

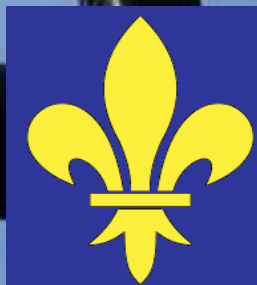


Traumatic Haemorrhage in the Spine

Professor Elizabeth Dick, MRCP, FRCR, MD
Consultant Radiologist & Professor of Practice, St Mary's
Campus, Imperial College NHS Trust, London, UK
Past President, British & European Societies Emergency
Radiology



Nordter, Oslo NO June 2025
elizabeth.dick1@nhs.net



DISCLOSURES

- Everlight Radiology hosted me in Sydney 2024



[Pollev.com/edick900](https://pollev.com/edick900)



Learning Objectives

1. To learn the imaging findings of traumatic haemorrhage in spinal canal
2. To understand the anatomy of different compartments in the spinal canal
3. To become familiar with the particular imaging features which help to identify which compartment contains blood

Spinal haematoma



Pollev.com/edick900

- Relatively uncommon (**Level 1 trauma centre, 2/week**)
- Causes:
 - Trauma (major or minor)
 - Anticoagulation
 - Post intervention (eg anaesthesia)
 - Spontaneous
- Presentation:
 - Pain
 - Paralysis/neurological impairment
 - Less commonly headache/cerebral irritation



What affects outcome

WORSE OUTCOME

- greater severity of symptoms
- Very rapid onset of symptoms
- longer time to surgery from symptom onset
- Presence of intramedullary haemorrhage
- Cord transection
- Cord swelling and oedema
- High lesions
- Longer length of involved cord

BETTER OUTCOME

- Early recognition
- Correct diagnosis of anatomical space affected



What affects outcome

WORSE OUTCOME

- greater severity of symptoms
- Very rapid onset of symptoms
- longer time to surgery from symptom onset
- Presence of intramedullary haemorrhage
- Cord transection
- Cord swelling and oedema
- High lesions
- Longer length of involved cord

BETTER OUTCOME

- Early recognition
- Correct diagnosis of anatomical space affected

RADIOLOGY MAKES A DIFFERENCE



What affects outcome

WORSE OUTCOME

- greater severity of symptoms
- Very rapid onset of symptoms
- longer time to surgery from symptom onset
- Presence of intramedullary haemorrhage
- Cord transection
- Cord swelling and oedema
- High lesions
- Longer length of involved cord

BETTER OUTCOME

- Early recognition
- Correct diagnosis of anatomical space affected

RADIOLOGY MAKES A DIFFERENCE



Pollev.com/edick900

When to operate

- If cord compression present – as soon as possible
- If intramedullary haemorrhage present, delaying operation may improve outcome
- If subarachnoid haemorrhage – conservative management may be best
- If mild/no neurological deficit – conservative management may be best

When to operate

RADIOLOGY MAKES A DIFFERENCE

- If cord compression present – as soon as possible
- If intramedullary haemorrhage present, delaying operation may improve outcome
- If subarachnoid haemorrhage – conservative management may be best
- If mild/no neurological deficit – conservative management may be best

What predicts functional recovery?



Pollev.com/edick900

- N=800, multicentre, North America

Functional recovery 1 year post injury depends on:

1. ASIA Score (American Spinal Injury Association) Grade A (worst) to D
2. Initial ASIA motor score
3. MRI findings: Normal/Cord Oedema/Cord Haemorrhage

Wilson, Grossman, Frankowski et al A Clinical Prediction Model for Long-Term Functional Outcome after Traumatic Spinal Cord Injury Based on Acute Clinical and Imaging Factors JOURNAL OF NEUROTRAUMA 2012

Magu S, Singh D, et al. Evaluation of Traumatic Spine by Magnetic Resonance Imaging and Correlation with Neurological Recovery Asian Spine J 2015

What predicts functional recovery?



Pollev.com/edick900

- N=800, multicentre, North America

Functional recovery 1 year post injury depends on:

1. ASIA Score (American Spinal Injury Association) Grade A (worst) to D
2. Initial ASIA motor score
3. **MRI findings:** Normal/Cord Oedema/Cord Haemorrhage

RADIOLOGY MAKES A DIFFERENCE

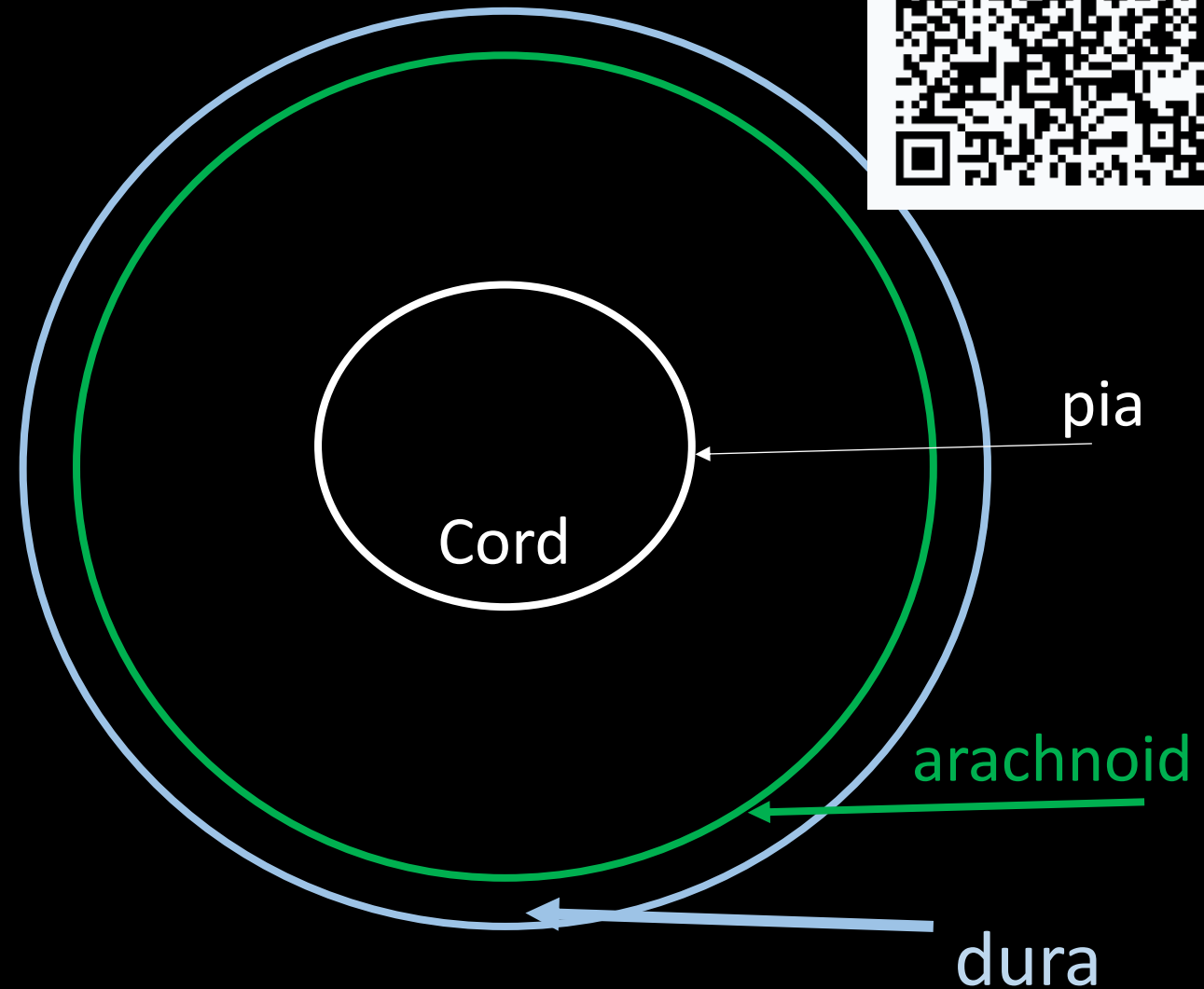
Wilson, Grossman, Frankowski et al A Clinical Prediction Model for Long-Term Functional Outcome after Traumatic Spinal Cord Injury Based on Acute Clinical and Imaging Factors JOURNAL OF NEUROTRAUMA 2012

Magu S, Singh D, et al. Evaluation of Traumatic Spine by Magnetic Resonance Imaging and Correlation with Neurological Recovery Asian Spine J 2015



Anatomy

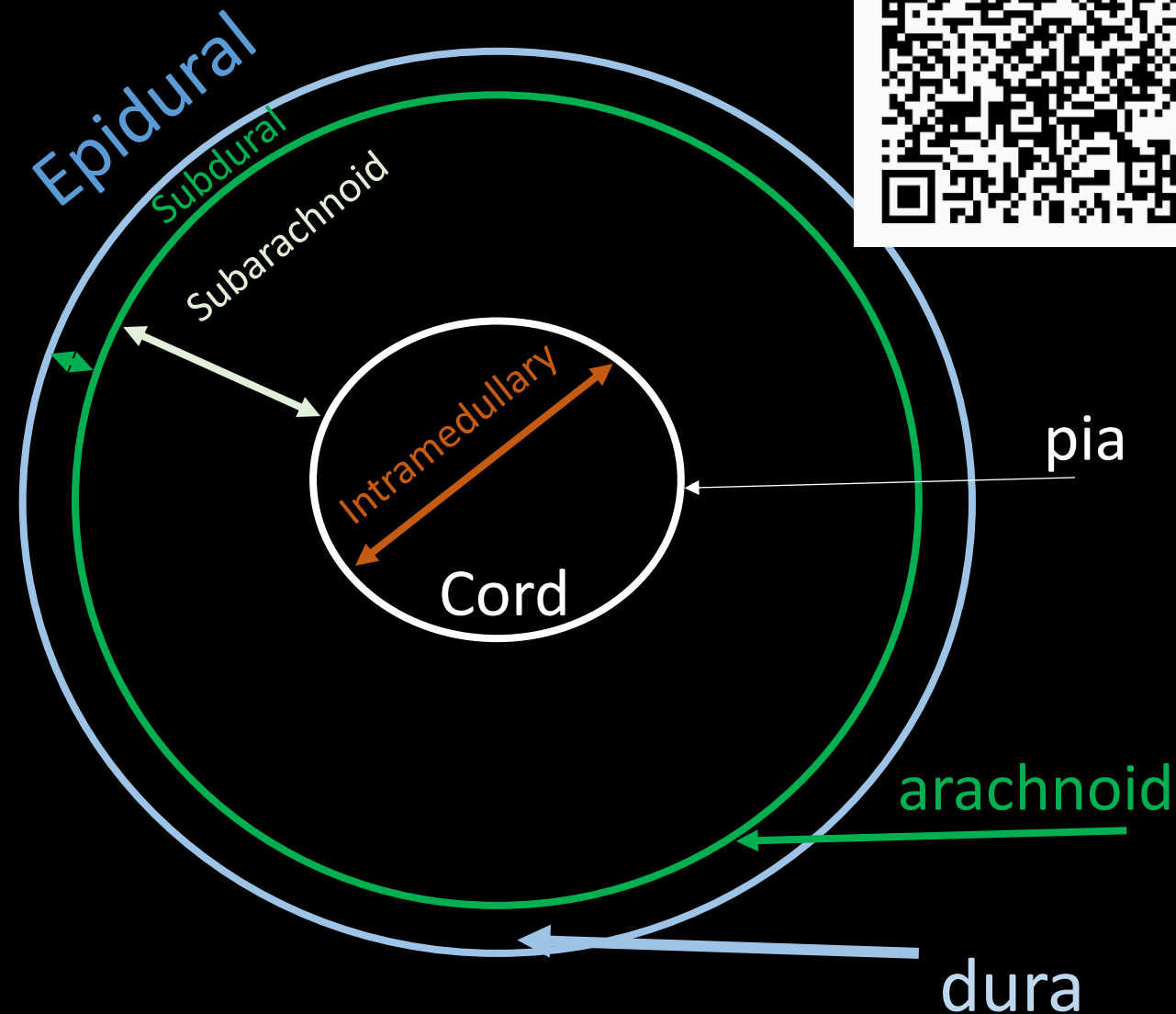
- Epidural (outside dura)
- Subdural (btwn arachnoid and dura)
- Subarachnoid
- Intramedullary





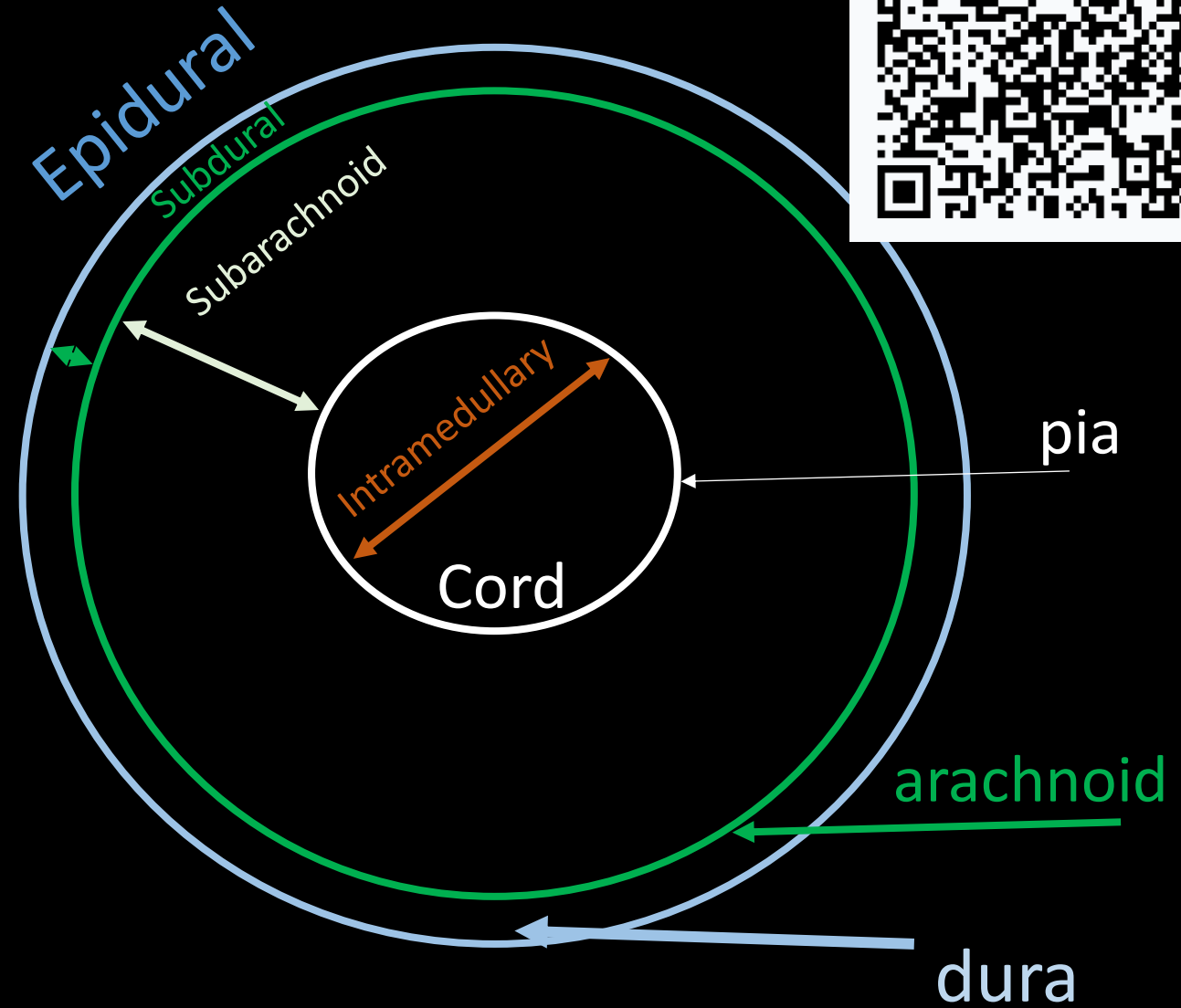
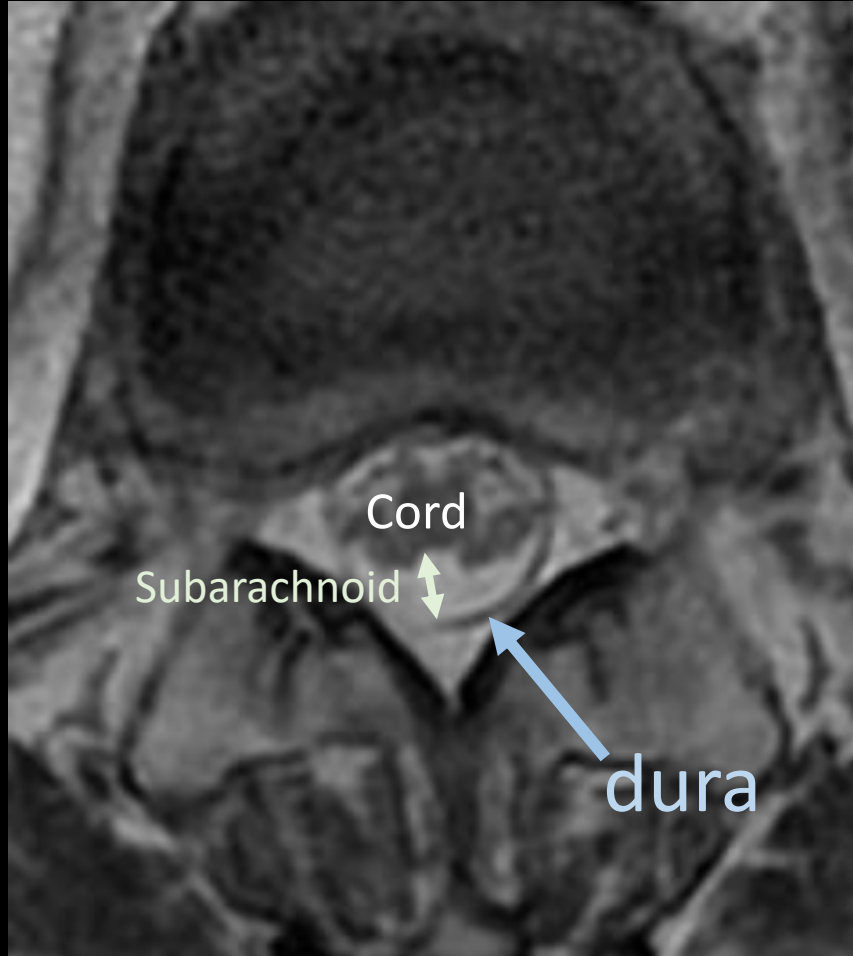
Anatomy

- Epidural (outside dura)
- Subdural (btwn arachnoid and dura)
- Subarachnoid
- Intramedullary



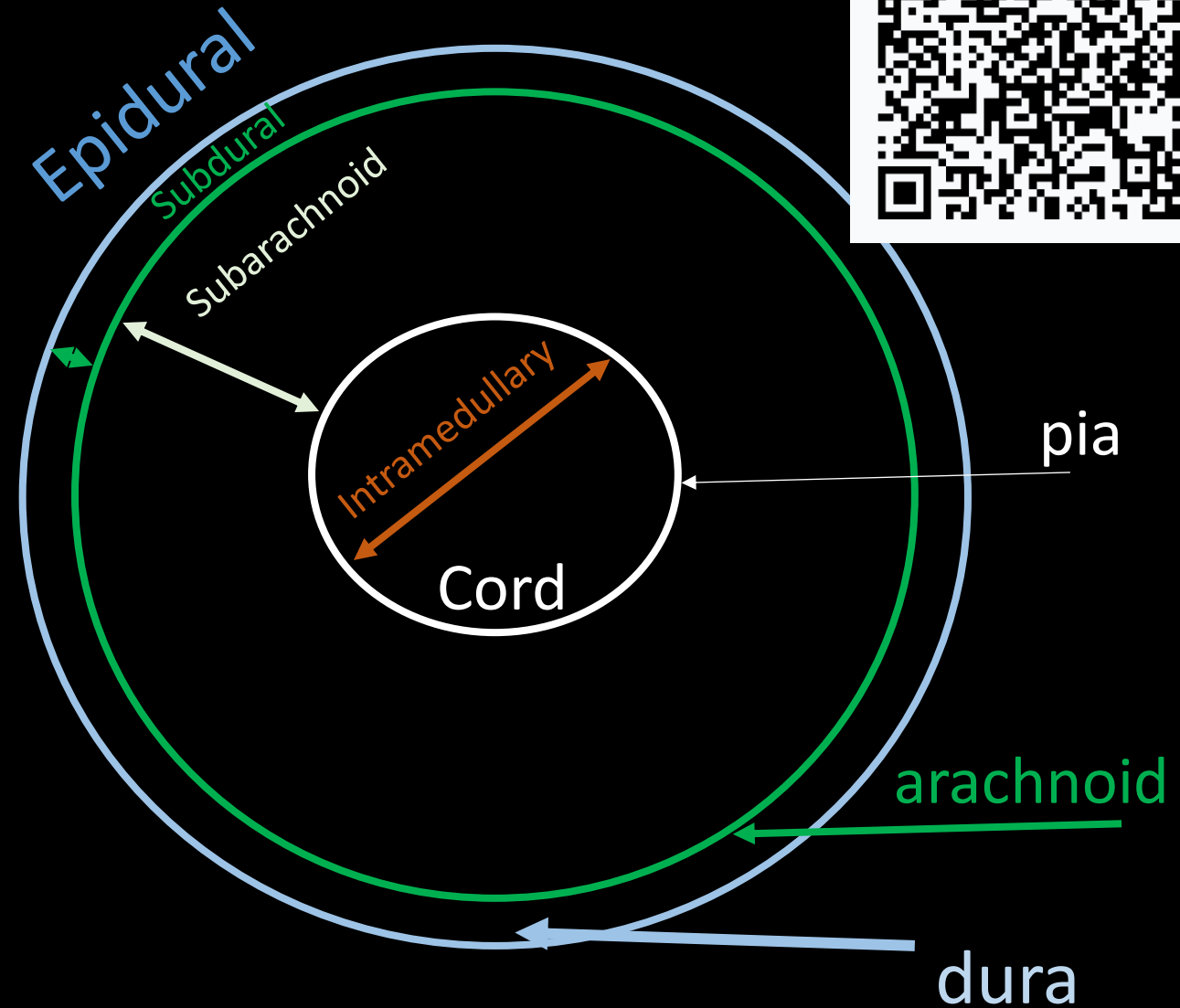
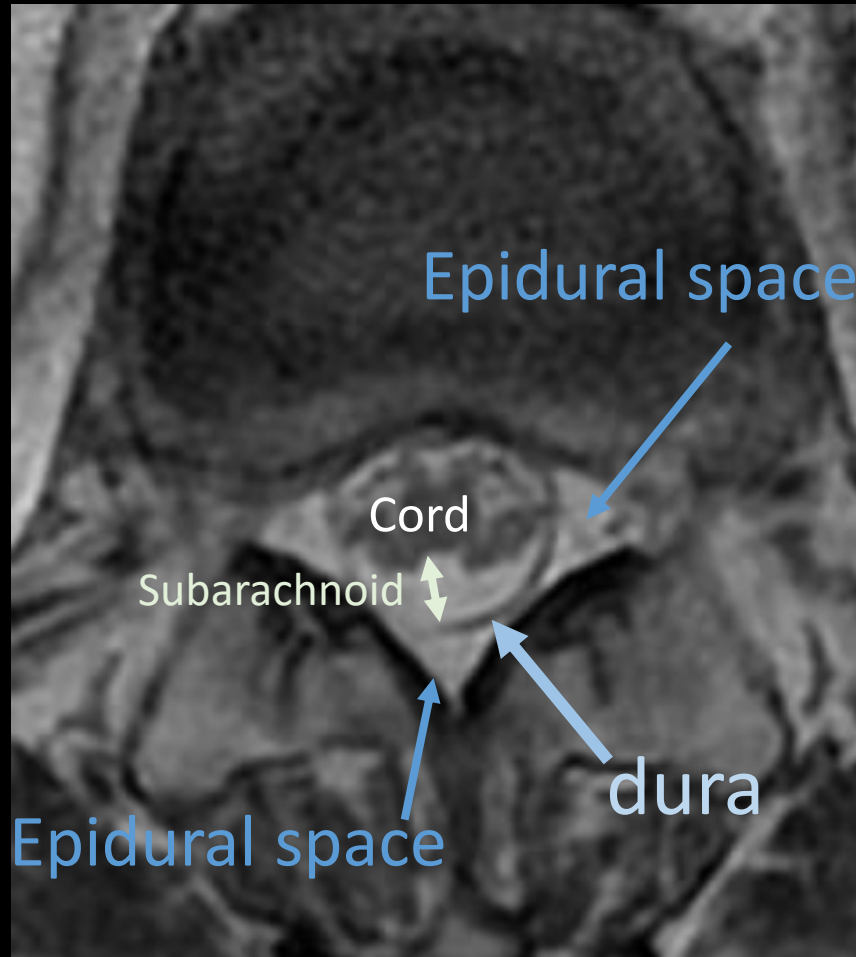


Anatomy





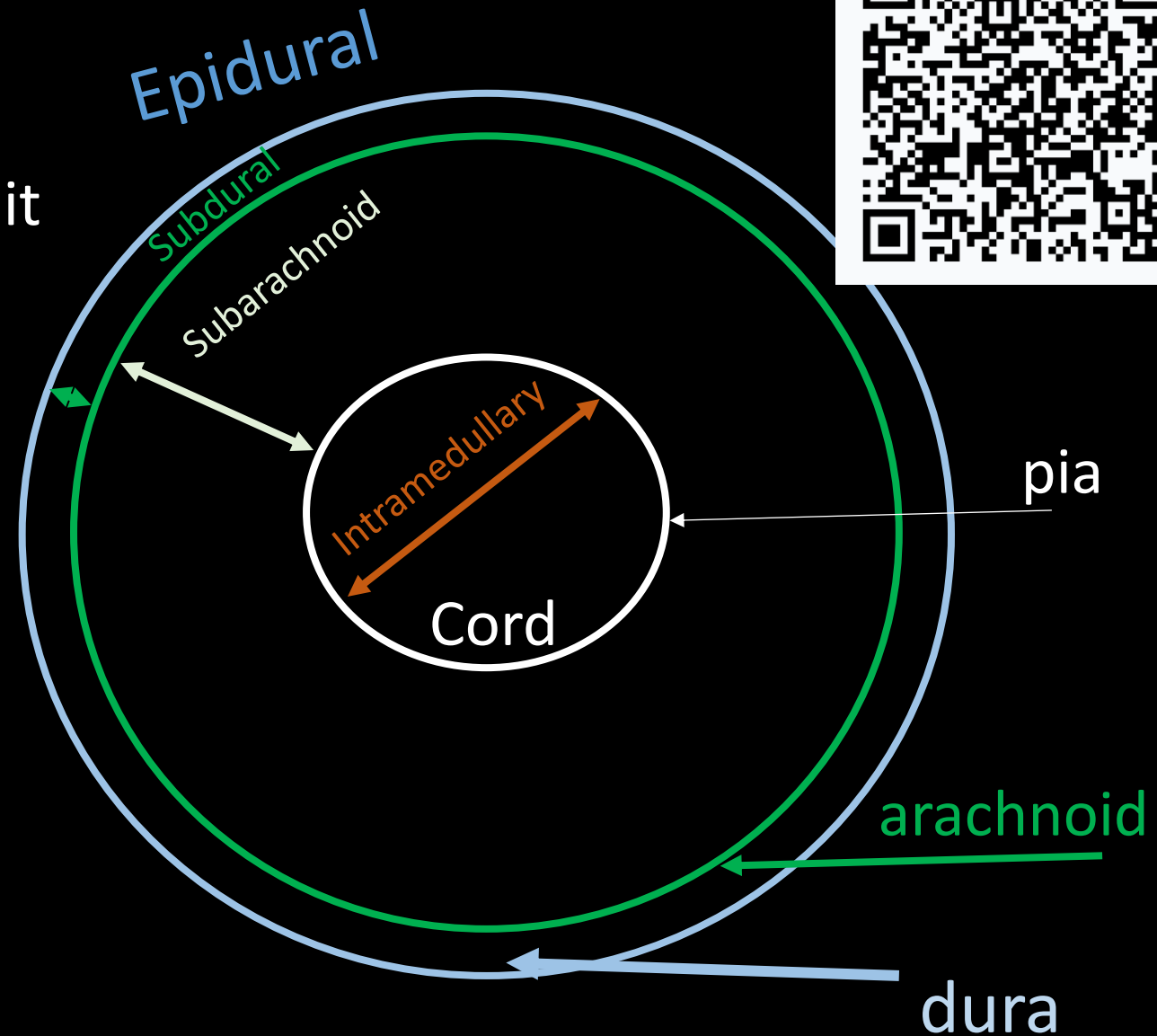
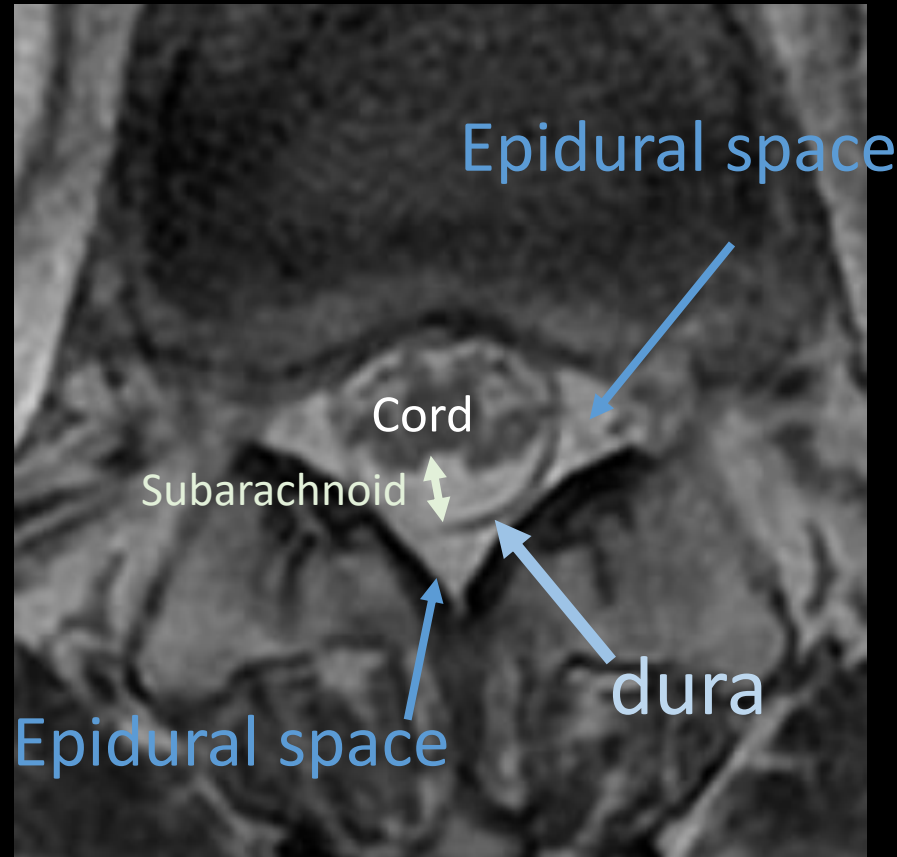
Anatomy



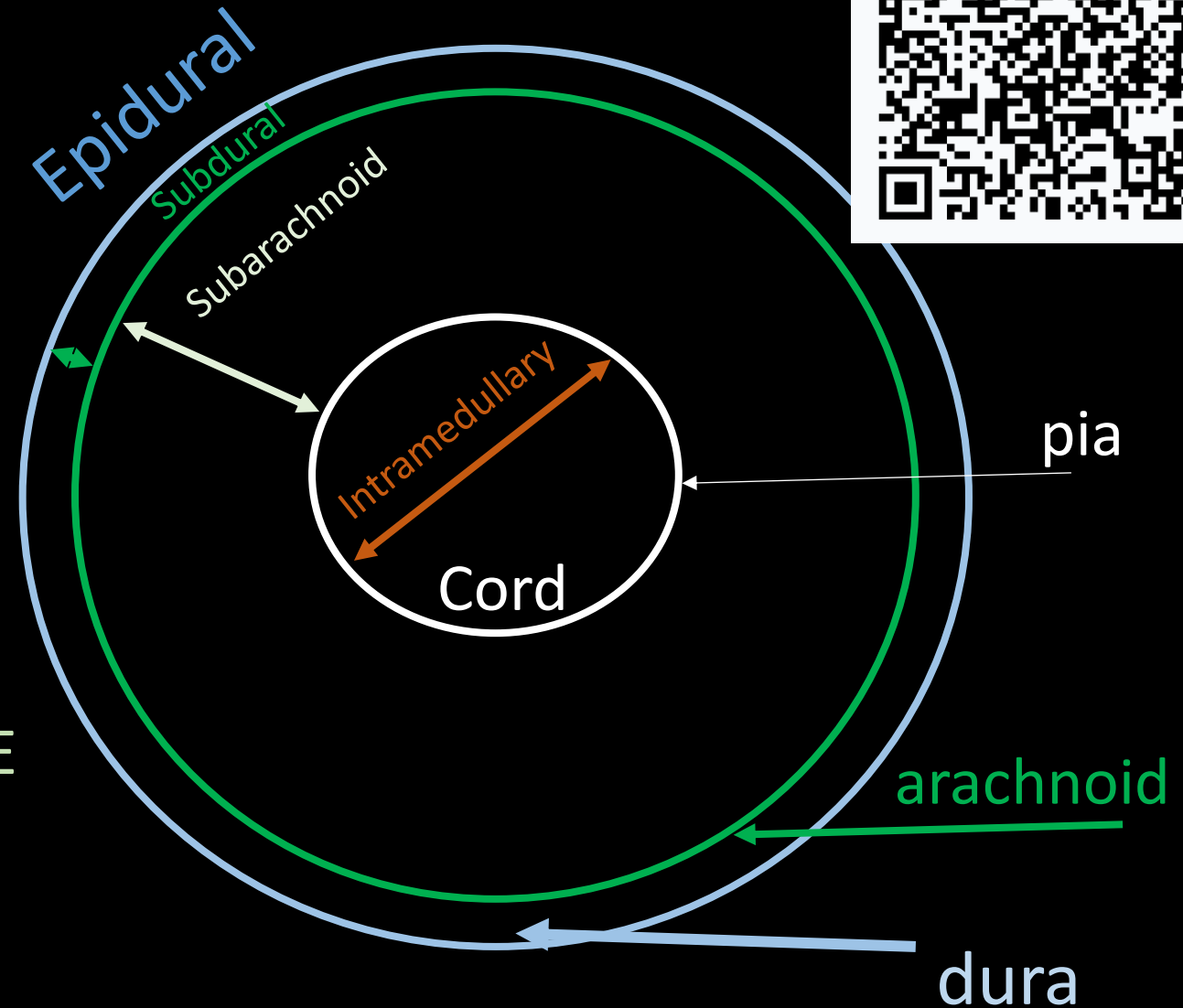
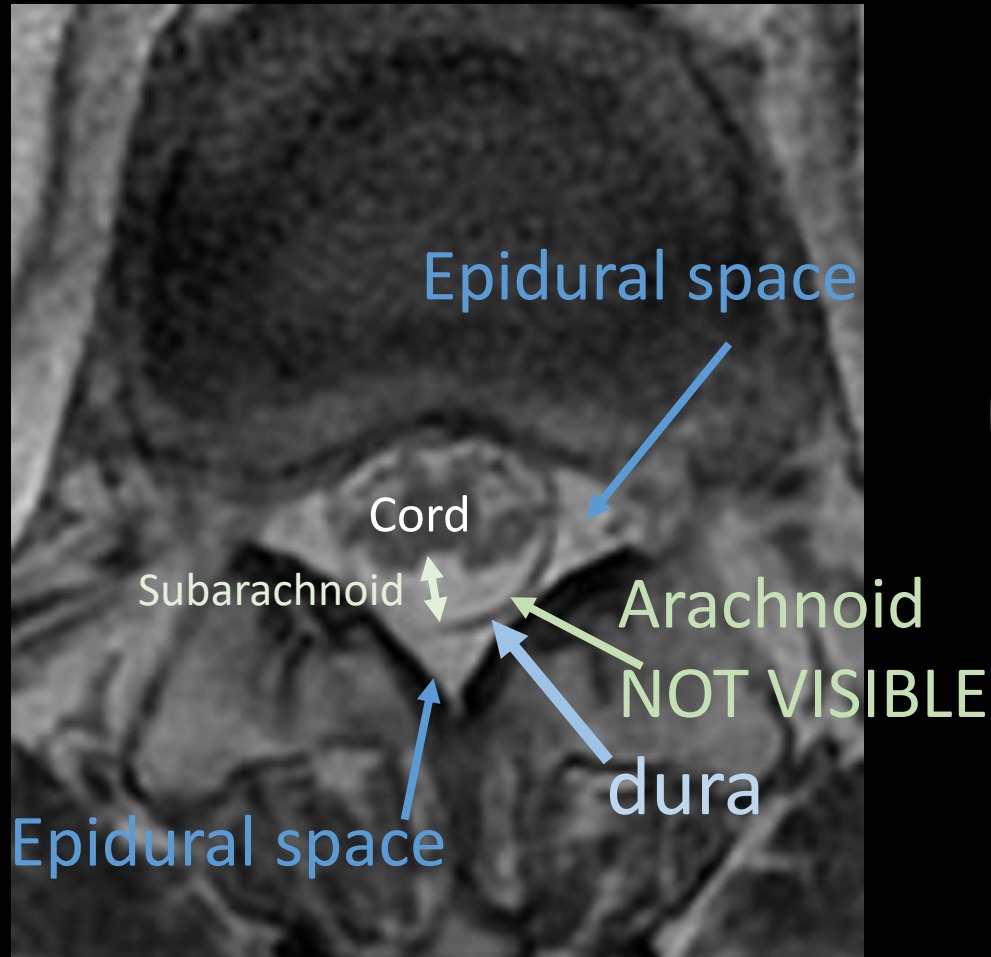


Epidural (outside dura)

between dura and vertebral column, no bridging veins, does contain septations but fluid can communicate freely within it



Subdural (btwn arachnoid and dura – a potential space)



Which of the following are true

(A) Subarachnoid space contains CSF

0%

(B) Fluid can communicate freely within epidural space

0%

(C) In normal patient arachnoid cannot be separated from dura on MRI

0%

Imaging features of blood on MRI

	<24 hrs	1-3days	3-7days	7 days-1 month	>1 month to years
HGB=haemoglobin	<u>OxyHGB</u>	<u>DeoxyHGB</u>	i/c meth HGB	e/c meth HGB	Haemosiderin
T1					
T2					
	HYPERACUTE	ACUTE	EARLY <u>SubACUTE</u>	LATE <u>SubACUTE</u>	CHRONIC

HGB = haemoglobin

i/c = intracellular

e/c= extracellular

Extracranial blood – Signal change is variable (unlike intracranial blood)

Which of the following statements are true in suspected spinal haemorrhage

T1 and T2 are useful to detect blood

0%

T1 and T2 are useful for anatomical distortion

0%

Gradient Echo is not useful

0%

Imaging Protocols

- T1, T2 useful (NB include T2 fat suppressed sequences for oedema)
- Gradient Echo (for intramedullary haemorrhage)

Moriarty HK, Cearbhaill RO et al. MRI of spinal haematoma, a pictorial review BJR 2019

MRI following Spine Trauma Kurd MF, Alijanipour M, Schroeder GD, Millhouse PW, Vaccaro A. JBJS Reviews 2015

