Spinal Tumor Surgery (techniques)

Last updated: October 17, 2025

EXTRAMEDULLARY TUMORS

Read also intramedullary tumors (below).

Videos:
Resection of a cervical dumbbell schwannoma with stabilization (by Paul C. McCormick, M.D., MPH Columbia University) – 14 mins >>

INDICATIONS

1. Symptomatic cord compression
2. Functional nerve root (C5-T1 or L3 – S1) impingement
3. Tumor progression

CONTRAINDICATIONS

1. **Asymptomatic** tumors affecting **nonfunctional** or **noncritical** nerve roots (especially in NF2 patients)
2. **Small** tumors that have not shown progression on serial imaging studies

PREOP

Extensive vascular imaging (CTA or MRA) of cervical tumors should be performed to determine optimal approach.

- in tumors where vertebral artery is encased within the tumor, consideration can be given to preoperative endovascular test occlusion and subsequent obliteration via coiling/embolization.

PERIOP

Steroids
MAP > 85
Neuromonitoring

APPROACH

- vast majority of these lesions can be safely removed through a standard posterior exposure.
  - approaches range from non-destabilizing **laminotomy** / **hemilaminectomy** (for tumors that do not extend beyond midline), **osteoplastic laminoplasty, full laminectomy**, to laminectomy with **partial or full facetectomy**.
  - approach extends past the rostral and caudal tumor poles
- most ventral tumors occupy a unilaterally eccentric ventrolateral location and produce some degree of spinal cord rotation and lateral displacement – **partial / total facetectomy** and **suture retraction of cut dentate ligaments** (over several levels) provide adequate exposure.
  - midline ventral intradural tumors *without spinal cord rotation or lateral displacement* (rare) → more formalized posterolateral or even anterior exposures (corpectomies).

DUMBBELL TUMORS - usually require a **unilateral facetectomy** to allow access to foraminal and extraforaminal extension up to ~ 2.5 cm from the lateral dural margin.

- whenever possible, it is preferable to remove the tumor through a single operative exposure to reduce morbidity and preserve surgical options.
- decompression of spinal elements should be done before addressing the tumor and whenever possible to visualize both components of dumbbell-shaped tumors in the surgical field.
- **instrumented fusion** that extends one level above and below facetectomy is usually performed.

DURA

INTRADURAL TUMORS

- ultrasound may help locate level (esp. thoracic) of dura opening.
- dural opening for most intradural, extramedullary tumors usually needs to include a lamina above and below the pathology.
- **midline** or **paramedian longitudinal** dural opening, just beyond the polar tumor margins - to facilitate tumor removal and precise identification of the afferent and efferent nerve origin attachments.

- dural edges are everted laterally and sutured to the paraspinal muscles to maximize intradural exposure and prevent the introduction of blood from the epidural space or paraspinal muscles into the dependent intradural surgical field.

DUMBBELL TUMORS – durotomy of nerve root sleeve is performed **along the axis of exiting nerve root**.

- dural opening is often **T-shape**: lateral extension of midline opening.
- muscles that attach to the posterior tubercle of the transverse process (levator scapulae) are detached increasing the lateral exposure.
- dissection of the vertebral artery from the tumor is performed and intertransverse foramen opened allowing for mobilization of artery medial to the tumor.
- for an extraforaminal tumor, approach between anterior and middle scalene muscles is another possibility with the theoretical advantage of lowering the chances of injury to the surrounding neurovascular structures.

TUMOR

Identification of tumor **origin/attachment**!

Arachnoidal plane of dissection can be established and followed to delicately **detach the capsule** from pia of spinal cord (possible for meningiomas and nerve sheath tumors)

- capsule is generally cauterized to shrink and decrease vascular input to the tumor

Internal decompression (Sonopet or CUSA) of tumor enables safe visualization / mobilization of tumor margins into the surgical field!

- avoid going through tumor capsule.
- in cases where the tumor capsule is very adherent to the pial surface or to nerve rootlets, the surgeon may elect to leave behind that material and coagulate it with bipolar cautery.
- healthy distal and proximal portion of involved nerve root must be identified prior to proceeding with tumor removal; schwannomas can be dissected off nerve root!
- surgeon can gently pull on capsule to aid in visualization and gently dissect it from surrounding neurovascular structures.
- pause every few minutes to assess 3D anatomy.
- for more ventral components, cut denticulate ligaments (at several levels – to prevent excessive cord torquing) → place 7-0 Prolene through the base of the denticulate ligaments to provide a means of gently rotating the spinal cord (frequently check evoked potentials).

Intraoperative neural **stimulation** may help to assess the **functional capacity of affected nerve roots**.

A. If the affected nerve appears to have robust motor function, a **nerve sparing debulking** of the lesion may be reasonable.
B. If **nerve root must be sacrificed**:
    - pre-ganglionic cut.
    - dura at the stump should be closed in a watertight fashion with either a clip or ligature to avoid a CSF leak.
    - postop deficit is much more rare than expected!

After tumor resection, the **spinal cord** should be carefully **dissected from arachnoid adhesions** to the dura that often develop with chronic cord compression and local inflammation.

MENINGIOMAS

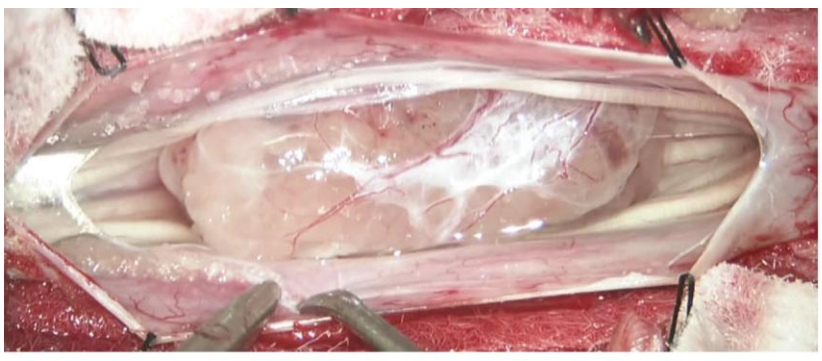
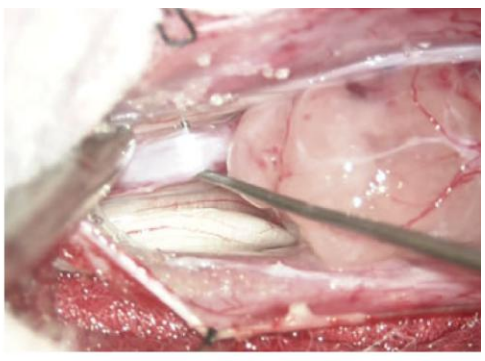
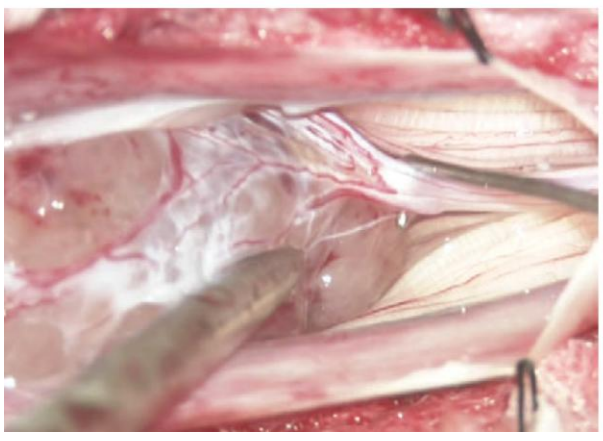
- exposed tumor surface should be visualized, including the rostral and caudal tumor poles.
- small cottonoid is placed in each lateral gutter above and below the tumor margins.
- division of one or more of the dentate ligament attachments to the lateral dura may improve access.
- well-defined arachnoid plane typically exists between the spinal cord and tumor capsule.
- tumors are usually removed by cautery of the capsule, internal debulking, release of the dural attachment to free the tumor, and finally, excision of the dural attachment zone.
    - depending on the size and consistency of the tumor, internal debulking with CUSA facilitates visualization and development of the tumor margins.
- all traction on the tumor should be away from the spinal cord.
- tumor surface may be quite friable and of variable vascularity.
- cauterization of the dural base may reduce bleeding from highly vascular or friable lesions.
- fortunately, due to a well-developed spinal epidural space, bony involvement does not typically occur.
- management of the dural attachment depends on practical considerations:
    - dorsal tumors - resect dural attachment.
    - lateral and ventral tumors - cauterization of the tumor origin is preferred because of the difficulty of dural reconstruction in these locations.

FILUM TERMINALE TUMORS

– aim for en-bloc resection to prevent CSF dissemination / recurrence:

- tumor is carefully freed from adjacent nerve roots, and the filum is identified visually and tested with a neurostimulator.
- filum terminale is cauterized above and below the tumor and divided, and the tumor is carefully rotated out of the canal.
- It is often not possible to achieve en-bloc resection safely in larger tumors:
    - tumor may lack sufficient internal integrity and fall apart with even gentle manipulation.
    - tumor may be too large to tease out without putting unacceptable amounts of traction on overlying nerve roots.
    - large tumors may exhibit sheet-like growth along arachnoid fenestrations.
    - functional roots may appear to course directly through the substance of the tumor.
    - safe resection can be impossible in these cases because the lack of supportive connective tissue matrix (i.e., epineurium) in the cauda equina nerve roots does not allow safe dissection of tumor off the involved roots - only subtotal resection may be possible.

Cauda equina ependymoma: (a) initial intraoperative exposure - both the rostral and caudal tumor poles are well visualized. (b) Magnified view of the rostral pole identifies the tumor origin from the filum terminale. The filum is differentiated from the surrounding cauda equina nerve roots by its white color and vascularity. (c) Magnified view of caudal pole demonstrates a distal filum terminale attachment to tumor. (d) tumor following en-bloc resection.


NERVE SHEATH TUMORS

- gross total removal can be achieved in most non-NF2 cases.
- most nerve sheath tumor capsules are adherent to the arachnoid of the nerve root, and this layer must be incised to reach the lesion:
    - intermediate arachnoid layer is sharply opened over the dorsal tumor surface.
    - second arachnoid layer is usually tightly applied to the tumor surface - this layer effectively compartmentalizes and ensheathes individual dorsal and ventral roots; although the proximal portions of corresponding segmental dorsal and ventral nerve roots remain separate, they become compartmentalized within a common arachnoid sheath as they course toward the dural root sleeve.
- identification and opening of the arachnoid nerve sheath is important for two reasons:
    - First, it enables the dissection to take place directly on the tumor surface. This layer is ultimately reflected off the tumor surface at its margins and can make mobilization and visualization of tumor margins difficult if the dissection is performed outside this layer. This is particularly important with regard to nonvisualized tumor margins that abut the spinal cord.
    - Second, the corresponding nerve root is usually tightly applied to the tumor capsule within this arachnoid layer. Upon initial inspection, this nerve root may appear to be the nonfunctional nerve root of origin because of its tight attachment to the tumor surface. Upon opening this layer, however, it becomes clear that this root may be dissected off the tumor capsule and preserved.
    - The same is not the case for the **actual nerve of origin**. Although a portion of the afferent and efferent components of the nerve of origin may be dissected and separated from the tumor capsule, eventually this dissection plane disappears as the nerve root becomes incorporated into the tumor capsule.
- dorsal tumor capsule is entered, and **internal decompression with an ultrasonic aspirator or laser** is performed. Sufficient internal decompression enables the progressive delivery of initially nonvisualized tumor into the resection bed. Division of the lateral dentate ligament attachment facilitates ventral access. Ultimately, the afferent and efferent tumor attachments need to be divided to achieve removal. In some cases, the afferent and efferent components may be immediately apparent on the dorsal surface of the tumor. Early division of these attachments facilitates removal of the tumor, particularly at the thoracic levels. More commonly, however, the afferent and efferent tumor attachments are not visualized on initial tumor exposure. The afferent root is often identified by its enlarged, congested, and hypervascular appearance. In contrast, the efferent root component usually appears normal. Progressive internal decompression enables the delivery of the tumor margins into the resection bed until the attachments are visualized.
- cauda equina tumors: dorsal and ventral nerve roots may already be contained within a common arachnoid sheath at the proximal origin. At these levels, the functional corresponding nerve root may appear to be part of the afferent root of origin. However, fascicles from the corresponding root will be reflected onto the tumor surface and can be dissected and preserved. Occasionally, some of the fascicles from the actual nerve root of origin may also be reflected onto the tumor surface and may be separable from the tumor capsule over much of, or occasionally the entirety of, the tumor surface.
- unless dorsal and ventral nerve roots arise from critical cervical or lumbosacral levels and demonstrate intraoperative stimulation, they need not be preserved, as such futile dissection unnecessarily prolongs the resection.
- tumors that arise from the very proximal portion of the nerve root may not have a definable afferent nerve root attachment. Instead, these tumors may abut and be adherent to the spinal cord at the root entry zone.
    - proximal tumor growth may actually elevate the pia, where it is reflected at root entry zones, and occupy a subpial location - care must be taken to safely remove this subpial tumor component to avoid injury to the spinal cord or fragile epipial vascular network – use microsurgical dissection directly on the tumor surface (this dissection can be difficult for removal of ventral root tumors, even with gentle retraction of a detached dentate ligament; H: some portions of the pia may have to be incised to follow the subpial tumor component. If uncertainty regarding tumor margin remains, then there should be no further dissection.
- conversely, tumors arising more distally along the root of origin may have their distal margin near or just beyond the dural nerve root sleeve - internal decompression, as well as early identification and division of the afferent attachment, provides adequate visualization and mobilization of the distal tumor component to enable preservation of a critical corresponding functional nerve root. Nerve root stimulation can be useful during this part of the dissection.

