Chapter 20 – Bleeding during Endoscopic Sinus Surgery

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Bleeding during endoscopic sinus surgery is generally minor and rarely precludes completion of the operation. Bleeding from the mucosa is increased in the presence of inflammation and in revision cases. This bleeding is usually effectively controlled with removal of the diseased tissue, selective electrocautery, application of hemostatic material, and hot-water irrigation.[1–4] The use of powered instrumentation (microdébrider) facilitates visualization when bleeding from the mucosa is excessive. Abnormal bleeding may also reflect an underlying coagulopathy, most commonly the effect of antiplatelet medications.

Injury to vessels that supply the mucosa of the nasal cavity can result in significant blood loss but is generally readily controlled with electrocautery or ligature (placement of hemoclips) of the vessel. Transection of the anterior ethmoid artery can result in retraction of the end of the vessel into the orbit with resultant orbital hematoma (see Chapter 19). Injury to the posterior nasal branch of the internal maxillary artery occurs frequently when sphenoidotomy is performed but is readily controlled with electrocautery. Rarely, delayed bleeding from this vessel may occur as long as several weeks after surgery.

The most dreaded complication of sinus surgery is injury to the internal carotid artery (ICA). Potential risk factors include abnormal or distorted anatomy, poor visualization, greater extent of surgery, and limited experience of the surgeon. There is a significant risk of permanent neurologic morbidity and death from an unanticipated injury to the ICA. Vascular injury can be avoided with a thorough knowledge of sinus anatomy and good surgical technique. The use of intraoperative navigation (image guidance) may also decrease the risk of inadvertent injury, especially in more complex sinus surgery.

An endoscopic sinus surgeon should be skilled in various hemostatic techniques and be prepared to deal with vascular emergencies, including injury to the ICA.

ANATOMY

The nasal cavity and paranasal sinuses have a rich blood supply derived from branches of the external and internal carotid arteries. Terminal branches of the external carotid artery include the sphenopalatine, posterior nasal, and superior labial arteries. The superior labial artery supplies the anterior nasal septum and anastomoses with other arterial branches at Kiesselbach's plexus (Little's area). The sphenopalatine and posterior nasal arteries are terminal branches of the internal maxillary artery and exit the sphenopalatine foramen at the posterior attachment of the middle turbinate (Fig. 20-1). The sphenopalatine foramen is situated at the posterior superior corner of the maxillary sinus. In many cases the sphenopalatine and posterior nasal arteries branch proximal to the sphenopalatine foramen and exit through separate foramina.[5] The sphenopalatine artery sends branches along the turbinates of the lateral nasal wall, and the posterior nasal artery crosses the anterior surface of the sphenoid sinus at its inferior margin to supply the posterior nasal septum. Terminal branches of the ICA include the anterior and posterior ethmoid arteries. The anterior ethmoid artery crosses the roof of the nasal cavity posterior to the nasofrontal recess and is located in a coronal plane that is tangential to the posterior surface of the globe (Fig. 20-2). The position of the posterior ethmoid artery is more variable, but it is usually found crossing the roof of the ethmoid anterior to the sphenoid sinus approximately 4 to 7 mm anterior to the optic nerve canal.

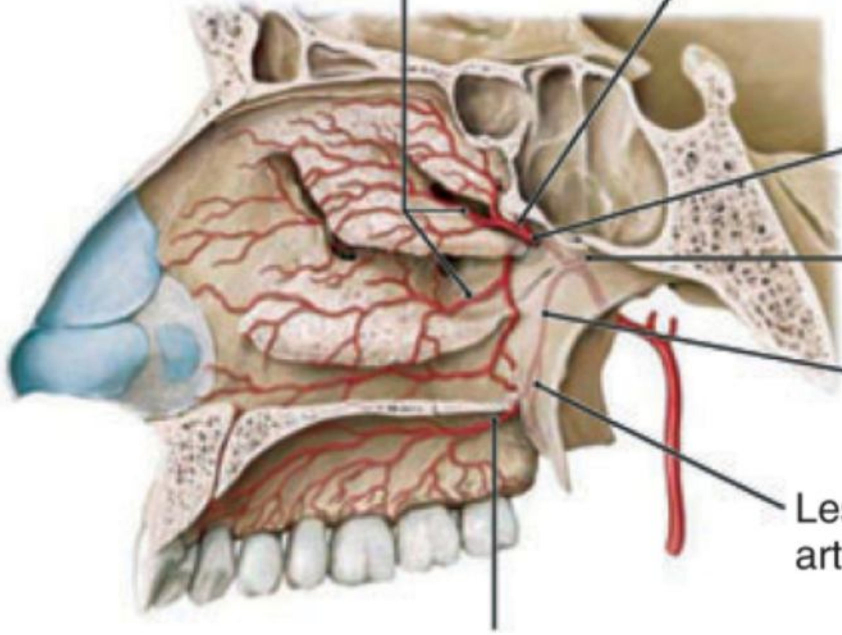

Figure 20-1 The sphenopalatine and posterior nasal arteries exit the sphenopalatine foramen at the posterior attachment of the middle turbinate.

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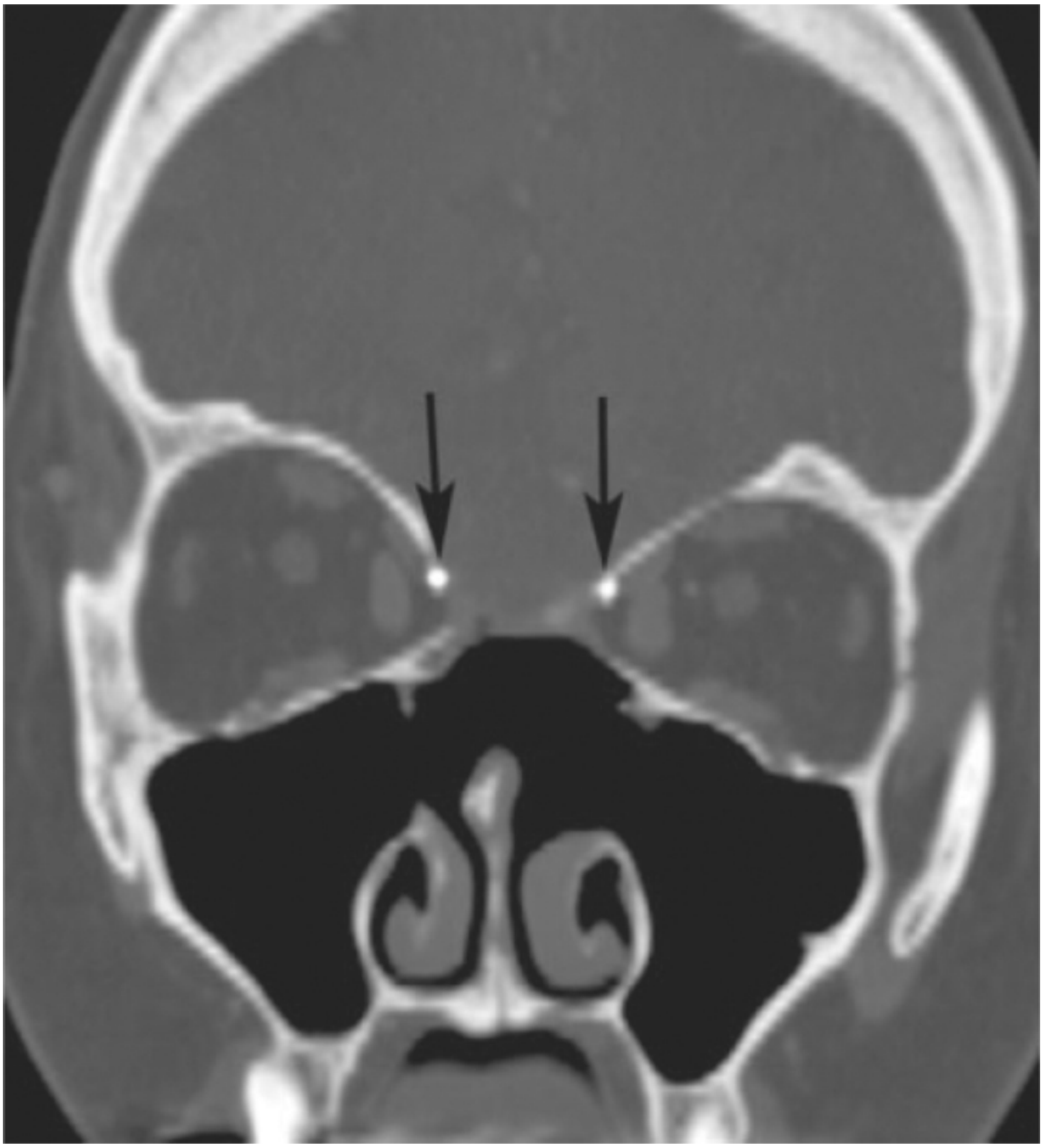

Figure 20-2 Coronal computed tomography scan after endoscopic skull base surgery with ligation of the anterior ethmoid arteries (metal hemoclips, *arrows*).

The course of the ICA is usually apparent in a well-pneumatized sphenoid sinus. When lateral septations are present, they invariably lead to the ICA, which may be dehiscent in a small percentage of cases (Fig. 20-3). The petrous portion of the ICA turns vertically at the second genu to form the paraclival ICA and is in line with the medial pterygoid plate. The vidian artery and the pterygoid canal are useful landmarks for locating the second genu of the ICA when removal of pterygoid bone is necessary (Fig. 20-4). The vertical segment of the ICA continues into the cavernous segment, where it courses lateral to the optic nerve. The lateral optic-carotid recess separates these structures and represents pneumatization of the anterior clinoid (Fig. 20-5). The medial optic-carotid recess is less apparent but is of greater significance because the ICA deviates medially here before it courses behind the optic nerve and is at greater risk of injury.