Locating haematoma by compartment

CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

EPIDURAL HAEMATOMA - non compressive

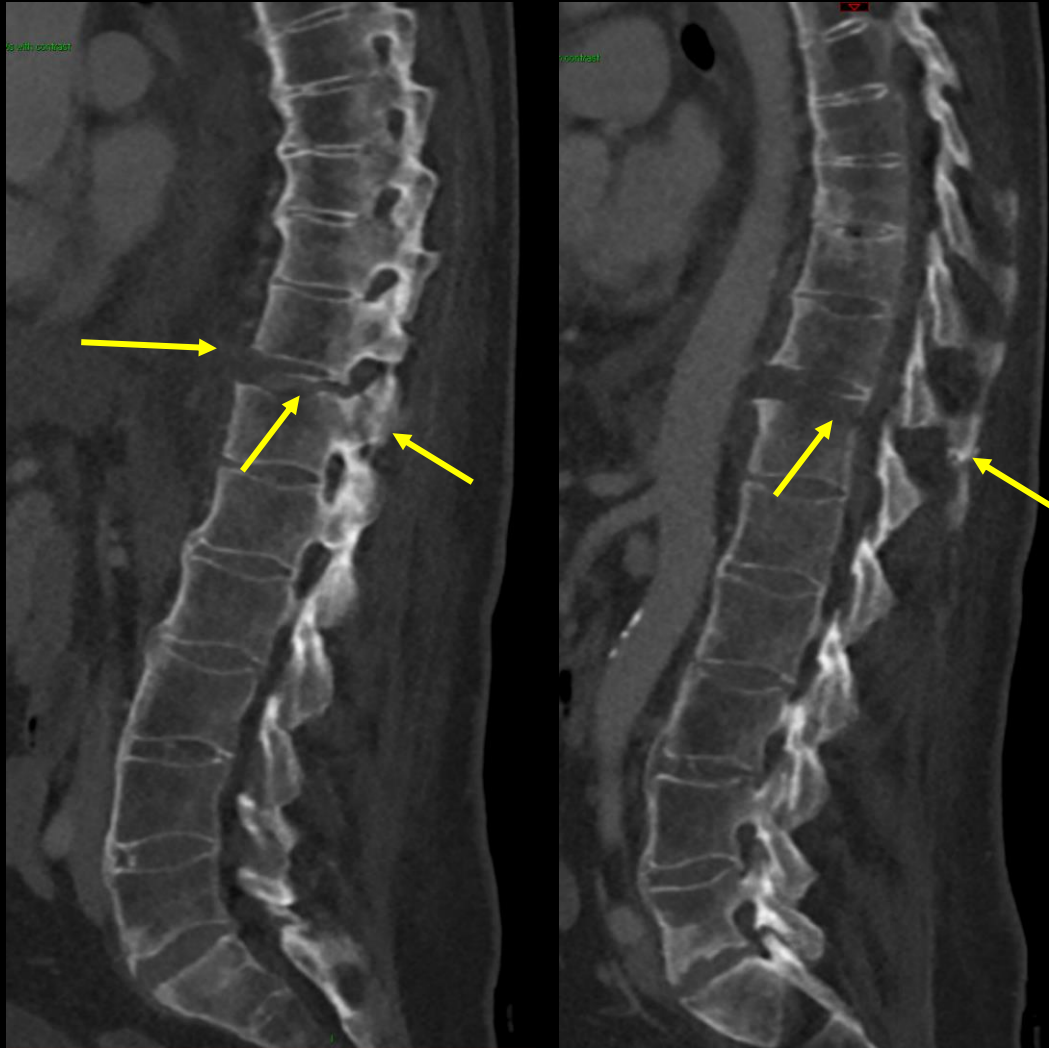
Locating haematoma by compartment

- Epidural compartment
 - Anterior, posterior, lateral
 - Look for loss of posterior epidural fat
 - Smooth contour (because contained by dura) **CLUE!!!**

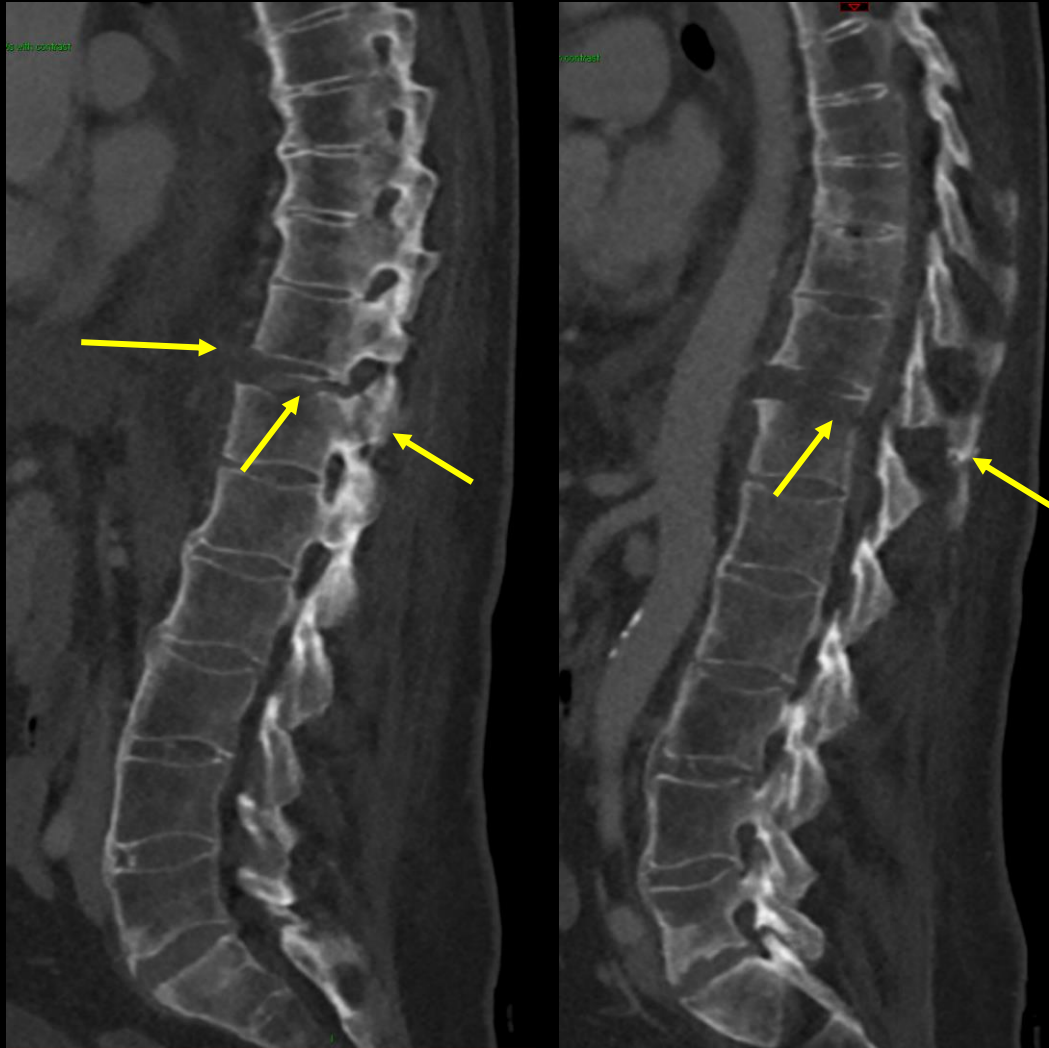
Ankylosing Spondylitis: Hyperextension/flexion 3 column injury T11/12



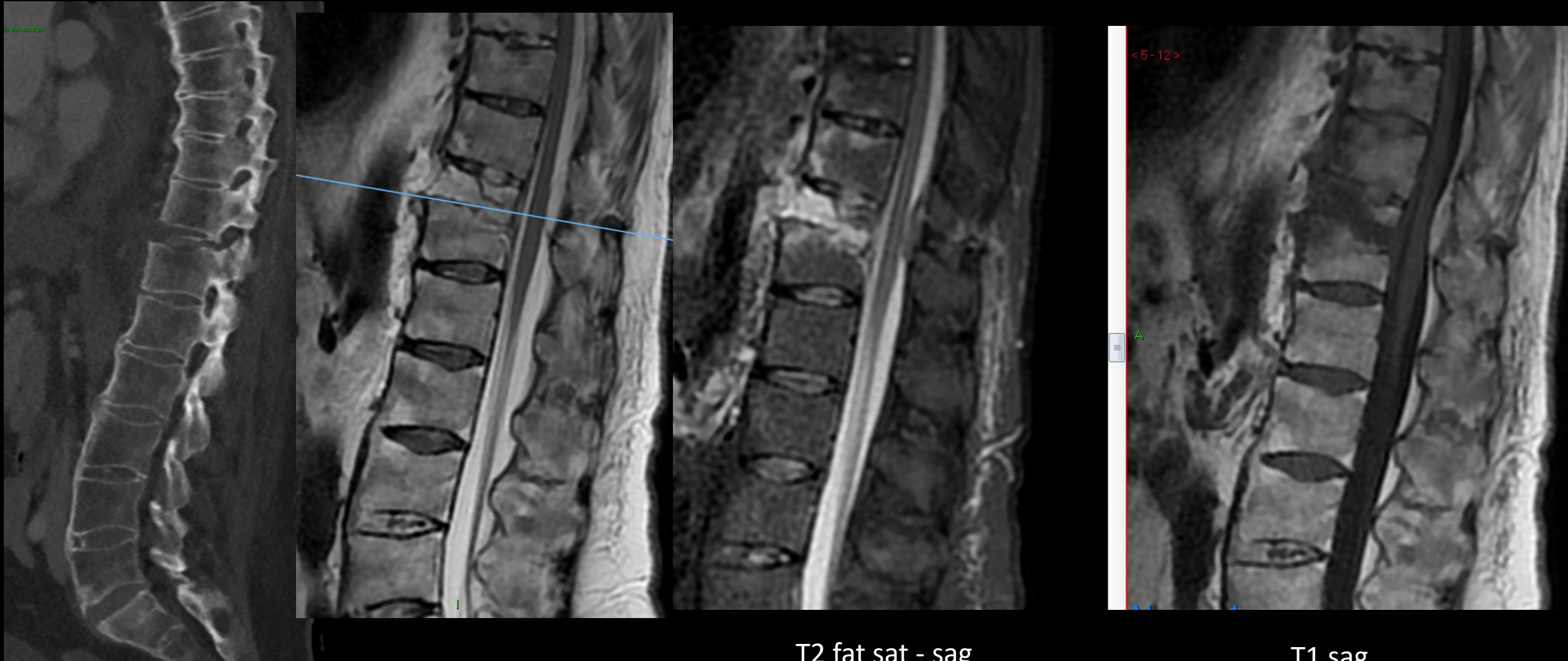
Ankylosing Spondylitis: Hyperextension/flexion 3 column injury T11/12



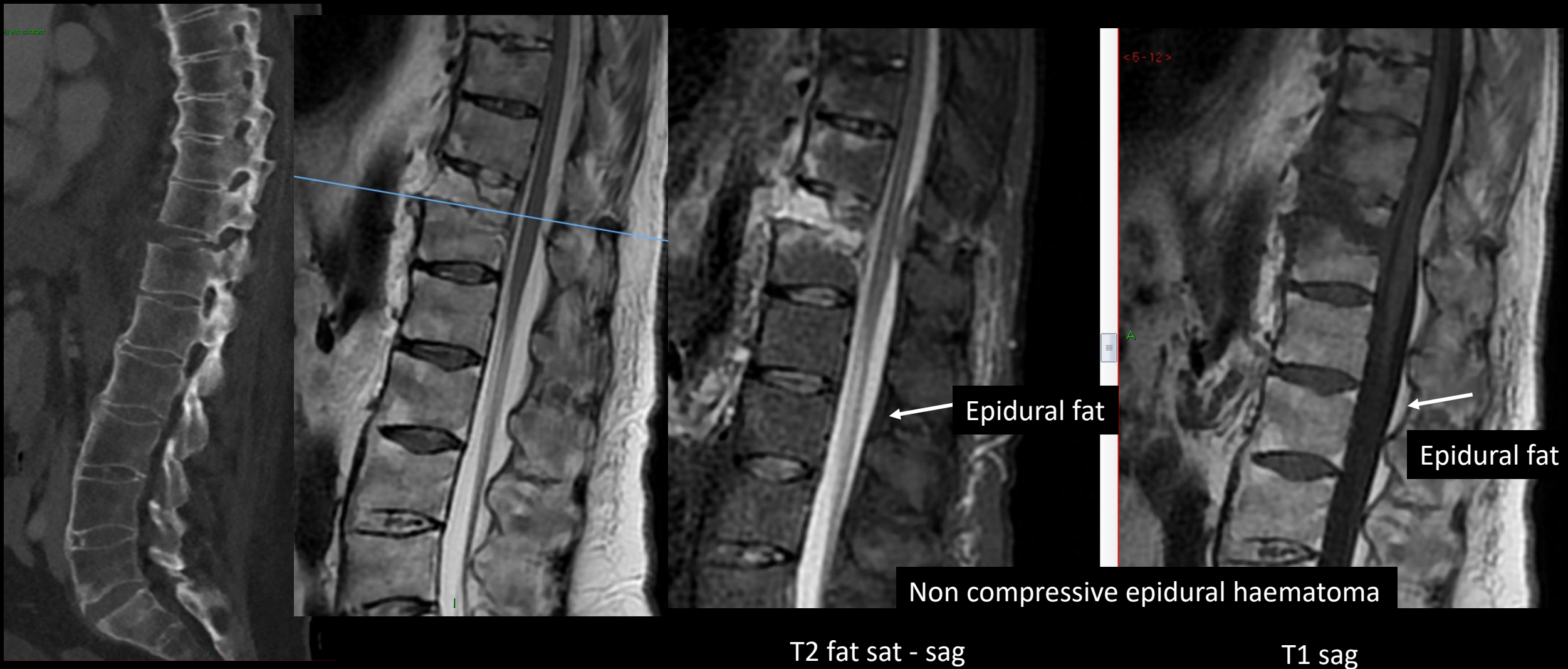
Ankylosing Spondylitis: Hyperextension/flexion 3 column injury T11/12



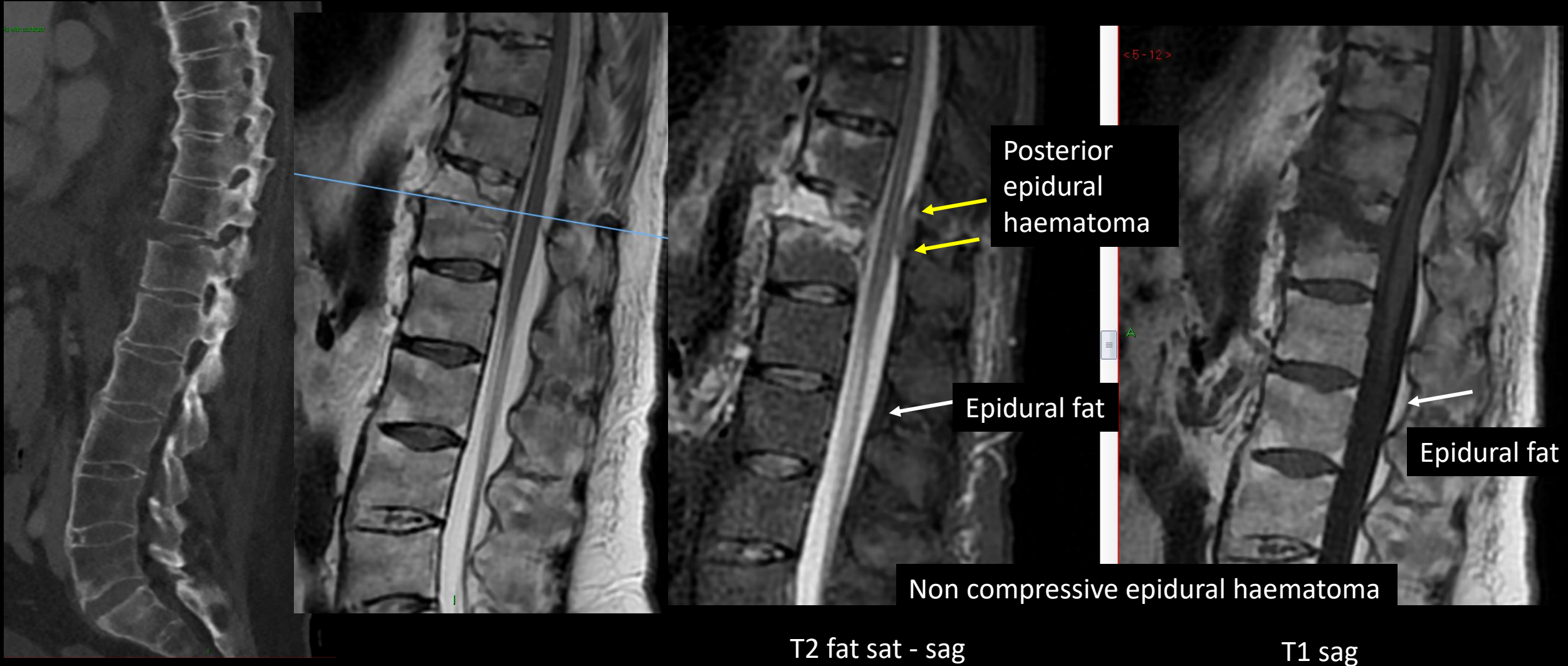
Ankylosing Spondylitis 3 column injury T11/12



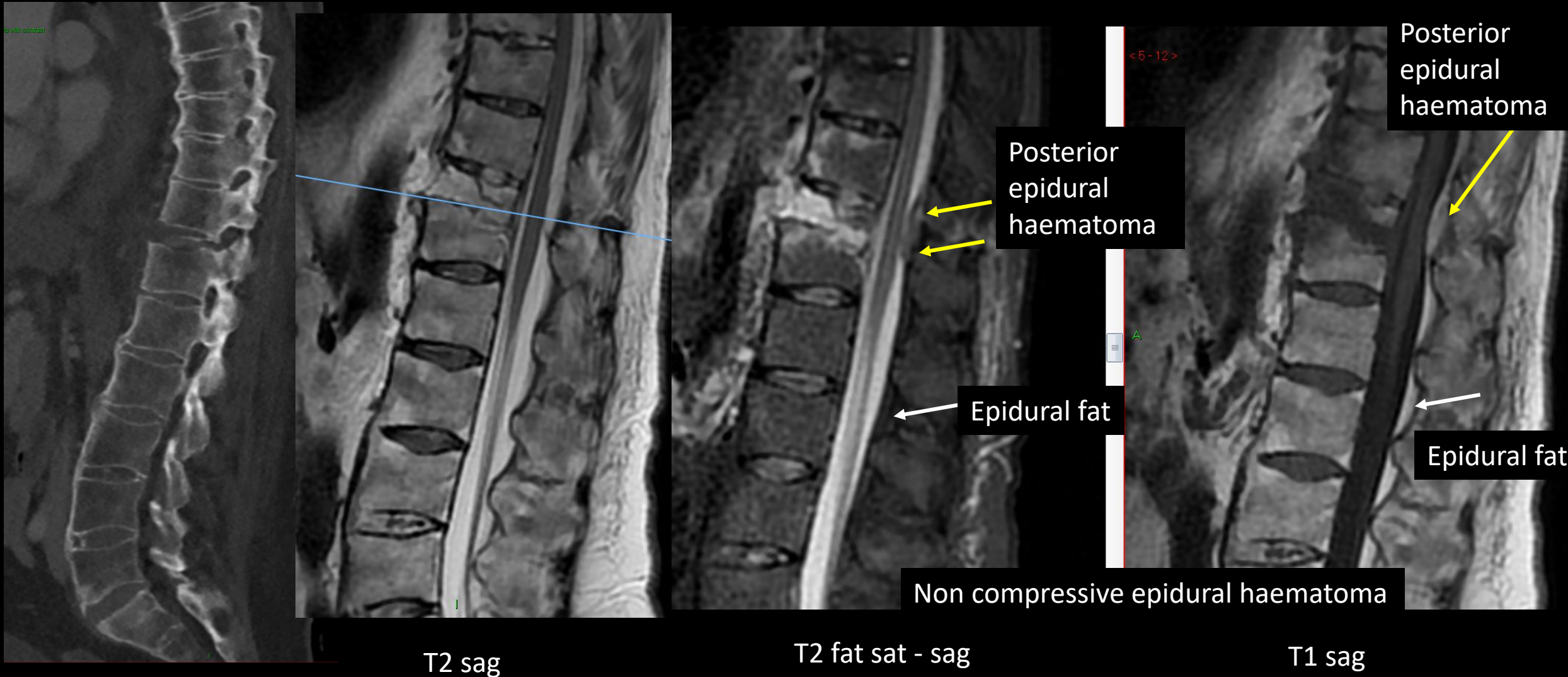
Ankylosing Spondylitis 3 column injury T11/12



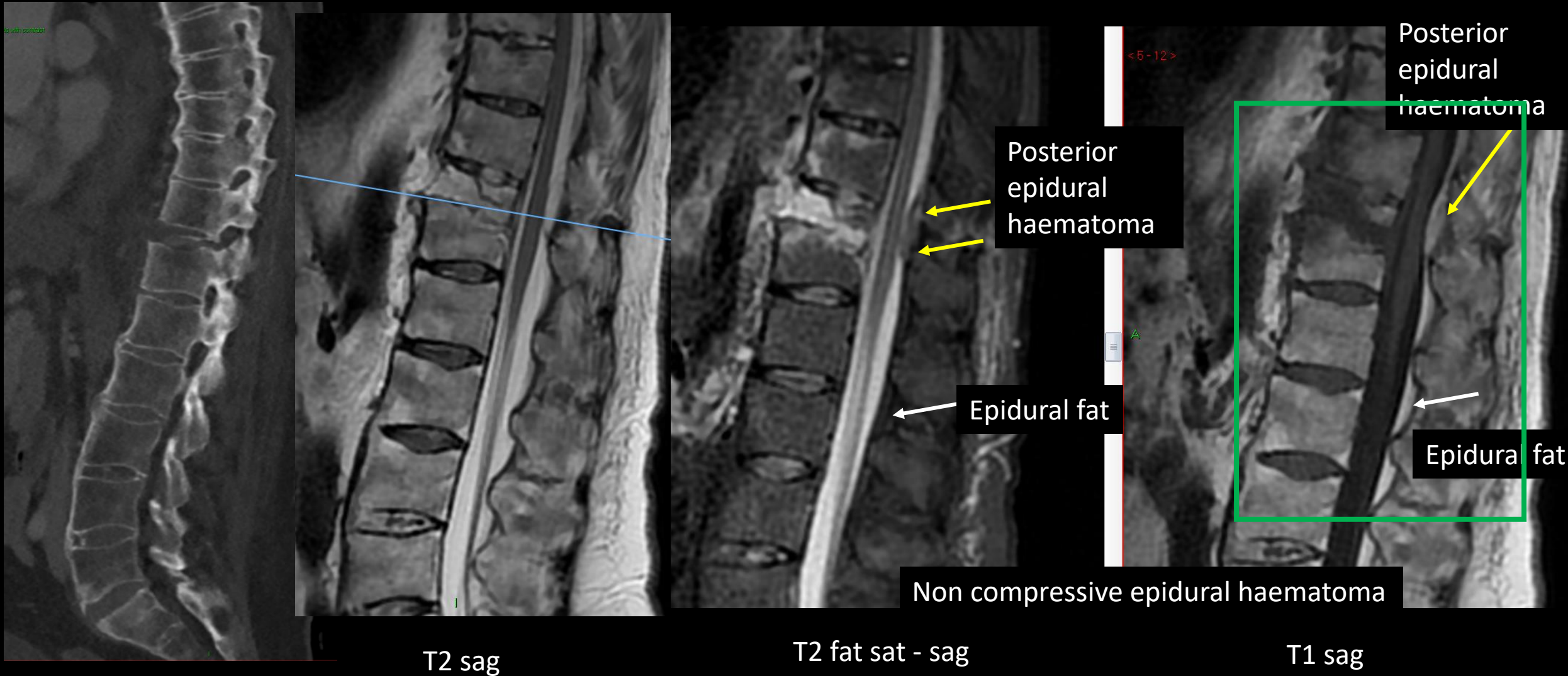
Ankylosing Spondylitis 3 column injury T11/12



Ankylosing Spondylitis 3 column injury T11/12



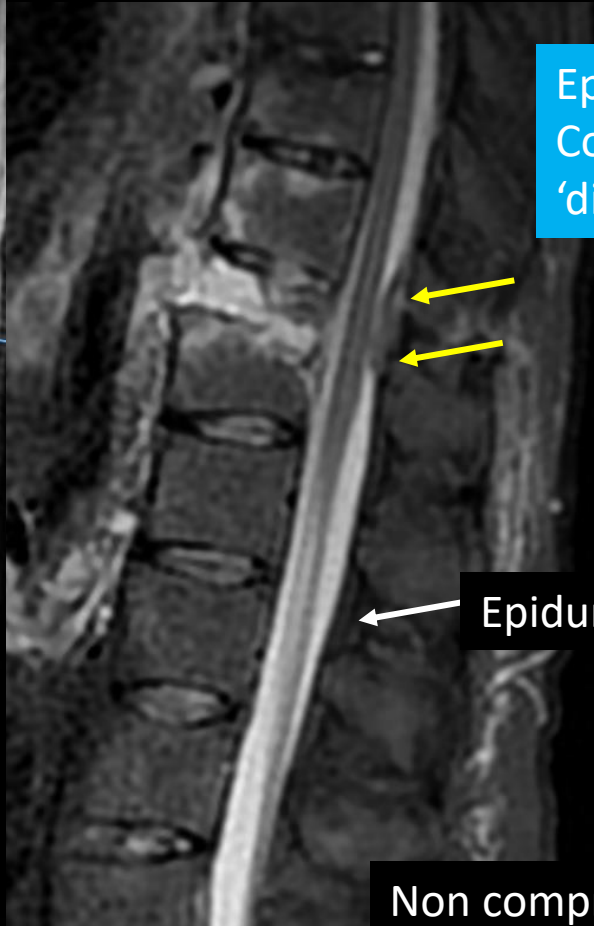
Ankylosing Spondylitis 3 column injury T11/12



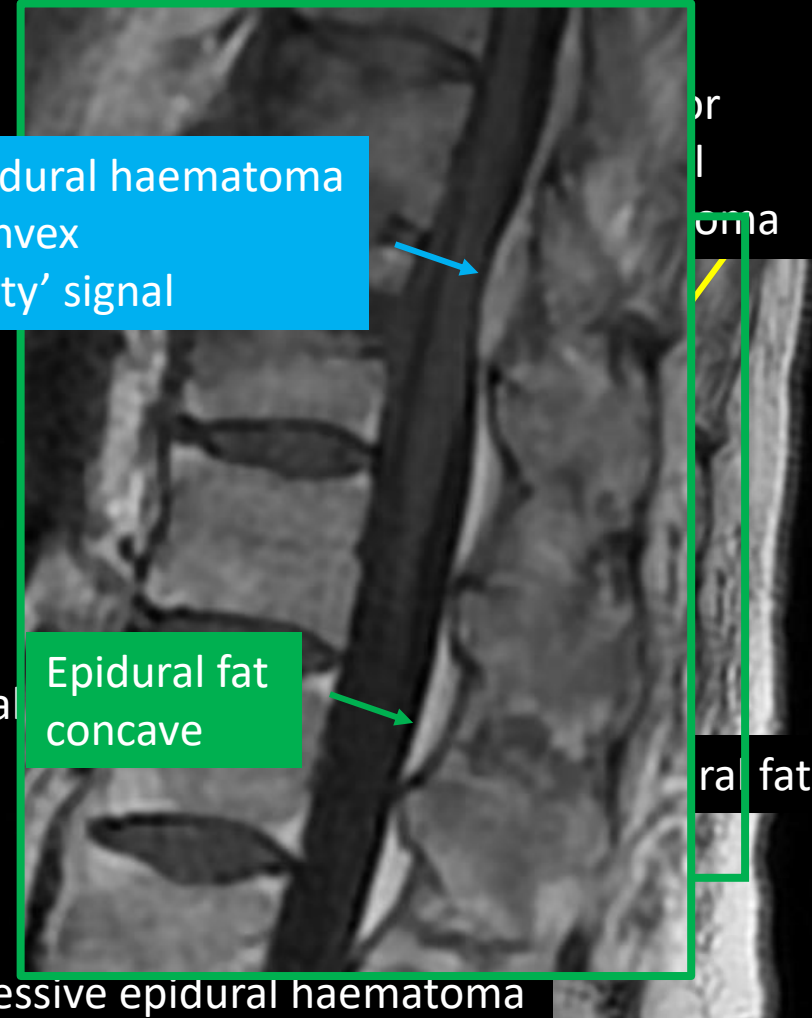
Ankylosing Spondylitis 3 column injury T11/12



T2 sag



T2 fat sat - sag



T1 sag

Epidural haematoma
Convex
'dirty' signal

Epidural fat
concave

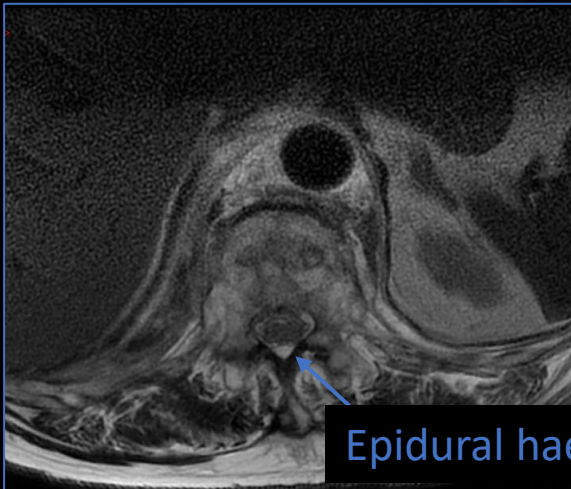
Epidural

Non compressive epidural haematoma

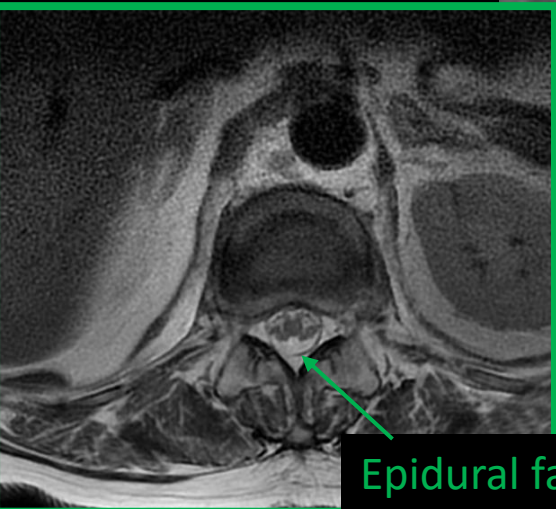
ra fat

Ankylosing Spondylitis 3 column injury T11/12

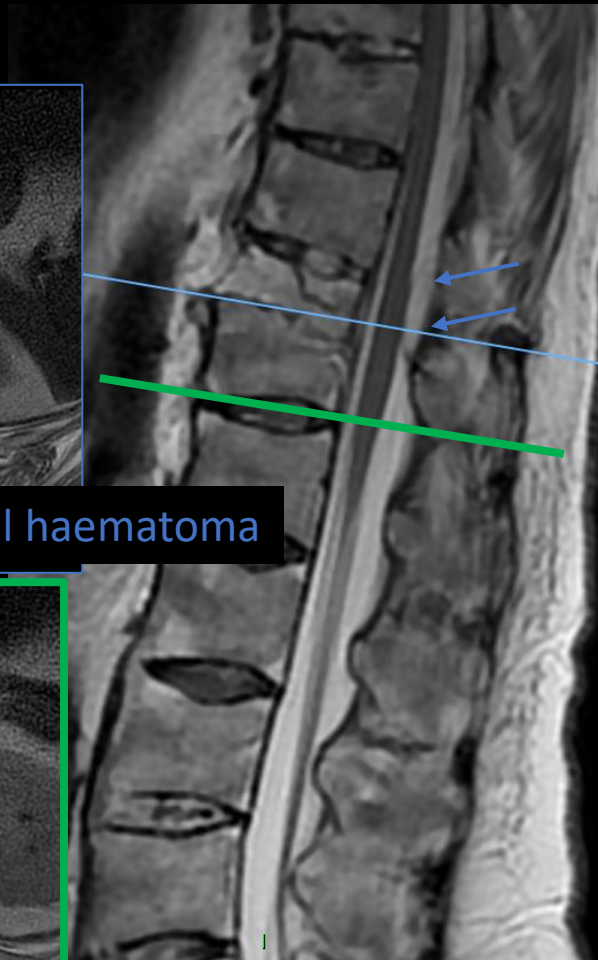
T2 axial



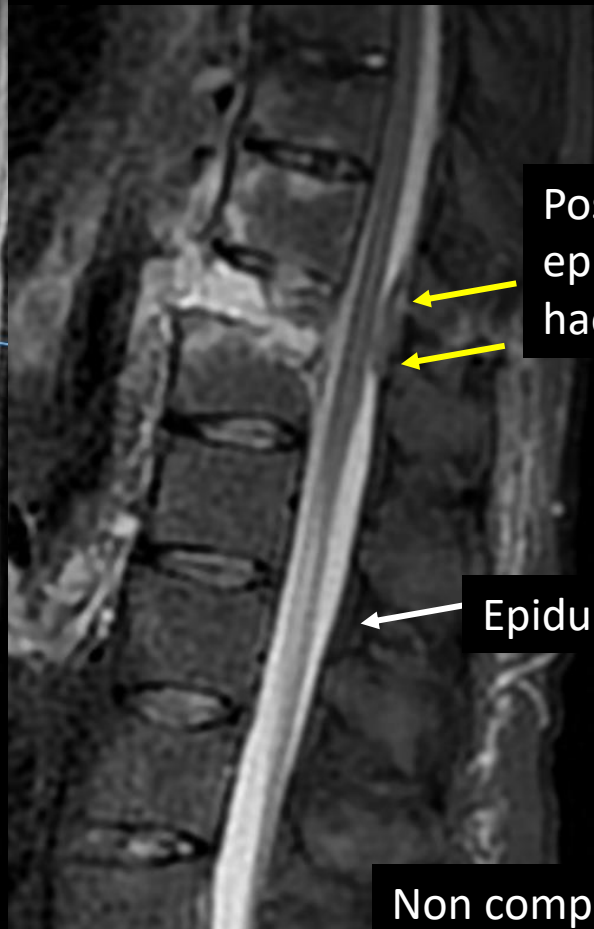
Epidural haematoma



Epidural fat



T2 sag

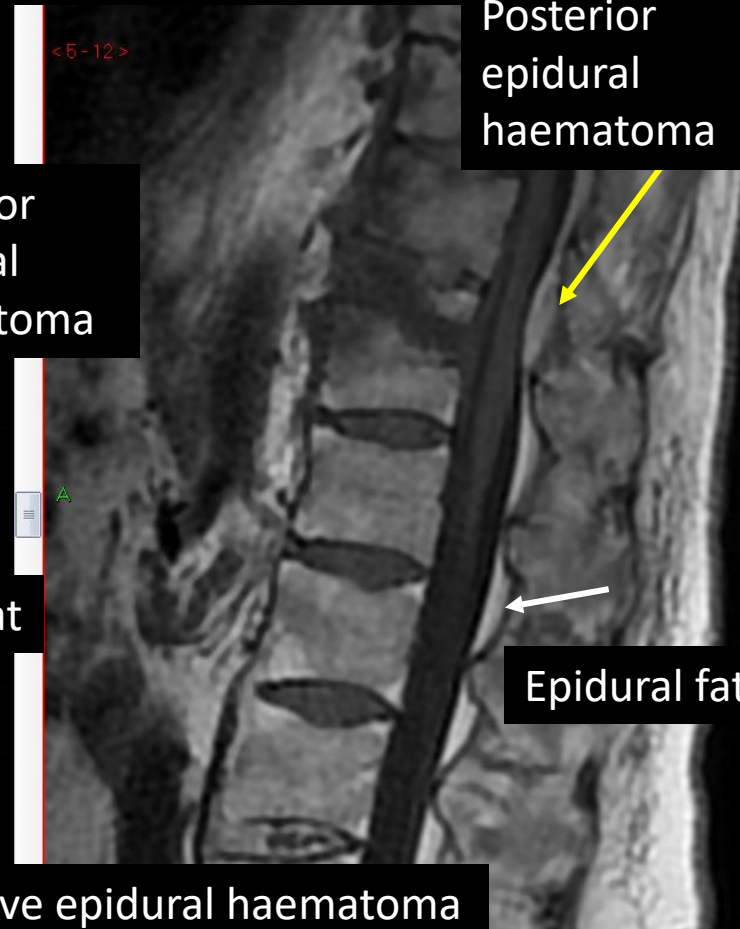


Epidural fat

T2 fat sat - sag

Posterior
epidural
haematoma

Non compressive epidural haematoma



Epidural fat

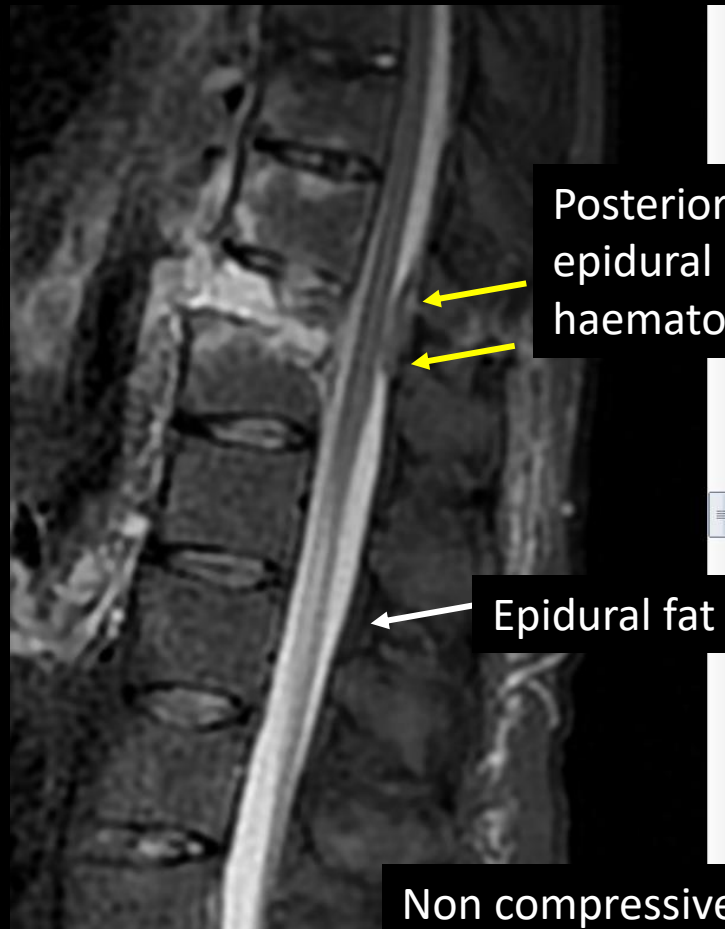
T1 sag

Posterior
epidural
haematoma

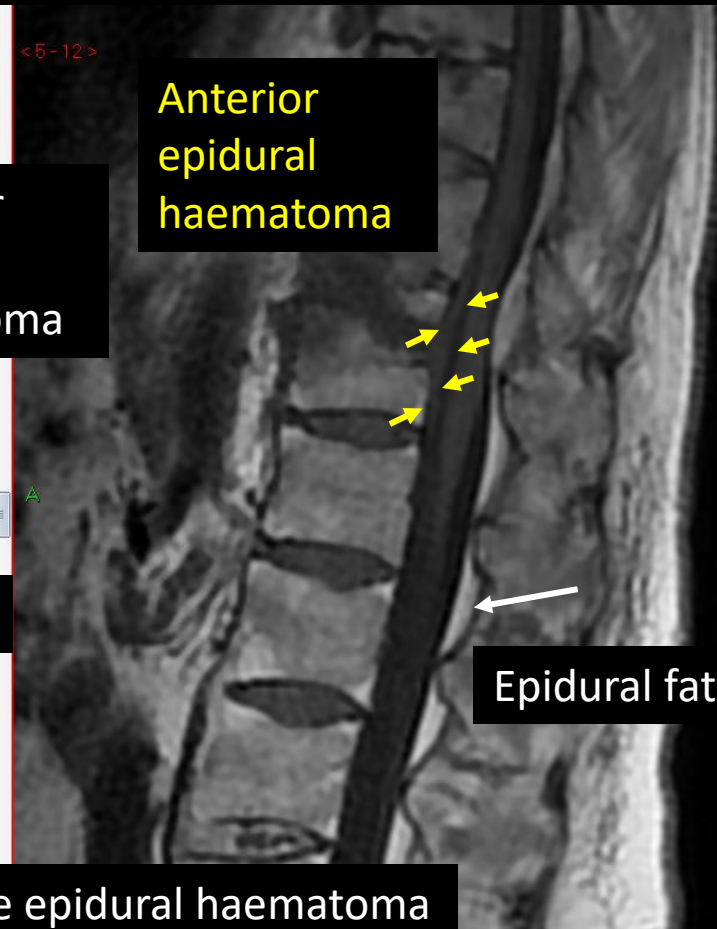
Ankylosing Spondylitis 3 column injury T11/12



