CERVICAL SPINE V2

ALIGN (Ⓝ lordosis / straightening: - spine board - spasm - # - DJD) Kyphosis: - # if focal. - DJD.

11 June 2011

ANATOMY/MEASUREMENTS

CRANIOCERVICAL JCT.

- Ⓝ – the skier descending the clivus jumps onto the top of the dens. (middle of it)
- 3 major concerns:
  - basilar invagination
    - odontoid drives up into skull.
    - soft bone, skel dysplasias, arthropathy.
  - tonsillar herniation (Chiari I)
    - medullary pyramids stuffed thru f. magnum
  - at-occip dissocin
    - usu lethal.
    - aden. posterior to usual line severs cord.

LINES/RULES:

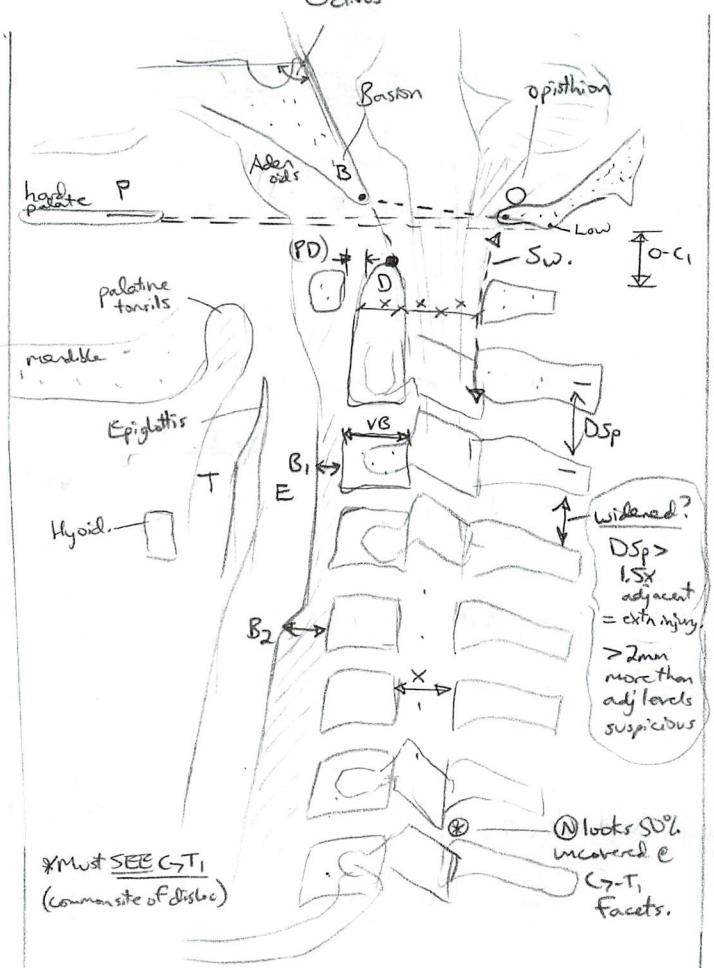
- McRae – shortest name, shortest line
- B-O – dens > 0mm above = abn (invagination)
  - tonsils ≤ 3mm below = Ⓝ
    - >6mm <10yo
    - or >5mm adult
    - = Chiari I
    - in between 3-6mm = ectopia.

Other lines (from Xrays)

- McGregor (P-Low) palate → opisth.
  - basilar invag >5mm above.
- Chamberlain – P-O; invag >6mm above.
- Wackenheim – line down clivus.
  - odontoid post. to this = dissociated.

Canal Width

- Ⓝ 12-14mm @ C6, 18mm @ C3-4.
- <10mm = stenosis likely



Other Measurements

- x-x-x = 1/3 odontoid, 1/3 cord, 1/3 safe zone
- Vertical Occip-C1 distance:
  - O-C1 ≤ 0.5cm Ⓝ
  - clivus-dens < 1cm Ⓝ (B-D)
- Platybasia = "Basal angle".
  - * Ⓝ Clivus = >143° (Xray) >125-130° (MRI)
  - if less, flat clivus — dysplasia, soft bone, (OI, cer dysost, rickets, Pagets)
  - further narrows f. magnum.

Prevert. Soft Tissues:

- Ⓝ thin ant to upper C. vert, then step off C5, thicker below.
- concern is prevert hematoma (#) or abscess, if no step off, too thick, or convex.

- false ⊕: esp peds.
  - SUXLLOW (hyoid above C4)
    - neck flexion
    - expiration (floppy trachea)
- try for view in extn/full inspiration
- worry more re: step off than x mm.

Prevert. (B1, B2)

Adult: "7 at 3, 7x3 at 7"
7mm C3, 2cm @ C7 (21mm = 7x3)

Peds:
Ⓧ <3yo: C3 / vert body width. (B1)
>3yo: C3 ½ v body width (B1)
OR
Ⓑ B1 < VB: 1:1 <1yo
0.7 <2yo
0.6 <4yo
0.5 <10yo.

PreDental Space (PD)

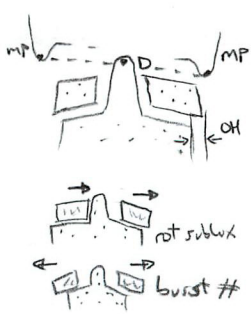
– sign of At-Ax instability.

- Ⓝ ≤ 3mm adult] in extension
  ≤ 5mm child]
- Up to 2mm increase on flexion ok.
  >8mm likely needs surgical fusion.

Swischuk's Line

– spinal lamina line. ±1mm+ deviation from line abn.
<5yo, up to 2mm ok
– pseudosublux in flexion up to 5mm ok <10yo
esp if @ 2+ levels (C23/C34) – should resolve in extension.

Frontal/Odontoid (Ⓝ)



- well positioned if intermastoid line (MP-MP) ±2mm of odontoid tip D.
- Overhang OH:
  - Ⓝ ≤ 2mm adult
    ≤ 5mm peds
  - *if >3mm, rot sublux likely
    if >7mm, definite burst # C1
  - *asymm L-R ≤ 2mm ok
    if asymm but ∅ overlap, rot sublux.

REVIEW PATTERN:

- C1 to T1, adequate odontoid?
- alignment (lost lordosis?)
- ant/post VB lines – teardrop #, sublux.
- lamina line (Swischuk)
- sproc (splaying?) ← (sign of 3 col. injury!)
- facets (uncovering?) Ⓝ at C7-T1
- VB/disk heights
- odontoid/C2 lat.
- lesions
  - skull, lung apex, clavicle
- S/T's.

Odontoid

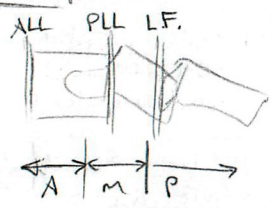
- os odontoideum: trx ligs, can be unstable. Call if found!
  - unstable >5mm, or cord space ≤13mm, abn.

CERVICAL SPINE v2 (1a)

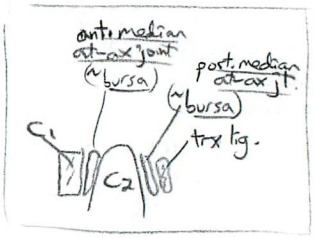
11 June 2011

ANATOMY CONCEPTS REVIEW

3 COLUMNS

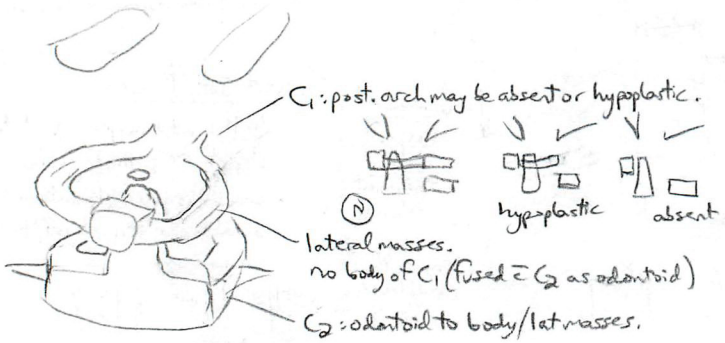


- Ant. column – V. body except its post. wall (ie ant compr #=1 col.)
- Middle column = centred on PLL.
  - post 1/3 of V body + pedicles + spinal canal, foramina.
- Post. column = lig flava, lamina, sproc, (±facets?)
- >1 column = unstable

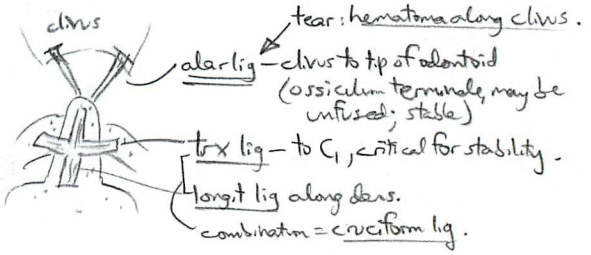


C_0-C_2: AtAxic (Atlas = C_1, above Axis = C_2)

occip. condyles – can fuse congen. ± C_1

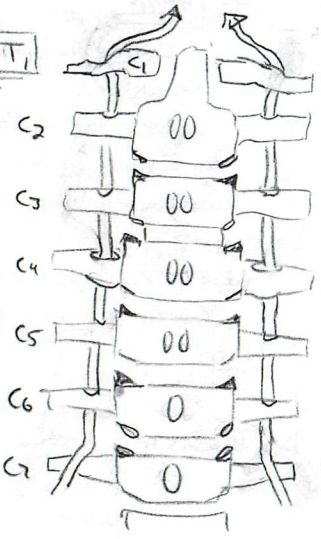


Back of Dens



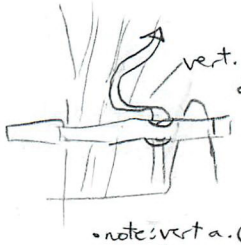
C_3-T_1

- tonsillar lithiasis
- hyoid
- carotid bulbs
- cric/thy cart.
- thyroid



Vertebral a./trx foramina

- trx f. from C_1 to C_6
- vert aa. from subclav aa. b.lat, go out to C_6 trx prox, then enter trx foramina from C_6 to C_1 inclusive. At C_1, loop posteriorly along arch until entering to form basilar a. @ f. magnum.

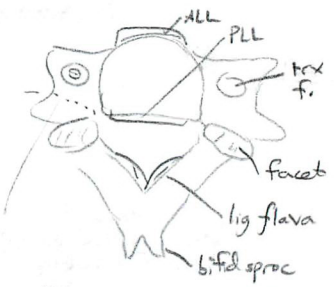


- note: vert a. @ ant. edge of neural foramen, hence do injec posteriorly.

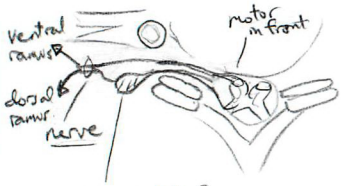
Uncovertebral joints of Luschka

- disks don't reach edges of C_{23} to C_{67}.
- instead, small synovial jts at edges, get DJD over time. Limit bending.
- NOT at C_{12} or C_7T_1.
- "uncinate process" @ sup V body C_3-C_7 forms base of each uncinate jt.
- dist osteophyte complex only likely from C_{23} to C_{67}!

bifid sproc from C_2 to C_5 typical.