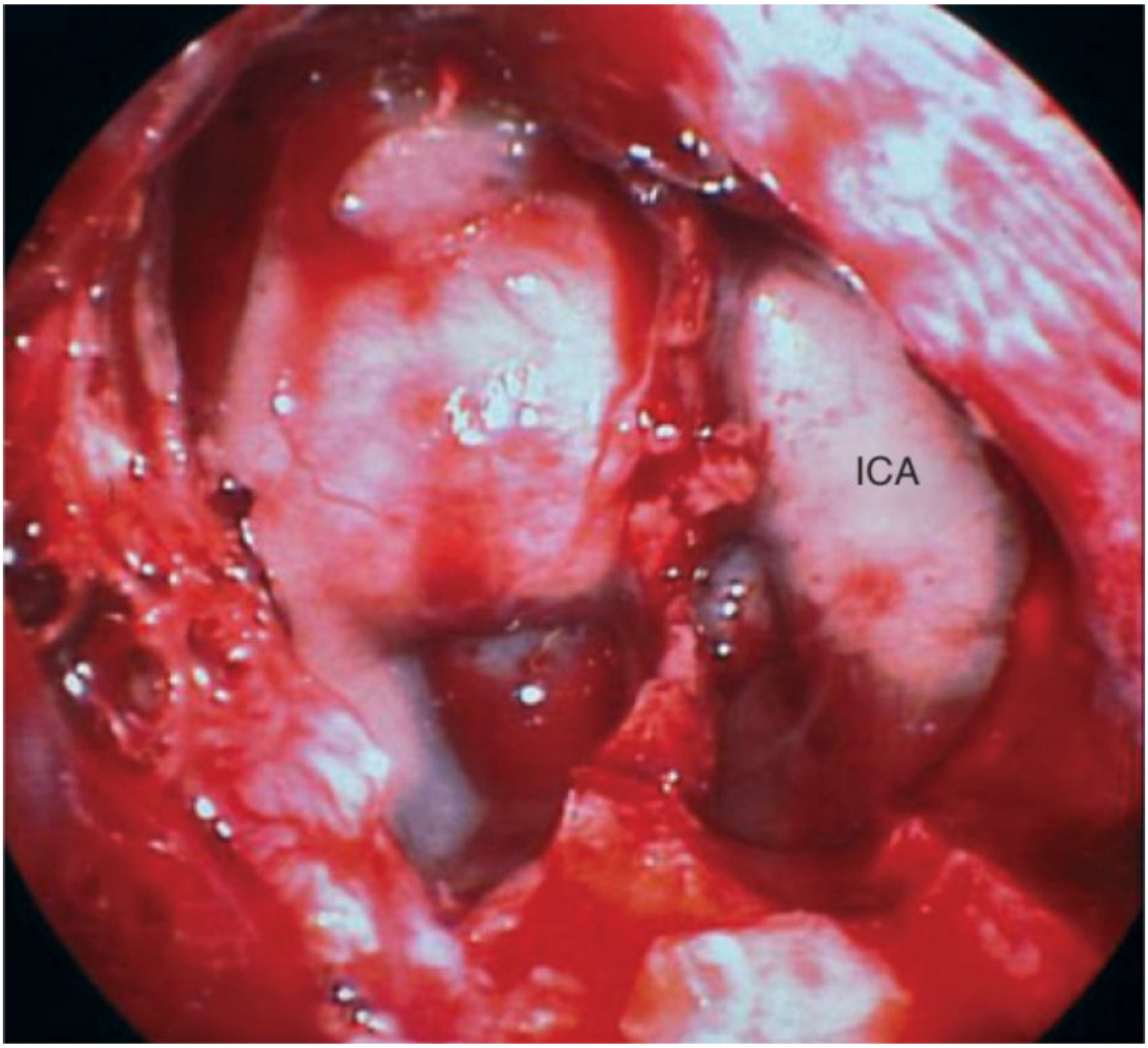

Figure 20-3 Endoscopic sphenoidotomy with a left lateral septation deviating toward the left internal carotid artery (ICA).

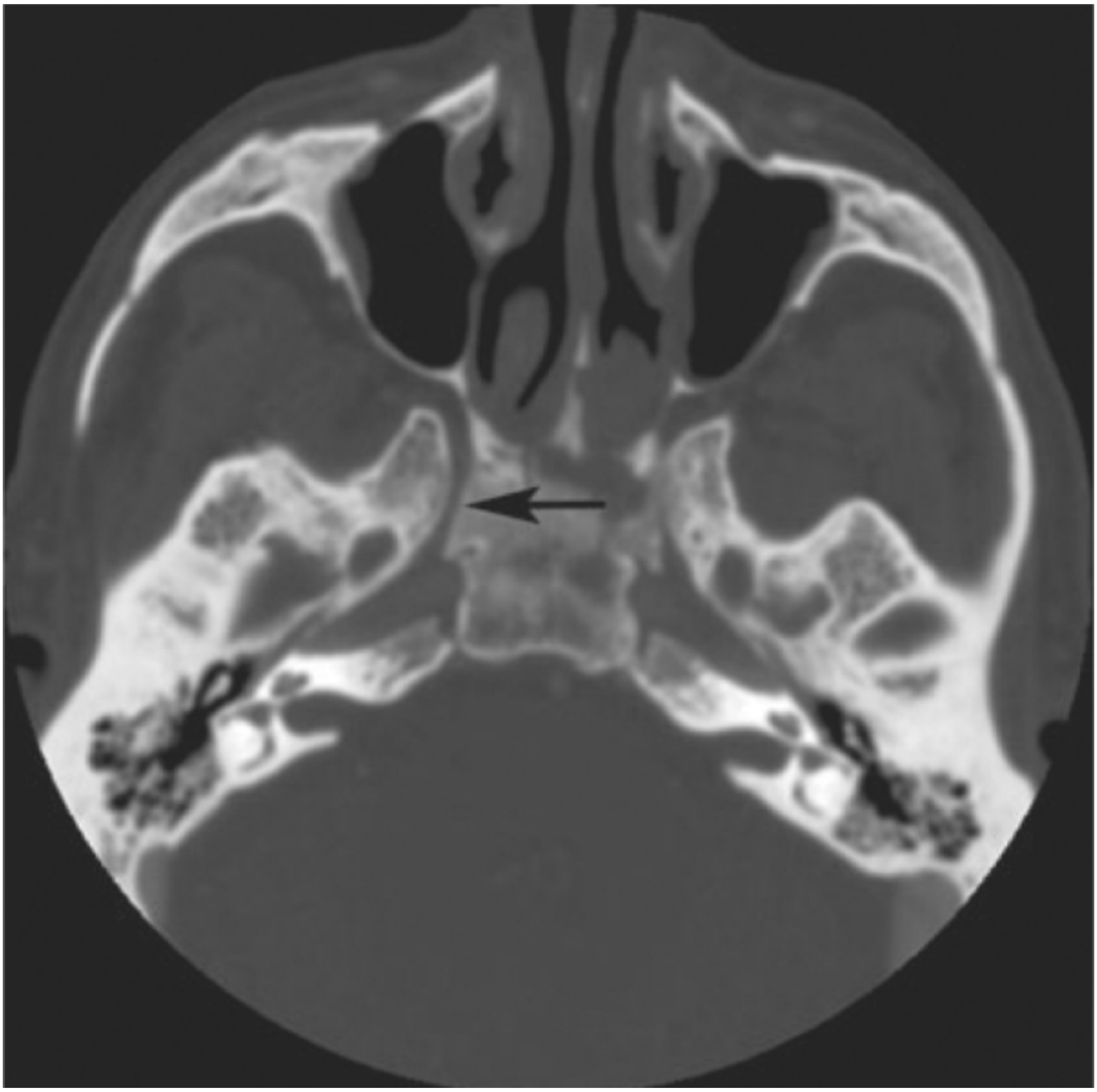

Figure 20-4 The vidian artery and pterygoid canal *(arrow)* are important landmarks for locating the second genu of the internal carotid artery.

