OVERVIEW OF PITUITARY SURGERY

PREOP WORK UP

Imaging

1. MRI
2. CT
3. Endoscopy

CONTRAINDICATIONS

1. Severe co-morbidities

APPROACHES

1. Transsphenoidal
2. Transcranial

COMPLICATIONS

1. Hemorrhage
2. Infection
3. Hydrocephalus

OR EQUIPMENT

1. Coagulation device
2. Microscope

PREPARATION IN OR

1. Sterile technique
2. Patient positioning

TRANSSPHENOIDAL APPROACH

1. Indications
2. Contraindications
3. Technique

MICROADENOMAS

Rhoton

Badie

Guidelines

R. Townsend:

E.

TOURELY SEPTAL

UMOR

NDOSCOPIC

RANSNASAL APPROACH

SED SOURCES

1. Strauss

7. Guidelines on the Management of Patients with Neoplastic Pituitary Adenomas (CNS 2016)

Anterior Skull Base, part 2

TRANSSPHENOIDAL APPROACH

1. Indications
2. Contraindications
3. Technique

TUMOR REMOVAL

1. Dural opening
2. Tumor dissection and debulking
3. Bleeding control
4. Cavernous sinus invasion
5. Giant Pituitary Adenomas
6. Strategies for suprasellar extensions
7. Chemonavigation
8. iMRI
9. Complications (intraop)
10. Carotid injury
11. Complications (postop)

POSTOPERATIVELY

1. See p. Onc26

OVERVIEW OF PITUITARY SURGERY

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

- possible for fairly large medial suprasellar extensions, as long as tumor is soft (usual case) and can drop into sella with progressive resection (alternatively: follow postop 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 CRANIODORSAL:

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

- when choosing craniotomy approach, consider the following:
  1) position of chiasm (esp. if it prefixed)
  2) position of ACA/ACA complex: ACA perforators (go superiorly from ACA/MCA) are very fragile!
  3) position of foramen

Indications for subfrontal approach:

- In cases of suprasellar tumors, esp. when primary purpose is to decompress optic nerves
- Lateral extension into middle fossa
- Frontoextension into supraorbital fovea
- 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 chiasm is prefixed (severely limited view of tumor mass) - retract tuberculum sellae and open sphenoid sinus.

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

Used Sources:


MARSHALL B. ALLEN, ROSS H. MILLER “ESSSENTIALS OF NEUROSURGERY: A GUIDE TO CLINICAL PRACTICE”, 1995

R. J. JANUAL: “CORE TECHNIQUES IN OPERATIVE NEUROSURGERY” (2011), PROCEDURE 9

GUIDELINES ON THE MANAGEMENT OF PATIENTS WITH NEOPLASTIC PITUITARY ADENOMAS (CNS 2016)

BADIE “NEUROSURGICAL OPERATIVE ATLAS - NEURO-ONCOLOGY”, 2nd ED., 2007 (P. 1-8)

NADER “NEUROSURGERY TRICKS OF THE TRADE – CRANIAL”, 2014 (P. 257-263)

Think that sella-sphenoid sinus is “pelvis” and tumor is “baby” – look at MRI if baby can be delivered vaginally (transsphenoidal) or needs C-section (subfrontal)

See also cranioopharyngioma aspects.
Lumbar drain

Doppler

Endoscopes

Microscope

Navigation / fluoroscopy

– CSF leakage, o

Pituitary surgery endoscopic visualization revealed residual tumor tissue after initial microsurgery

portions of tumors remaining after standard microsurgery recommended to

Level III recommendation

grade 1

Level III recommendation

for symptomatic relief

Level III recommendation

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

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Peripheral plate of the ethmoid.

sphenoid sinus. 1.

A mucoperichondrial flap is then elevated from the septum. (Inset) A developed using an elevator in the direction of the sphenoid sinus. After perforation cartilage with

posterior direction. Axial sections and through the nasal aperture show the relation of the septal

(A) A mucosal incision is made following the inferior border of the septal cartilage from an anterior to

vertical incision in septal mucosa (additional small incision in ala if it is necessary to enlarge nostril enough for speculum):

(epinephrine 1:100,000 or 1:200,000 (PHENYLEPHRINE

fat graft results are inferior). If expect CSF leak – it is hard to predict CSF leak from MRI features; prefers to place lumbar drain at the end of case only if needed (same with Dr. Holloway).

Dr. Broaddus

- considers prepping abdomen (above waist line)

- consider prepping abdomen (above waist line) for fat graft* harvesting (Dr. Broaddus thinks that fat graft results are inferior). *or thigh for fascia lata

- lumbar drain:

a) may place preop if expect CSF leak – tumor goes and likely breaches diaphragm of sella; b) may place preop if tumor goes above sella – may inject saline through lumbar drain to push tumor into sella

c) place postop PRN d) skip at all.

