and to follow vital signs and changes in hematocrit values. One must realize that the vagina is a distensible organ. If a clot occludes the vaginal introitus, a large amount of blood—sometimes several hundred milliliters—can distend the vagina behind it and not be evident on a perineal pad. When significant vaginal bleeding is present, the patient should be examined. Vaginal packing for significant vaginal bleeding is usually ineffective. Sometimes adequate examination can be performed in the recovery room with analgesia, but a return to the operating room for an examination under anesthesia should be used if necessary. The vaginal apex should be inspected. If the bleeding point can be seen, it should be clamped and ligated from below. Figure-of-eight no. 0 or 00 delayed-absorbable transfixion sutures should be placed to include the vaginal mucosa and underlying paravaginal tissue. Care must be taken to avoid the inadvertent placement of a suture into the musculature of the bladder wall, the ureter, or the underlying rectum. If bleeding is not controlled by this technique, it is unwise to continue to add suture on suture in a frantic effort to control the vaginal bleeding. In such cases, it is probable that the bleeding vessels have retracted well above the vaginal apex and cannot be reached by this approach.

If surgical hemostasis cannot be achieved transvaginally, laparotomy may be necessary. A vaginal pack will not control significant bleeding from the vaginal vault that has already required a return to the operating room, although a temporary pack may slow the blood loss while the patient is prepared for laparotomy. In some patients, the hemorrhage will be delayed until 10 to 14 days after surgery, when the sutures lose their tensile strength. Posthysterectomy disruption of the vaginal vault with hemorrhage also can result from coitus.

Bleeding from anterior and posterior colporrhaphy usually is from veins that have not been secured. In this situation, a fairly tight vaginal pack effectively compresses these vessels and controls the bleeding. It seldom is necessary to reexplore an anterior or posterior colporrhaphy to locate and ligate a specific bleeding vessel. The patient will feel an uncomfortable sensation of urgency of urination that will be relieved when the pack is removed in 24 to 48 hours. A Foley catheter will be needed while the pack is in place.

A *postoperative pelvic hematoma* can cause serious morbidity, especially if it is large and becomes infected. Hematomas can develop above the vaginal vault, along the pelvic sidewall, in the retroperitoneum extending up to the kidneys, in the paravesical space, in the abdominal wall, and in the ischiorectal fossa and vulva. A hematoma in the ischiorectal fossa and on the vulva may be obvious on examination when the patient reports discomfort in the area. If it is below the puborectalis muscle attachment to the vagina, it will not dissect into the pelvis above but will be limited to the perineum and buttocks. A pelvic hematoma may be recognized in a patient whose postoperative discomfort and anemia exceed what is normally expected, whose temperature is progressively increasing, and whose postoperative abdominal distention is slow to resolve. If a patient is on anticoagulant therapy, even simple coughing can spontaneously cause a tremendous postoperative pelvic hematoma. Abdominal and pelvic examinations may reveal a mass. A definitive diagnosis can be made by ultrasound or CT scan, which is helpful in delineating its exact size and location. An extended, morbid, and complicated postoperative course may be alleviated if a large hematoma can be drained. Sometimes simple drainage through the vaginal vault can be accomplished by probing with a uterine dressing forceps. A small Penrose drain can be inserted through the drainage tract and left in place for a day or so. If drainage cannot be achieved in this simple way, drainage with guidance of CT or through an abdominal incision may be necessary. In our experience, if a large hematoma can be drained, the patient's recovery will be expedited. But in some cases, drainage is difficult or contraindicated and infection is not present. In such a patient, it may be preferable to allow the hematoma to gradually resolve over a few months. Unfortunately, sometimes a hematoma will not resolve completely, and residual fibrosis will persist and continue to cause pain. We have removed large pieces of an organizing hematoma as late as 1 year after operation. For these reasons, we prefer to drain pelvic hematomas initially whenever possible.

There are a few other special circumstances. *Hemorrhage after uterine curettage* is extremely rare, even with perforation of the uterus. The perforation is usually caused by the uterine sound and occurs through the corpus. Under most circumstances, the curettage should be stopped and the patient's vital signs checked for several hours. It is extremely unlikely that any problem will develop, and overnight hospital admission as a precautionary measure may be unnecessary. However, if the perforation was caused by a wide, blunt instrument (such as a curette or a suction device), if the uterus is pregnant or contains cancer, or if fatty tissue appears in the curettage specimen, then overnight observation should be considered and the patient closely observed for intraperitoneal bleeding or a broad ligament hematoma. Ultrasound, CT scan, or laparoscopy also may be performed in high-risk cases to assess the damage and determine if a hematoma or active bleeding is present. A misdirected curette can lacerate the uterine artery and vein, with subsequent intraperitoneal bleeding or broad ligament hematoma formation. In such cases, laparotomy or laparoscopy should be considered to evaluate and control the bleeding and evacuate the hematoma. A hysterectomy may or may not be necessary, depending on the damage to the uterus.