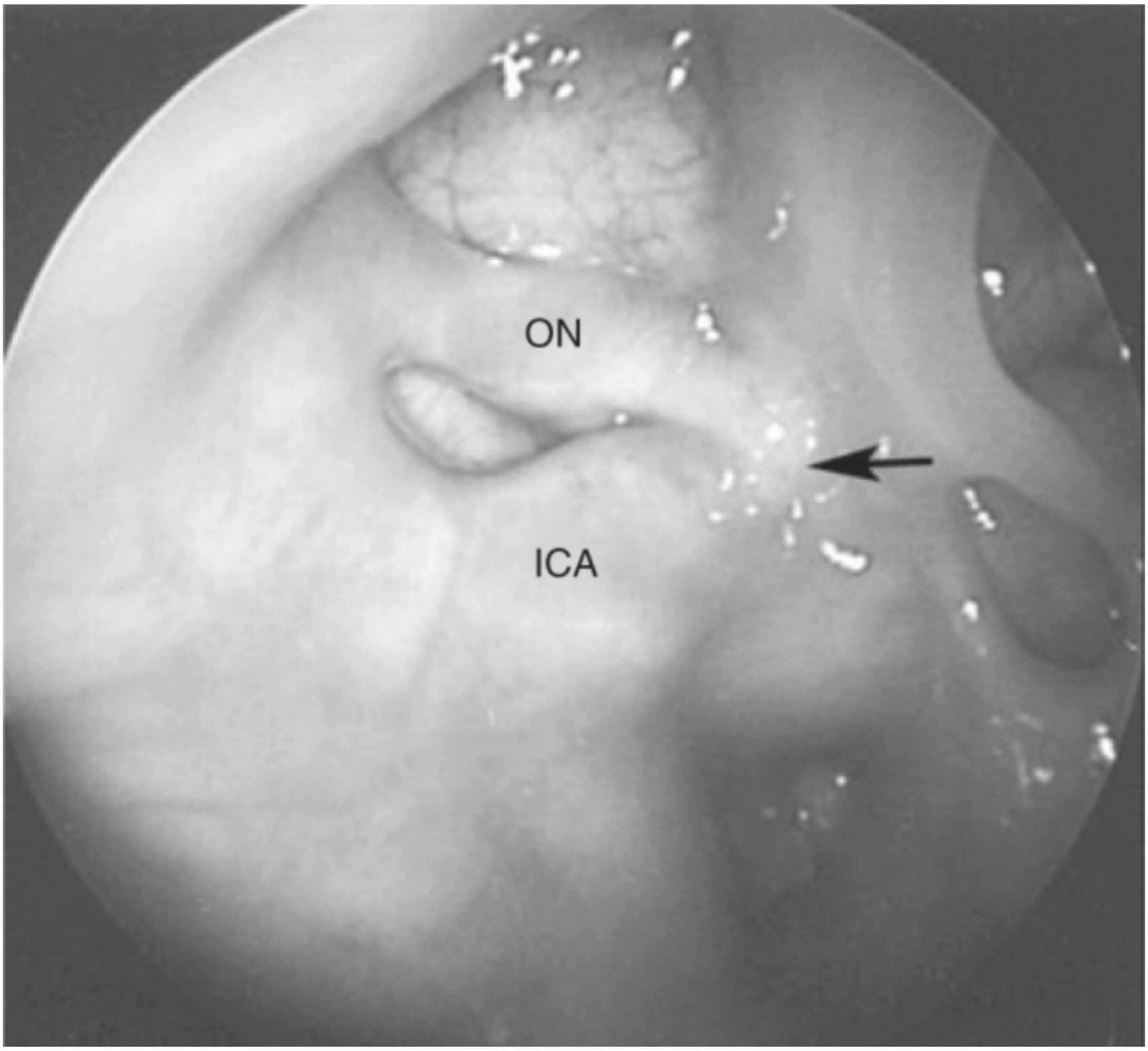

Figure 20-5 Endoscopic view (cadaveric dissection) of the right lateral optic-carotid recess with a prominent optic nerve (ON) and internal carotid artery (ICA) canal. Note how the internal carotid canal turns medially at its junction with the optic nerve *(arrow).*

PATIENT SELECTION

Indications for endoscopic sinus surgery include inflammatory and neoplastic conditions. Acute infectious problems include sinusitis associated with severe pain, sinusitis in an immunocompromised host, or sinusitis associated with an orbital or intracranial abscess. The goal of surgery performed for nasal polyposis is to primarily improve the airway, but it may also relieve sinus obstruction and have a secondary benefit on pulmonary function in patients with asthma. In patients with chronic sinusitis, surgery is designed to relieve irreversible sinus obstruction. Other non-neoplastic conditions include expansile mucoceles and approaches for orbital (Grave's exophthalmos, optic nerve decompression after trauma) and skull base (meningocele, cerebrospinal fluid [CSF] leak) conditions. Neoplastic conditions include both benign and malignant neoplasms of the sinonasal cavity and cranial base.

Before surgery, patients should be screened for a history of a bleeding diathesis, and all medications with antiplatelet properties should be stopped at least 1 week before surgery if possible. Depending on the underlying condition, patients taking warfarin (Coumadin) may need to have their medication switched to intravenous heparin before surgery.

Patients who have undergone any type of surgery should be questioned about bleeding as a complication of surgery. In the presence of a positive history of operative bleeding, previous operative reports should be reviewed for details regarding the extent of surgery and bleeding problems encountered.

PREOPERATIVE EVALUATION

Imaging studies should be reviewed before surgery to assess the extent of disease, gather evidence of previous surgery, and look for anatomic variations. Anatomic landmarks to identify on computed tomography include the level of the cribriform plate relative to the roof of the ethmoid sinus, the degree of pneumatization of the sphenoid sinus, lateral sphenoid septations, and a dehiscent or aberrant ICA. Rarely, the carotid canal may be dehiscent from a previous surgical misadventure.

If the ICA is at significant risk for injury during surgery because of the extent of the pathology and the planned procedure, collateral intracranial circulation can be assessed preoperatively with a balloon occlusion test. This test will provide useful information regarding the risk for a major neurologic event if the artery needs to be sacrificed. Such information may alter the surgical plan.

PREOPERATIVE PLANNING

Routine hematologic tests of coagulation and platelet function are not necessary in patients without a personal or family history suggestive of a coagulopathy. In patients with a history of significant bleeding at the time of previous endoscopic sinus surgery, angiography of the ICA may be indicated to rule out a pseudoaneurysm (Fig. 20-6). The time interval since previous surgery is not relevant because delayed rupture of a pseudoaneurysm of the ICA can occur as long as several years after the injury.

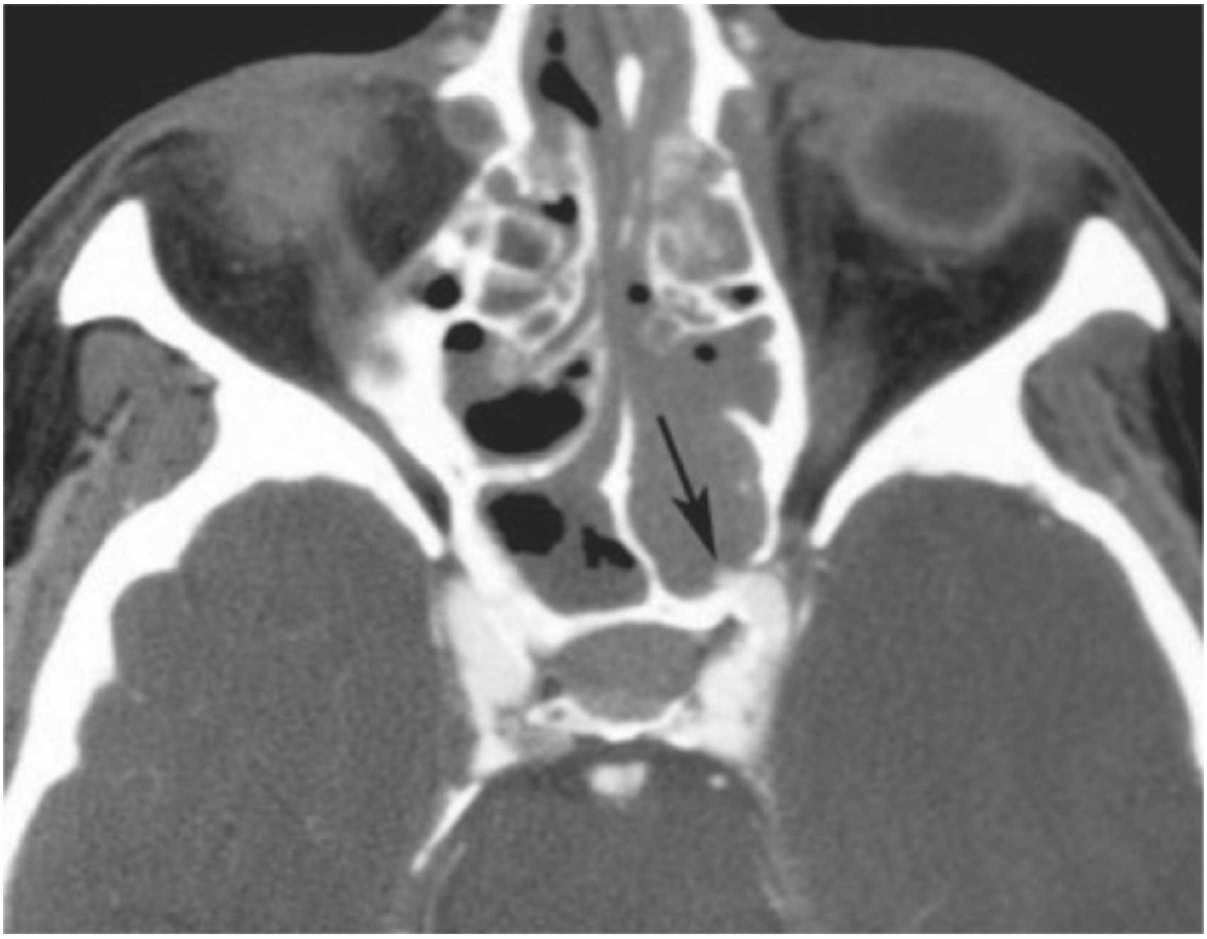

Figure 20-6 A computed tomographic angiogram of a patient referred after endoscopic sinus surgery complicated by profuse hemorrhage demonstrates a pseudoaneurysm of the internal carotid artery *(arrow).*

If injury to the ICA during surgery is anticipated,[6] a femoral sheath can be placed at the time of the balloon occlusion test and left in place during surgery. If a vascular injury occurs, a balloon catheter can be floated up to the site of injury under fluoroscopy and be used to occlude the ICA temporarily until more definitive care can be provided. Intraoperative neurologic monitoring of cortical function is performed when dissection in proximity to the ICA is expected.