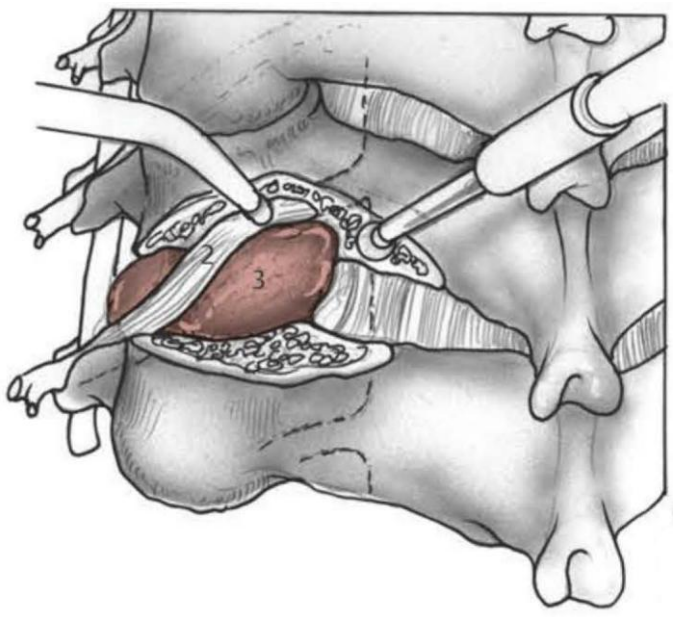
Subaxial cervical tumor (posterior approach)

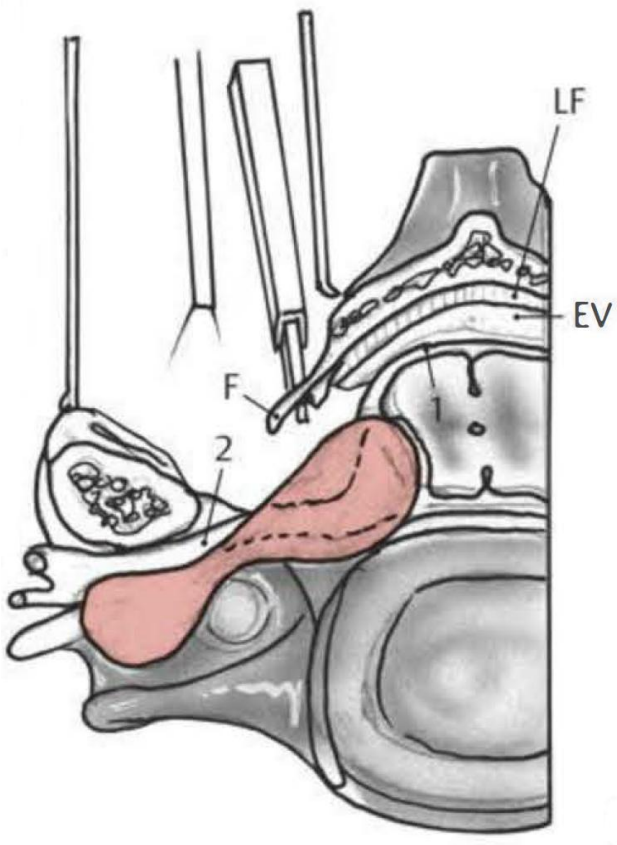
- single-staged posterior approach is possible to remove lesions if they do not extend > 4 cm from lateral dural margin (lesions reaching more lateral locations require an additional anterolateral procedure)

Removal of superior and inferior facets:

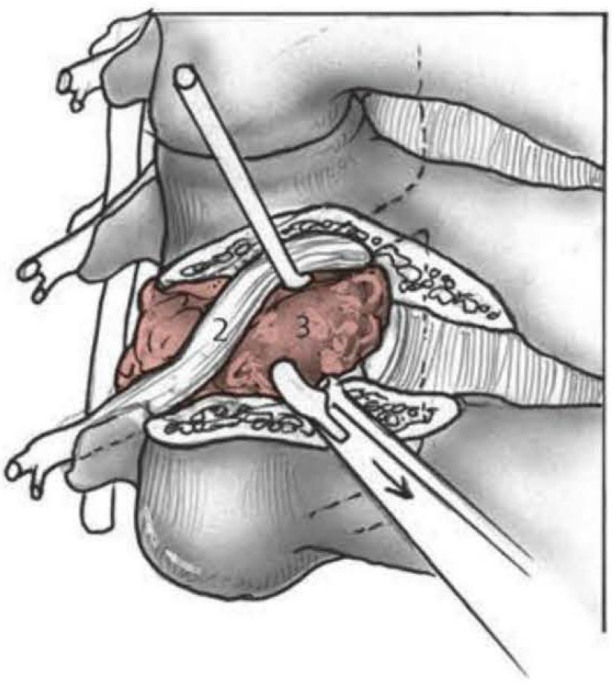
1. Dura
2. Exiting nerve root
3. Tumor.

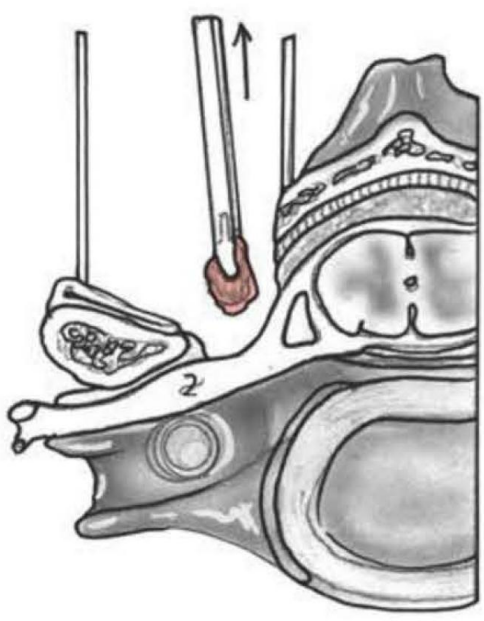
LF. Ligamentum flavum.
F. Lamina.
EV. Epidural venous complex





Piecemeal tumor removal:





C1-2 tumor (incl. types in relation to vertebral artery) – see p. Op210 >>

Thoracic tumor

- lateral extracavitary approach is the approach of choice for large dumbbell-shaped tumors of the upper thoracic region. It has the advantage of minimizing manipulation of the cord at this level and offers wide exposure of the paraspinal region, especially ventrally, without violation of the pleura or the abdomen. The patient is placed in a true lateral position. The head of the rib of the level below the tumor is removed to allow for visualization of the involved foramen. The intercostal artery and vein are coagulated and cut. If the foramen is not enlarged or the tumor is mainly in the spinal canal, the operation begins with relief of spinal cord compression by removing the canalicular extension of the tumor via a standard posterolateral approach with laminectomy and unilateral facetectomy.

Lumbar tumor

- posterolateral approach is used to address almost every SS, even ones with an extensive lateral extension, as previously described.
- most difficult part of the operation remains at the end of the procedure when the capsule is detached from the vascular structures, kidneys, ureters, and the lumbosacral plexus. If the capsule is very adherent, it is better to leave a piece behind than risk injury to one of these structures.

Sacral tumors usually require a combined approach with the first procedure being performed anteriorly with a transdural approach.

CLOSURE

- subarachnoid space is irrigated with warm saline - to prevent arachnoiditis.
- dura is closed with a running 4-0 silk or 5-0 Prolene; may need dural substitute.
  - ventral dural defect - autologous fat or muscle graft may be placed along the defect with fibrin glue.
- Valsalva maneuver to 35 mm Hg is performed to verify watertight dural closure.
- DuraGen may also be placed over the suture line.
- deep subfascial drain is infrequently used.
- decide if lumbar drain is needed (e.g. poor dural closure); if a watertight dural closure is achieved, lumbar drain is unnecessary.

POSTOP

- ICU for blood pressure control and frequent neuro exams.
- patient is kept on bed rest until POD 1-2 and then progressively mobilized.
- wean steroids.

COMPLICATIONS

- CSF leak.
- intramedullary hemorrhage
- radicular dysfunction and deafferentation pain - low risk of as gradual growth of the tumor allows for functional compensation by neighboring nerve roots.
  - if involved nerve root is found to be functional with electrical stimulation and cannot be safely detached from the tumor → abort procedure (remove only safe parts of tumor) → second look surgery if the tumor continues to grow and the compensation from the neighboring roots allows for safer removal. • Vessel tears, such as, should be repaired
- quadriplegia – sometimes cannot be avoided and may occur even when very delicate handling of spinal cord and tumor tissue.

  - prevention: short amplitude, delicate movements of the microinstruments; maintenance of normal blood pressure and oxygenation; and preservation of normal arteries, arterioles, veins, and venules.
- spinal instability is a risk in cases of extensive bone removal, especially at the cervical level when **combined anterolateral and posterolateral approaches** are used or in cases of **total facetectomy** (H: fusion – be mindful of metal artefacts on follow up MRIs).
- vertebral artery injury → enlarge bony exposure, repair with 10-0 silk. See p. Op210 >>
- delayed pseudomeningoceles are followed over time because many spontaneously resolve

OUTCOME

- even subtotally resected nerve sheath tumors (esp. schwannomas) are rare and slow to recur (important in NF2 cases).
- Klekamp and Sammi: 87 patients:
  - 17 patients with NF2 and symptomatic neuromas presented with more severe neurologic symptoms compared with patients without NF2.
  - neurologic symptoms tended to remain unchanged in patients with NF2, as compared with patients without NF2 for whom most preoperative deficits and/or symptoms improved.
  - NF2 patients presented with a 39% recurrence rate at 5 years.

INTRAMEDULLARY TUMORS

References to check

"Management of Intramedullary Spinal Cord Tumors - 2024 Update" by Dr. Anthony Frempong-Boadu, NYU Langone Health, New York, NY. Click here to view: Management of Intramedullary Spinal Cord Tumors - 2024 Update

"Intradural Intramedullary Tumor: What Dictates Treatment? General Principles of Spinal Cord Surgery" by Dr. Jean-Paul Wolinsky, Northwestern University Feinberg School of Medicine, Chicago, IL. Presented at the LSRS 13th Annual Meeting. >>

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Surgical extirpation is treatment of choice for *benign tumors*! (cures have been reported only after complete surgical resections)

Total removal with preservation of neurologic function!

PREOPERATIVE

- **steroids** in perioperative period (start at least 24 h prior to surgery; begin tapering 3-5 days after surgery).
- baseline ***urodynamic studies***!
- do preop ***VA balloon occlusion test*** if anticipate vertebral artery sacrifice; if VA is nondominant, one may consider sacrificing (e.g. coiling) VA preop.

PROCEDURE

These are high-risk operations that require special expertise in spine and microsurgical techniques.

- it is sometimes recommended to have two surgeons in this operation (or an experienced assistant).

MONITORING

Monitor spinal cord function using intraoperative electrophysiology (real-time feedback regarding possible ischemia or retraction injury):

1) *somatosensory-evoked potentials (SSEP)*
2) *motor-evoked potentials (MEP)*
3) epidural *D-waves* - correlates with expected outcome. see p. D25 >>
4) *EMG* (extremity muscles, anus + bulbocavernosus reflex*)

– spinal cord is sensitive to decreased perfusion - avoid hypotension (keep MAP > 85), use TIVA!

– pre-positioning baseline recordings are not obtained for intradural lesions.

*for conus / cauda tumors

SSEP, MEP, D-wave – alarm decrease by 50%
EMG, bulbocavernosus reflex – "lost or retained"

Nerve root stimulation is recommended for tumors in cervical (C5-T1) or lumbosacral (L2-S1) levels

See p. D25 >> (including protocol for intraop spinal cord injury)

APPROACH

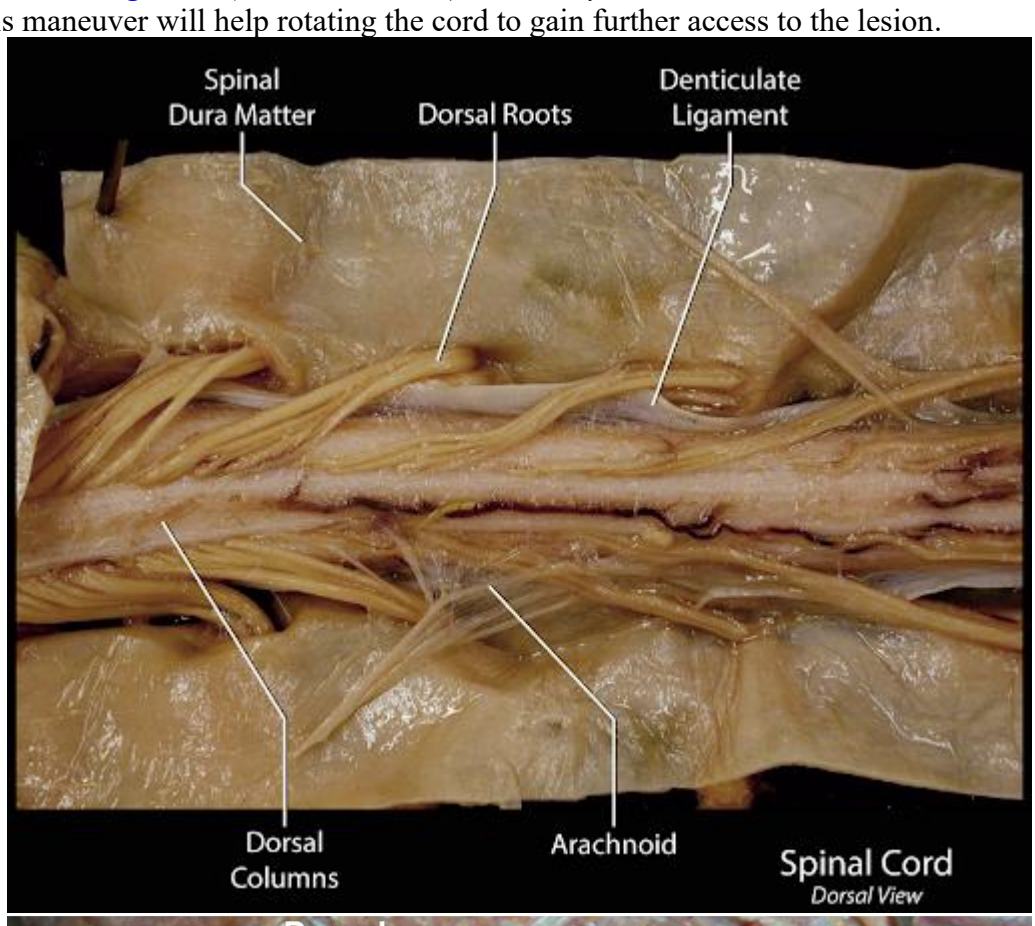
- depending on tumor location – either laminectomy (posterior approach) or corpectomy (anterior approach).

