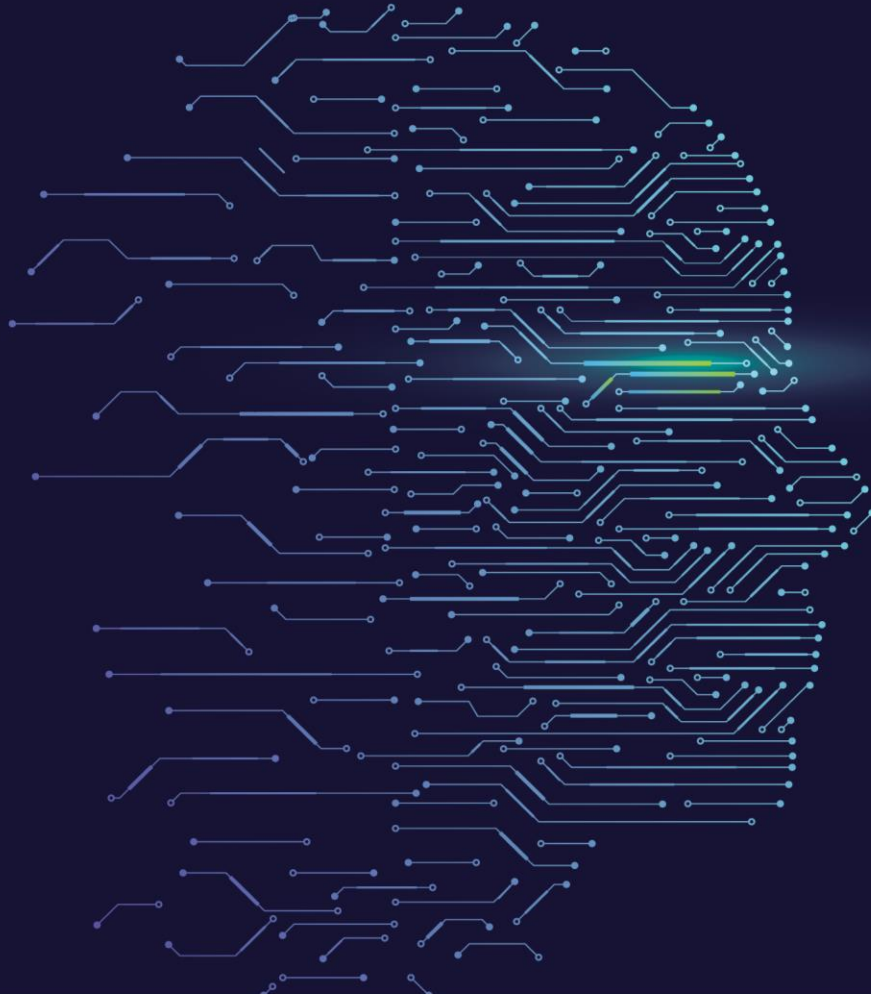


# 2019 IMAGING INFORMATICS SUMMIT



## Augmenting Machine Intelligence with Radiology Reporting

Wende N Gibbs MD

Senior Associate Consultant

Mayo Clinic

# Disclosures

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- No disclosures

# Learning Objectives

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- Reiterate the importance of report structure, content, and terminology in creation of valid labels/ground truth for algorithm development
- Describe the types of report “structure”, including common data elements (CDE), CDE macros, and templates
- Relate potential challenges in creation, dissemination, and acceptance of structured reports

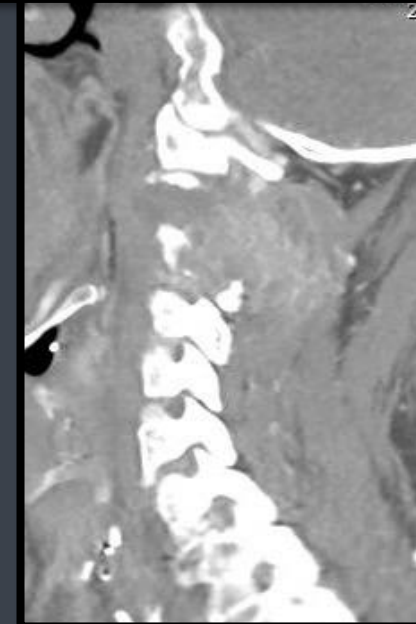
# Algorithm Development for ML Computer Vision

- If algorithms are to be trusted clinically, must have valid ground truth
  - Major obstacle: lack of large volume of accurately labeled data for training
  - Our reports contain reliable labels applied by experts
  - Costly and difficult to extract from prose or semi-structured reports
- Structure in our reports decreases language variability and ensures inclusion of required content
- Structure requires buy-in from “regular” radiologists

