Intramedullary tumors:
ongoing technical & decision-making challenge
With emphasis on children

A surgeon's view

Shlomi Constantini, MD, MSc

Department of Pediatric Neurosurgery,
Dana Children's Hospital,
Tel-Aviv Medical Center, Tel Aviv, Israel
sconsts@netvision.net.il

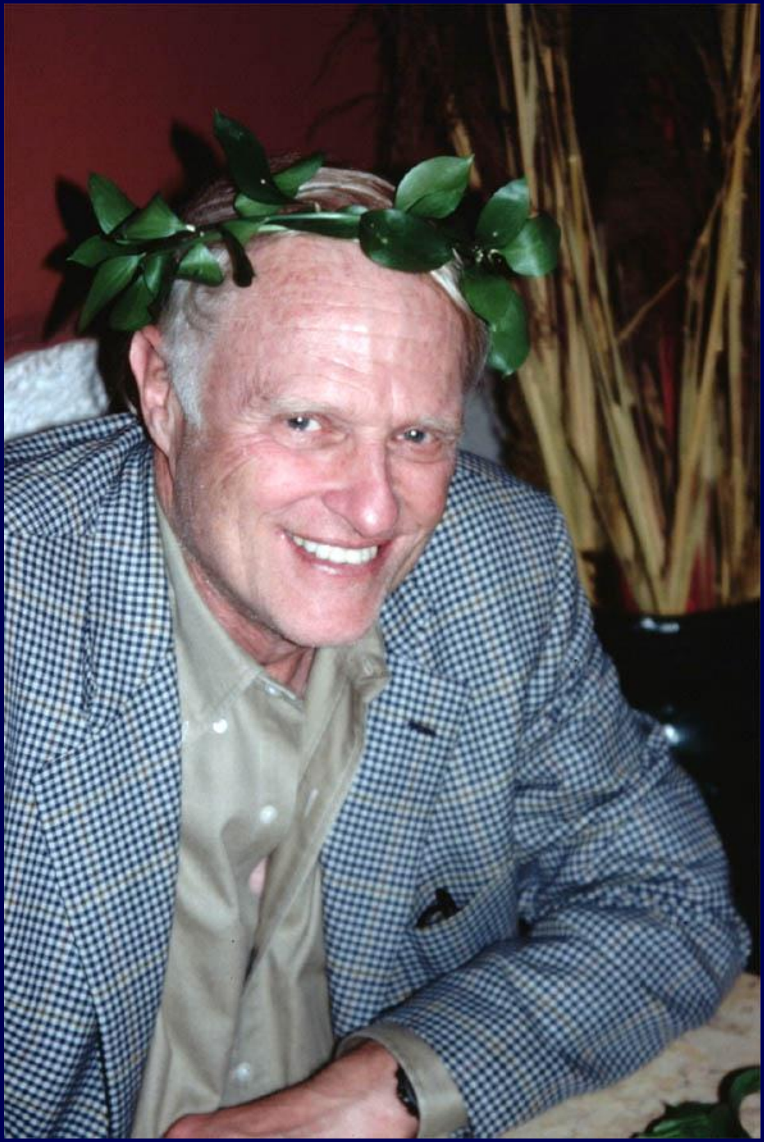
The plan for today..
IMSCT's

- ***Overview***
- ***Clinical***
- ***Imaging***
- ***Setup***
- ***Surgery***
- ***Oncology***
- ***Conclusions***

Intramedullary tumors (& IOM): My bias!

- **Fred Epstein's legacy**
- + my own experience:
- Long Follow-up: available
- Awareness of morbidity
- Gradual change in strategy

Fred: an "inspiration" giant



Intramedullary tumors (& IOM): My own bias!

- Fred Epstein's legacy
- **+ my own experience:**
- Long Follow-up: available
- Awareness of morbidity
- Gradual change in strategy

Added:

- **Additional 5 years of follow-up**
- **Additional >300 Intra Dural spinal cases**
  - **In Israel**

J Neurosurg 85:1036–1043, 1996

(27 cases)

Intramedullary spinal cord tumors in children under the age of 3 years

SHLOMO CONSTANTINI, M.D., M.SC., JOHN HOUTEN, M.D., DOUGLAS C. MILLER, M.D., PH.D., DIANA FREED, B.A., MEMET M. OZEK, M.D., LUCY B. RORKE, M.D., JEFFREY C. ALLEN, M.D., AND FRED J. EPSTEIN, M.D.

J Neurosurgery 85:1036–1043 ,1996

J Neurosurg (Spine 2) 93:183–193, 2000

(164 cases)

Radical excision of intramedullary spinal cord tumors: surgical morbidity and long-term follow-up evaluation in 164 children and young adults

SHLOMI CONSTANTINI, M.D., M.SC., DOUGLAS C. MILLER, M.D., JEFFREY C. ALLEN, M.D., LUCY B. RORKE, M.D., DIANA FREED, AND FRED J. EPSTEIN, M.D.

J Neurosurgery 93:183–193 ,2000

Pediatric papers IMSCT

Intramedullary tumors (& IOM): My own bias!

- Fred Epstein's legacy
- + my own experience:
- **Long Follow-up: available**
- Awareness of morbidity
- Gradual change in strategy

Intramedullary tumors: My own bias!

- Fred Epstein's legacy
- + my own experience:
- Long Follow-up: available
- **Awareness of morbidity**
- Gradual change in strategy

Hua Tuo, Patron of Surgeons

or, How to Get Into Another ~~Head~~ *Spinal cord* Without Losing Your Own! *Head*

A. Sherer, F.Epstein, M.D., S.Constantini, M.D.

Surgical Neurology 2004

There is lots of talking to do before & after the surgery

Always more when you deal with children

Intramedullary tumors: My own bias!

- Fred Epstein's legacy
- + my own experience:
- Long Follow-up: available
- Awareness of morbidity
- **Gradual change in strategy**

Major role to

Intra-operative Monitoring IOM

IMSCT: History & Overview I

- *< 80's*
- *"It is not feasible to carry out extensive removal of tumors from within the center of the spinal cord without inflicting injury"*

Textbook of neurosurgery

IMSCT: History & Overview II

- Decompression+RxT (*not that bad for old-age*)
- There is no "alternative treatment" ??
- Major change in the late 70's…
- Pre-MR data is useless!
- Long-term follow-ups are available
- 2000: Gradual balanced view..
- :+2000
  - ***Employ Multi-modality treatment***
  - ***Implement modern techniques***
  - *Tailor treatment individually*

- *Pediatric IST are rare*
- *P-IMSCT's are rarer*
- *About 2-3/100,000 children per year*
- *More adult IMSCT then children 1:8*

Better if same surgeon does both kids & adults!

Ependymoma/Astro ratio goes up with age

Intraspinal tumors in 872 children

Tumor Type and Location	No.	%
Intramedullary	**315**	**36.1**
Astrocytoma	201	23.1
Ganglioglioma	35	4.0
Ependymoma	3	0.3
Other	76	8.7
Intradural Extramedullary	**235**	**26.9**
Schwannoma	32	3.7
Meningioma	21	2.4
Ependymoma	58	6.7
Dermoid/Epidermoid	55	6.3
Teratoma	37	4.2
Lipoma	32	3.7
Extradural	**212**	**24.3**
Neuroblastoma	69	7.9
Sarcoma	62	7.1
Lymphoma	5	0.6
Aneurismal Bone Cyst	7	0.8
Metastatic	33	3.8
PNET	36	4.1
nonclassified	**110**	**12.6**
Total:	**872**	**100**

From: Constantini & Epstein, Schmidek 1995

P-IMSCT's:
Reasons for Investigation

• Motor regression	65%
• Pain	45%
• Gait abnormalities	37%
• Dysesthesia	32%
• Progressive kypho-scoliosis	32%

P-IMSCT's: Clinical Presentation I

- **Pain**: the most common symptom

At night! True for children & adults!

Night pain=MR+BS

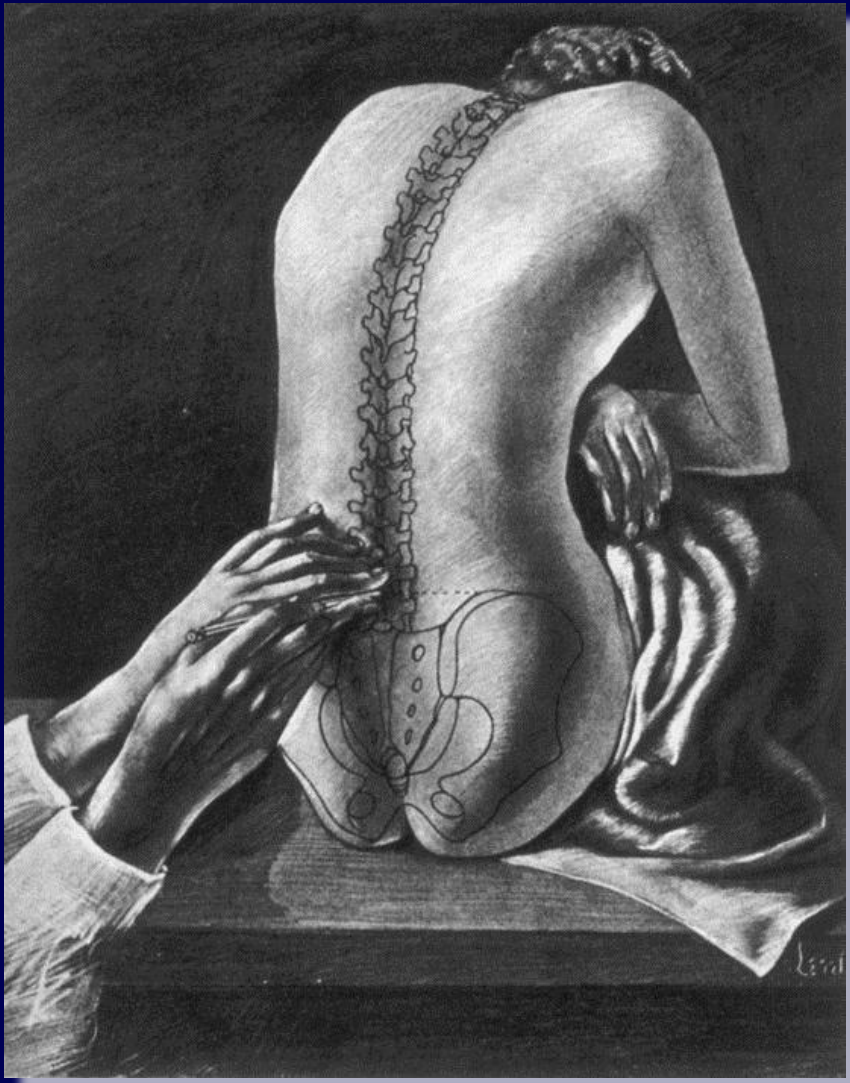
Corresponds to the bony level

Abdominal pain: Non-specific!

For adult ependymomas: Sensory complains

P-IMSCT's: Clinical Presentation II

- Pain
- **Scoliosis**
- Urinary dysfunction
  - Rare & late
  - In cauda / conus lesion
- **Torticollis**
- Hydrocephalus
- Malignant tumors



When to MR patients with scoliosis

- Documented Rapid Progression
- Atypical curve
- Age: early onset < 8y
- Any neurological/urological sign
- Vertebral and midline anomalies
- Pain (especially at night) (Bone scan)
- As screening in dysraphic children

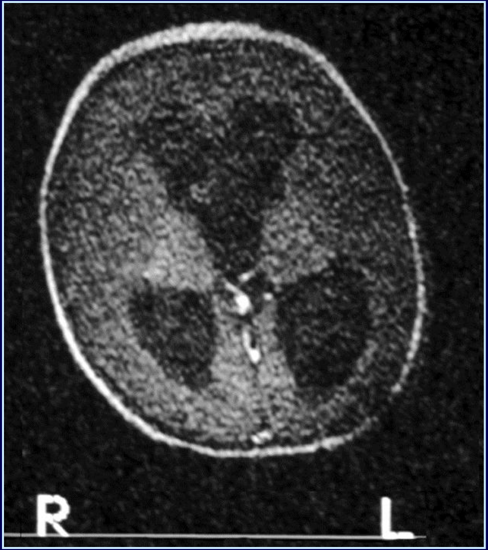
P-IMSCT's: Clinical Presentation II

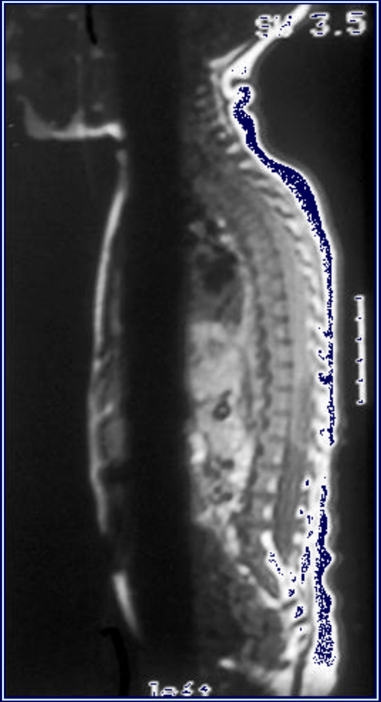
- Pain
- Scoliosis
- Urinary dysfunction

  Rare & late

  In cauda / conus lesion
- Torticollis
- **Hydrocephalus**
- Malignant tumors: fast!

2y old came for a shunt





No reason HCP + high protein CSF----
Investigate the cord!

P-IMSCT's: Clinical Presentation III

- **Motor (may be subtle!)**

  Alternation of normal gait

  Regression

  Late walker

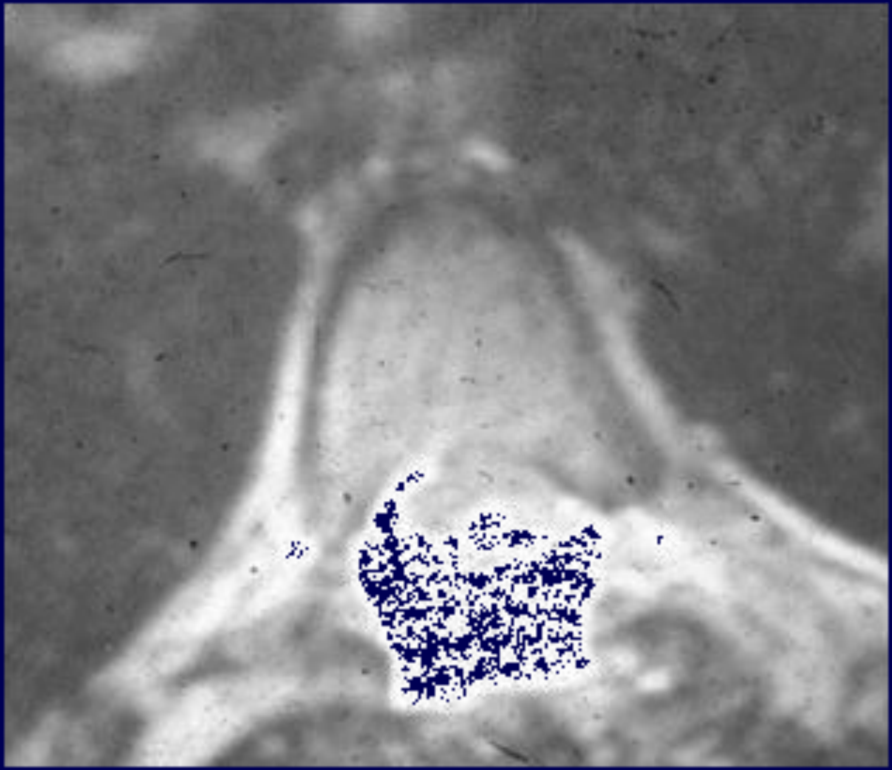
  Switching handidness

  Muscle atrophy

  (low cervical)

P-IMSCT's: Radiology I: X Ray+CT
Probably, totally useless

- Diffuse widening
- Erosion of pedicles
- Scalloping



IMSCT's: Radiology II: MR imaging

- Always with Gd
    - May or may not enhance (75%)
- T1: solid & cystic components
- T2: myelographic effect
- Alway get the entire spine!
- Consider getting a brain MR for baseline

10 y old   1998

Drooling & neck pain

C3-6 astrocytoma

15 years old

Came after she had a biopsy, dural decompression & RxT

Enjoyed..

Symptoms back 3 years later

Astrocytoma

2 years old girl

Continence-regression

Conus ganglioglioma

Solid tumor!