SURGICAL APPROACHES

Most bleeding complications of endoscopic sinus surgery are dealt with at the time of surgery.[7] Bleeding from a transected anterior ethmoid artery requires visualization of the anterior ethmoid air cells and the nasofrontal recess. Medial orbital decompression (see Chapter 95) may be necessary to provide access to the proximal end of the vessel for ligation. Ligation of the sphenopalatine and posterior nasal arteries is performed endoscopically via a middle meatal antrostomy. Exposure of an injured ICA requires an endoscopic transpterygoid approach if focal packing does not adequately control the bleeding until the patient can be transported to the interventional radiologist.

Ligation of the Anterior Ethmoid Artery

An anterior ethmoidectomy is performed with exposure of the nasofrontal recess (see Chapter 12). The anterior ethmoid artery can usually be visualized crossing the skull base just posterior to the nasofrontal recess. If intraoperative navigation is available, the location of the artery can be ascertained by finding a coronal plane tangential to the posterior surface of the globe (see Fig. 20-2). The bony canal of the artery travels in a slightly posterior-to-anterior direction as it courses medially and is often dehiscent. If active bleeding is noted, it can be controlled with bipolar electrocautery (pistol grip design). Monopolar electrocautery in this region is discouraged because of its proximity to the brain. Unroofing of the canal is not performed because of the risk of injury to the dura and subsequent CSF leak, especially at the thin bone of the lateral lamella of the cribriform plate.

If the proximal end of the vessel cannot be adequately cauterized or if it retracts into orbital tissues, medial orbital decompression is performed to ligate the vessel. The thin bone of the lamina papyracea is fractured with a Cottle elevator and then elevated and removed from the underlying periorbita to the level of the skull base. If laceration of the periorbita occurs and herniated orbital fat obstructs the view, it can be shrunk with the judicious use of bipolar electrocautery. The periorbita is then elevated from the roof of the orbit superior to the plane of the skull base anterior and posterior to the anterior ethmoid artery. Tenting of the vessel is observed at its exit from the orbit (Fig. 20-7). A hemoclip (small or medium) is placed across the vessel on the orbital side of the bone with a flat adjustable hemoclip applier (see Video 20-1).

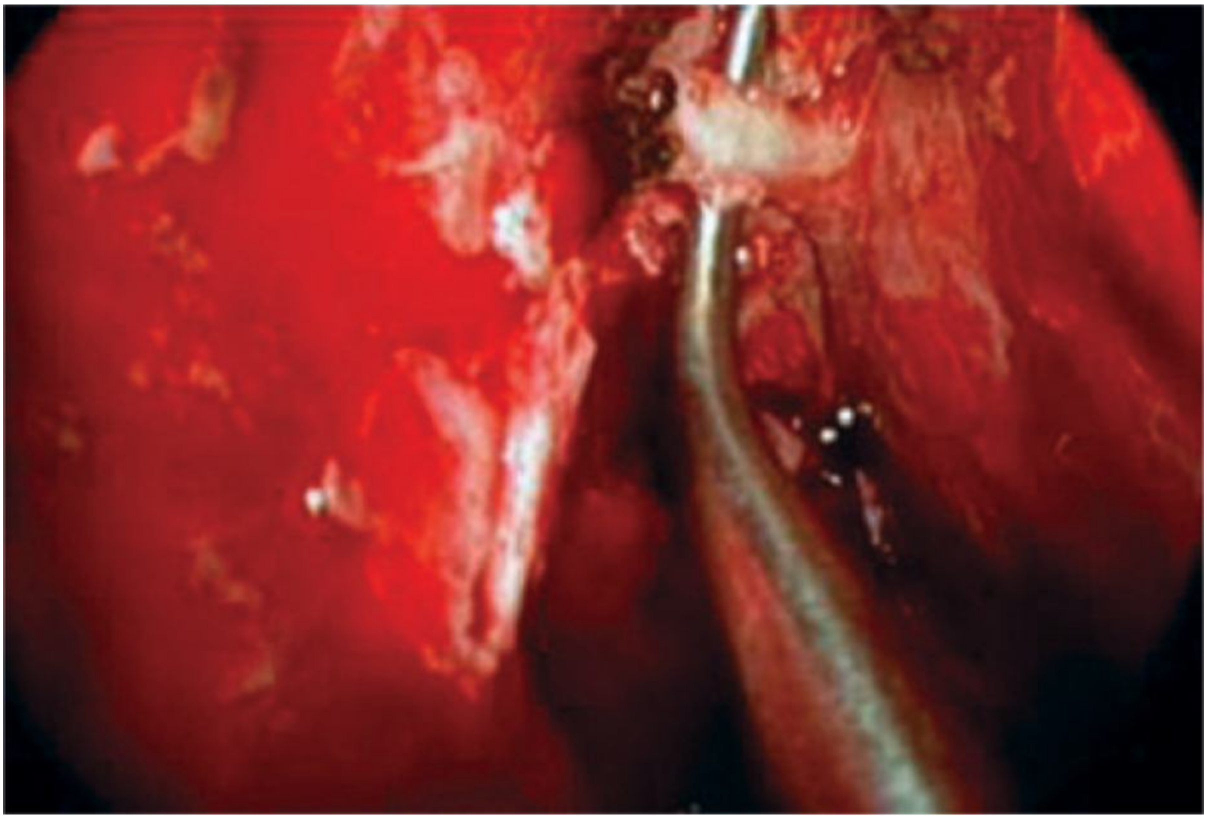

Figure 20-7 The anterior ethmoid artery can be isolated and ligated at the point where it crosses from the orbit to the cranial base after removal of the medial wall of the orbit (left side).

If ligation of the posterior ethmoid artery is necessary, it is approached in a similar manner after posterior ethmoidectomy and sphenoidotomy. The vessel diverges from the anterior ethmoid artery and travels in an anterior-to-posterior direction as it courses medially across the skull base.

Ligation of the Sphenopalatine and Posterior Nasal Arteries

Middle meatal antrostomy is performed (see Chapter 7) to identify the sphenopalatine foramen, as well as to provide extra space for instrumentation.[8,9] The antrostomy is enlarged posteriorly and inferiorly until it is flush with the posterior wall of the maxillary sinus (Fig. 20-8). The mucoperiosteum of the lateral nasal wall is elevated with a Cottle elevator at the posterior margin of the antrostomy, starting inferiorly and sweeping superiorly (Fig. 20-9). If the artery is approached directly, it is more difficult to identify and there is greater risk of direct injury to the vessel. The sphenopalatine foramen is located at the posterior-superior corner of the maxillary sinus at the posterior attachment of the middle turbinate (Fig. 20-10). A small triangle of bone (crista ethmoidalis) usually projects medially just superficial to the foramen. A suction elevator facilitates dissection when bleeding is present. Alternatively, a 7F Frazier suction can be used as a dissector.

