Paparella: Volume III: Head and Neck

Section 2: Disorders of the Head and Neck

Part 1: Nose and Paranasal Sinuses

Chapter 11: Sublabial Transseptal Hypophysectomy

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Patients who require a pituitary operation usually do not have symptoms that cause them to seek the attention of an otolaryngologist. Those with prolactinomas will present to family practitioners, endocrinologists, and gynecologists with symptoms suggestive of galactorrhea, amenorrhea, or infertility. Acromegalic individuals eventually reach an endocrinologist when their growth hormone side effects are recognized, and it is often surprising how extensively deformed their facial features have become by the time this happens. Many are already under treatment for what are really secondary complications, like arthritis and diabetes. Some are not recognized until a visual field defect leads to consultation with an alert ophthalmologist. Cushing's disease and the Nelson-Salassa syndrome engage the attention of internists. Early on, the tumors are often occult, but the metabolic, endocrine, or dermatologic features can be striking. There are numerous instances of relatively asymptomatic hypopituitarism in which the diagnosis is made by a radiologist noting expansion of the sella on a standard lateral head radiograph. Suffice it to say that the presentation of pituitary tumors is very diverse through their mass effects or endocrine dysfunction, or both, and they involve the otolaryngologist as part of the treatment team after the diagnosis has been made.

Nearly every pituitary adenoma can be exposed and removed through the nasal septum. This may seem surprising. The nose *should* offer a long, narrow, contaminated surgical field, which provides limited access if the surgeon is expected to control venous sinus bleeding, cerebrospinal (CSF) leaks, suprasellar extension, and a host of anatomic (optic chiasm, carotid artery), and pathologic (occult adenoma, cystic extensions) challenges. However, collaboration between rhinologic surgeons and neurosurgeons over the past 20 years has brought us to the point at which all these challenges and more are routinely and reliably met. Sophisticated techniques and instrumentation for total disassembly and subsequent reconstruction of the central midfacial structures have become commonplace in otolaryngology, and to some extent standardized. Special transseptal operating specula and the illumination and magnification of the operative microscope are as familiar to the neurosurgeon today as they are to the otolaryngologist. Complex reproducible endocrine tests such as radioimmunoassay have greatly improved the precision and promptness of the diagnosis. Ophthalmologic assessments now include sophisticated perimetry equipment that can demonstrate very subtle abnormalities of the visual fields, Undreamed-of imaging techniques like computed tomography (CT) scanning and nuclear magnetic resonance imaging (MRI) pinpoint microadenomas before any enlargement of the sella has occurred. Powerful laboratory and histochemical tools, such as immunoperoxidase techniques that identify hormone products in fixed-tissue surgical specimens, upgrade our understanding in ways never

imagined until recent times.

In summary, advances in physics and biochemistry have supported substantial improvements in diagnosis and management so that transsphenoidal transseptal hypophysectomy is one of the most predictable operations performed for brain tumors. At the Mayo Clinic, this procedure accounts for one quarter of all neurologic tumor operations. It is probably fair to say that the only limiting variable on the safety and completeness of the operation itself is the degree to which the skills of an interested rhinologist and an experienced neurosurgeon can be integrated and optimally used in every case that appears.

Some Historical Aspects of the Transsphenoidal Approach

Early attempts to remove pituitary tumors included a lateral transcranial approach that was impeded by numerous anatomic obstacles like the cavernous sinus, the carotid artery, and the optic chiasm, tract, and nerve. Autopsy studies showed that it might be better to operate from below, since pituitary tumors usually grew down into the sphenoidal sinus anyway. Also, the diaphragm sella was usually stretched out over the upper surface of the tumor. If this barrier between the sella and the brain could be kept intact instead of being breeched by the surgeon from above, it would probably reduce the danger of meningitis after the surgery.

The first extracranial approach to the hypophysis was reported by Schloffer in 1906. He resected not only the nasal contents but also most of the facial structures between the two orbits. Von Eiselberg enlarged Schloffer's approach to include the frontal sinus. The early surgeons were dealing with big tumors, and anything that improved access was tried. Orbital exenteration was even reported for access. This may not have been an unreasonable step, as the eyes was already blind from the tumor. Moszkowicz used the nasal approach not only to remove the tumor but also to deliver a forehead flap into the sella for dealing with the difficulties of sealing off the exposed intracranial contents from prolapse, CSF leakage, and contamination. In those days, there were, of course, no antibiotics to resist organisms from the nasal and sinus cavities, so postoperative sepsis was lethal.

It was soon recognized that any approach that resected the septum or turbinates, or both, produced permanent nasal crusting (and airway obstruction). In some patients, severe recurring infections and epistaxis were the inevitable results. (The air we breathe is too cold and dry for the lungs. The nose is its air conditioner. For the nose to function as the initial conduit for inspired air, one needs two separate chambers that "cycle"; one rests in the semiobstructed, congested state, whereas the other does most of the warming, humidification, and filtration. The normal nasal air passage apparently stays wet and healthy by shifting its respiratory demands from one side to the other on a 5- to 12-hour rotation. For this mechanism (called the nasal cycle) to work, the nasal cavity must be divided into two chambers by a septum, and the turbinate mucosa must be relatively intact. We are usually unaware of this alternating, unilateral nasal congestion in our daily lives, because of the sum of the resistance; that is, the total resistance to breathing, remains constant.) Conversely, when conservative techniques, which entered the nostril and spared the nasal septum and turbinates, were used, access was inevitably