4 years old with incontinence

Conus/Cauda ependymoma

Note the large bladder

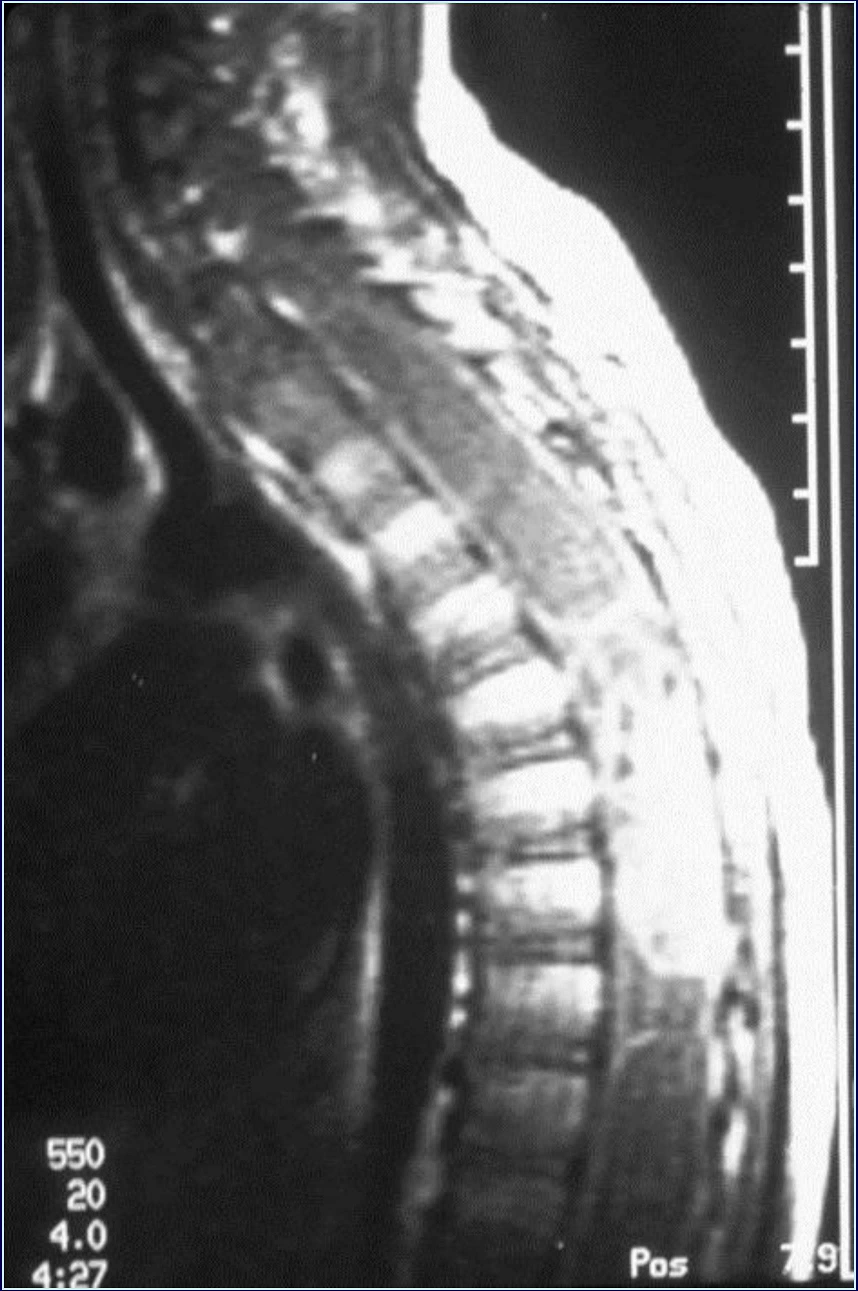
These are not "true" IMSCT's

14 years old

Mother insisted to get imaging because of pain

CT: “Normal”

Ganglioglioma

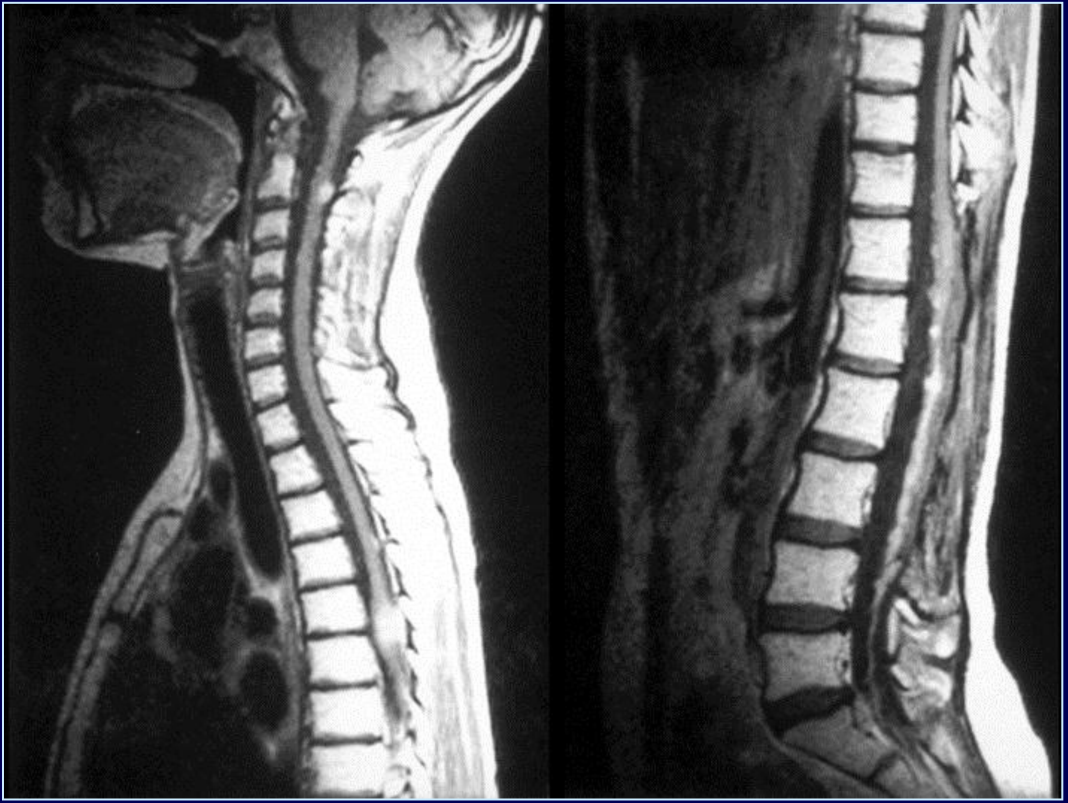


12 years old with pain

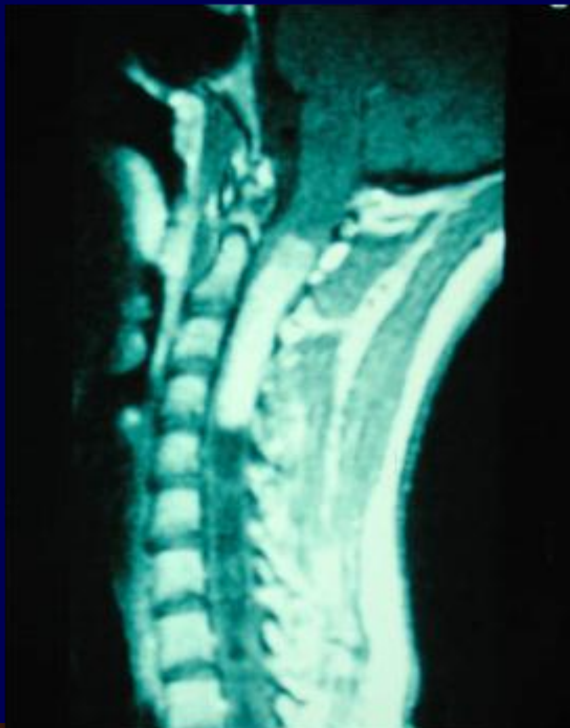
"primary" spinal PNET

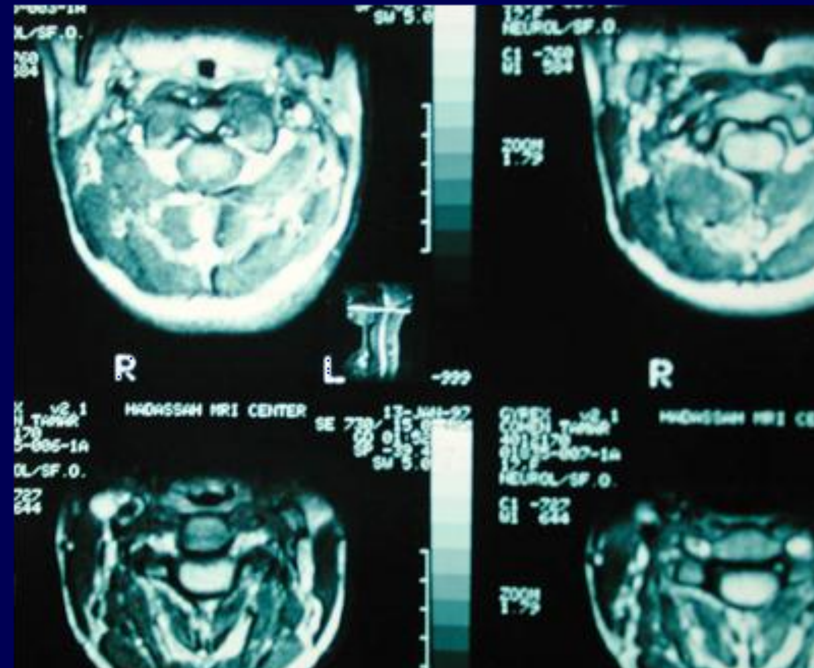
No brain lesion

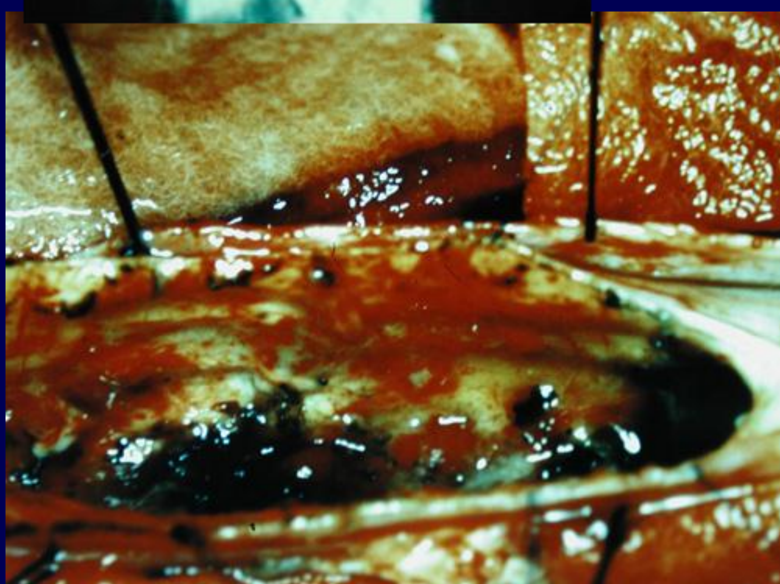
Not a true IMSCT



Subarachnoid tumors





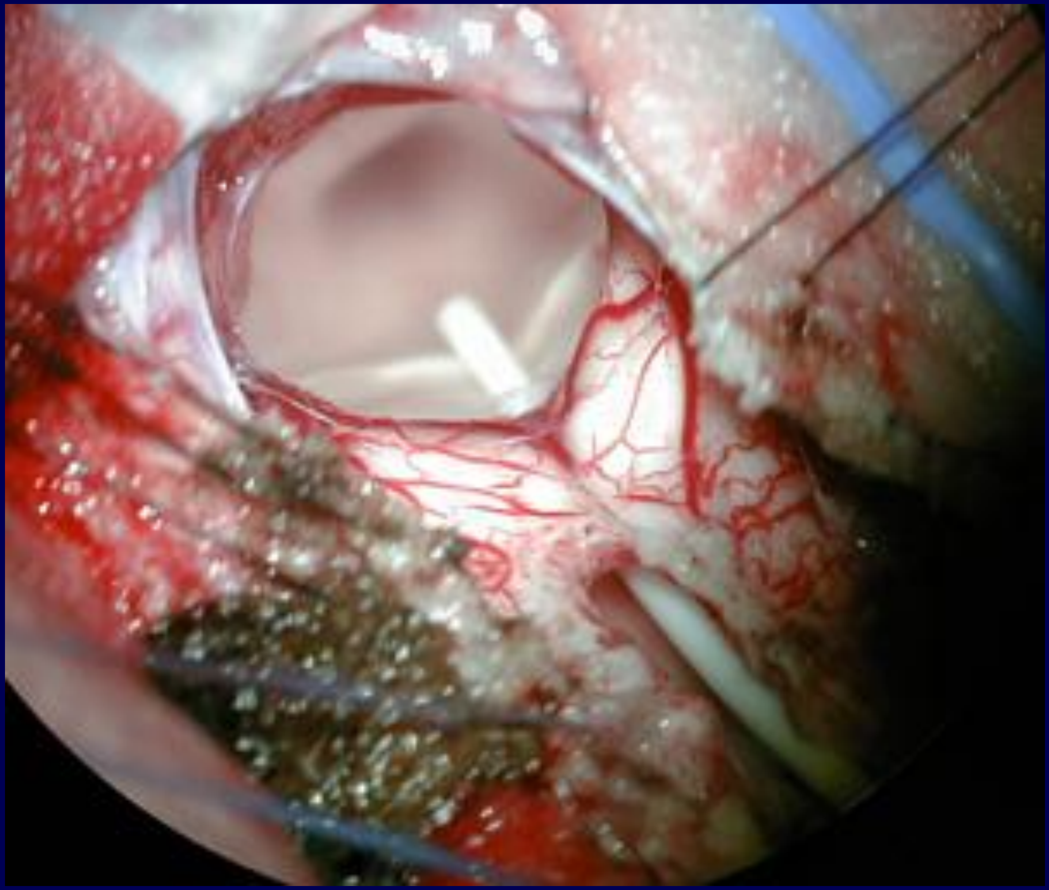


16 y with 9y clumsiness
Almost paralyzed deltoids
Astrocytoma

A long symptomatology does not exclude a neoplasm!

Intramedullary astrocytoma
Post operatively

3y old Presented with drooling & torticollis
Astrocytoma: Cervico-medullary



Note dorsal direction after hitting pyramid decussation

2 years after surgery:

Local recurrence..

V+C chemotherapy---CR

No evidence of disease 3 years later

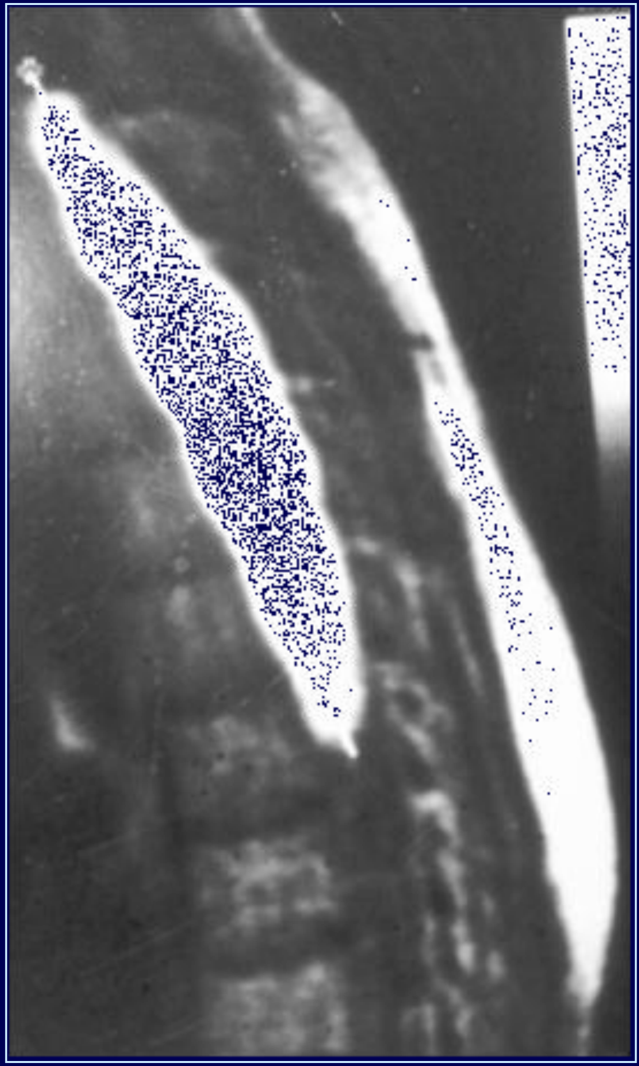
3 years later

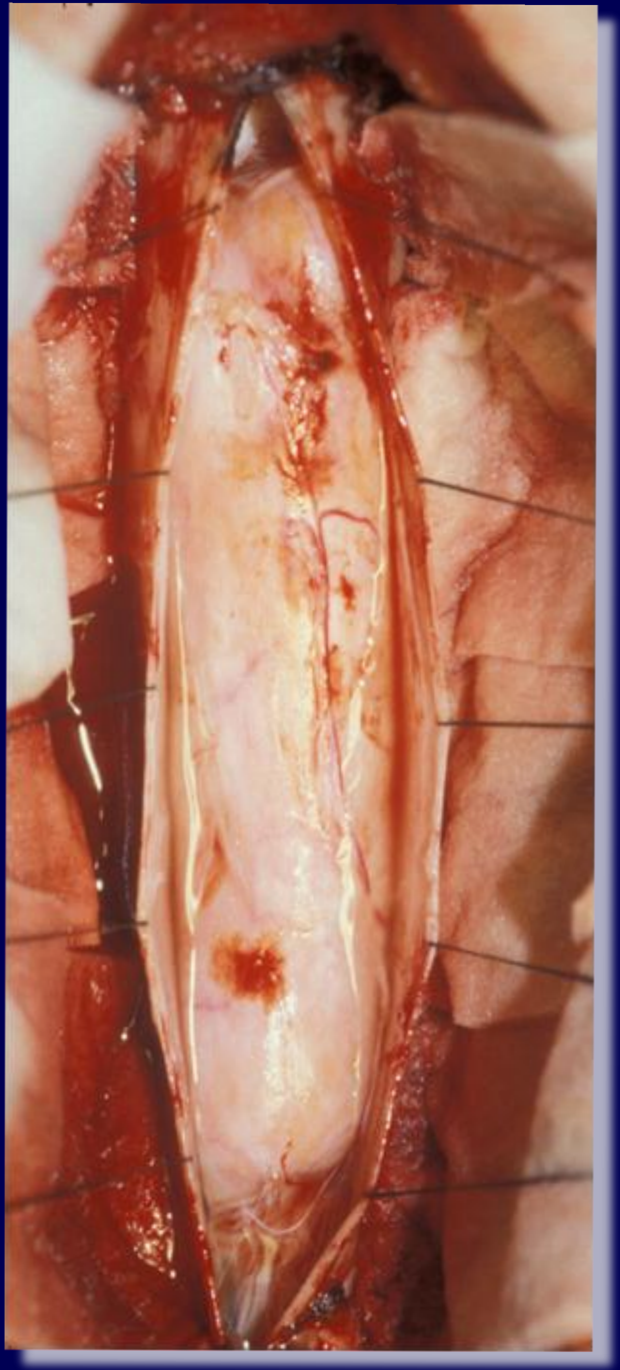
Intramedullary lipomatosis:

A different entity

Cautious with indication

Cautious with resection





Scoliosis in IMSCT's is a major problem

ding editorial in this issue, pp 460–462.