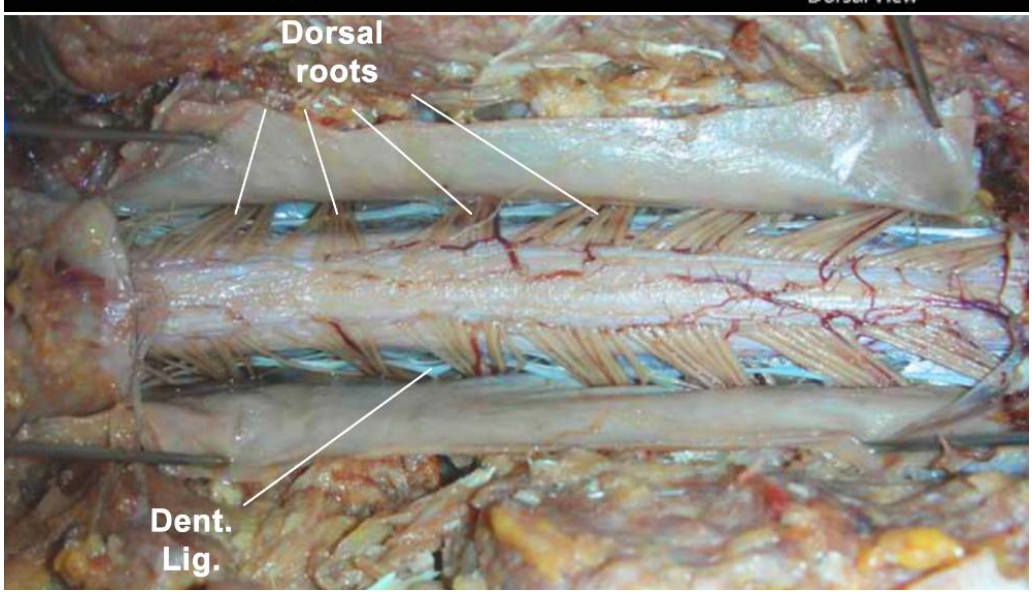
Posterior approach - wide **laminectomy** (**laminoplasty*** in children and select adults);

*removing all laminae as single unit en bloc with footplate ("lobster tail") → at the end, place back and suture to the facet/pars with silk sutures (drill bone holes with C bit) - to protect spinal cord, to lessen risk of subsequent spinal deformity;

Dr. Jallo does **laminoplasty** for all adults (esp. true for kids) – "it does not prevent deformity but it helps with epidural scar and less CSF leaks"

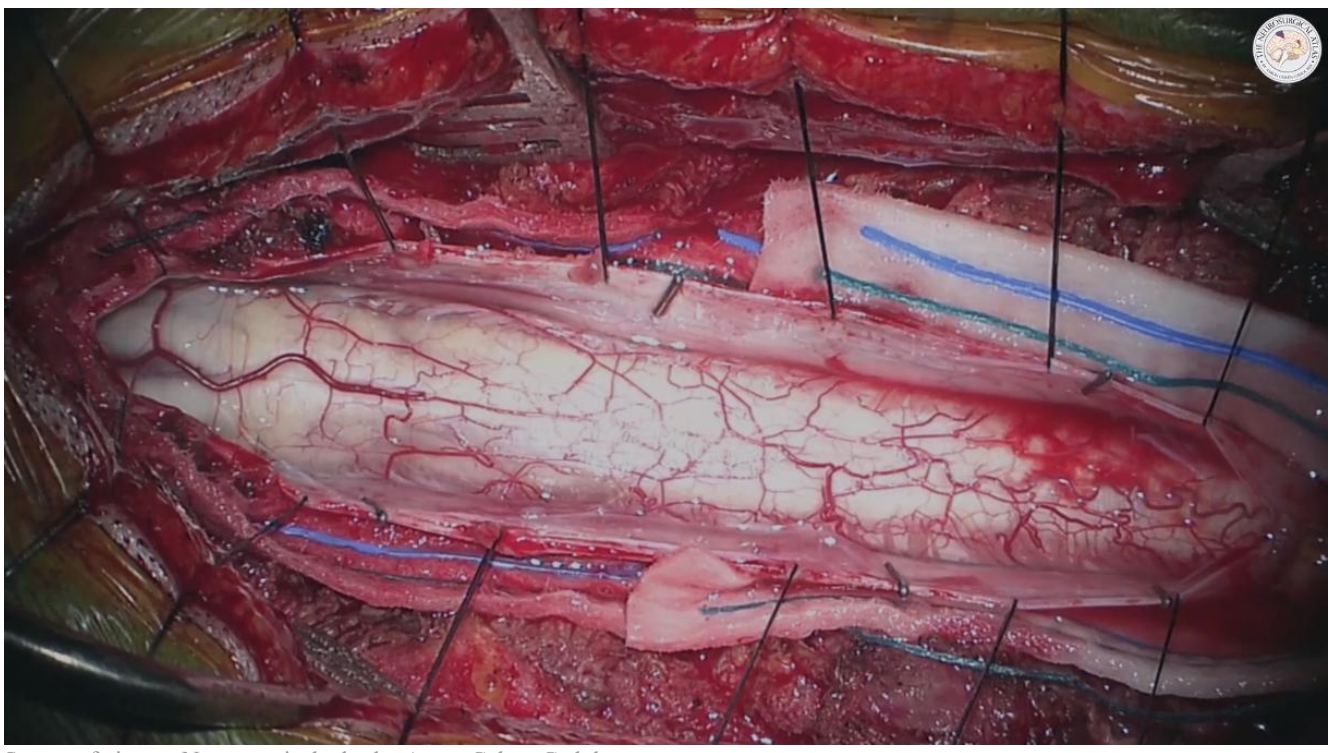
- for tumors below T6, headrest is used and the arms are abducted not more than 90 degrees at the shoulders; for lesions above T6, Mayfield head clamp is utilized and arms are tucked at the side.
- laminectomy should be of sufficient size to allow visualization of healthy cord above and below neoplasm.
- when using a posterior approach for ventral and lateral lesions, the spinal cord can be released by *cutting the dentate ligament (± dorsal rootlets) bilaterally* at the level of the lesion, above and below - this maneuver will help rotating the cord to gain further access to the lesion.





DURA

- prior to dural opening, tumor is localized with ***intraoperative ultrasound*** or ***spinal stereotaxy*** (esp. in thoracic spine where level localization is often unreliable).
  N.B. use US to determine dural opening extent.
- ***perfect hemostasis*** before opening dura (epidural bleeding only tends to get worse once dura is opened); wax bone edges then lay 0.5x3 patties along gutters to absorb blood ooze.
- open dura under microscopic magnification.
- midline durotomy extending above and below lesion as confirmed by intraoperative ultrasound.
- be mindful of *potential adhesions of the spinal cord or vascular structures* to the undersurface of the dura – operating on previously resected or radiated tumors may present a special challenge - err on the conservative side so as not to compromise spinal cord function.
- place 4-0 silk tuck-ups to retain dura open.

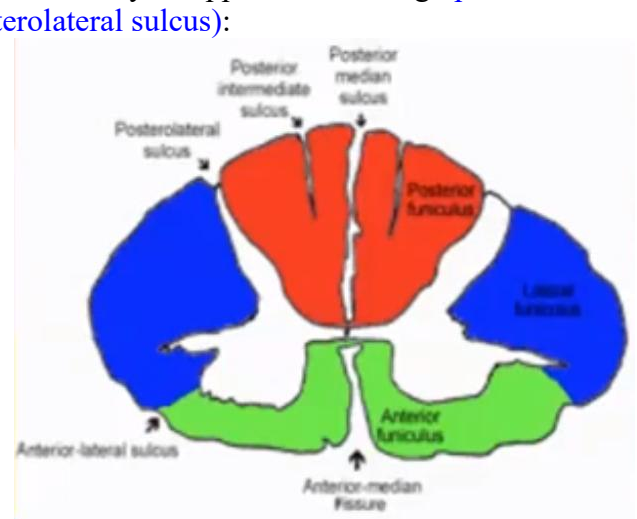


Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

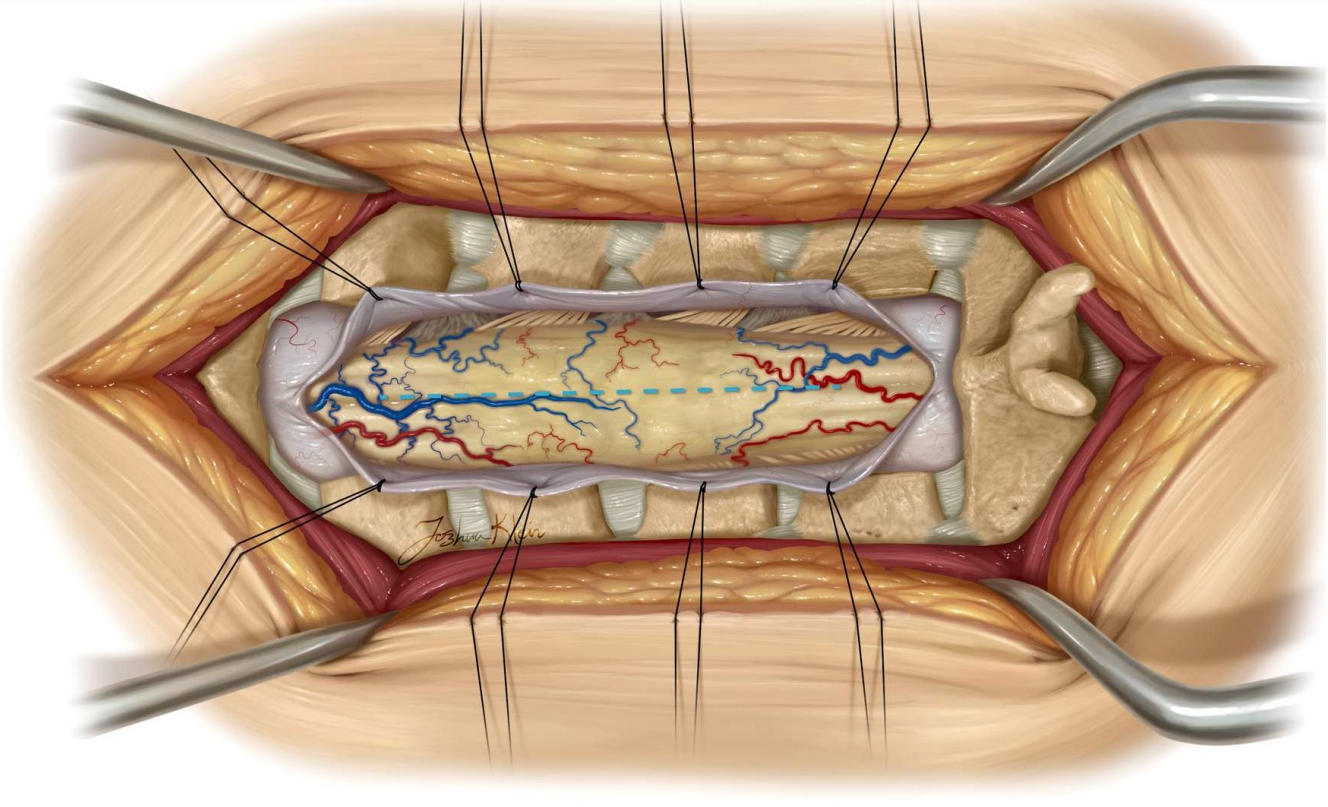
CORD

Under microscope, linear* midline** myelotomy at thinnest area between tumor and spinal cord.
*to spare vertically running white matter tracts.
**between the sensory fibers

- eccentric lesions may be approached through posterior intermediate sulcus or dorsal root entry zone (posterolateral sulcus):