Hemorrhage from cervical conization can occur in the first 24 hours or 7 to 14 days later, when cervical sutures lose their tensile strength. If the patient is bleeding heavily at any time after conization, the cervix should be inspected. Measures to control the bleeding include resuturing, cautery, and Monsel's solution. If bleeding is not profuse, Monsel's solution, Gelfoam, and/or a small pack can be tried. In taking the conization specimen, one must be certain that the apex of the cone intersects the endocervical canal. If the cervical incision is misdirected to one side or the other, the uterine vessels are in danger of laceration. Serious hemorrhage or broad ligament hematoma may result. To prevent this problem, the cervix should first be sounded to ascertain the direction of the endocervical canal and the incision planned accordingly.

SUMMARY

Careful preoperative evaluation of the patient and thoughtful preoperative planning on the part of the surgeon and surgical team will help prevent or minimize significant operative blood loss. However, intraoperative or postoperative hemorrhage does occur from time to time and represents a significant challenge to the technical skill and the emotional control of the surgeon. He or she must take charge of the situation, organize a plan to control the bleeding, instruct and motivate the other members of the surgical team, and, finally, execute the technical steps necessary to obtain hemostasis. Each part of this approach is important. We hope that the ideas and techniques discussed in this chapter will make the reader more prepared to meet this challenge.

BEST SURGICAL PRACTICES

- Preparation to prevent and control operative bleeding starts before the surgical procedure. The patient should be thoroughly evaluated for risk factors that may increase the possibility of hemorrhage. Congenital and acquired coagulation disorders need to be diagnosed by a careful and thorough history and appropriate lab tests. The problem to be treated surgically should be thoughtfully considered and the surgical approach devised, adjusted, or modified to suit the patient, her lesion, and the abilities of the surgical team. Preoperative consultations with other specialists should be sought if indicated. The medical conditions of the patient should be optimized.
- The possibility and risks of blood transfusion should always be discussed with the patient as part of informed consent before surgery. The risk of a febrile reaction to transfusion is approximately 1%. Transmission of hepatitis B via transfusion occurs about 1 in every 180,000 transfusions, whereas the risk of HIV transmission with modern blood banking procedures is approximately 1 in 1.9 million.
- During the operative procedure, the surgical approach should be well planned, and possible problems and their management should be considered. Good exposure, proper use and awareness of the anatomy, and careful dissection, clamping, and suturing are all important technical skills that will reduce the risk of uncontrolled hemorrhage. Finally, and perhaps most importantly, good surgical judgment must be used to reduce risk and obtain the best outcome for the patient.
- When life-threatening intraoperative hemorrhage occurs, the surgeon should control the bleeding by pressure and organize and lead the operative team in the complex task of identifying and controlling the hemorrhage. This is one of the most challenging of all emergencies and requires leadership, judgment, knowledge, and technical skill.
- When intraoperative blood loss exceeds 15% of the patient's blood volume (about 500–1,000 mL), transfusion should be considered. The patient's medical history, her vital signs, the probability of additional blood loss, and response thus far will all determine how quickly transfusion is initiated. Packed red blood cells or other appropriate blood components should be used for transfusion rather than whole blood.
- Hematocrit and coagulation factors—as well as serum calcium, electrolytes, and glucose—should be followed every 120 minutes or after 10 U of transfusion. Although it is best to use actual serum levels of coagulation factors, as a rough guide, after every 6 to 8 U of packed red cells, 2 U of *fresh frozen plasma* should be given. If fibrinogen levels fall below 100 mg/dL, 20 U of *cryoprecipitate* should be given. A bolus of *6 U of platelets* should be given if the platelet count falls below 100,000 and the patient is actively bleeding.
- The pelvic surgeon should be able to use special techniques such as packing, thrombotic agents, and hypogastric artery ligation and know their indications for the control of pelvic hemorrhage.
- Postoperative bleeding may be difficult to diagnose. Attentive and well-trained recovery room and ward nursing personnel are essential. Abdominal and pelvic ultrasound and/or CT scanning are very helpful in making the diagnosis of postoperative bleeding and localizing the site of bleeding.
- Embolization of arterial bleeders by interventional radiology techniques and reoperation are both effective techniques to manage postoperative hemorrhage. When the patient is relatively stable and an experienced interventional radiology team is available, embolization is generally preferred today because it is associated with less morbidity.

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