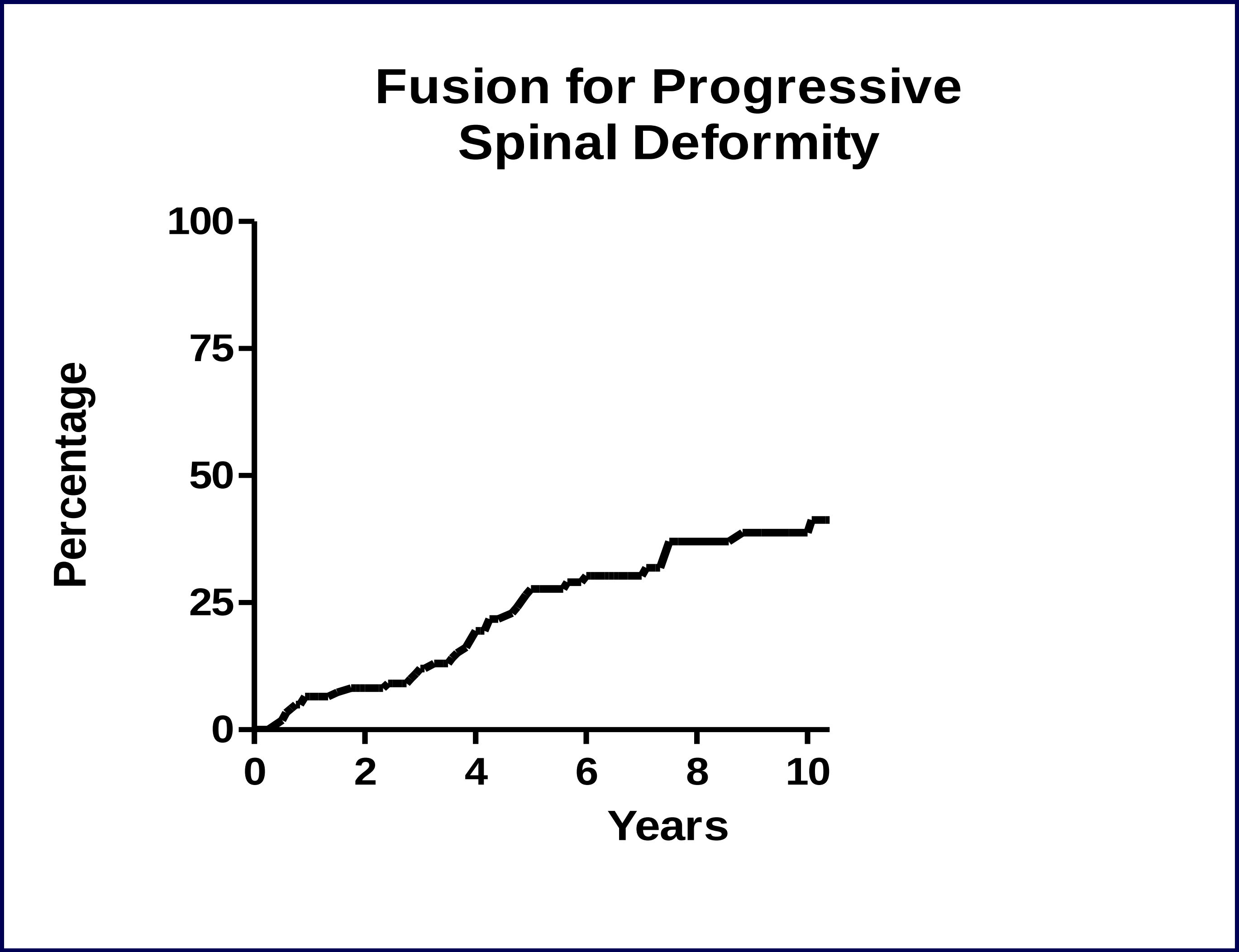
J Neurosurg (6 Suppl Pediatrics) 107:463–468, 2007

Risk factors for progressive spinal deformity following resection of intramedullary spinal cord tumors in children: an analysis of 161 consecutive cases

KEVIN C. YAO, M.D.,[1] MATTHEW J. MCGIRT, M.D.,[2] KAISORN L. CHAICHANA, B.S.,[2] SHLOMI CONSTANTINI, M.D.,[3] AND GEORGE I. JALLO, M.D.[2]

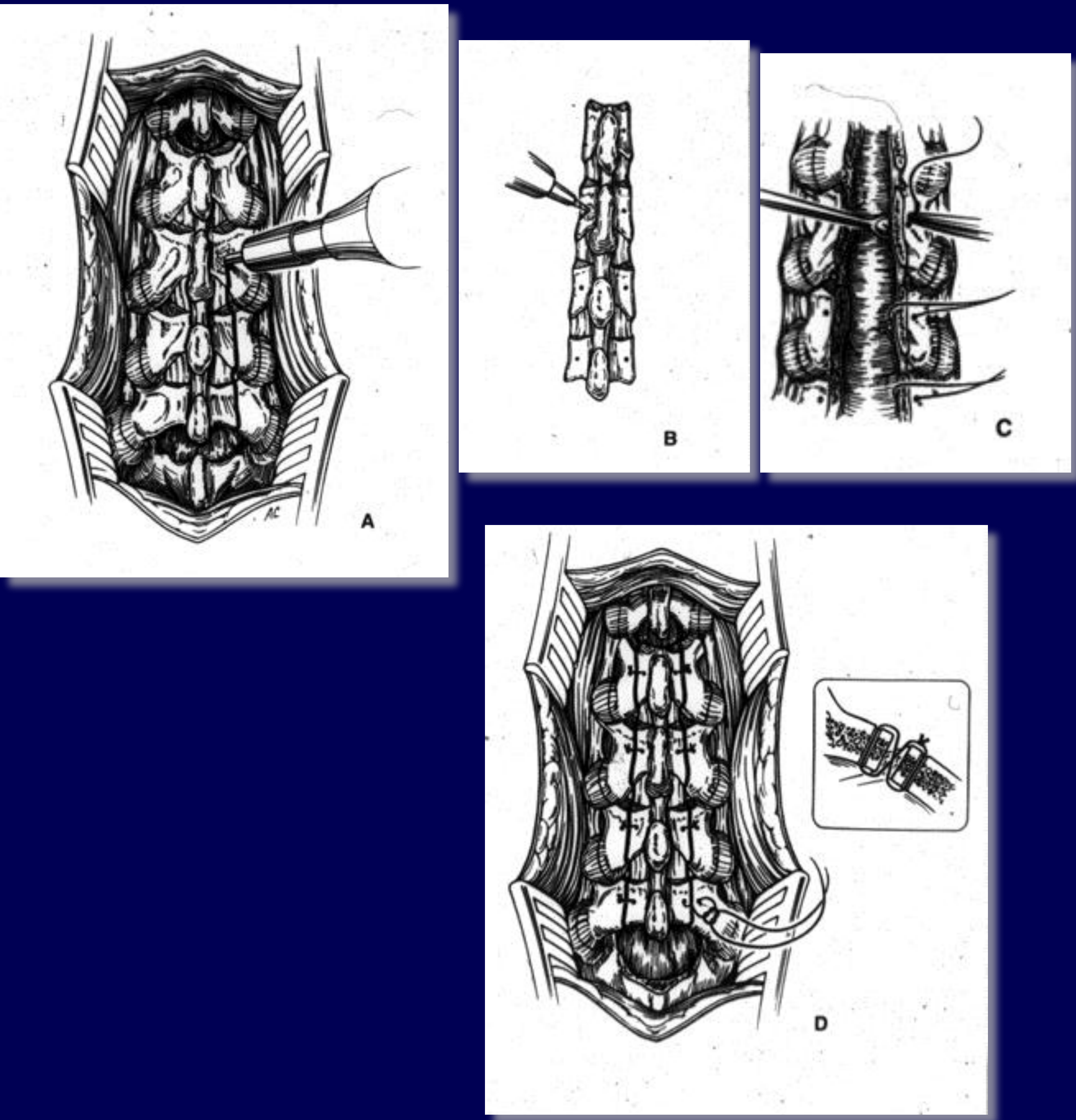
Estimated Incidence of Fusion for Progressive Deformity

Median follow-up: 9 years



Laminotomy Vs Laminectomy:

Is it worth the time?



Conclusions

- Progressive spinal deformity requiring fusion occurred in 27% of children undergoing resection of IMSCT and was associated with decreased functional status

- Preoperative scoliosis, increasing number of surgical resections, age<13 years, tumor-associated syrinx, and surgery spanning the thoraco-lumbar junction independently increased risk for progressive spinal deformity

- Patients possessing one or more of these characteristics should be monitored closely for progressive spinal deformity following surgery

Ultrasonic aspirator

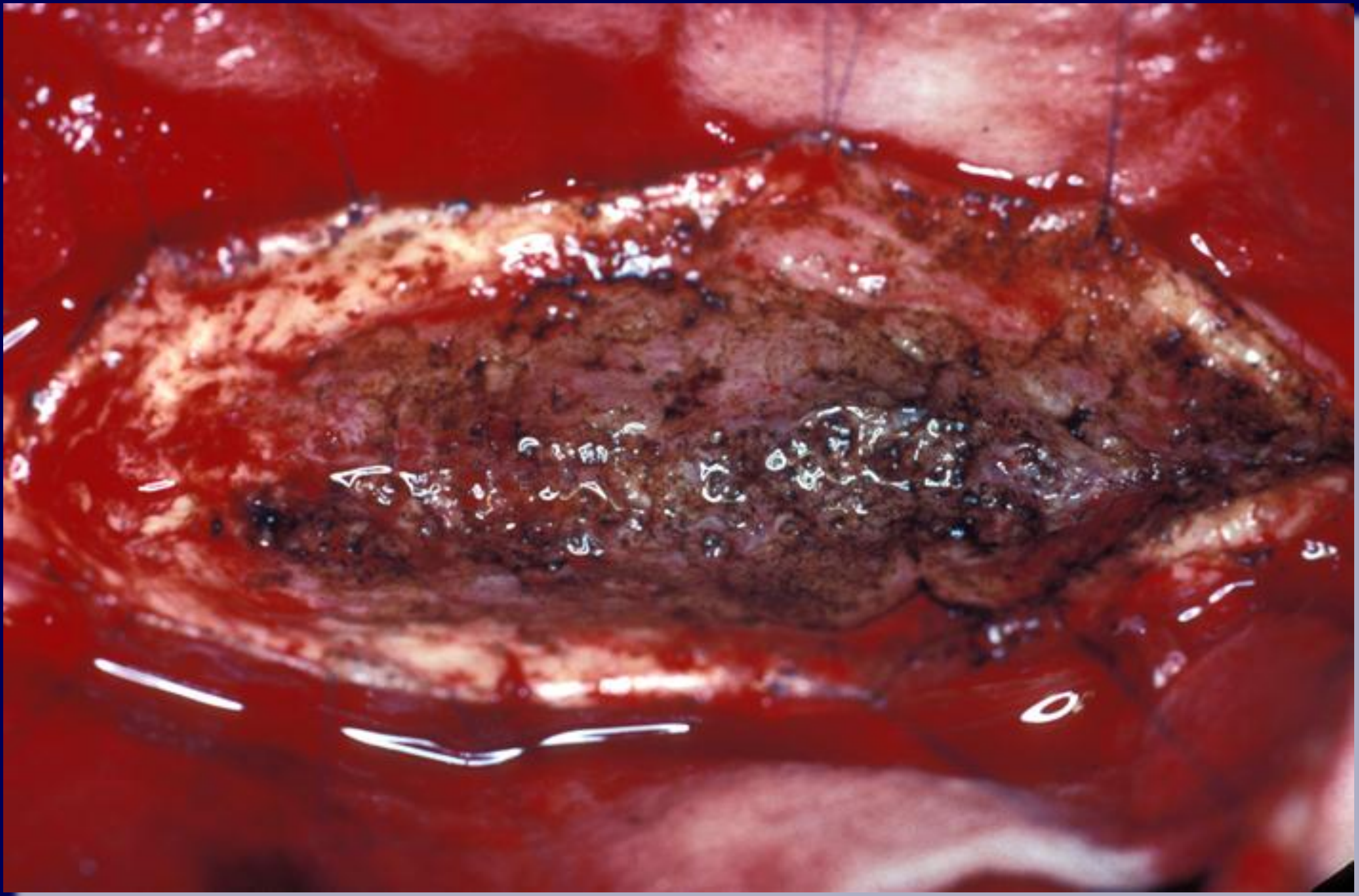
CUSA

Lasers....not important

CO2

YAG-
Neomodium

CO2 laser: Midline myelotomy & "charcoaling" the residual

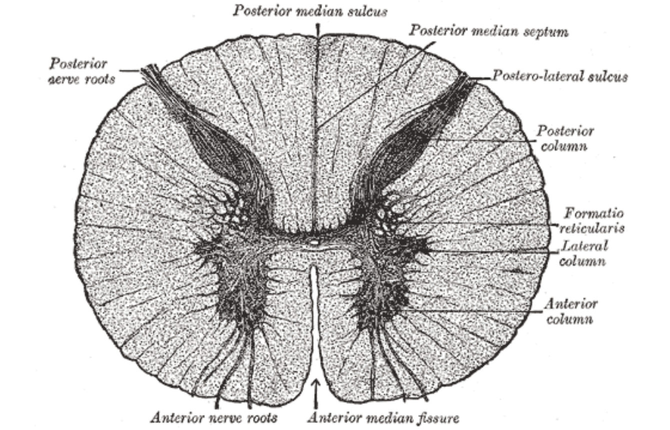


Lately some revival with "touch" fibers

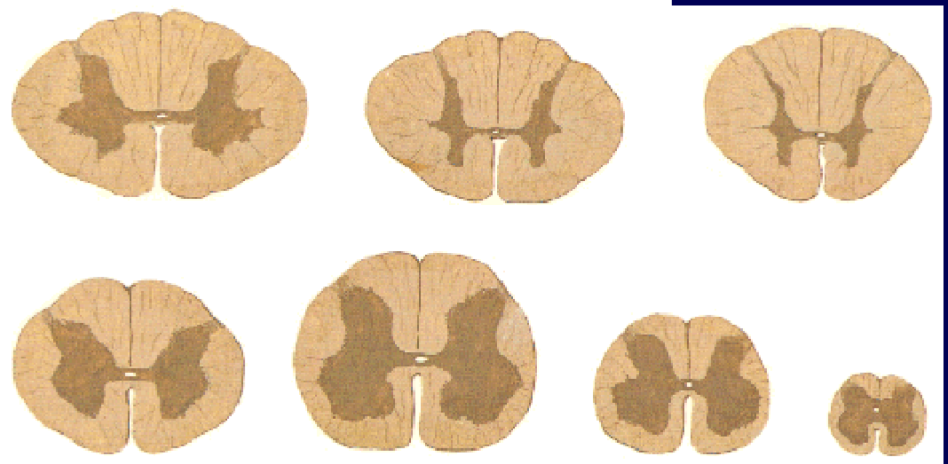
Spinal Cord anatomy

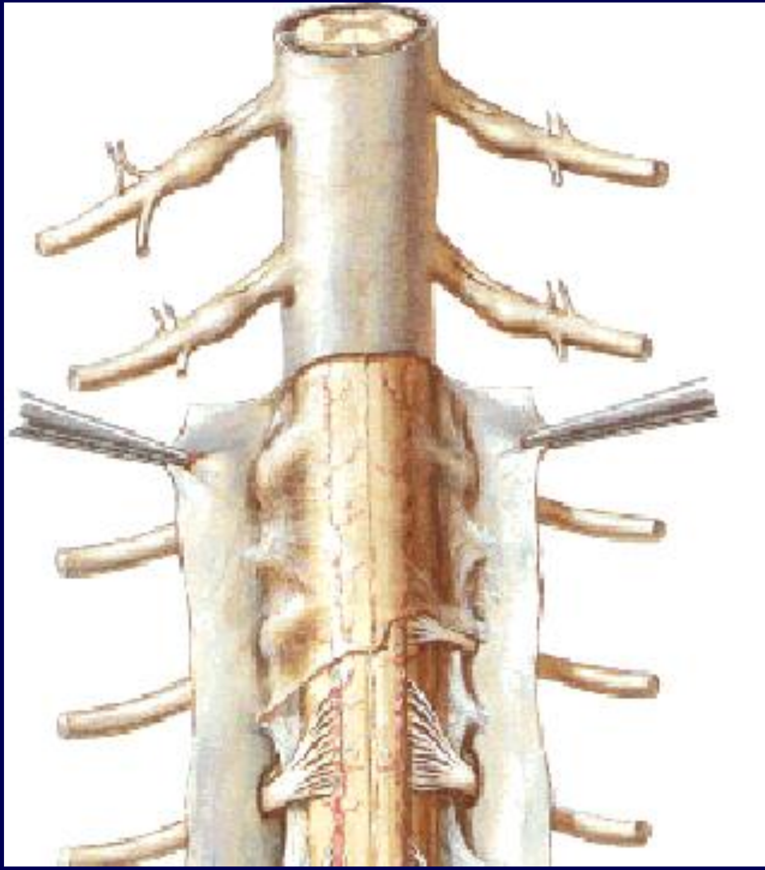
Where to enter?