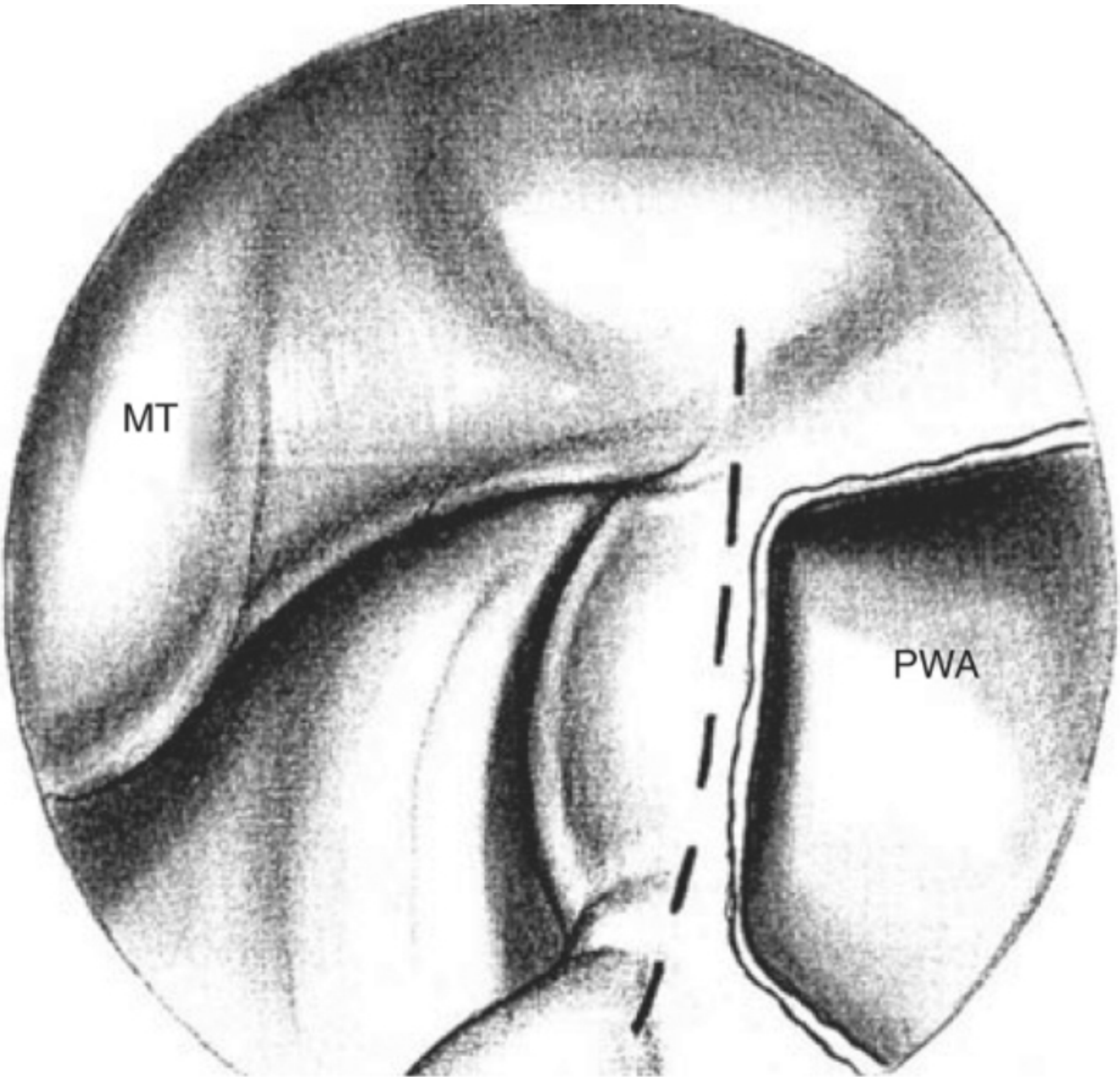

Figure 20-8 Middle meatal antrostomy is performed to provide optimal visualization and room for instrumentation.
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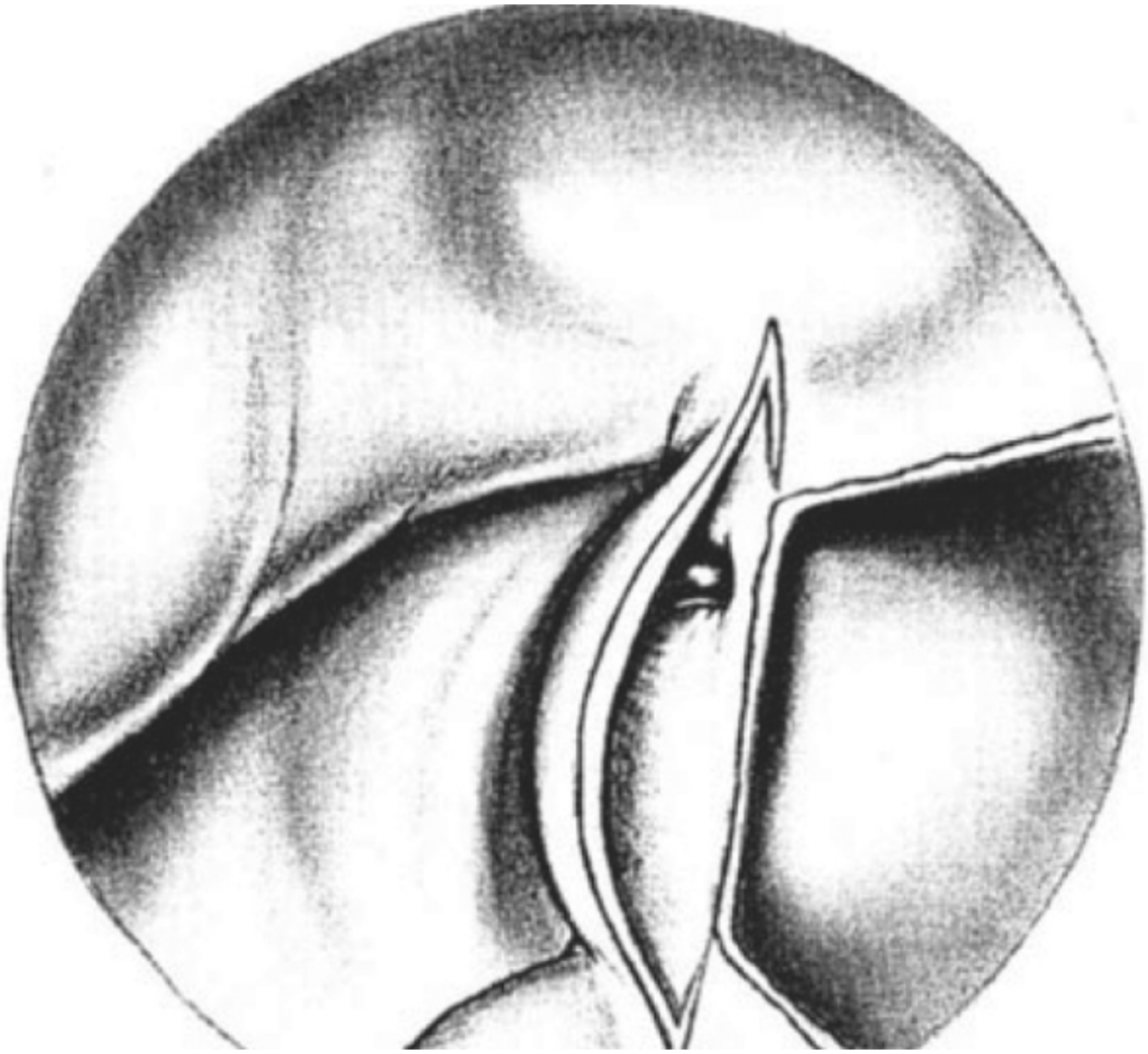

Figure 20-9 The mucoperiosteum at the posterior margin of the antrostomy is elevated to identify the sphenopalatine foramen.
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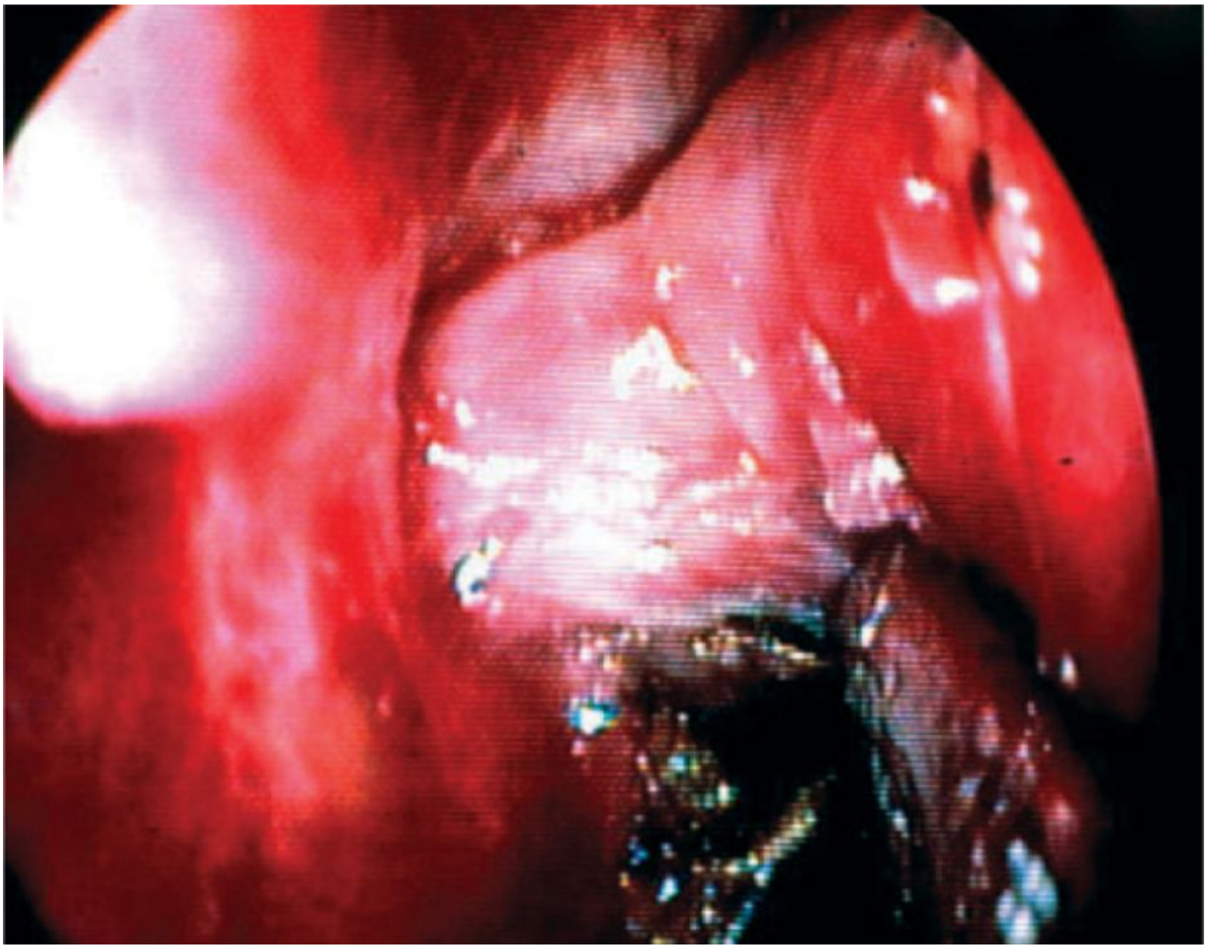

Figure 20-10 Vessels are seen exiting the right sphenopalatine foramen.

Once the foramen is identified, the overlying bone is removed with a 1-mm angled Kerrison rongeur (Fig. 20-11). The use of larger rongeurs increases the risk of additional injury to the vessel. Approximately 1 cm of bone is removed to expose the proximal sphenopalatine vessel in the pterygopalatine space. This is done to identify proximal branching of the vessel and to create more room for instrumentation. Blunt dissection of the proximal vessel and its branches can be performed with Montgomery hooks or similar instruments (Fig. 20-12). Medium-size hemoclips are then placed across the main trunk and its two distal branches with a flat adjustable hemoclip applier (Fig. 20-13).