reduced. In Vienna, Hirsch was able to combine the Killian submucosal resection and the Hajek sphenoidal sinusectomy to gain access to pituitary tumors. However, without the microscope, image intensifiers, steroids, and antibiotics, such evacuation of soft tumor contents and decompression with partial resection was probably the best that could be hoped for in most cases. During these years, a wide variety of external facial incisions were employed to get at the pituitary region. They included glabellar, lateral nasal, and submucosal variations, in many combinations or alone. Halsted continued to resect the septum, but he at least bypassed the nostril and moved the incision off the face altogether by going into the upper gingivolabial sulcus. It was Cushing who combined Halsted's oral incision with the nasal function-preserving submucosal approach of Hirsch. His first patient was a 38-year-old acromegalic individual from Columbia, South Dakota, referred to him by Dr. Charles H. Mayo, and by 1922 he had reported 203 transseptal hypophysectomies, with a 7.38 per cent mortality rate and only one death in his last 50 cases.

Considering that steroids, antibiotics, modern neuroanesthesia, CT scans, and the operating microscope were not available to those early pioneers, their success and persistence were remarkable. In contrast, it is not surprising that they were eventually overshadowed by a more powerful development like a more direct and sophisticated approach - the growth of transcranial neurosurgical technology in the 1930s. Cushing himself embraced this route and abandoned the transseptal approach. Dandy went so far as to state that the transseptal exposure was no bigger than a lead pencil and that subsequent transfrontal removal would be impossible because the tumors would be infected nasally. It was not long before others were emphasizing the difficulty of dealing with suprasellar disease through the nose or the necessity of supplementing incomplete removals with radioactive substances because tumor extension above the sella was left behind. By 1940, Nager was able to observe that the success of the neurosurgeons had put the extracranial approaches to the pituitary out of fashion.

In 1953, Luft and Olivecrona reported the value of surgical ablation of the normal pituitary gland for hormonally dependent metastatic adenocarcinoma. However, these patients had terminal cancer, and a craniotomy was a formidable ordeal. The extracranial operations reappeared (but this time it was the trans-ethmoid route that was popular). Steroid replacement was available, antibiotics reduced the fear of using a mucosa-lined passageway to the area, and late recurrence caused by limited access was irrelevant to removing a normal gland. It was the patient's illness and the inability to tolerate a craniotomy that were paramount. The ethmoidal (and sometimes antral) approaches that were selected by otolaryngologists were logical enough; having already perfected their microsurgical skills in the ear, they were adept at introducing the surgical microscope to other sites. They were also quite skilled in antral and ethmoidal exenteration for infection. These operations had only recently been partially retired by the antibiotic revolution. In a sense, their techniques were already perfected, and the normal sella just presented a new opportunity for their use.

Bateman and Angel-James in England and Briant in Toronto acquired considerable experience with the transethmoidal approaches through the 1960s. They reconfirmed the feasibility of the extracranial approach and the adequacy of its exposure using the microscope.

Hirsch had moved (just before World War II) to America, where he kept the transseptal operation alive. And, Cushing's pupil Dott in Edinburgh taught the nasolabial transseptal technique to the French neurosurgeon, Guiot. It was Guiot, working in the 1960s with Bouche in Paris, who probably did more than anyone to demonstrate among neurosurgeons that the transseptal extracranial operation was efficacious. He introduced the image intensifier into pituitary surgery, and by 1973 he had reported 490 cases, with an operative mortality rate of 1.9 per cent. Then Hardy in Montreal described the surgery of microadenomas and demonstrated that by combining the microscope, the transseptal midline approach, and careful dissection in the sella, microadenomas could be removed with the preservation of normal pituitary function. More recently, advances in chemotherapy and oncology have superseded pituitary ablation for adenocarcinoma, and the transseptal procedure has displaced the transethmoidal method as the standard approach to the sella.

Current Radiologic Diagnosis

An enlarged sella may be caused by a pituitary adenoma, empty sella syndrome, craniopharyngiomas, metastases from elsewhere, meningiomas, aneurysms, and a long list of rare cysts, neural tumors, developmental tumors, granulomas, sphenoidal lesions, and disturbances of intracranial pressure dynamics. Plain skull x-ray films are only a screening tool. The incidence of falsely abnormal and falsely normal results is exceedingly high. Polytomography has, for the most part, been superseded by CT and MRI scanning. The normal gland on CT is a homogeneous object that is isodense with brain and enhances uniformly with contrast. In the coronal view, its upper surface should be concave downward or flat. Bolus contrast images with an automatic injection apparatus during high-resolution coronal cuts by a scanner like the GE 9800 will nicely demonstrate the relationships of the carotid-cavernous vascular structures to the tumor. MRI is probably better at demonstrating the nerves, but its omission of bone is a drawback.

Sometimes, a hypodense area can be produced by a cyst or a cystic tumor, or it could represent the so-called empty sella syndrome. Use of the newer, nonionic contrast agents like Omnipaque or Isoview in the subarachnoid space via lumbar puncture helps resolve this confusion. It also helps to outline the upper border of the tumor when it cannot be identified on plain CT. When an aneurysm is suspected, subtraction angiography is valuable. It is certainly not essential for all cases of pituitary tumors, especially since third-generation CT scanners have become available. Also, the subtle issue of tumor blush identification is probably no longer of practical significance.

The role of radiologic imaging in preoperative assessment of the nose and sinuses is beyond the scope of this chapter. However, when rhinologic or paranasal sinus abnormalities are suspected, high-resolution 5-mm coronal CT cuts without contrast probably give the most information for the cost and risk.