Gray Vs. White matter

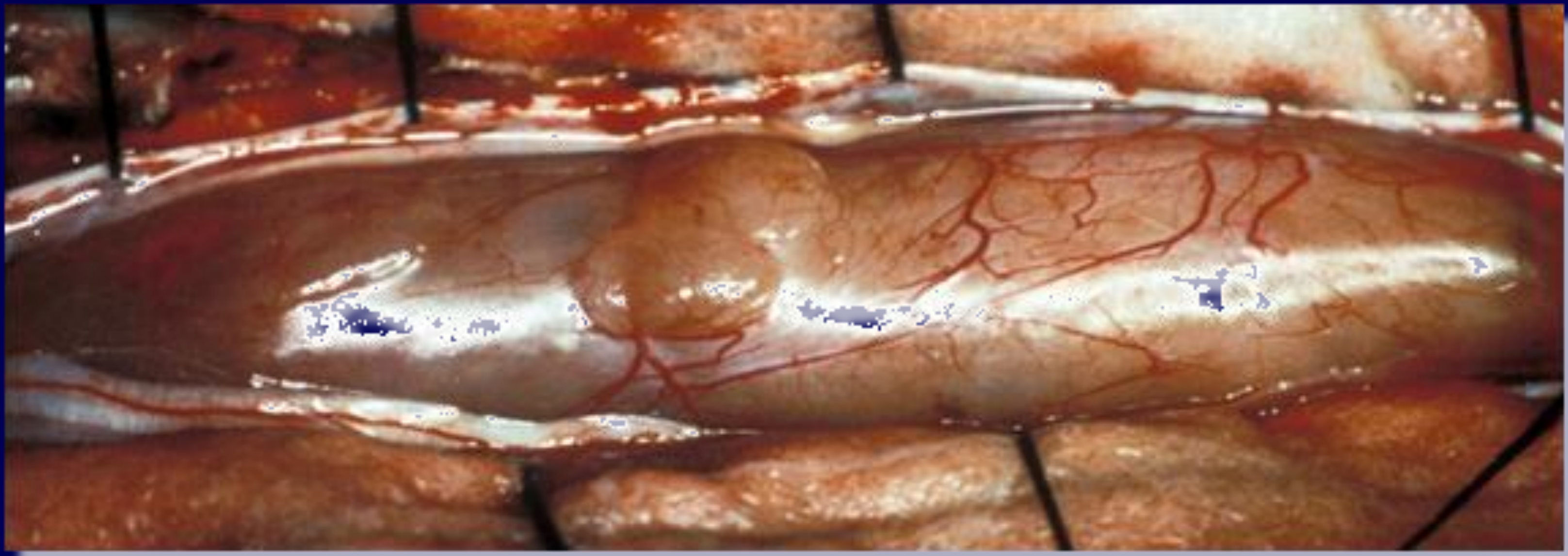


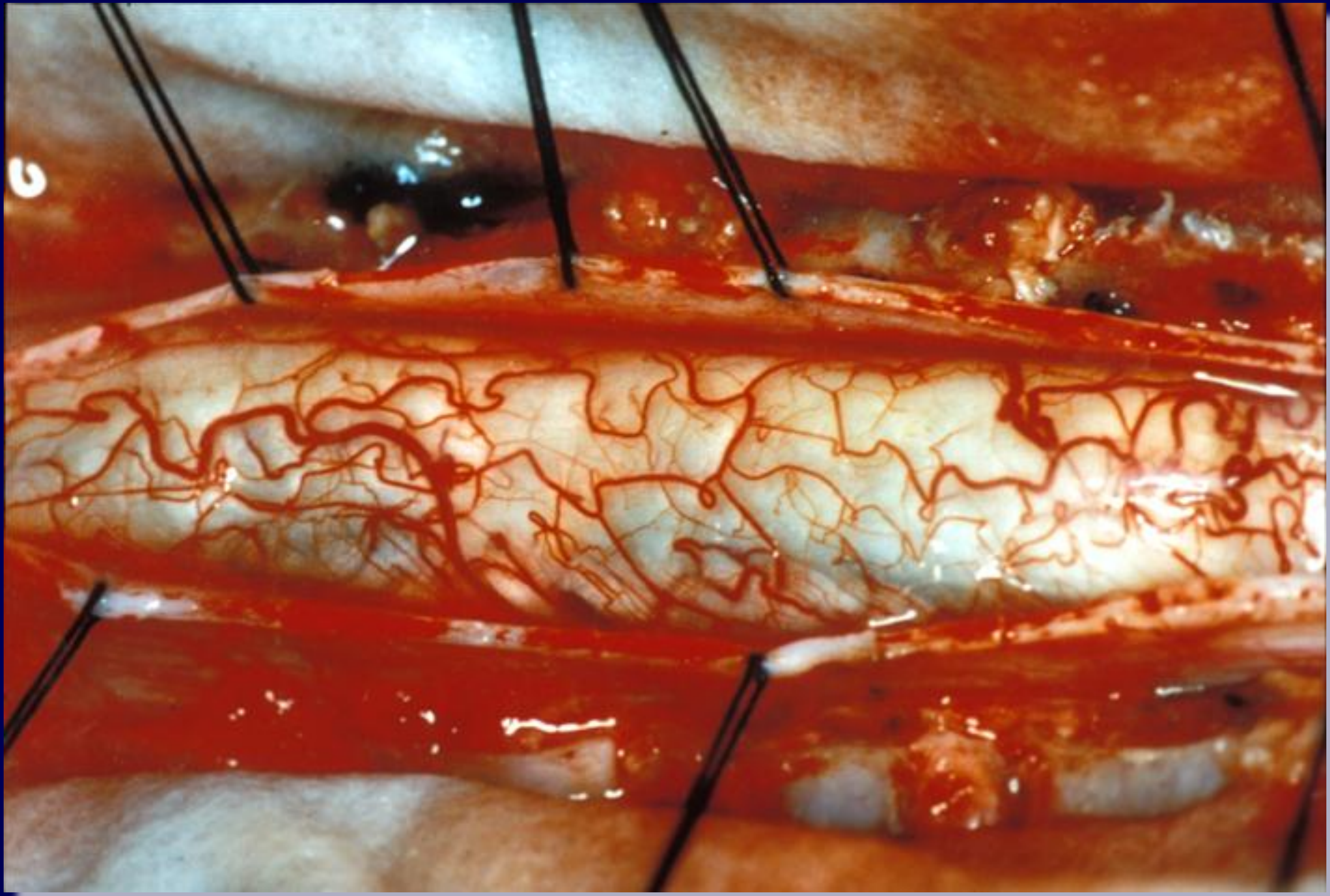
Transverse section of the medulla spinalis in the mid-thoracic region.





Astrocytoma: makes the way out…

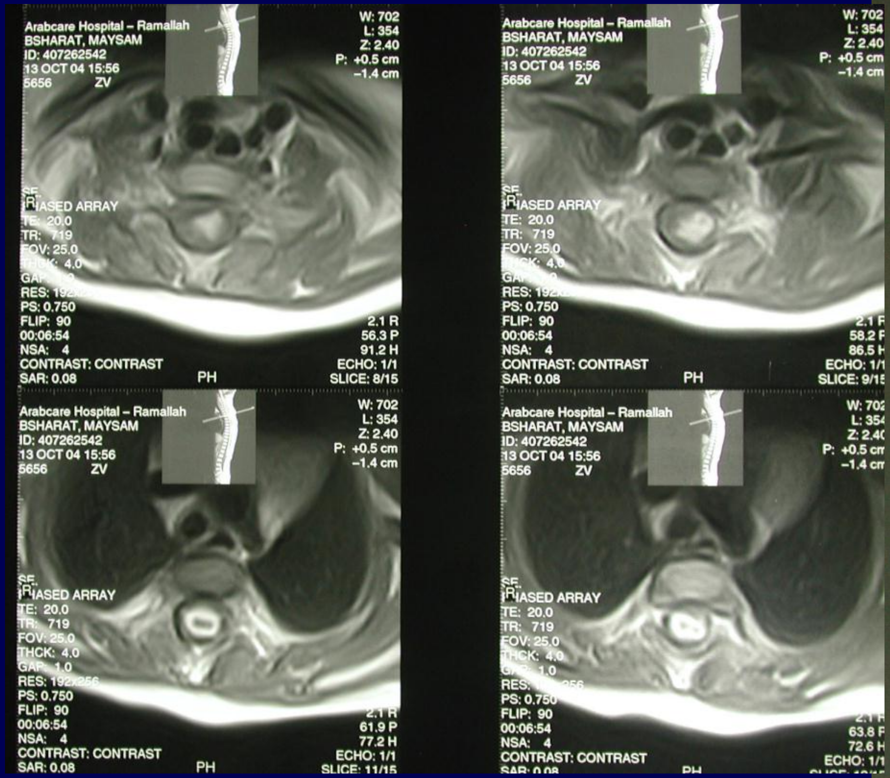




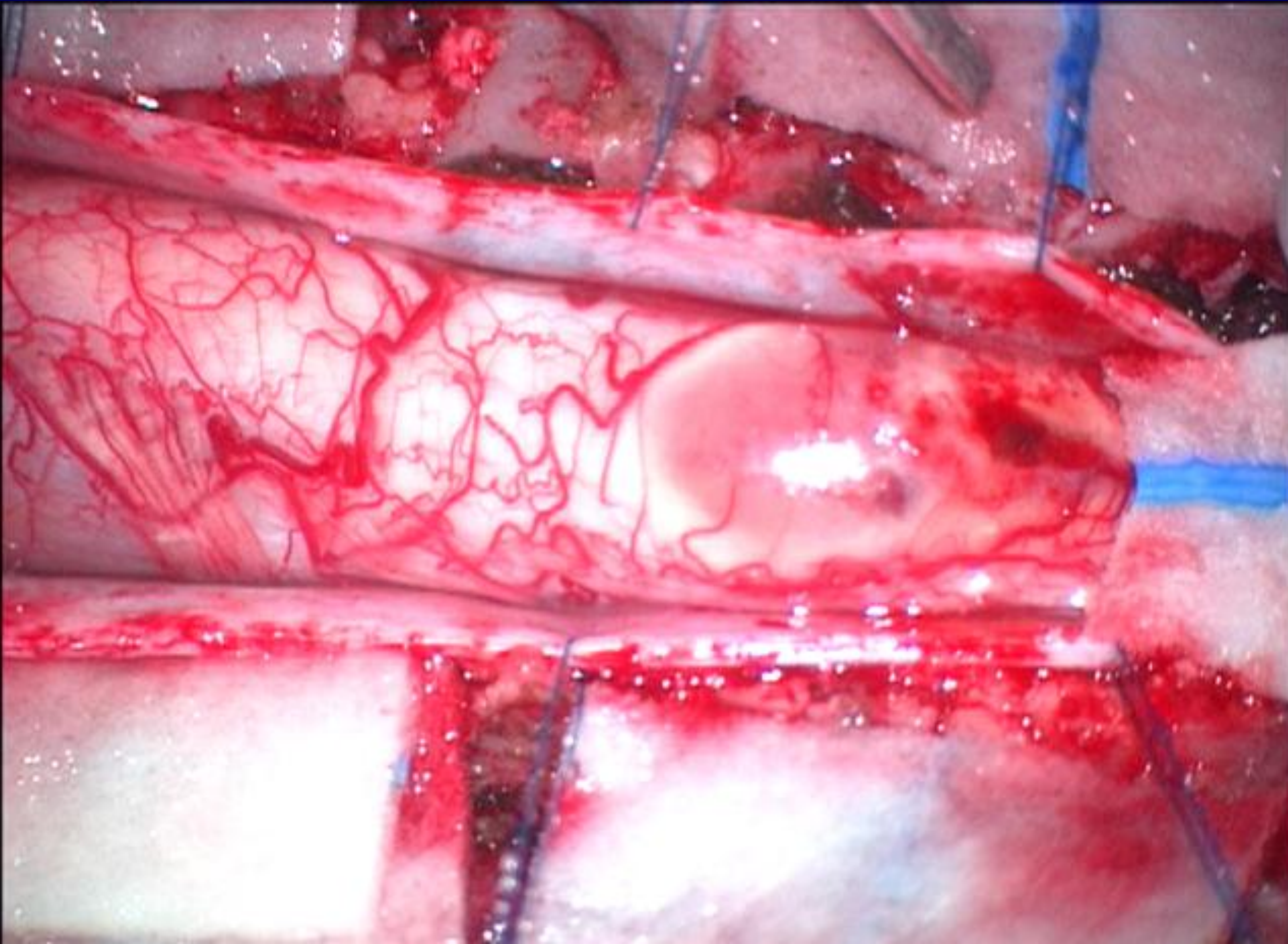
DREZ protrusion

1.5 years old:

Right hand plegia over 3 weeks

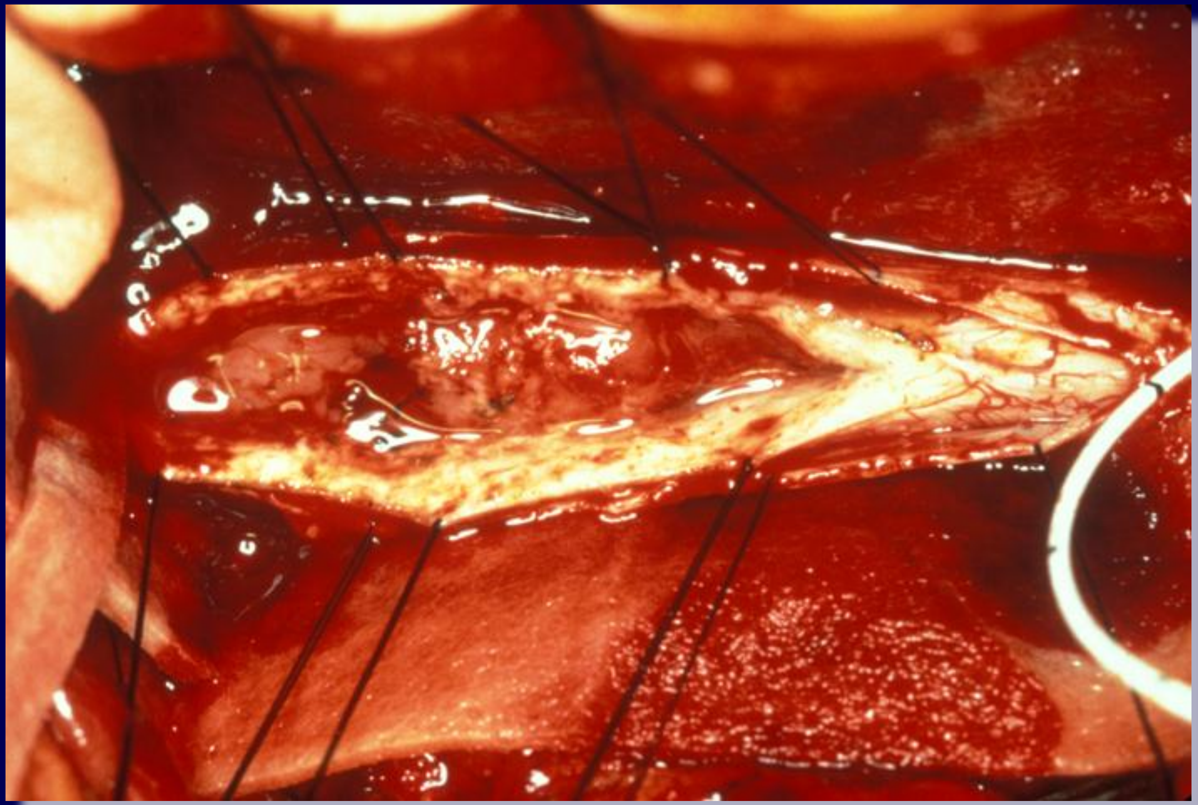


Show film of DREZ entry to IMSCT



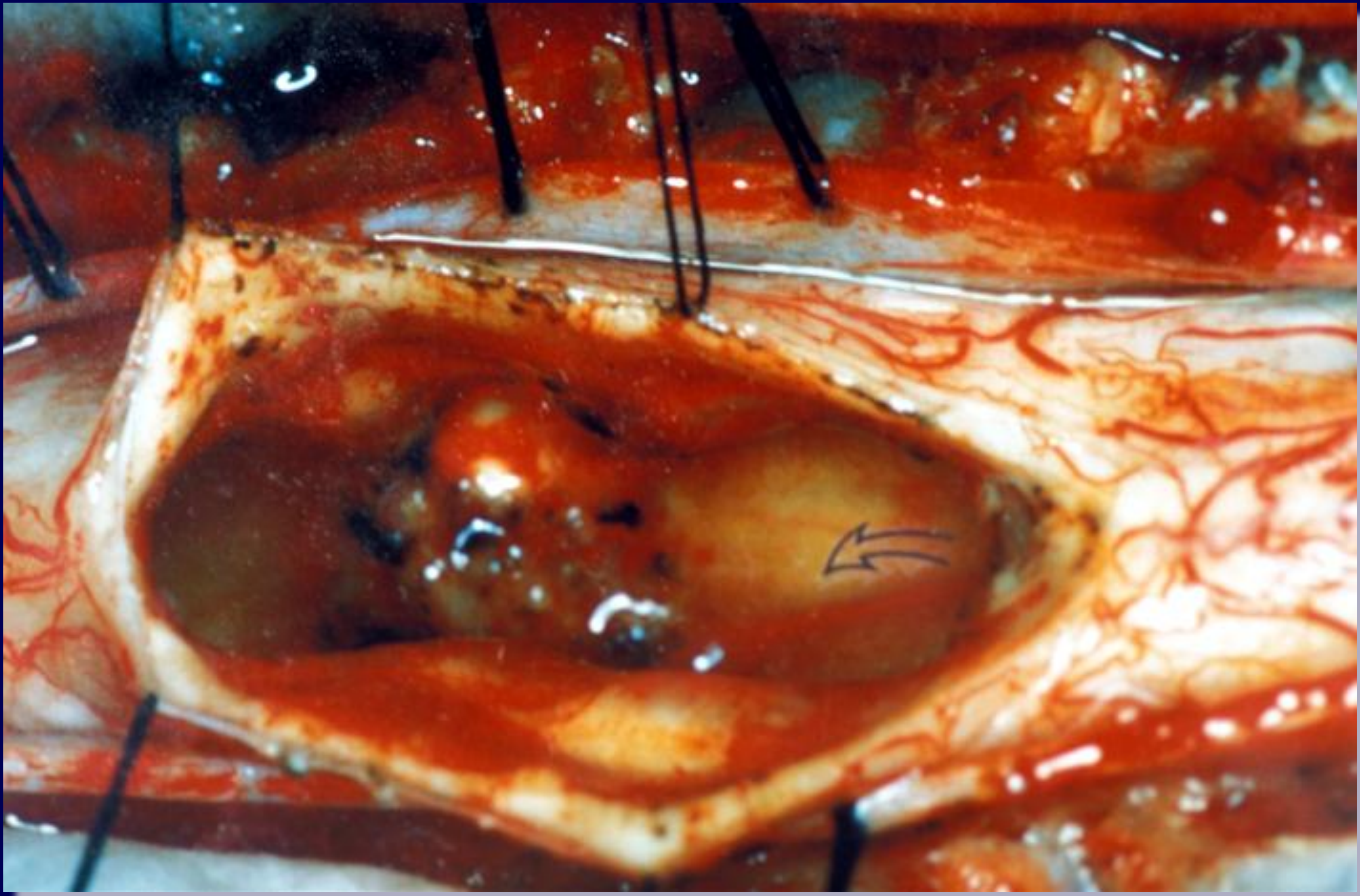

Midline entry
Don’t do that!