Figure 20-11 The foramen is enlarged with rongeurs to expose the main trunk of the sphenopalatine artery in case there is proximal branching.

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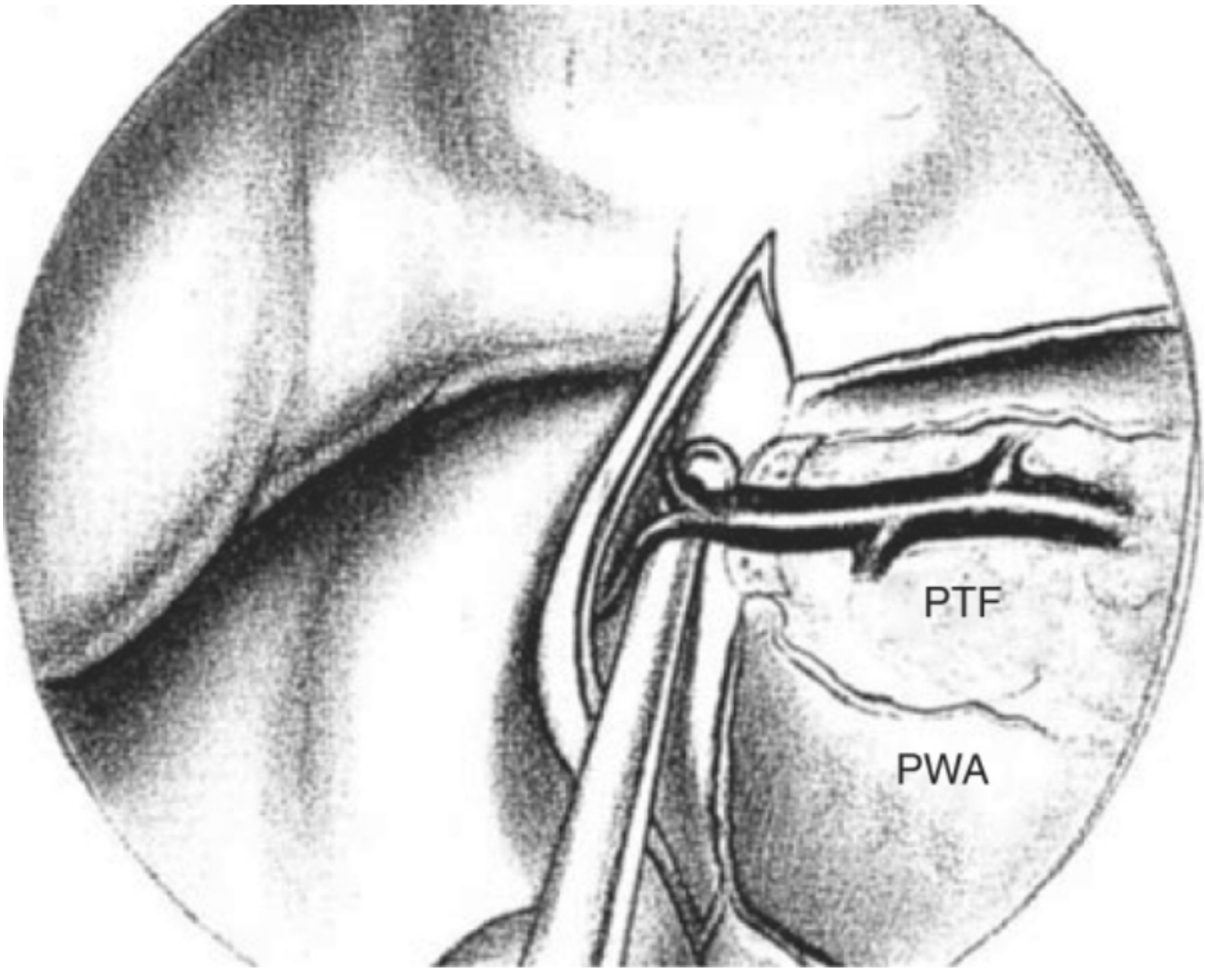

Figure 20-12 The distal vessels are dissected with blunt hooks.
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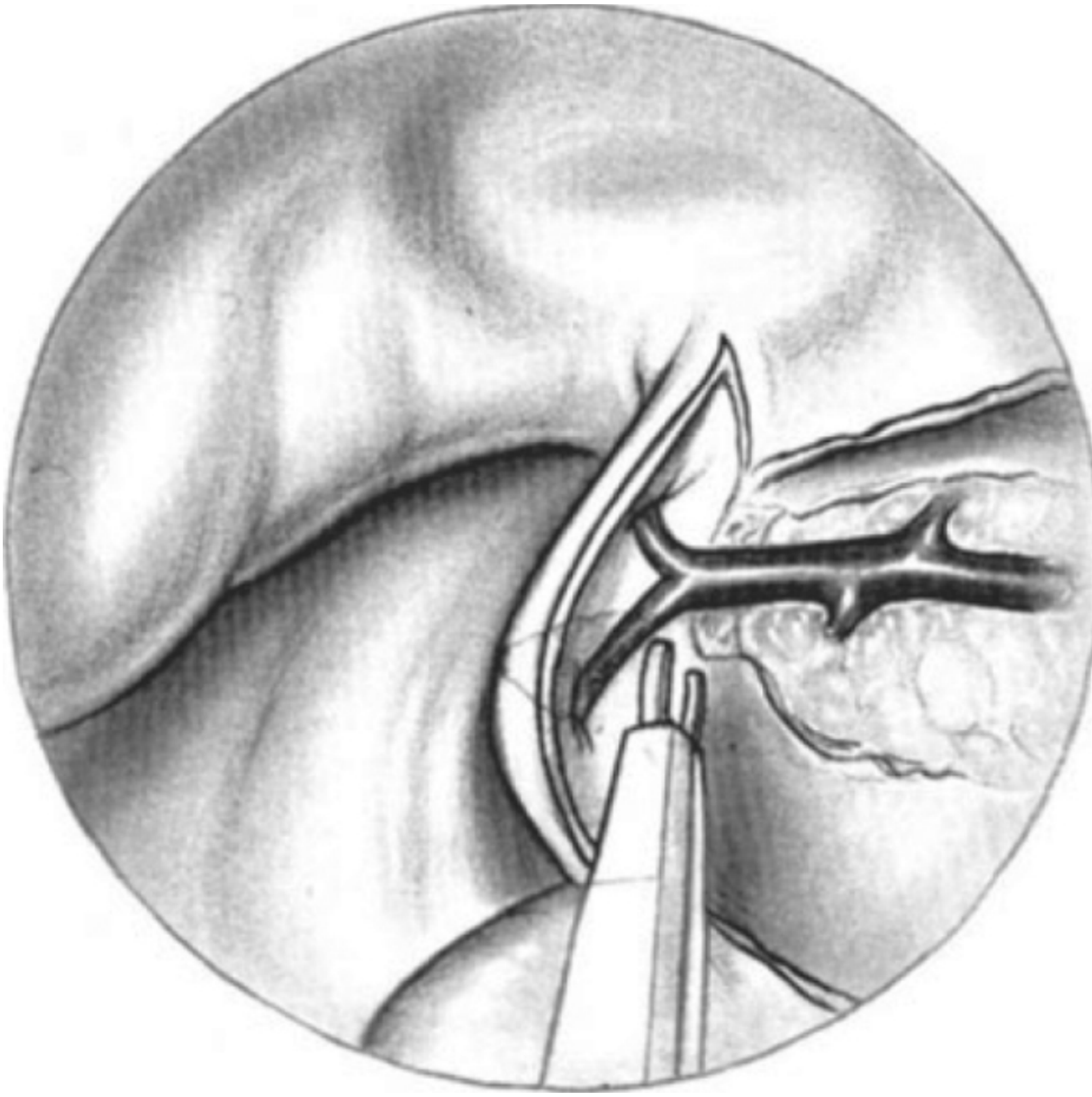

Figure 20-13 The vessels are ligated with medium-size hemoclips via an endoscopic clip applier.
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Exposure of the Petrous Internal Carotid Artery

Most injuries to the ICA occur in the sphenoid sinus along its vertical segment. In the event of an injury to the ICA, direct repair is not feasible and packing should be placed in the sphenoid sinus to control hemorrhage. The choice of packing material is not a critical factor inasmuch as a multitude of biologic and inorganic materials have been used successfully. In the absence of intracranial communication, there is time to transport the patient to the radiology department for assessment and occlusion of the artery by the interventional radiologist. If a breach of the skull base has also occurred, there is a significant risk of blood tracking intracranially with potentially disastrous consequences. In such a situation, it is desirable to expose the ICA more completely so that it can be focally occluded. This is best performed by an experienced team of endoscopic skull base surgeons.

A transpterygoid approach is used to expose the petrous portion of the ICA proximal to the site of injury.[10,11] A large middle meatal antrostomy is performed and the sphenopalatine and posterior nasal arteries are cauterized and transected as already described. The sphenoidotomy is enlarged inferolaterally so that the walls of the sphenoid sinus can be visualized (Fig. 20-14). The contents of the pterygopalatine space are elevated from the underlying pterygoid bone and displaced laterally. The vidian artery and nerve are identified at the pterygoid canal along the inferolateral aspect of the sphenoidotomy. The bone inferior and medial to the vidian artery is drilled with a 3-mm hybrid diamond bit until the plane of the ICA is reached (Fig. 20-15).[12] Careful drilling along the course of the ICA is performed until the bone of the canal is thin enough to fracture with the tip of a 1-mm angled Kerrison rongeur. Removal of bone continues to the level of the vascular injury (see Video 20-2). The ICA is compressed within the canal to control bleeding. It is possible to seal a small laceration of the vessel wall with bipolar cautery. The goal in most cases, however, is to occlude the vessel with a focal pack (hemostatic material, muscle, and cottonoids) to allow more definitive management in a controlled setting.