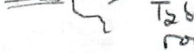
Cervical Foramen



- DRG – lat to foramen. (between vert a. and facet)
- anterior motor root + post. sensory root join after DRG, lat to foramen, to give nerve, recombine;
  - ventral ramus (motor + sensory → viscera)
  - dorsal ramus (motor + sensory → local neck)

Erb-Palsy

- nerve root avulsion./pseudomeningocele.



- can possibly repair if lateral to neural foramen.

CERVICAL SPINE V2 (2)

12 JUN/11

ATLAS OF # BY LEVEL

N	Clin	Im
C1 BURST/ JEFFERSON #	• axial compr, eg. diving injury. • mech. unstable but often ∅ Sx since canal widened. • named after British neurol. Geoff Jefferson • isolated post. arch # → stable. • Rx halo 3 mo. C1 = ring, breaks in 2+ places	widened arch. >7mm definite suspect if >3mm± • usu 4 part (A+P arches) or stable.
C1: ROTATORY SUBLUX'N	• stuck in asymm position. Maybe spasm/strain of one trx lig. / imb. D. RA (AP ↑) is it torn? • trauma, inflamm, or assoc Down's, RA (20% → 50%) • most common in child ± URTI = Grisel syndrome. (torticollis) • L-R minor; AP disp! may need collar or fusion. • Test by CT in max L, R head rot'n (fixed deformity?) • May occur ± erosion of trx lig attach to C1 arch. • Rx – kids: (I) at-odon (N), just rotated → soft collar, muscle relax – grade (II) or (III) – try hard collar or halo if acute (trx lig may heal) – adults – (or kids chronic or neuro Sx) – fusion C1-2.	(N): turn head to (L), (L) space C1 mass/odontoid widens (C1 pulled to (L)) – on CT, lat mass of C1 ahead of C2 ((R) if turned to (L)) Grades: (only matters AP) from lat Xray (I) Atl-Odon ≤ 3mm (5 in flexion) – ligs ok. (II) 3-5mm – trx lig failing (III) >5mm – also alar ligs failed; totally unstable. • one side wide/one narrow • if one side wide/one (N) or both wide → Jefferson #.
C2: # ODONTOID	– (I) avulsion @ alar ligs, vs. congen os odontoideum → stable if very tip only – do flex/ext ± MRI – (II) most common, at base, unstable – esp in kids (see on Xray, ∅ CT needed) → I or II if trx lig disrup → ORIF. – (III) stable – thru C2 body – lots of bone contact, heals well. – use collar. Best Rx.	(I) (II) (III) like upside down Weber scale (I = A = avulsion.) peds <5 yo: # @ C1-2 synchondrosis @ base of dens, ± ant tilt of dens peg.
C2: # HANGMAN'S	– spondylolisthesis of C2, common in kids (heavy head falls back) – C2-3 anterolisthesis often (N). in kids in flexion, unless >2mm ((N): 2mm @ C23, 2mm @ C34, multilevel, ∅ PVST) – exth teardrop # often assoc @ base C2 ant. – Px good – canal widened – Rx ORIF – check vert aa by angiogram (trx foramina @ C2)	C1 ant C2 as a unit. hyperext'n/distraction • hanging, • chin on dashboard, • child heavy-head. post line ok PVST facet uncovered >50% >2mm anterolisth C2 on C3 exth teardrop # (ALL) – tall # fragment ○ circled = 2° signs, if absent helps reassure somewhat.
C3-C7 ANT COMPR #	• common, DDx from (N) variant minor wedging.	minor ant wedg (N).
BURST #	• pure axial load. Lost height, ↑ width of v body. • usu 2 column injury (retropulsion → stenosis/cord injury)	may have horiz # thru post els
FLEXION TEARDROP #	• worst Cspine injury, 3 columns. Axial load + flexion, usu C5. (dive into pool) • beware the splaying of post. els. • compr → retropulsion of v body; torn interspinous ligs, unstable. • bad Px (narrow canal, ant cord syn (retropuls) or other neuro Sx)	Focal kyphosis AP sagittal # typical. horiz # teardrop fragment @ ant inf v body – large fragment ± compr.
SPRAINS	• hyperflexion sprain – tear of post ligs ∅ #	
	• hyperext'n sprain – tear of ALL, ∅ #	
		Teardrops flexion teardrop – big frag/compr v body. ant/inf esp C5 – v body post displ. exth teardrop (esp C2) – small, tall ant/inf ring apophysis, limbus vert – physiologic, small, smooth, multilevel.

→

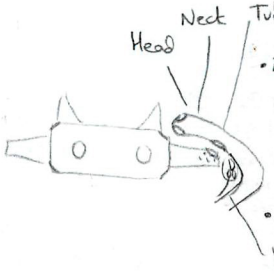
C-SPINE cont'd

N	Clin	Im
C3-C7 FACET PERCH/ LOCK	• with disrup of lig flava, interspinous/intertrx ligs, facets shift. • Unilat perch/locked facet — tough Dx – rotatim – bare facet – traction/closed reduc. • bilat locked facets – a severe injury, sign of cord transection/quadriplegic 75%. (displ was worse!) – C56 usu.	AP: sproc line shift in roth; lat: ≤Gr I anterolisth.; sudden Δ in degree of facet overlap, ± s process widening; naked facet lat: anterolisth.; may be widened interspinous dist >2mm; likely gr 2+ anterolisth. (D2+)
CLAY SHOVELER #	• sproc of C_7, T_1 # • easily missed due to film penetration • stable but pain. • shear – vertical # – unlike tensile horiz # seen in flex teardrop	AP: dual sproc @ C_7 or T_1 lat: vertical # unlike the horiz # in burst or flex tear.
OPLL	• Ossificn of Post Longit Lig. – usu Csp, Asians >50yo, M>F – assoc ≥ DISH. Rx O.R., bt high risk of dural tear	ossif!
PEDS CSPINE SPECIAL NOTES	• from Swischuk, guest lecture @ MGH in early 2011. concepts • child has a heavy head (most injuries hyperextn @ C_2) • technical factors key — extension, inspiration needed. • multilevel findings are (N) — a # is at only one level. ↳ C23 + C34 both anterolisth 2mm ± both wedged = (N). • C45, C56, or one only, likely # (teardrop) esp if facets <50% uncovered • look @ facets coverage — uncovering >50% is abn. – "sprung"? • kids need less CT — dens or hangman # most often, and seen well on lat Xray.	C_1: high C_1 ant proc — (N) in extension; – hypoplastic/absent post arch C_1 (N) ("no arch at all! I'm not even worried!"); "smooth edges and bizarre shapes" C_2: ostoid ossifies posteriorly ("post tilt" of dens (N)) — ant tilt abn. fragmented dens (N) (# does not make fragments) # dens <5yo, is @ base, ant tilt in hyperflex injury @ synchondrosis up to 5mm ok; >2mm increase in flexion — <5yo, ok. Facets: (N) (covered parallel); >50% uncovered abn; diverged abn Limbus vert/ unfused ring apoph — simulate small flexion teardrop # but small, smooth, multilevel.
SCIWORA	• Spinal Cord Injury w/o Radiographic Abn • often in kids/young adults • consider: – interspinous lig injury ± flexion → try F/E views – trx lig of C1/2 injury → try F/E views – adult: disk bulge, osteophyte impinge. • MRI.	•
WHEN TO CLEAR	Cdn C Spine Rules: – cannot clear clinically if: – mechanism: fall >3 ft; axial load to head; bicycle or MVC except city rearend. – if mech ok, age 17-64 + Ø paresthesias + pain delayed only; able to sit or walk; no midline tender – then try 45° active neck rot. If ok, Ø Xray needed.	NEXUS Csp Rules: clear if: – Xray ok AND – Ø midline tender – Ø focal neuro Sx – alert, Ø intoxicated – Ø distracting injuries.

T/L SPINE V2 – ANATOMY

June 13/11

Ribs



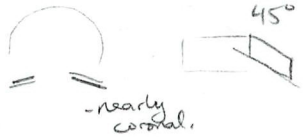
- Each rib articulates mostly with its own vert,
  - nth rib:
    - costovertebral jts (n-1), (n)
    - costotrx joint (n)
- so 1st rib articulates c C7, T1, T1.

VAN – vessels/art/nerve under rib.

Facets (zygapophyseal jts)

- Isolated severe arthropathy: CPPD, gout, RA, infec.
- Look @ lateral sag slices.

cervical



- nearly coronal.
- allows sliding motion in flex/extend, and rotation LR.
- hence injection steep @ low neck, AP

thoracic

- coronal.
- steep and coronal
- little motion due to ribs.

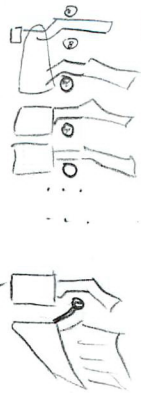
lumbar

- very steep, for flex-ext, limit AP.
- nearly sagittal — prevent LR instability
- NWS on lat, sclerosis only.
- hence inject ok AP.

(N) sharp edges. T2 bright fluid. not enlarged. ⇒ abn dark T2/sclerotic, enlarged, remodel. ⇒ severe: effusion subluxn edema.

NERVE ROOTS NUMBERING

O/C1 : C1
C1/2 : C2
C2/3 : C3
C3/4 : C4
...
L5S1 : L5



C-spine: root is above its pedicle
eg: C6 at C5-6.
(to make room for C8 between C7 and T1)

T, L spine: root is below its pedicle.
eg L4 at L4/5
L5 at L5/S1.

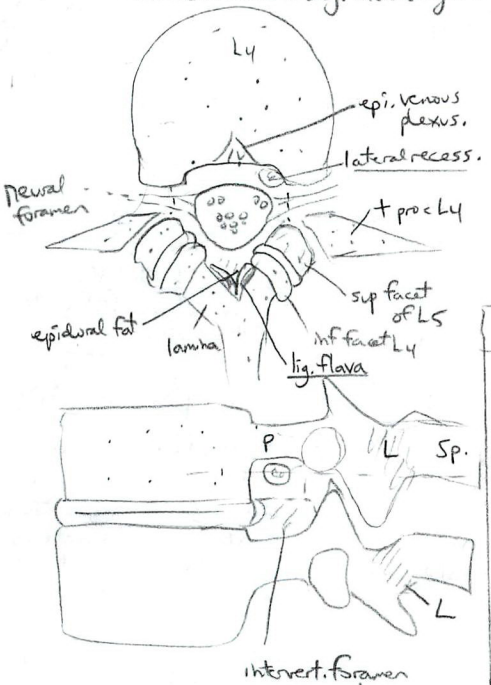
Kyphosis/Lordosis – erect, arms horizontal.