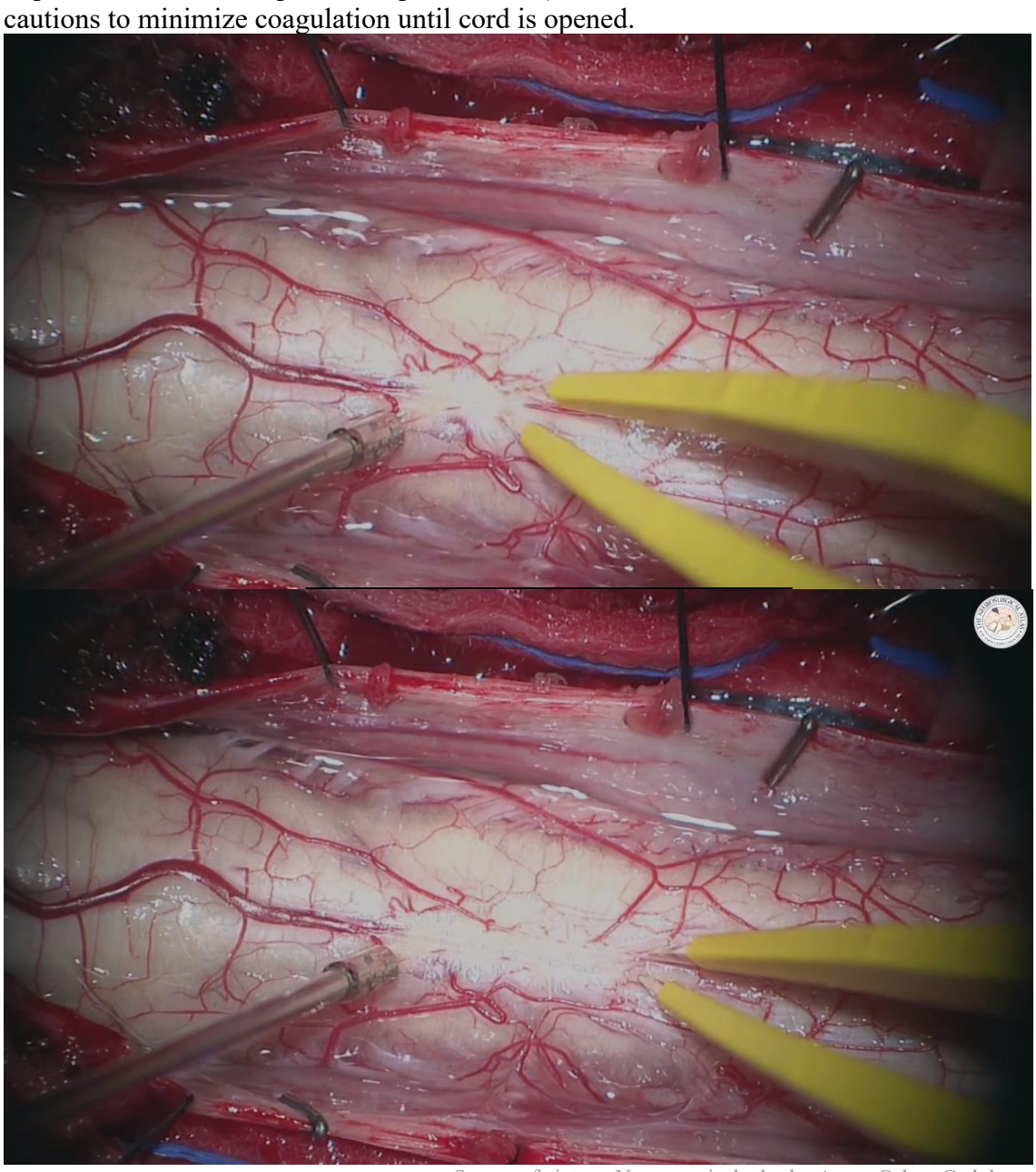


- **dorsal midline** must be studied carefully to identify **median raphe** so that injury to posterior columns is avoided.
  - pattern of the dorsal roots can help with this identification.
  - converging small vessels and avascular areas suggest the position of posterior median sulcus.
  - bilateral dorsal root entry zones may be used as landmarks.
  - visualize the adjacent normal cord and follow midline raphe across the tumor (some tumors may be growing further in one hemicord than the other and may actually rotate or shift the dorsal midline); dorsal median vein is another landmark.
  - dorsal column monitoring can be useful in determining location for midline myelotomy.
    - *electrical mapping* of posterior columns is also helpful - stimulate with bipolar fork where it is safe to cut.
  - if tumor has exophytic component, this is initial area of approach (pia mater is opened directly over tumor), i.e. debulk any exophytic component prior to addressing tumor located within parenchyma.



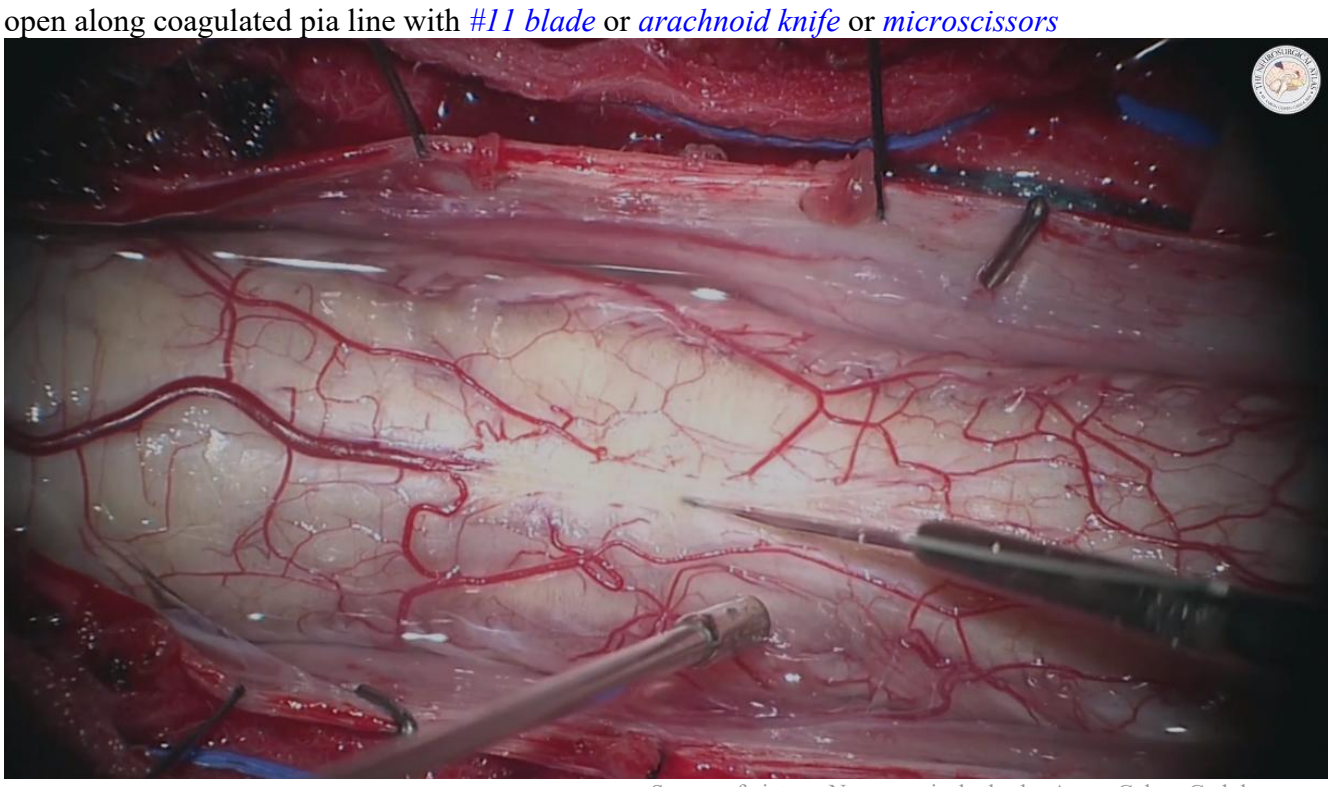
Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

- **dorsal vasculature** is saved by dissecting it from the pia and rotating it to one side of the spinal cord.
  - blood vessels crossing dorsal midline or penetrating into dorsal midline are coagulated with fine bipolar forceps on the lowest coagulation setting (avoid excessive coagulation to preserve most of the posterior spinal vessels) – do it in strict midline! Dr. Jallo cautions to minimize coagulation until cord is opened.



Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

- open along coagulated pia line with *#11 blade* or *arachnoid knife* or *microscissors*



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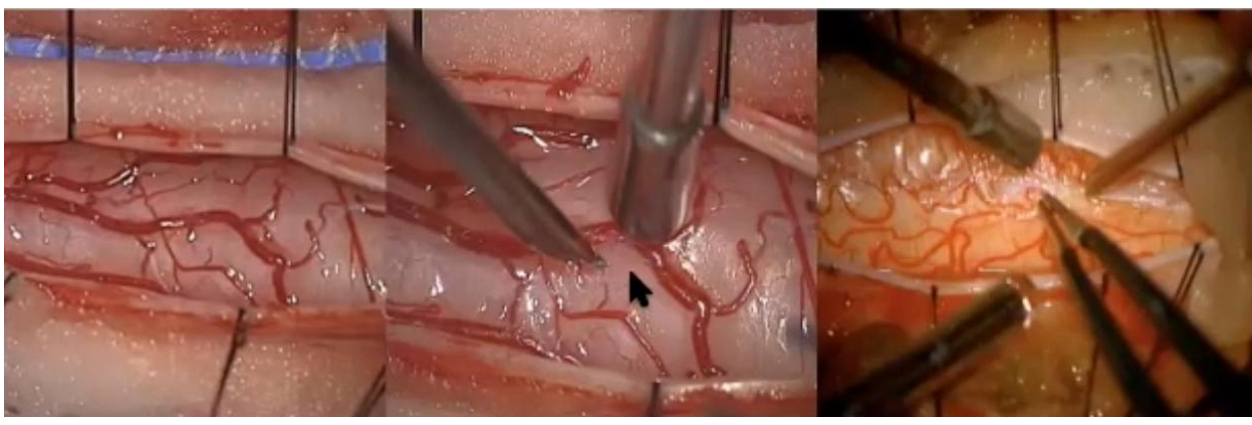
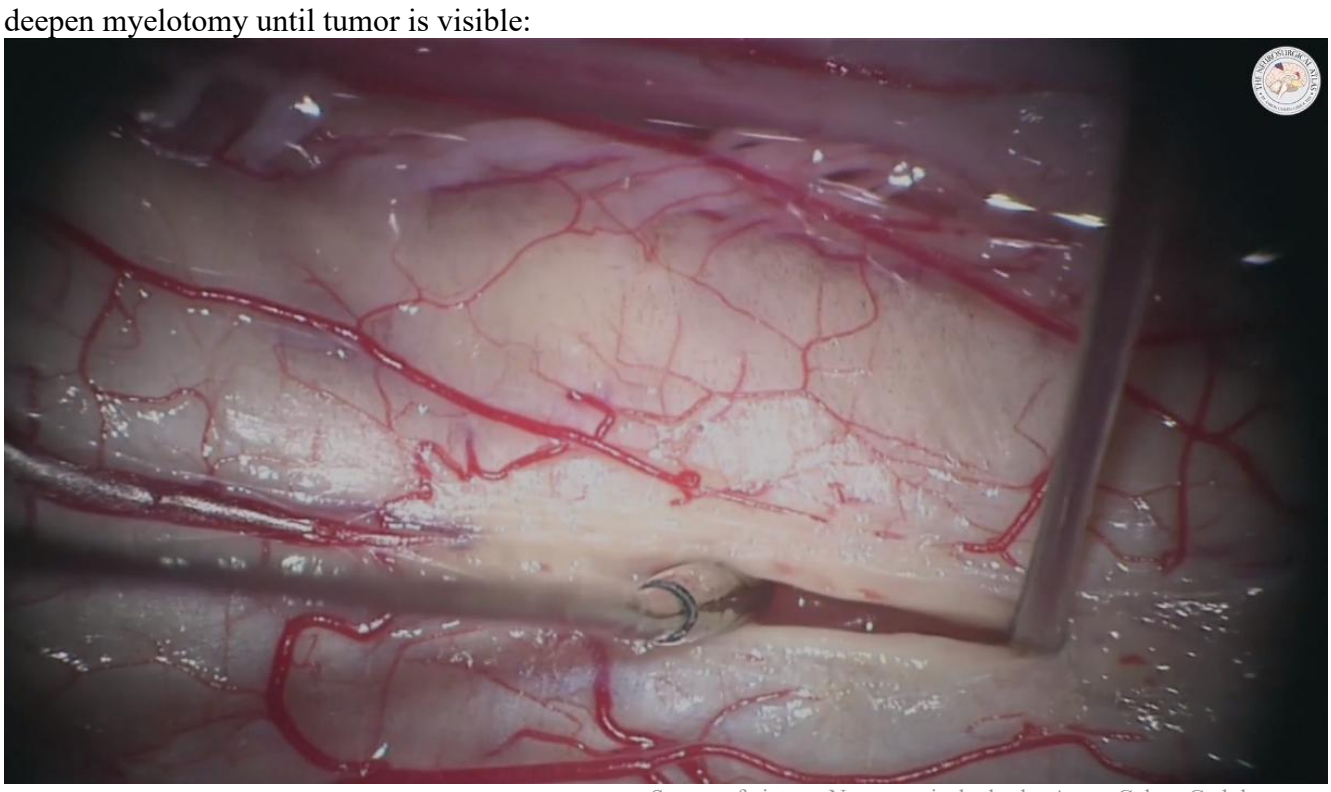
  - Dr. Nader recommends *double-edge razor blade* - sharper than most scalpels.
  - Dr. Jallo uses *16G needle*:

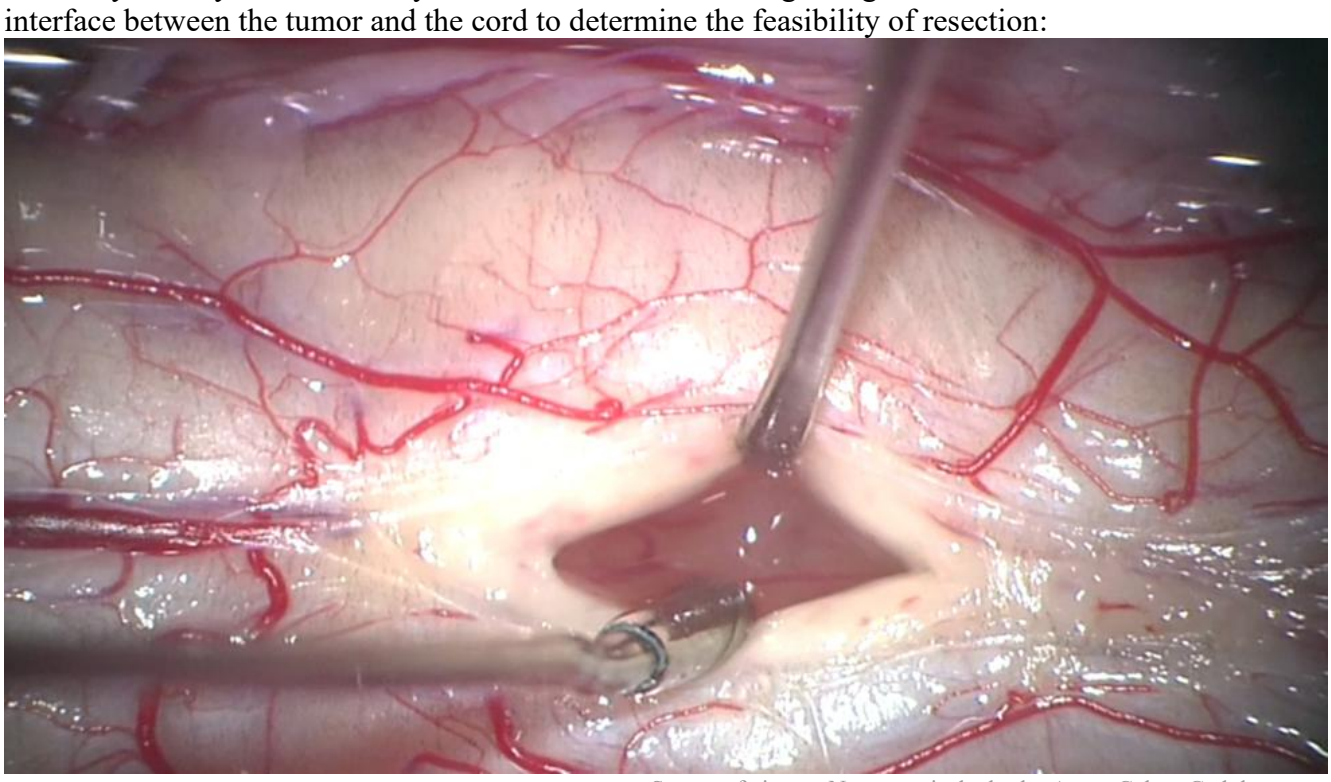


- deepen myelotomy until tumor is visible:



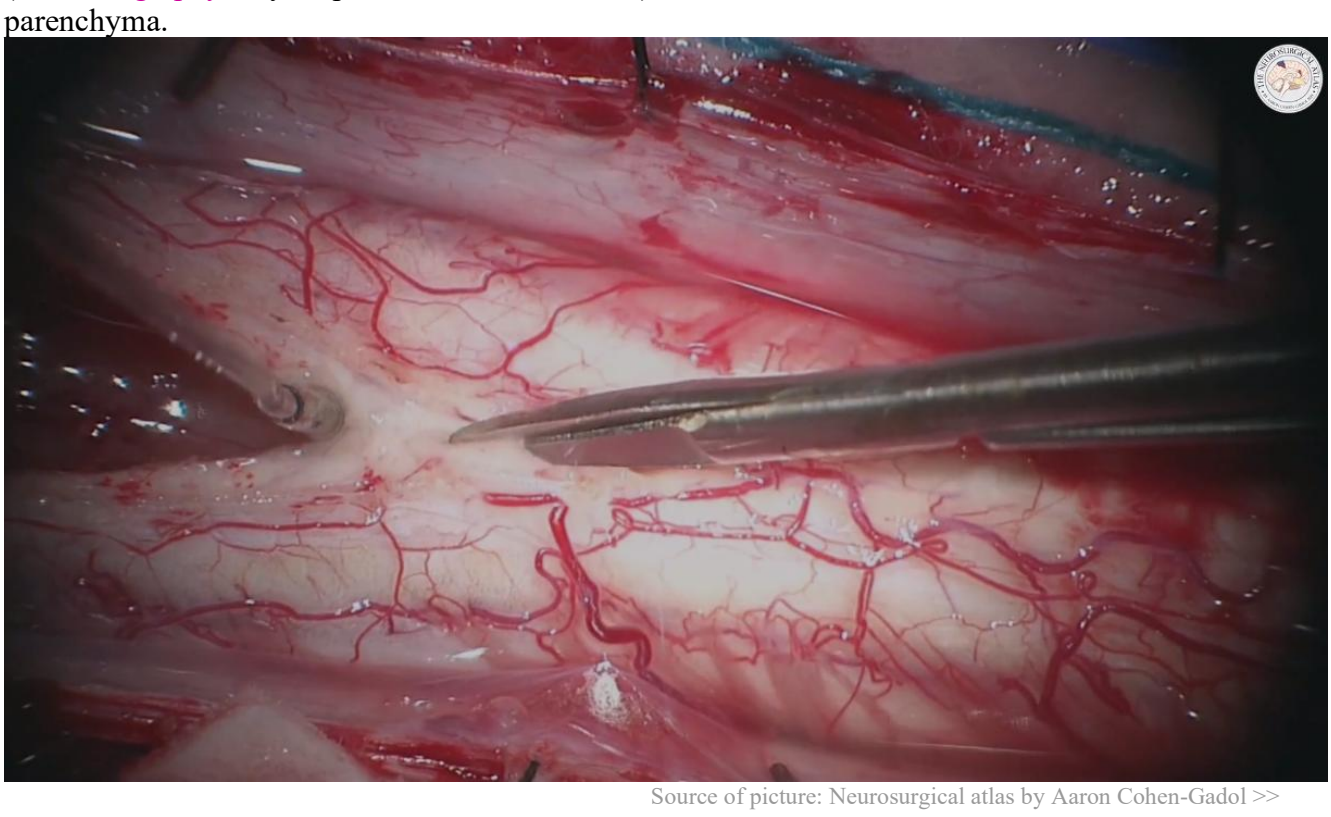
Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

- ***initial myelotomy*** should be only 1-2 cm over the most enlarged segment of the cord - examine the interface between the tumor and the cord to determine the feasibility of resection:



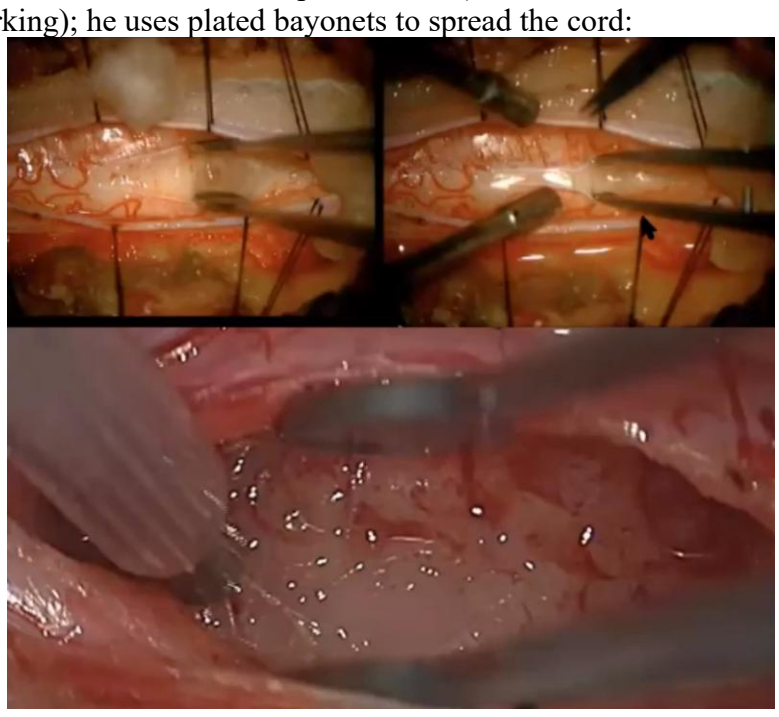
Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

- if reasonable planes are present, extend myelotomy for the entire length of tumor is exposed (ultrasonography may help to define tumor extent) – to allow tumor removal without traction on parenchyma.



Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

- dissect pia and place 5-0 or 7-0 Prolene retraction sutures (Dr. Cohen-Gadol: to keep myelotomy open – better see tumor - and minimize repetitive cord manipulation via dynamic retraction) suturing edge of pia* to edge of dura (may place vascular Weck clips instead of tying knots).
  *Dr. Jallo recommends no pial stitches (so cord can relax in areas where surgeon is not working); he uses plated bayonets to spread the cord:

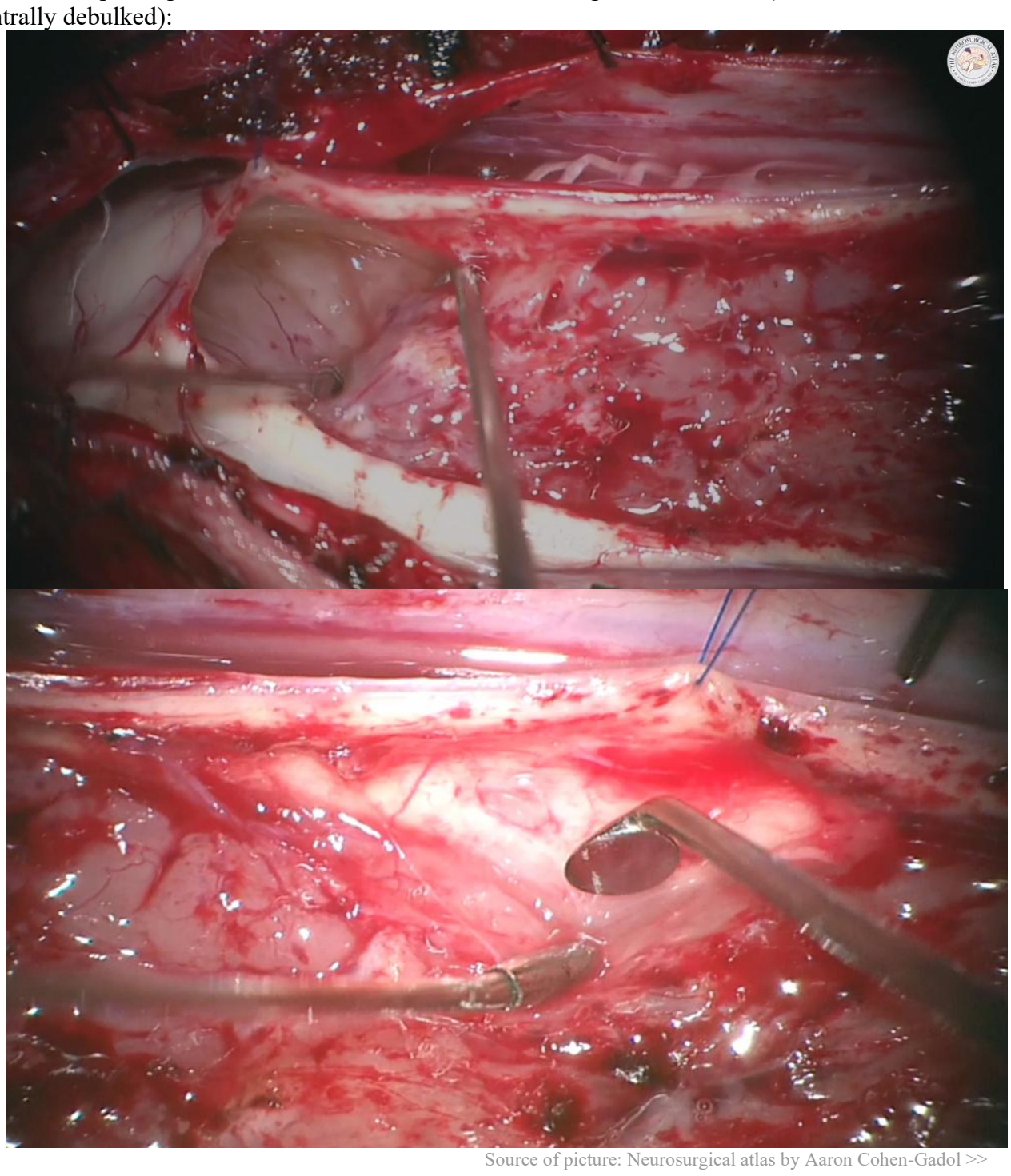


TUMOR

- strategy:
  - a) **vascular tumors** (e.g. hemangioblastoma) first need to control* feeders – bipolar them first, then resect tumor.
    *some experts recommend intraop ICG angiography to find feeding vessels
  - b) **nonvascular tumors** can be removed in piecemeal fashion (vascular tumors – en bloc).
- find cleavage plane and dissect* tumor around.
  *sweeping along the plane (along with very gentle traction on the tumor with a fine-toothed forceps) alternating Fukushima microsuction tip, angled dissectors (e.g. Rosen, Rhoton) >>, Beaver blade, sharp canal knives, microbipolar cautery.