Midline entry

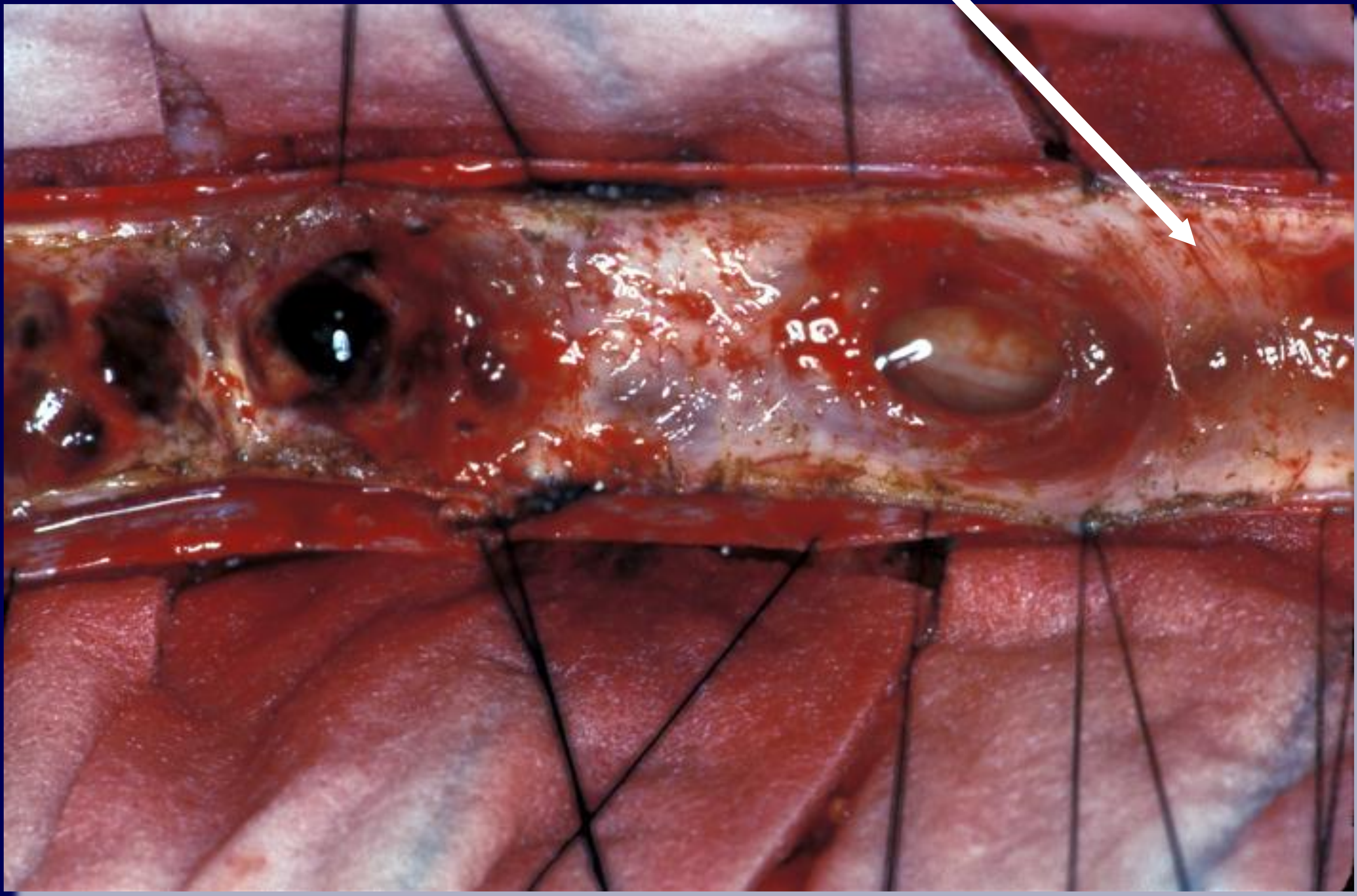


Risk proportional to the thickness of the DC's

Locating the cyst

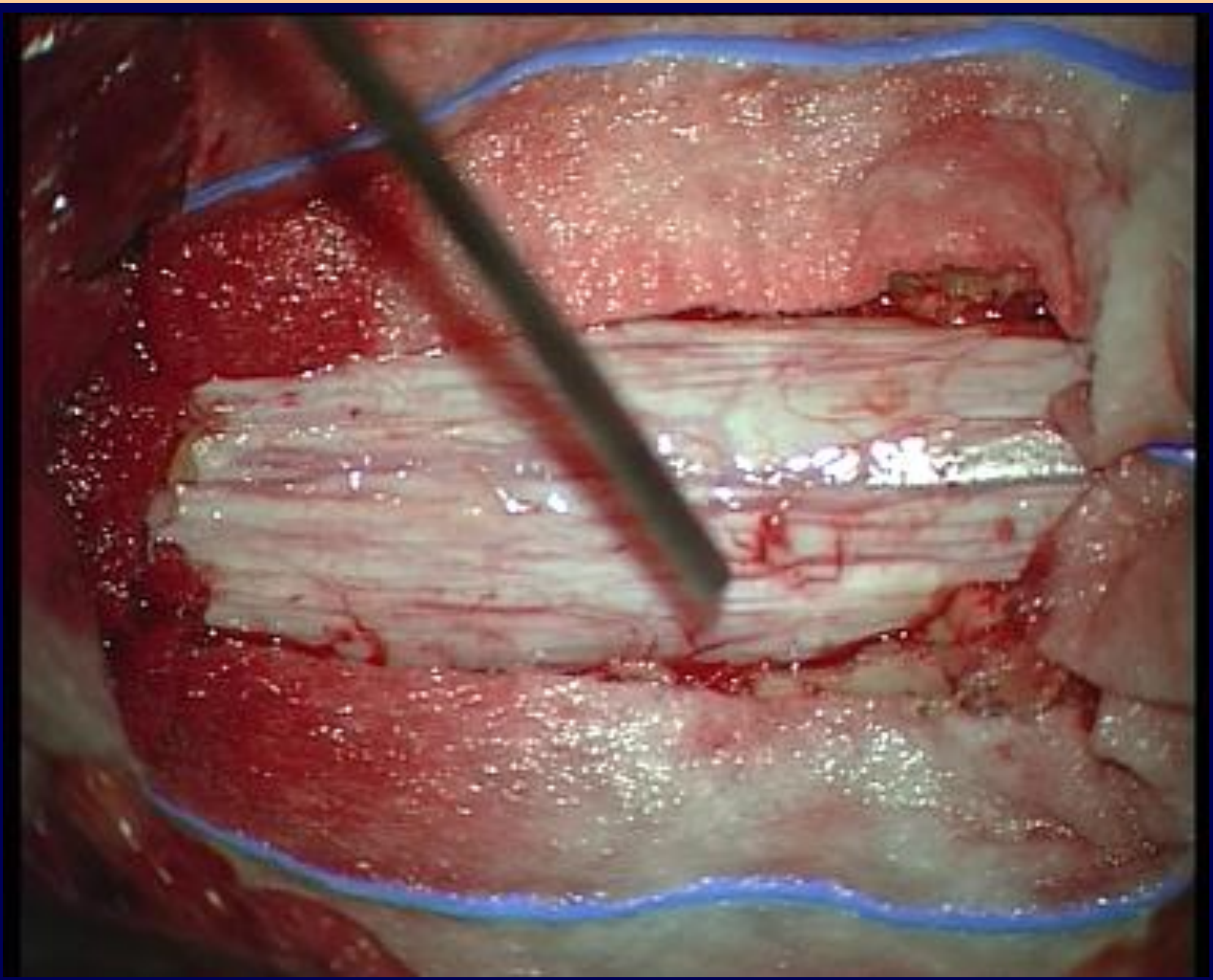


Note diagonal vessels

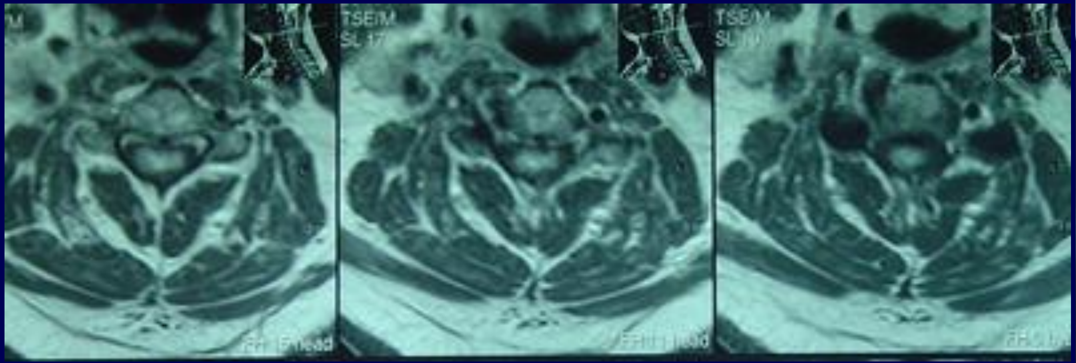


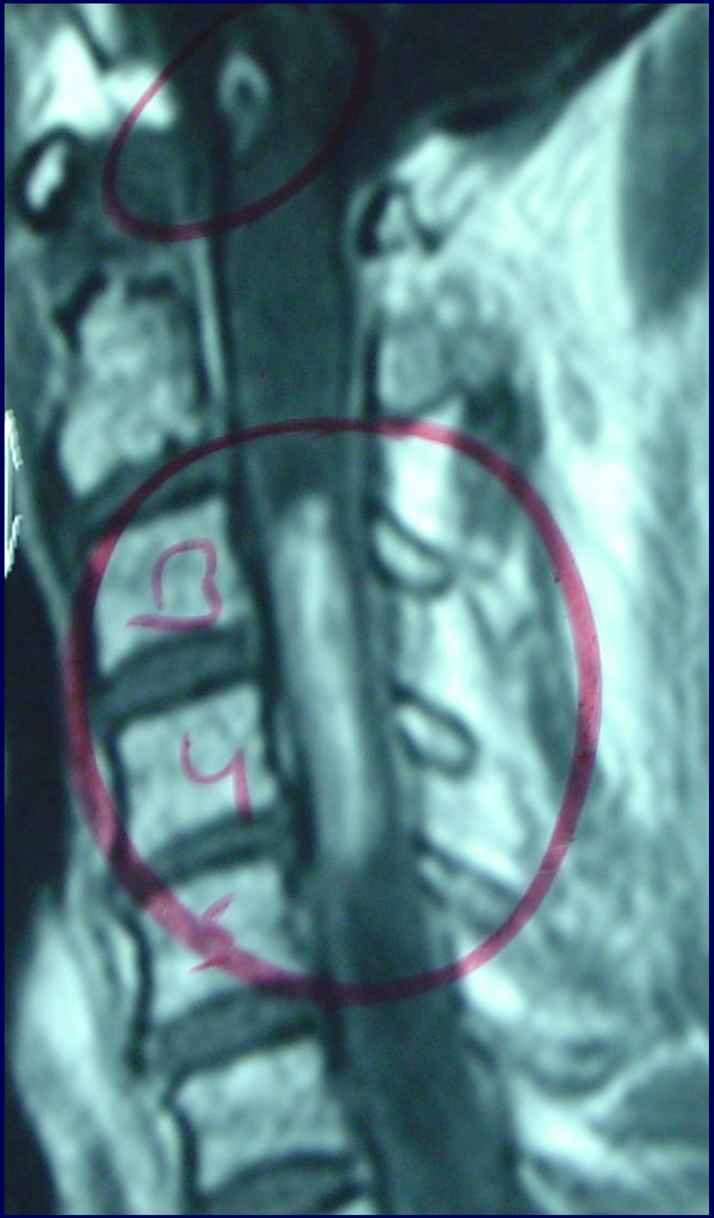
Midline entry: astrocytoma

Midline entry: astrocytoma



50 y male Progressive Spastic paraparesis

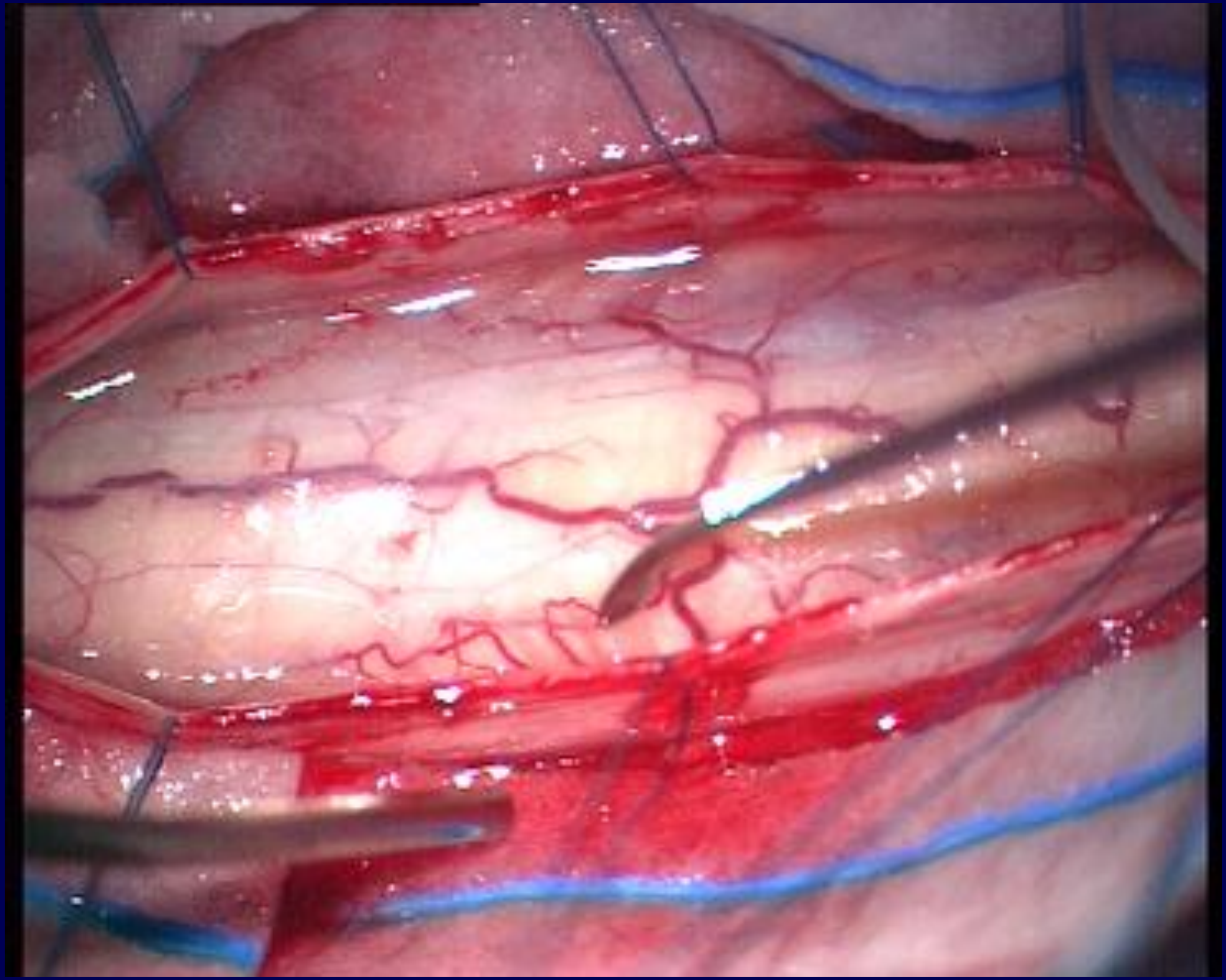




Show midline myelotomy

Midline: adult ependymoma

Midline entry for Adult ependymoma



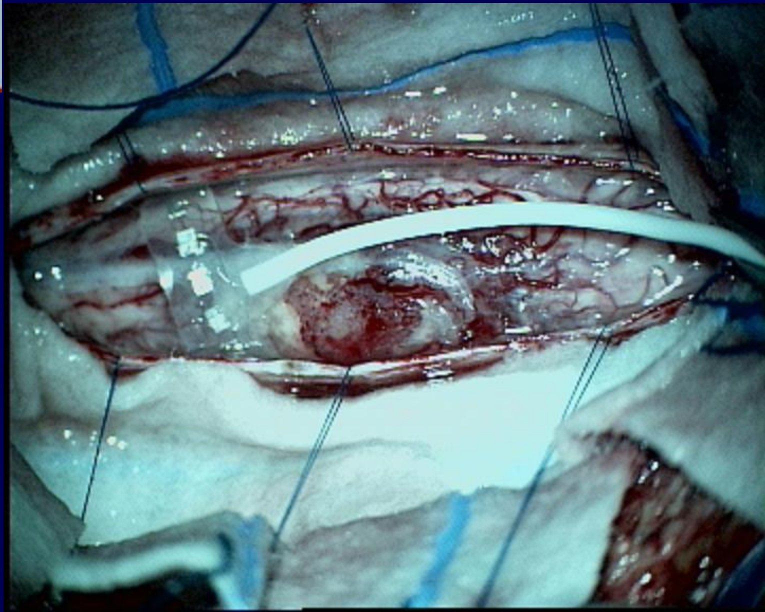
Position-sense loss Following IMSCT surgery

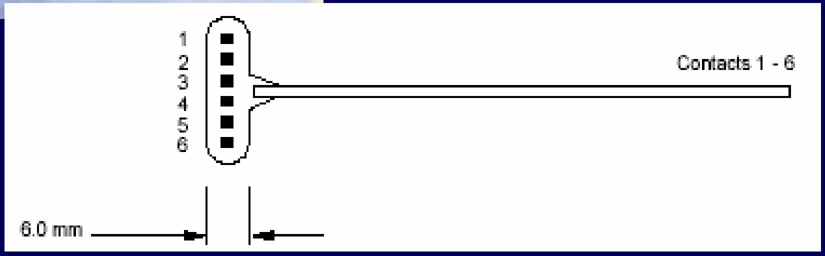
Mr. A

C1-5 ependymoma:

GTR

Walker and runner





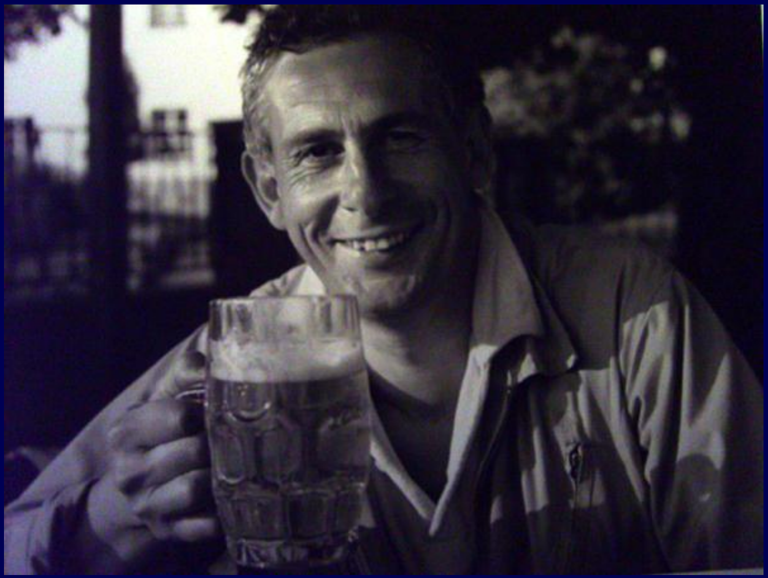
When to stop ?

- Normal white matter appears
- When you get to the anterior vessels
- Be cautious at the “poles”
- In conus 50%
- When MEP’s drop!

"You can teach a monkey how to operate

You cannot teach a monkey when not to operate"

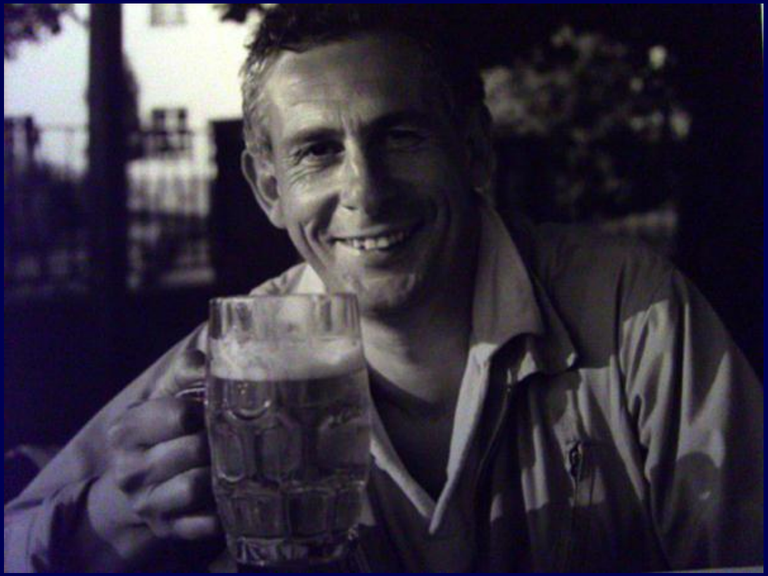
Sir John Garfield



"You can teach a monkey how to begin an operation

You cannot teach a monkey when to stop"

Modified from: Sir John Garfield



Radical excision of intramedullary spinal cord tumors: surgical morbidity & long-term follow-up evaluation in 164 children and young adults

CONSTANTINI, MILLER, ALLEN, RORKE, FREED, EPSTEIN

J Neurosurgery 93:183–193, 2000

164 Pt Age: 6m-21y

Operated 14 years

64% had previous surgery (30% previous RxT)

Policy: after GTR no further treatment

Location of tumor site

(164 patients) with IMSCT's

Spinal Level	No. of Patients	Percent
cervicomedullary	14	8.5
cervical	26	15.6
cervicothoracic	44	26.8
thoracic	64	39.0
conus	16	9.8

tumor span* 2–10 bone levels, average 5.4

•Tumor span was calculated for the solid part of the tumor, excluding caudal or rostral cysts.

•*Only 2 patients with LGG: metastatic disease on presentation*

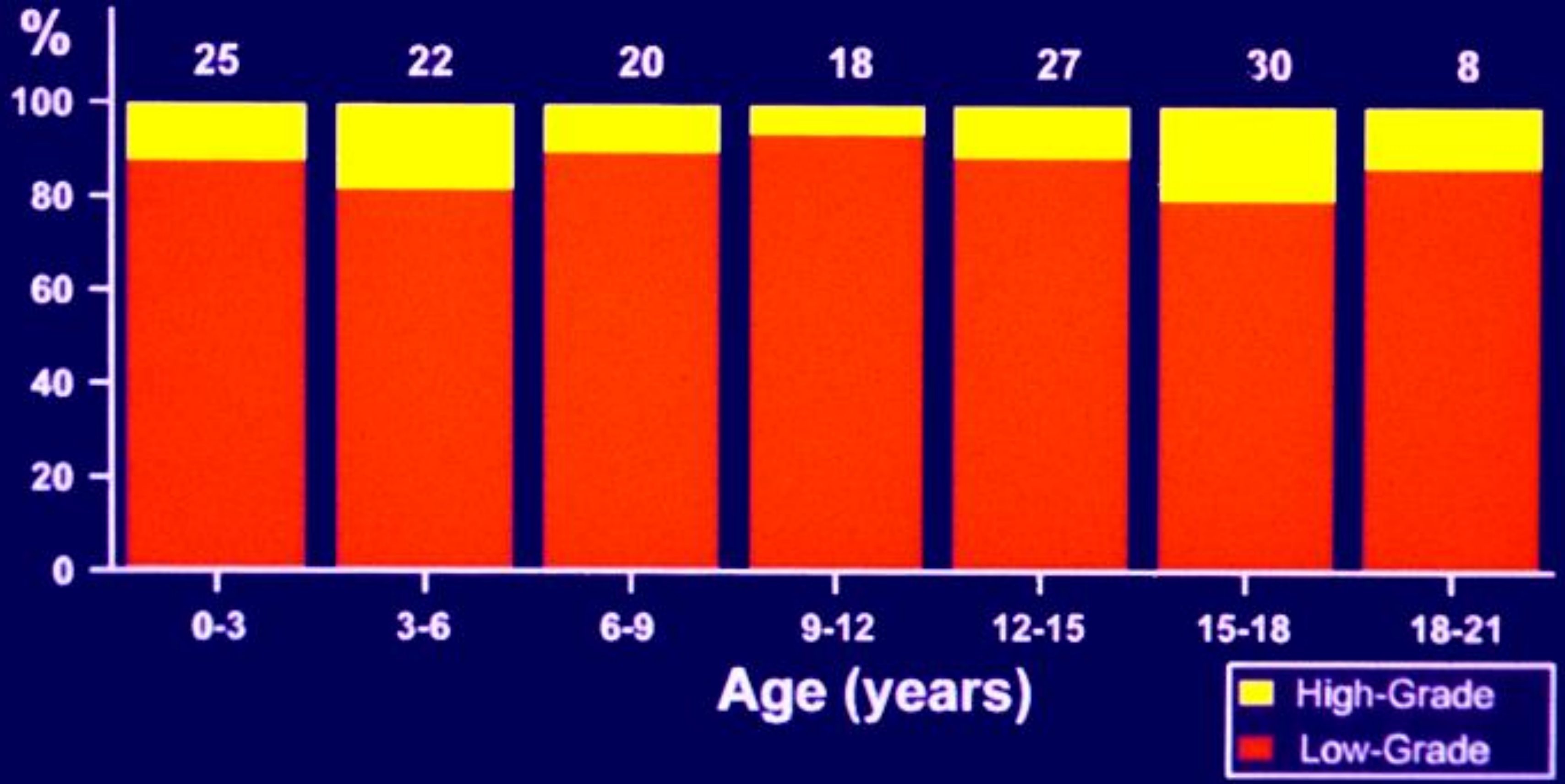
EXTENT OF RESECTION
(164 children) WITH IMSCT'S

Type of Resection	No. of Patients (%) 1st Op	2nd Op
GTR (>95%) clean MR	126 (76.8) (66)	29 (70.7)
STR (80-95%)	33 (20.1) (30)	11(26)
partial	5 (3.0) (4)	1 (2.4)
	164	41

In Yellow SC's data on 75 cases

Note the STR is still a very aggressive surgery!

LOW GRADE VERSUS HIGH-GRADE TUMORS ACCORDING TO AGE



Histo-pathology (164 Ped IMSCTS)

Histological Type	No. of Tumors		Percent
Astrocytoma	76		46.3
Low grade		58	
Anaplastic		14	
Glioblastoma		4	
Ganglioglioma	44		26.8
Ependymoma	19		11.6
Regular		12	
Myxopapillary		7	
Mixed glioma	10		6.1
Astro/Oligo		6	
Astro/Oligo/Ependymoma		1	
Astro/Ependymoma		3	
GGNC	11		6.7
GNF	3		1.8
PNET	1		0.6

Children:
- Ependymomas are rare
- No pilocytic astrocytomas
- No pure oligo's
- The GG issue in NY
- HG group=19

Adults:
- Ependymoma 65%
- Astrocytoma 25%
- Others 15%

FUNCTIONAL GRADE BEFORE OR

Grade	n	%
1	15	9.1
2	76	46.3
3	33	20.1
4	22	13.4
5	18	11.0

I - neurologically intact; walks normally;may have minimal dysesthesia
II - mild motor or sensory deficit; maintains functional independence (walking, feeding, &using the bathroom)
III - moderate deficit;limitation of function; independent with external aid
IV - more severe motor or sensory deficit;limited function with dependency
V - paraplegia or quadriplegia (even if there is flickering movement)

*Scale modified from McCormick PC,Torres R,Post KD,et al:
*J Neurosurg 72:*523–532,1990.

PREOPERATIVE COMPARED WITH POSTOPERATIVE FUNCTIONAL GRADES (164 PATIENTS) WITH IMSCTS

	Postoperative Grade					No.
Preop Grade	**I**	**II**	**III**	**IV**	**V**	**Patients**
I	10	4		1		15
II	6	50	11	6	3	76
III	1	10	13	6	3	33
IV		1	5	11	5	22
V			1	2	15	18
total patients	17	65	30	26	26	164

Below the line: Improvement!

MORBIDITY

No effect:

- Symptomatology length
- Previous treatment (OR-RT-Chemo)
- Tumor level
- Cysts
- Enhancement
- Span
- Age
- Extent of resection (tribute to FE)
- Histology (high Vs. low grade)

Negative effect

- Higher Functional grade!!! $p=0.032$
- Children with shunts $p=0.029$

MORBIDITY

FE RESULTS		SC RESULTS
60.4%	Same	54%
15.8%	Improved	20%
23.8%	Deteriorated	26%
7.9%	Deteriorated >1 grade 13/164	4%
2.4%	Deteriorated >2 grades	4%

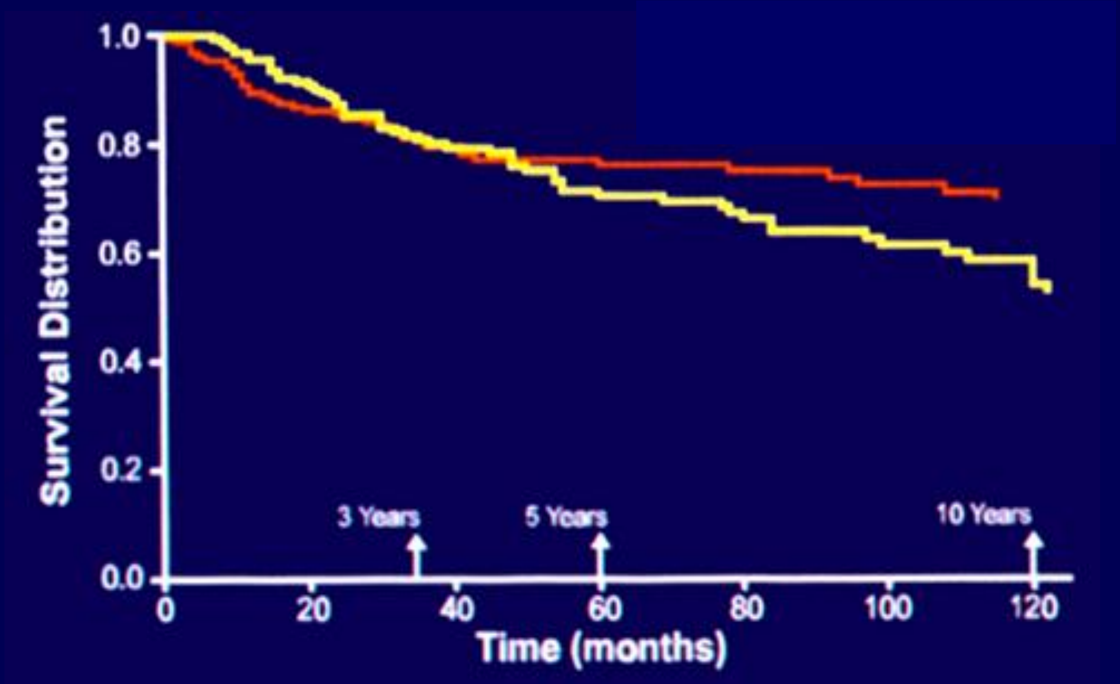
In second half of study; No patient in Grade 1 deteriorated more then 1 grade