The Rhinologic Surgeon's Preparation for Transseptal Transsphenoidal Surgery

The rhinologic surgeon will be asked to anticipate and deal with all those special problems that affect operative safety and exposure, not only in the normal nose but also in the nose affected by syndromes of pituitary dysfunction. In addition, patients with incidental nasal and sinus pathologic conditions will be encountered. The sphenoidal sinus may be hypoplastic, for example, but the prepared rhinologist can manufacture a sphenoidal sinus cavity at the time of operation! The septum may be perforated from a previous unsuccessful transseptal approach, but the maxilla-premaxilla septal approach can be used, and the septal perforation can be repaired at the same operation as the revision hypophysectomy. Some patients will want more than cure of their pituitary tumor. They may want their coexisting nasal obstruction corrected. Some want an improvement in appearance and will request a simultaneous rhinoplasty. Hesitation to meet these requests have slowly given way so that now most of the ancillary goals are, in fact, satisfied in healthy patients at the same time as their pituitary operation. Simple strategies are available to solve so many of the coexisting rhinologic problems that arise in patients with pituitary abnormalities that it is usually just a matter of planning ahead and carefully individualizing each approach.

Outline of the Procedure

The septal portion of the transseptal transsphenoidal approach to the pituitary gland that has been used now in more than 2000 cases at the Mayo Clinic is simply an extension of the Cottle maxilla-premaxilla approach to the septum. This approach is familiar to almost all rhinologic surgeons, and hence it is widely performed in North America. The object is to dismantle and mobilize the skeletal support of the septum, out-fracture the turbinates, and use the entire nasal cavity (both sides) to directly approach the sphenoidal sinus in the midline. The sublabial incision is simply an addition or minor modification to bypass the restriction imposed anteriorly by a single nostril. The posterior extensions are just a way of entering the sphenoidal sinus safely, that is, in the midline, without much bleeding and with reliable landmarks to help define the upper and lower limits of exposure.

Over the years, we have found it unnecessary to remove the anterior nasal spine. It does not get in the way when the majority of the dissection is completed through the nose (as opposed to working from under the lip). Once the pituitary portion of the operation is under way, the optical axes of the microscope straddle the spine, so it again fails to hinder the operator. Leaving the nasal spine so improves the simplicity and reliability of the nasal operation that we advise preserving it intact in almost every case. We have also found that any facial incision that communicates with the nostril skin (to avoid the sublabial incision) is unnecessary. Thus, the nasal alotomies and the transcolumellar "open approach" incision seem pointless, since they add an unnecessary external scar to an operation that normally produces none. No one has shown a meaningful improvement in exposure or a decrease in infection over the sublabial route, so the advantages for these modifications are obscure.

The rhinologist's mission is to provide unparalleled exposure of the sella. The neurosurgeon should be presented with an exposure so complete that the limits to pituitary access are set not by the nose but by the intracranial structures that surround the gland! At the same time, it is essential to avoid injury to the sphenoidal roof or the cribriform plate, or to any vascular or neurologic structures that may have protruded into the sphenoidal region from the cranial cavity.

When the sella is completely exposed, the neurosurgeon enters a dry, easily oriented field, and is free to deal with the intracranial challenges, which include the problems of identifying the intrasellar pathologic condition, controlling bleeding from the dural venous sinuses and intrasellar contents, differentiating tumor to be removed from normal gland to be preserved, protecting the optic chiasm, avoiding or repairing CSF leaks, and preventing injury to vulnerable structures like the hypothalamus of the third cranial nerve or a carotid siphon to which the tumor may be adherent. After sealing the sellar defect with autologous soft tissues, the neurosurgeon should be free to withdraw, completely confident that the rhinologist will secure the closure, balance the dressings, and meet the specific rhinologic concerns that have been discussed with the patients before surgery.

The Team Approach

An integrated team of specialists can probably best manage the patient with pituitary abnormalities. An endocrinologist "quarterbacks" the management and attends to the patient's medical and endocrine needs both before and after surgery. An ophthalmologist monitors the visual fields. The rhinologist evaluates, dismantles, and reconstructs the nasal septum and follows it up in the postoperative period. The sella is opened, the adenoma is delineated and removed, and the sellar defect is repaired by the neurosurgeon.

Quick-section histopathologic procedures and follow-up microscopic diagnosis is entrusted to a pathologist who is experienced in pituitary appearance. A radiation oncologist may render follow-up radiotherapy. The diagnostic neuroradiologist, the referring physician, the angiographer, the neurologist, the laboratory specialist, and others may also play a role in the program.

The possibility that the care given by a two-surgeon operating team might become fragmented has not materialized in the institutions in which this concept is supported and endorsed by all members of the team. The difficulties of scheduling two surgeons diminish as the number of cases attracted by the team approach increases. The possibility that two surgeons might prove redundant is not a sound medical objection. The neurosurgeon's unique training and experience are critical for evaluating the angiography and the suprasellar, lateral, and hypothalamic extensions. The recognition of microadenomas, the management of the intrasellar tissues and neighboring cranial nerves, and the evaluation of unexpected neurologic deterioration or persistent postoperative headaches are all in the province of the neurosurgeon. The rhinologist's background is indispensable to the patient with gross septal pathologic conditions, cosmetic concerns, previous nasal trauma, intraoperative mucosal lacerations, epistaxis, postoperative CSF rhinorrhea, and instances of delayed recurrent sinusitis, deformity, or nasal obstruction.