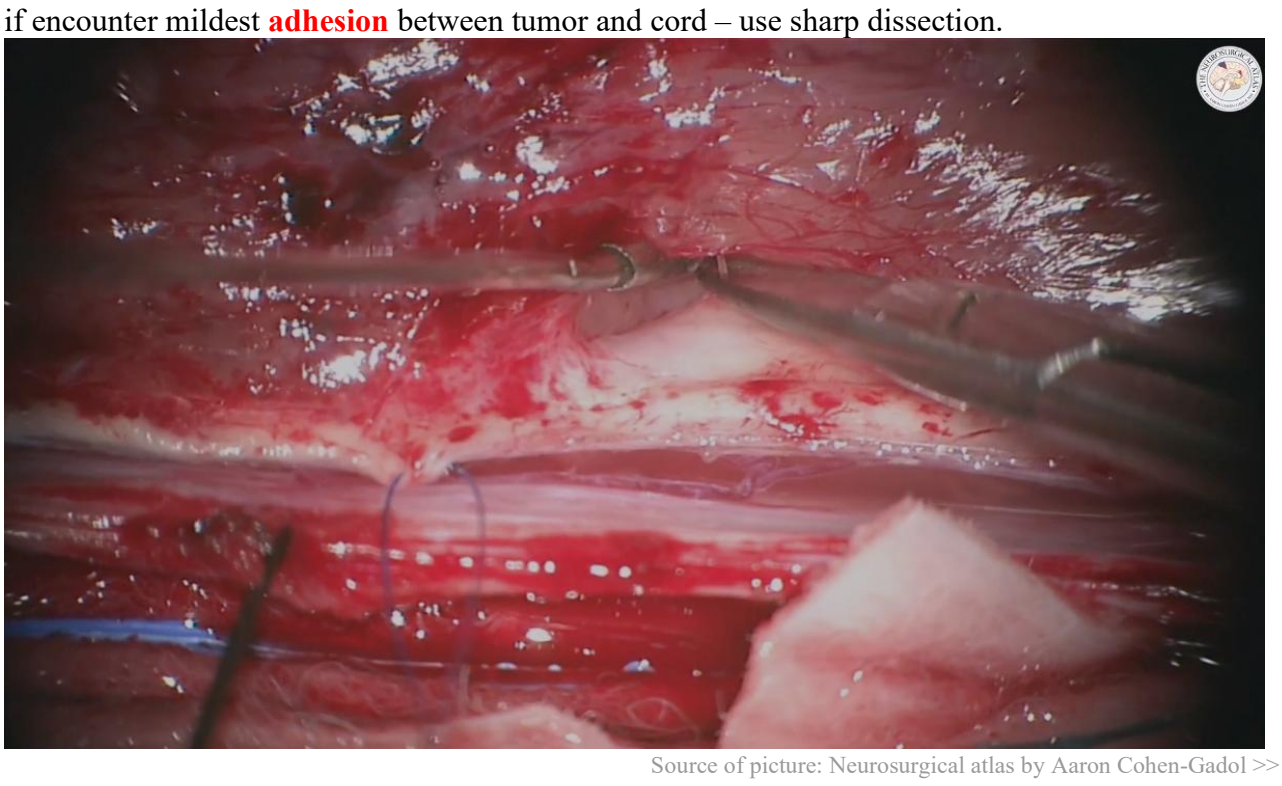
McCabe Canal Knife:

- defining the plane of dissection between tumor and cord can be difficult (preoperative T2-weighted MRI must be thoroughly studied to identify the cyst-tumor junction that can be used to begin the dissection between tumor and spinal cord).
- traction on the cord should be avoided and kept to a minimum at all times.
  N.B. mobilize tumor away from cord (vs. mobilizing cord parenchyma away from tumor)!
  Dr. Cohen-Gadol: preferential retraction on the decompressed capsule rather than the cord to develop the dissection planes!
- debulking instruments: NICO Myriad side-cutting dissector, Cavitron ultrasonic surgical aspirator (CUSA), fine-tipped contact laser (CO_2, KTP).
  Dr. Cohen-Gadol: ultrasonic aspirator provides the most atraumatic method of tumor decompression; alternative - fine tumor forceps.
- cyst at the superior pole of the tumor facilitates the initial stages of dissection (after tumor is centrally debulked):



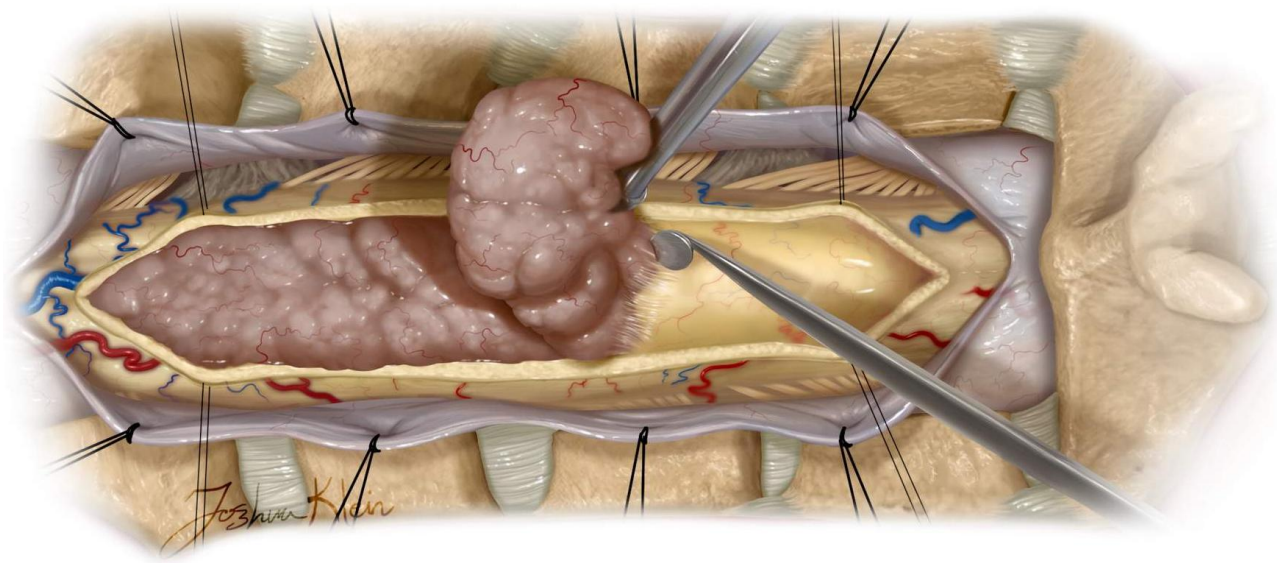
Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

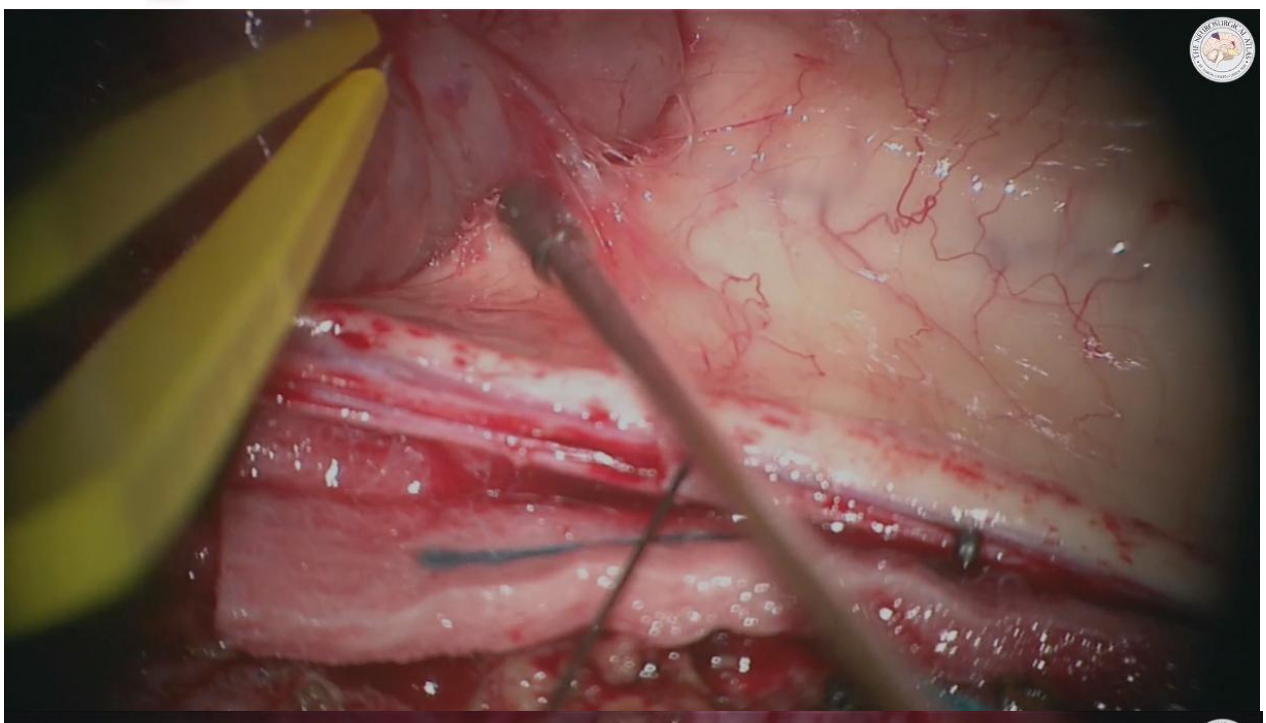
- send to ***frozen pathology*** for confirmation – if pathologist is not sure of diagnosis, better stop and come back for a second operation rather than to hurt the patient.
  N.B. wait for frozen pathology before proceeding with resection (astrocytoma – do not do aggressive resection!)
- if encounter mildest **adhesion** between tumor and cord – use sharp dissection.

