Transsphenoidal Pituitary Resection

OVERVIEW OF PITUITARY SURGERY

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Used Sources:
R. Jadad “Core Techniques in Operative Neurosurgery” (2011), procedure 9
Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)
Rhoton collection – Anterior Skull Base, part 3 >>

OVERVIEW OF PITUITARY SURGERY

Typical pathway is TRANSSPHENOIDAL APPROACH – gold standard – high safety and efficiency (incl. pituitary microsurgery) confined to sella and larger tumors that, in past, could be approached only by transfrontal craniotomy!

- possible for fairly large midline suprasellar extensions, as long as tumor is soft (usual case) and can drop into sella with progressive resection (alternatively: follow stop MRI – when remaining tumor falls down – second look surgery)
- approach was originally developed by Cushing and popularized by others, especially Hardy;
- less surgical morbidity than transcranial approaches – transsphenoidal approach avoids brain retraction, does not create visible scars, and provides excellent visualization of the pituitary.

If sella is not enlarged, transsphenoidal approach is contraindicated!

- sella can be approached by three transsphenoidal approaches:
  a) direct transsphenal – endoscope (ENT) or microscope (Dr. JRC)
  b) anterior (trans/ septal)
  c) sublabial (trans/septal)

If tumor will be difficult to deliver transsphenoidally, think about CRANIOTOMY:

1. Subfrontal
2. Interhemispheric
3. Pterional
4. Subtemporal

- when choosing craniotomy approach, consider the following:
  1) position of chiasma (esp. if it prefixed)
  2) position of AComA-ACA complex: AComA perforators (go superiorly from AComA) are very friable!
  3) position of fornice

Indications for subfrontal approach:

- frontal lobe is carefully retracted, exposing optic nerves and ipsilateral carotid artery (N.B. only by subfrontal approach one can visualize both optic nerves and carotid arteries).
- if chiasma is prefixed ( severally limited view of tumor mass) - resect tuberculum sellae and open sphenoid sinus.

Pterional and Subtemporal approaches are used for parasellar tumors (MENINGIOMAS, CHORDOMAS).

See also cranioangiography aspects >>

PREOP WORK UP

Check for: sinusitis, nose trauma, OSA (obstructive sleep apnea), ossified / small sphenoid sinus.
Make sure you are not operating on undiagnosed prolactinoma! see p. OnC26 >>

Make sure visual changes are documented!

N.B. some antiseccretory medications can lead tumors to be denser and more fibrotic - technically more challenging to remove during microsurgery; H: stop medications 4-6 weeks preop!
3. CT – high risk of carotid injury during surgery; if circle of Willis is incomplete (cannot expect carotid cross-filing) – cannot sacrifice carotid if injury happens.

N.B. review imaging carefully for position of carotid! (look for “kissing” carotids)

**APPROACHES**

- the microscope affords magnification, illumination, 3D viewing, and two instruments simultaneously;
- the endoscope expands the surgeon’s field of view;
- both tools can be used simultaneously to complement each other.

**COMPARISONS**

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)

**Level III recommendation:** Transsphenoidal microsurgery or endoscopic resection is recommended for symptomatic relief.

**Level III recommendation:** Transsphenoidal approach is recommended for NFPA resection in ASA grade 1-3 elderly patients.

**Level III recommendation:** Adequate bony exposure of the sphenoid and sellar regions is recommended to improve extent of NFPA resection.

**Level III Recommendation:** Endoscopic approaches are recommended for better visualization of portions of tumors remaining after standard microsurgery (in multiple Class III studies direct endoscopic visualization revealed residual tumor tissue after initial microsurgery).

**Level III Recommendation:** For select, invasive NFPA(s) with significant suprasellar, frontal, and/or temporal extension, the combined transsphenoidal and transcranial surgical strategy is recommended.

**Oral Endotracheal Intubation**

- Adequate bony exposure
- Endoscope
- Mayfield
- Simultaneous
- Magnification, illumination, 3D viewing, and two instruments simultaneously
- Expand surgeon’s field of view
- Can be used simultaneously to complement each other

**CSF Leakage, olfactory disturbances post-op.**

**endoscopic vs. microscopic**

- Comparative effectiveness of transsphenoidal surgery: endoscopic vs. microscopic approach. Kahilogullari G1, Beton S, Al Beyati ES, Kantarcioglu O, Bozkurt M, Kantarcioglu E, Comert O, Çilingir MA, Muço C.
- prospective study – 25 pts operated on with the endoscopic approach and 25 patients operated on with the microscopic transsphenoidal approach.
- Smell Diskettes Olfaction Test was used during the preoperative period, 1 month after the operation; and 6 months after the operation.