Epidural haematoma:
smooth contour
Anterior and posterior compartments
Loss of epidural fat



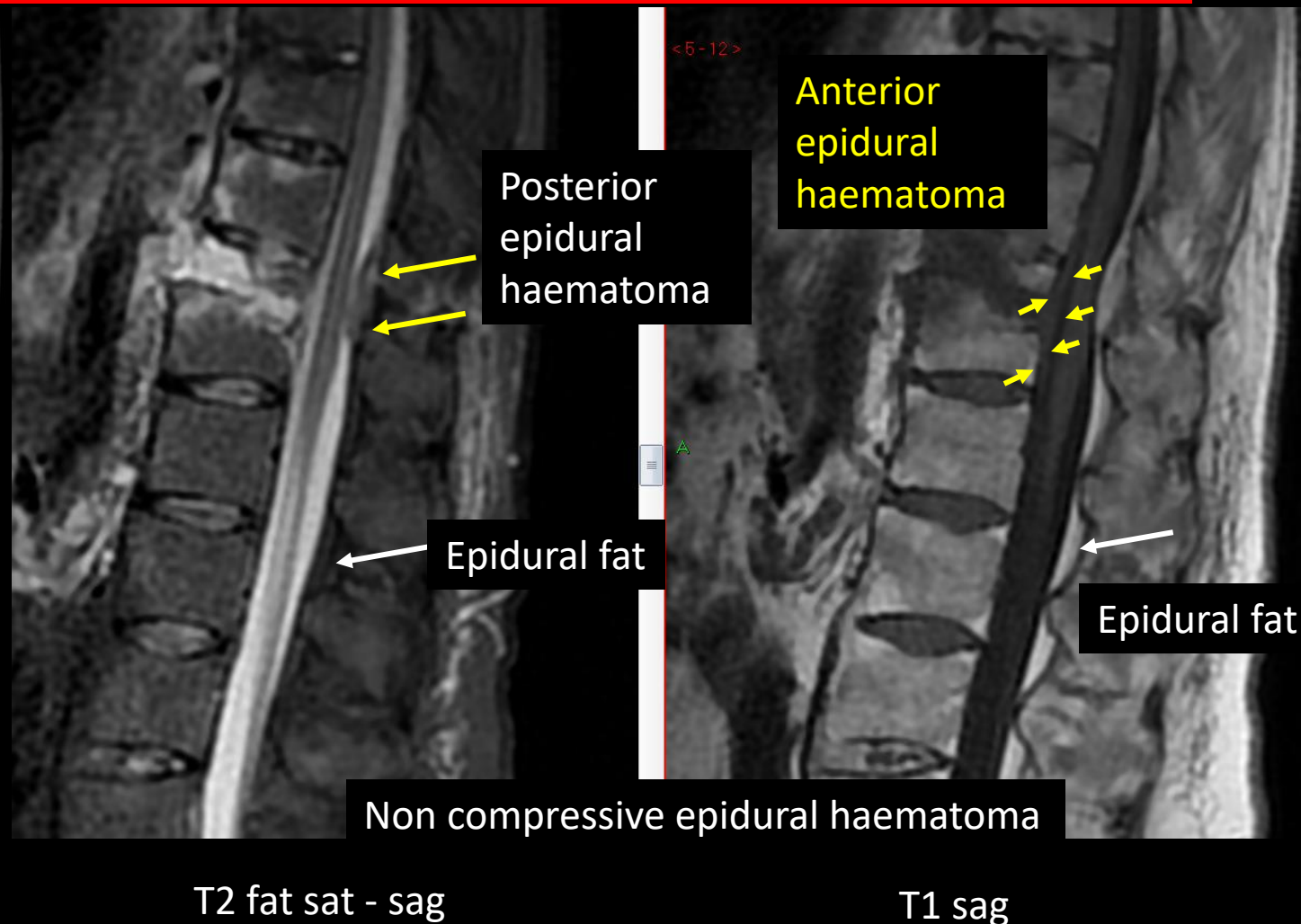
T2 fat sat - sag



T1 sag

Non compressive epidural haematoma

Learning Point: Different haematomas have different signal depending on associated oedema, dilution, haemoglobin concentration, amount of fat within haemorrhage, dural tear



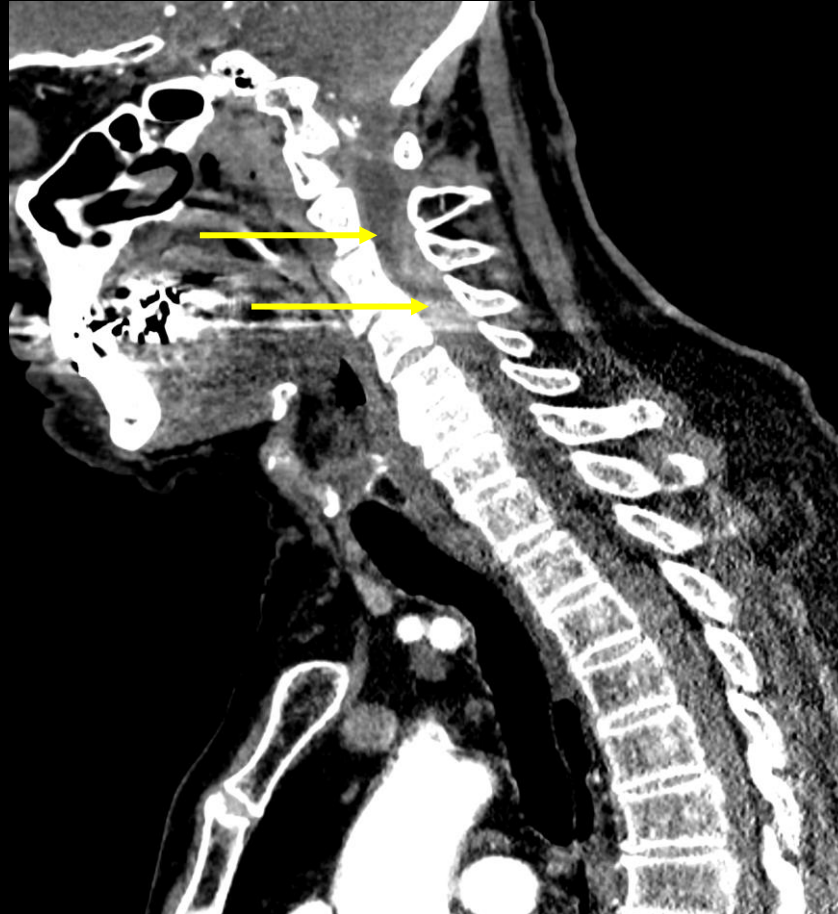
CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

EPIDURAL HAEMATOMA - compressive

Minor trauma, 85, anticoagulated, leg weakness

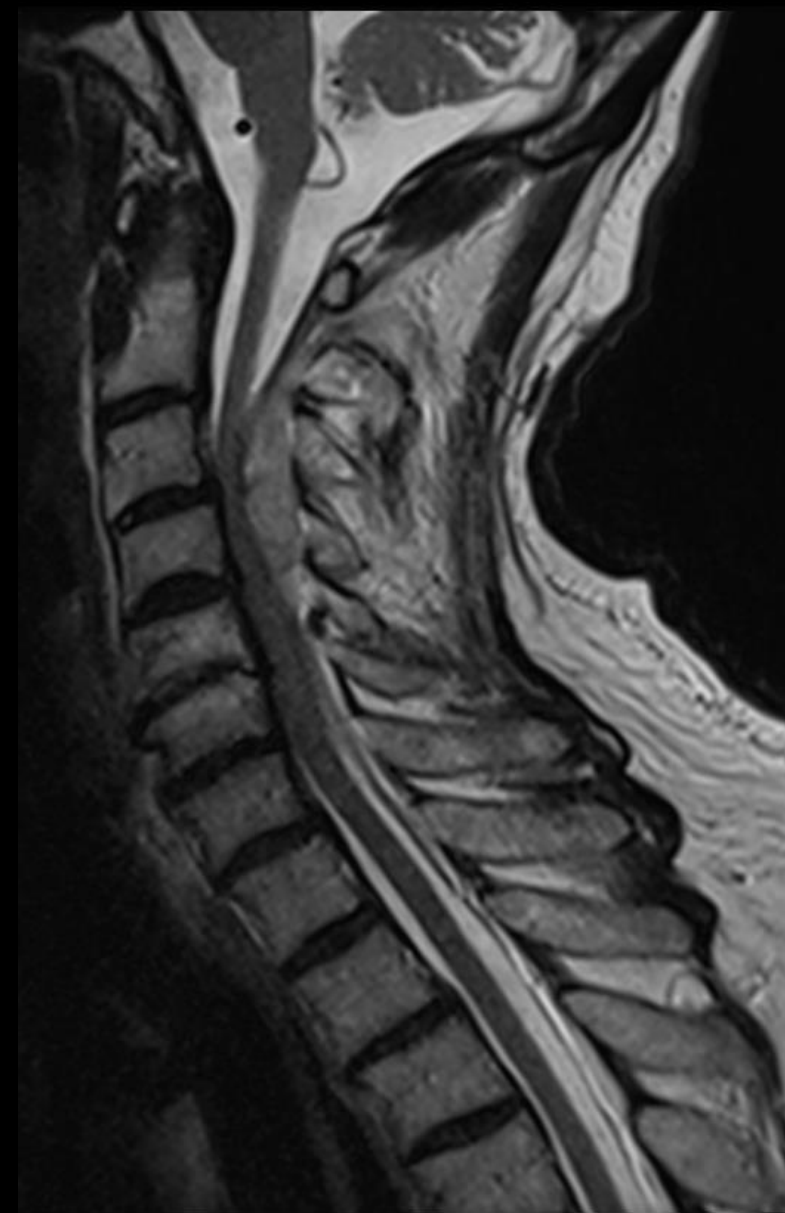
Epidural haematoma



T1

T2 fat sat

T2



T1

T2 fat sat

T2



T1

T2 fat sat

T2

Epidural haematoma

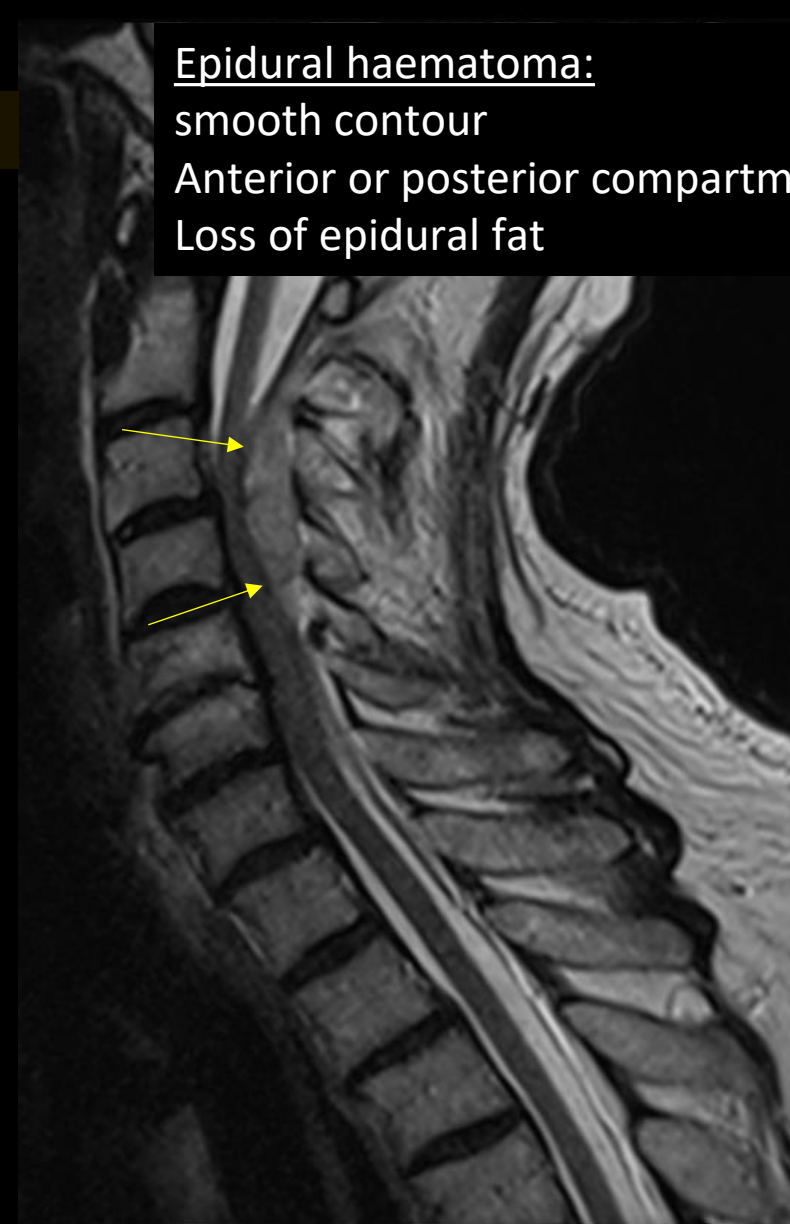
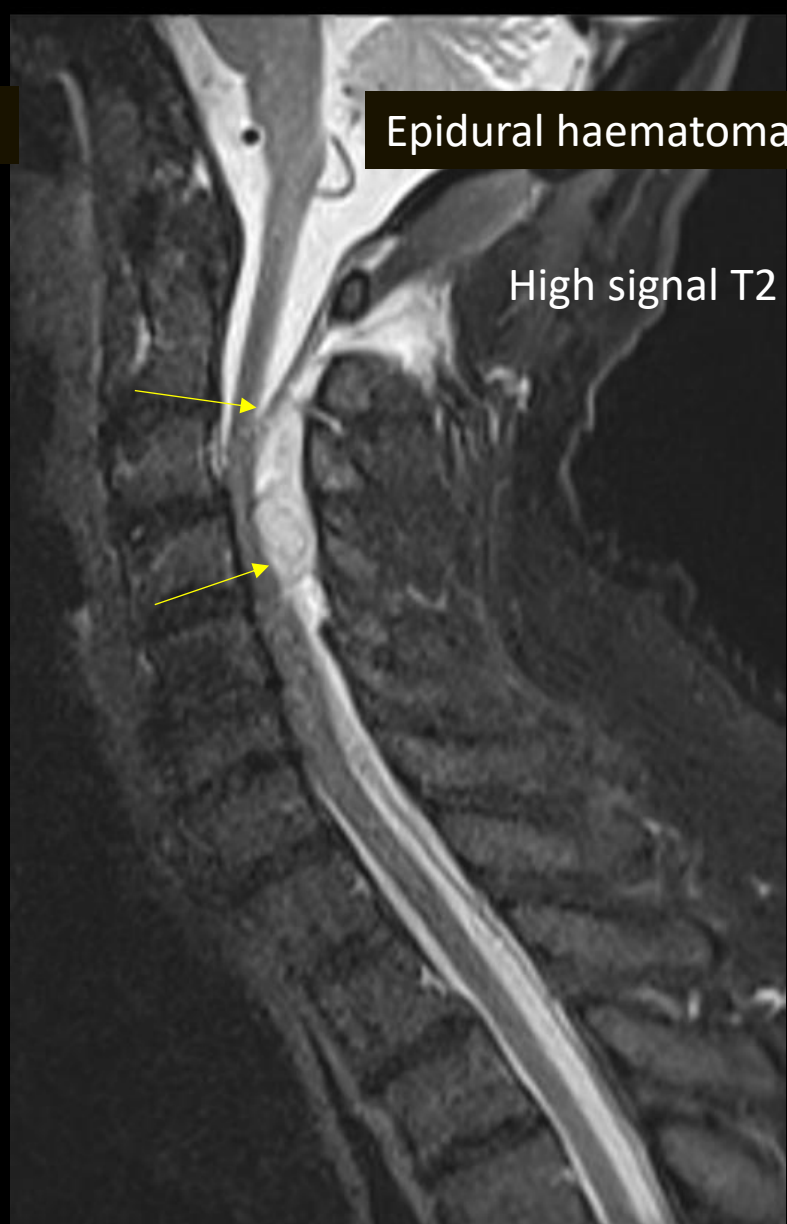
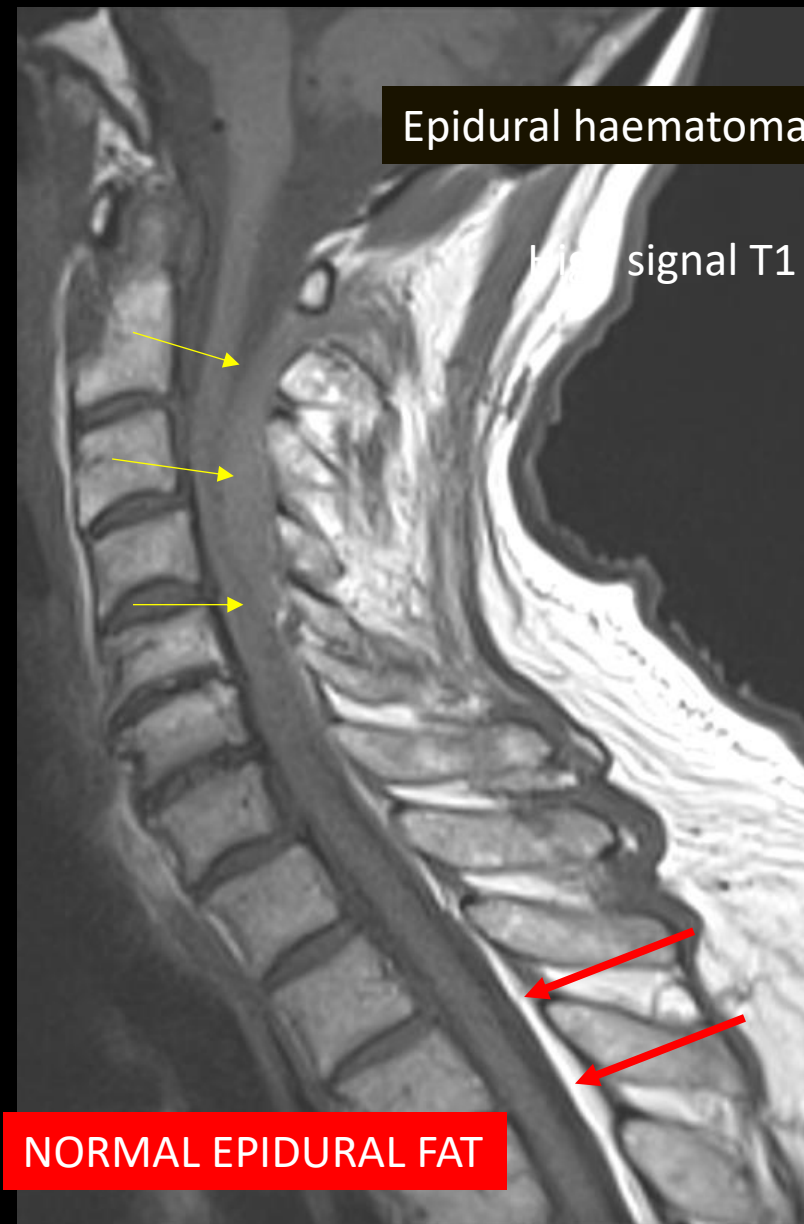
Epidural haematoma

Epidural haematoma:
smooth contour
Anterior or posterior compartments
Loss of epidural fat

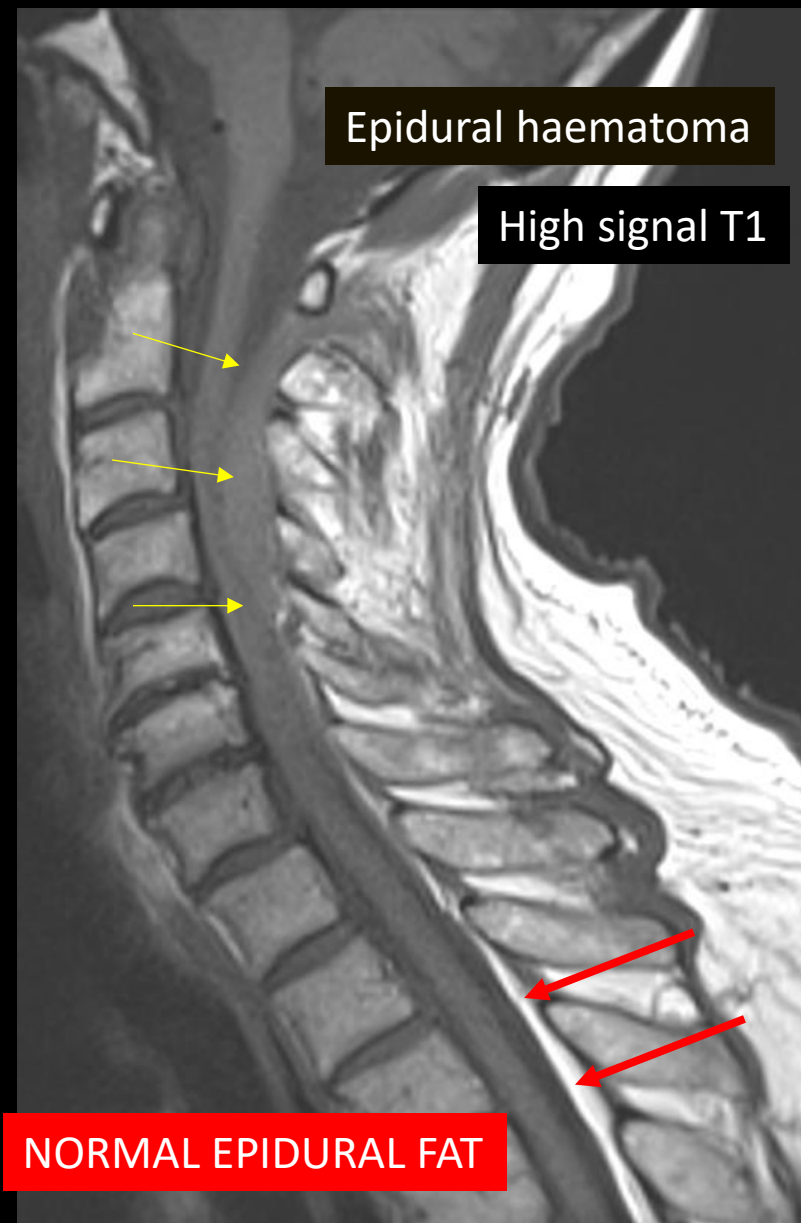
High signal T1

High signal T2

NORMAL EPIDURAL FAT



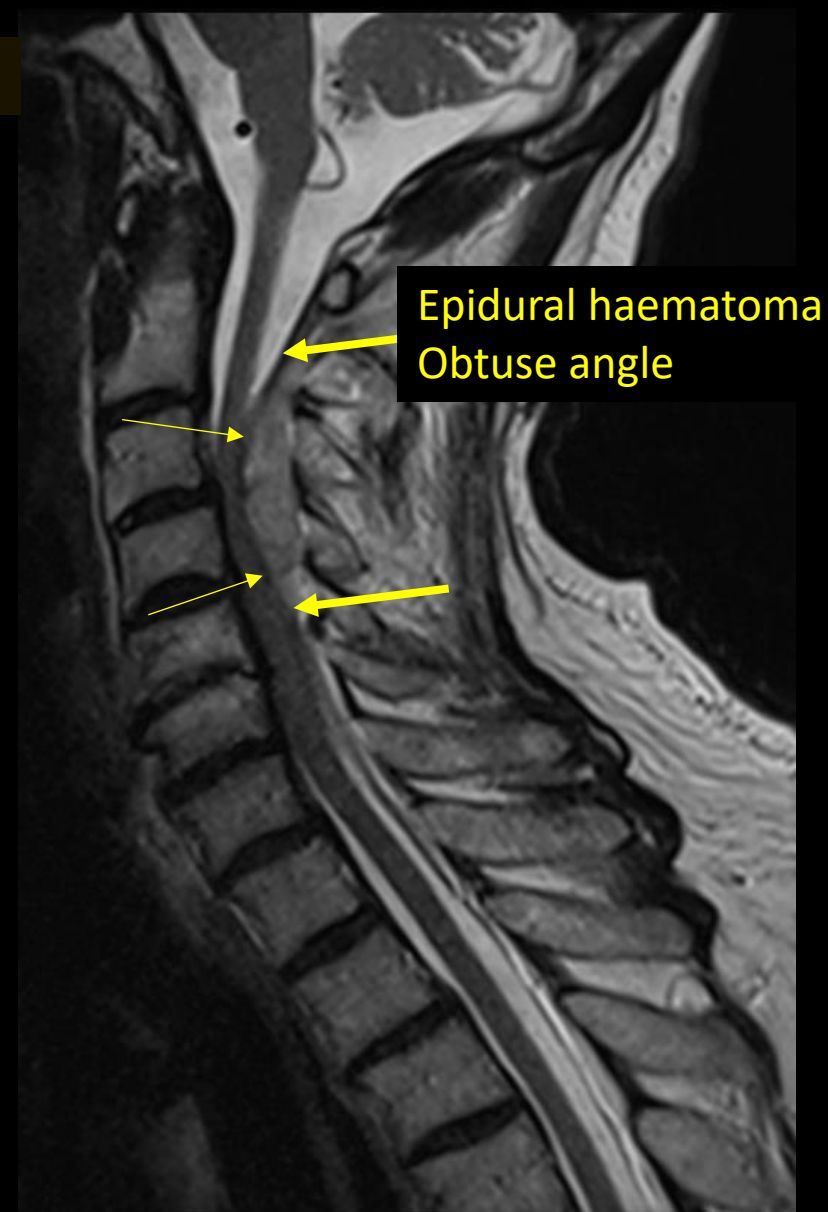
T1



T2 fat sat



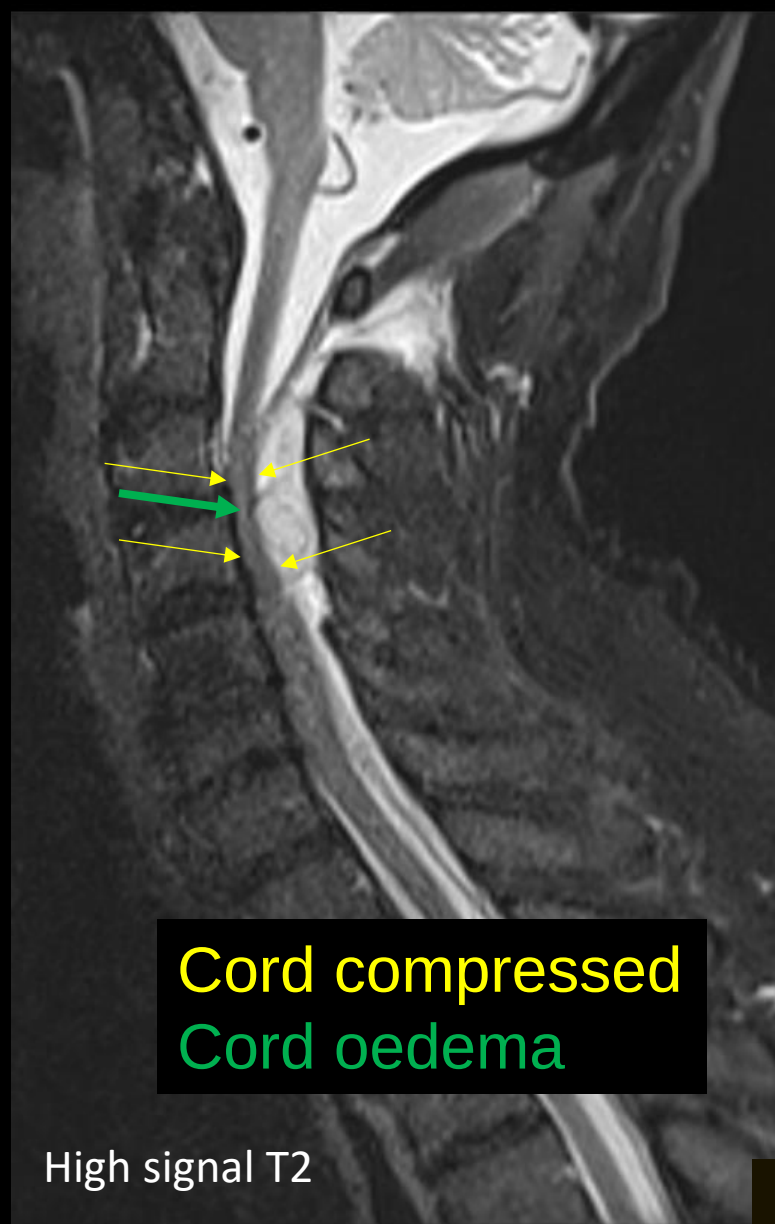
T2



T1

T2 fat sat

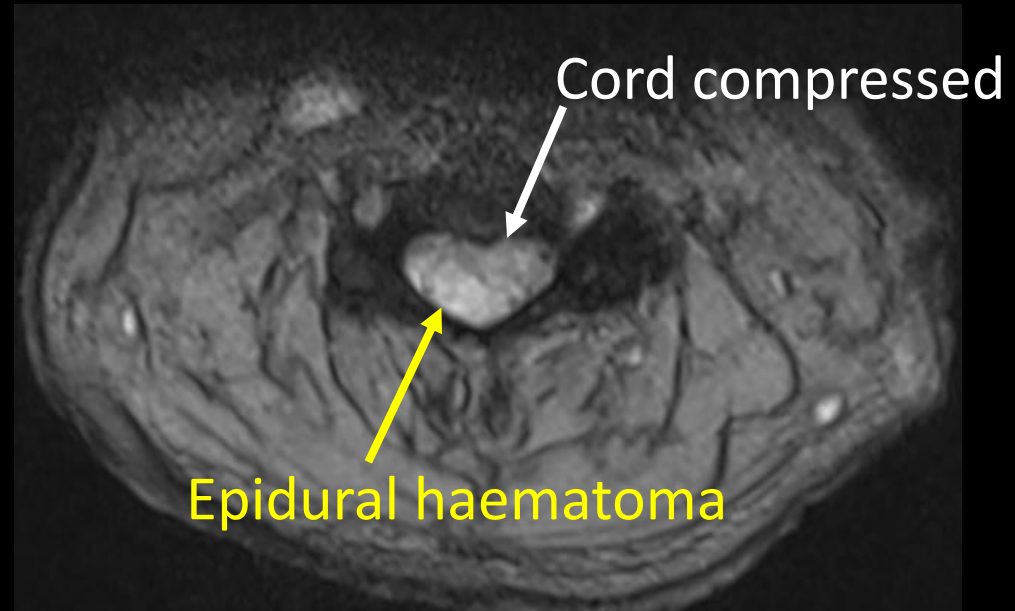
T2



Epidural haematoma compresses cord



Sag T2

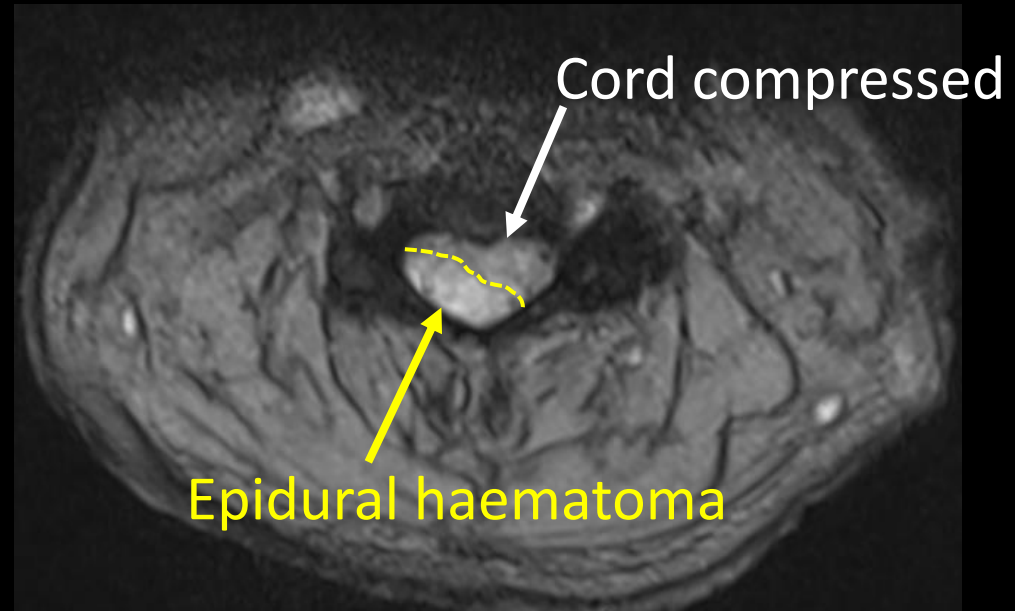


Ax Gradient echo

Epidural haematoma compresses cord



Sag T2



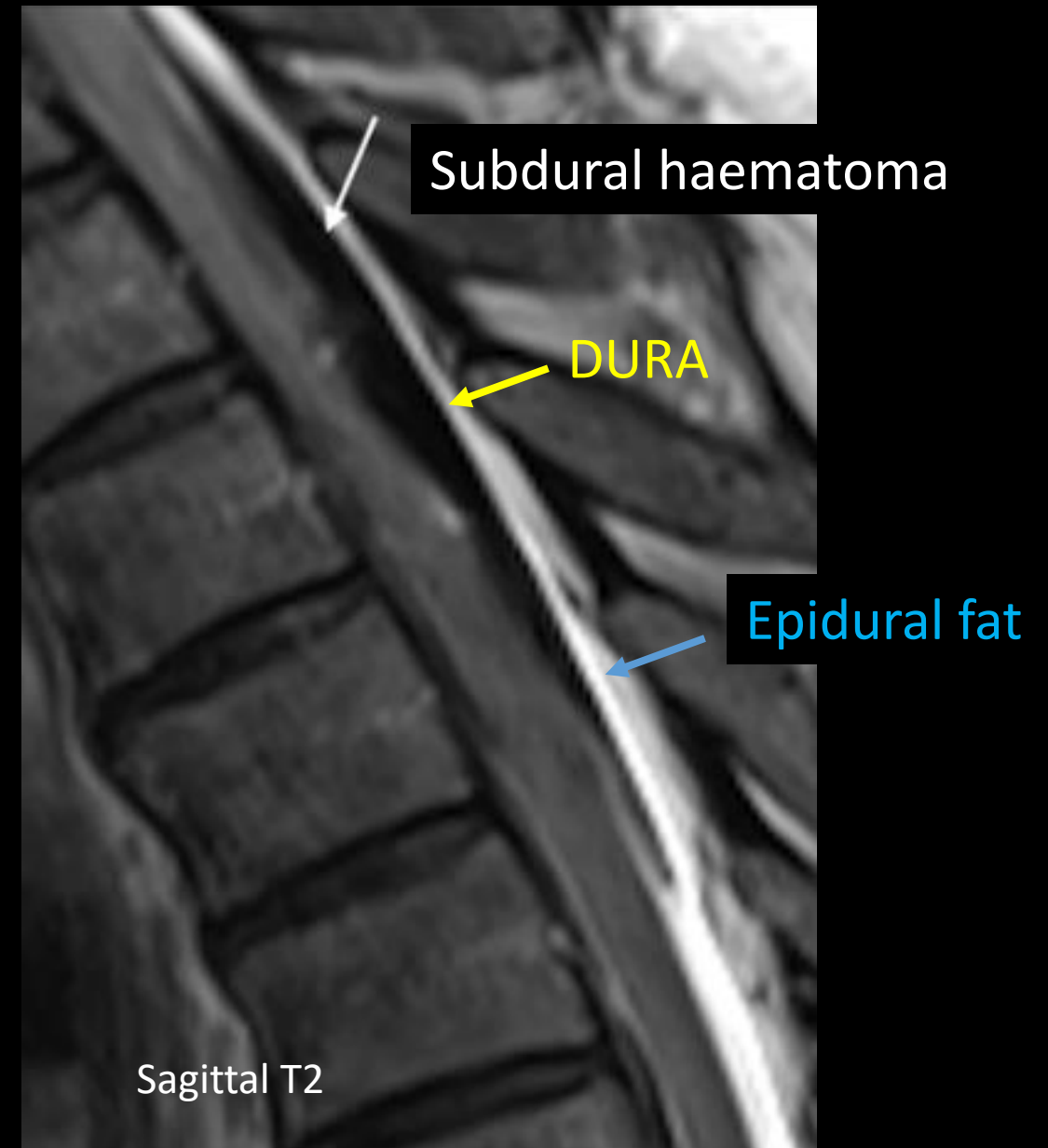
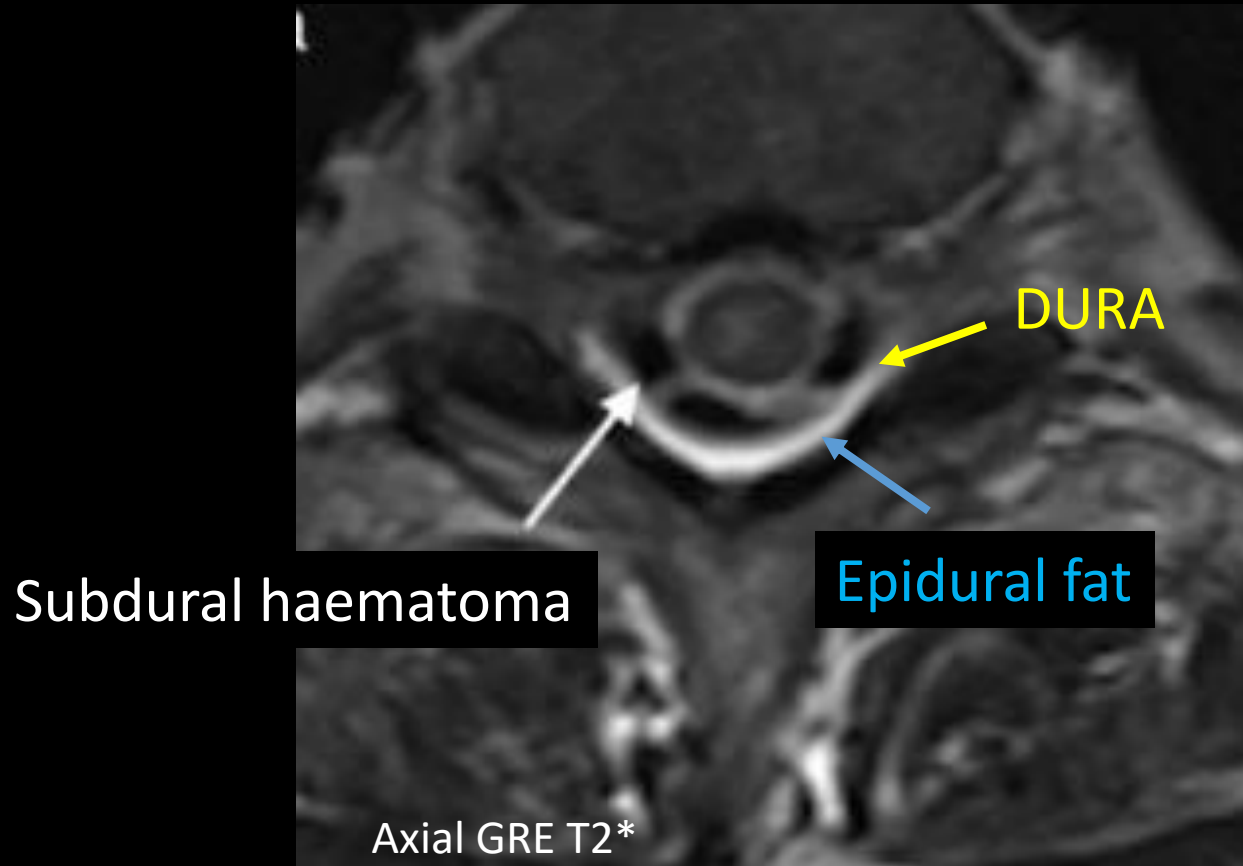
Ax Gradient echo

CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

Locating haematoma by compartment

- Subdural compartment (potential compartment)
 - Separate from epidural fat (which should be preserved)
 - Dura= T2 dark line btwn epidural fat and haemorrhage **CLUE!!!**
 - Inner contour is irregular
 - Can cause mass effect on cord (which flow artefact will not)

Subdural haematoma



Reproduced with permission from: Moriarty HK, O Cearbhaill R, Moriarty PD, Stanley E, Lawler LP, and Kavanagh EC. MR imaging of spinal haematoma: a pictorial review. *Br J Radiol* 2019; **92**: 2018053

Subdural haematoma

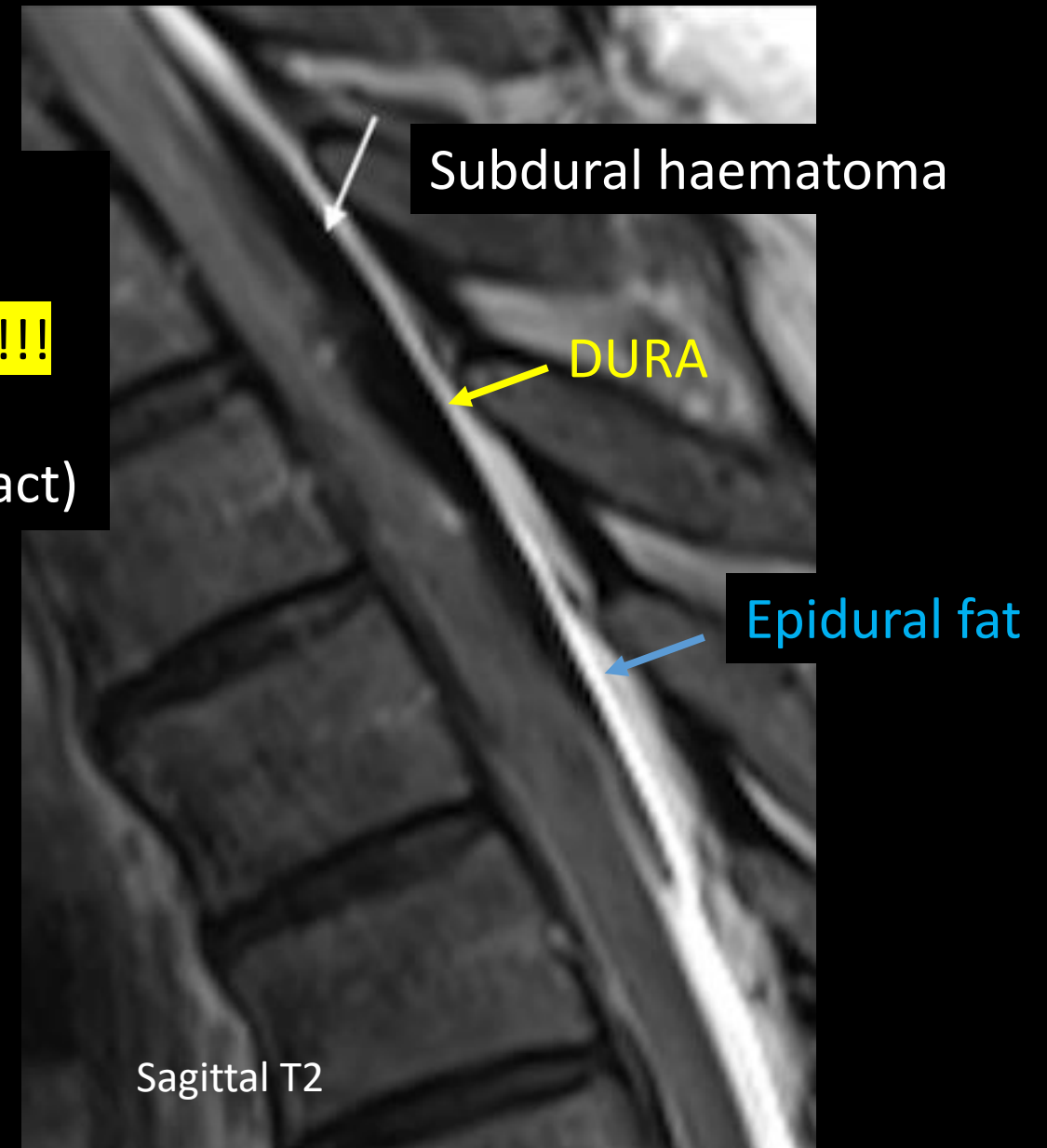
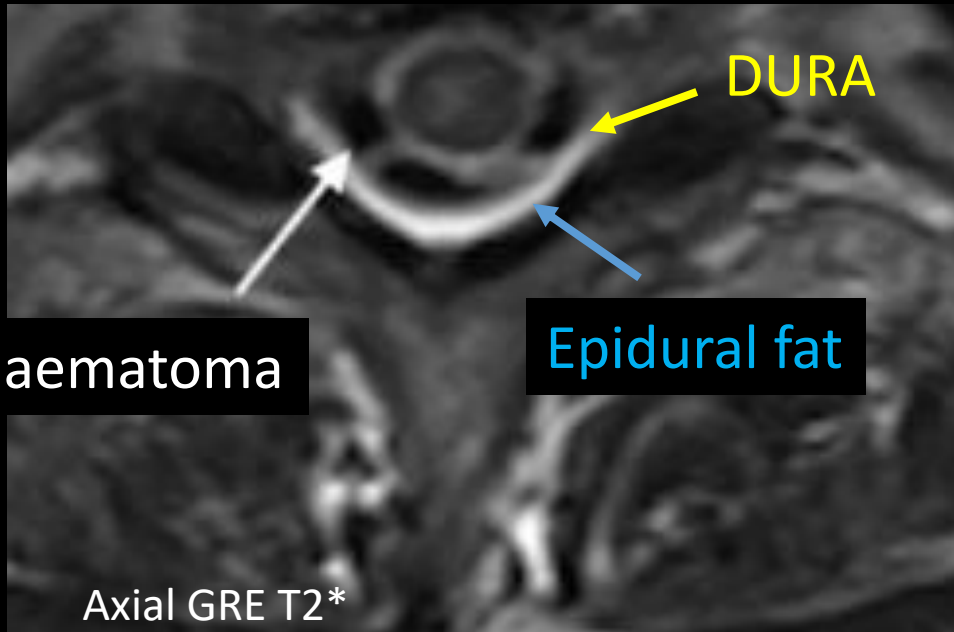
Subdural compartment (potential compartment)

Separate from epidural fat

Dura= btwn epidural fat and haemorrhage **CLUE!!!**

Inner contour is irregular

Can cause mass effect on cord (unlike flow artefact)



CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

Locating haematoma by compartment

- Subarachnoid space
 - Spreads throughout CSF space
 - Forms layers (dependant – either horizontal or distal thecal sac) **CLUE!!!**

SUBARACHNOID HAEMATOMA

No trauma, Sudden Leg weakness, on anti-coagulation



No trauma, Sudden Leg weakness, on anti-coagulation

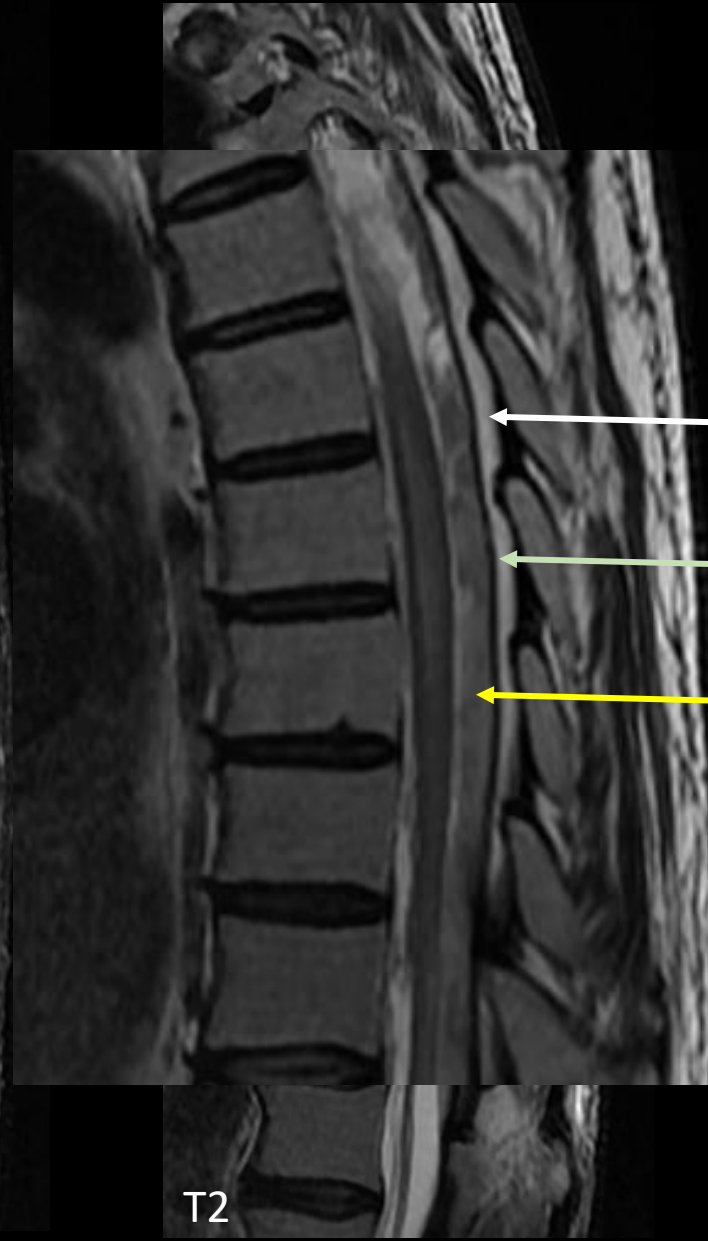


← Epidural fat preserved

No trauma, Sudden Leg weakness, on anti-coagulation



No trauma, Sudden Leg weakness, on anti-coagulation

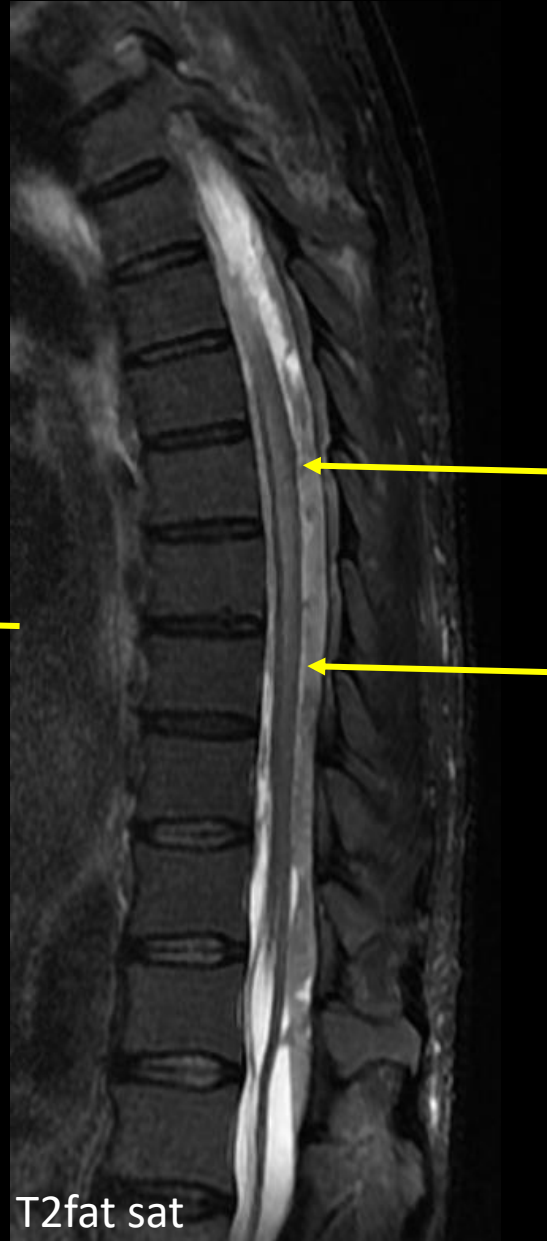
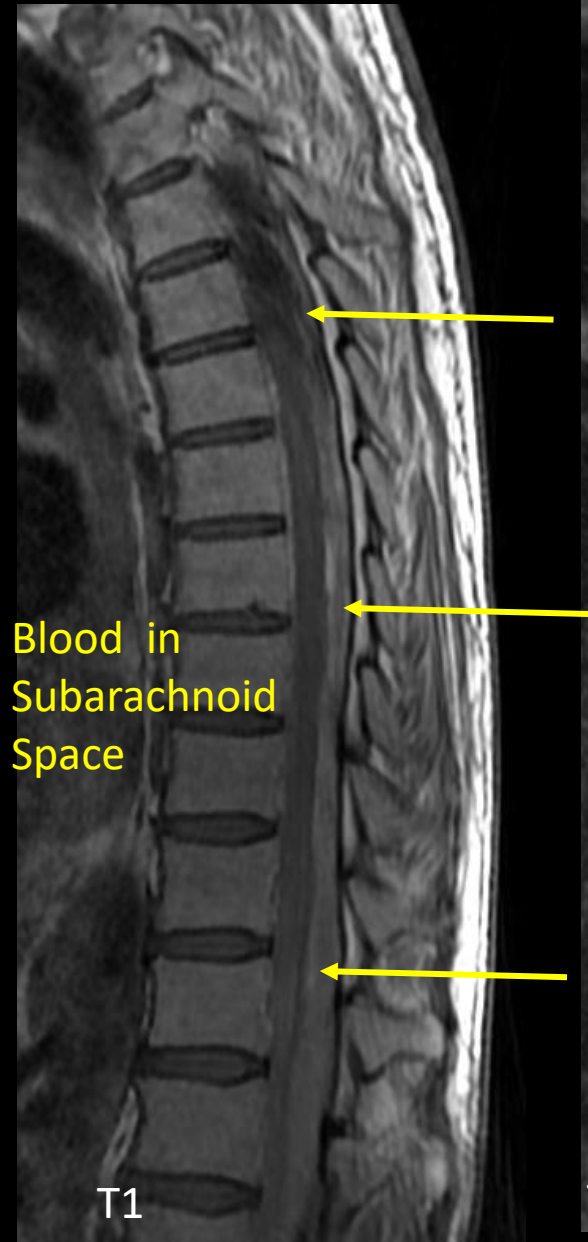


← Epidural fat preserved

← DURA

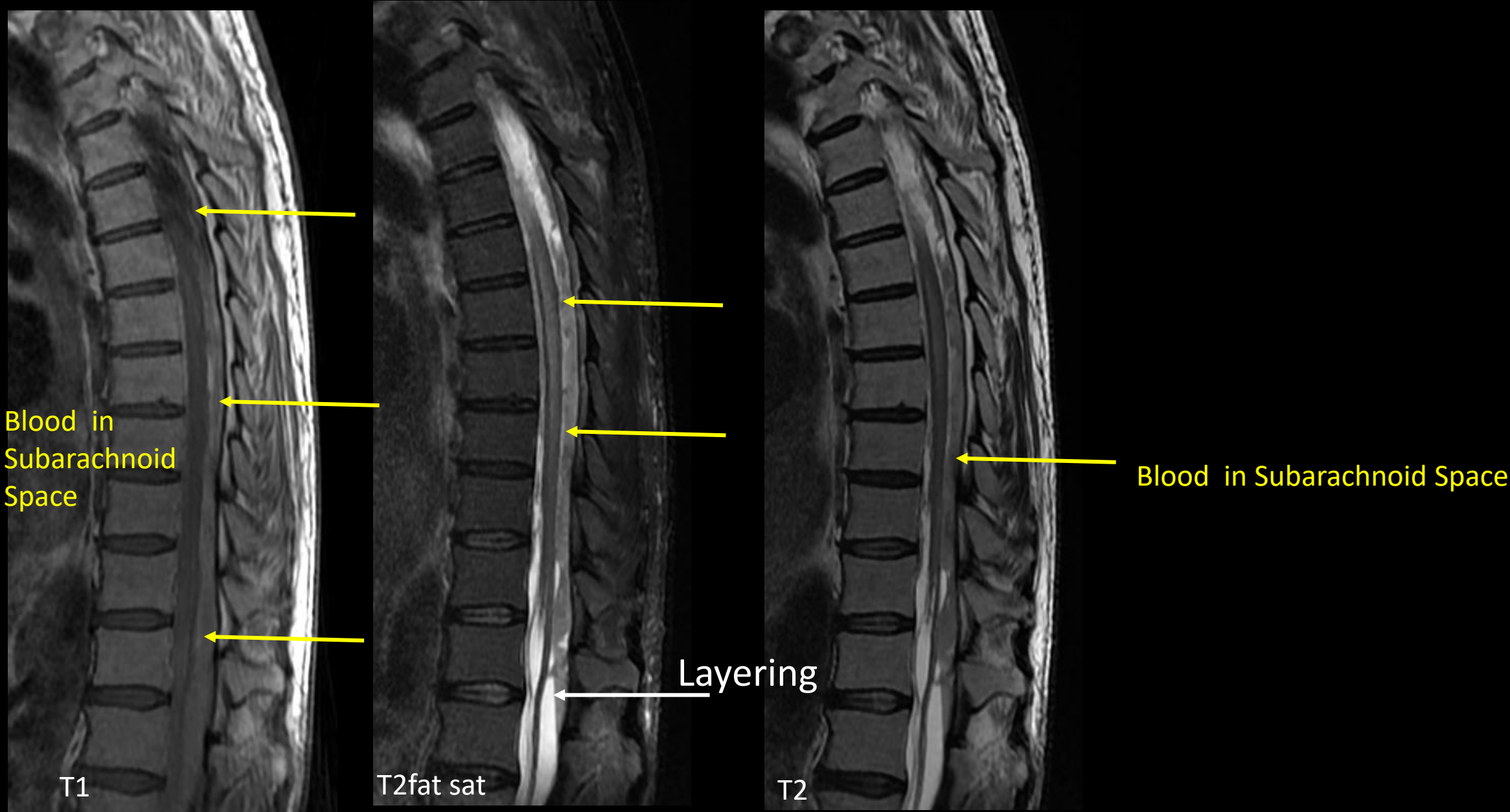
← Blood in Subarachnoid Space

No trauma, Sudden Leg weakness, on anti-coagulation

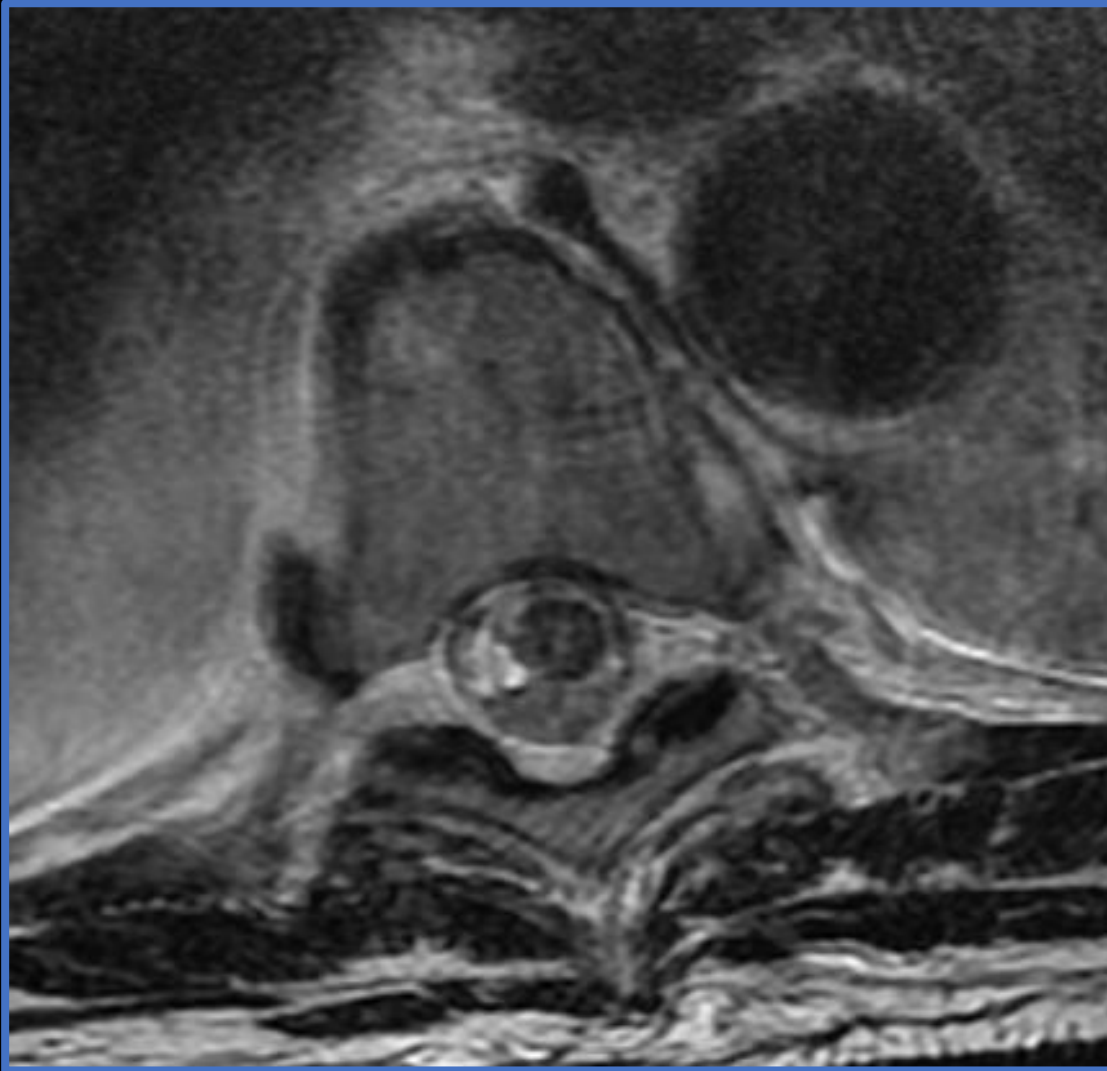


Blood in Subarachnoid Space

No trauma, Sudden Leg weakness, on anti-coagulation

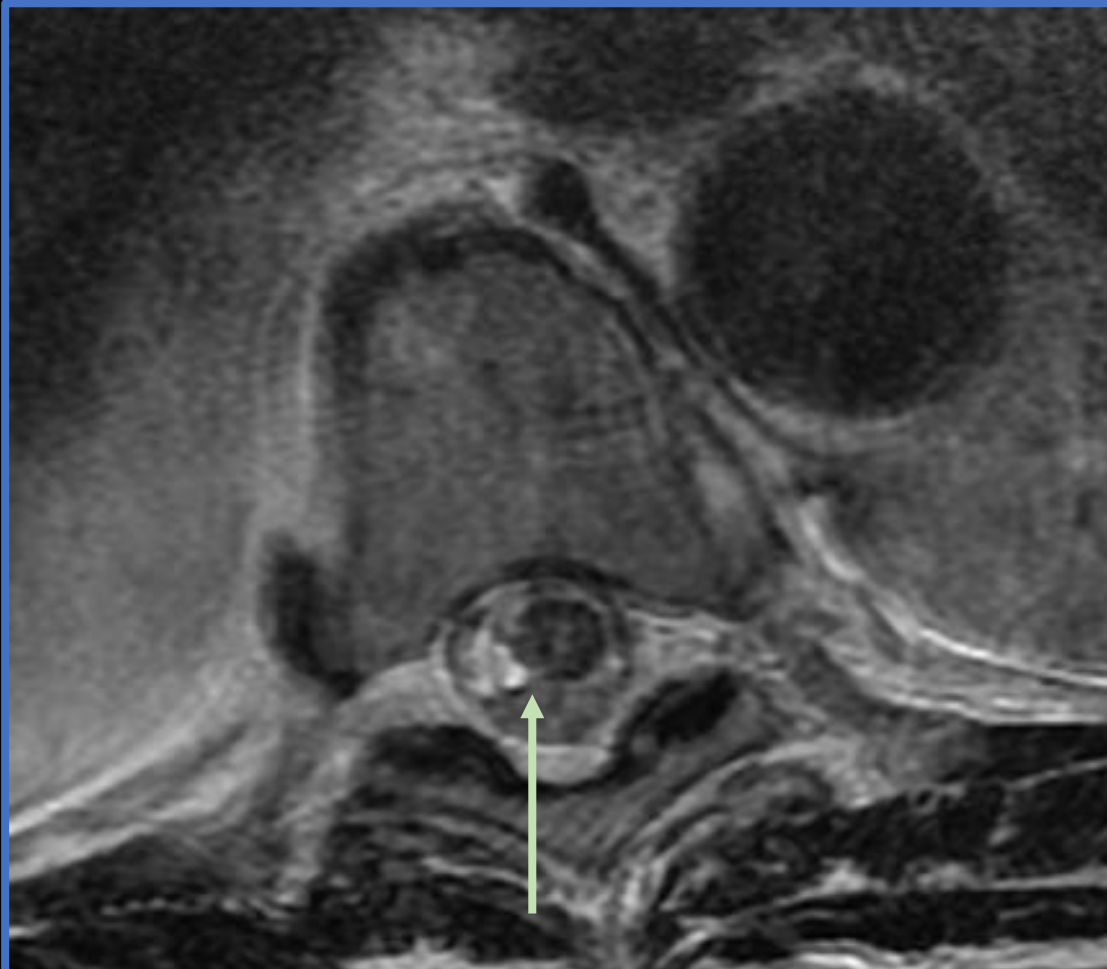


No trauma, Sudden Leg weakness, on anti-coagulation



Layering

No trauma, Sudden Leg weakness, on anti-coagulation

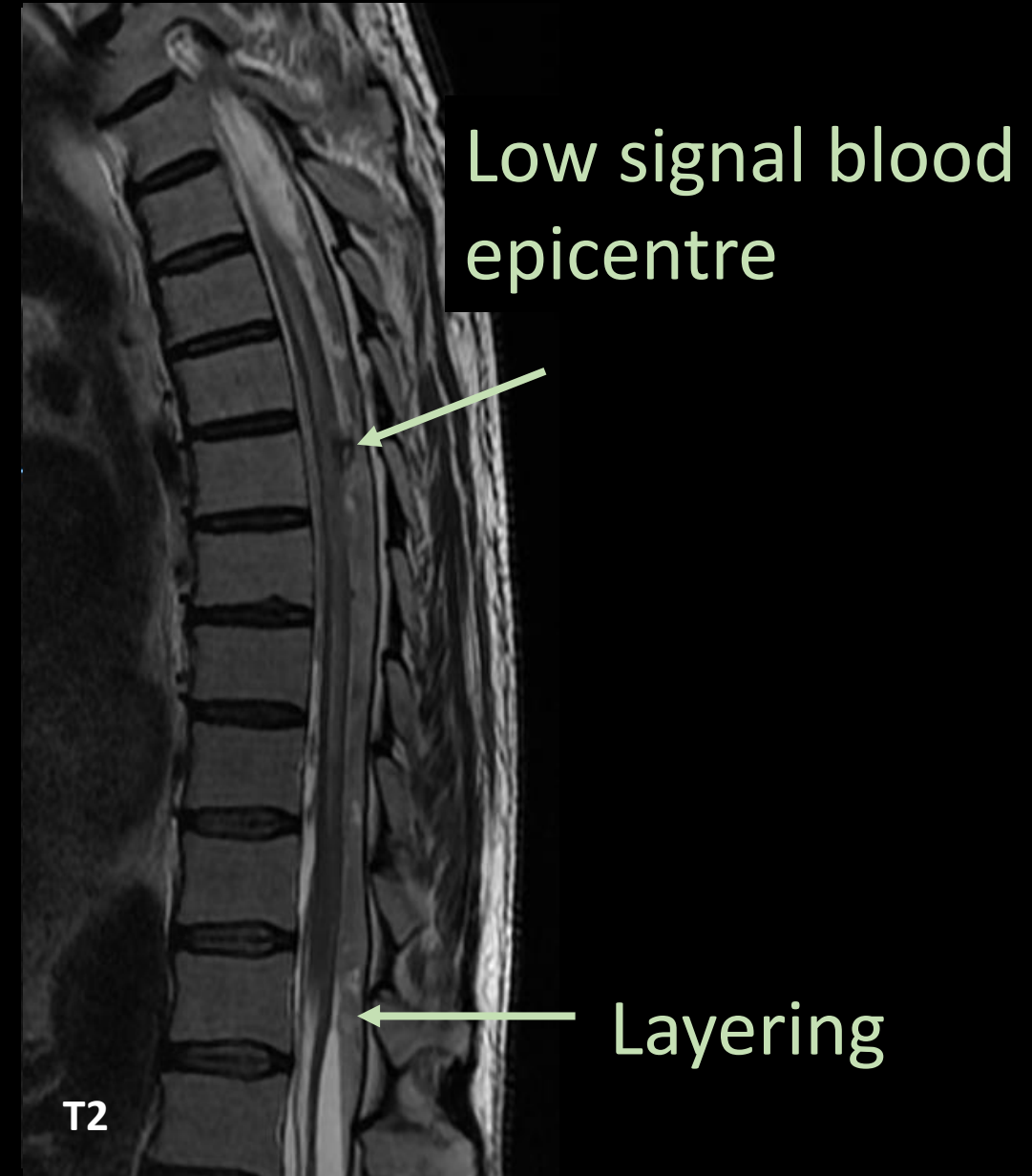


Layering of subarachnoid blood

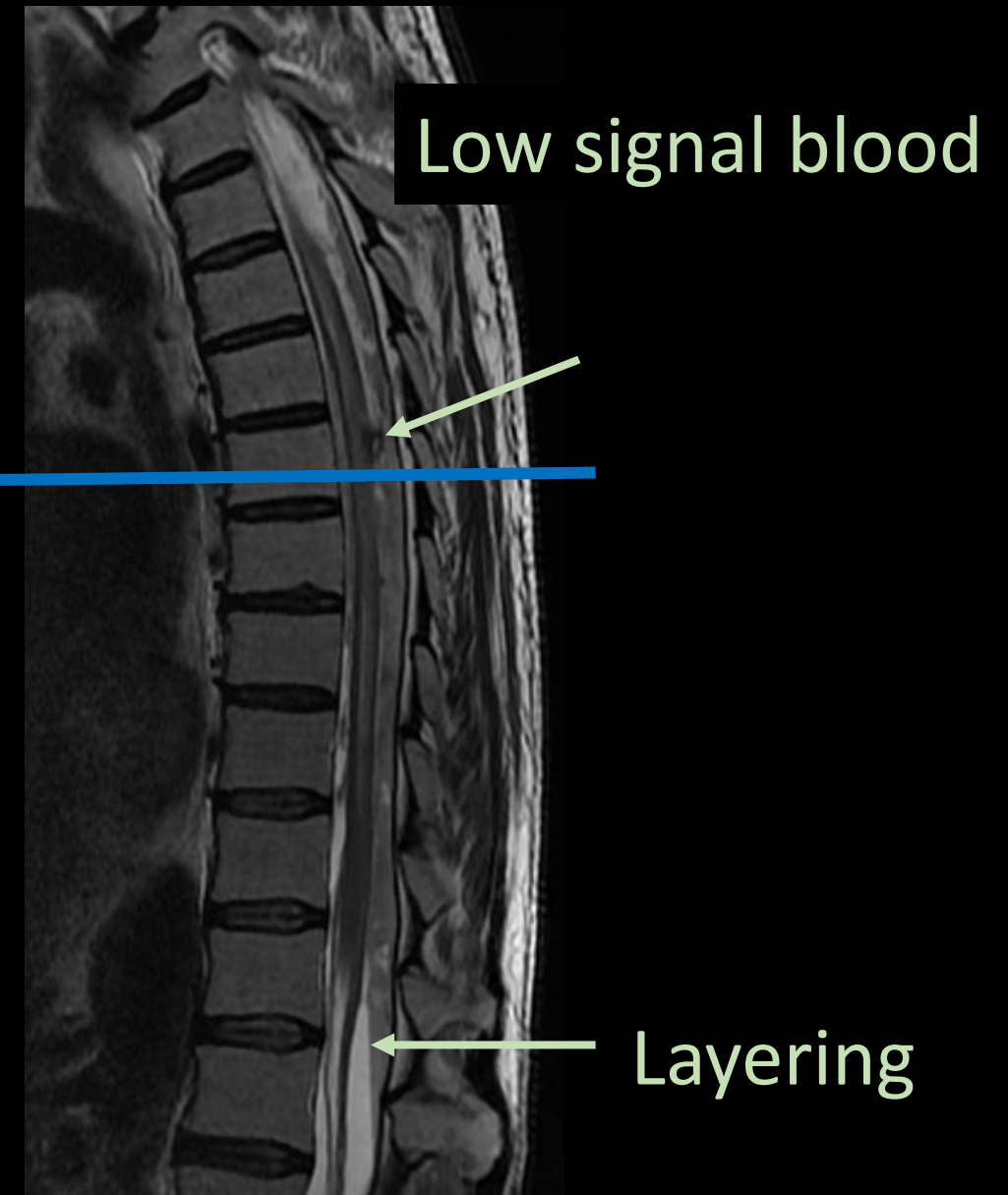
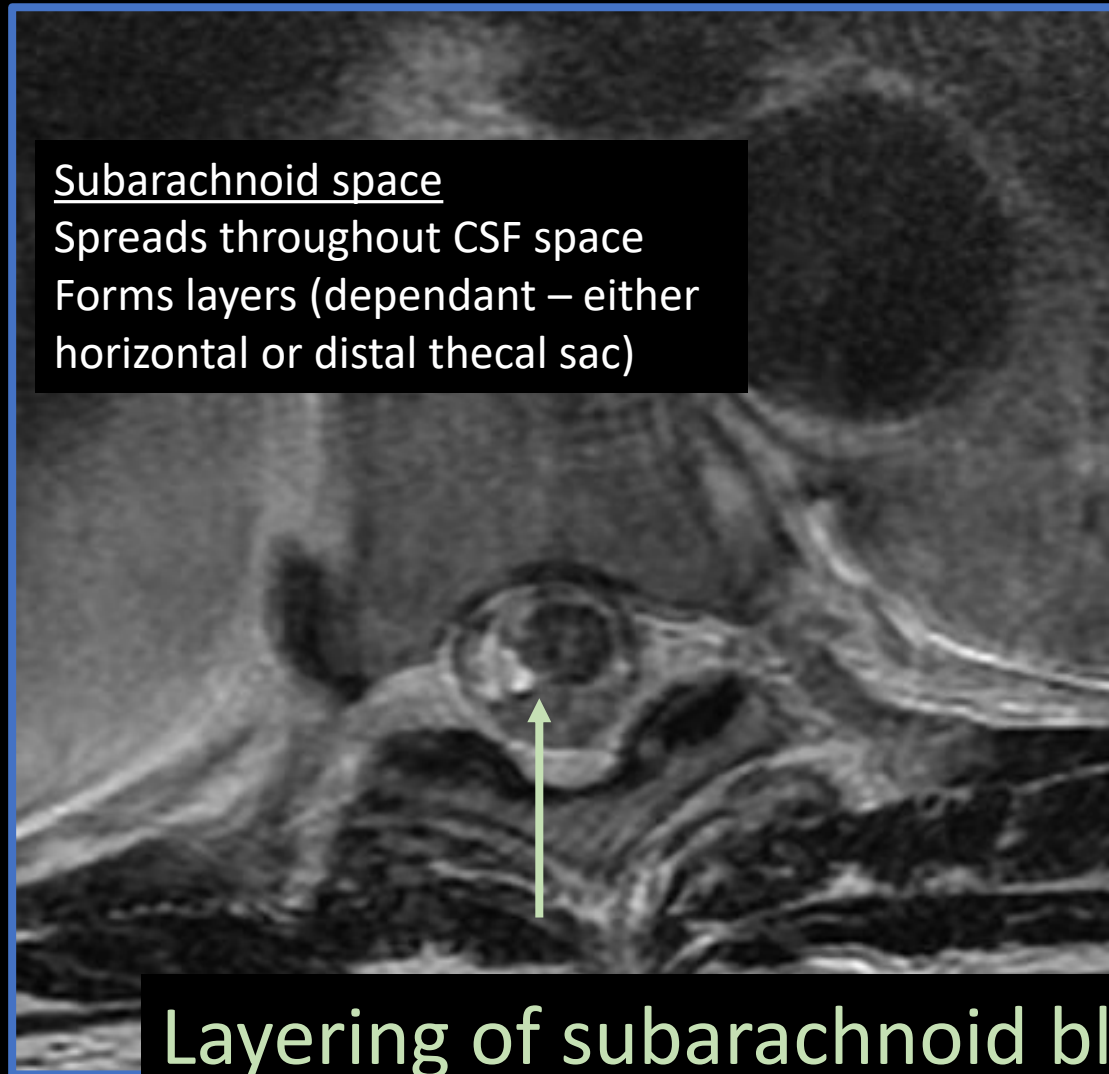