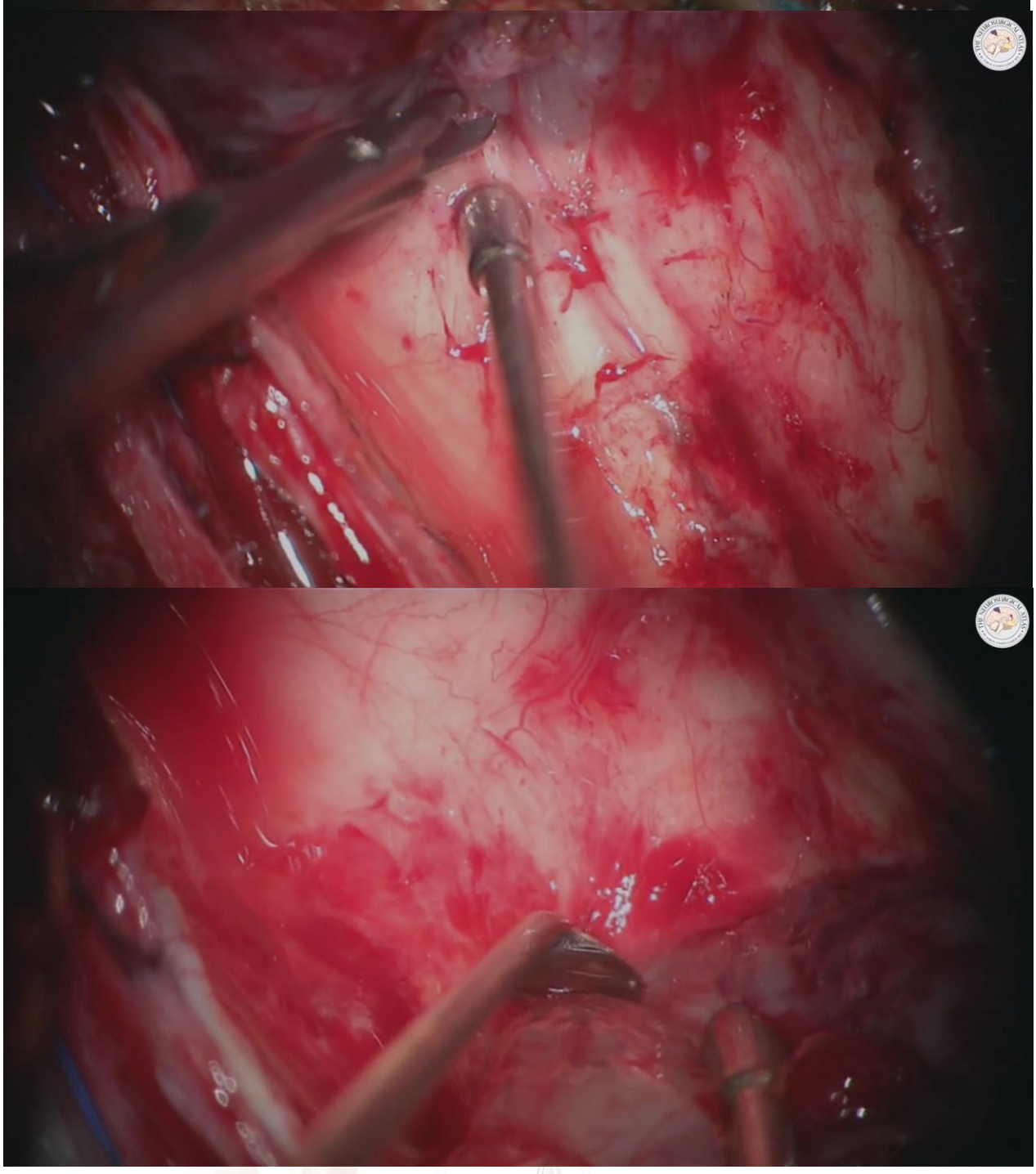


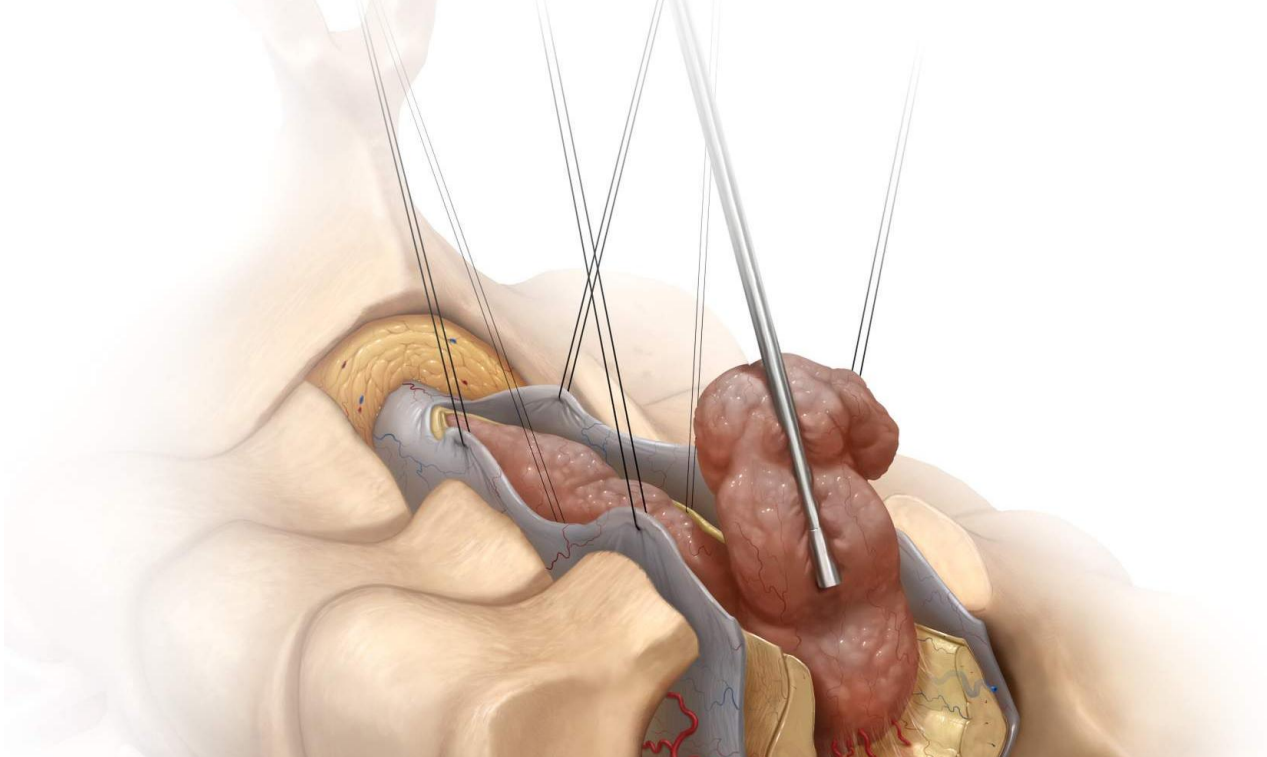
Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

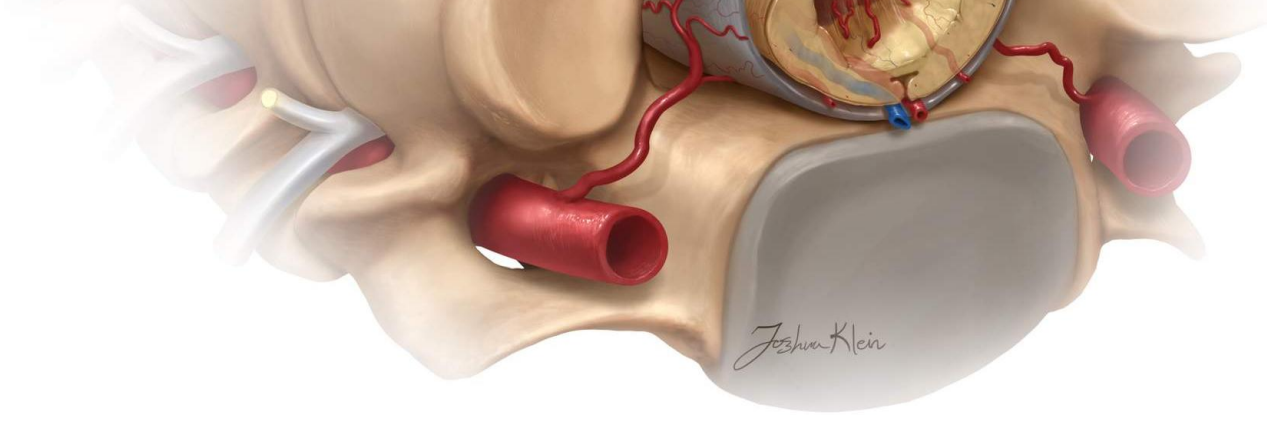
- after lateral dissection, continue on ventral surface by rolling tumor away from cord.
  - the most adherent part tends to be along the *anterior aspect of tumor midbody* – gentle retraction on tumor allows finding the dissection plane as close to tumor capsule as possible (i.e. cut adhesion on tumor capsule, away from cord); feeding vessels from anterior spinal artery should be carefully handled and cauterized/severed (indiscriminate traction leads to avulsion → ventral cord and anterior spinal artery injury during the process of securing hemostasis):

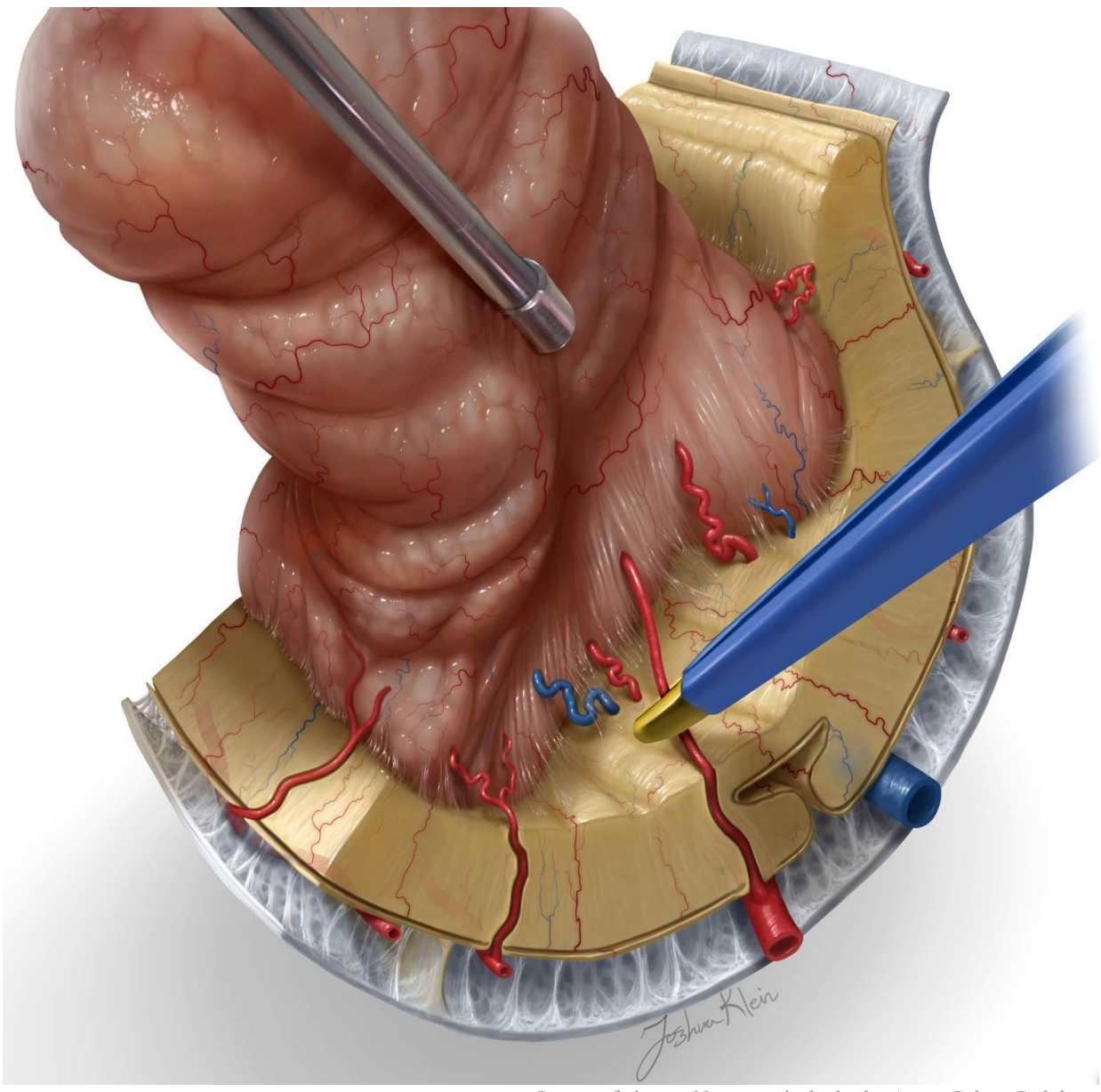












Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

- tumors tend to be avascular and may have true capsule (or definable plane).
  - if ill-defined plane is present, risk-to-benefit ratio for aggressive removal is not clear (e.g. developmental tumors can be quite adherent to spinal cord).
  - for biopsy-proven high-grade* lesions, only biopsy and dural patch graft (to enlarge space for spinal cord) may be alternate approach to attempted resection.

*rapid progression even after aggressive resections

EPENDYMOMAS, PILOCYTIC ASTROCYTOMAS have plane – easy to dissect;

- blood supply to ependymoma arises from branches of anterior spinal artery penetrating through the ventral median raphe - these vessels are coagulated and divided as they are encountered on the ventral surface of the tumor.

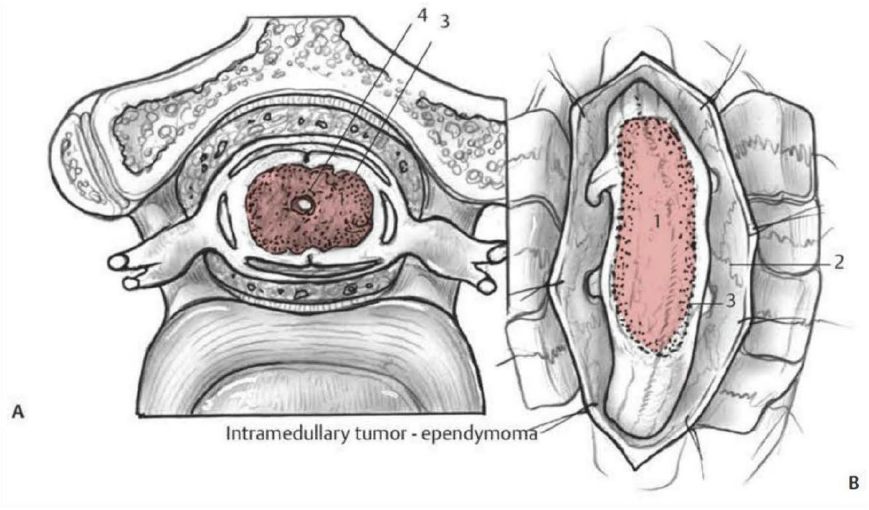
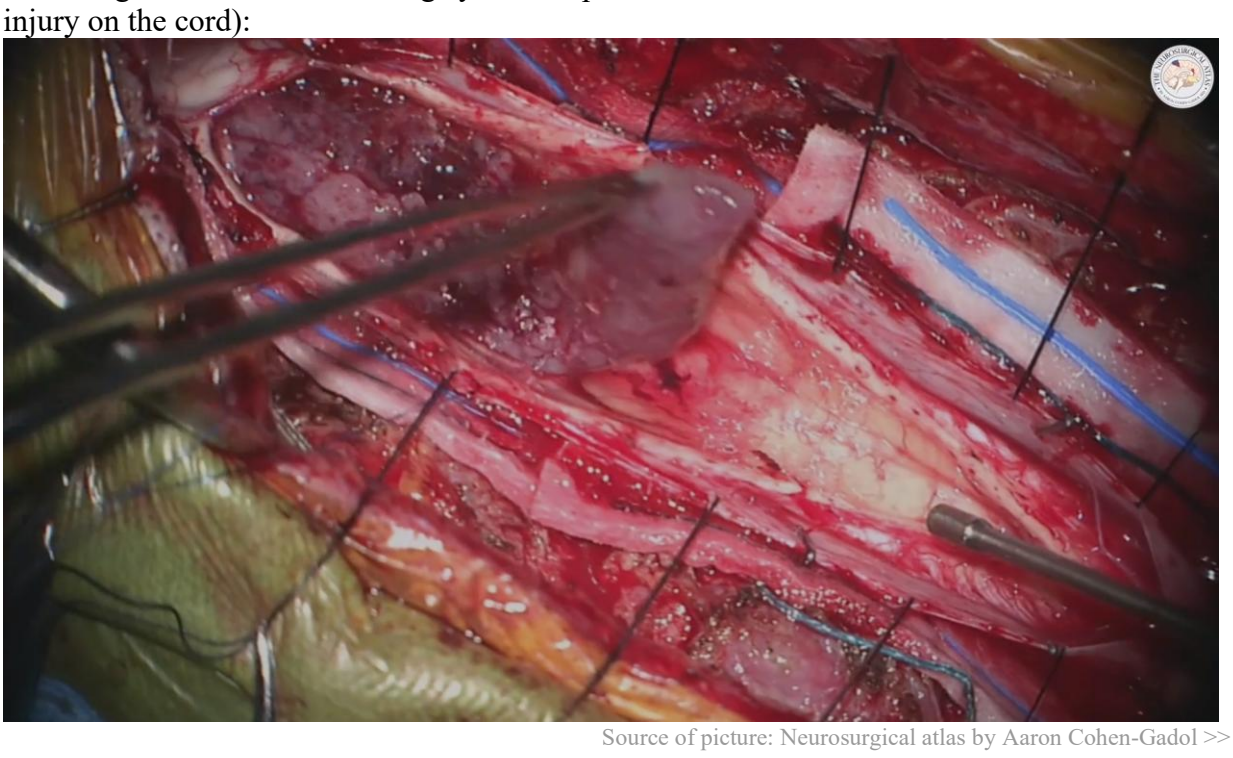