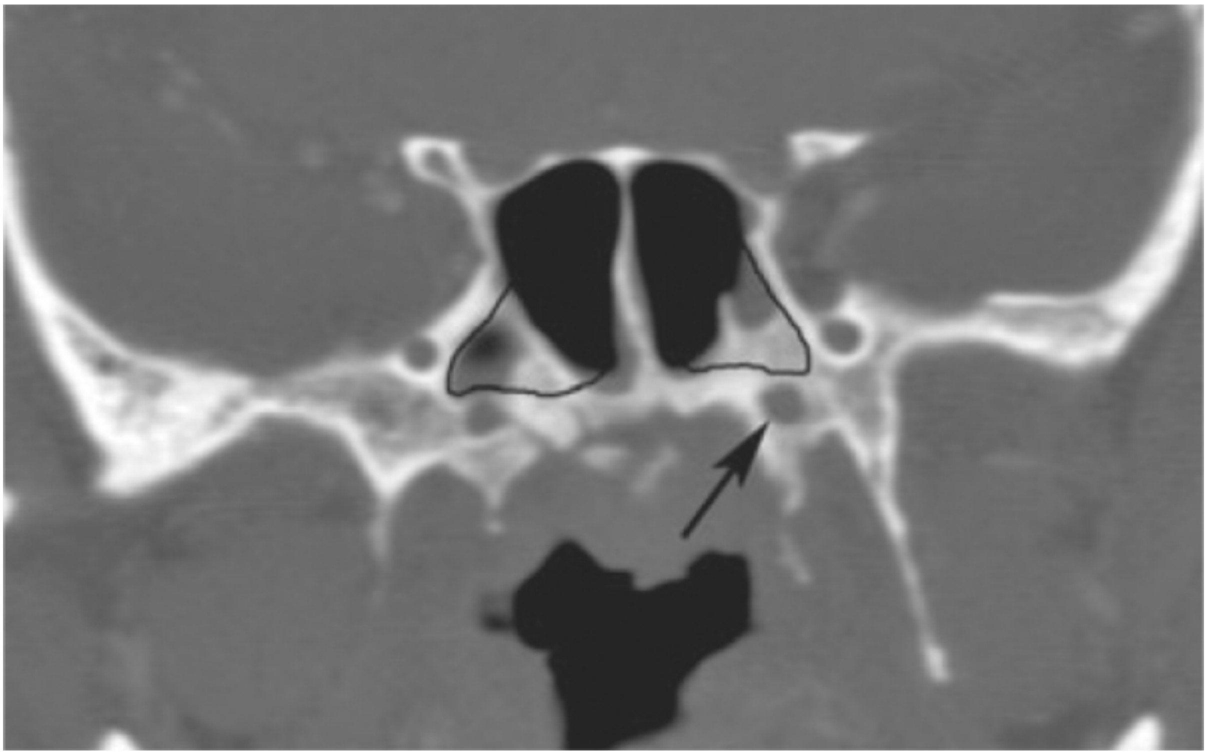

Figure 20-14 The sphenoidotomy is maximally enlarged by ligating the sphenopalatine artery and elevating the contents of the pterygopalatine space from the medial pterygoid plate. This allows removal of bone over the lateral recess *(outlined areas)* between the foramen rotundum and pterygoid canal *(arrow).*

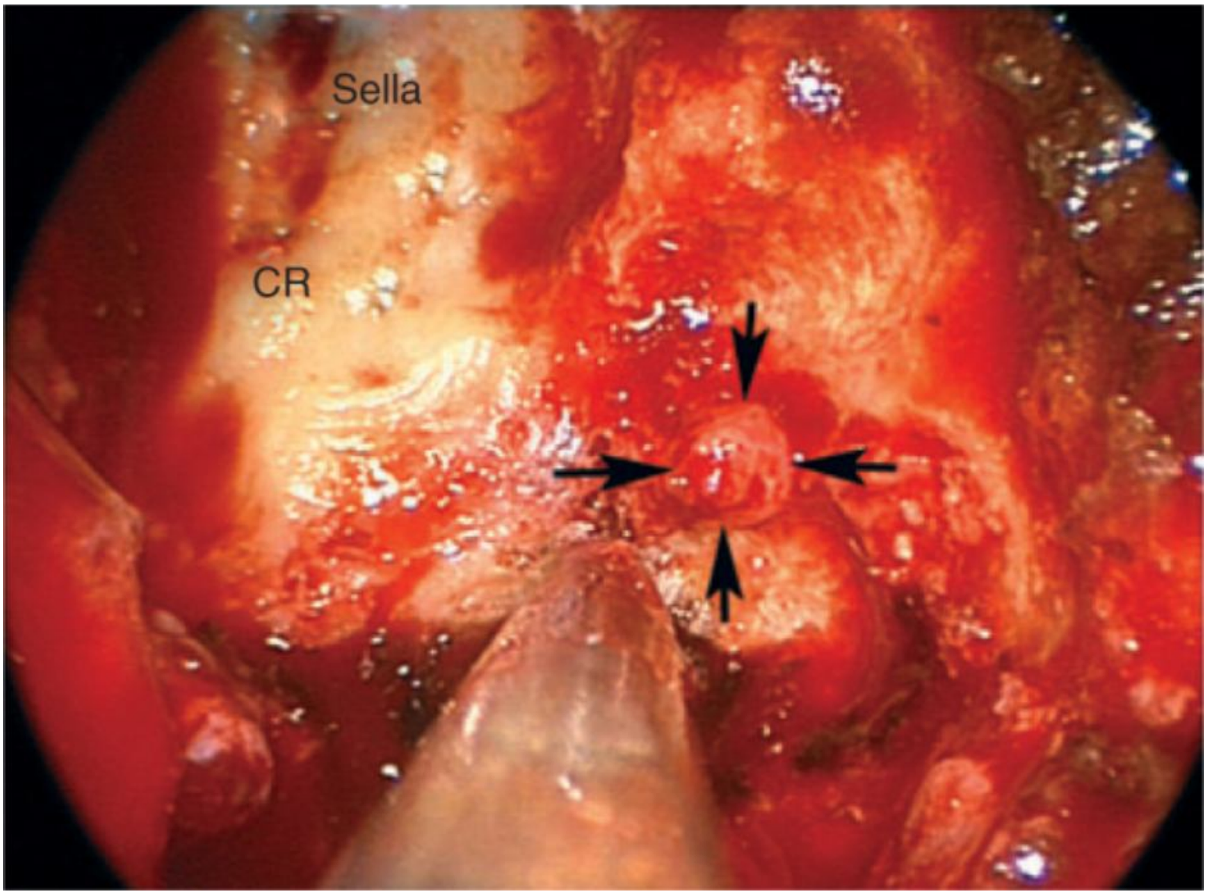

Figure 20-15 Bone medial and inferior to the left pterygoid canal *(arrows)* is drilled to expose the second genu of the internal carotid artery. CR, clival recess.

Blood pressure should be kept at a normal level when injury to the ICA occurs to maintain adequate collateral cerebral circulation. Neurophysiologic monitoring of cortical function can be very helpful in such situations to assess the adequacy of collateral cerebral blood flow and take steps to optimize it.

POSTOPERATIVE CARE

After ligation of the ethmoidal or sphenopalatine vessels, postoperative care is the same as for any endoscopic sinus surgery and may include temporary nasal packing or splints, as well as saline irrigation and gentle débridement. If a tampon is inserted intranasally at the completion of surgery, it should be done under direct endoscopic vision so that hemoclips are not accidentally displaced. If the periorbita has been violated, patients should be instructed to not blow their nose because of the risk of orbital emphysema. Preexisting hypertension should be treated and medications with antiplatelet effects should be avoided.

Injury to the ICA requires emergency consultation from a neurosurgeon with vascular experience and an interventional neuroradiologist (Fig. 20-16). Extremes of blood pressure should be avoided. Even in the presence of a negative preoperative balloon occlusion test of the ICA, hypotension can result in cerebral infarction in watershed areas of the brain. There is also a risk of embolic episodes from clot distal to the site of occlusion. With any vascular injury, postoperative angiography is essential to rule out pseudoaneurysm formation.