Layering

No trauma, Sudden Leg weakness, on anti-coagulation



No trauma, Sudden Leg weakness, on anti-coagulation



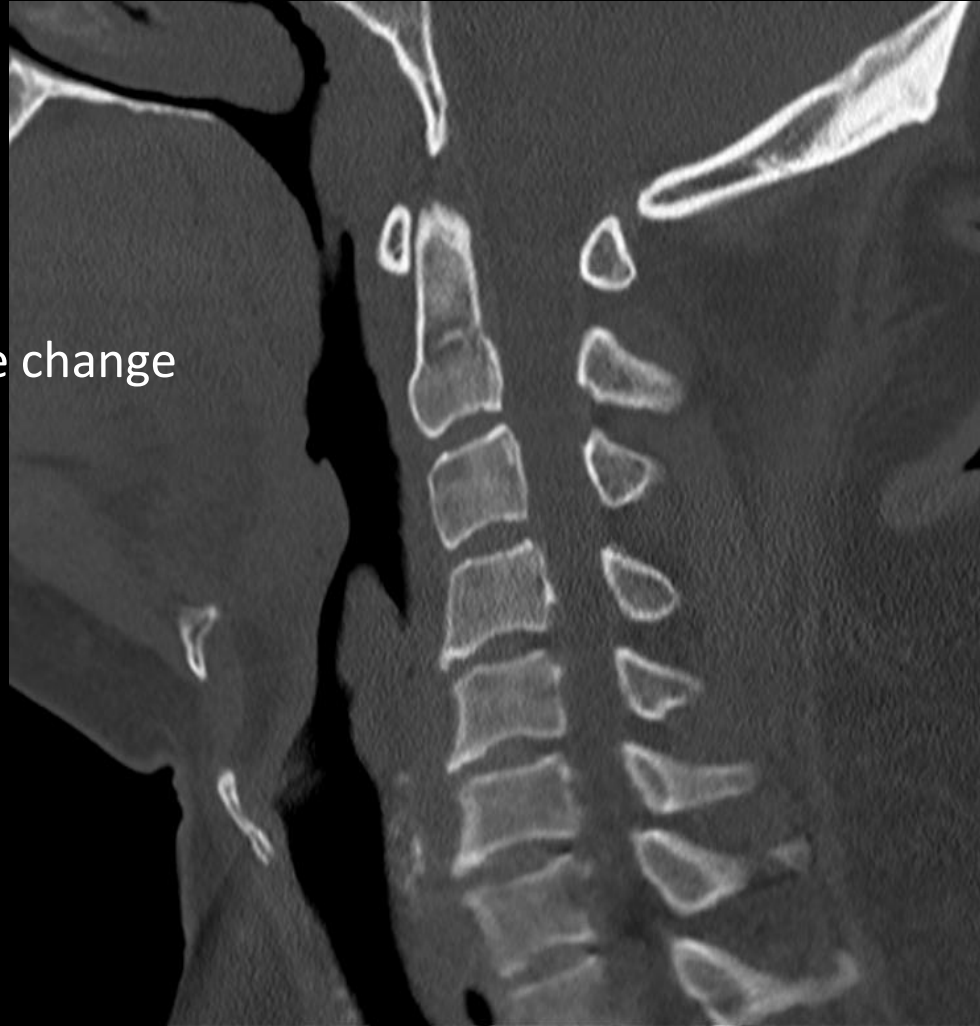
CORD OEDEMA, CONTUSION (=) HAEMORRHAGE

CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

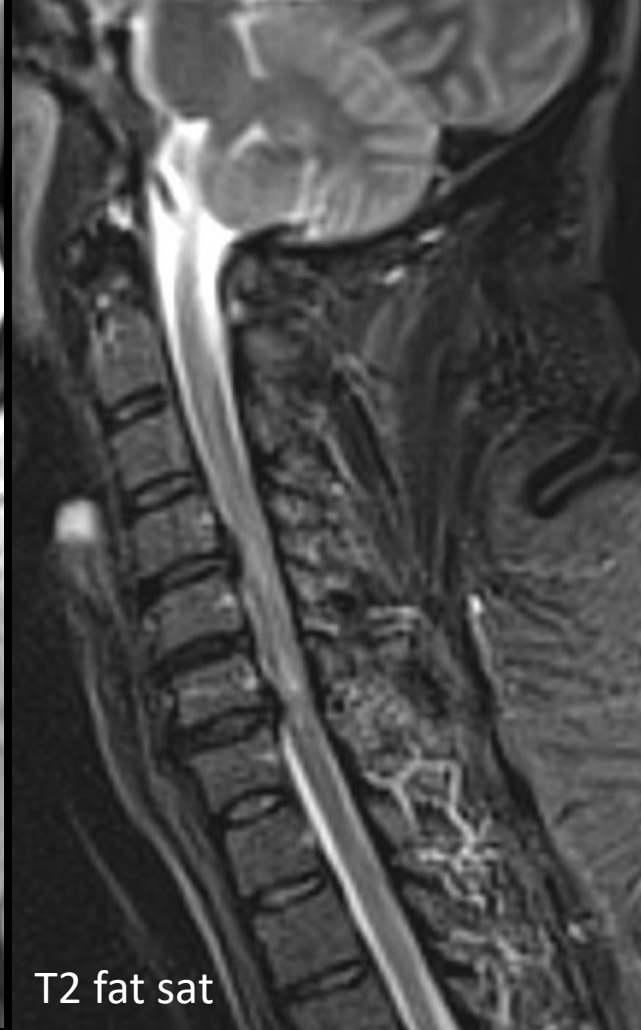
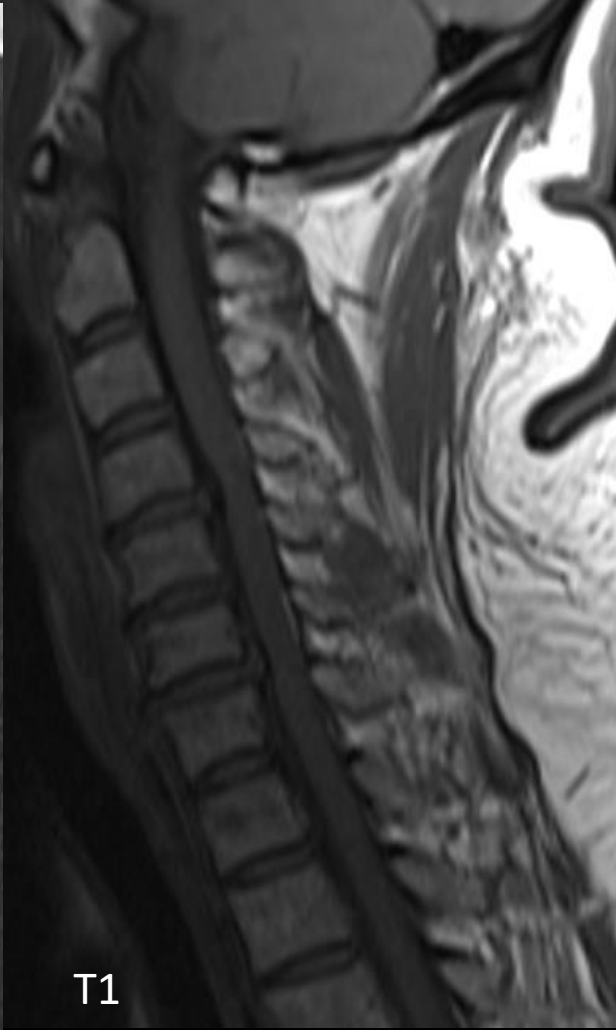
CORD OEDEMA

Fall from standing, initially ASIA A (no motor or sensory function)

CT: Spondylosis/Degenerative change
Especially C6/7
No fracture



Fall from standing, initially ASIA A (no motor or sensory function)



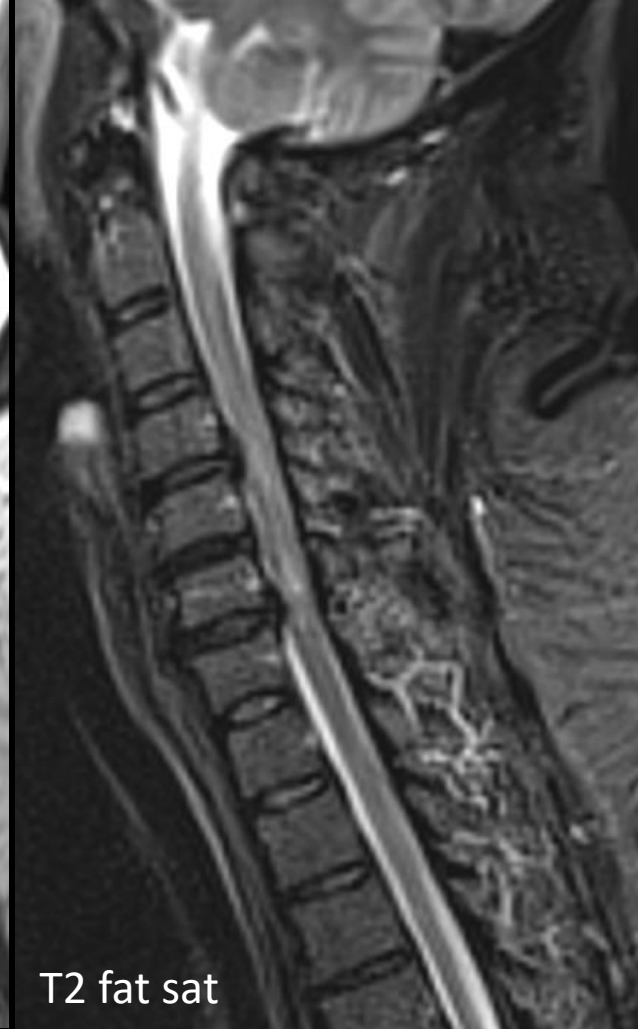
Sagittal CT and MRI

T1

T2 fat sat

T2

Fall from standing, initially ASIA A (no motor or sensory function)



Sagittal CT and MRI

T1

T2 fat sat

T2

Fall from standing, initially ASIA A (no motor or sensory function)

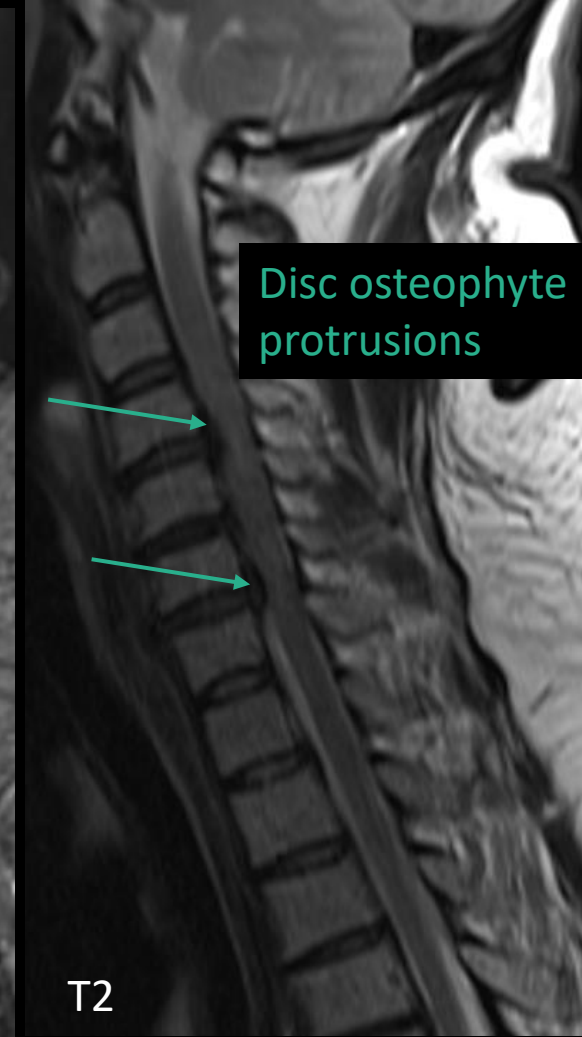


Congenitally narrow canal

T1



T2 fat sat



Disc osteophyte protrusions

T2

Sagittal CT and MRI

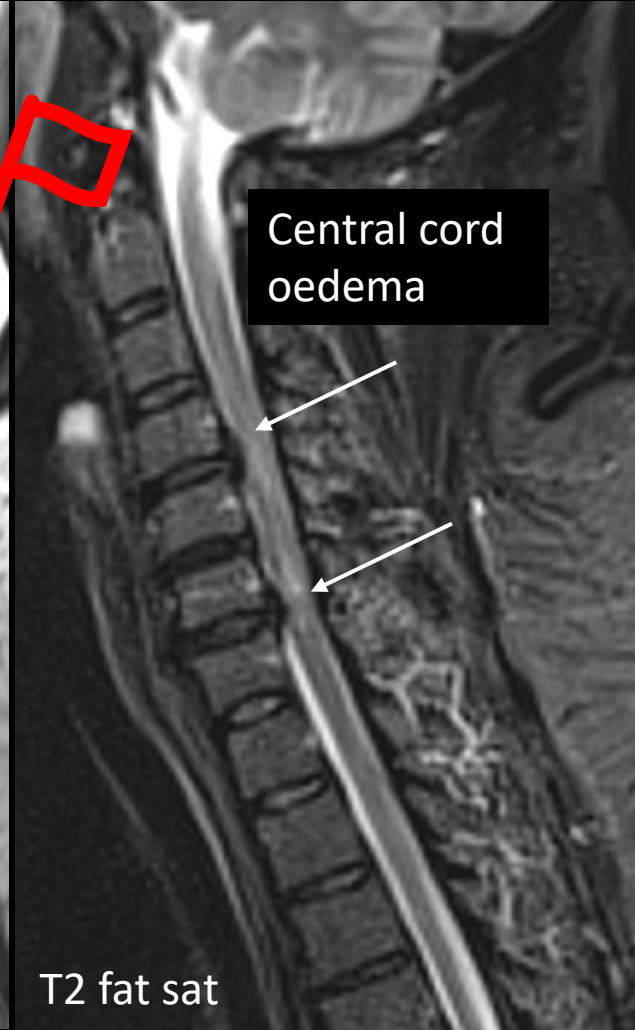
Fall from standing, initially ASIA A (no motor or sensory function)



Congenitally narrow canal

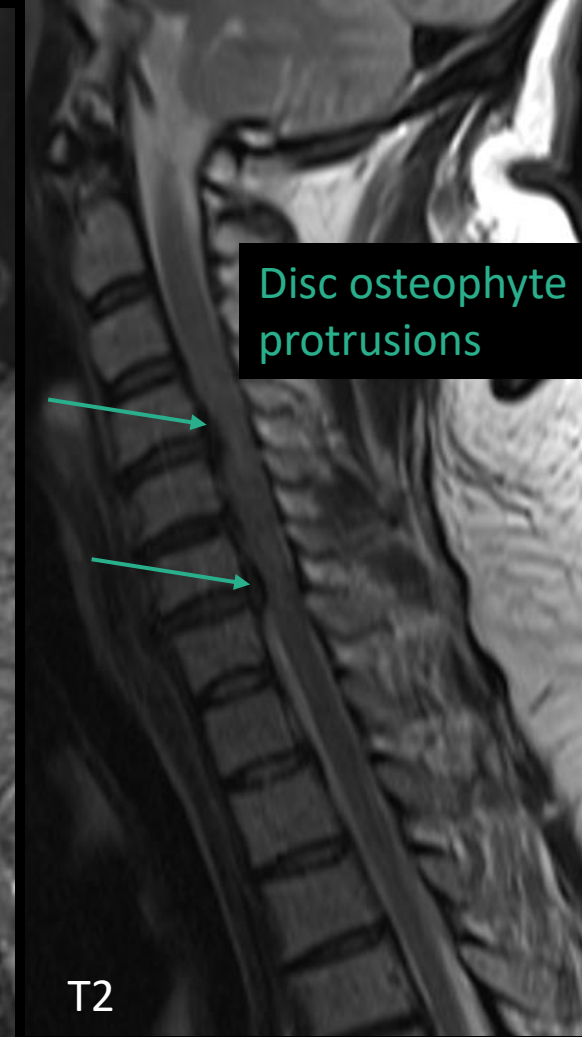


T1



Central cord
oedema

T2 fat sat



Disc osteophyte
protrusions

T2

Sagittal CT and MRI

Fall from standing, initially ASIA A (no motor or sensory function)



Congenitally narrow canal

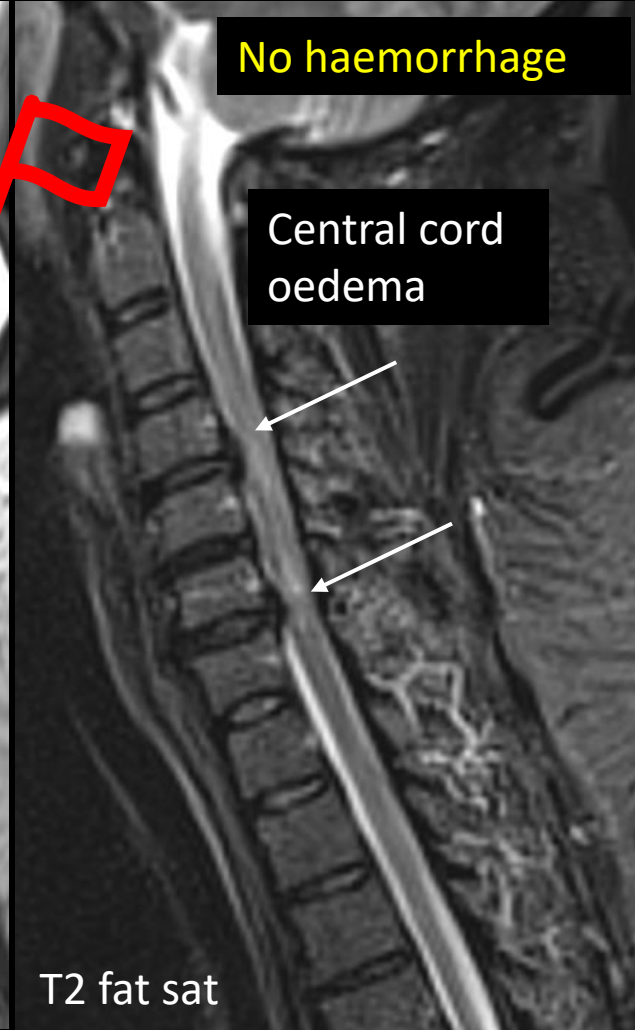
T1



No haemorrhage

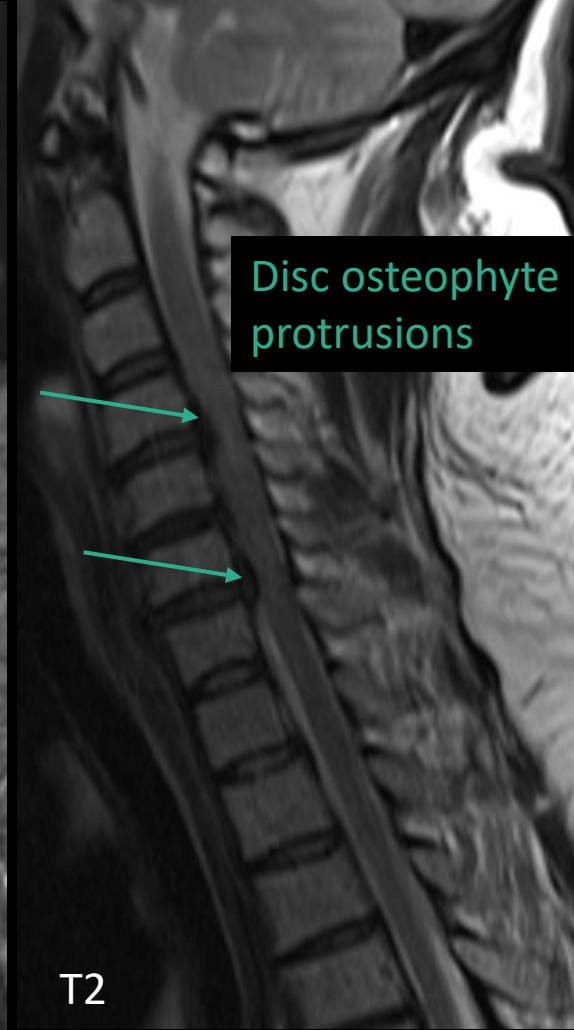
Central cord oedema

T2 fat sat



Disc osteophyte protrusions

T2

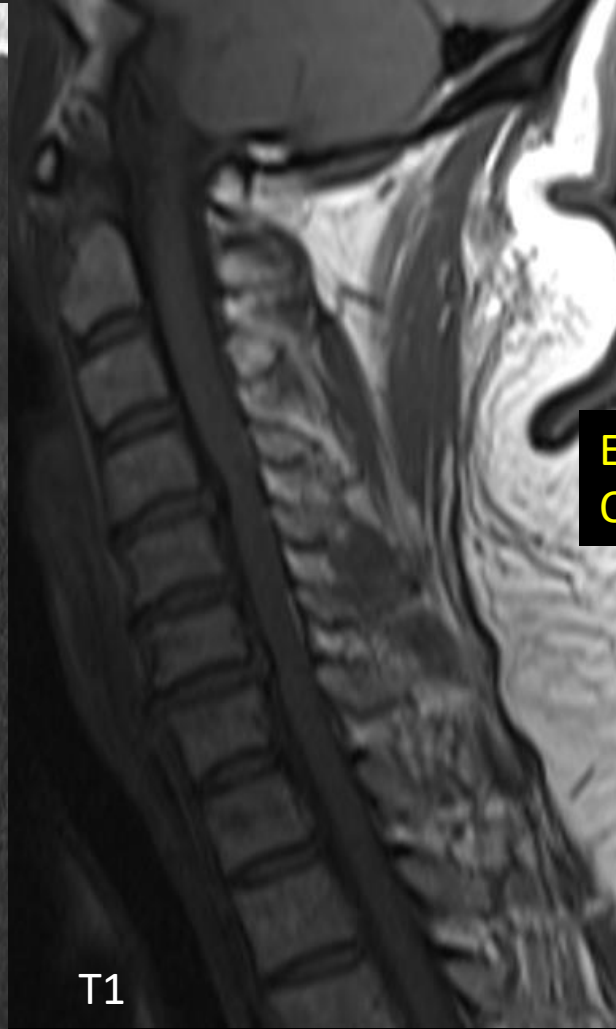


Sagittal CT and MRI

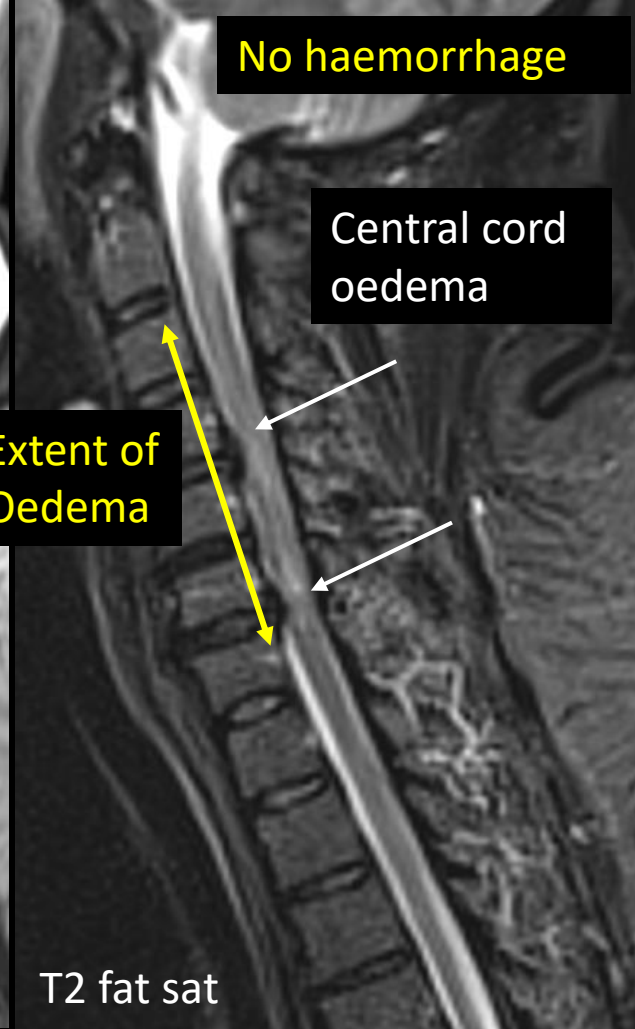
Fall from standing, initially ASIA A (no motor or sensory function)



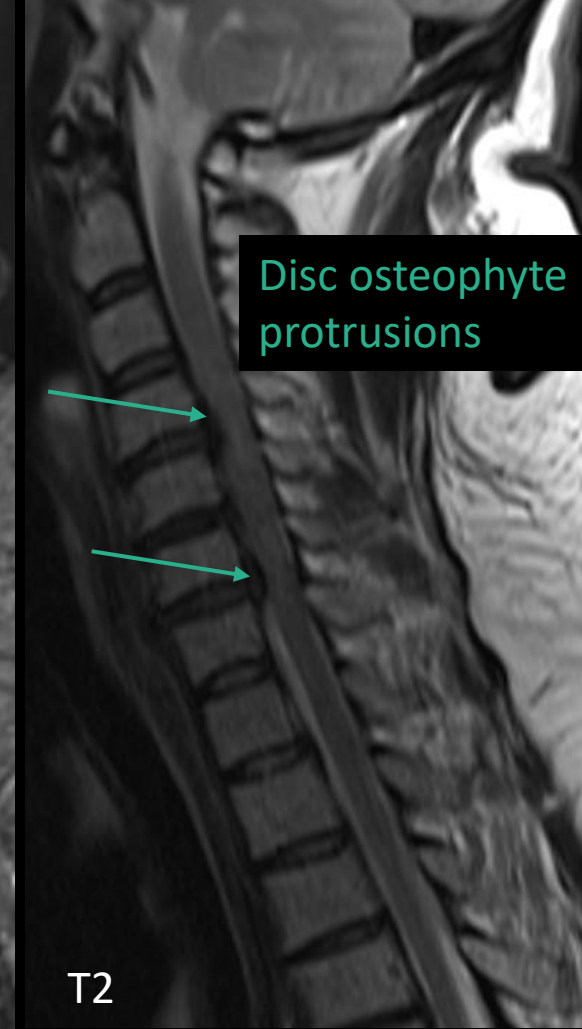
Sagittal CT and MRI



T1



T2 fat sat



T2

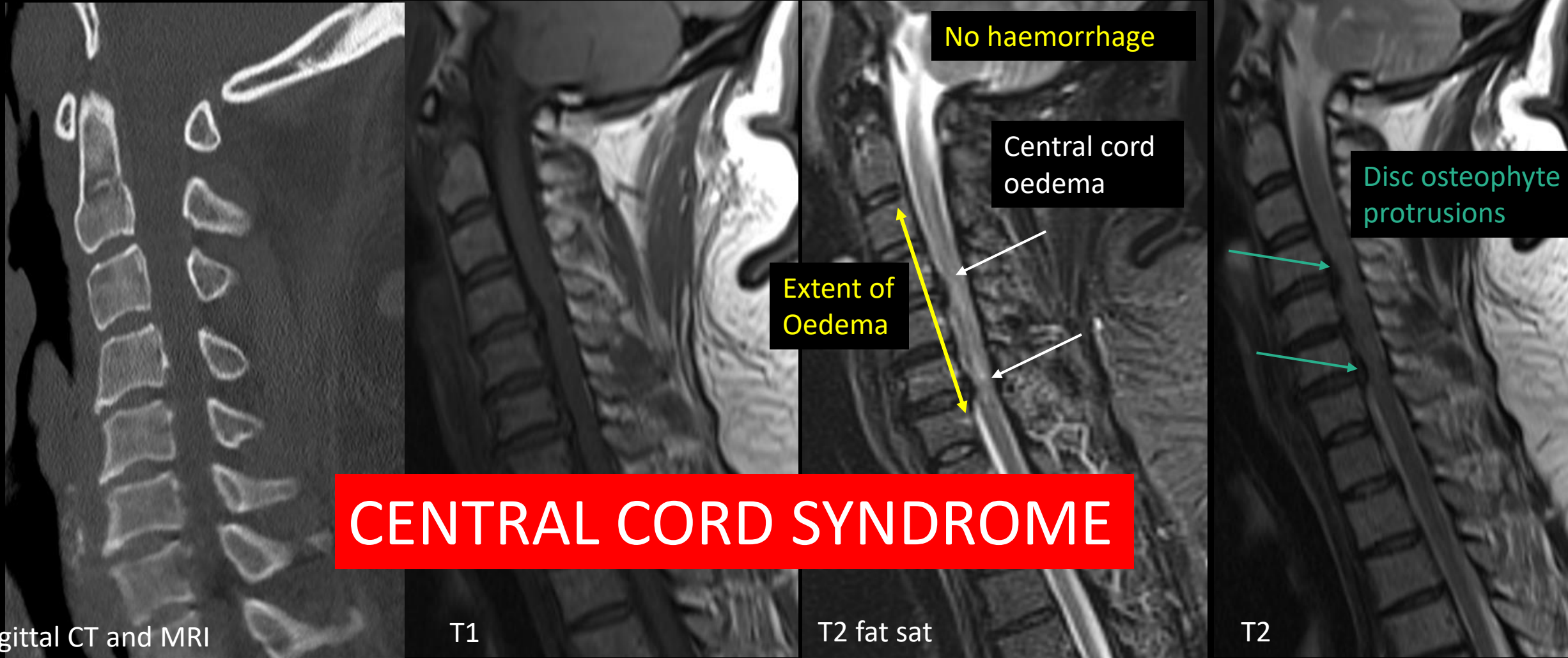
No haemorrhage

Central cord
oedema

Extent of
Oedema

Disc osteophyte
protrusions

Fall from standing, initially ASIA A (no motor or sensory function)



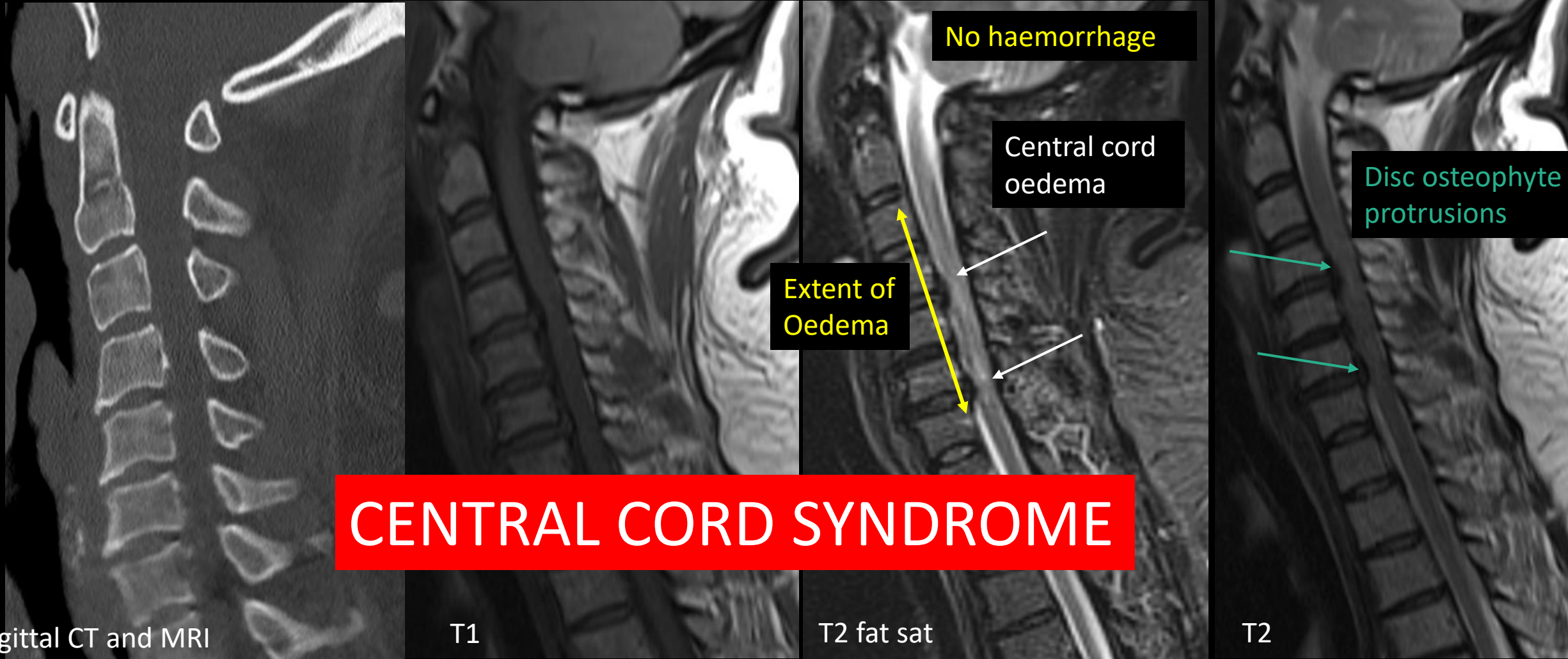
Sagittal CT and MRI

T1

T2 fat sat

T2

Fall from standing, initially ASIA A (no motor or sensory function) – made complete recovery



Sagittal CT and MRI

T1

T2 fat sat

T2

CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	+/-
Intra-canal, extra-axial	Epidural	+/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	+/-
Intra-axial	Intra-medullary	Oedema +/-
		Contusion +/-
		Haemorrhage +/-
Extra-canal	Interspinous	+/-

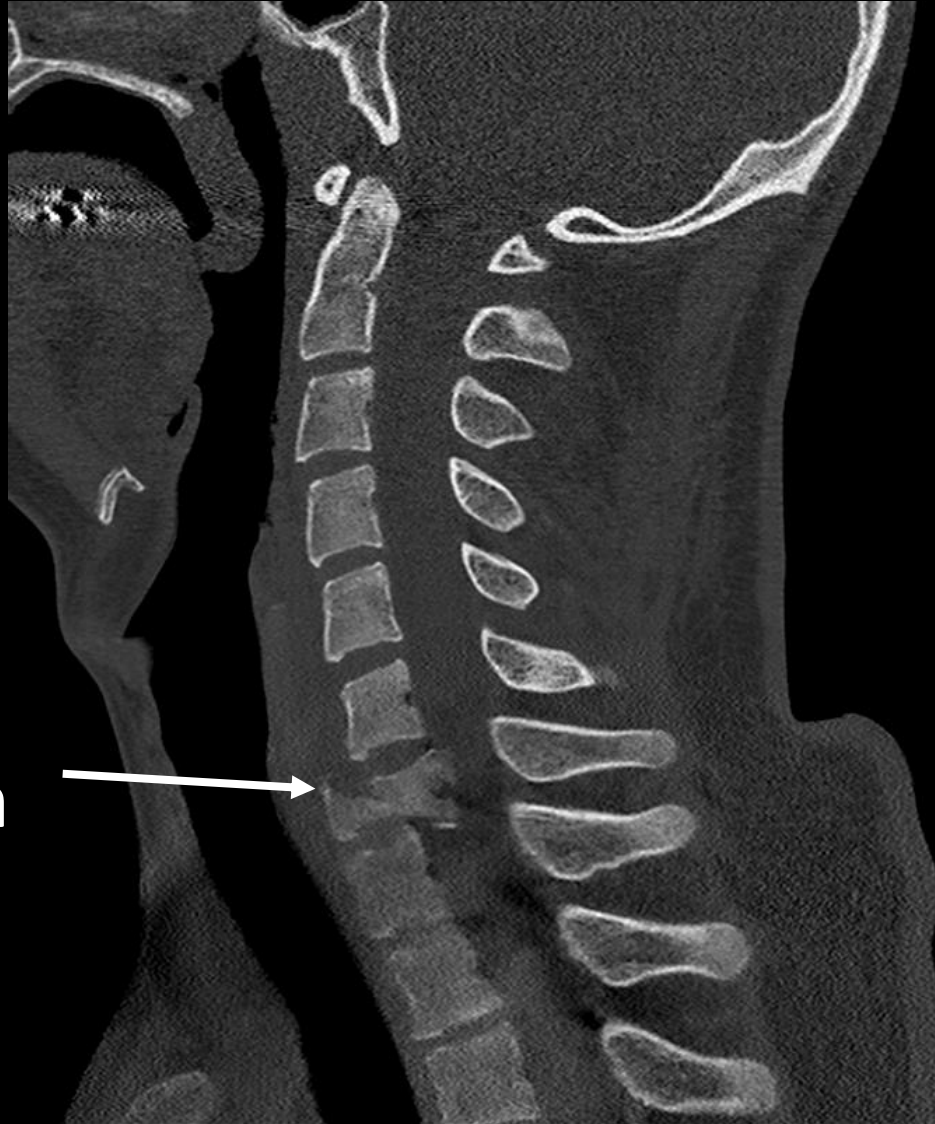
CORD HAEMORRHAGE

CONTUSION = HAEMORRHAGE

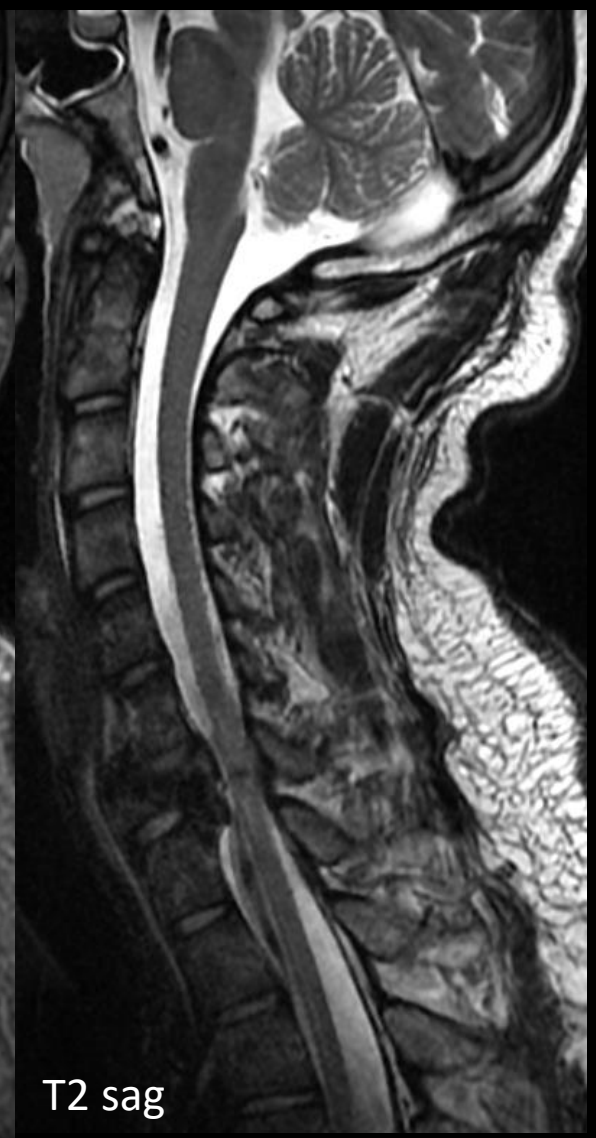
C7 Burst fracture

ASIA B (sensory function preserved, motor lost)