<table>
<thead>
<tr>
<th>Endoscopic group</th>
<th>Microscopic group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoaesthesia</td>
<td>8%</td>
</tr>
<tr>
<td>Atrophia olfactoria</td>
<td>6%</td>
</tr>
<tr>
<td>CSF leakage</td>
<td>36%</td>
</tr>
<tr>
<td>Synchilia</td>
<td>4%</td>
</tr>
</tbody>
</table>

**OR EQUIPMENT**

**Navigation / fluorescopy (Dr. Holloway)**

**Microscope**

Endoscope

Doppler

**Lumbar drain**

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016); insufficient evidence to recommend perioperative CSF diversion to prevent postop CSF leak.

**PREPARATION IN OR**

- particular importance - replacement of adrenal insufficiency and significant hypothyroidism in perioperative period (HYPOTHYROIDISM 100 mg 12 hours prior to surgery, 100 mg just prior to surgery; 100 mg q8hrs after surgery, taper* over 3-7 days to maintenance 20 + 10 mg). IV BP tolerances.

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)

**Level II Recommendations:** replacement for adrenal insufficiency and significant hypothyroidism is recommended in all patients preoperatively.

**Level III Recommendations:** perioperative corticosteroid supplementation is recommended for NFPA patients with preoperative or immediate postoperative (day 2) hypocortisolism.

- i.e. not for patients with normal adrenal function

- systemic antibiotics (CEFTAXIMIN / CLEMBEPIDON / TETRAZARINONE) are used prophylactically (some surgeons prefer topical antibiotics on nasal mucosa).

- sphenoid: general oral endotracheal; tape ET tube down to lower lip.

- supine position with head:
  - a) on gel donut (Dr. Holloway) – neck extended, head rotated slightly towards operator.
  - b) in Mayfield frame (Dr. Broaddus) – neck in extended sniffing position - nose tip remains vertical – operative trajectory straight down.
• use nasal speculum for retraction (not Hardy retractor!).
• once close the sphenoid sinus, septum is rotated to break posterior septum (position is verified with navigation to avoid fracture into orbit!).

PURELY SEPTAL approach

• anterior inferior nasal septum and septal mucosa infiltrated with 0.25-1% lidocaine with epinephrine 1:100,000 or 1:200,000 (Dr. Broaddus uses only epinephrine); ENT also infiltrates palatine foramina from oral cavity side.
• vertical incision in septal mucosa (additional small incision in ala if it is necessary to enlarge nostril enough for speculum):

SUBLABIAL-SEPTAL APPROACH

• maxillary gingiva and anterior inferior nasal septum (through lip skin) infiltrated with 1% lidocaine with epinephrine 1:100,000 (Dr. Broaddus uses only epinephrine).

INCISION

• beneath upper lip - curvilinear anterior maxillary oral gingival / lip (preferred)* mucosa incision from canine-to-canine (few mm from gingival fold) with # 15 blade down to the bone:
  *incise lip – better mucosal cuff for repair, less straightforward path for CSF leak, lesser chances of gum numbness
  Leave enough of mucosal cuff for repair!
  Keep the lip protected with bacitracin ointment application!
**Penfield #1 / Freer dissector** used to dissect up maxillary bone to inferior maxillary choanal ridge:

![Penfield #1 / Freer dissector](image1.png)

**DISSECTION**

- Elevate nasal mucosa on both sides of nasal floor (hard palate) staying on bone with Freer dissector / Penfield #1 → elevate mucosa from right side of cartilaginous septum with Penfield #2 (its blunt edge helps to not perforate mucosa) → inferior portion of cartilaginous septum is detached from maxillary spine using #15-blade / Freer → elevate mucosa from bony septum back to the vomer and continued posteriorly to rostrum of sphenoid sinus → septum is removed with pituitary rongeur / Jansen-Middleton Septum Forceps (save large bone pieces for implantation on sella floor inside sphenoid sinus at time of closure):

![Dissection](image2.png)

N.B. all dissection must proceed as much cephalad (superiorly) as possible – superior part of sphenoid sinus is the most difficult to visualize!

- Hubbard or Hardy retractor is inserted and dissection continued with the navigation used to verify positioning.