MORBIDITY

FE RESULTS		SC RESULTS
60.4%	Same	54%
15.8%	Improved	20%
23.8%	Deteriorated	26%
7.9%	Deteriorated >1 grade 13/164	4%
2.4%	Deteriorated >2 grades	3%

90% of deteriorating adult patients:
Sensory

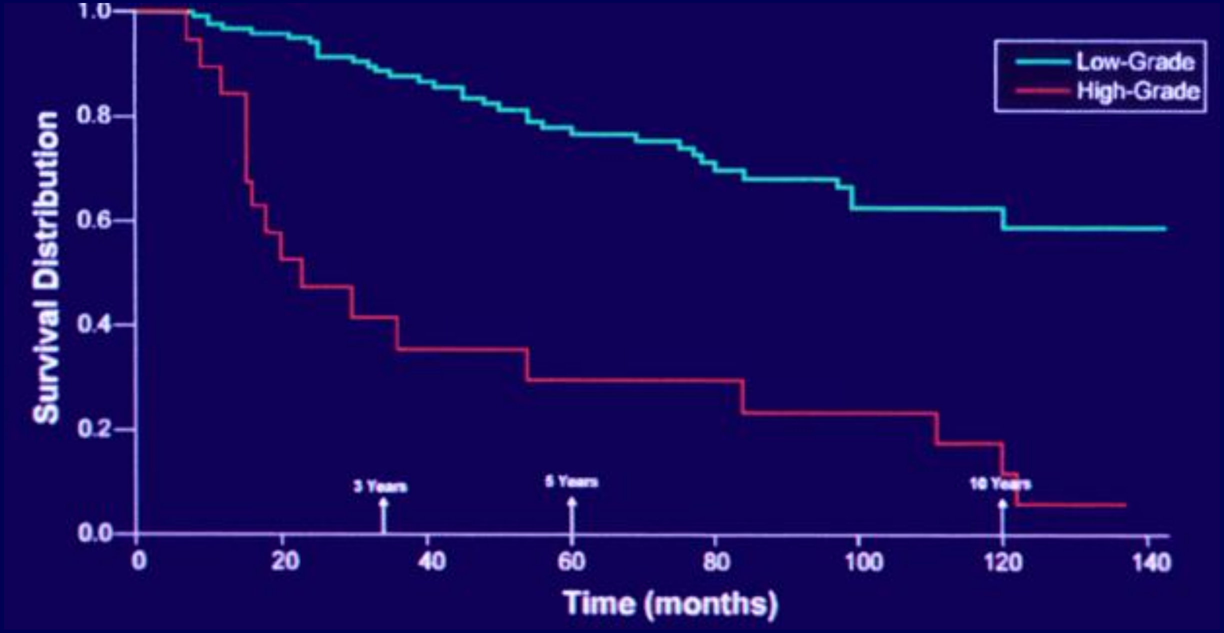
SURVIVAL & PROGRESSION FREE SURVIVAL (PFS) 155 CHILDREN WITH IMSCT



	No. of cases	3 Years	5 Years	10 Years
Survival	155	0.80 (0.74-0.86)*	0.76 (0.69-0.83)	0.70 (0.61-0.79)*
Progression Free Survival	155	0.80 (0.74-0.86)*	0.71 (0.63-0.79)	0.54 (0.44-0.64)*

* 95% confidence interval

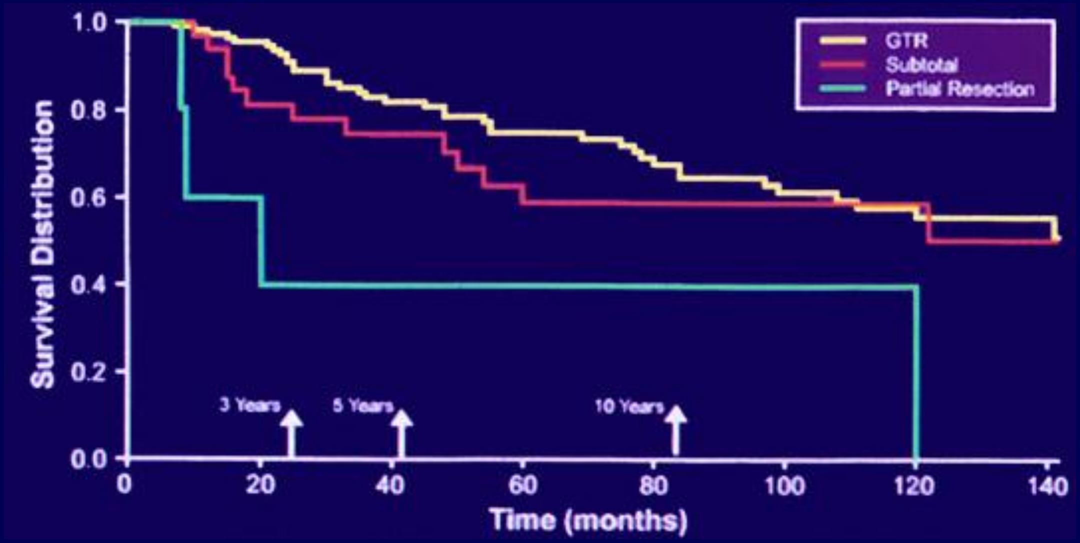
PROGRESSION FREE SURVIVAL FOR LOW-GRADE VERSUS HIGH-GRADE IMSCT



	No. of Cases	3 Years	5 years	10 Years
Low Grade	124	0.88 (0.12-0.94)*	0.78 (0.70-0.86)*	0.63 (0.52-0.74)*
High Grade	19	0.36 (0.13-0.57)*	0.30 (0.08-0.51)*	0.12 (0-0.27)*

* 95% confidence interval p<0.0001

EFFECT OF EXTENT OF RESECTION ON PROGRESSION FREE SURVIVAL



* 95% confidence interval p=0.001

	No. of cases	3 Years	5 Years	10 Years
GTR (>95%)	117	0.83 (0.76-0.90)*	0.75 (0.67-0.84)*	0.56 (0.45-0.67)*
Subtotal (80-95%)	33	0.75 (0.60-0.90)*	0.59 (0.41-0.77)*	0.59 (0.41-0.77)*
Partial Resection	5	0.40 (0-0.03)*	0.40 (0-0.83)*	0

At 3 & 5 years; significant difference. At 10y no! True for the entire

FOLLOW UP

N	155	(9 Pts. Lost)
Average	7.09years	1-16 years
Only Surgery	73.5%	

116 alive (74.8%)

39 dead (25.2%)

- **33/39 who died, from lepto-meningeal disease**

Tumor recurrence

- **58 patients: mean time to Rec: 38m**
- **Typically in original site**
- **37: repeat surgery**
  - **Of these 26 alive (8y) later**

    Same morbidity!

Re-surgery is an option when a LG tumor recurs

Clinical status at follow-up

- 116 pt with a mean follow-up of 13.1y
- >60% grade I or II
- 65% are independent
- 86% normal schooling
- 72% kypho-scoliosis 27.1% Surgery

Urinary problems: 40.5%

Pain in 6.9%

Still an extremely challenging disease!

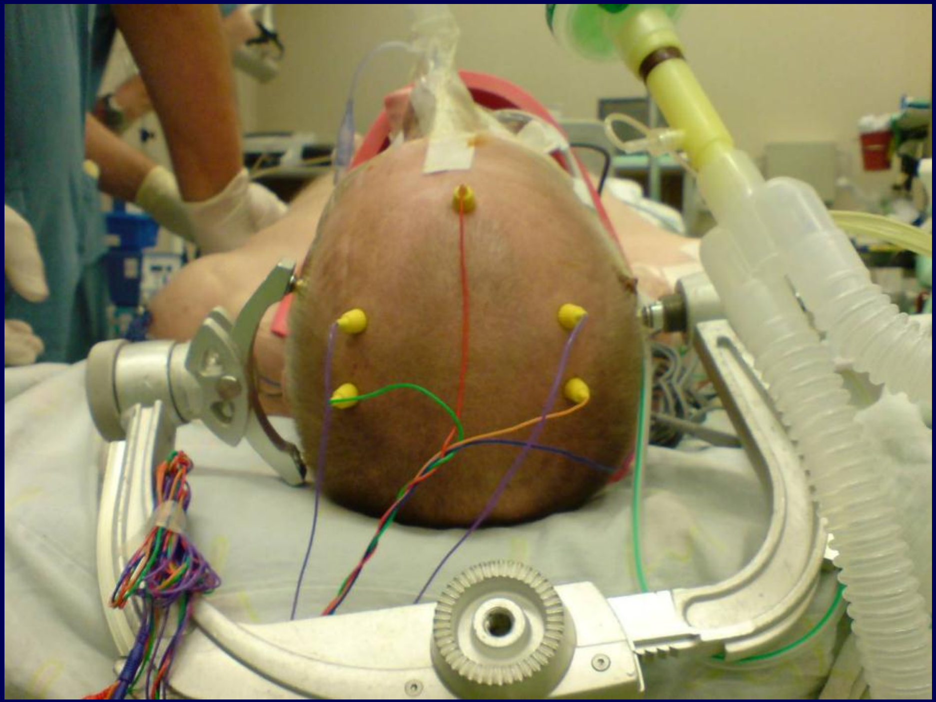
CONCLUSIONS

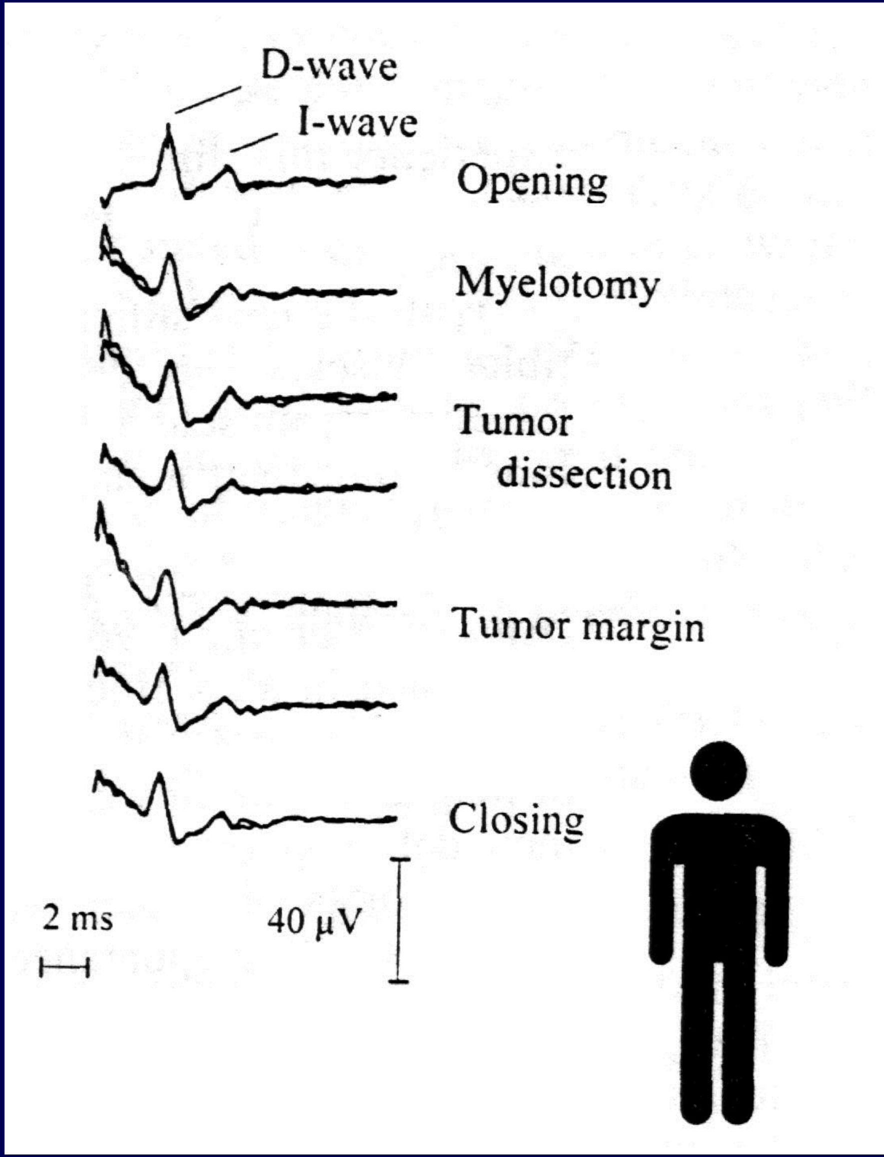
- Surgery for IMSCT's in children can be performed radically & rather safely.
- The postoperative functional performance is determined by the preoperative defect
- IMSCT's should be recognized as potentially excisable lesions upon their presentation & when they recur.
- **Less then radical tumor removal in IMSCT's may be sufficient for low-grade lesions.**
- The optimal treatment for malignant lesions is still to be determined.

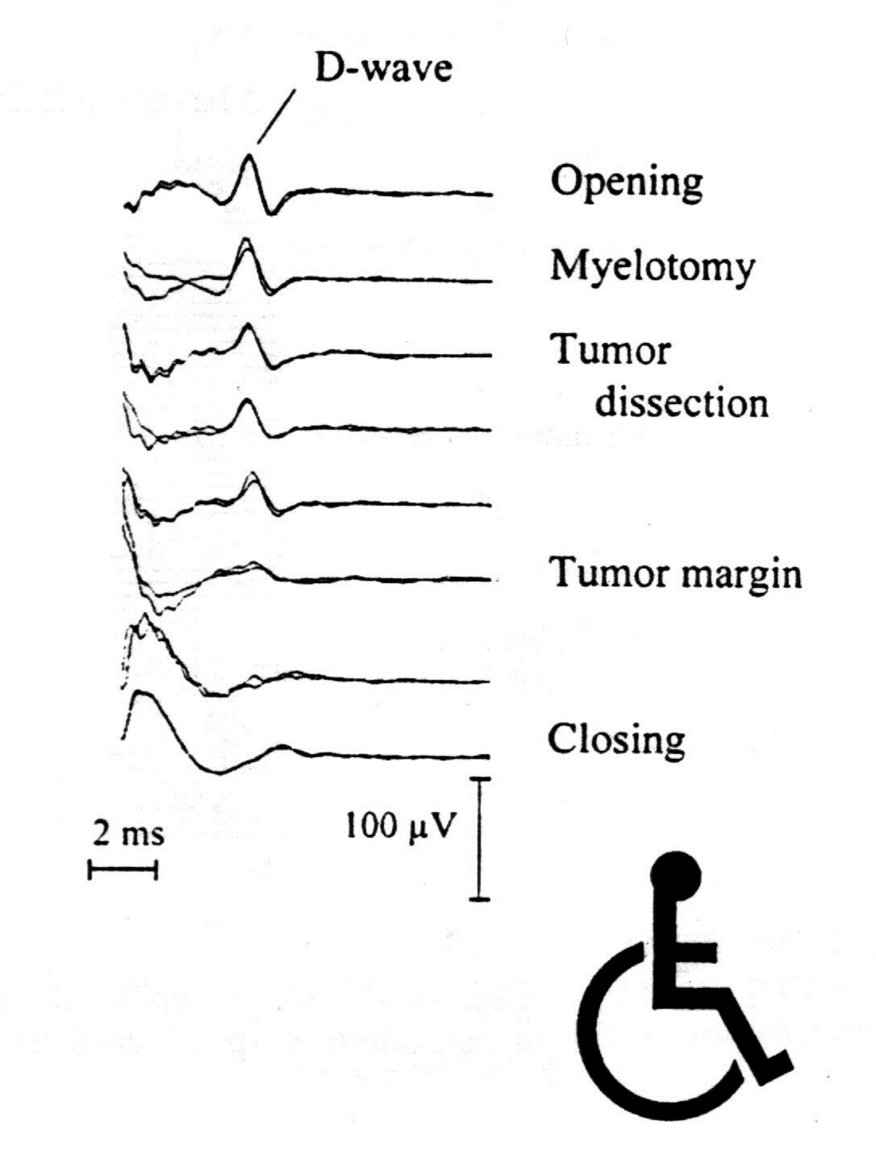
Tc MEP's:
Where are we today

- Interesting
- Informative
- Useful
- Extremely useful
- Increase safety
- Mandatory?
- Standard of care?

Standard MEP stimulation & SSEP recording setup







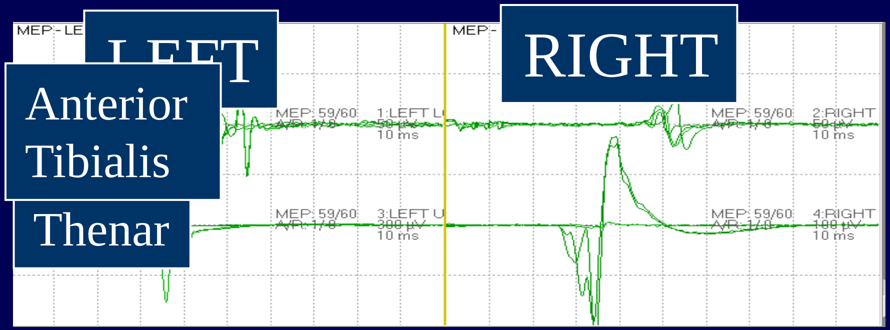
MEP's: sensitive and not always specific!