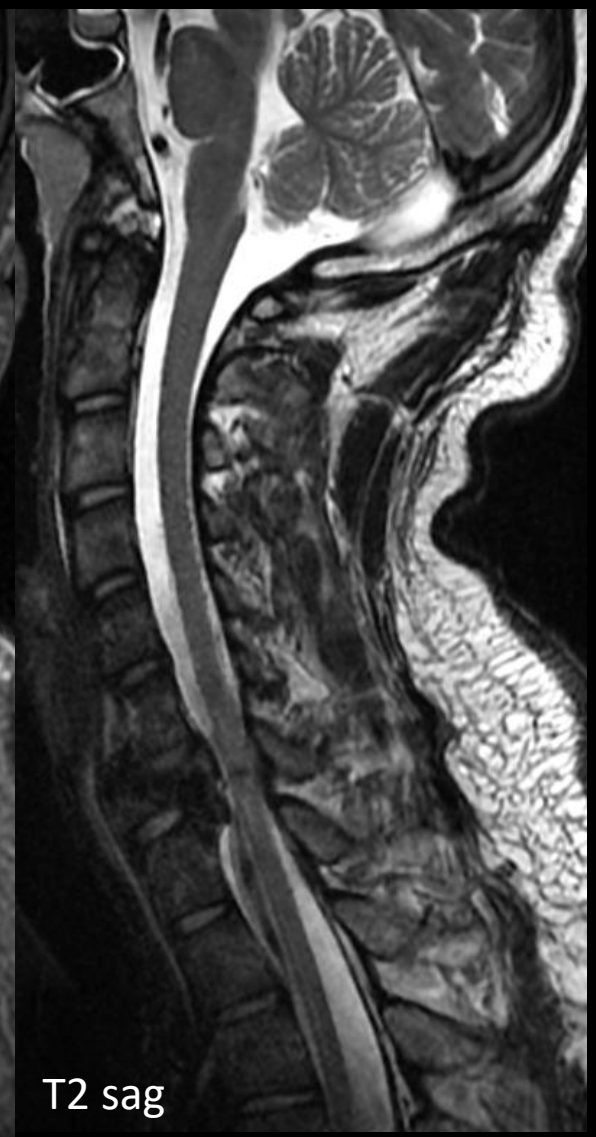
C7 Burst #
retropulsion



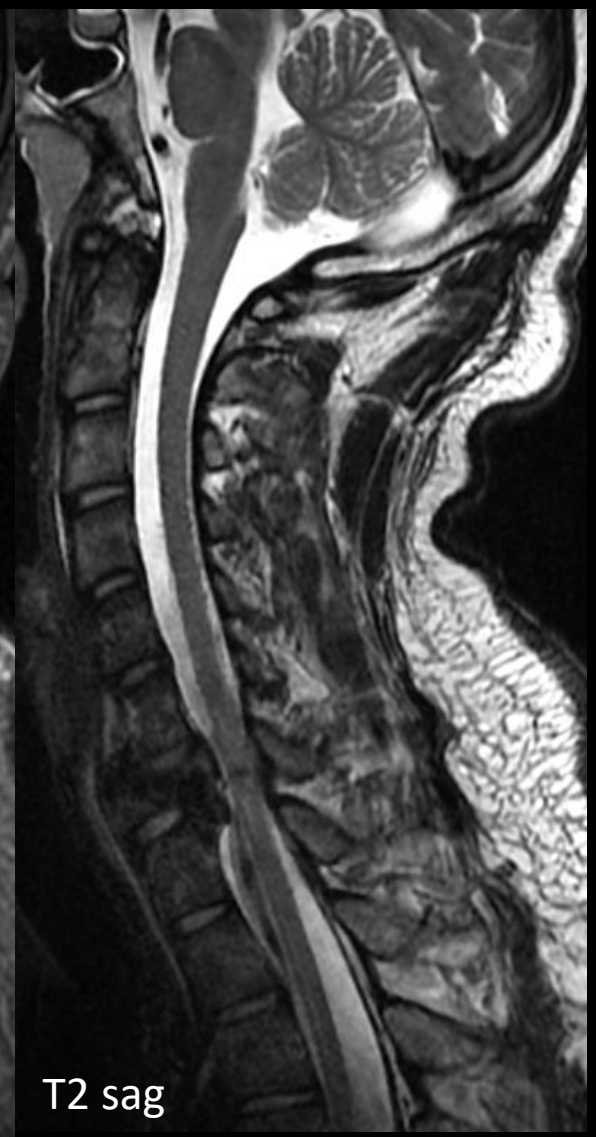
C7 Burst fracture - ASIA B



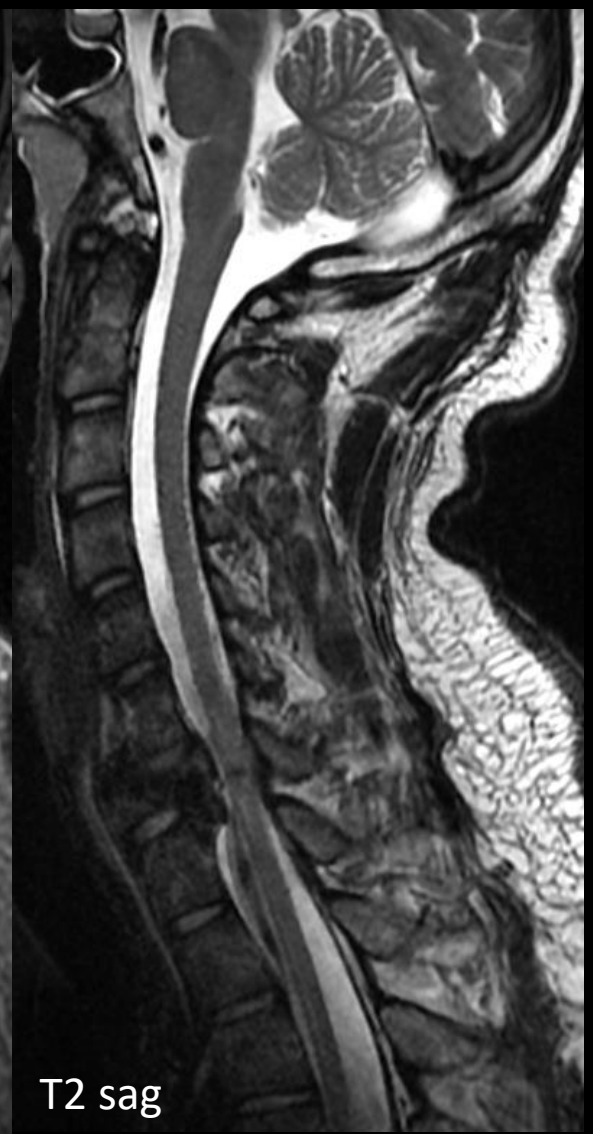
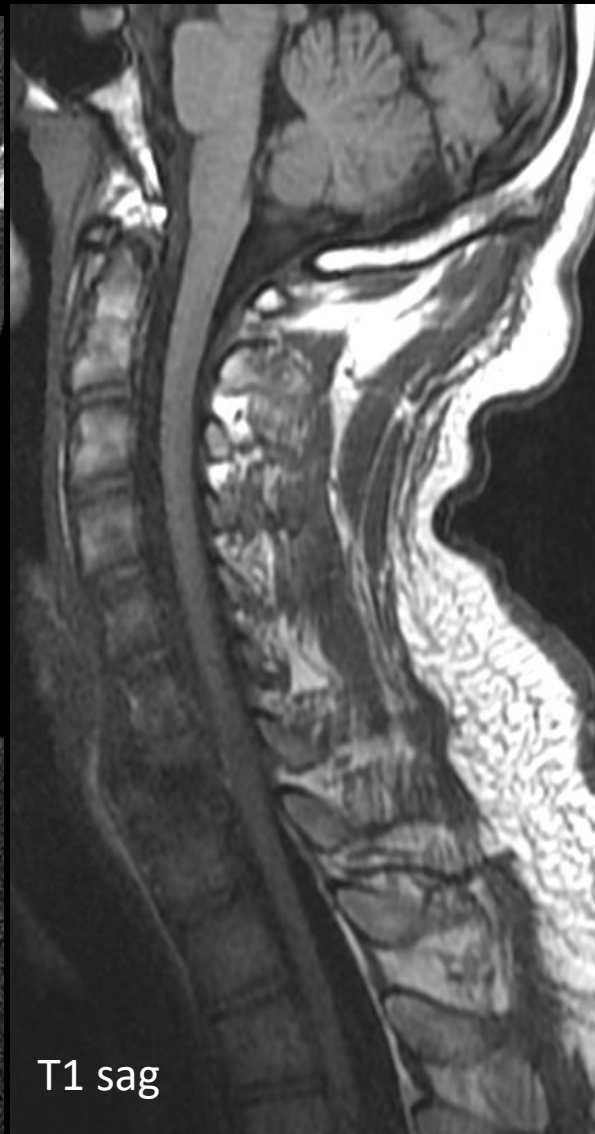
C7 Burst fracture - ASIA B



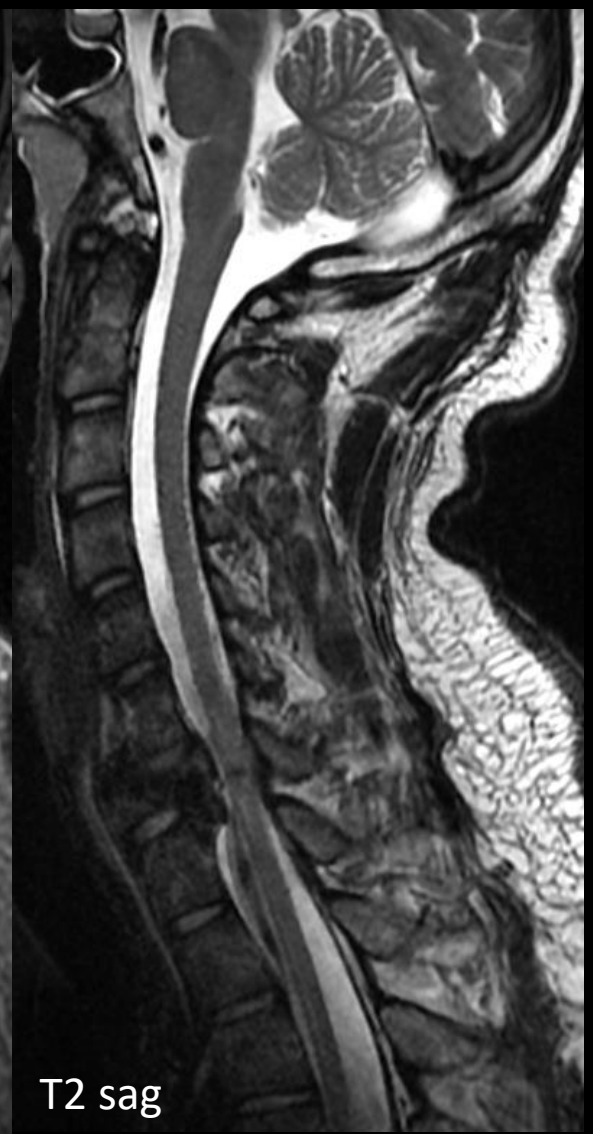
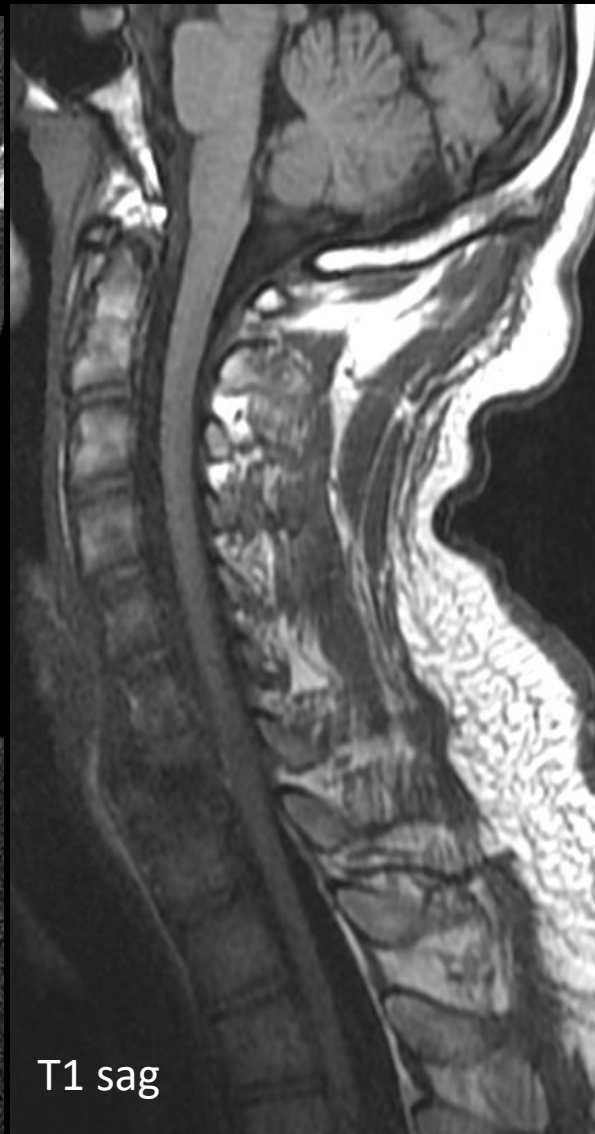
C7 Burst fracture - ASIA B



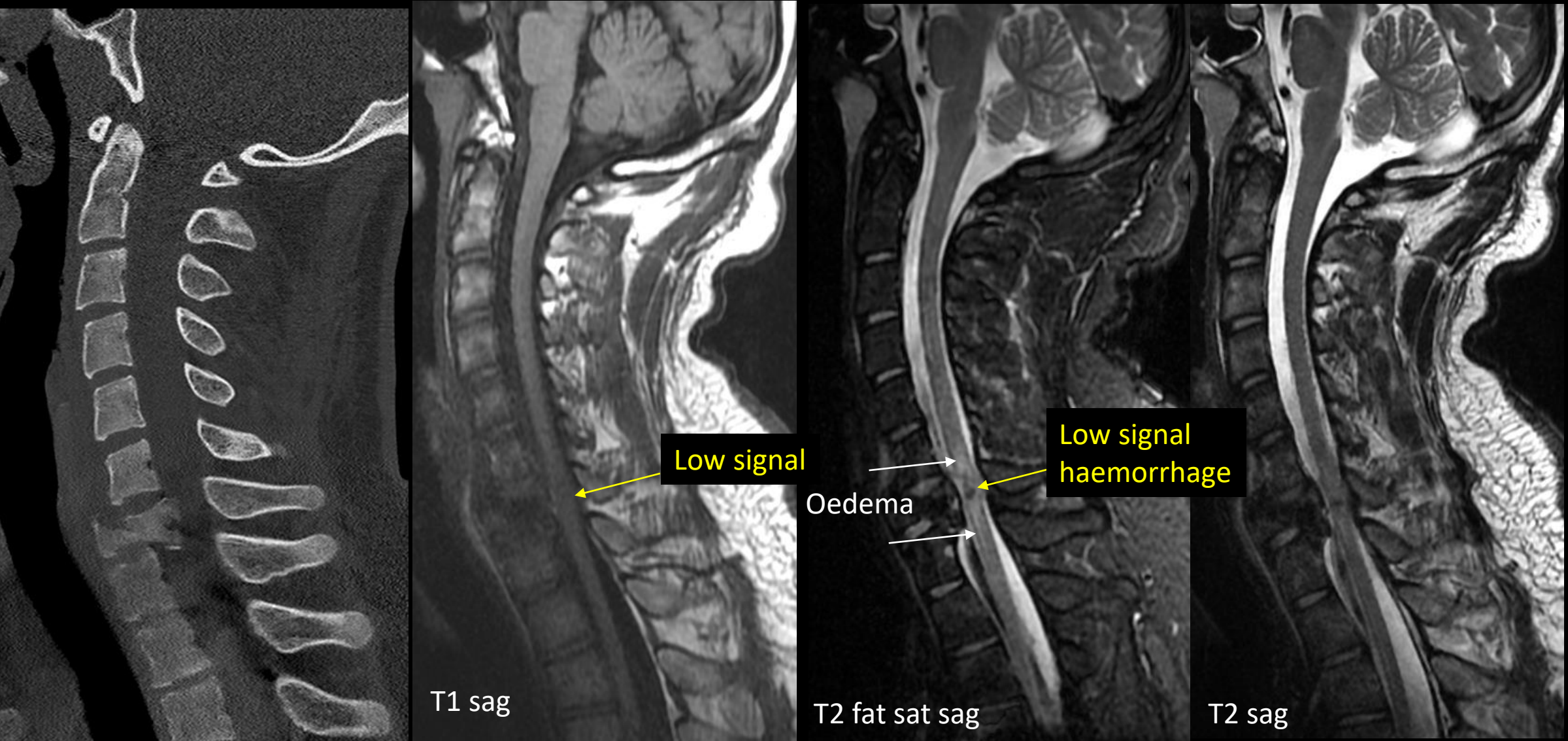
C7 Burst fracture - ASIA B



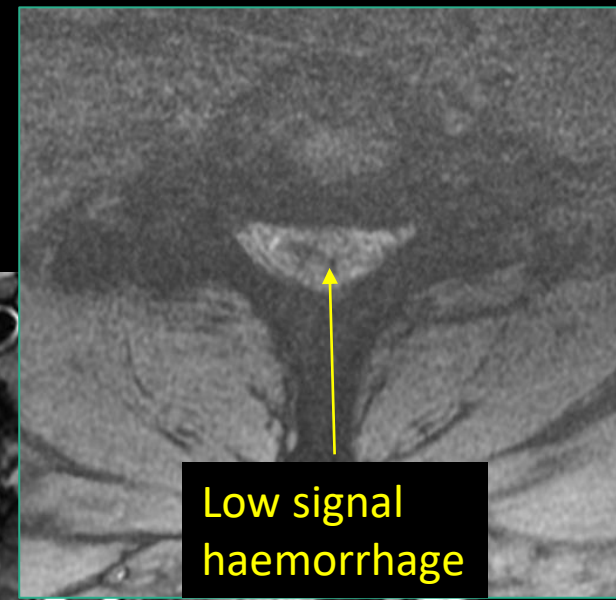
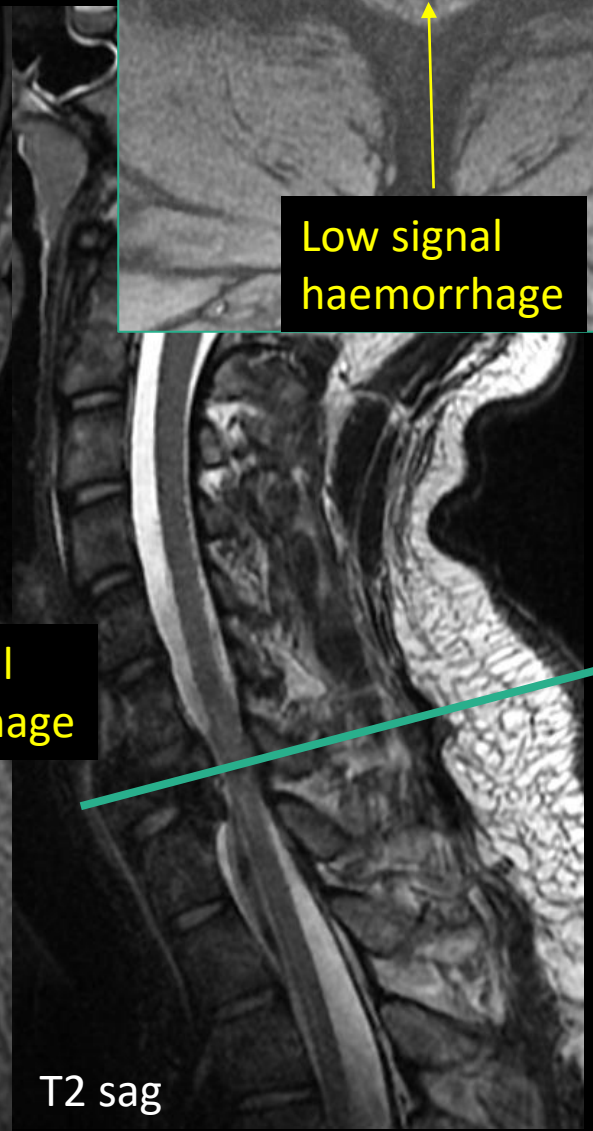
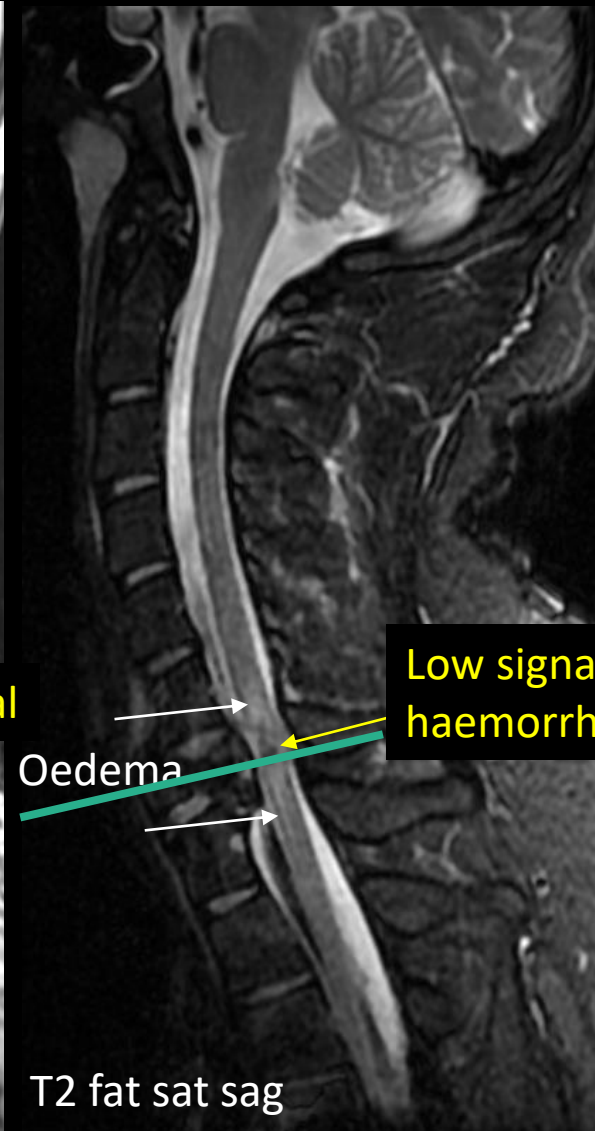
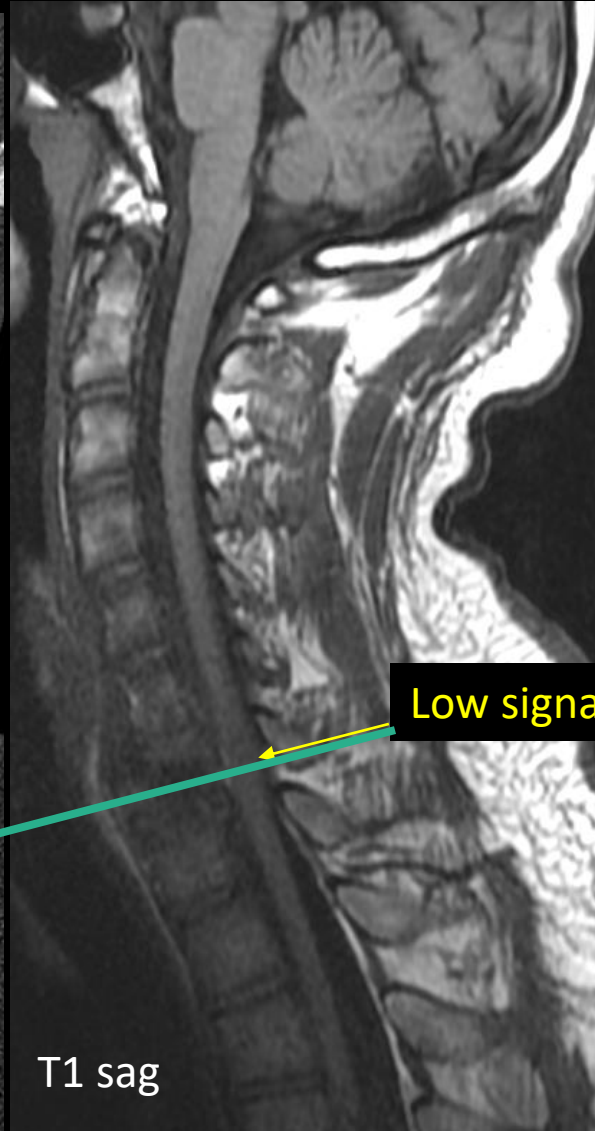
C7 Burst fracture - ASIA B



C7 Burst fracture - ASIA B



C7 Burst fracture - ASIA B



CHECKLIST- SPINAL HAEMATOMA		
Extra-canal	Pre vertebral	☐ +/-
Intra-canal, extra-axial	Epidural	☐ +/-
	Subdural	+/-
	Subarachnoid	+/-
	CORD COMPRESSION?	☐ +/-
Intra-axial	Intra-medullary	Oedema ☐ +/-
		Contusion +/-
		Haemorrhage ☐ +/-
Extra-canal	Interspinous	☐ +/-

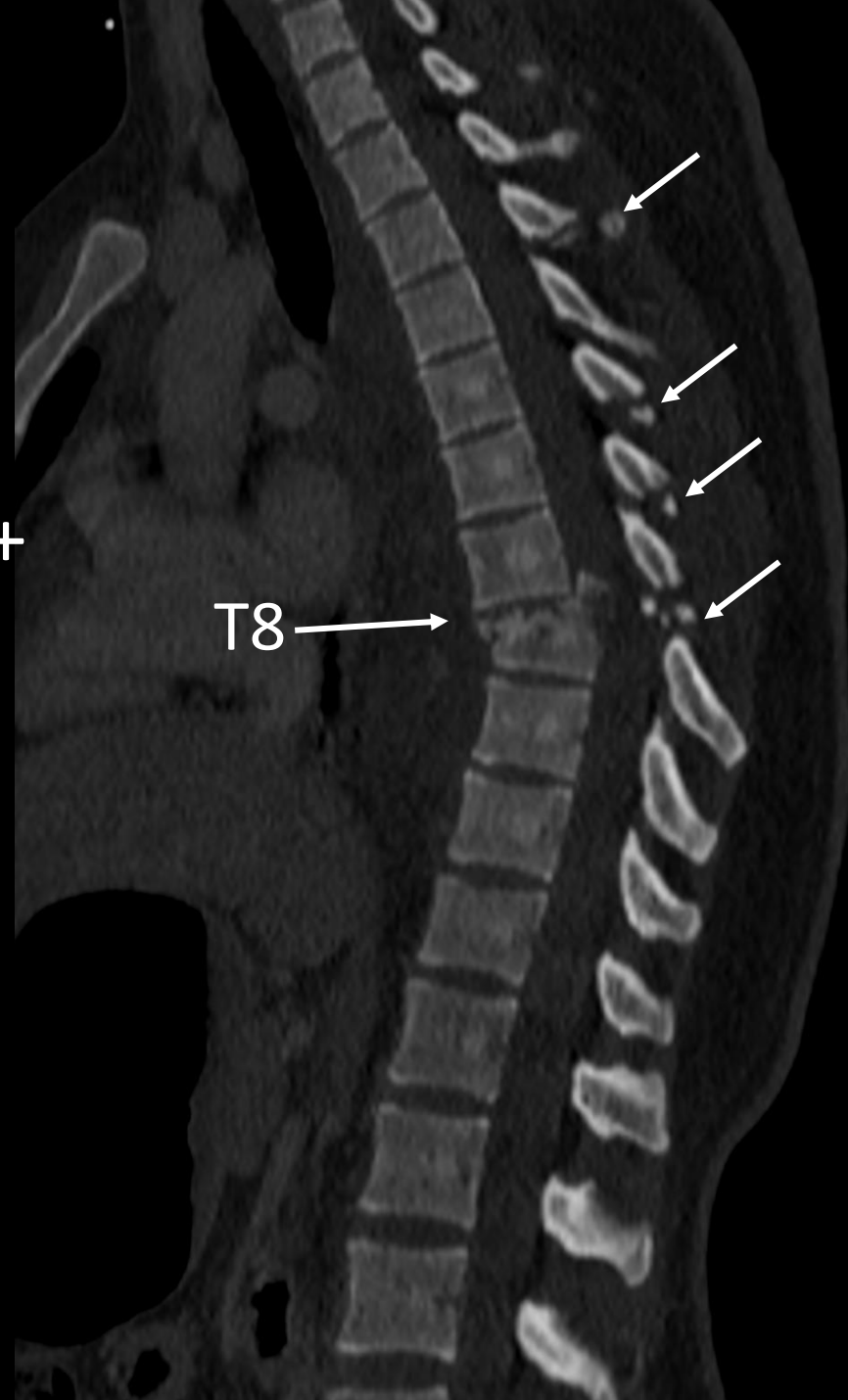
CORD OEDEMA , HAEMORRHAGE

PLUS LACERATION

High Energy Injury

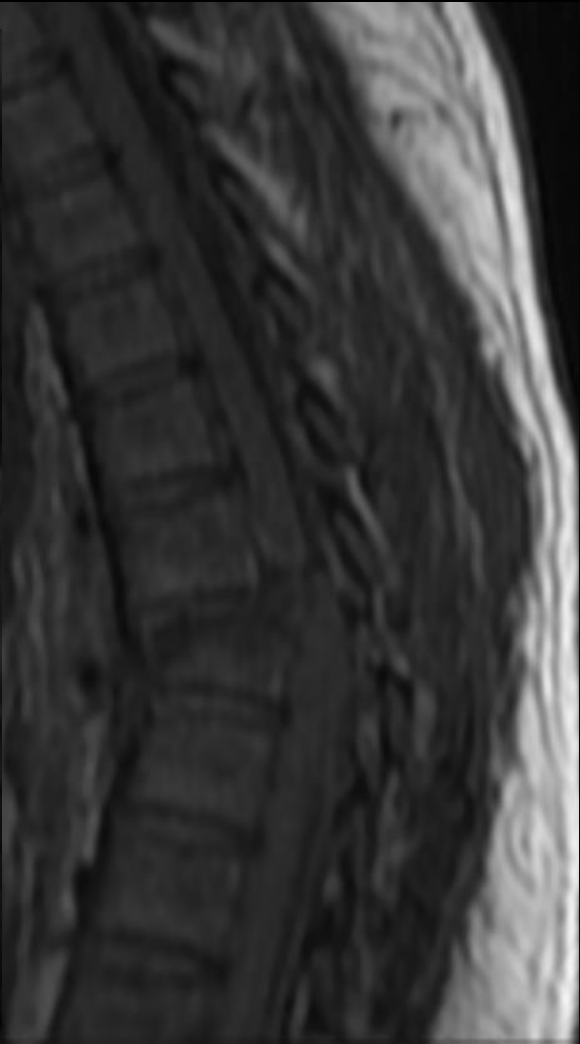
Cord haemorrhage, contusion and laceration

T8: 3 column fracture, displaced +++
Multiple spinous process fractures
Pre vertebral haematoma

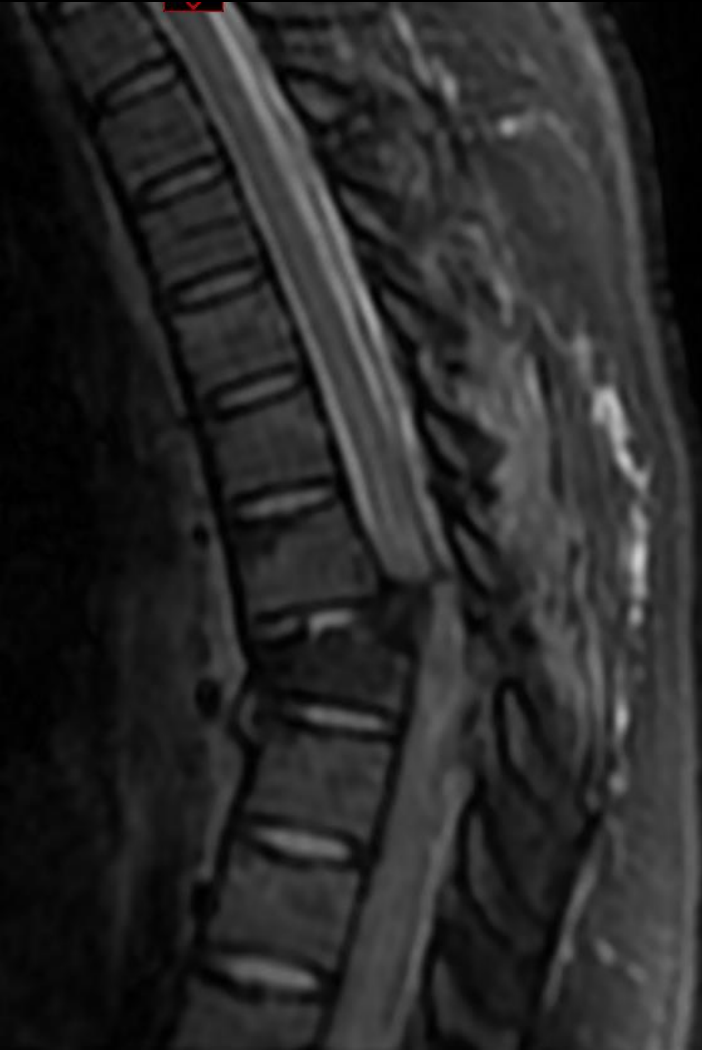




T8



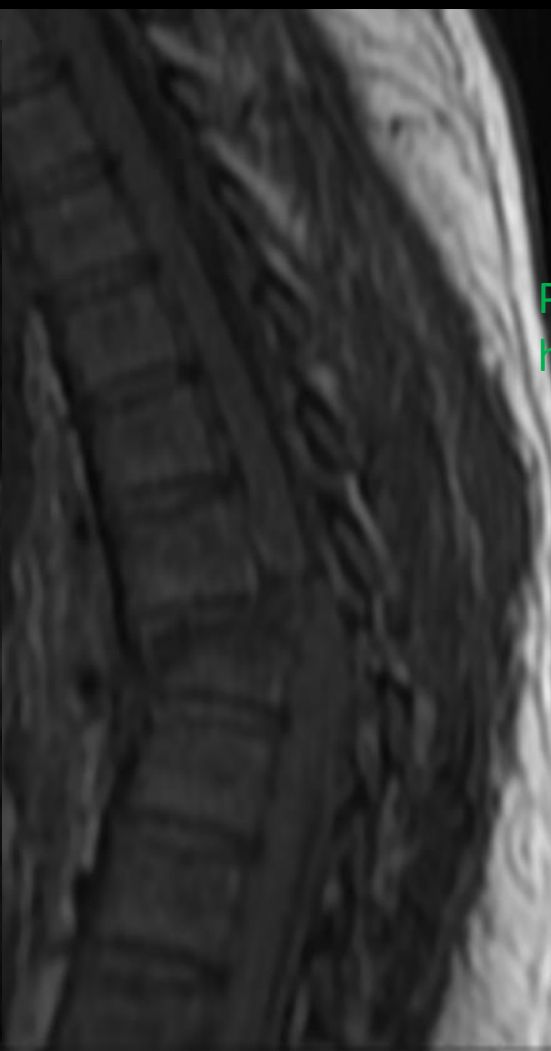
T1 sag



T2 fat sat sag



T2 sag



T1 sag



T2 fat sat sag



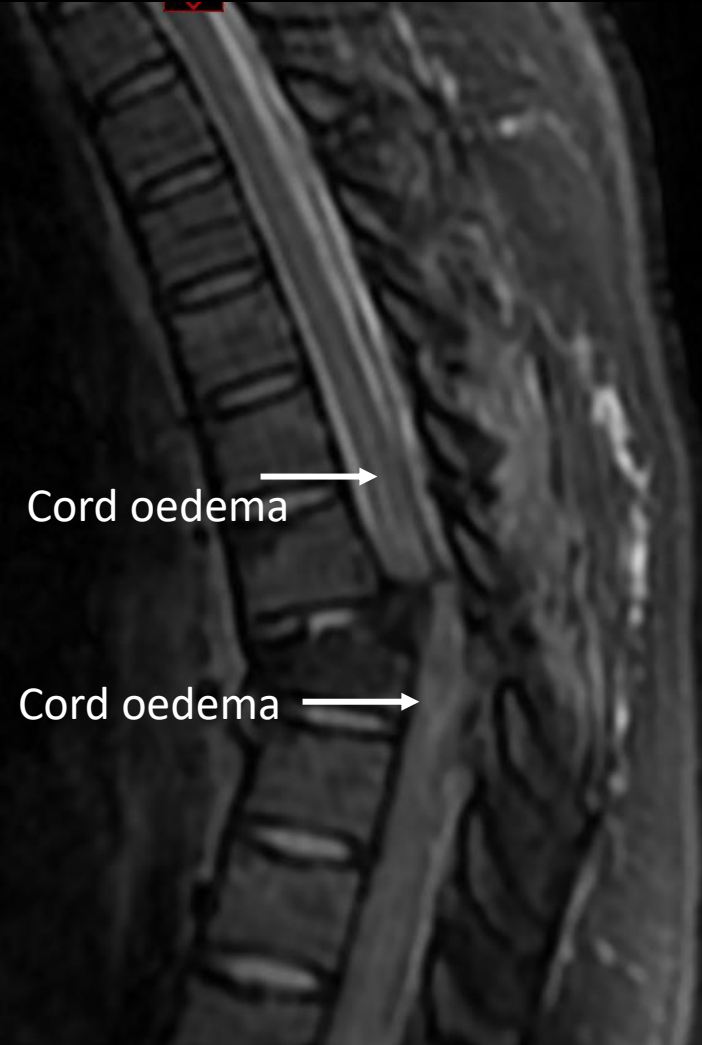
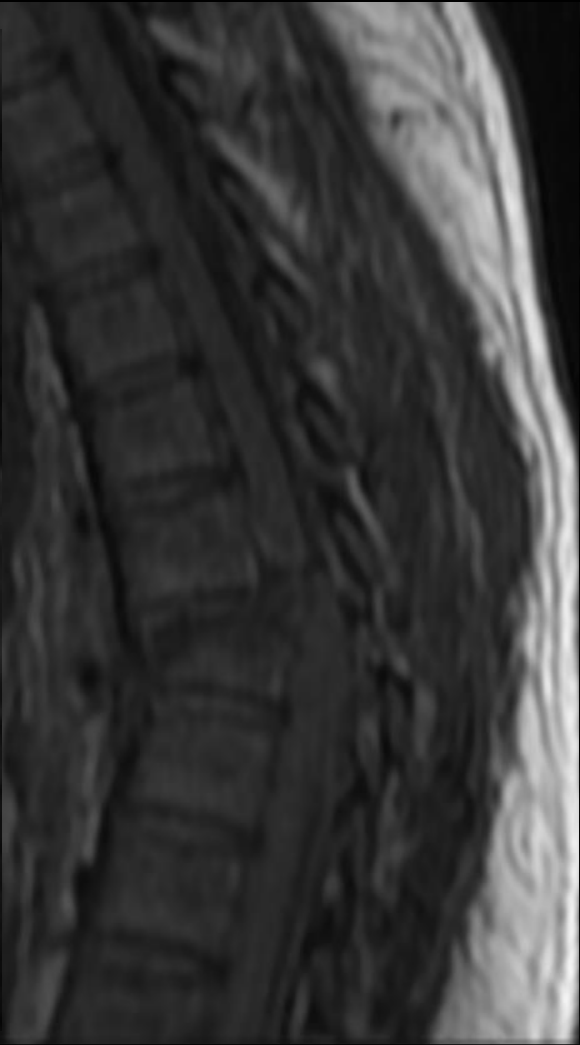
T2 sag