We consider the team approach vital to our concept of pituitary surgery. Each phase of the operation needs the attention and expertise that can come only from the training and experience of both surgeons. The most gratifying by-product of the team approach is the fact that virtually every case is operable. No pituitary patient need be turned down for technical reasons (ie, a nasal pathologic condition, a tumor that is too large, and so on), and appropriate support is readily available for any problem or complication that may arise.

Visual Aspects of Pituitary Tumors

The optic chiasm is located directly over the pituitary gland, immediately anterior to the pituitary stalk. Bitemporal hemianopia is the most common visual defect identified in pituitary tumors. Occasionally, tumors that extend up the stalk to press on the papulomacular bundles in the posterior part of the chiasm produce central scotomas. Sophisticated neuro-ophthalmologic consultation is essential before pituitary surgery. Patients sometimes present with oculomotor abnormalities or the potential for third-nerve injury at surgery. Furthermore, many patients with field defects are unaware of the loss until it is documented. Visual improvement resulting from chiasmatic decompression is an attainable goal in many patients, and the ability to follow any improvement or deterioration postoperatively is an important asset. In our practice, all patients undergo ophthalmologic examination and perimetry preoperatively, and the field charts are always posted with the CT scans in the operating room.

Hypothalamic Considerations

The hypothalamus and pituitary gland function as an endocrine unit. In the hypothalamus, two systems influence the gland. One is the neurohypophyseal system (supraoptic and paraventricular nuclei), which synthesizes the octapeptides (antidiuretic hormone (ADH), and oxytocin) and the neurohypophysins, which are the specific carrier proteins in the granules that migrate along axons into the posterior lobe of the pituitary gland. The second is the tuberohypophyseal system, which synthesizes and produces the hypothalamic regulatory hormones. They include somatostatin, which inhibits growth hormone release, growth hormone-releasing factor (GHRF), which does the opposite, prolactin-releasing factor (PRF), prolactin-inhibiting factor (PIF), which may be dihydroxyphenylalanine (DOPA), releasing hormones for the gonadotropic pituitary hormone follicle-stimulating hormone (FSH), luteinizing hormone (LH), the corticotropin hormone adrenocorticotropic hormone (ACTH), and thyrotropic hormone thyroid-stimulating hormone (TSH).

The hypothalamus lies directly above the pituitary gland. Obviously, both tumors and surgery have the potential to affect it adversely. Certain drugs also affect the hypothalamus, such as bromocriptine, which is a dopamine agonist that has been used to temporarily suppress hyperprolactinemia, and sometimes, excessive growth hormone. Dopamine agonists have also been used as a primary treatment for the hypersecretion pituitary endocrinopathies, especially when surgery or radiation is deferred.

The Basic Rhinologic Operation

Opening

A typical operative note describing the rhinologist's portion of the transseptal transsphenoidal operation is as follows: Under general anesthesia, the nose and face are prepared and draped in a suitable fashion. Cocaine is applied to the nasal cavity, and the columella and nasal base are infiltrated with 1% lidocaine and 1:100.000 epinephrine. Through a right hemitransfixion incision, a left anterior submucoperichondrial tunnel and bilateral inferior tunnels are created. The premaxilla and nasal spine are thoroughly exposed. The three tunnels are connected, and the septal cartilage is displaced from the vomer and the ethmoidal plate. By swinging it to the right, a right posterior tunnel is opened, then bilateral posterior tunnels are extended along the vomer and ethmoid bone to the face of the sphenoidal sinus, and the rostrum and sphenoidal ostia are visualized. The videofluoroscopic image intensifier is entered into the field. A sublabial incision is connected to the premaxillary dissection. The lip is elevated, and the pituitary speculum is inserted. The turbinates are out-fractured. The sphenoidal rostrum and face of the sphenoid bone are removed, along with the lining of the sphenoid bone and the intersinus septum.

At this point, the neurosurgeon enters the procedure and operates on the intrasellar pathologic condition. The neurosurgeon's work finishes with an autologous tissue plug being fixed in the sellar defect with a batter of septal bone so that no CSF leak is evident when the rhinologist re-enters the field.

Closure

The speculum is removed. The nose is thoroughly inspected for any mucosal tears, which are repaired with 4-0 chromic catgut using ophthalmic needles, the Noyes alligator forceps, and the Castroviejo needle holder. The sublabial and hemitransfixion incisions are closed with interrupted chromic catgut sutures. Bilateral polyethylene splints are transfixed to the septum with a single nylon mattress suture. The nasal cavities are packed with Cortisporin-soaked petrolatum gauze, and an external supportive tape and mustache dressing are applied.

Rhinologic Details of the Transseptal Procedure

Initial Preparation

We use the Mayfield headrest to allow the patient's head to be cocked toward the left shoulder. A right-handed surgeon ought to be able to stand beside the patient but align himself or herself with the nasofacial midline without having to lean over the patient's chest. A soft anesthesia pack is placed in the oropharynx to intercept any blood that drains from the nasopharynx, and the proximal end is tied around the endotracheal tube. In large tumors, the anesthesiologist places a lumbar cannula (we use a malleable needle) in the subarachnoid space before the surgery begins. This allows intraoperative pneumoencephalography, which can be

helpful when large suprasellar extensions are present. Later during surgery, as semiliquid tumor delivers itself into the sphenoidal region to be aspirated with suction, the diaphragm sella can be observed to descend.