- thoracic T_3-T_{12} kyphosis (N) 20-35°, or 40° as teen. 95% CI = 10°
- lumbar lordosis L_1-L_5 (N) 30-50°

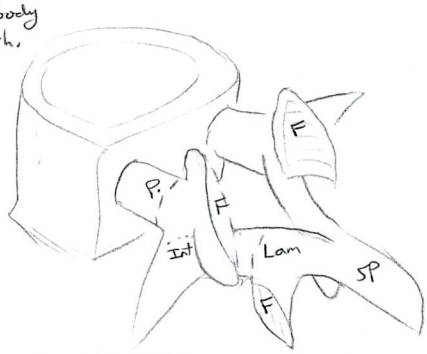
- reduced or reversed curve:
  "straightening of normal lordosis"
  - DDx – scoliosis (curve is lateral)
  - muscle spasm
  - post OP

VERTEBRAE

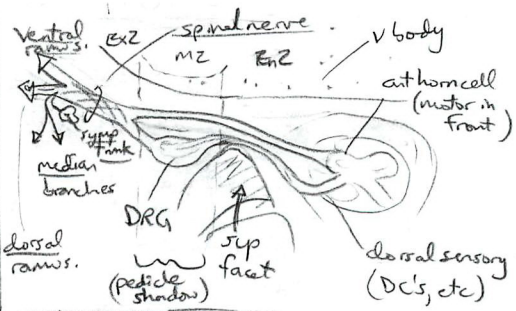
→ neural f. lies below pedicle, formed by sup. artic process of next facet and the V body
– hence stenosis c seg. instability, if retrolisth.



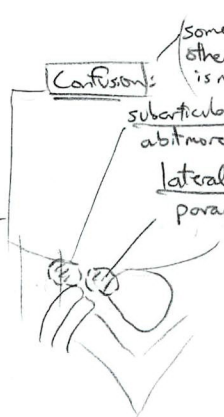
intervert. foramen (disk level)



FORAMEN DETAIL



Confusion: (some say same area, others say subartic is more lateral)



- lumbar DRG are in foramen hence pain
- Cervical DRG are lateral to foramen (between facet/vert. a.)

- Entrance zone/central zone – between sup. facet of next vert and V body. Site of facet hypertrophy, disk. = Lat. recess.
  "Subarticular zone" stenosis = this area (sub-disk?)
- Middle zone = below shadow of pedicle.
  - contains DRG. (Motor branches from ant cord, internal ganglia; sensory from post.; DRG/paraspinal symp. ganglia chains)
- Exit zone: motor/sensory recombine, form ventral ramus (motor + sensory to viscera) and dorsal ramus (motor/sensory to abd wall) and symp. trunk (vertical, // to foramina) and median branch (motor/sensory to facets above, below)

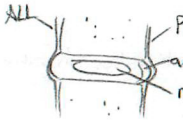
Foramina c Facet/Disk

Facet hypertrophy pushes forward to narrow the lateral recesses.

T/L Spine Anatomy v2

13 June/11

Disks:

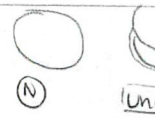


- T_2 bright young
  → dessication T_2 dark with age.

* **Annular Tear**
- T_2 ↑ "high intensity zone" HIZ, enh.

* **Calcn** - (N) in nucleus ≤ 3 disks, else ochronosis, CPPD.

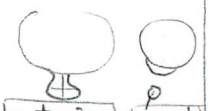
* **Gas** - (N) (nitrogen). Excludes infection if present



Uncovering
- at antero/retrolat. sk.
- still conforms to v body.

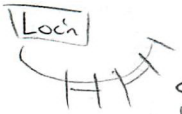
Bulge
- if > 2mm outside v body line
- concentric
- asymmetric (>50% circumf)
- focal (<25% of circumf)

protrusion (AP < LR size)
- or base wider than apex
- focal or broad based,
- "contained" disk
- sequestrum: usu ± 5mm from disk. need open discectomy to find.



extrusion
- AP > LR
- or narrow base.
- cranially or caudally directed along v body.
- "non-contained"

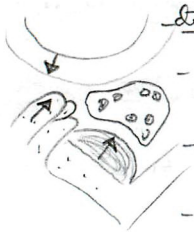
Locn



central
paracentral] 90%
foraminal
far lateral - rare, easily missed.
- see on sag only (outside sag)

GRADING STENOSES
- 90% occur @ C56, C67, L45, L5S1.
- most disc dz. dissolve/resolve spont in 6 mo.

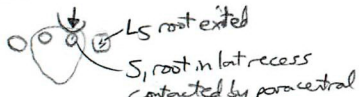
• Contributing Factors



- disk bulge/prot/ext.
- facet hypertrophy or synovcyst
- lig flavum hypertrophy. (buckling)
- anterolisthesis.
- #.
- mass.

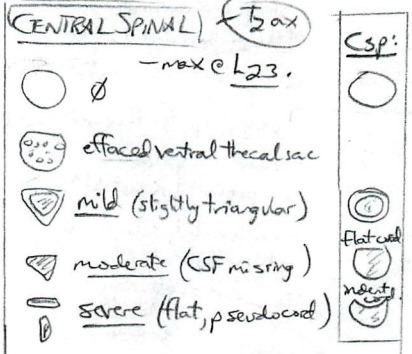
• Disc? (T_2 bright)
vs Disk-osteophyte complex (T_2 dark esp on GRE; C spine usu.)

• Lateral Recess stenosis affects NEXT set of roots.
Typical: L5



Rational Approach

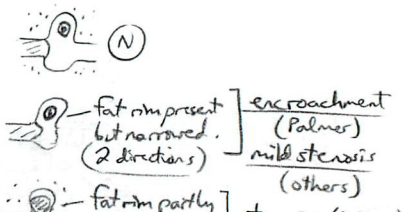
CENTRAL SPINAL (+ T_2 ax) - max @ L23.



Bill Palmer: upgrade x1 if you know segment unstable!

FORAMINAL (T_1 sag) - "keyhole"

* Bill Palmer — only call it if U would inject it c steroid as pain-generator.



ENDPLATES

Schmorl Nodes (Spine, 2010)
- intraosseus disc herniation
- asymp usu.
- more common @ L1/2, L2/3 (more vertical load?)
- less if disk extr/prot/annular tear (decompresses disk?)
- = more in M, but ↓ endplate strength.

Compression # Grading (Radiology Vol, 2009)

Grade: 0 < 20%; I: 20-25%; II: 25-40%; III: 40%+

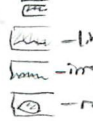
- physiologic possible @ T12.

Gas - Kummel dz - gas in crushed v. body.

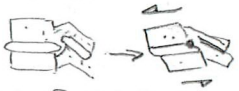
Biconcave* - consider SS anemia, causes weak subendpl. or dysplasias (s-epiph d.)

Modic Changes

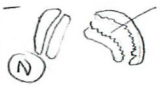
- originally thought to be a continuum.
- now, any Δ suggests ? segmental instab. if with facet Δ.
- "discogenic endplate signal Δ"
- must be BOTH SIDES.
- ONE side = FRACTURE INFECTION MASS



Segmental Instability
- controversial concept, favorite of Bill Palmer.



- if disk + facets both degen., ↑ edema @ endplates as sign, likely unstable — in spine flexion, facets override, anterolisthesis develops, worsens central + foraminal stenosis.



- do Flex/Ext Xrays (≥ 3mm motion?) since spine MR underestimates
- Rx fuse that segment.

N	Clin	Im
L-Spine MRI/Xray How-To	• **When To Image** **Xray** – very low yield, not recommended – except flex/ext. – look for • fracture • spondylolisthesis/anterolisth. ; or scoliosis. * • (instability (flex/ext) **MRI**: – per Dr Rosenthal, also low yield – not rec for routine low back pain, – indichs: • intractable pain needs surgery, where is abn? (decision to O.R. or injection already made!) • suspect non-mechanical (infec, tumor) • trauma • post op (scar vs recurrent disk)	**Scan Sequence**: • sag T_1, T_2, STIR. • ± portgd sag/ax T_1FS • ax T_2. • **Incidentals** – localizer + all, for retroper/paraspinal S/T – kidneys/adr/CBD/GB/Ao/IVC/retroAo renal V. • **numbers** – transitional L-S jct? • **alignment** – (N), straightened lordosis, ant/retrolisth (sag) – localizer for scoliosis • **marrow** – (N), diffusely abn, focal lesions (sag T_1, T_2), #, – check L,R edges of sag scans for facets etc! • **discs** – (N), dessicated. facets – hyper, • **neural** – conus (L sp) on T_1; C-cerv jct/brainstem on T_2. – epidural hematoma/abscess? • **level by level** – use sag T_1 for foramina "key hole" ax T_2 for central spinal. • same system for Xrays and CT and MRI. (–R. Kanath)
TYPICAL AT EACH LEVEL	• C1/2: congen anomalies, #'s (Jefferson, odontoid, hangman) arthropathy @ odontoid (RA, RA etc) • C2/3: facet arthrop. (CPPD), Peds #. • C3/4, C4/5: facet arthrop. • C5/6, C6/7: main disk/facet OA • C7/T1: facet OA asymp; stenosis. • mid T: OA endplates. Compr # (T_7)	△ T12/L1: V body wedging vs compr # L1/2, L2/3: burst #, Schmorl node. Conus, spinal stenosis, Baastrup. L4/5: disk/facet OA. L5/S1: transitional anat, Spondylolisthesis, S. bifida occulta.
T/L Spine FRACTURES	**WEDGE compr #** – usu osteoporotic, esp low T spine – report, since sentinel # of worse ones, + painful – stable anterior column only – may be pathologic (myeloma, lymphoma, met..) – is it really a burst? **BURST #** – "wedge compr" in young pt # trauma – UNSTABLE – look @ post paraspinal S/T, s processes **CHANCE #** – distraction injury, eg lap belt near TL jct – 3 column injury but like house in hurricane, can be "stable" in back extension when held together – but Rx as unstable. – up to 50% intra-abd injury assoc. **TRXPROC #** – easily missed. Stable but painful. – risk to ureters	wedge or bicancave or crush 0–20% 0 2009 Radiol. 20–25% I 25–40% II 50% + III – widened inter-pedicle distance on AP – 3 column compr, or ant compr/post distrac, (centre of rot in middle?) horiz # of post els, centre of rot'n is ant to spine. may be subtle # of vertebral body
OSTEO POROSIS ON CT	• Dan Rosenthal's method. estimate BMD from L spine CT.	• trx image, centre of V body, largest ROI outside cortex • at level of pedicles • avoid veins < 100 Hu: osteoporotic spont # > 150 Hu: (N).