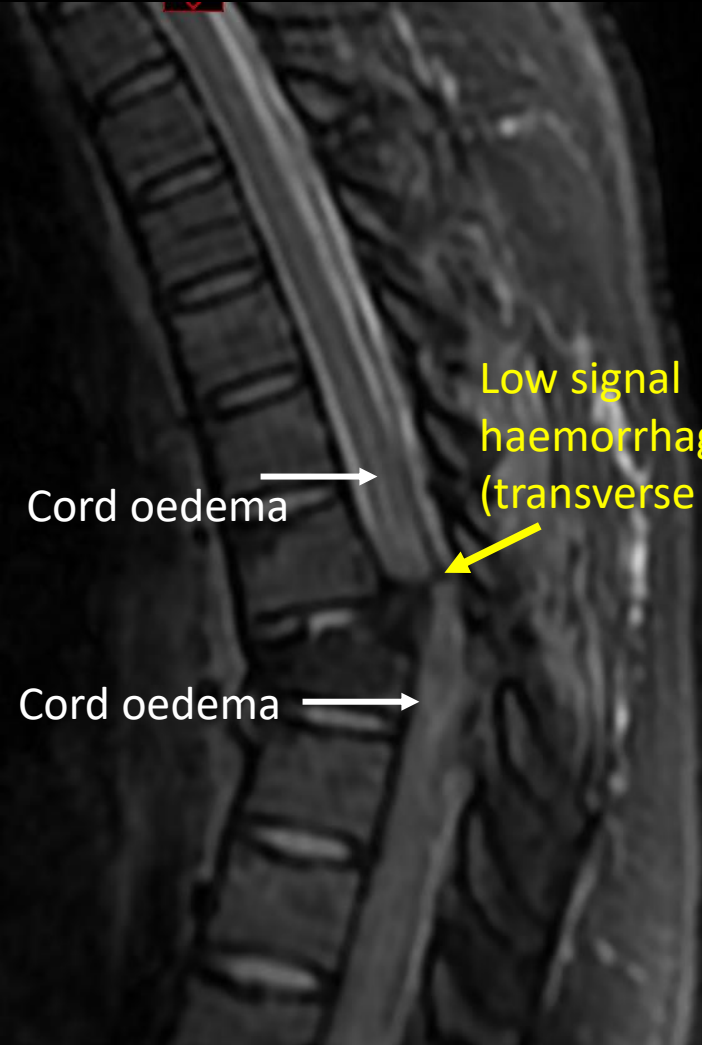
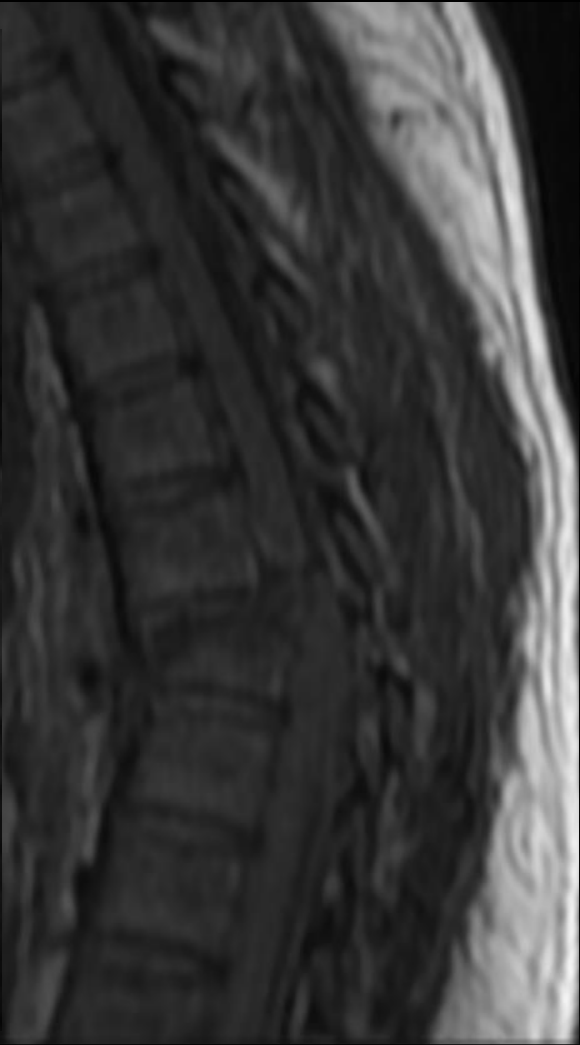


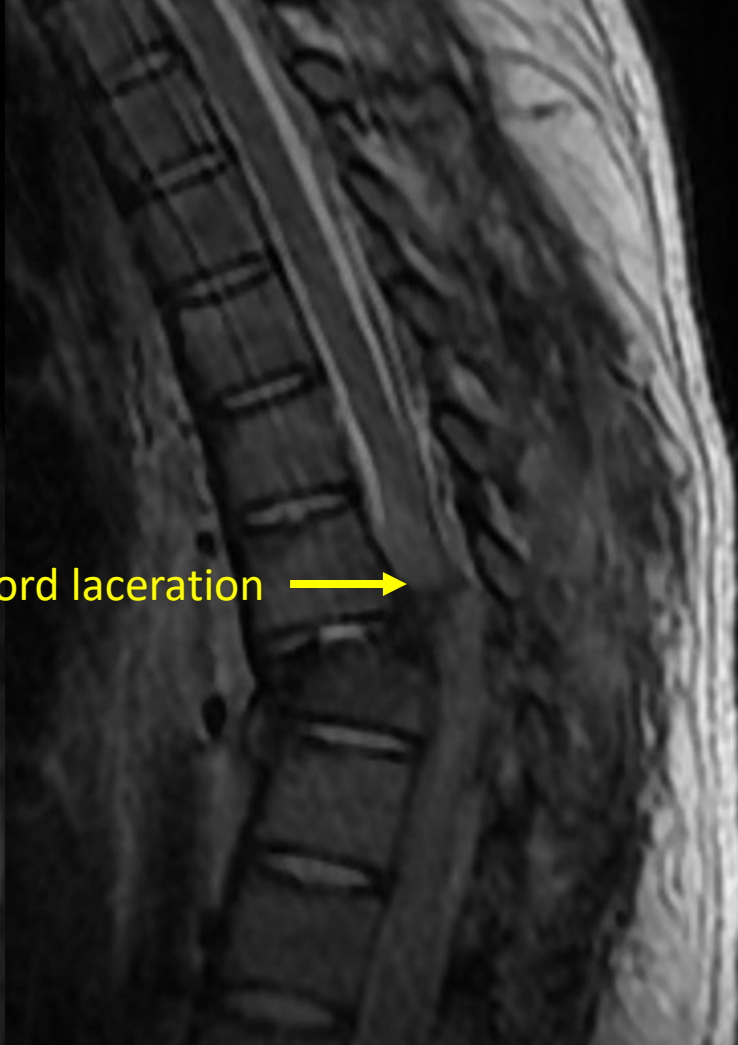
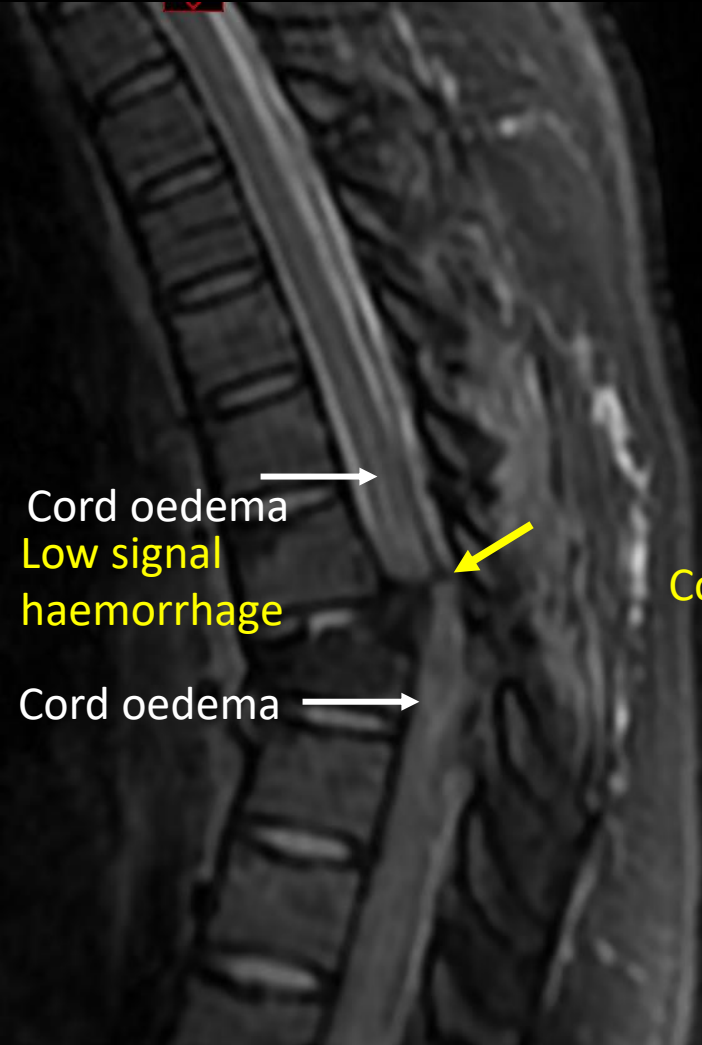
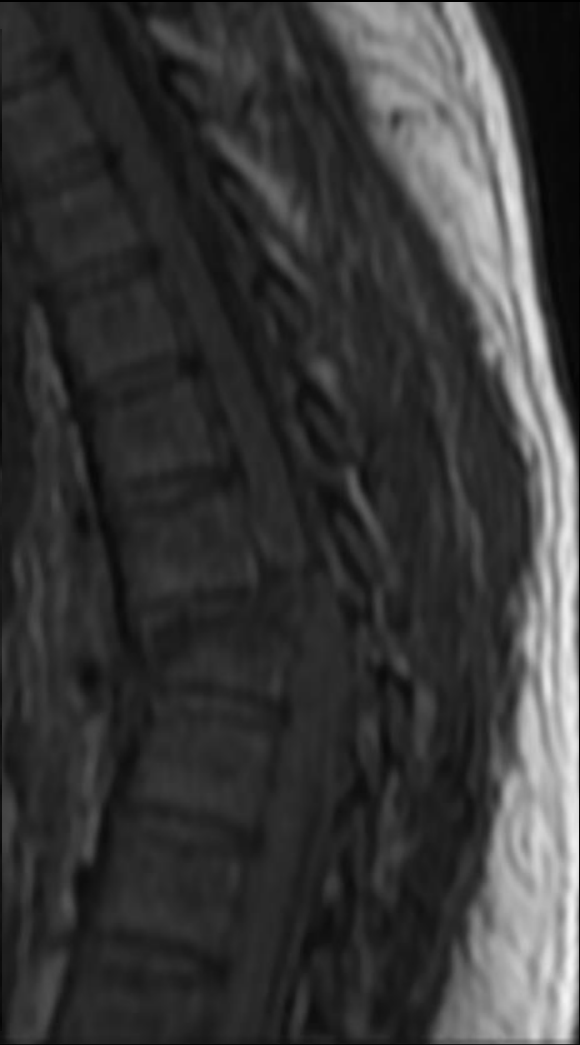
T1 sag

T2 fat sat sag

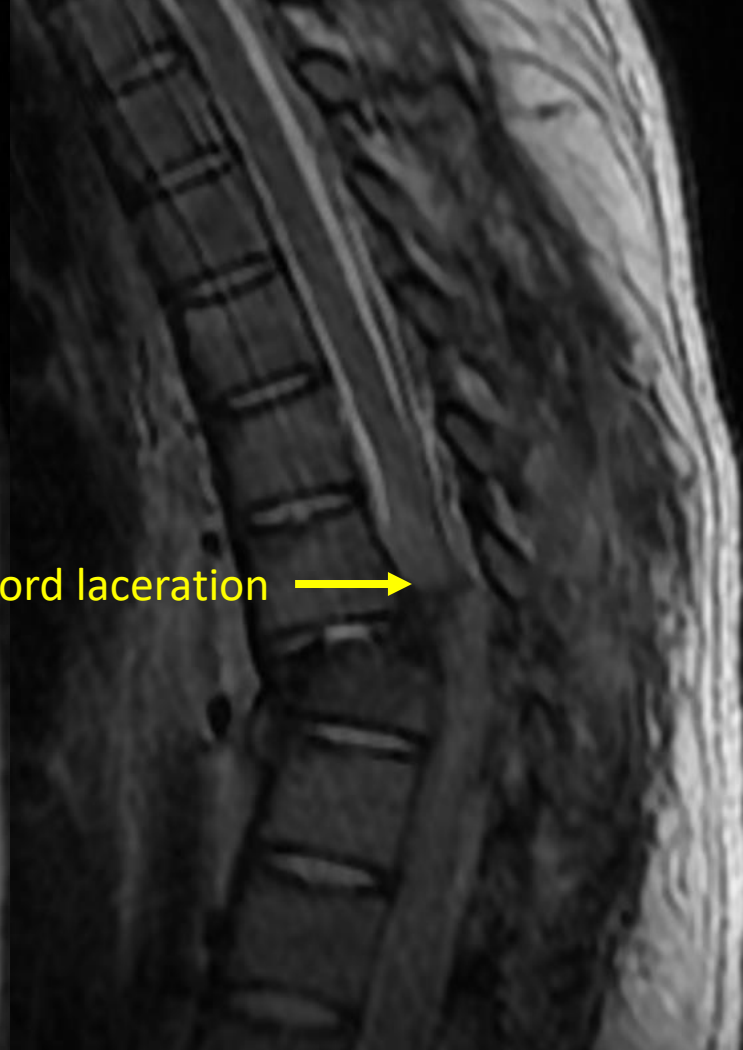
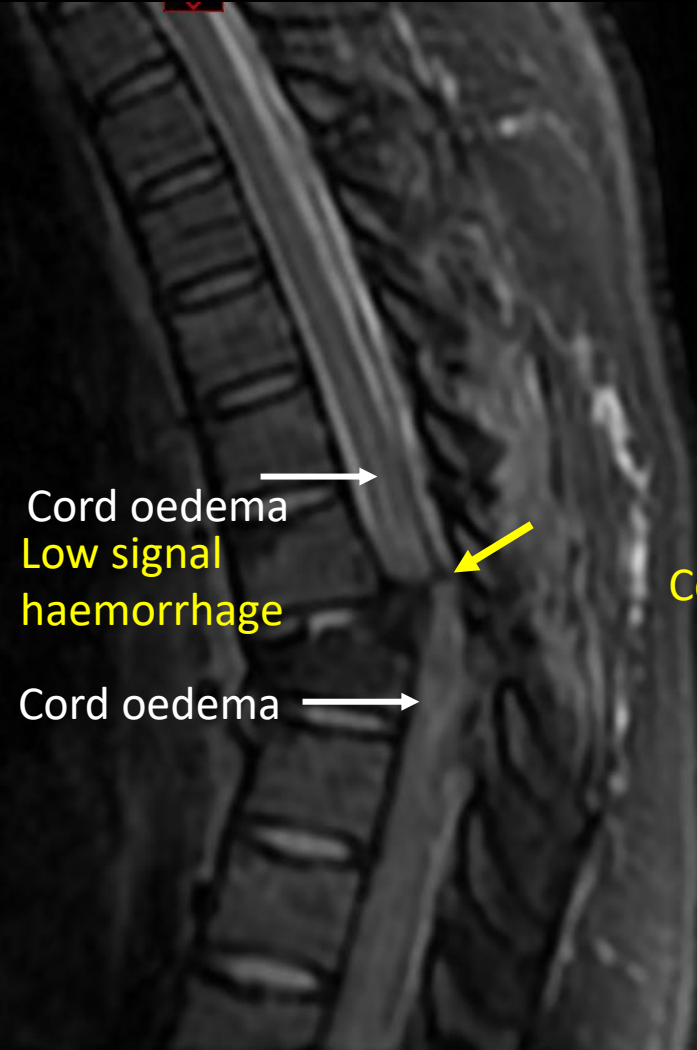
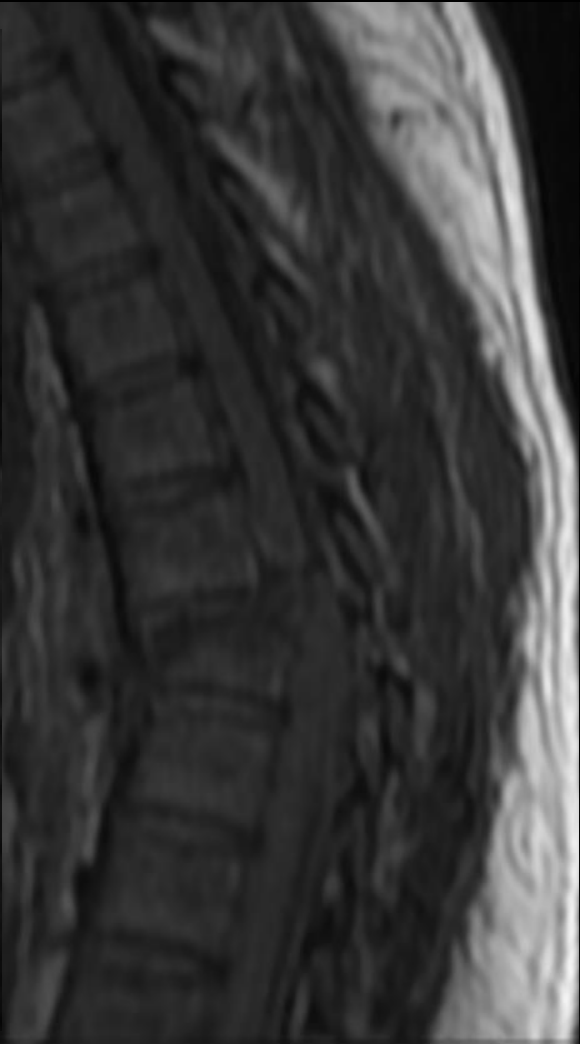
T2 sag





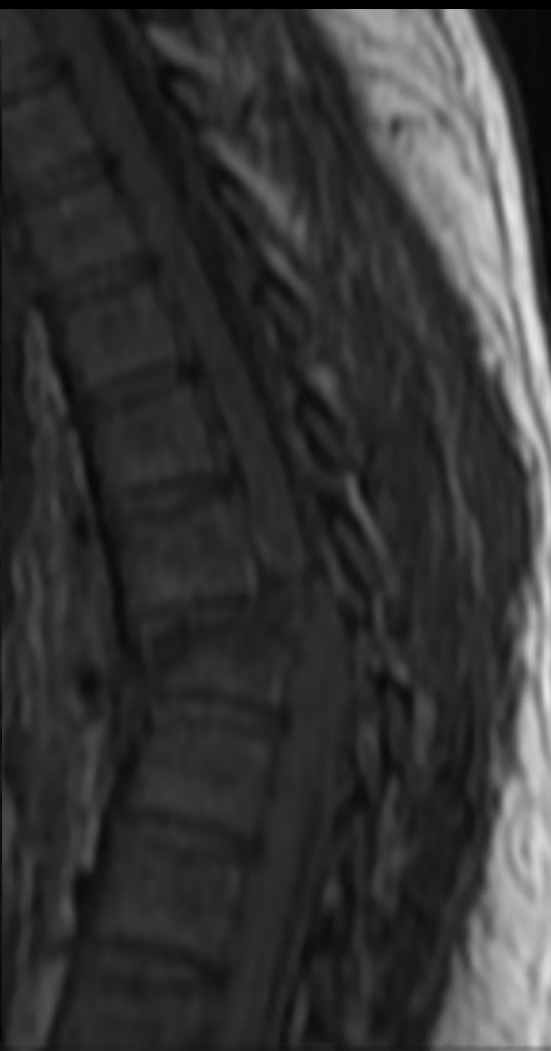


At operation: Long dural tear, bony fragment protruding into it



T2 fat sat sag

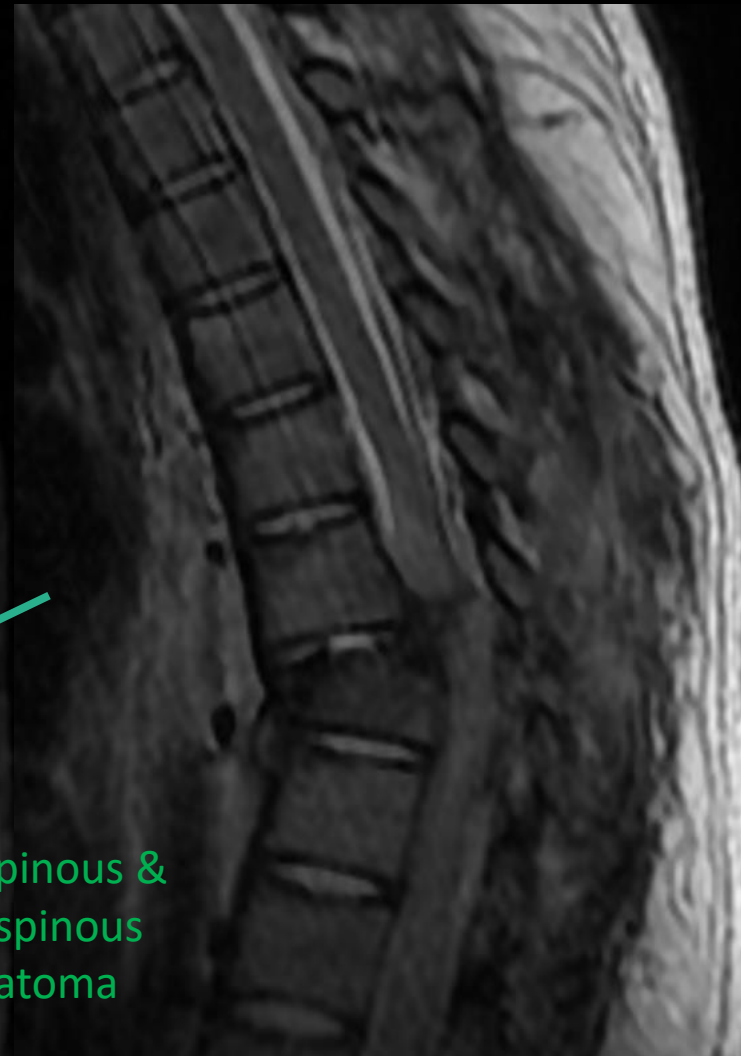
T2 sag



T1 sag



T2 fat sat sag



T2 sag

Interspinous &
Supraspinous
haematoma

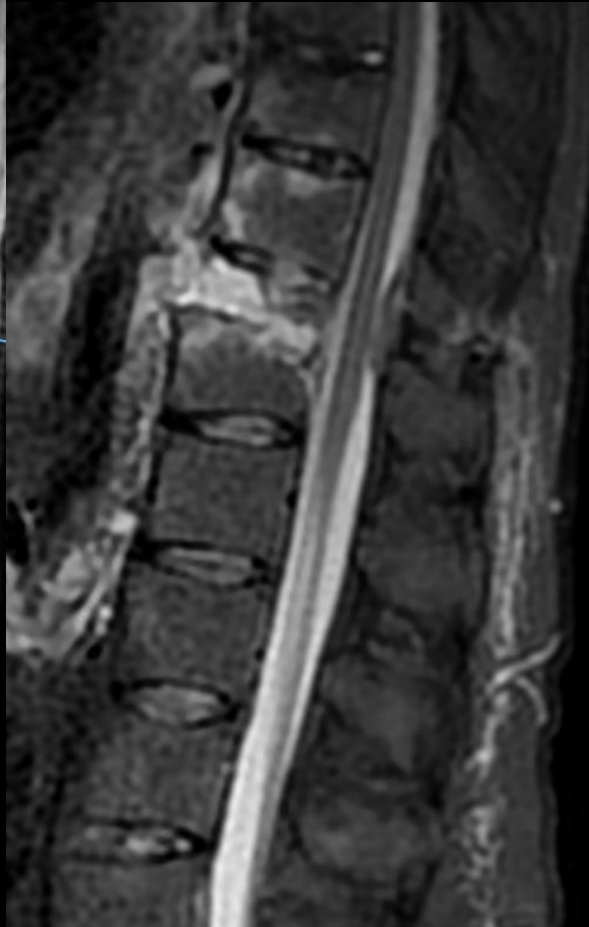
QUIZ

- Let's go back to a couple of the cases we have already seen

QUIZ #1 (AnkSpond 3 column injury T11/12)



T2 sag

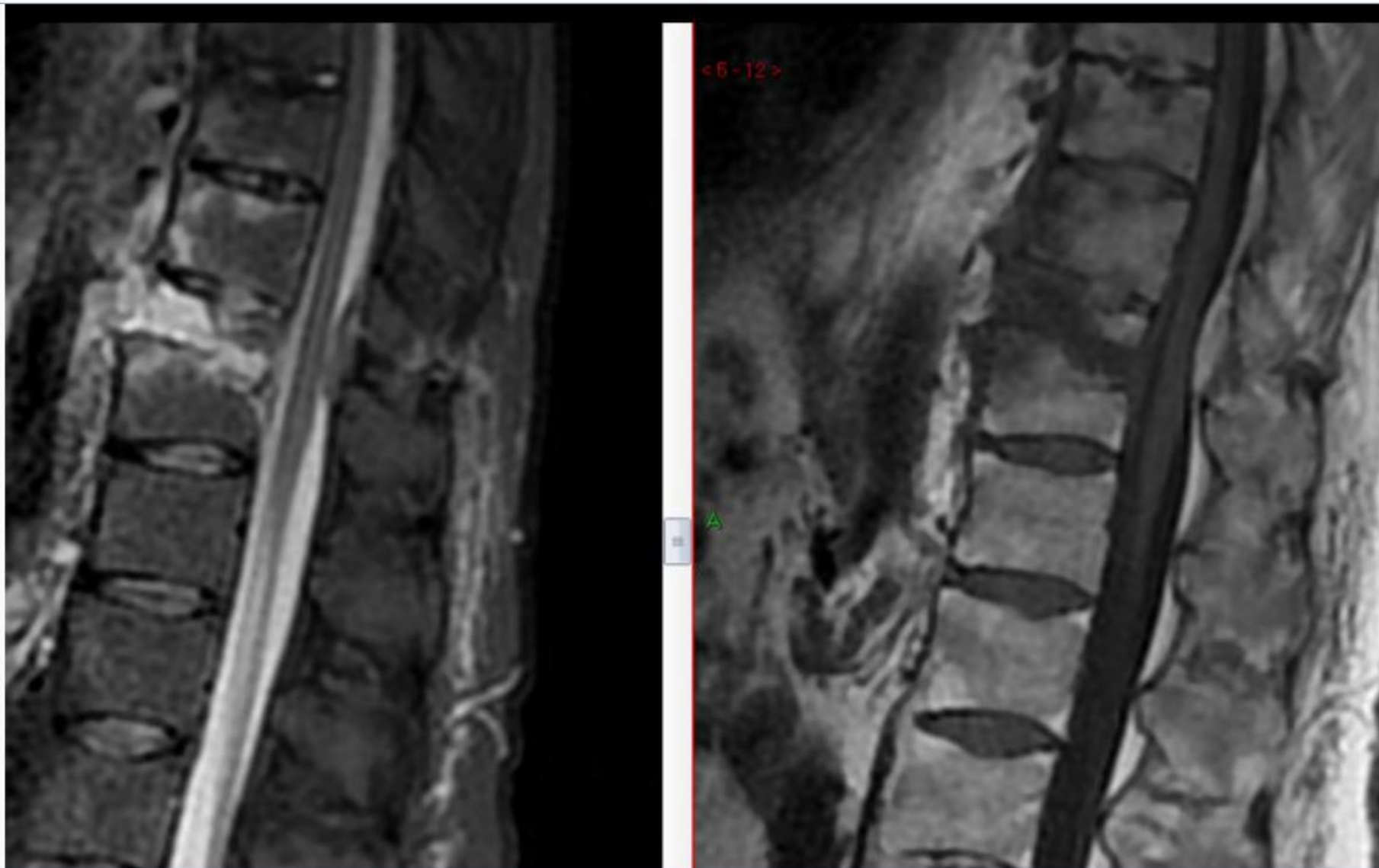


T2 fat sat - sag

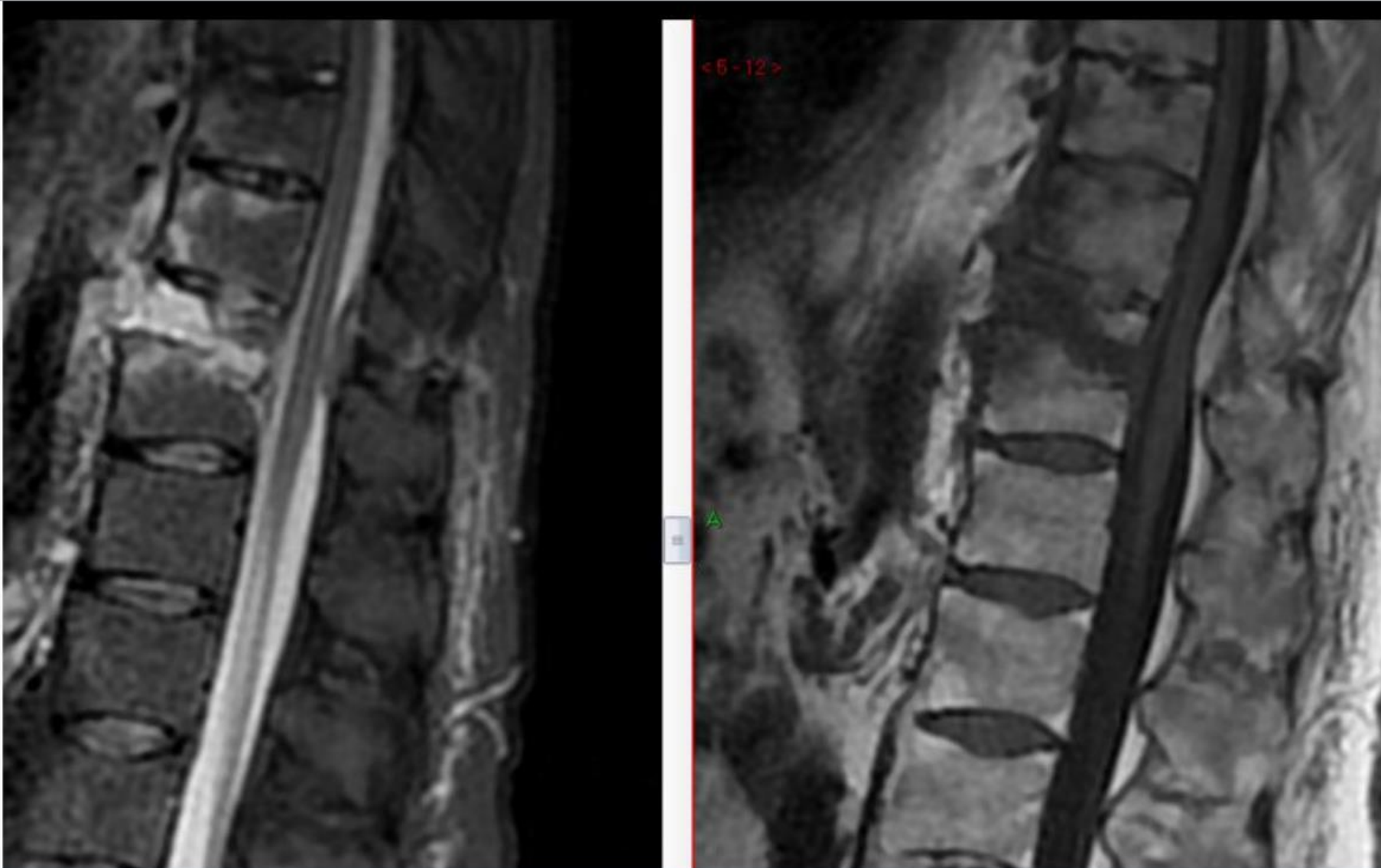


T1 sag

Point to normal epidural fat



point to posterior epidural haematoma



QUIZ #1 (AnkSpond 3 column injury T11/12)



T2 sag



T2 fat sat - sag

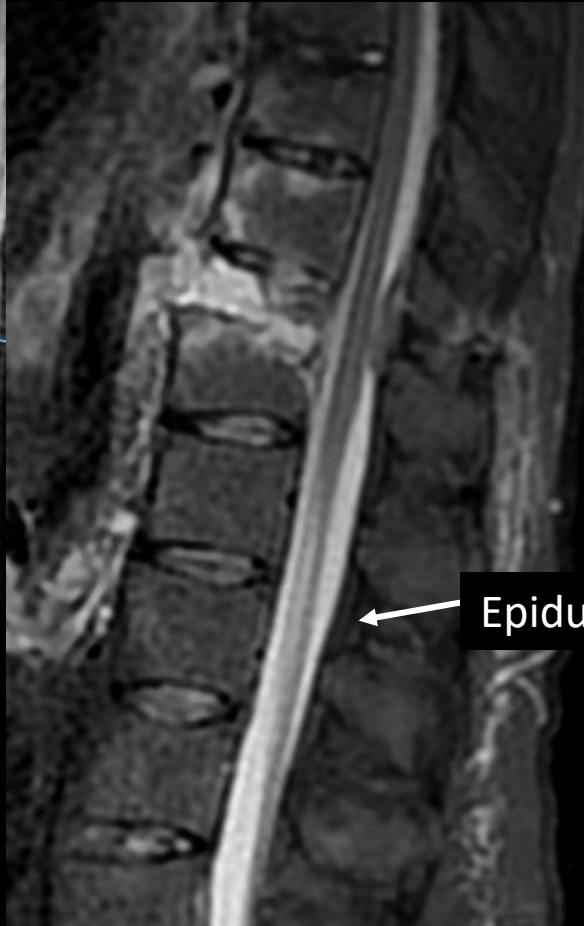


T1 sag

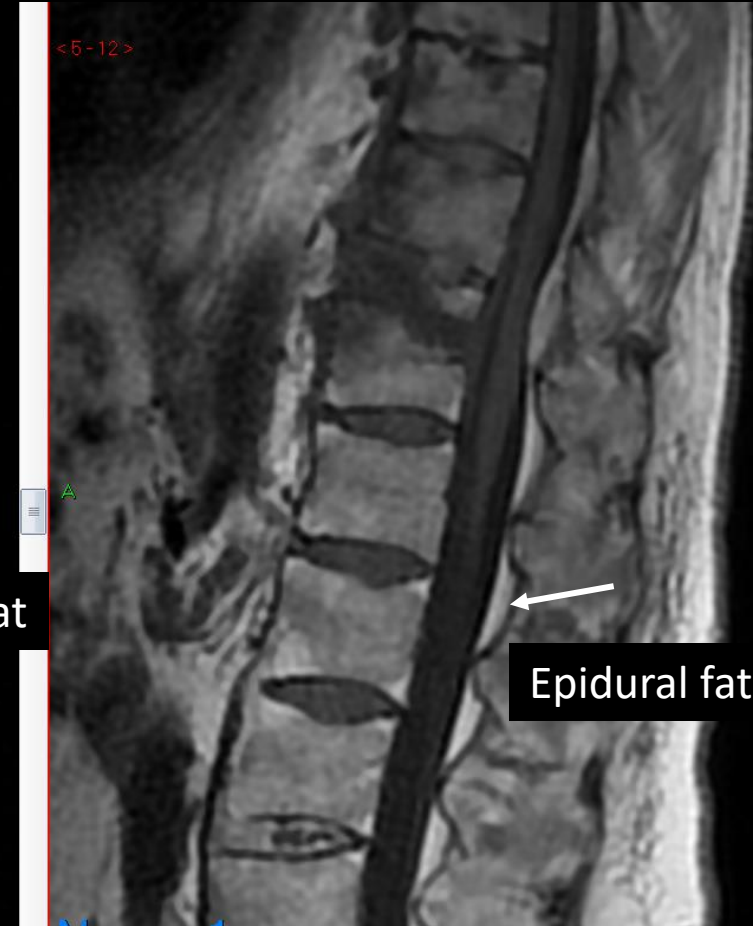
QUIZ #1 (AnkSpond 3 column injury T11/12)



T2 sag

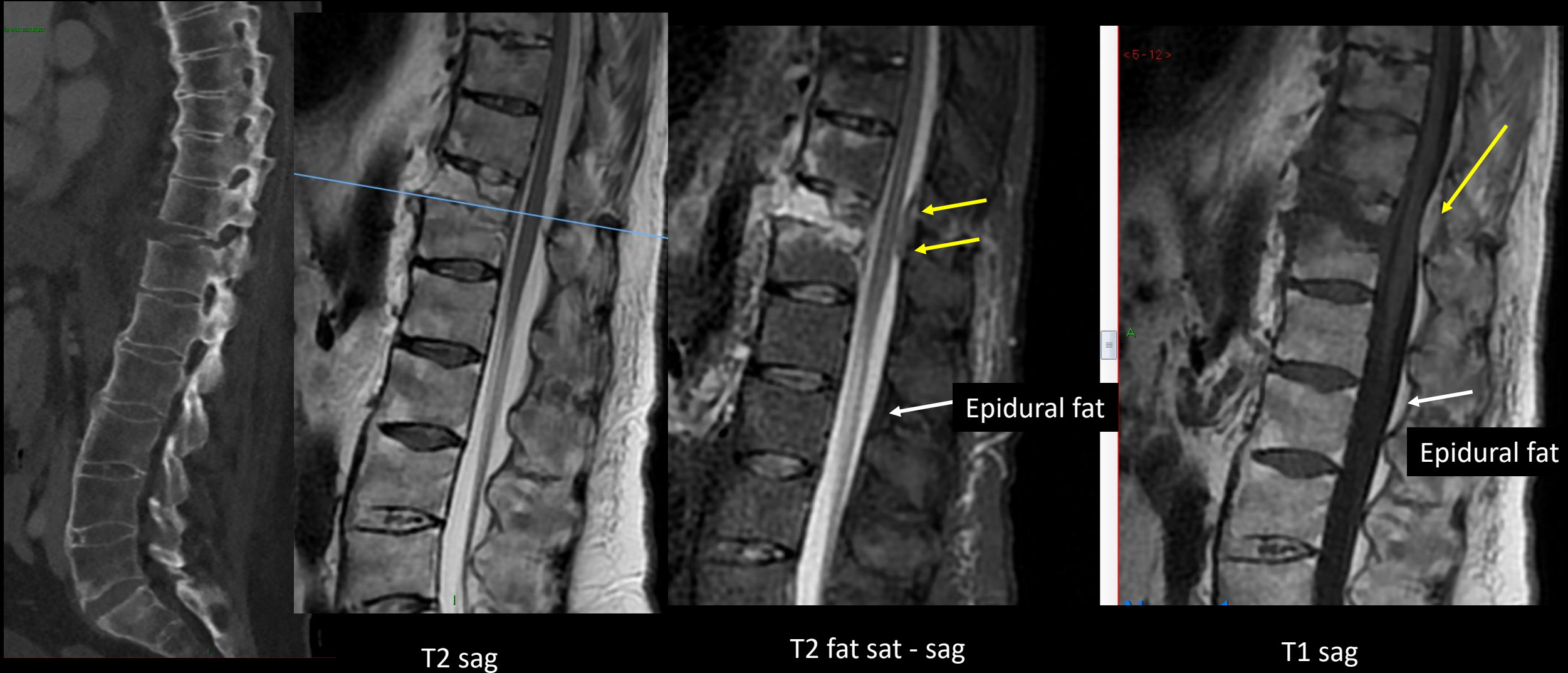


T2 fat sat - sag

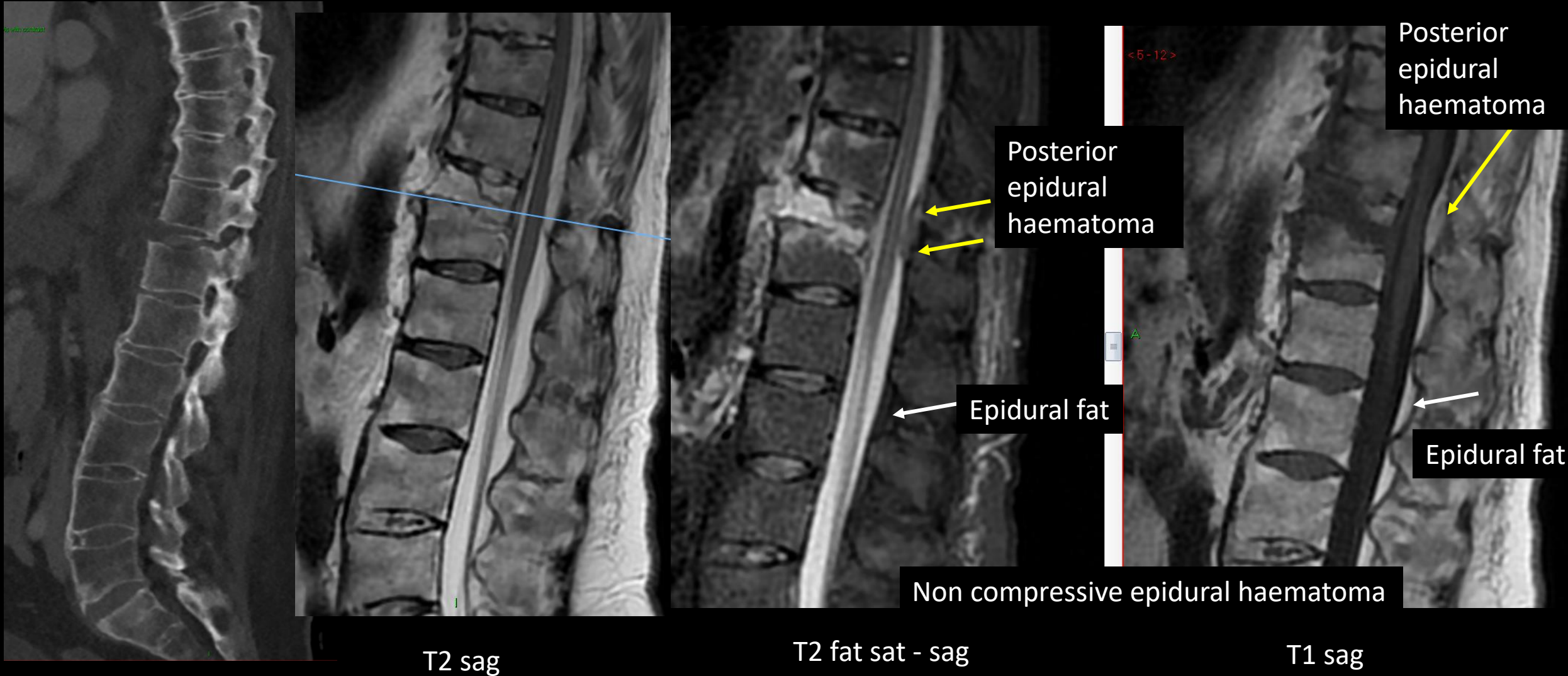


T1 sag

QUIZ #1 (AnkSpond 3 column injury T11/12)