The right lower side of the patient's abdomen is prepared and draped for the procurement of a fat autograft. The eyes are protected with adhesive strips, and the face is cleansed only with sterile saline.

Thorough local nasal cavity vasoconstriction (with cocaine nasal pledgets and columellar-premaxillary infiltration with dilute epinephrine) is a necessary prerequisite to hemostasis and satisfactory visualization during septal surgery. Atraumatic insertion of the cocaine pledgets is important to avoid unnecessary bleeding from the turbinates. Of course, optimal decongestion of the turbinates is essential to maximize the space available in the nasal cavity when the Hubbard pituitary speculum is introduced.

The Anterior Submucosal Dissection

Like Guiot, Bouche, and Hardy, we initially employed the oronasal approach. They could rapidly gain access to the septal spaces and the sphenoid bone, working entirely under the lip. However, working into the nose from a low angle under the canopy of the orbicularis oris muscle does restrict visibility at the point you need it most, over the premaxillary wings. The nasal spine gets in the way, and familiar instruments like specula and suction dissectors are not as well adapted to this approach as they are to the nasal route.

In 1973, we began performing the entire septal dissection through a right septal columellar hemitransfixion incision, saving the sublabial incision until later in the operation when we wanted to insert the pituitary speculum. This approach improved our ability to elevate the mucoperichondrium from the anterior-inferior regions of the septum in the premaxillary region without perforation. The nasal spine ceased to be an issue because it was no longer in the way. In the occasional acromegalic patient, the sublabial incision was unnecessary, because the nostril was gigantic and the transsphenoidal speculum could be inserted into the septal space through the hemitransfixion incision itself.

The Cottle tunnel technique has proved to be our most effective way of avoiding intraoperative mucosal bleeding. The first (left) anterior tunnel starts at the caudal edge of the septal cartilage. The right hemitransfixion incision is made with the assistance of a columellar clamp and sharp dissection along the caudal and left anterior surfaces of the cartilage. The strongly adherent mucoperichondrium is raised off the first 2 cm of septal cartilage using a sharp Cottle knife, then a fine dissection, and then a tapered rigid Cottle suction tube. The left anterior tunnel is not completed (ie, the entire septal cartilage surface is not exposed) until after the premaxillary dissection is performed. Once the anterior ends of the *inferior* tunnels are raised, the exposure and orientation provided by the premaxillary dissection allow nasal dissection to proceed much more easily. The surgeon initiates the left and right inferior tunnels at the sharp inferior bony margin of the pyriform aperture after the anterior surface of the premaxilla and the

spine have been clearly exposed with a MacKenty elevator. The fully curved Cottle elevator can quickly raise the mucoperiosteum off the floor of the nose. Anteriorly then, only the dense transverse fibrous insertion (from the mucoperichondrium) into the joint between the premaxillary wings and the septal cartilage binds the mucosa down. This is the point at which tears occur. To avoid them, sharp dissection is required. By first connecting the inferior and anterior tunnels on the left, then dislocating the septal cartilage off the premaxillary wings and vomer into the right nostril, the newly created left submucosal space can be sharply connected into the inferior tunnel on the right. Deeper extension of the left submucoperiosteal dissection raises a left "posterior" tunnel, over the vomer and the ethmoidal plate, and back to the sphenoidal rostrum. Simple dislocation of the septal cartilage to the right, off the ethmoidal plate, opens the anterior end of a right posterior tunnel. The whole septal cartilage swings right, still attached to its unelevated right mucosa. At the same time, the suction dissection tube elevates the right posterior mucosa off the ethmoidal plate and the vomer, back to the rostrum, and the ethmoidal plate is now straddled by two posterior tunnels, leaving it open to resection with a strong septum forceps.

Cottle described the systematic creation of these five tunnels through a large right hemitransfixion incision to provide immediate orientation to the caudal edge of the septum and excellent exposure of difficult septal deformities. It also provides the tension and hemostasis to facilitate sharp dissection of the tightly adherent septal mucosal flaps off the premaxillary wings. This is important because this is precisely the place at which most perforations begin, and blunt dissection is sure to initiate a tear here. In Cushing's disease, in which the tissues are especially fragile, and in patients with metastatic adenocarcinoma, in whom platelet deficiencies from bone marrow invasion are common, a reliable technique to avoid perforation and bleeding is especially pertinent.

Why are intraoperative perforations so detestable? They rob the septal mucoperichondrial flaps of their tension and initiate troublesome bleeding. They permit the sphenoidal speculum blades to pass out through the perforation into the nasal cavity, which greatly complicates the exposure. They prolong the operation by requiring closure. After the surgery, mucosal lacerations delay healing, encourage crusting, and permit the possibility of a permanent postoperative septal perforation. Chronic nasal septal perforations can be a source of persistent complaints. They whistle, crust, and bleed. If they can be avoided by this well-established approach (they can even be repaired through it at the time of a secondary transseptal operation), the patient's welfare is protected.

The Posterior Septal Dissection

The sphenoidal rostrum projects into the back of the septum at the junction between the ethmoidal plate and the vomer. Thus, the tail of the septal cartilage, which projects along this junction, points to the rostrum. The submucoperiosteal septal dissection is forced laterally by the rostrum and is liable to fan out into the anterior surface of the sphenoidal floor as one approaches the choanae. (Almost all of the posterior tunnel dissection is accomplished with a tapered Cottle suction.) By outfracturing the superior turbinates and remaining sensitive to the feel of the septal dissection, the sphenoidal ostia are usually encountered. The sucker tip tends to fall through them

into the sphenoidal sinus. Exposure can generally be improved by removing that portion of the bony septum between the posterior tunnels at this point, but the rostrum should be maintained for orientation.