- place postop PRN

- fat graft

- vertical incision in septal mucosa (additional small incision in ala if it is necessary to enlarge nostril enough for speculum):

use nasal speculum for retraction (not Hardy retractor!).

- use nasal speculum for retraction (not Hardy retractor!).

- close the septal sinus, speculum is rotated to break posterior septum (position is verified with navigation to avoid fracture into orbit!)

- Dr. Holloway puts fat graft into sphenoid sinus and sprays Tisseel; she does not use any bone for reconstruction.

- Dr. Holloway puts fat graft into sphenoid sinus and sprays Tisseel; she does not use any bone for reconstruction.

- horizontal incision is made following the inferior border of the septal cartilage from an anterior to

- use nasal speculum for retraction (not Hardy retractor!).

- use nasal speculum for retraction (not Hardy retractor!).

- interior anterior 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).

*top inset* - removal of sella floor with small rongeurs.  
*bottom inset* - exposed inferior aspect of pituitary adenoma.

**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!

Recommended:

Not recommended:
**Penfield #1 / Freer dissector** used to dissect up maxillary bone to inferior maxillary choanal ridge:

- **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 and reflected to the side → elevate mucosa from bony septum back to the vomer:
Hubbard or Hardy retractor is inserted and dissection continued with the navigation used to verify positioning.

- bony 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):

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

- dissection continued posteriorly to rostrum of sphenoid sinus.
- mucosa is dissected from anterior wall of sphenoid sinus.
- sphenoid sinus is entered at rostrum and ossea using osteotome/chisel.
- removed portion of anterior sinus wall is saved for reconstruction.
- once inside sphenoid sinus, mucosa is removed (beware dehisced bone and exposed carotid!); if left in place - risk of mucocele (esp. if Hadad-Bassagasteguy vascularized naso-septal flap is used)

N.B. others recommend removing mucosa only from sella!

N.B. tips of the retractor should never be placed into the sphenoid sinus (after the completion of the anterior sphenoidotomy) - overexpansion of the retractor can fracture the sphenoid bone and the optic canals → catastrophic optic nerve injury.

- floor of the sella turcica reveals itself as a smooth bulge in the superior midline region of the sinus.
- microscope is brought into field.
- it is best to prepare the widest possible surgical field: removing the middle turbinate (not necessary in microadenomas), performing a wide sphenoidotomy (from one sphenopalatine artery to the contralateral one, exposing both ICAs), opening the sella from the inferior intercavernous sinus to the superior one and from one cavernous sinus to the contralateral one, cruciate dural opening with coagulation of the margins and coagulation of the inferior intercavernous sinus also serves to widen the working area.

Extended sella exposure (needed for tuberculum sellae meningiomas):
TUMOR REMOVAL

See below >>

CLOSURE

- hemostasis is achieved using bipolar electrocautery, packing with Gelfoam, pledges, 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 (± wrapped in Surgicel – “Surgicel sling”) – only if there is CSF leak. N.B. any placement of intracranial fat will obscure postoperative imaging of residual tumor! (Dr. Caldwell: fat gets absorbed and allows perfect MRI follow ups compared to using titanium mesh or Medpor)
- sphenoid sinus itself is not packed! (case report of blindness from too big of fat graft jammed into sella)
- N.B. placement of intracranial fat will obscure postoperative imaging of residual tumor!

Fat graft inside sella:

- bone (e.g. nasal septum) fragment / Medpor patch is placed intradurally to close entrance into sella followed by DuraSeal® spray (through Angiocath threaded through the ring of curette).
- Medpor patch in sella floor (over fat graft):
  a) Dr. Broaddus technique: DuraGen to cover sellar floor → bone → another layer of DuraGen → DuraSeal spray.
  b) Medpor patch is removed microsurgically. Dr. Doyle splints – suture with Prolene to septum (through-and-through) – keeps septal mucosa apposed.

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) ± avoid septal hematoma, 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); packs are inflated with some saline spray.

Fat graft inside sella:

- nasal mucosa falls into place when retractor is removed
- gingiva is closed using interrupted inverted 3-0 or 4-0 chromic gut or Vicryl suture with meticulous attention to align labial frenulum.
- Merocel packs are placed in both nasal passages to maintain midline nasal septum (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.
- orogastric tube is used to decompress the stomach and suction out the oropharynx.

Reconstruction of large defects - gasket closure technique with tissue (dural substitute or fascia lata) that is circumferentially at least 1 cm larger than the bony defect is used. This layer of tissue is countersunk and held in place by a Porex rigid implant (Stryker) cut to the appropriate size; nasoseptal flap is placed over the gasket seal; the lateral edges of the flap should extend beyond the lateral edges of the fascia lata layer; flap is then covered with tissue sealant, either fibrin glue or DuraSeal (Covidien) to keep it in place. Floseal (Baxter) is then used to control mucosal bleeding.