**TUMOR REMOVAL**

See below >>

**CLOSURE**

- Hemostasis is achieved using bipolar electrocautery, packing with Gelfoam, pledgets, and SurgiFoam.
- If there is CSF leak and no lumbar drain, lower head of the table to drain some CSF and then elevate it to stop CSF leak.
- Sella maybe packed with:
  - a) Gelfoam
  - b) fascia
  - c) fat
- Bone (e.g. nasal septum) fragment is placed to close entrance into sella followed by DuraSeal spray. *Some experts do not use it.*
- Dr. Broaddus technique: DuraGen to cover sellar floor → bone → another layer of DuraGen → DuraSeal spray.
- Remove microscope.
nasal mucosa falls into place when retractor is removed
gingiva is closed using interrupted inverted 3-0 chromic gut suture with meticulous attention to align labial frenulum.
Merocel packs (with removed inner tubes and lubricated with bacitracin ointment) are placed in both nasal passages to maintain midline nasal septum (so direction of insertion is along hard palate and not towards sphenoid sinus); packs are inflated with some saline spray; strings from packs are secured to patient's face using Mastisol and Steri-Strips; "pituitary" mask may be placed on patient's face to contain secretions;
ENT likes Doyle splints – suture with Prolene to septum (through-and-through) – keeps septal mucosa apposed.

orogastric tube is used to decompress the stomach and suction out the oropharynx


ENDOSCOPIC TRANSNASAL approach

- minimal access method done by endoscopic rhinologist for exposing midline skull base
http://www.neurosurgicalatlas.com/grand-rounds/endoscopic-transnasal-surgery-personal-perspectives

INDICATIONS
1. meningiomas of planum sphenoidale / tuberculum sellae / olfactory groove
2. medial cavernous sinus, pterygoid bone, juvenile nasal angiofibromas arising from pterygopalatine fossa
3. infrasellar clivus (e.g. chordomas).
4. encephaloceles, meningoencephaloceles, and other midline skull base defects prone to CSF leakage can be repaired through endonasal endoscopic approaches, avoiding craniotomy.
5. large tumors that cannot be completely removed with endoscope are not always contraindications to this approach (endoscopic approach helps to biopsy and may augment secondary cranial approach with internal decompression or staged resection).

CONTRAINDICATIONS
1. Pathology extending laterally over orbits or lateral and posterior to carotid arteries - difficult to access, even when using extended endonasal approaches.
2. Lesions extending into or posterior to frontal sinus - difficult to reach even with angled scopes; also, nasoseptal flap may not reach this far anteriorly, and skull base closure may be challenging.
3. Invasion of cavernous sinus is not absolute contraindication but requires careful preoperative evaluation of surgical goals.

TECHNIQUE
1. topical decongestion with Neo-Synephrine soaked pledgets
2. 0° endoscope (some experts recommend 30-40° scope)
3. 1% lidocaine with 1:100,000 epinephrine solution injected into the bilateral middle turbinates and head of the superior turbinates.
4. Frazier tip suction to clear out secretions from the nasal cavity.
5. middle turbinate lateralized using a Freer.
6. through-cut forceps used to resect inferior aspect of the superior turbinate - visualization of the sphenoid os which is entered with the Frazier tipped suction and enlarged using the sphenoid (mushroom) punch medially and inferiorly.
7. once bilateral sphenoidotomies are performed, Cottle is used to make a posterior septal incision, and the Blakesley and through-cut forceps are used to perform a posterior septectomy.
8. James-McBride rongeurs used to help take down the inner sinus septum
9. Kerrison gently used to resect area of bone directly overlying the tumor.
Linear incision is made in the mucosa overlying the posterior septum, and the septum is fractured and deviated to the opposite side with the use of a No. 2 Penfield dissector.

Closure
- defect filled with DuraSeal*, followed by a graft middle turbinate / abdominal fat graft, followed by additional DuraSeal and Gelfoam.
- 8 cm Merocel packs placed in bilateral nasal cavities and taped to the patient's cheek using Steri-Strips.

Blakesley nasal forceps.

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*some experts do not use it
TUMOR REMOVAL

- sellar floor inspected for tumor penetrations.
- sella is opened using chisel → removed laterally to cavernous sinus area using 2 mm Kerrison / Stryker Sonopet drill.
- dura is cauterized using suction Bovie cautery and opened using #11 blade (X or +/− shaped incision).

N.B. use navigation and Doppler to check for carotids!

N.B. use 25G needle puncture before using #11 blade!

Three types of dissection:

1. EXTRA-CAPSULAR – avoid it as you are doing hypophysectomy of normal gland!
2. INTRA-CAPSULAR – traditional way when tumor is removed in piecemeal fashion using various ring curettes and pituitary forceps – messy, leaving tumor behind.
3. PSEUDOCAPSULAR – dissecting along PSEUDOCAPSULE plane – removing tumor en masse;
   • possible for microadenomas and macroadenomas; not possible for tumors invading cavernous sinus;
   • no difference in DI rates
   • need very wide exposure – must see “4 blues” (both cavernous sinuses, both intercavernous sinuses)
   • find normal gland then follow where it interfaces with tumor pseudocapsule
   • open dura carefully – do not disturb anterior normal gland (always there in front of tumor)
   • find plane with Rhoton # 3 dissector – goes easy inside capsule plane (may debulk tumor if it is too big)
   • dissect carefully from diaphragm or it will lead to CSF leak

- if diaphragma sellae starts sinking into the field → drain 50 mL of CSF from lumbar drain - diaphragma then recedes.
- 100% alcohol soaked pledgets may be placed into sella cavity (when arachnoid remains intact) for a few minutes to achieve additional tumoricidal effect (but only if no CSF leak).
- if tumor invades cavernous sinus – almost impossible to remove (causes CN deficits – mostly permanent)
- no reason to send for frozen pathology (but Dr. Broaddus does!)