Our previous illustrations showed the septal cartilage to be transected vertically in preparation for initiating the posterior tunnels; however, we preserve it intact and simply dislocate it off the anterior edge of the ethmoidal plate. At most, only the posteriorly projecting tail of the septal cartilage is removed.

By inserting the pituitary (Hubbard) speculum through the sublabial incision before removing the rostrum, the midline will be a little easier to discern. The speculum is inserted until it straddles the rostrum, then the tips are opened while the pressure of insertion is maintained, until they slide out into the sphenoethmoidal recesses. The rostrum looks like an owl's beak and the ostia are the two eyes. By avulsing the rostrum, and subsequently removing the sphenoidal mucosa, one encounters the tumor or the first direct visualization of the sella.

We try to resect sufficient sphenoidal floor inferiorly so that the infrasellar recess of the sphenoidal sinus is clearly apparent. (Sometimes it is lacking by virtue of variant anatomy or a gigantic tumor, but this should be known from the lateral preoperative radiologic projections.) Superiorly, the bone between the ostia is resected. Then, judiciously, the upper edges of the ostia and the interostial bone are trimmed, until we can identify the junction between the flat horizontal roof of the sphenoidal sinus and the vertical coronal anterior wall of the sella. This is the upper limit of the dissection, and indeed, the upper limit of the sella. The speculum is cranked open as far as it will go, taking great care to keep the tips applied to the face of the sphenoid bone. This involves maintaining the direction of the speculum so that the tips go deeper into the dissection as they are opened. We often reintroduce the tips of the speculum and raise and extend them more deeply, right into the sphenoidal sinus if any nasal mucosa obscures our lateral exposure by bulging into the field.

Once the sella is fully exposed, and all mucosa is removed from the sinus to further reduce bleeding and highlight the bony anatomy, the surgical microscope and the x-ray image intensifier are brought into place. The C-arm of the image intensifier surrounds the head to obtain a satisfactory sagittal view of the sella and the instrument tips.

The Neurosurgical Dissection

The neurosurgeon introduces the microscope and orients the image intensifier. The floor of the sella is sometimes already opened by tumor erosion. If not, he or she opens it with a fine chisel and a bone hook. After primary needle aspiration, the dura is cauterized and opened. The plane around the tumor or the gland is identified with great care to avoid dissecting inadvertently between the two layers of dura and thus entering the cavernous or transverse intercavernous sinuses. Long-handled pituitary dissectors help enucleate the tumor and, whenever possible, normal anterior and posterior pituitary gland is preserved. In about 40 per cent of cases, the subarachnoid space protrudes down through the diaphragm sellae to envelop the upper portions

of the pituitary gland. In other cases, this does not happen; the diaphragm may even be well distended by the tumor superiorly, but it can remain intact. Depending on several variables, then, a CSF leak may or may not be encountered. When it is, it must always be sealed. A sterile, antibiotic-soaked autograft of abdominal fibrofatty tissue is placed into the defect left by the tumor resection, and a small piece of preserved septal (vomerine) bone is placed like a batten across the bony sellar opening to support the graft. No grafts are left in the sphenoidal sinus itself, as they soon disappear and the sinus becomes pneumatized again.

Rhinologic Closure

At the conclusion of the procedure, the speculum is removed and the nasal mucosa is carefully inspected for tears, as they are specifically repaired. Tears smaller than 1 cm are ignored, but larger ones are approximated with a 4-0 chromic catgut suture on a small curved ophthalmic needle. The small diamond-jawed Castroviejo needle holder is used for insertion, whereas the Noyes otologic alligator forceps is used for retrieval. The alligator forceps is also employed to tie down the knots.

Before closing the hemitransfixion incision, we usually insert preserved crushed septal bone chips back in the septal space. The object is to assist any subsequent surgeon who has to relocate the septal space. The sublabial and hemitransfixion incisions are closed with 3-0 chromic catgut. Some surgeons prefer to stabilize the septal cartilage in the midline by suturing it to a few wisps of premaxillary fascia that have been left attached to the nasal spine. Perhaps this is worthwhile, as the septum dissected int he manner described has a tendency to undergo caudal displacement to the right during the first postoperative year.

To help maintain the position and integrity of the septum anteriorly, two flat polyethylene splints, one in each nostril, are transfixed to the septum with a single mattress suture of 2-0 nylon. After the nasal cavity is lightly packed with four to five loops of layered 0.5-inch Cortisporin ointment-impregnated gauze, postoperative congestion of the turbinates will embrace these splints through the dressing. The splints maintained in the midline this way will, in turn, project their support to the healing septum, anteriorly in the midline. In this region, stabilization from the turbinates themselves would be lacking.

Postoperative Care

All patients undergoing transsphenoidal procedures are managed in the intensive care unit initially so that they can be observed by nurses sophisticated in the care of neurosurgical patients. They are observed for vital signs, neurologic parameters, intake and output, bleeding, swelling, and discomfort. In most cases, the recovery is uneventful, but pituitary surgery is intracranial surgery, so meningitis (masked by the steroid coverage), tension pneumocephalus, CSF leakage, intracranial bleeding with neurologic deterioration, cerebrovascular vasospasm, blindness, diplopia, and dehydration complicated by diabetes insipidus are always possibilities.