POSTOPERATIVE
→ see p. Otu26 >>

ENDOSCOPIC TRANSNASAL (s. ENDONASAL) 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
- broadened indications for transphenoidal approach:
  1) meningiomas of planum sphenoidale / tuberculum sellae / olfactory groove
  2) medial cavernous sinus, pterygoid bone, juvenile nasal angiofibromas arising from pterygopalatine fossa
3) infrasellar cleft (e.g. choriodomas).
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

- topical decongestion with Neo-Synephrine soaked pledgets
- 0° endoscope (some experts recommend 30-40° scope)
- 1% lidocaine with 1:100,000 epinephrine solution injected into the bilateral middle turbinates and head of the superior turbinates.
- Frazier tip suction to clear out secretions from the nasal cavity.
- middle turbinate lateralized using a Freer.
- posterior attachment of the middle turbinate is used as a landmark to localize the sphenoid sinus.
- 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 (or suction Bovie) and enlarged using the sphenoid (mushroom) punch medially and inferiorly.
- 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 (fracture vomer).
- Jansen-Middleton rongeurs used to help take down the inner sinus septum
- Kerrison gently used to resect area of bone directly overlying the tumor.
- resection of mass. see below >>
Closure

- defect filled with DuraSeal®, followed by a graft middle turbinate / abdominal fat graft, followed by additional DuraSeal and Gelfoam.

- after the nasal speculum is removed, the middle turbinate and the nasal septum are realigned into normal anatomical orientation - insertion of a lubricated fifth digit into the contralateral nares is often sufficient to check for septal alignment.

- 8 cm Merocel packs placed in bilateral nasal cavities and taped to the patient’s cheek using Steri-Strips; some experts do not use nasal packing.

Blakely nasal forceps:
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.
- opening should not extend to the chiasmal sulcus or tuberculum sellae because this can increase the likelihood of a postoperative CSF leak.

DURA OPENING:
- dura is cauterized using suction Bovie cauter and opened using # 11 blade (X or + -shaped incision).
- some experts warn - diagonal incisions should be avoided because they increase the risk of injury to the carotid arteries (esp. at upper aspect of sella); thus, make the vertical incision first (horizontal incision may result in the tumor decompression and descent of the arachnoid superiority, which may be inadvertently opened with a subsequent vertical cut).

TUMOR DISSECTION AND DEBULKING:

Microadenomas:
- microadenomas that are not present on the surface of the pituitary require a systemic search through seemingly normal appearing gland: transverse incision is made in the gland, and blunt dissection is then performed around the normal-appearing tissue to search for the tumor.

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

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!); use curved suction tip (last is center of tumor – 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).
- use larger curettes at the interface between the tumor and the sellar wall and along its deep parts because it causes less pressure to the wall compared with a small curette; hence, there is less chance to tear the wall by using a larger curette.
- central diaphragm is indicator of stalk.
- 100% alcohol soaked pledgets may be placed into sella cavity when arachnoid remains intact for a few minutes to achieve additional tumor/casual effect (but only if no CSF leak).
- no reason to send for frozen pathology (but Dr. Broadus does!)

DEBULKING:

- tumor squeezed normal collagen reticulum of pituitary.
- possibility of removing tumor en masse or piecemeal with a small curette; hence, there is less chance to tear the wall by using a larger curette.
- central diaphragm is indicator of stalk.
- 100% alcohol soaked pledgets may be placed into sella cavity (when arachnoid remains intact) for a few minutes to achieve additional tumor/casual effect (but only if no CSF leak).
- no need to disturb anterior normal gland (always there in front of tumor).
**Bleeding control**
- Most bleedings are venous – keep head above heart level.
- Consider TXA

**Giant Pituitary Adenomas**
- Look at the smoothness of tumor dome – if smooth, likely diaphragm is intact and TSR will be successful.
- Wide sella opening* is very important - CS to CS (use Kerrison with footplate between bone and dura) – will help to stay extradural and expose vasculature without risk.
- Navigated suction is helpful.

**Strategies for Suprasellar Extensions**

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 and 45 degree endoscopes
   d) 90 degree US probe, e.g. UST-5311 by Hitachi Aloka

B. Pushing tumor down:
   a) Valsalva (does not work if there is CSF leak)
   b) Insufflating subarachnoid space with 1-3 mL preservative-free saline via lumbar drain
   c) Removal of more of superior bone (beware optic chiasm and nerves – use navigation with segmented bone and optic apparatus)
   d) Ask anesthesia to compress bilateral jugulars for 30 seconds = “Valsalva on steroids”

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.

CHEMONAVIGATION

OLSL - 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 upregulate 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 immediate 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) anesthesiologist 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; muslin 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
   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 angiography every 10 minutes until clot resolved.
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 angiography 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 (other experts say that navigation is all you need).
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 >>