Patients may not be "monitorable"

Trans-cranial- Motor Evoked Potentials (tcMEP)

Morota, Deletis, Constantini, Kofler, Cohen, Epstein
The role of motor evoked potentials (MEP's) during surgery for intra-medullary spinal cord tumors.
Neurosurgery 41 (6) 1327-1336 1996

We did not have enough disasters



Wolters Kluwer Health | Lippincott Williams & Wilkins

NEUROSURGERY Online

The Role of Motor Evoked Potentials during Surgery for Intramedullary Spinal Cord Tumors

Author(s): Morota,, Nobu MD; Deletis,, Vedran MD, PhD; Constantini,, Shlomi MD; Kofler,, Markus MD; Cohen,, Henry MPH; Epstein,, Fred J. MD

Issue: Volume 41(6), December 1997, pp 1327-1336
Publication Type: [Technique Applications]

Publisher: Copyright © by the Congress of Neurological Surgeons

Division of Pediatric Neurosurgery (NM, FJE), Departments of Anesthesiology(VD) and Environmental Medicine (HC), New York University Medical Center, New York, New York; Department of Neurosurgery (SC), Hadassah University Hospital, Jerusalem, Israel; and Department of Neurology (MK), University Hospital Innsbruck, Innsbruck, Austria

ISSN: 0
Accessi

Francesco Sala, M.D.
Section of Neurosurgery, Department of Neurological and Visual Sciences, University Hospital, Verona, Italy

Giorgio Palandri, M.D.
Section of Neurosurgery, Department of Neurological and Visual Sciences, University Hospital, Verona, Italy

Elisabetta Basso, M.D.
Section of Neurosurgery, Department of Neurological and Visual Sciences, University Hospital, Verona, Italy

Paola Lanteri, M.D.
Section of Neurosurgery, Department of Neurological and Visual Sciences, University Hospital, Verona, Italy

Vedran Deletis, M.D.
Division of Intraoperative Neurophysiology, Institute for Neurology and Neurosurgery, Beth Israel Medical Center, New York, New York

Franco Faccioli, M.D.
Section of Neurosurgery, Department of Neurological and Visual Sciences, University Hospital, Verona, Italy

Albino Bricolo, M.D.
Section of Neurosurgery, Department of Neurological and Visual Sciences, University Hospital, Verona, Italy

Motor Evoked Potential Monitoring Improves Outcome after Surgery for Intramedullary Spinal Cord Tumors: A Historical Control Study

OBJECTIVE: The value of intraoperative neurophysiological monitoring (INM) during intramedullary spinal cord tumor surgery remains debated. This historical control study tests the hypothesis that INM monitoring improves neurological outcome.

METHODS: In 50 patients operated on after September 2000, we monitored somatosensory evoked potentials and transcranially elicited epidural (D-wave) and muscle motor evoked potentials (INM group). The historical control group consisted of 50 patients selected from among 301 patients who underwent intramedullary spinal cord tumor surgery, previously operated on by the same team without INM. Matching by preoperative neurological status (McCormick scale), histological findings, tumor location, and extent of removal were blind to outcome. A more than 50% somatosensory evoked potential amplitude decrement influenced only myelotomy. Muscle motor evoked potential disappearance modified surgery, but more than 50% D-wave amplitude decrement was the major indication to stop surgery. The postoperative to preoperative McCormick grade variation at discharge and at a follow-up of at least 3 months was compared between the two groups (Student's *t* tests).

RESULTS: Follow-up McCormick grade variation in the INM group (mean, +0.28) was significantly better ($P = 0.0016$) than that of the historical control group (mean, –0.16). At discharge, there was a trend ($P = 0.1224$) toward better McCormick grade variation in the INM group (mean, –0.26) than in the historical control group (mean, –0.5).

CONCLUSION: The applied motor evoked potential methods seem to improve long-term motor outcome significantly. Early motor outcome is similar because of transient motor deficits in the INM group, which can be predicted at the end of surgery by the neurophysiological profile of patients.

KEY WORDS: Motor evoked potentials, Neurophysiological monitoring, Outcome, Spinal cord tumor

Neurosurgery 58:1129-1143, 2006 DOI: 10.1227/01.NEU.0000215948.97195.58 www.neurosurgery-online.com

The advent of magnetic resonance imaging (MRI) now permits an early diagnosis of intramedullary spinal cord tumor (ISCT) (46), which has proven to fa-

Intraoperative neurophysiological monitoring (INM) has been increasingly used to assist in the surgical management of these tumors. Somatosensory evoked potentials (SEPs) have

Tc MEP's: Intra-op classification

Non-Monitorable

Existing & stable MEP's

Existing-deteriorating-recover

Existing-deteriorating

Simplistic approach!

"MEP's for dummies"

Tc MEP's: Intra-op classification

Non-Monitorable

Existing & stable MEP's

Existing-deteriorating-recover

Existing-deteriorating

Around 30% (Morota-1996)

These are the patients were MEP is most important

Tc MEP's: Intra-op classification

Non-Monitorable

Existing & stable MEP's

Existing-deteriorating-recover

Existing-deteriorating

"allowing" further resection (Re-assurance)

What is the rate of False-negative (D Waves & mMEP)??

Prolongation of the surgeon's life-expectancy

Tc MEP's:
Intra-op classification

Non-Monitorable

Existing & stable MEP's

Existing-deteriorating-recover

Existing-deteriorating

Abort??

Yes! Immediately??

Check for "technical" reasons, wait (how long?), Change place

Tc MEP's: Intra-op classification

Non-Monitorable

Existing & stable MEP's

Existing-deteriorating-recover

Existing-deteriorating

What is a "significant" deterioration?

What is a “significant MEP drop?

- When you loose muscle MEP’s
  - Binary measurement
- When D-wave <50%
  - Quantitative

Tc MEP's:
Intra-op classification

Non-Monitorable

Existing & stable MEP's

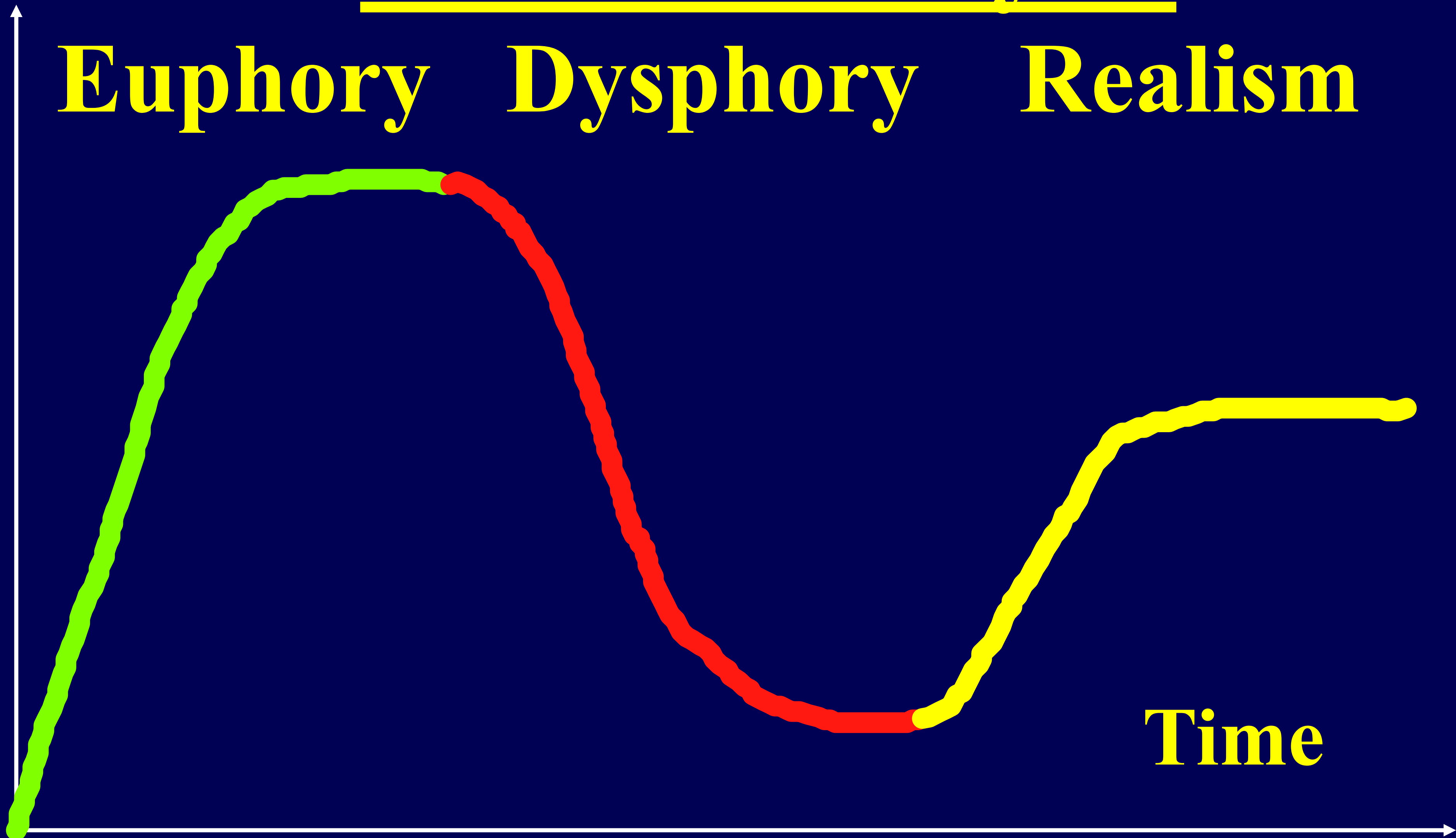
Existing-deteriorating-recover

Existing-deteriorating

Decision-making is difficult!   Has to be individualized

First-do-no-harm

Innovation Cycle



From Aschoff

Tc MEP's:
Where are we today?

Interesting

Informative

Useful

Extremely useful

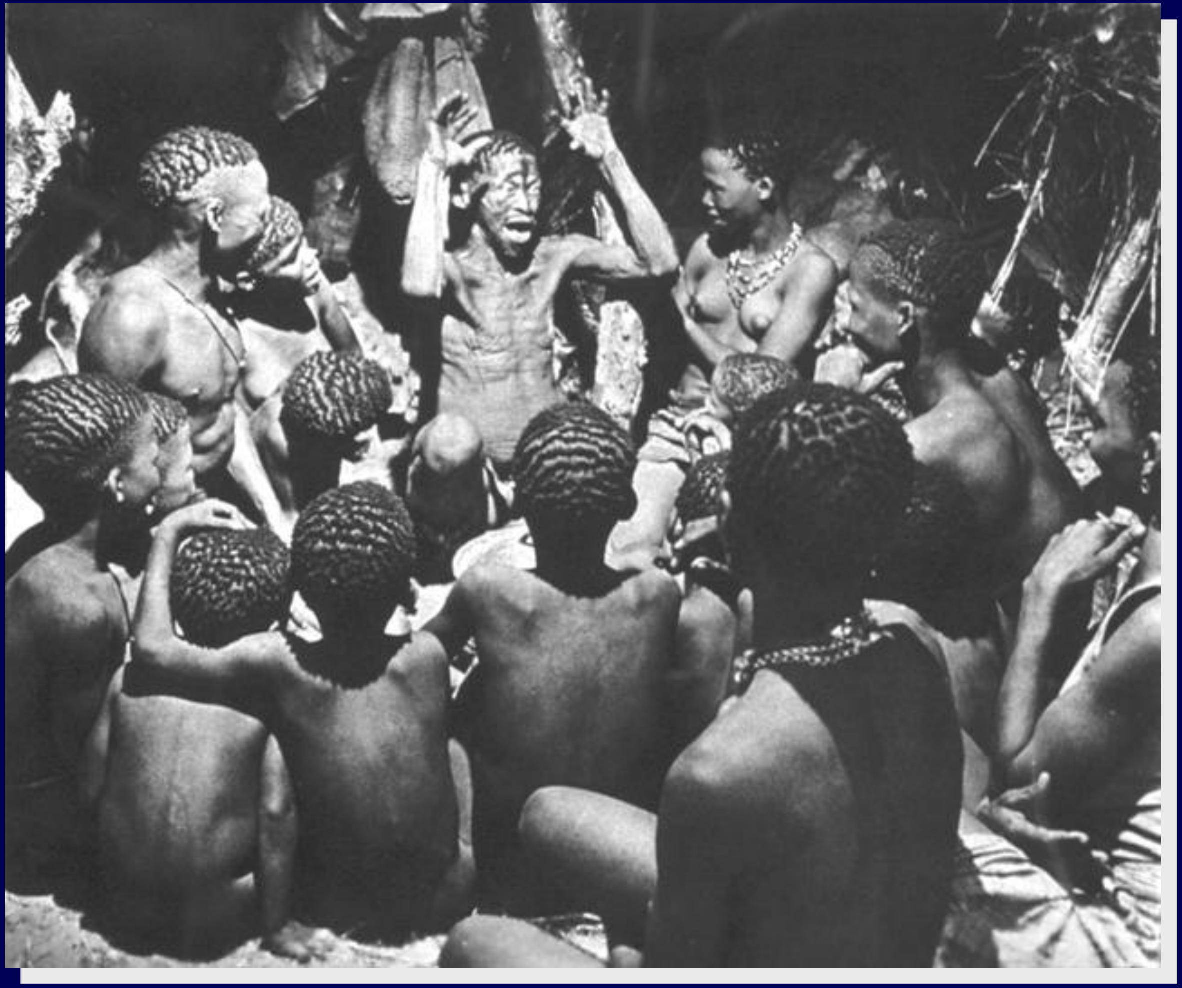
Increase safety

Mandatory?

Standard of care?

Our job is to learn more, train, educate

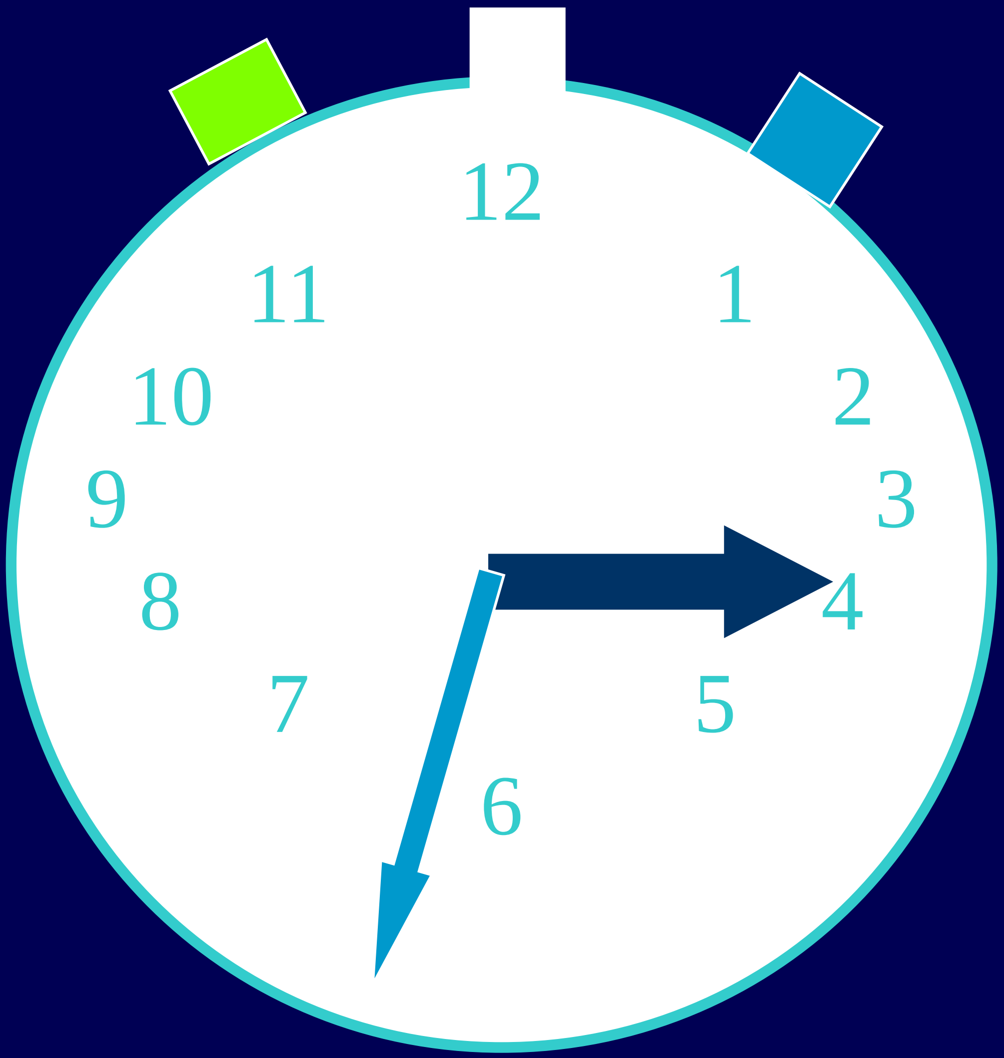
There will be no Level-I evidence to show that IOM for SCT's improves resection & safety



Suggestion: multi-center cooperation and data collection

Bruegel's
The fight between Carnival & Lent

Saving one patient from paraplegia


12
11
1
10
2
9
3
8
4
7
5
6

The Challenge!

Think!

Consult!

Listen!

Know your limitations!

Our fellows:

Russia, Turkey, Israel, Palestine, India, China, Greece

Team Work