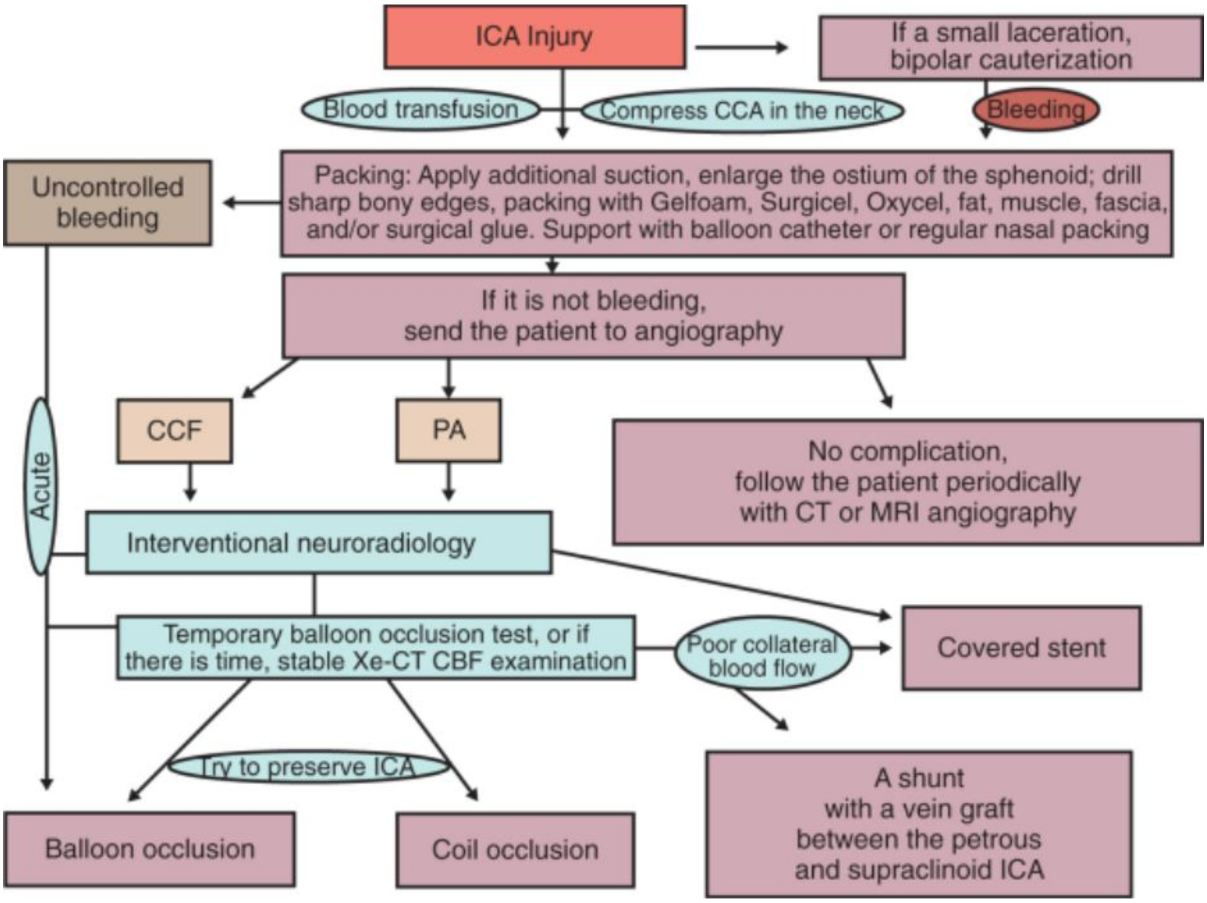

Figure 20-16 Algorithm for the management of an injury to the internal carotid artery (ICA). CBF, collateral blood flow; CCA, common carotid artery; carotid-cavernous fistula; CT, computed tomography; MR, magnetic resonance; PA, pseudoaneurysm.

Recurrent bleeding after surgery may be multifactorial. Proper management depends on the extent of the surgery and how bleeding complications were managed intraoperatively. Selective electrocautery or ligation of offending vessels may be the most expedient way to manage significant bleeding. When the site of bleeding is unclear and vessels have already been ligated, angiography (with embolization) should be both diagnostic and therapeutic.

COMPLICATIONS

Knowledge of anatomic relationships is important for locating the major vessels of the sinonasal cavities. Bipolar electrocautery should not be used in proximity to neural tissue, the skull base, the orbit, and the ICA to minimize the risk of thermal injury. Monopolar electrocautery should never be used beyond the anterior wall of the sphenoid sinus.

Risks related to exposure of the anterior ethmoid artery include a dural injury with CSF leakage, retraction of a transected vessel into the orbit with the formation of an orbital hematoma, and stenosis of the nasofrontal duct. Identification plus ligation of the vessel along the orbital side of the bone helps minimize these risks.

Ligation of the sphenopalatine vessels may fail as a result of displaced hemoclips, unrecognized proximal branching with separate foramina (Fig. 20-17), and bleeding from other sites (anterior ethmoid artery). Wide exposure of the sphenopalatine foramen with elevation of mucoperiosteum and removal of overlying bone prevents missing a separate vessel exiting through its own foramen. Excessive removal of bone posterior to the sphenopalatine foramen risks injury to the greater palatine nerve with resultant palatal anesthesia. Excessive dissection of pterygopalatine tissues risks additional vascular injury from other branches of the internal maxillary artery, as well as injury to the vidian nerve and decreased tearing.

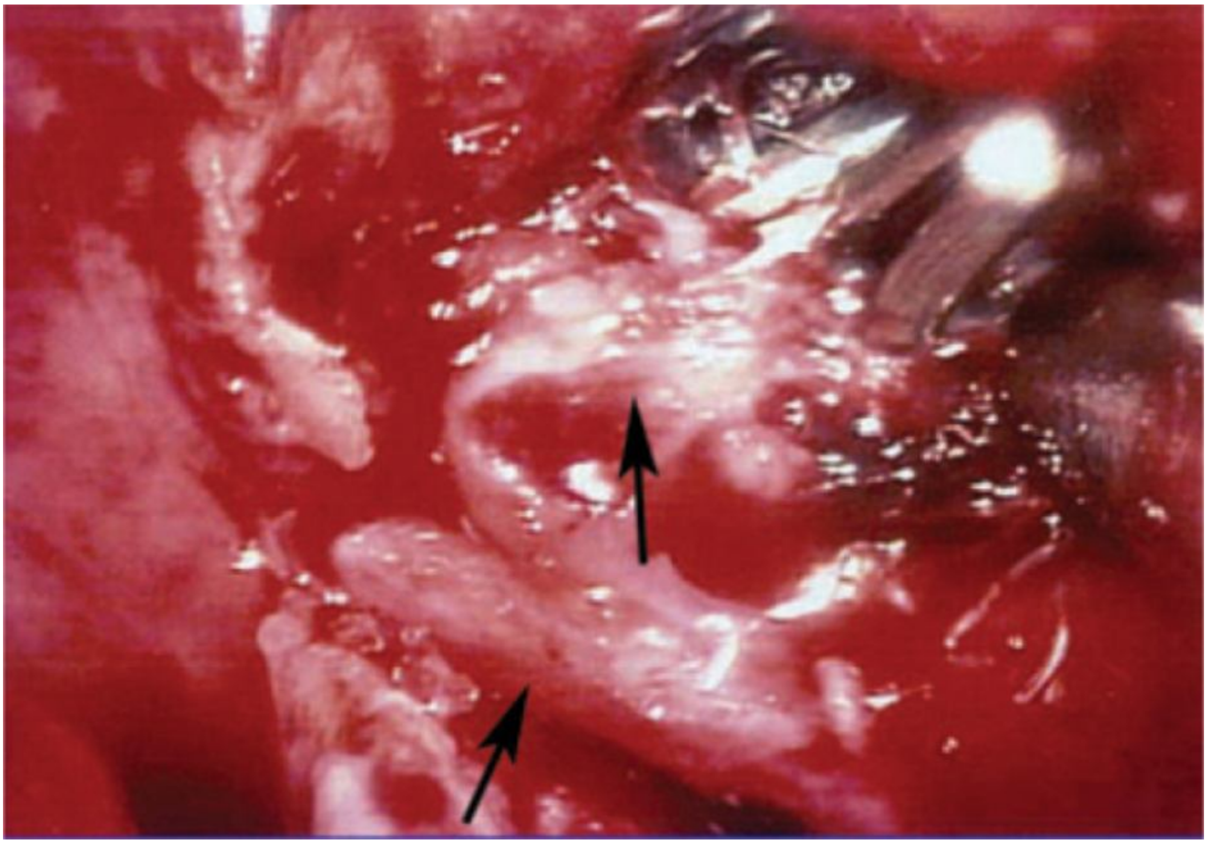

Figure 20-17 This patient failed right sphenopalatine artery ligation. Re-exploration with performance of middle meatal antrostomy revealed a separate foramen with missed vessels inferior to the site of the previous hemoclips *(arrows).*

SUMMARY

Most intraoperative bleeding during endoscopic sinus surgery can be effectively controlled with conservative measures, including the application of hemostatic material and hot-water irrigation. Injury to major arteries traversing the nasal cavity and sinuses can be avoided with anatomic knowledge, good visualization, and proper operative technique. Ligation of major vessels may be necessary for control of hemorrhage and can be done endoscopically through a transnasal approach. Every surgeon should have a treatment algorithm for dealing with inadvertent injury to the ICA.

PEARLS

- Preoperative radiologic studies should be reviewed to identify anatomic variations to decrease the risk of vascular complications.
- The anterior ethmoid artery is located in the coronal plane tangential to the posterior surface of the globe.
- The sphenopalatine foramen is situated at the posterior attachment of the middle turbinate.
- The sphenopalatine artery branches proximal to the sphenopalatine artery more than 40% of the time.
- The vidian (pterygoid) canal is a useful landmark for identification of the second genu of the ICA.

PITFALLS

- Transection of the anterior ethmoid artery too close to the orbit can result in retraction of the severed artery into orbital tissue and the development of a retrobulbar hematoma.
- Dissection of the anterior ethmoid artery at the skull base risks a CSF leak, especially at the junction of the fovea ethmoidalis and lateral lamella of the cribriform.
- Incomplete exposure of the sphenopalatine foramen risks missing one of the vessels when there is proximal branching with separate foramina.
- Aggressive removal of lateral septations in the sphenoid sinus can injure the ICA.
- Monopolar electrocautery should not be used within the sphenoid sinus because of the risk of injury to the optic nerve or ICA.