Macroadenomas:
- sella is emptied with ring curettes – start at inferior sella, then go lateral (do not pull if curette catches on something – may be carotid!) – this way making superior tumor portions to sink down and diaphragm shows up when tumor is removed (otherwise diaphragm would be on the way to reach tumor).

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)

There is insufficient evidence to recommend the use of intrathecal saline or air for suprasellar tumor delivery to augment NFPA resection.

A. Visualizing superior aspect of tumor

a) intraop MRI
b) draining 20 mL of CSF from lumbar drain → insufflating subarachnoid space with 20 mL of air via lumbar drain → fluoroscopy; one can see air at the top of tumor

c) 30 degree endoscope
d) 90 degree US probe, e.g. UST-5311 by Hitachi Aloka:

B. Pushing tumor down

a) Valsalva
b) insufflating subarachnoid space with 1-3 mL, preservative-free saline via lumbar drain.

c) may also use removal of more of superior bone (beware optic chiasm and nerves – use navigation with segmented bone and optic apparatus).

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)
Microadenomas - frequently necessary to make vertical pituitary incisions to search for adenoma - adenoma is curetted.

CHROMONAVIGATION

OTL38 - fluorescent dye of two parts: vitamin B9 s. folic acid (a necessary ingredient for cell growth), and a near infrared glowing dye.

- as tumors try to grow and proliferate, they overexpress folate receptors.
- pituitary tumors can overexpress folate receptors > 20 times above the level of the normal pituitary gland in some cases - dye binds to these receptors and allows to identify tumors.

MRI

Guidelines on the Management of Patients with Nonfunctioning Pituitary Adenomas (CNS 2016)

Level III Recommendation: intraoperative MRI can improve gross total resection, but its use is associated with an increased false-positive rate and is thus not recommended.

- although intraoperative MRI helps improve overall gross total resection of nonfunctioning pituitary adenomas, intraoperative MRI for estimating residual tumor is not recommended due to a reported variable false-positive rate. This false-positive rate may contribute to the higher rate of gross total resection occurring with intraoperative MRI (but at the cost of removing normal tissue) and underscores the importance of incorporating surgical experience in the interpretation of intraoperative MR imaging for surgical decision-making.

COMPLICATIONS (INTRAOP)

CAROTID INJURY

N.B. brisk bleeding can occur with a breach in McConnell’s capsular arteries, which arise from the cavernous carotid that often supply vascularized sellar tumors.

Treatment:
1) large bore suction and call for blood
2) anaesthesiologist may compress carotid in the neck (helps to slow down bleed rate)
3) pack tightly (Gelfoam wrapped in Surgicel; best thromboplastic material – muscle*, then fat, muscle gauze for smaller lacerations);
- some experts of endoscopic skull base surgery have thigh prepped in case muscle plug will need to be harvested; others – cut the piece of tongue and use as a plug (last resort, but tongue is right there)
4) keep intubated with tight BP control → CTA
- N.B. watch for delayed pseudoaneurysm formation! – presents with profuse nose bleed; treatment: coiling + pipeline stent.
5) if still bleeding → angiography:
   a) ICA coiling (even after sacrificing ICA patient may wake up asymptomatic; if TIAs – may consider ECA-ICA bypass)
   Look at CTA (if available) – if circle of Willis is incomplete (cannot expect carotid cross-filing) – cannot sacrifice carotid!
   b) covered ICA stent: Jostent – very stiff and difficult to navigate; no need for heparin but load with Aspirin and Plavix in OR through NG tube; if angio shows in-stent thrombosis – give glycoprotein IIb/IIIa receptor blocker (e.g. ReoPro) and repeat angio every 10 minutes until clot resolved.
Prevention:
1) Review imaging - MRI with contrast, CT (sometimes intrasphenoidal septation leads to carotid canal)
   (Labib et al. Neurosurg 2013 – ICA projection into sphenoid sinus)
2) Neuronavigation – accuracy too low.
3) Doppler probe then cut dura away from carotid; may also try to aspirate with #25 needle before cutting dura
4) ICG angiography (microscope or endoscope with filter) – shows major vessels; tumor lights up later (craniopharyngiomas remain “cold”).
5) Chondroid tumors have highest carotid injury rate – may do preop carotid occlusion test.

COMPLICATIONS (POSTOP)
- see p. Onc26 >>