→

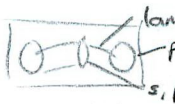
T/L SPINE BONE ATLAS V2

N	Clin	Im
Spondylolysis / listhesis	• ...listhesis = ant displacement (X) on (X+1) – due to a # of pars, or to loose facet joints/disks (DJD) • ...lysis = # of pars, ... osis = DJD. * peds check pars ? (#1 cause of back pain) • pars # 95% at L5 or L5S1 (also Hayman S2) • Sx – cord ok, lamina narrow. • Instability → pain. Rarely surgery though • often a stress # in young adults – by age 7yo. • Orient'n of sacrum may predispose • Grades: I: 0-25% ← often 2° to facet OA. II: ≤50% III: >50% only ← true pars defects IV: 100%	• pars # • continuous facet sign on axial CT/MR • "long canal" AP – pars, interarticularis between sup/inf facets – nearly coronal plane • Xray Findings • predisposing: trapezoid L5 (ant wall taller than post) horiz. sacrum If DJD only, ant+post lines shift at SAME level ↔ Sx of # • If pars defect, post elts. shift one level above anterior due to #. (# leaves spinous process behind) • long neural foramen on sag • canal wider @ L5 than L2. or figure 8 foramen • Bone scan – hot, but need SPECT. "Spondylosis deformans" = osteophytes.
DISH Diffuse Idiopathic Skel Hyperostosis	• Forestier dz – ossific of A.L.L. • DISH – more diffuse spinal enthesopathy • Dx: flowing ant osteophytes ≥ 4 levels – no SI fusion or other vert fusion – not primarily disk disease. • older M. (A.S. much younger)	DISH: flowing vert aphytes ANT to v bodies (not ALL) or bat/asymm; SI NOT fused; whistering enthes. thru pelvis A.S.: – syndesmophytes IN ant. disks; sword (spine fusion); SI fusion Ps or Arth/ Reiter's: Asymm. large horiz aphytes. ± SIJ's
Baastrup Phenomenon	• bursae (adventitious) form between S. processes L spine at points of contact. ?pain?	sclerosis, bursa
Hemispheric Spondylo Sclerosis	• mainly at L4 (50%), then L5. F>M • endplate centred, sclerotic/rounded, has no signif – not cancer, not ank spond.	or or – often endplate erosion or small Schmorl's node c sclerotic response?
Facet Synovial Cysts	– at DJD, mimics disk, – can be fluoroscopically or under CT "popped" – aspirate, or inject to explode.	– T2 intense susv., peripheral – adj to facet – tongue posterior
SPINAL STENOSIS	• Congenital – pedicles short (Down's, idiopathic) – laminae short (achondroplasia, others) • Acquired – the usual mechanical – disk + facet hypertrophy + lig flava. – epidural mass/fluid collection – ~~Retro~~listhesis, or anterolisthesis WITHOUT pars defect – #, instability – Paget's. etc.	made up of pedicles + laminae. Approx: W canal ≥ 15mm (N) (v body → base of spine) ≤ 12mm stenosis (SP) 13mm + (N) / <10mm stenosis or canal / v body = 1, if < 0.8, stenosis.

SPINE - POSTOP (Resnick) 1 Nov 2010

Terms:
- Laminotomy – hole in lamina for microdiscectomy
- Laminectomy – for a larger discectomy
- Laminoplasty – reconstruction of lamina in Cspine.
- Foraminotomy – widen a foramen
- Facetectomy – resect medial part of facetonly
- Corpectomy – V body resected.

- Look at AP for what is missing!



Indications: – NOT MRI findings!
- intractable pain failing conservative measures
- progressive neurologic deficit
- cauda equina syn. (urin retn, fecal incont late, saddle anaesthesia, bilat leg weak/sciatica.)

General Strategy
- disc dz – fix ± resection of the protusion via ant approach (in Csp – avoid post. approach except in stenosis) or post approach (laminotomy, Lsp.)
- stenosis – decompress levels.
  – fuse to maintain stability.

spinal fusion: – will fail without bony fusion (fatigue # of metal)
– metal fails in posterior Cspine (? too much force in flexion?) and along s processes] – hence fuse interlaminar not @ midline.

Fusion Materials: allograft (cadaver) or autograft (iliac crest – risk of #)

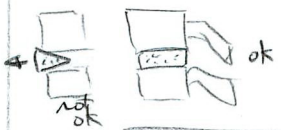
PMMA – polymethylmethacrylate – has S/T density (hard to see on Xray), can contain air bubbles (and not be infec.!)
– good in compression but ⊘ tensile strength. Bonds less well than bone.
– use: ant. fusion in malignancy, for early mobility.

interbody fusion cage – metal cage, graft inside. For ant fusion
– metal is scaffolding; graft marrow inside.

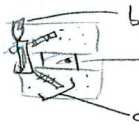
strut graft – eg. fibula, rib – in Cspine or post. els. Fib a very slow to incorporate.
– cortical bone slow to incorporate, but early strength.
– not strong enough for Tsp/Lsp.

PLIF – posterior lumbar interbody fusion.
– must not have wedge shape or will extrude on back ot'n!
– approach to disk via posterior (eg laminectomy)

ACDF – ant cervical discectomy + fusion.



Fusion Results: (N) 6-9 mo+! → 3 yrs to full bony union on Xray.
– slow to fuse; pseudoarthrosis → pain? / failed. But fusion usu. better than Xrays show.
– Signs of Nonfusion/Pseudoarthrosis:
- indirect:
  - >10° or 3mm shift on flex/ext views
  - disc ant to V. body by >2mm.
  - new pain
- direct
  - discontinuity of bone trabeculae
  - gap bet. endpl/graft
  - shift in hardware or of graft.



SPINE POSTOP (cont'd)

FAILED BACK SURGERY SYN (FBSS) — up to 15%.

Causes:
- (early) wrong lesion/wrong level
- hardware malposition — pedicle screw in disk, etc
- fluid:
  - hematoma
  - infection (2% diskitis/osteomyelitis, mostly c metal hardware; abscess. Rare in discectomy. ↑ in DM/comorbid.
  - dural tear (esp. c revision surgery as scar tears @ dura) — pseudomeningocele.

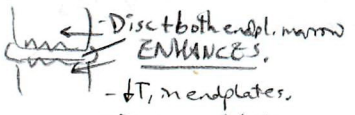
(DDx of fluid collec.)

(late)
- disc vs scar — did herniation recur? or just scar. Give gad. (DDx epidural fibrosis from disc)
  - (scar — all enh.) — disc — (nonenhancing portion) — <6mo, scar also non-enh centrally; better DDx later.
- pseudoarthrosis — (see over)
- facet instability
- arachnoiditis, neuritis — but nerve root enh is (N) × 6mo.
- annular tear → but (N) annular enh x years.

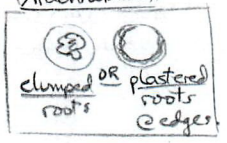
Disc	Scar
displaces.	encases/envelops.
- crisp edge	- irreg. edges.
- contig. c main disk.	- maybe separate
- Ø enh central.	- fibrous/black.
- iso to disk	- enh. central >6mo. (<6mo may not enhance yet; not vascularized)
- ? may do repeat D.R.	- no repeat D.R.!

- Best DDx is >6mo postop.

Discitis/Osteomyelitis:



Arachnoiditis:



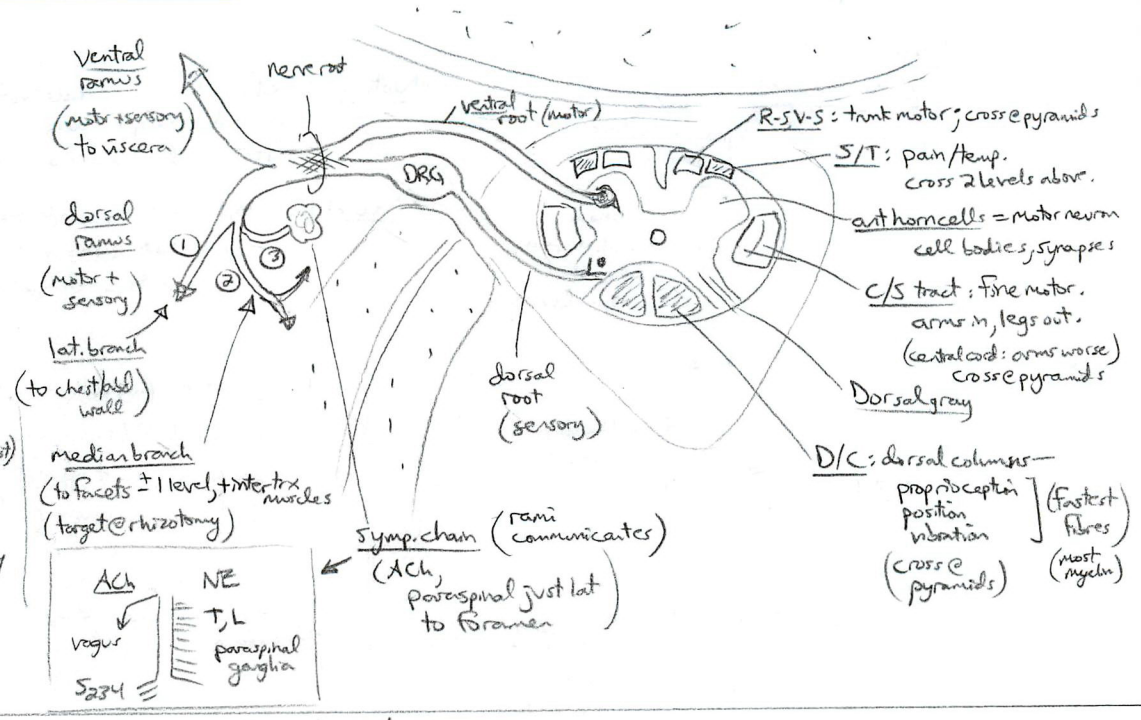
SPINE V2 — SPINAL CORD ANATOMY

16 June 2011

Nerves:

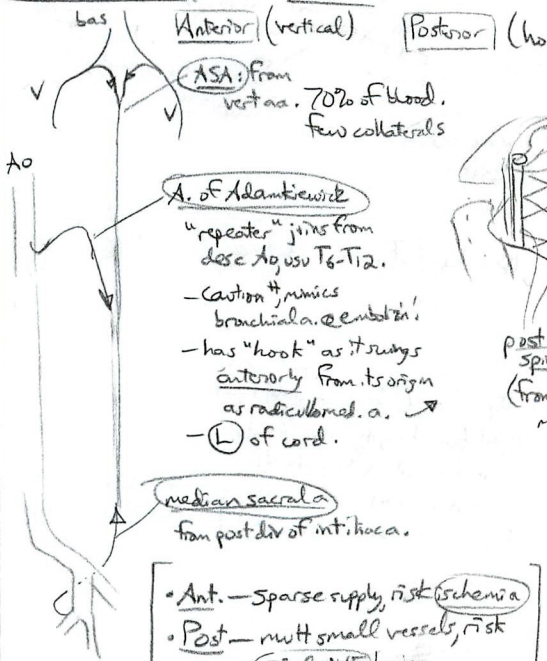
- alternate motor/sensory
- C/S tract: "arms in"
- DRG is IN neural foramen, usu inferior — may be squeezed in intervert. f. even if neural f ok.

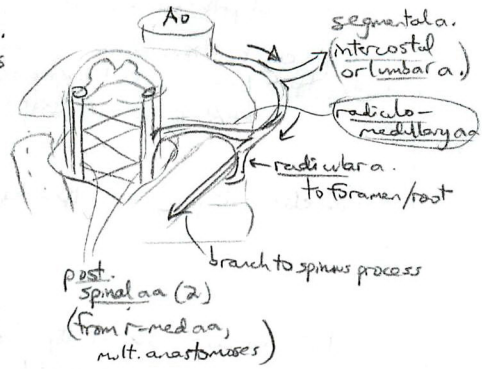
- Note how motor (ant) / sensory (post) merge/recombine in foramen then separate into rami lat. to it, giving mixed motor/sensory to the correct locations.