Fig. 61.3 (A) Illustration of axial view of ependymoma within the spinal cord. Note the central location of the tumor as well as clear demarcation of a tumor plane. 1. Tumor (stippled); 2. dura; 3. cord; 4. central canal (tumor pushing cord out circumferentially). **(B)** Intraoperative surgical dorsal view of the tumor clearly delineating the tumor edge with respect to the surrounding spinal cord. 1. Tumor (stippled); 2. dura; 3. cord; 4. central canal (tumor pushing cord out circumferentially).

Dr. Cohen-Gadol removes smaller ependymomas en bloc (but for larger tumors, internal debulking tumor mass or draining cystic components is needed to minimize the risk of traction injury on the cord):



Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

ASTROCYTOMAS *do not have plane* (tumor cells infiltrating among axons of the spinal cord – debulk, i.e. resection is limited to the portion of the tumor that can be clearly defined as distinct from normal cord; in cases of cord compression, where the astrocytoma needs to be debulked, portions of the tumor can be resected, which are usually discolored (i.e., gray or yellow) relative to the whiteness of the spinal cord (consistency tends to be different as well, and discerning this can require some tactile feedback gained by the experience of tumor neurosurgeon); if uncertainty arises during resection, further very tiny tissue specimens may be sent to pathology for spinal cord versus tumor differentiation.

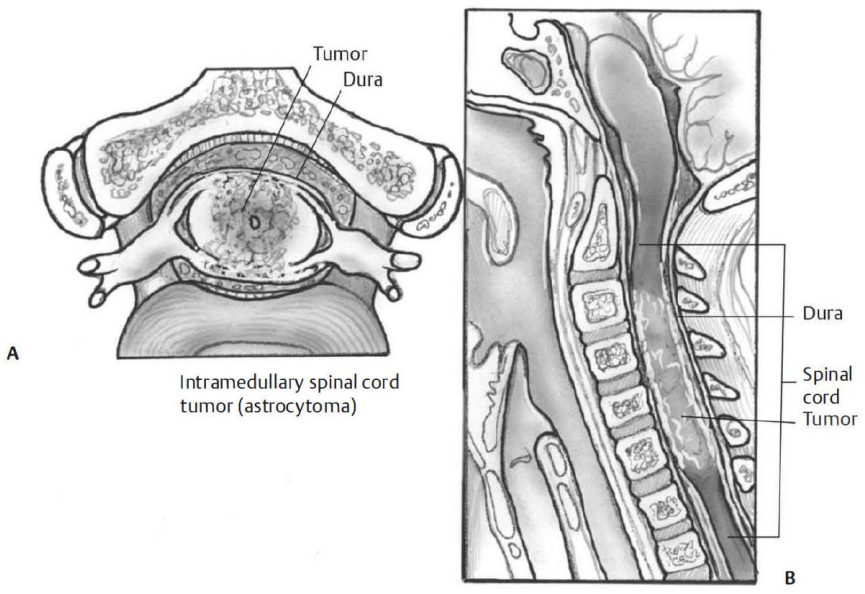
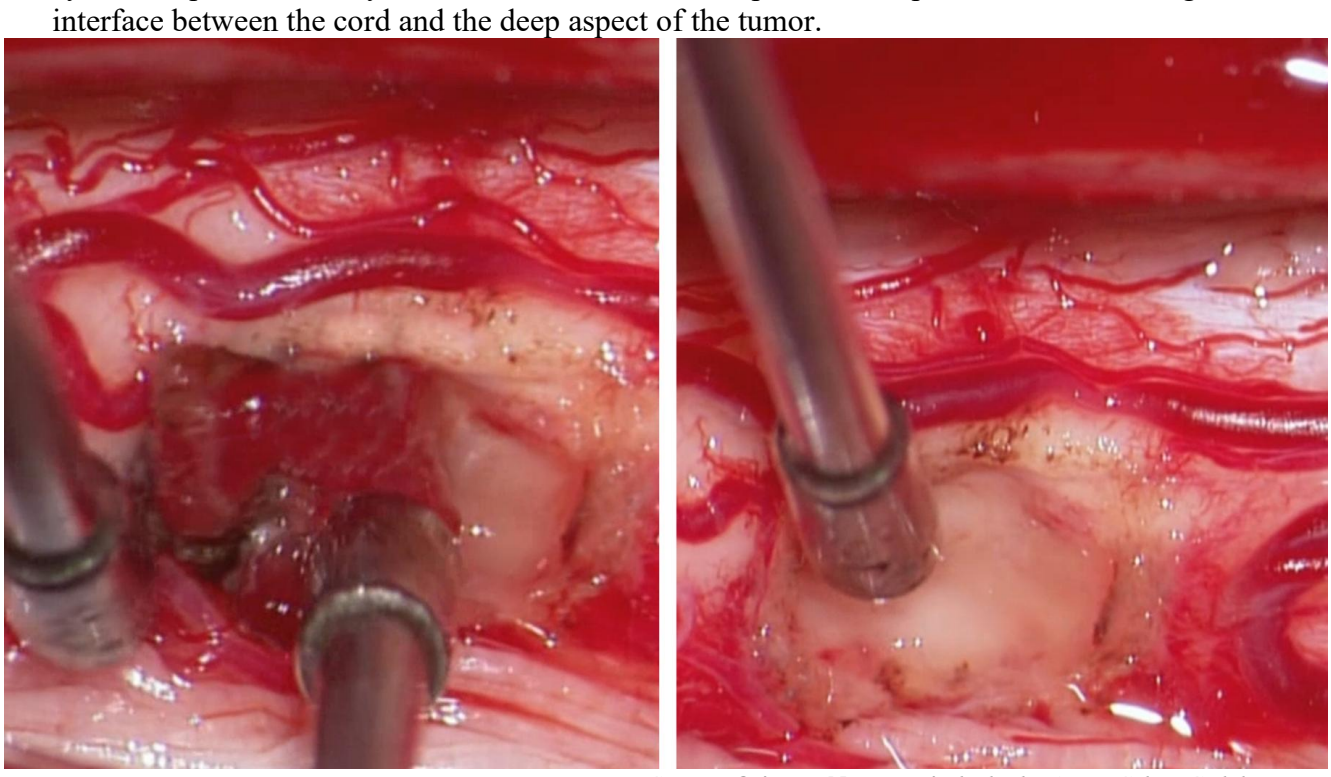


Fig. 61.4 **(A)** Illustration of axial view of astrocytoma within the spinal cord. Note the blurred margin between the tumor and spinal cord. **(B)** Midsagittal view illustrating enlargement of the spinal cord at the location of the tumor as well as blurred margins of the tumor.

– if frozen section shows tumor to be malignant → surgery is aborted (→ radiotherapy).

HEMANGIOBLASTOMAS are highly vascularized tumors that are *primarily epipial and not intraparenchymal masses* - dissection should also be confined within epipial planes to avoid cord injury.

– best removed in *en bloc* manner, given that any attempt at their debulking is associated with profuse bleeding.
– tumor is usually positioned at the posterolateral sulcus (dorsal root entry zone).
– these "arteriovenous malformation-like" masses should be carefully devascularized around their capsule before their dissection (coagulation of the deeper feeding arteries while preserving the draining veins until the completion of devascularization).
– then bipolar coagulation at a lower power is useful to shrink tumor mass so that circumferential dissection is made progressively more possible.
– cystic components or a syrinx facilitate creation of deep dissection plane; there is also a gliotic interface between the cord and the deep aspect of the tumor.



Source of picture: Neurosurgical atlas by Aaron Cohen-Gadol >>

N.B. extent of resection must be based on combination of presence of **plane-of-dissection** and intraoperative **monitoring** data; plus, surgeon's **experience** and patient's **wishes**!!!

Dr. Cohen-Gadol: intraoperative judgment regarding decision to attempt gross total resection should be based on appearance of **tumor-cord interface** rather than the histologic diagnosis;

- intraoperative histological diagnosis of ependymoma should encourage surgeon to find a reasonable plane of dissection.
- infiltrative tumors (mostly astrocytomas) are debulked until the transitional peritumoral zone is encountered; resection should stop if no clear dissection plane is detected.

- any **cysts/syringes** encountered should be drained, septations divided (spinal cord pulsations demonstrating adequate decompression are monitored).

  N.B. do not attempt to remove thin walls of cysts associated with ependymomas because these walls are not neoplastic and their dissection places cord at risk.
- for hemostasis use irrigating bipolar cautery (e.g. MALIS), irrigation and absorbable gelatin sponge (Gelfoam) with thrombin.

  N.B. try avoid using coagulation on normal pial vessels; gently apply Gelfoam sponge and micro-cottonoid and most bleeding will stop in tiny vessels!
- any vessels en passage should be spared.
- when operating on tumors of *conus medullaris*, filum terminale should probably also be removed.
- if monitoring signals change – pause, lessen retraction, increase BP, papaverine-soaked Gelfoam pledgets to relieve vasospasm. see p. D25 >>

  Dr. Cohen-Gadol: irreversible but minor changes in the potentials do not usually prevent me from continuing the operation, but a significant loss of evoked potentials will lead me to abandon the procedure and awaken the patient for definitive evaluation.
- predictors of GTR - histology, tumor edema, no motor deficits.

CLOSURE

- defect in *neural tissue* does not need to be closed (Dr. Spetzler); alternative - approximate myelotomy edges with Prolene (but leave gaps – to prevent intramedullary hematoma).
- watertight *dural* closure (may use dural grafting*) to minimize CSF leak.

  *esp. if unable to totally resect tumor – duraplasty gives room and time
  – irrigate intradurally – leave no blood.
  – simple running 4-0 silk / 5-0 Prolene suture (ideally, Hemo-Seal (HS-7) needle).
  – Valsalva maneuver → layers of Surgicel + DuraSeal / Tisseel / Adherus.
- epidural drain may be left in place (but risk of infection or CSF tracking along drain); H: place drain above muscles (to avoid pulling CSF).

SPINE STABILIZATION

- consider instrumentation to ***prevent postoperative kyphosis***.
- Dr. Jallo avoids it during original surgery to avoid hardware artefacts on MRI.

SPECIAL SITUATIONS

HOLOCORD TUMORS

- typically, low grade tumors.
- Dr. Jallo operates on upper end of tumor (to decompress arm area) and then chemoradiation for the rest of tumor.

LIPOMAS

- usually solid, bright yellow and easily distinguished from normal spinal cord parenchyma.
- tumor mass may be discovered to be in liquid, oily form rather than solid tissue.
- tumors usually are visible on the pial surface and can even be exophytic, but ventrally and laterally, the fatty tissue can blend in with the normal parenchyma - gross total resections may not be possible without the increased risk of neurological injury, so small rim of lipomatous tissue is left behind.

CYSTIC HEMANGIOBLASTOMAS

- surrounding spinal cord tissue does not necessarily have to be opened along the entire extent of the cystic cavity.
- myelotomy should be performed closest to the level where mural nodule is located, and often only a portion of the cystic cavity is exposed that allows adequate visualization of the tumor.
- vessels identified under magnification that are feeding and draining the tumor are coagulated and cut and the tumor can often be dissected off of the wall of the cystic cavity.
- fluid of the cavity typically drains out spontaneously after working and irrigating during tumor removal.
- meticulous hemostasis (as always) is confirmed prior to dural closure.

POSTOPERATIVE, PROGNOSIS

- see p. Onc50 >>