QUIZ #1 (AnkSpond 3 column injury T11/12)

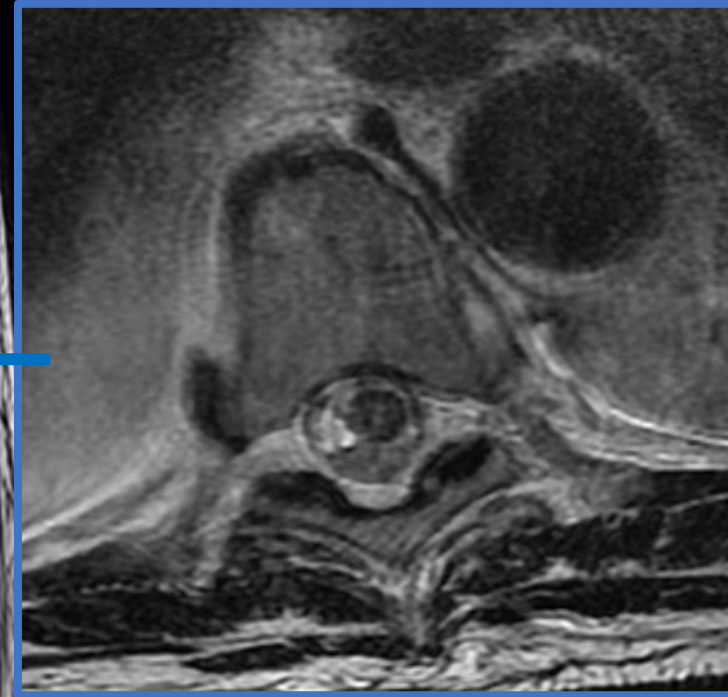
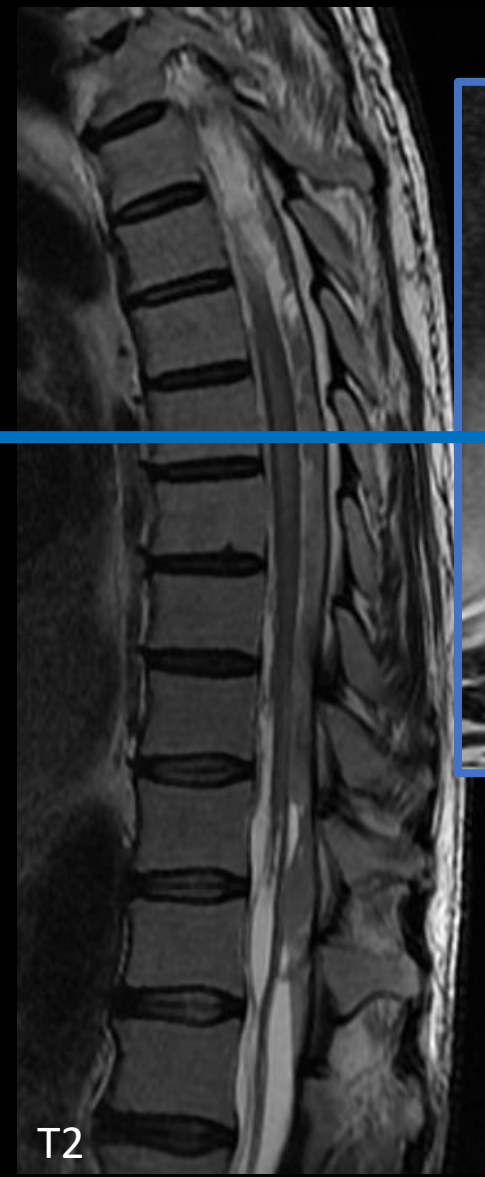


What are the features that tell us this is subarachnoid blood NOT epidural blood?

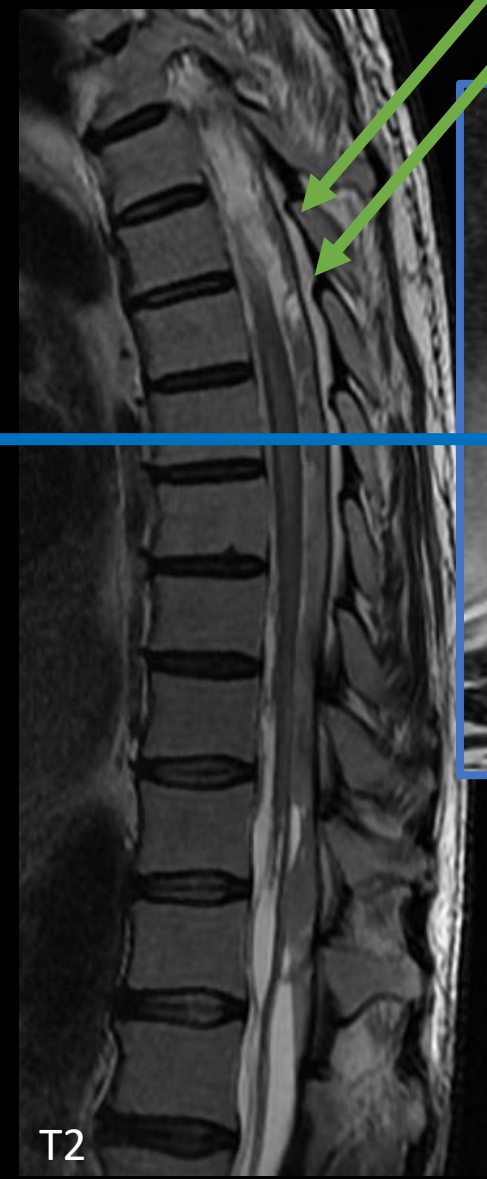
Nobody has responded yet.

Hang tight! Responses are coming in.

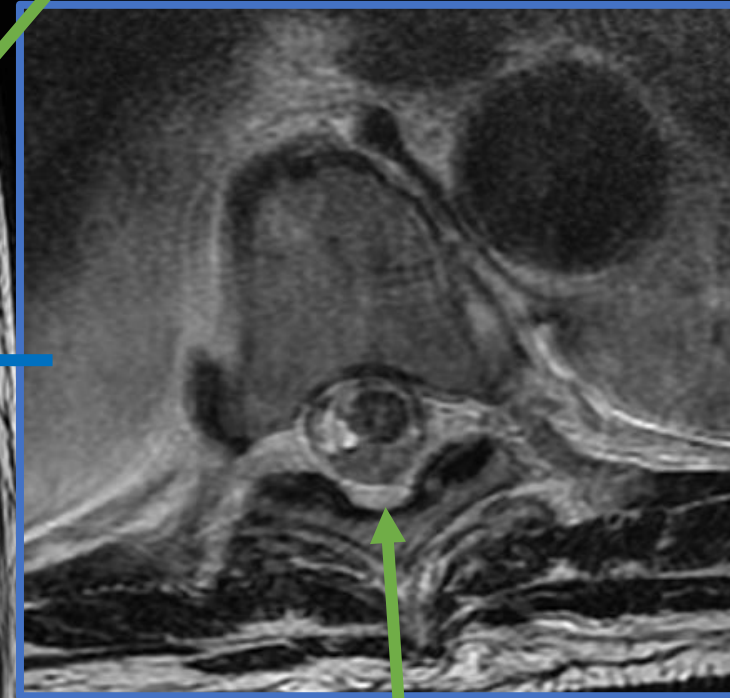
QUIZ #2: What are the signs that this is subarachnoid NOT epidural blood?



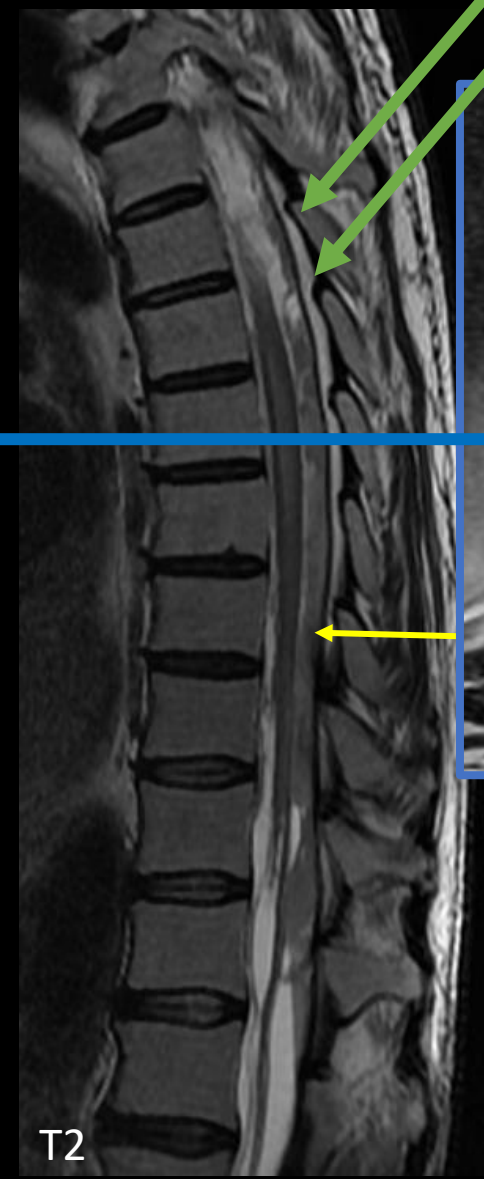
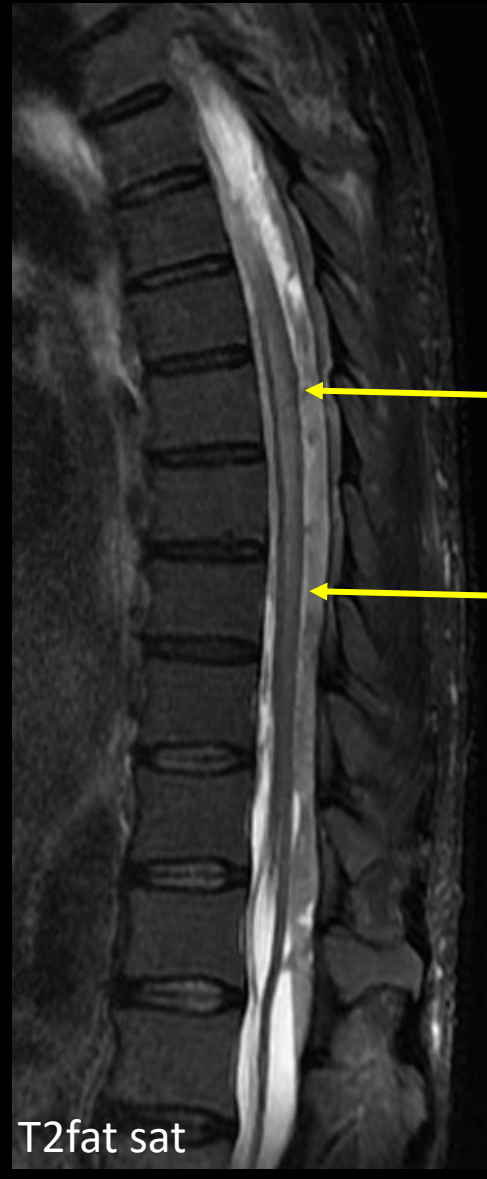
QUIZ: What are the signs that this subarachnoid NOT epidural blood?



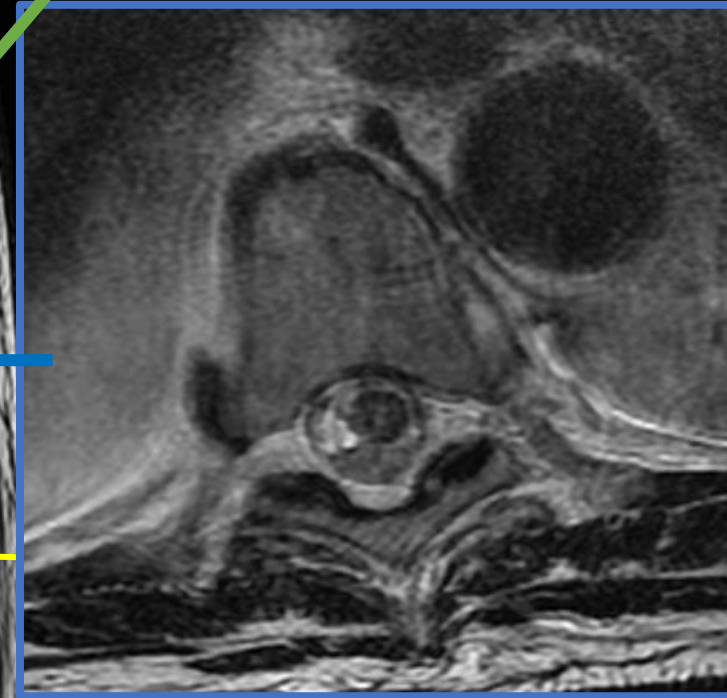
NORMAL EPIDURAL FAT



QUIZ: What are the signs that this subarachnoid NOT epidural blood?

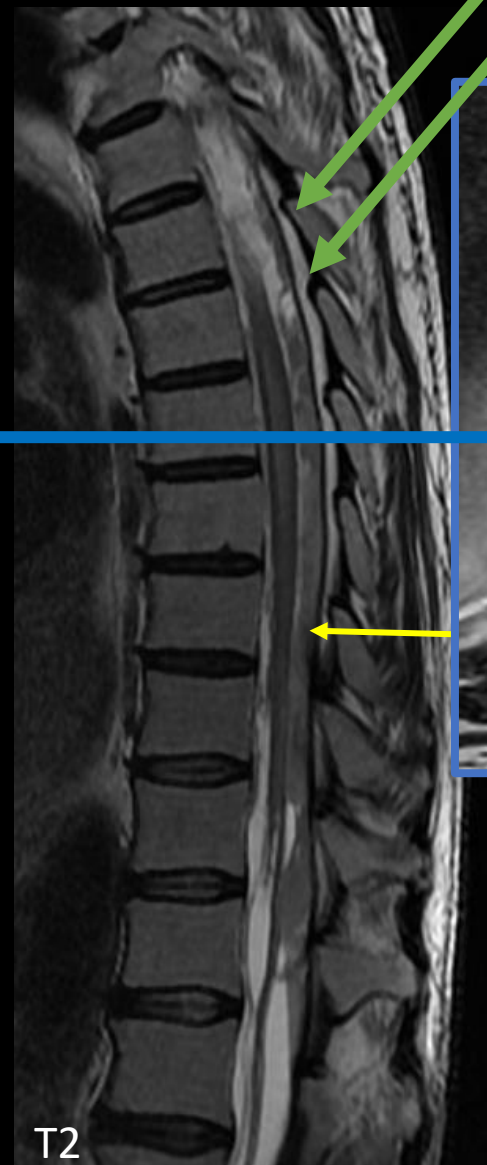
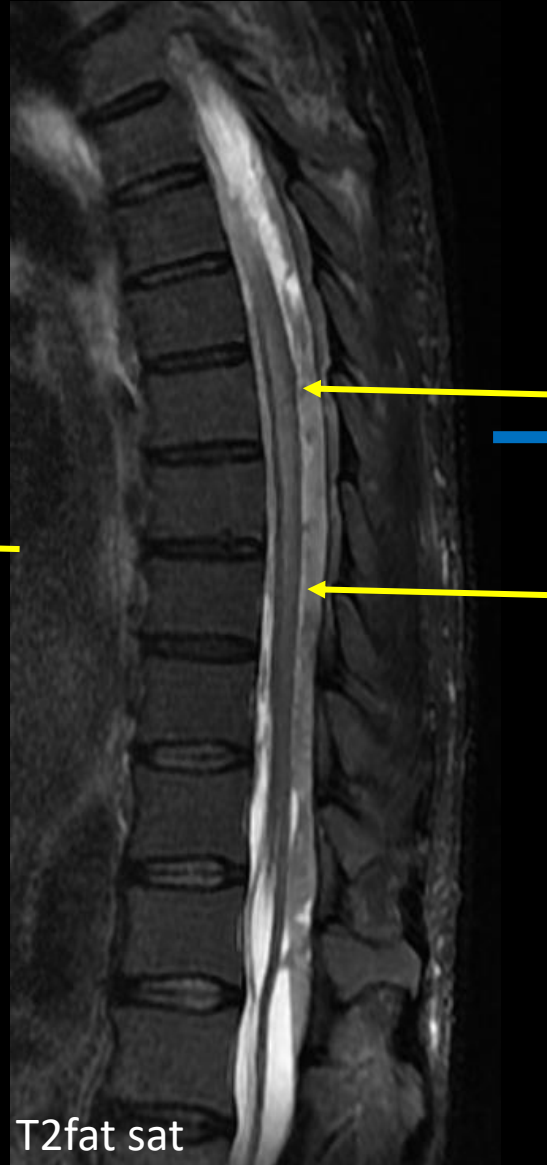


NORMAL EPIDURAL FAT

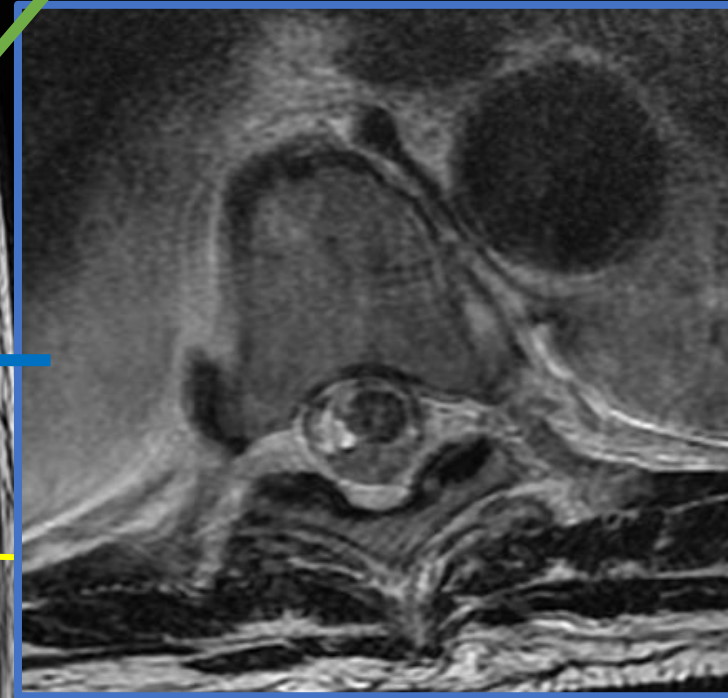


QUIZ: What are the signs that this subarachnoid NOT epidural blood?

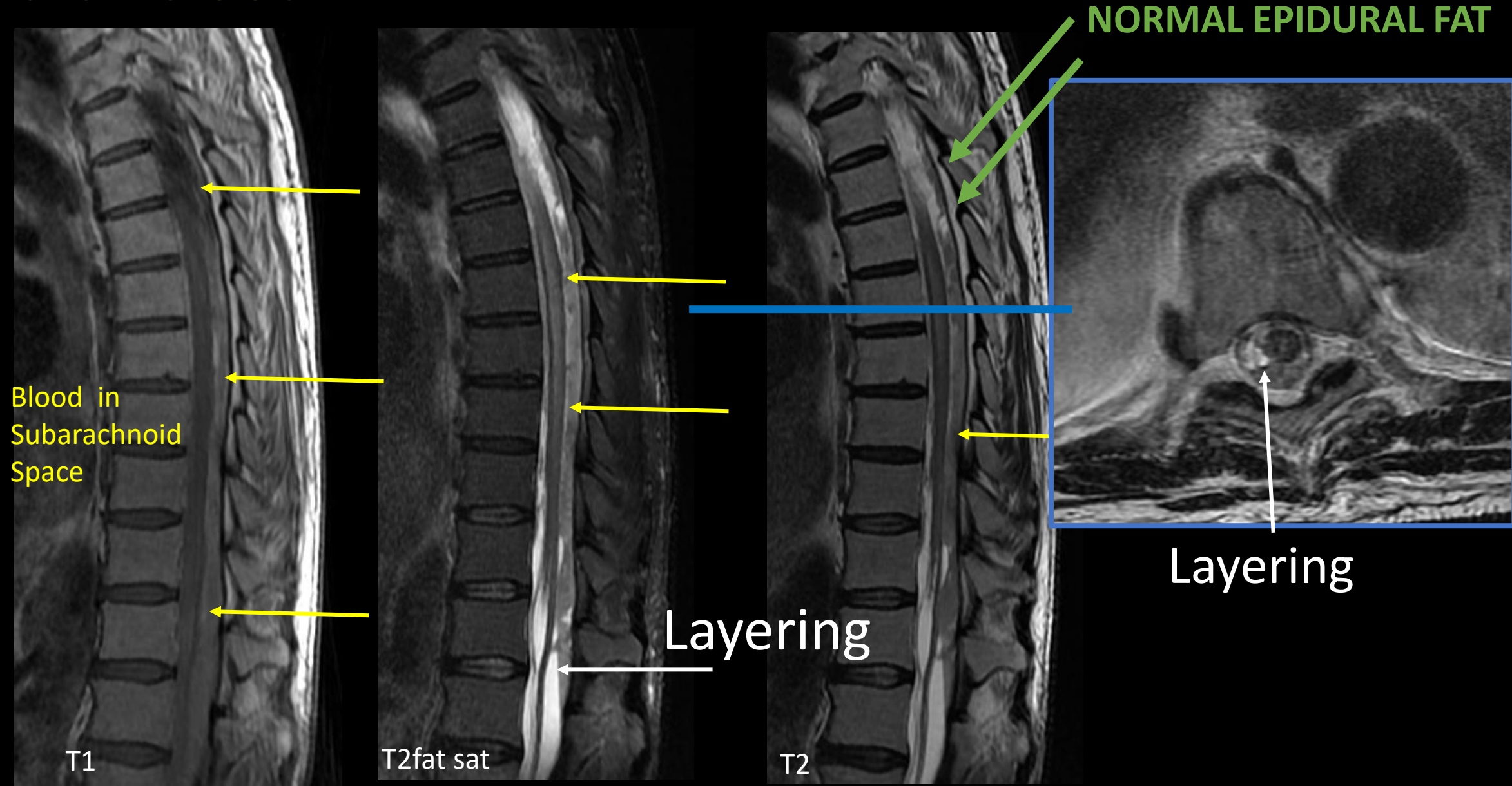
Blood in
Subarachnoid
Space, DEEP
to dura



NORMAL EPIDURAL FAT



QUIZ: What are the signs that this subarachnoid NOT epidural blood?



Conclusion

- Spinal haematoma is uncommon
- Urgent MRI will improve outcome
 - to identify if haematoma present
 - which compartment is affected
 - Extent
 - Cord compression
 - Where in the cord

Conclusion

- Spinal haematoma is uncommon
- Urgent MRI will improve outcome
 - to identify if haematoma present
 - which compartment is affected
 - Extent
 - Cord compression
 - Where in the cord

RADIOLOGY MAKES A DIFFERENCE



Thank you



Thank you:
Dr Wajanat Jan
Dr Olga Kirmi
Mr Reza Mobasheri

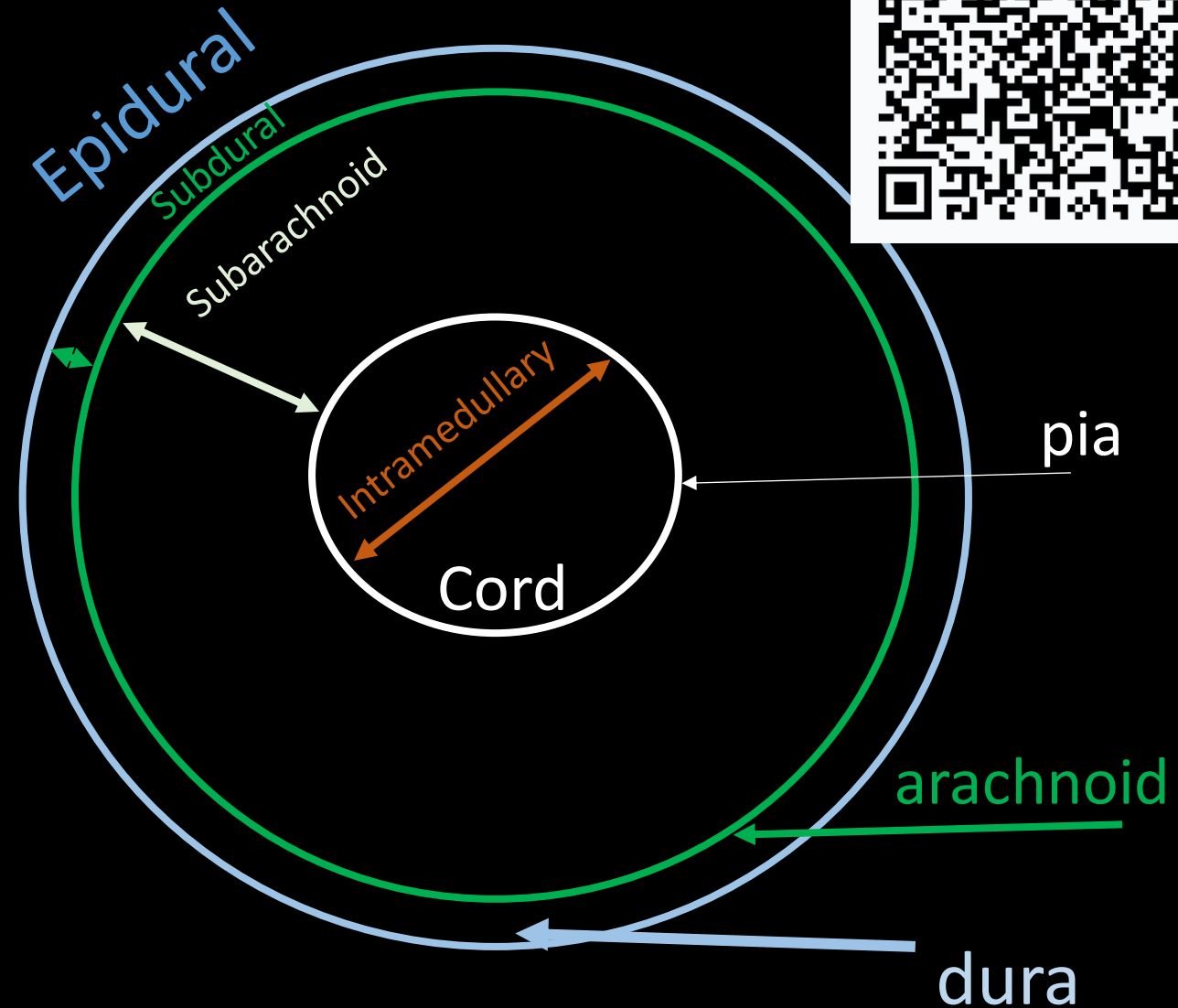


Thank you to the patients



Anatomy

- Epidural (outside dura)
- Subdural (btwn arachnoid and dura)
- Subarachnoid
- Intramedullary



QUIZ How do you identify epidural haematoma

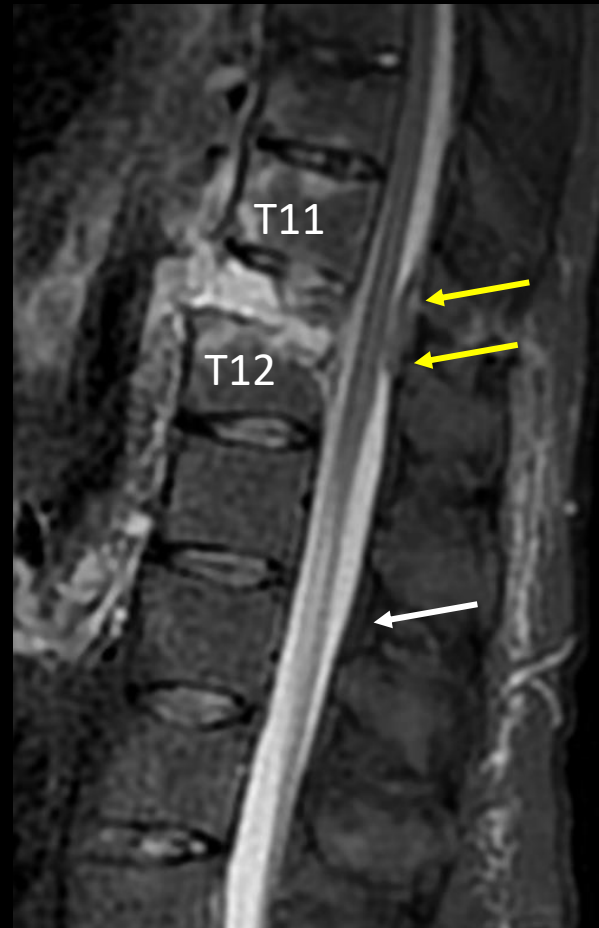
- 1. Start with T2W imaging F
- 2. Start with T1W imaging T Identify normal epidural fat on a T1W image

QUIZ: Locating haematoma by compartment

1. The subdural compartment is a potential compartment **T**
2. The subdural compartment is separate from epidural fat **T**
3. The dura is a T2 bright line between epidural fat and the subdural space **F It is T2 dark line**
4. Both Flow artefact and Subdural haematoma can cause mass effect on the cord **F Only subdural haematoma causes mass effect on the cord**

QUIZ: 3 column injury T11/12. Which of the following are true?

- 1. The yellow arrows points to epidural fat F
- 2. The white arrows point to epidural fat T
- 3. Epidural fat is most easily identified on a T1W image T
- 4. The yellow arrow points to a posterior epidural haematoma T



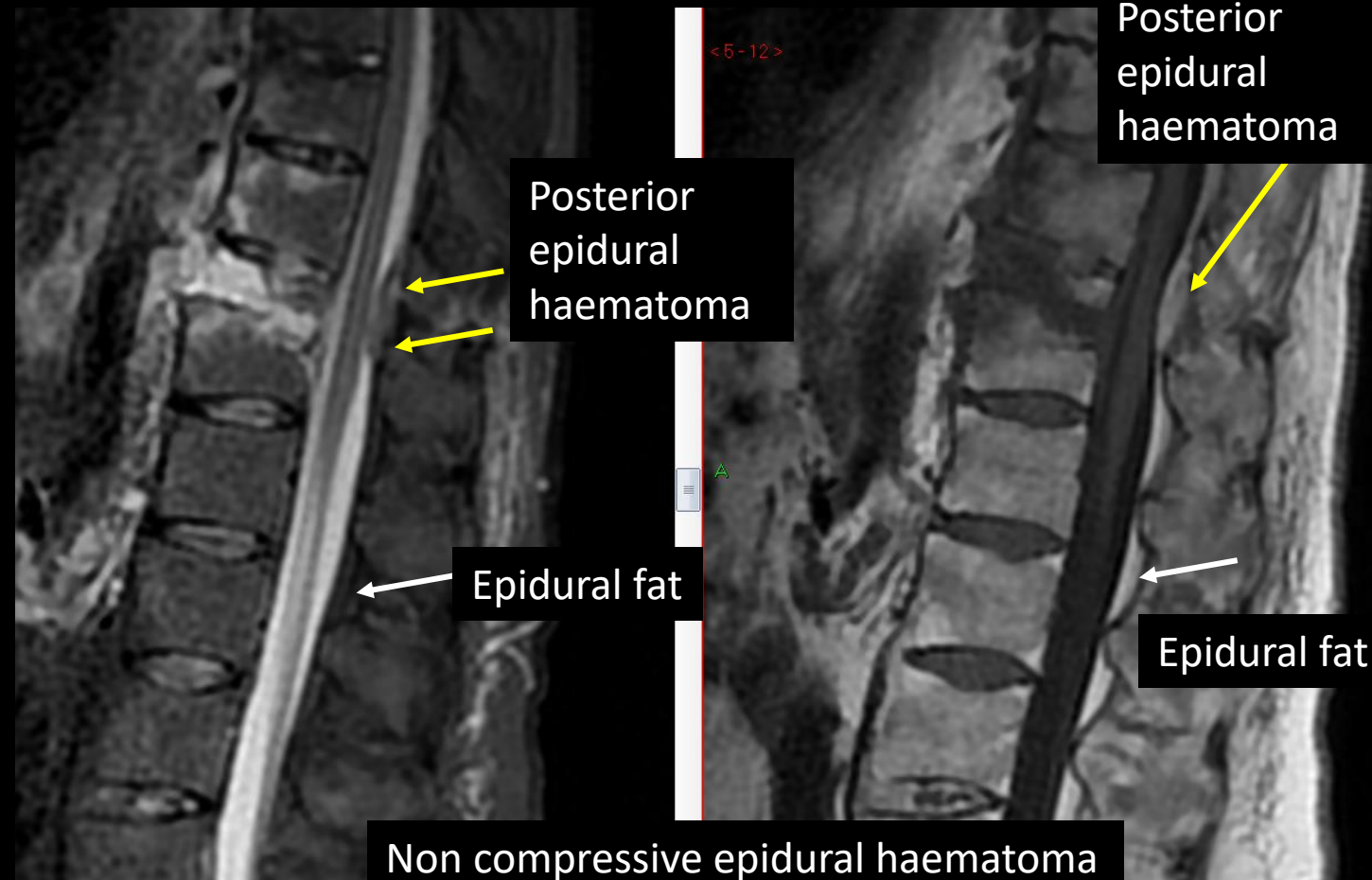
T2 fat sat - sag



T1 sag

QUIZ 3 column injury T11/12

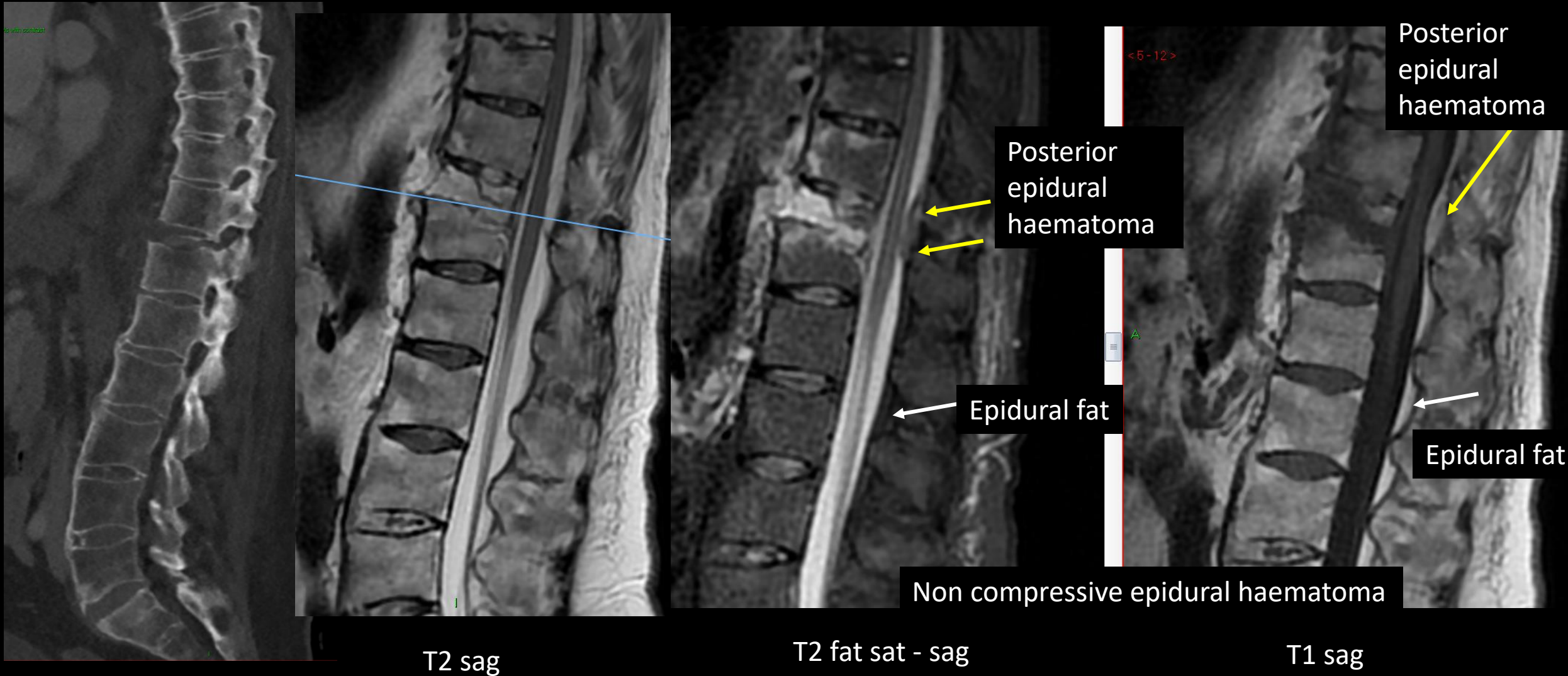
- 1. The yellow arrows points to epidural fat F
- 2. The white arrows point to epidural fat T
- 3. Epidural fat is most easily identified on a T1W image T
- 4. The yellow arrow points to a posterior epidural haematoma T



T2 fat sat - sag

T1 sag

Ankylosing Spondylitis 3 column injury T11/12





Anatomy

- Epidural (outside dura)
- Subdural (btwn arachnoid and dura)
- Subarachnoid
- Intramedullary