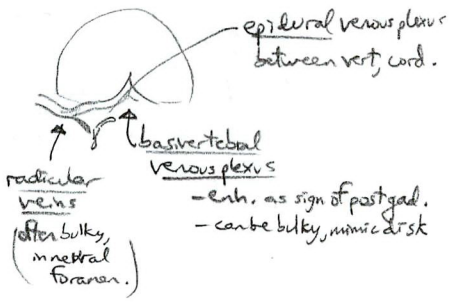
BLOOD SUPPLY

Arteries — to find pial AVF, need to inject all circled arteries.





Vens // to arteries.

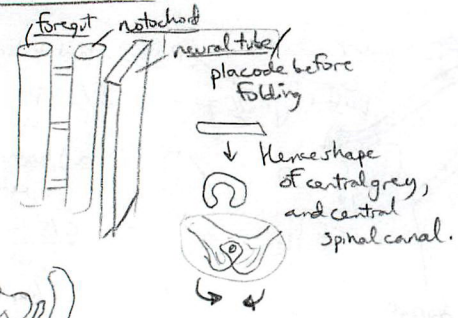


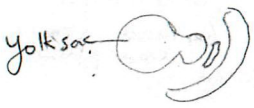
CONUS / CAUDA EQUINA — see over.

SPINAL CORD ANATOMY V2

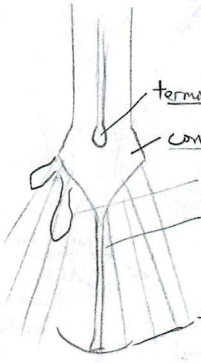
CONUS / CAUDA EQUINA

- Early dev:

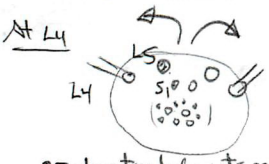




- Notochord – clings to sacrum, skeleton for v. bodies; connects to foregut
  - dissolves except @ disc nucleus pulposus
  - notochord remnants or chordoma possible
- Neural tube – initially flat placode from brain to sacrum
  - cord starts @ sacrum but spine grows faster, nerve roots stretch up as a result.

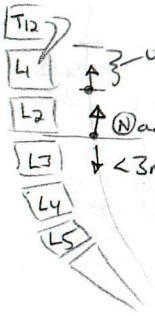


Organiz'n of Roots – like airport runways.



- Root exiting below its pedicle = n
- "traversing (n+1) root in lat recess
- (n+2) root is "next up", central.

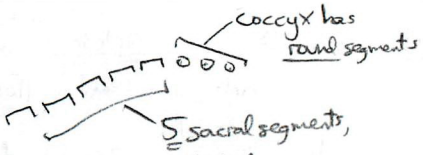
CONUS LOC'N



- usual: above L1/2 or at it.
- (Wilson, AJR 1989)
- (N) any age above L2/3 disc.
- < 3 mo, might still be (N) at L3

SPINE U/S TIPS (NEONATE)

- cross-correlate 3 ways:
  - lowest rib
  - renal pelvis is @ L2 on (L)
  - count up from sacrum
- other tips: L3 – usu widest trx process
  L4/5 – iliac crests / ASIS.



* • If all else fails, put paper clip @ level of conus, do Xray!

Cauda Equina Syn: S2/3/4

- Urinary retention (parasymp pees – ganglia S2/S3/S4)
- fecal incontinence (sphincters mostly muscle S2/S3/S4)
- saddle numbness
- blat leg weak ± sciatica.

Tethered Cord – Sec: Fatty filum (? may be only sign)

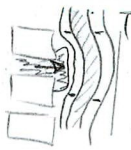
- tight boustringy filum/roots
- no motion with CSF pulsation.
- scoliosis, DDH
- leg weakness, urin. incont.

} like chronic cauda equina.

SPINAL CORD – EXTRAMEDULLARY LESIONS V2

17 Jun/11

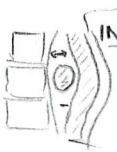
Patterns of Spinal Canal Lesions



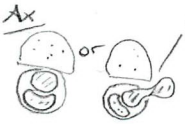
EXTRADURAL
- cord, sac displaced together over lesion
- CSF space tight just above/below lesion

Myelogram: block ± rough-feathered edges of cord.
(unlike extrinsic mass in GI tract = smooth)

~Top 3: (Disk.)
- Epidural abscess
- Hematoma.



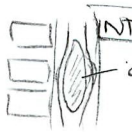
INTRADURAL/EXTRAMEDULLARY
- cord displaced away from dura
- CSF space widened near lesion
- aka "extra-axial" mass in brain



Dumbbell lesion @ foramina common.

Myelogram: → block ± sharp edges, expanded adj. CSF space (subarachnoid "cap")

~Top 3:
- Schwannoma
- Meningioma
- Pial AVF



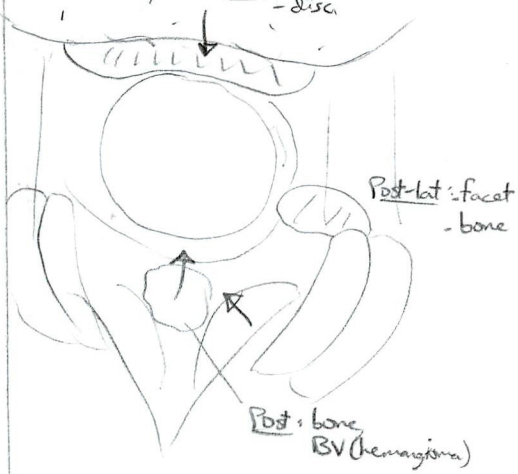
INTRAMEDULLARY
- cord itself enlarged.

Myelogram: block ± sharp edges narrow CSF space.

~Top 3:
- M.S.
- Astrocytoma
- Ependymoma

Specific DDx

EXTRADURAL: usu. non-neoplastic – 90% discs (approx)



(I) epidural abscess

- 80% assoc ± diskitis
- spreads beneath PLL
- remember septic facet (post/lat).

(N) rarely:
- mets most often (if path # usu)
- 1° tumor: GCT (T_2 dark) chondrosarcoma osteoblastoma
  chordoma (T_2 bright) EG
- lymphoma (+ paraspinal S/T mass) (soft, creeps thru neural fts to cord)
- paraspinal – paraganglioma (g-neuroblastoma)

(I) lipomatosis (eg steroids) – can have mass effect

(T) compr # ± retrolisthesis (burst? chance?)
- disc bulge – by far most common, ant/ant-lat
- facet synov cyst – ± OA facets, post-lat

Pathologic #
- whole V body abn, round edge

Compr #
- angular edge.

if rounded, target for rad therapy

(M) extramedullary hematopoiesis – can be paraspinal masses
– usu $T_1 \rightarrow T_2$ = marrow (not T_2 bright)

(V) hematoma in trauma – epidural
- check clivus carefully!
- T_1 bright + T_2 bright?

easy to miss.

hemangioma – parasite crouching on post. cord.

(C) arachnoid cysts, perineural cysts.

INTRADURAL EXTRAMEDULLARY – very short specific DDx:
"extra-axial" in brain.
– need post-gad, hires.

(I) meningitis
parasitic cysts (echinococcus, ± cysticerc)

(N) schwannoma #1 – dumbbell foramina, ? NF1.

mets to CSF – eg. PNET, ependymoma
– enhancing nodules or "cake" on nerve roots

meningioma (1°, or post rad'n) – broad dural tail, ± spine #1

(I) sarcoidosis – dural thick/enh.

(T) meningocele from trauma (eg Erb's palsy)

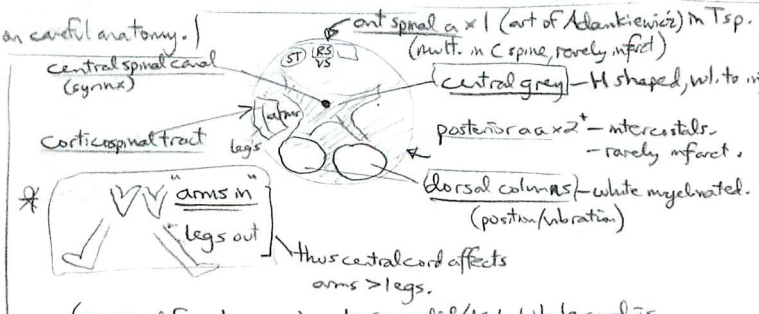
(M) (V) pial AVF (posterior), hemangioma

(C) arach/epidermoid/dermoid cysts – possible neurenteric cyst (anterior, ± V. body anomaly)

SPINAL CORD: INTRAMEDULLARY LESIONS

14 Feb 08 ♡

- Often non-neoplastic. Skinny structure but DDx depends highly on careful anatomy.
- Cord expansion — worry about tumor; others possible.
- Biggest Dx — MS, trx myelitis, tumor, infarct.
  - other inflamm/infec are rarer, but treatable.
- What's involved — grey / white / both — for how far, does it enhance?
  - tumor, trx myel.
  - demyelinating
  - infarct
  - long: B12



(reversed from brain, where leg is medial/ACA. Whole cord is reversed — gray is in middle rather than outside.)

Non Neoplastic

Pattern DDx: loc'n of abn signal (usu ↑ T_2) is...

central grey "H": (V) infarct — subacute. Ant spinal artery (post op, vasculitis, dissec) (anterior cord syn) — eventually ant 2/3 of cord. Like other sites, should extend to edge.

imagine cortical dz in brain

(T) central cord syn: hyperextended neck injury — old MI, spinal stenosis. Sx arms weak, legs ok — can't golf anymore.

— likelihood MCA stroke (face, arms worse than legs)

hydrocephalus/coning — if crush @ f. magnum, outer (legs) worse than arms; outer edge.

(I) encephalitis — viral

(I) ant. horn cells — polio! (can be 2° to live vaccine)

dorsal columns (white matter):

short patchy lesion(s): (I) MS — usu patchy, enhance if active. — usu SHORT < 2 v bodies, SMALL < ½ cord.

peripheral lesion that enhances centrally

many inflamm, a few infec

- ADEM — can become diffuse.
- Sarcoid — multifocal, ill defined.
- SLE — gray + white — vasculitis.
- (I) syphilis — "tabes dorsalis"
- HIV — vacuolar myelitis — starts T sp, creeps upward, may enhance.
- Lyme dz
- (N) lymphoma

[key to DDx]

long confluent lesion: (M) B12 def = "subacute combined degen." — single long lesion.

- (I) Devic's Dz — NS variant (optic nerves/spine only) — good Rx. — usu C-sp.
- (C) maple syrup urine dz — child
- other dysmyelinating dz.

poly radiculitis —

most of Xsection: too big for MS. Tumor vs Trx myelitis.

enh.

central lesion that enhances peripherally.