We usually remove the nasal splints and packing on the fifth postoperative day. If a cerebrospinal fluid leak ensues (less than 1 per cent of case), the patient is advised to allow immediate reoperation. At surgery, the sphenoidal speculum is reinserted through the weakly healed sublabial incision (there is no need to reopen the hemitransfixion incision). The sella is re-explored and repacked with a new autograft, and the nose is repacked. This virtually always works. It is certainly preferable to repeated spinal taps, prolonged hospitalization, and eventual difficult attempts at secondary transseptal re-exploration through a septum in which the flaps have had time to become adherent.

Clinical Notes on the Various Endocrine Hypersecretion Syndromes

Prolactinomas

The Forbes-Albright syndrome is spontaneous non-puerperal lactation in association with a pituitary tumor. Prolactinoma is the most common (60 to 80 per cent) pituitary tumor that comes to surgery. Drugs, hypothyroidism, and renal failure can also cause hyperprolactinemia, but the internist will have screened these cases out.

"Idiopathic" hypoprolactinemia raises the question of a pituitary tumor too small to recognize or a basic hypothalamic defect. Follow-up with yearly CT scans may resolve this dilemma in some cases. How dangerous a prolactinoma might be has also been called into question. They seem to grow slowly. The large ones can be difficult to cure surgically. Some patients tolerate hypoprolactinomas with little ill effect. Others have galactorrhea and some even have gonadal dysfunction.

Most patients with prolactinoma have normal noses, and they are usually good surgical risks. Often the tumor is a microadenoma (less than 10 mm), and a good deal of normal postoperative pituitary function is retained.

Acromegaly

The clinical features of acromegaly are protean and not readily confused with other diseases. Also, most acromegalic individuals have pituitary abnormalities that are seen radiographically, which facilitates the diagnosis and treatment planning. Acromegaly is characterized by hypersecretion of pituitary growth hormone after epiphyseal fusion. Earlier activity adds gigantism. The nose, jaw, fingers, and toes enlarge. Patients complain of headaches, arthralgia, and arthritis. Fifty per cent of these patients develop diabetes mellitus. Thyroid problems, menstrual irregularities, and bitemporal visual field defects are not uncommon, and a few individuals have multiple endocrine neoplasia (MEN) syndrome, characteristically type I.

Acromegaly can present additional problems at surgery. Intubation is often complicated by the presence of an extremely large tongue. The nasal septum is hyperplastic and irregular, but operable. The nasal spine is often huge, and this gives rise to the occasional case in which anterior nasal spine resection (and replacement) is indicated. Occasionally, the nostril is large

enough to introduce the speculum through the hemitransfixion incision; the sublabial incision may be avoided if this is the case. We have found a longer pituitary speculum (at least 11 cm) to be required if all cases are accepted. Some medium-sized specula will not extend all the way back to the sphenoidal face in an acromegalic patient.

Cushing's Syndrome

The ACTH-secreting pituitary tumors that cause Cushing's disease are frequently too tiny to be detected by radiologic techniques. Cushing's syndrome, the complex described by Cushing, can be caused by extrapituitary sources, such as an ACTH-secreting carcinoid tumor of the lung, an excess of cortisone from the adrenal glands primarily, iatrogenic causes, or a cortisol-producing tumor. Cushing's syndrome includes rapidly developing adiposity of the face, neck, and trunk, osteoporosis with kyphosis, hypertension, diabetes mellitus, amenorrhea, hypertrichosis in females, impotence in males, striae, polycythemia, and muscular wasting and weakness. The nasal mucoperichondrium is fragile in Cushing's disease, and the hypertension causes more bleeding than normal from a small mucosal laceration. even after the most careful dissection, postoperative periorbital and facial ecchymosis can be severe. Many patients experience minor degrees of intraethmoidal hemorrhage, probably related to the outward crushing effects of the pituitary speculum on the middle and superior turbinates, but in Cushing's disease this feature of the surgery is more pronounced.

Nelson's Syndrome

Sometimes we are called upon to operate on patients with a Nelson-Salassa syndrome (a more appropriate name than Nelson's syndrome, but less common). These patients have ACTH-secreting pituitary tumors, which have developed after adrenalectomy and they become pigmented. About half experience a return of normal skin color after surgery. The Nelson-Salassa syndrome was originally reported to arise from pituitary adenomas that occurred following bilateral adrenalectomies for hyperadrenalism. It is not believed that most cases of Cushing's disease are caused by pituitary microadenomas, not primary adrenocortical hyperplasia. The adenoma is often undetectable until pituitary exploratory surgery. The Nelson-Salassa syndrome is probably not the development of a pituitary tumor *following* adrenalectomy, but the eventual recognition of the tumor that earlier *caused* the adrenal hyperplasia for which the adrenalectomy was done.

Multiple Endocrine Neoplasia Syndrome, Type I

Insulin-producing islet cell tumors of the pancreas, gastrin-producing adenomas, and primary hyperparathyroidism (from chief cell adenomatosis) can be seen with pituitary tumors like nonfunctioning chromophobe adenomas, GH-producing adenomas, or prolactinomas. If patients in need of hypophysectomy are also discovered to have hyperparathyroidism, their parathyroid surgery is usually performed first.