- transverse myelitis: — > 2/3 of Xsec, > 2 v bodies in height (ie, too big ↕ ⇔ for M.S.)
  - may enhance @ periph. cord may be expanded.
  - half not seen at all on MRI (clin Sx only) — sensory level, central cord (arm weak) bilat).
  - (I) HIV myelopathy (flame shaped)
  - DDx causes: — 50%+ idiopathic — post viral/post vaccine
    - others; identifiable → MS, ADEM, Lyme, sarcoid, syphilis, tumor, SLE vasculitis
  - Clinical: age 20-40, progress 1-2 wks, ⅓ recover, ⅓ bad defects. Rx IV steroids.

(a Dx of exclusion)

- intramedullary tumor: — diffuse enh, rather than just edges. May have cystic/hemorrhagic areas.
  - + EXPANSION of cord must be present, should enhance

Big 3

- (N) Ependymoma — #1 50% — bleed @ edges; 50% cervical, 50% @ filum; adults
- astrocytoma — 25% — homogeneous C sp expansion, kids, often pilocystic
- hemangioblastoma — multiple, VHL, enhance.

mets — "drop" @ central canal.

dermoid/lipoma — at cauda equina. Hence T_1 images for fat. C sp kids — may be mostly cystic

- (I) SARCOIDOSIS — enhances, mass Fx
- (V) AVM — rarer than AVF. Infarct
- (T) edema, hemorrhage. "Compression myelopathy" [Radiation — bright cord T_1, bright v bodies — peds: spine growth arrest @ site]

syrinx — well defined T_2 ↑

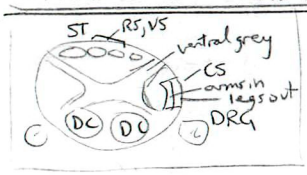
- central canal dil'n
- 1° ± Chiari I
- * 2° to obstructing lesion — neoplasm or other ↑, keep looking!

all T_2 bright, ± septae

or

TRAUMA — SEE OVER

SPINAL CORD — TRAUMA SYNDROMES



Ant. Cord Syn — ASA vascular insult (emboli)
— Flexion teardrop (crush ant. cord)
— Sx: DC (vib/position) spared.
motor, pain/temp gone.
Legs worse than arms ("arms in")

Brown-Sequard Syn — rare.
- penetrating trauma (gunshot)
- cervical disk.

— Sx: (R) motor/sensory except loss of
(L) pain/temp 2 levels below
(early crossing fibres)

* **Incomplete** — may recover **some** function.

* **Complete** — no recovery.
- fuse anyway.

* check LIGAMENTS in C spine

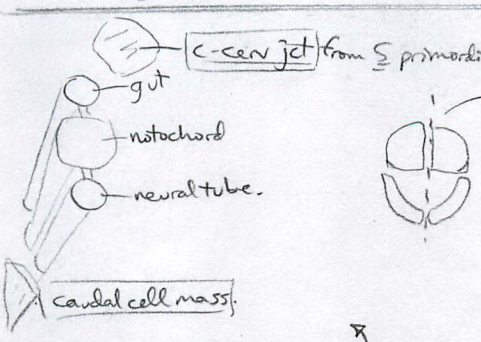
* Cord **contusion** T_2↑
hematoma T_1+T_2↑
myelomalacia chronic thinning

Central Cord Syn — common, older pt ± disc dz/trauma. — Sx:
- motor weak **arms > legs**
(central part worse)
- sensory, bladder dysfunc
- poor ADL's due to weak arms, bladder spastic/incontinent

#1
- hyperextn injury — lig flava buckle, + osteophytes, squeeze centre of cord,
- axons more sensitive than gray.
- T_2 bright central any way.

MSk – Spine Development & Variants: complex esp @ top/bottom

6 Oct/09



= 4 cartilage ossif centres for each vertebra. — V body ossifies ant + post halves

- Notochord "dorsoventral sheath" thru centre.
- Hence: Segmentation Abn

lateral hemivertebra (scoliosis)

butterfly vertebra (sagittal cleft)

notochordal remnant

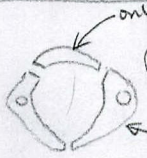
coronal cleft (A to P ossif centres) or posterior hemivertebra (severe focal gibbus)

block vertebra

(hemivert slips posteriorly)

"Dorsal Enteric Fistula" – skin to gut
- sinus, cyst if parts of tract closed.
- usu in S, T spine!

Craniocervical Jct



only 20% ossif @ birth

C1 – central ant. arch +2 lat

not fused until 3 yo (L → cerv.)

avoid Dx of spina bifida!

odontoid (6 parts!)
- apophysis (N)
- L+R peg
- L+R arch
- body.

* = (N) synchondrosis

Neonatal Vertebrae

coronal clefts – usu disappear @ 6 mo
- rectangular @ t spine
- ant/post vascular grooves
- ant notch (vessel).
- convex endplates.

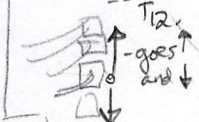
ovoid L-spine

neurocentral synchondrosis – V body to post arch
- may persist (ucut to 3-6 yo (Csp → Lsp)

ring apophyses – in puberty, fill in the ovals.

↑ enchondral ossif @ endplates
← ↓ → appositional growth @ walls
apophyses

Ossific'n

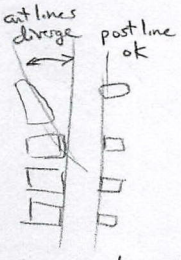


- starts T12, goes ↑ and ↓

(maybe explains beaking @ T12 L1 in dysplasias.

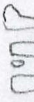
L5 16 wk
S1 19 wk
S5 28 wk

Pseudosubluxn:
- use posterior lamina line (should be < 1 mm off)
- if post (N)/ant malaligned, this is pseudosubluxn (N).



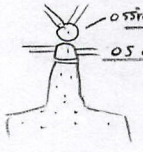
Lumbosacral Jct
- "transitional" 15% of pop
- small ↑ back pain esp if pseudoarthrosis
- careful c numbering
- "iliolumbar ligaments" at L5 → iliac crests.

Odontoid Dysplasia – risk at-ax instability!



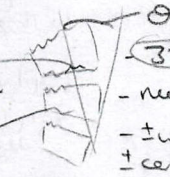
- hypoplasia
- aplasia
- detachment

esp in dysplasias, eg Down's achondro...



- ossiculum terminale – @ alar ligs; stable.
- os odontoideum – @ trx ligs, if nonunited may be unstable.

Scheuermann Dz
- confusing. Mid T spine, adolescent M > F.
- Alexander: "stress spondylodystrophy":
  - central Schmorl nodes = axial load
  - marginal Schmorl nodes (ant) = trauma
  - endplate # @ growth spurt
- ensure Xray done c arms horizontal



- θ usu > 35° (when imaged c arms horizontal)
- 3+ vert bodies (usu)
- need irreg endplates
- ± wedging
- ± central or marginal Schmorl nodes.

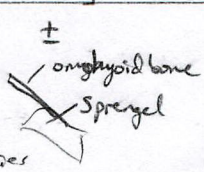
- total kyphosis > 40°
- and ≥ 1 vert wedged > 5°.

← Ozonoff.

Klippel-Feil
- fusion: 3+ cervical vert,
- often hypoplastic V bodies since very young
- 30% have Sprengel (elev scapula)
- orig. triad: limited movement, short neck, low hairline!] rare.

* DDx JRA (early childhood fusion @ facets/disks)

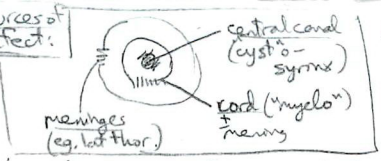
hypoplastic V bodies (old fusion)



APPROACH TO SPINE DYSRAPHISMS (AFIP)

11 Jan 07

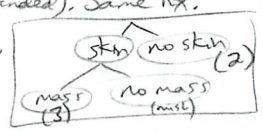
3 Sources of Defect:

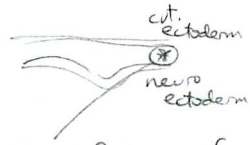


3 categories

① OPEN (exposed neural tissue)

- myelomeningocele – assoc $^{\#}$ Chiari II – failed closure; placode open, needs repair @ birth
- myelocele – similar but meninges don't protrude (sac not expanded). Same Rx.
- dorsal dermal sinus – T_1 or S_1 – Spectrum of split notochord so check for diastematob...

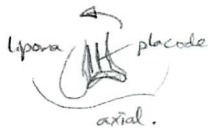




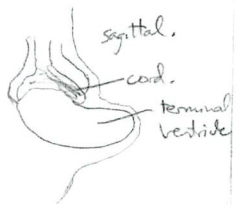
Open defect – superf and neural layers of ectoderm failed to separate.

② CLOSED, WITH SUBCUT. MASS (skin covered)

- lipomyelomeningocele – "fatty cousin of MMC" – has fat + skin. often rotated
- lipomyelocele – as above but not 'protruding' as much



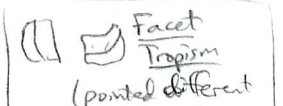
- meningocele – totally different – trauma, NF1 (lat. thoracic)
- terminal myelocystocele – dilated terminal ventricle – error of fusion with caudal cell mass – severe abn GI/GU
  ie, terminal syrinx (cyst within cyst)



Closed ± lipoma – incomplete separation. Lipoma trapped between.

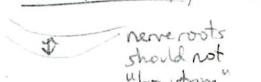
③ CLOSED, NO MASS ("grab bag" of lesions) – often have hair

- spina bifida (neural arch) – Ⓝ until 6yo!
- lipoma
  - fatty filum – abn of "caudal cell mass" (abn if > 2mm and T_1 bright, ± tether) – Rx resect
  - split cord (diastematomyelia)
  - dorsal enteric fistula
  - caudal regression syn
  - dermal sinus, neuroenteric cyst



U/S: of kid ± cleft etc.

- Ⓝ termination?
  L23 @ < 3mo only.
  L12 older.
- Loose/floating? / tethered



Lots of Ⓝ pulsation.

- Open sacrum? of course
- Sacral/coccyx mass?

Dural Cysts/Dural Expansion

- +tumor – neurofibroma, ependymoma etc
- +syrinx – from central canal

- meningeal cysts:
  - I – extradural – no nerve root fibres
  - II – extradural with nerve root
  - III – INTRAdural
  - assoc NF1/2 etc.
  - I_A – arach cyst
  - I_B – occult meningocele
  - no nerve root fibres (T spine 2/3, often adolescent)
  - II – Tarlov cyst – ± root fibres (adult)
  - III – intradural arach cysts
- dural dysplasia – no single cyst – just ectatic scalloped. – (Dx of exclusion)

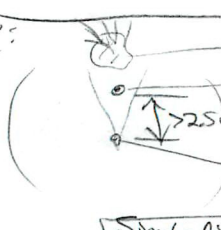
Re: Tethered Cord?

- count from TOP
- must see on AXIAL
- T_2 best for scanogram but use T_1 axial due to "fatty filum = tethered cord!"