Other Special Sellar Lesions

Craniopharyngiomas

About half of craniopharyngiomas occur in children or adolescents, and about 75 per cent of patients present before age 40 years. Hypopituitarism is the rule, but hypothalamic disorders sometimes accompany the disease. Craniopharyngiomas are usually suprasellar tumors, but in some cases they are intrasellar. They are known for their tendency to show calcification on x-ray film and to look absolutely identical to ameloblastomas at histopathologic examination. They may be epithelial tumors developing from Rathke's pouch, which gives rise to the anterior pituitary. The transseptal approach may be offered for a biopsy only or for the decompression of the enlarging cysts that are commonly formed. The high location (upper end of the pituitary stalk) and the adherence to elements of the hypothalamus, cavernous sinus, and carotid artery make complete removal uncommon. For this reason, reoperation should be anticipated, and fragments of bone removed at the septal dissection should be replaced at the closure to assist the next septal surgeon in re-establishing the plane.

Destructive Sellar Lesion

The most common tumors to metastasize to the pituitary gland are those of the lung and breast. The syndrome of diabetes insipidus without other hormonal problems is more frequent than anterior pituitary dysfunction when metastases occur. When pituitary tumors extend beyond the intact pituitary fossa to include bone, brain, or nerves, tumors other than metastatic ones should also be considered. Multiple myeloma, chordoma, and neuroblastoma, ependymoma, meningioma, and oligodendrogliomas are a few of the tumors reported.

Massive pituitary adenomas, chordomas, and metastatic carcinoma are treated with the knowledge that removal by either the transcranial or the transseptal route will be incomplete. If the operation that provides the lowest morbidity and decompresses them into the sphenoidal sinus rather than the cranial cavity is indicated, transseptal transsphenoidal hypophysectomy is advised.

Empty Sella Syndrome

The so-called empty sella syndrome, which is probably caused by the protrusion of an arachnoid cyst into the sella, causes enlargement of the sella, visual loss, and even spontaneous CSF leakage. The chiasm may lie in an abnormal location, and the glandular tissue is usually present as a crescent compressed against the posterior sellar floor. Radiologic diagnosis is preferable, of course, but occasionally an empty sella cannot be recognized with certainty until it is differentiated from other cystic lesions at surgery. Since the chiasm can prolapse down into the empty sella, the surgeon must be well aware of the risks.

Drugs and Radiotherapy

New knowledge of the hypothalamus and its pharmacologic properties has made the management of pituitary tumors more dependent than ever on experienced clinical judgment. They are usually the province of the endocrinologist, of course. It is basic for everyone involved with pituitary tumors to realize that surgery is only part of the treatment. It does not always remove all the tumor. Big or recurrent adenomas that are adherent to cranial nerves or that indent carotid arteries and the hypothalamus will often be incompletely resected. Furthermore, even when surgery *is* totally ablative, hypothalamic-driven endocrinopathy may sometimes continue. Thorough postoperative testing is essential to establish the results of surgery and the level of needed replacements.

Drugs like bromocriptine, cyproheptadine, and others that have been newly developed are unquestionably very valuable for the medical treatment of certain patients with pituitary tumors. They can be used *instead* of operating, to buy time for a better diagnosis *before* operating, and to treat persistent hypersecretory syndromes *after* operating. Some tumors have actually been observed to shrink under medical management. However, they immediately relapse when the drug is discontinued. Nausea, and the concern about teratogenicity in women trying to get pregnant, are practical limits to drug use. Cases have been reported in which drug therapy masked the undesirable endocrine effects of a pituitary tumor, only to allow continual growth. Ultimately, ophthalmologic defects occurred as the enlarging tumor encroached on the optic chiasm. Clearly, the success of a drug like bromocriptine in controlling hyperprolactinemia should not obscure the fact that a tumor is present. A delay of removal until mass effects render it essential only increases the risks of surgery.

Finally, it needs to be acknowledged by surgeons that drugs and surgery are not our only weapons. Radiotherapy is often effective at inhibiting or destroying pituitary tumors. In fact, it may be comparable to hypophysectomy if control of the tumor is the only criterion. Surgery is more selective, however, and it is more likely to preserve normal function in the residual pituitary tissue and surrounding structures. At the present time, we use radiation in an ancillary role, when resection is necessarily incomplete and persisting hyperfunction or mass effects remain to be controlled.

Conclusions

The transseptal operation is probably more popular than the transethmoidal procedure because it proceeds through such a familiar field. It holds to the midline, avoids a facial scar, and approaches the sella along an inferior to superior incline that seems to optimize the angle of view. The transethmoidal operation provides shorter distance, but in practice, with modern specula, pituitary dissectors, and microscopes, this is not a meaningful advantage. The transfrontal intracranial and occasionally the *lateral* intracranial approach still have occasional indications, depending on the extent of the disease and the nature of the pathologic process. For the most part, the transseptal approach has become the centerpiece of sellar exposure, and every rhinologic surgeon should be familiar with its features.

Transseptal pituitary surgery can be considered safe and effective only when it is managed with great care and precision. A team approach appears to maximize the chance that an adenoma will be successfully treated; each patient who permits surgery on this region deserves the best possible rhinologic and neurosurgical care. With the evolution of new technologies and the expansion of surgical experience, previous rhinologic contraindications to the transseptal operation, such as a poorly pneumatized sphenoid bone, or previous septal surgery, have proved not to be contraindications. If the dual primary objectives of the rhinologic surgeon - to produce a dry, wide open field for the neurosurgeon and to preserve all the septal mucosa and cartilage (and most of the bone as well) - are met, the contraindications to surgical treatment, and even to retreatment, become very few. There is certainly room for further development in this field, but the quality of what can be offered today would probably astound the pioneers of just about 50 years ago.