PRESACRAL MASS DDx:

- cystic – ant. meningocele (scimitar sacrum)
  - lymphangioma
  - ovarian.
- solid – teratoma $^{\#1}$ (coccyx destroyed but Ⓝ spine; cystic/fat/ca^{++})
  - neuroblastoma (kids – canal invasion!)
  - chordoma – NOT in KIDS! ($^{\#1}$ site, more than clivus)
  - neurofibroma (ant/lat, wide neural f)

Sx:



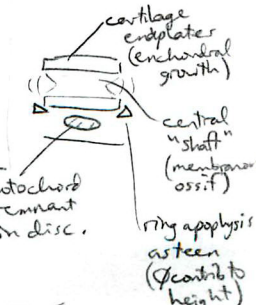
- hair, dimple, hemangioma – can be seen 5% of Ⓝ too! (usu. dimple only)
- "high" sinus >1" above anus: risk of dysraphism below
- sinus in gluteal cleft
  - usu. pilonidal sinus, Ødysraph

Simple dimple needs no imaging

- midline in cleft
- < 5 mm
- < 2.5 cm above anus
- no hair, discolorn, etc.

Do U/S on all others.

Ⓝ Dev:



4 parts hence latior post hemivert.

Hemivertebra: is there a growth plate (risk progression of scoliosis) or not?

N

Chn — SPINE from OZONOFF

23 Jan/10

Im

SCOLIOSIS

Congenital – assoc c fusion anomaly etc
– or neurofibromatosis

Infantile – common in UK before "back to sleep"
– <4 yo, usu (L) thoracic. Resolve spont in 2 yr.
– ?like plagiocephaly?

Juvenile 4-10yo
Adolescent 11yo+
– Rx 25-30° based on potential for progression.

↓

Braces:

Milwaukee – if high curve (apex above T7)
– chin to pelvis!

TLSO – thoracolumbosacral orthosis
– underarm c pads

Charleston bending brace – @ night only, bend vs. convexity

Surgery – near 50°, always c fusion around hardware

Harrington Rod – high pressure at upper/lower ends of rod, risk#. Need cast post op!
– also lose kyphosis.

Luke/Wisconsin – longer O.R. than Harrington
– L shaped rods, with wires below lamina (Luque) or in spinous processes (Wisconsin) — risk of migr'n to spinal canal!

Cotrel-Dubousset – pair of rods, flexible, mult. hooks.
– costly, but tailored correction without single anchor
– can also avoid lost kyphosis of Harrington

Anterior Fusion – use in congen scoliosis, NF1 — rare in idiopathic.
- **Dwyer** – cables between vert e convexity
- **Zielke** – rods bet vert not cables

Post Op → rod #. → lamina #, hook roth
→ pseudoarthrosis, spondylolysis
→ late: lat disc bulge if no ant fusion
→ gallstones 20% (massive hemolysis) 4 yr later.
→ SMA syndrome (spine elongated; stretch snx; obstructs 3° dvrod)
→ failed fusion, pseudoarthroses – >6 mo later
(late hardware failure implies pseudoarth)

vs.  has growth plate
∴ risk of progression!

└ fused, fixed deformity

Curve endpoints:
apex – max displ/lat rot vert
end-vert – lines along endplates will point maximally into concavity of curve.
– also least rotated.

– **Cobb** – upper endpl. of upper vert to lower endpl of lower vert.
– will overlap at L_1 usually.

95% CI ±10°

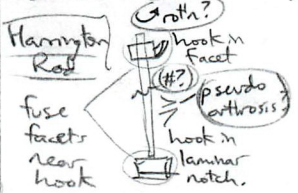
– **Risser**: for bone age
most growth is at risser 0 so use hand/elbow!

Risser 0 — I, II, III, IV quadrants. V fully fused
(iliac crest apoph. fuse late, last → med (late!)

Bone Age

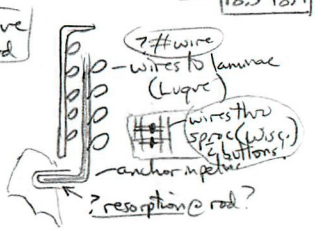
	M	F (yr)
I	14.6	13.7
II	15.6	14.5
III	16.2	15.2
IV	17	16.2
V	18.5	18.1

Harrington Rod

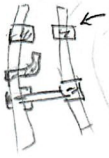


– look for hook roth or slippage.
– rod breakage if incomplete fusion

Luque Rod



Cotrel-Dubousset
system of rods, laminar hooks,

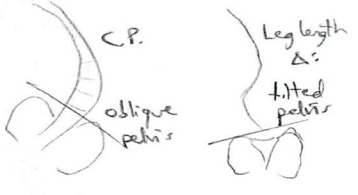


– good in roth
– distributes loads.
– rotate scol. curve from coronal to sagittal!
– TSRH (Texas Scottish Rite Hosp) similar to Cotrel – but easier to revise.

Dwyer

Red Flags/DDx

- **left thoracic** → ?syrnx/mass.
- **congen anom** → bar or fusion?
- **NF1** → short sharp curve, ↑kyphosis
- **post rad'n** → bone in bone
small ribs/hemipelvis
exostoses
- **pelvic tilt** — is it flexible 2° to leg length Δ?
get bending films. Convex to short side
- **neuromuscular** – C shaped single long curve
– lat dev'n, oblique pelvis
– disloc hip on concave side.
- **ost. osteoma** – sclerotic @ curve.



SPINE ATLAS (3) Osborn 19/20/21 8 Jun 06

DYSRAPHISMS (spina bifida; neural tube defects)

N	Clin	Im
MYELO MENINGO CELE	• failed closure of neural tube. • assoc Chiari II ((2) components are herniated) – 100% of Chiari II have M.M. (recall Chiari II = herniated cerebellum & 4th v into CSp, due to tube open at both ends; tethered at myelomeningocele) • very common – #1 neural abn. – 100/100,000 (More in Maritimes, less in BC) – usu. sporadic ↑MSAFP (made by fetal liver, leaks) – Sx hydro, needs repair; central apnea @ chiari • Assoc syrinx 50% • ↑MSAFP + ↑ACHE (neurotransmitter) (if doubt, check amniotic fluid AFP) 5, bifida – aperta – occulta	CSF in dural sac, stretched nerve roots, "neural placode" open to air!, Spinal dysraphism, failed to fold. cord, placode – Charcot joints – and unusual # – short fibula, metaph. #s – scoliosis above defect (tethered cord at surgical closure site) progress – kyphosis – at defect. Progresses if initially severe (q. lumbar m. flexors) – DDH/dislocs: – flexors (L234) ok, – extensors (L5S1) flaccid, ∴ L34 → disloc. L5 → late subluxation – coxa valga due to ilipsoas. – feet: – congen vert talus common, – calcaneovalgus due to unbalanced flex kyphosis at defect, stretched roots, pedicles with flared toward L-S jct, talus CSF, fat ± skin protrude, any tiny bit of fat, neural placode rotated (partial separ'n of superficial & neural ectoderm, lipoma trapped)
Lipomyelo meningocele	• nearly closed tube. Fat exposed to air, protects cord. Lumbosacral mass in adult. F>M. • NOT assoc Chiari II. • "closed neural tube defect" or occult • "sticky", tends to re-tether often	
INTRADURAL LIPOMA	• tiny fat island trapped during tube closure. • intradural extra/juxtamedullary, tethers cord (progressive weak/incont) • usu. Cspine or Tspine, not Lsp. #1 • filum terminale fibrolipoma possible – "fatty filum" 5% of pop. → cause of tethered cord	lipoma (T1 bright) from cord to dura. (filum, should be <2mm @ L5S1) most common in Tspine or fatty filum terminale, T1 bright
DORSAL DERMAL SINUS	• sinus tract from cord to skin, usu lumbosacral spine c dysraphism below. • Sx from infec. • epithelium lined → can get dermoid tumors	dysraphism, sinus tract, dermoid tumor possible, skin hair/mole/angioma occiput #2, L-S spine #1
(DORSAL ENTERIC FISTULA)	severe anomaly of caudal cell mass – gut to skin thru spine! Other anomalies ++.	
TETHERED CORD	• often 2° to any of the above (75% spinal lipoma) (any barrier to smooth regression/upward motion of cord tip) • but may be isolated. Sx spastic bladder/legs, pain/scoliosis • also assoc diastematomyelia • if filum is fatty → means tethered cord! • Rx – neurosurgery to untether	MRI – check T1 axial (is filum fatty). Count from T12. nerve roots may go uphill, low-lying conus, often (3/4) lipoma, dysraphism term. infant/lowest L3 (N) lowest L2 L2-3 disc or lower = tethered, fatty filum t. a cause
SACRAL MENINGO CELES	• Tarlov cysts – in enlarged sacral foramina (perineural cyst @ DRG) – ± comunicn c canal – Ø Rx unless nerve root compr • myelocystocele – "syringocele" – rare++ – skin-covered lumbosacral mass, # myelomeng. – sacral agenesis or s. bifida, then tethered cord c hydromyelia (syrinx) – protruding syrinx. • ant sacral m-cele – pelvic mass – seen in NF1, Marfan's – protrudes ANT instead of out the back	Tarlov cyst, syrinx, cord, lined c ependyma, protruding syrinx, skin, "cyst within a cyst on MRI", I.D. and fix since (N) @ birth, "scimitar sacrum" deformed by mass.
SACRAL TERATOMA	• solid sacral mass in neonate c Ca++, fat – usu benign although dramatic • #1 sacral mass in kids. 15% malig @ birth. • better Px as infant. If >2 mo, malig!	from coccyx, solid sacral mass – spine (N) aside from destrctive of coccyx – Ø cord invasion, Ø neural f invasion (DDx from n-blastoma, meningocele) internal/external/mixed, Internal have worse Px.
(MENINGO CELE)	• pouch of CSF from "flabby dura" ant/lat/post – eg NF1 "lateral thoracic" – "pulsion diverticulum" (no muscle covers the neural foramina) or post traumatic – Δ in size c Valsalva!	lateral thoracic (NF1) anterior: traumatic thru neural f

SPINE CONGEN ATLAS CONT'D

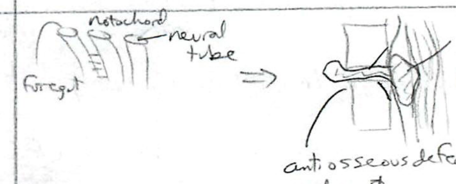
DIASTEMATOMYELIA

- nondisjunction of neural tube from ectoderm
- "spinal cord broken into two stems" – rare (15% of Chiari II)
- connec between gut and dorsal ectoderm forces cord to split. 50% = 2 dural sacs; 50% = 2 cords / 1 sac
- assoc tethered cord (75%), vertebral anom, clubfoot (at focal split)

- Xray: wide interpedicular dist. in thorax ± bar (rarely visible)

ENTEROGENOUS CYST / NEURENTERIC CYST

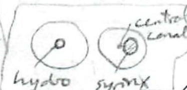
- cyst anterior to cord, remnant of foregut.
- usu @ T spine (notochord arises // to foregut)
- thin walled, fluid. Compressive Sx in late teens.
- often assoc vert anom. ("Ant + post spina bifida")
- split notochord – severe → dorsal enteric fistula.



SYRINGOHYDROMYELIA (SYRINX)

- fluid (hydro) (ependymal lining, in canal) or separate cyst (syrinx) (eccentric) inside cord, in central spinal canal – esp C spine near 4V.
- assoc Chiari I (mild cord tethering) (2% of Chiari I have syrinx)
- can be 2° dilation 2° to cord trauma, tumor, compression (assoc??)
- Neuro Sx when enlarged
- syringomyelia if extends laterally.
- syringobulbia – extends into thalamus
- or Ⓝ "ventriculus terminalis" @ conus – flaring.
- Asymp: F/U 1yr (early tumor?)
- Charcot jt – esp shoulder ("surgical" margins)
- #1 @ C spine

- Measure: – syrinx-cord ratio (>50% large); – absolute mm ???



- no cord lesion → dural AVF
- 60 M c̄ disc abn
- cord lesion → cord AVM

SPINAL AVM / aneurysm

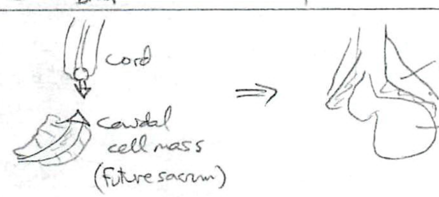
- a tiny bleed can be devastating – can cause "hidden" SAH (elderly M c̄ weak legs bow/bl)
- I – dural AV fistula (pial) – usu. near conus – at cervical nerve root. * most common 80% – almost half 2° to trauma (M 50+) (progressive neuro deterio! due to venous obstruc → myelop)
- II – glomus tumor in upper cerv cord young pt – acute bleed.
- III – juvenile, rare, large
- IV – intradural extramedullary – fed by ASA, outside cord. – 30-50+ pt, progressive deficits
- Cord AVM – worse than dural fistula! #1 cause of spinal epidural hematoma
- Angio: HUGE study, check entire spine.

① AVM
② AVF pial

- (elderly M Ø bleed)
- I: dural AVF – nidus on nerve root at neural foramen! Dil pial V. Sx myelopathy/radiculopathy. O/E – tortuous/dil veins, nidus.
- II: or cord AVM – nidus IN cord (intramedullary mass, from a/v) – AVM. (young pt acute bleed) Sx bleed – catastrophic.

TERMINAL MYELOCYSTOCELE

- error of distal cord fusion with "caudal cell mass" causes dilated terminal ventricle, sticks out the back
- assoc severe caudal anom GI/GU/cloacal/legs.
  - incontinent, ~ paraplegic



FATTY FILUM / TIGHT FILUM

- abn of jct. c̄ "caudal cell mass"
- risk tethering.
- Ⓝ filum ≈ 1 nerve root. If bigger, or fatty, abn.

CAUDAL REGRESSION SYN

- all the way to sirenomelia (no legs, mermaid-like!)
- assoc DM – 1/7500 births (milder version)
  - assoc VACTERL
  - high-terminating cord

on U/S:

SPINAL EPIDURAL HEMATOMA

- #1 cause = AVF bleed! – usu. 50yo,
- Consider also: – trauma, htn, coagulopathy, (tearing of epidural veins) vascular tumor
- Rx – often conservative despite dramatic Sx

- high T_1 (early subacute) ant to C/T spine cord (not LSP) + high T2 late
- check gradient for bloom (deoxy Hb)

SPINE LESION ATLAS (2)

9 Jan 06

N	Clin	Im
DISKITIS/ SPONDYLITIS	• usu hematogenous. - can be from adj. tissue (psoas) but usu the reverse. • TB (brucella also positive)/fungal (aspergill/blasto.) • 3rd world – in kids • NAm – 40ish (IVDU/ETOH etc. • Indolent, patchy/multifocal (spreads along ALL/PLL – common epidural/paraspinal abscesses) • Epidural abscess – early phlegmon, late abscess – dangerous extradural mass • Spondyloarthropathy of Dialysis – mimics multilevel discitis, but slow progr. – crystal deposition (like chronosis?) – esp amyloidosis.	Adult starts in endplate (vascular) of T/L vert. spreads to disc. DSN, erosion, paraspinal mass low T1 adj marrow (fat repl by edema/pus) feared: epidural abscess • Bacterial – Vert–disc–vert unit x1 • TB – indolent, behaves like tumor – – stays in vertebra (walled off at start) – skip lesions – looks like mets – disc nucleus pulposus stays bright (preserved) • Gas in disk EXCLUDES diskitis (low P/degen) edema BOTH sides: – discogenic – osteomyelitis vs. ONE side – fracture – mass
MENINGITIS, ARACHNOIDITIS	post op laminectomy/discectomy, post trauma or – clumped/thick/enhancing nerve roots – with calcif – arachnoiditis ossificans (remote infec/tr/infl/surg) → EXTRADURAL LESIONS	• l.n. enhance of meninges, nodular thickening or thick walls diffusely. nodularity, clumping. "naked sac" (roots adhered to wall) blunt nerve root sleeves "block" (adhesions)
DISK HERNIATION	• L4/5 or L5/S1 90%, nearly all into spinal canal. • annular tear necessary for nucleus to herniate thru. (radial) • Atypical disc fragment a more common "mass" than most neoplasms in canal. • Pain resolves in 6 wks in 80%. If not, O.R. • Scar vs recurrent disc: SCAR ENHANCES, esp <1yr postop • DDx tough: – recurrent herniated disc – retained fragment – epidural hematoma (acute) – scar	high T2 (HIZ) or enhancement at annular tear (very common assoc – necessary?) soft tissue mass extradural defect (block/feathered edge on myelogram) watch for lateral herniation or free fragment (can even be posterior to sac) Disc – continuous nucleus – high CT density, or gas/Ca++ – mass effect – ring enhance if any Scar – enhances
EPIDURAL LIPOMATOSIS	• obesity, Cushing's • usu chronic steroid use → cord compr.	• unencapsulated fat deposits
CHORDOMA	• notochord (vert disc – former) remnant in base – midline tumor @ clivus or sacrum – rarely, C/T spine (where mimics TB) #1 site – "typical" or "chondroid" – rare. NOT IN KIDS – "rare" in kids – DDx – GCT, chondrosarcoma – mets. – ependymoma, schwannoma "His silent Secretly #1 @ sacrum" (Hayden sign) Bad Bx – 5yr survival – slow grow, RT doesn't work well.	will metastasize to bone, lung (50% to nodes) infiltrative clivus/midline skull base (40%) • careful – clivus (N) enhance <3yo locally invasive chondroid form (red marrow) when sacral! tsp – mult vbodies, spare discs (mimics TB!) CT: low atten sacrum • often calcifies (SLI) • destructive lytic • T2 bright (#gelatinous) rabbit ears along sciatic n. – presacral 50% (tiny fluid-like droplets) many contain cartilage (chondroid) – thoracic spine, NOT cervical. crouching on sac: T2 bright, homog enh, may extend into neural f. – if from vert, also T1 bright as has fat.
EPIDURAL HEMANGIOMA	– #1 extradural benign lesion! Can be adj to/extn of vertebral hemangioma – Rx surgical excision for cure. NOT Bx.	
SYNOVIAL CYST	– close relation to capsule of degen facet jt – most in F > 60yo. Rx: aspirate or steroid injec under CT, or O.R. (+) mets @ central cord (gray confluent)	joint cyst – periph enh. 3/4. (give gad if suspicious) – esp @ L4/5 – rare elsewhere!
NON NEOPLASTIC CORD LESIONS (intramedullary)	see next pg.	

Trx myelitis

Spine Atlas

N	C	INTRADURAL MASSES	I
SCHWANNOMA	-see also CPA masses, post med. masses - grows @ Schwann cells — beside nerve - no nerve fibres thru lesion - has capsule - most common nerve root, most common intradural extramed - CN8 + meningiomas = NF2 — NOT spinal schwannomas! - BENIGN. Rx — can spare nerve during O.R.	#1 intradural	dumbbell eccentric from nerve root (Schwann cell lies beside n.) cystic, (sometimes (rarely) Ca++) has capsule look worse on imaging but BENIGN can be myxoid cyst "tail sign" (adj thick nerve) either schwanoma or neurofibroma
NEURO FIBROMA	-also tumor of Schwann cells but with "nerve fibres running thru"; fibrous prolif. - 40% have NF I (recall NF II is meningiomas) - if so, multiple. - 10% malig transform (fibrous elements?) - assoc scoliosis, ↑ deform - Rx — O.R. must remove nerve with mass.		- tangles - ø cystic ø Ca++ - nerve thru centre ribbon ribs scoliosis dumbbell no capsule. infiltrating. mult enlarged neural f + thinned pedicles = NF I.
SPINAL MENINGIOMA	• aggressive variant — hemangiopericytoma - #2 intradural but only 10% of all meningiomas. - 80% in F. Age 50's. - usu fully intradural. Slow growing, recur rarely on removal		90% extradural intradural, lat to thoracic cord. NOT (csp L spine! often anterior if cervical - Enhances ++ - rarely Ca++ - broad dural base - T2 usu ~iso to cord (need gad)
SPINAL EPIDERMOID CYST	• congen — 50% — rests of epi. tissue • ACQUIRED — 50% — LATE COMP OF L.P.! (yr later+ — when trochar embeds cord wall tissue in CSF.		L.P. complicn! (may see tract to LP site)
SPINAL ARACHNOID CYST	• Tough Dx • Arach diverticulum = dilated nerve root sheath		cord displ for no clear reason (cyst = CSF) — try phase contrast MRI to show flow
MYXOPAPILLARY EPENDYMOMA	• 90% of filum tumors • very heterogeneous, vascular • M 30yo, or kids. • 10% metastasize locally — higher risk than 4V ependy; poorer Px (70% vs 90% survival)		dilated syrinx (altered flow) big heterogeneous filum mass (bleed, cyst) scallop post V bodies hemosiderin widened canal enhance ++.
	INTRAMEDULLARY (CORD) LESION		
Spinal Ependymoma	• usu #1 in adult (age 40). • typical centred in cord (ependyma line the ventricles) or "myxopapillary" — exp site @ filum terminale. — age 30 • DDx — astrocytoma — syrinx (ø enh) — schwannoma if small @ filum.		multilevel cord expansion cystic, hemorrhage - can be cervical (50%) - more specific @ conus/filum ("base" of cord, like base of brain) tumor margin = "cap sign" - nonspecific on MRI - enhance ++ thus not syrinx. - rarely calcify (unlike in brain)
Spinal Astrocytoma	• child, C spine (or T spine if older) • cystic components common. [like pilocytic astrocytoma] • usu low grade — rarely GBM — but poorer survival than ependymoma		upper cord (C/T spine) long vertical extent diffuse cord thickening cystic degn, or adj. syrinxes thus C spine lesion is either ependy or astro - enhance ++. - more homogeneous. - ↓
SPINAL HEMANGIO BLASTOMA	- risk cord compr - VHL in 30yo, 1/3 of pts. Sol < 40yo otherwise (N). - late in VHL (retina, cerebellum 1st)		- feeding a/v. — very vascular thoracic spine DDx = AVM.