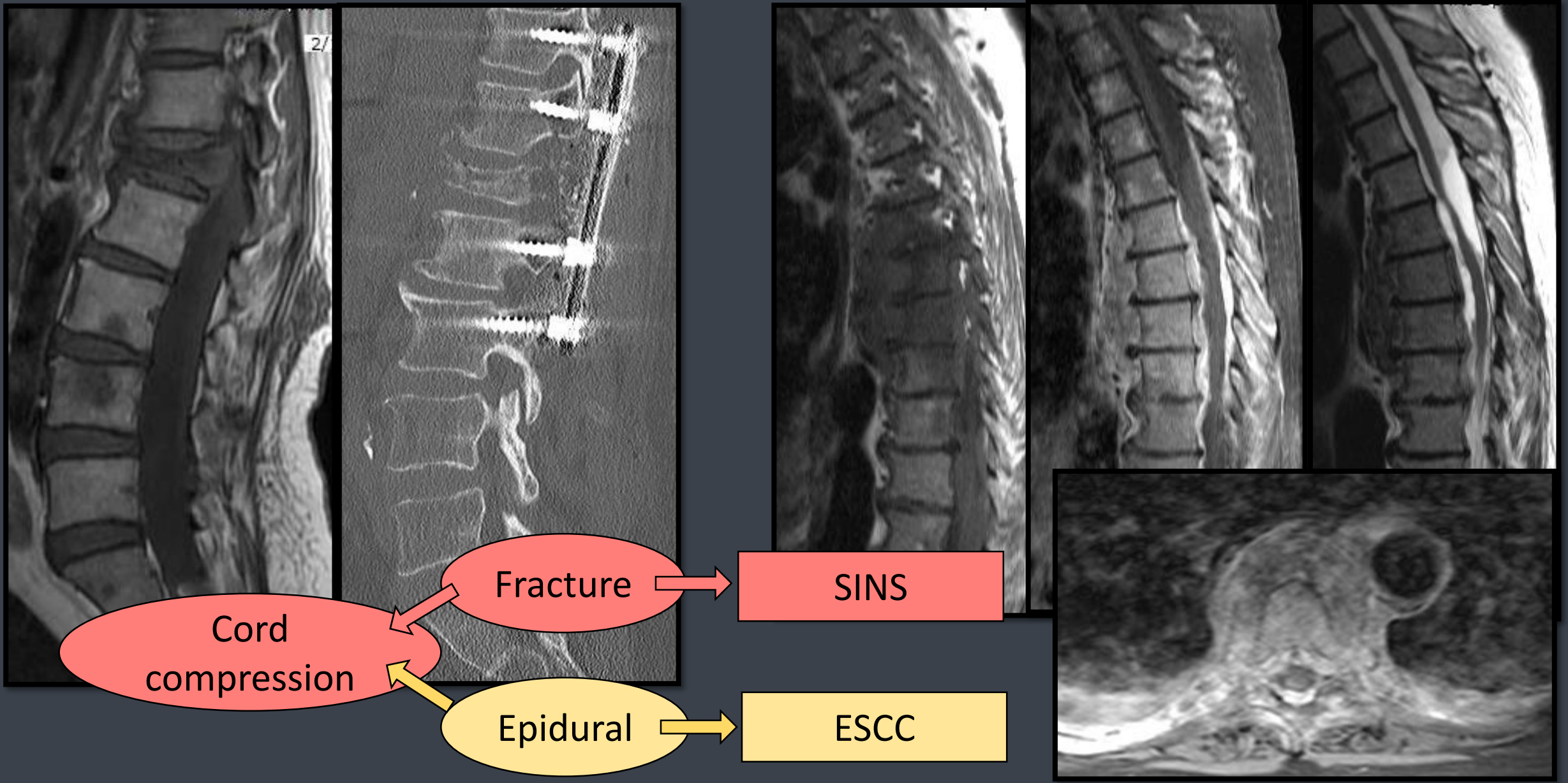


# Evidence based management (NOMS algorithm)

- Considers four aspects of disease status:
  - **N**eurologic (cord compression)
  - **O**ncologic (radiosensitivity to cEBRT)
  - **M**echanical stability
  - **S**ystemic status (life expectancy, comorbidities)
- Integration determines the use of radiation, surgery / cement augmentation, systemic therapy







# Spinal Instability Neoplastic Score (SINS)

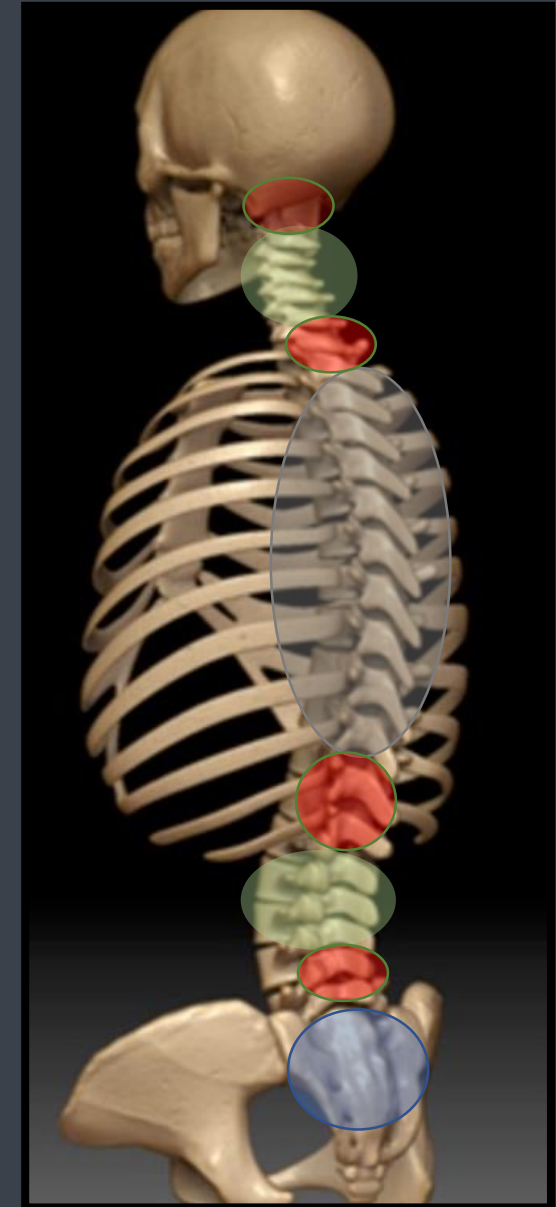
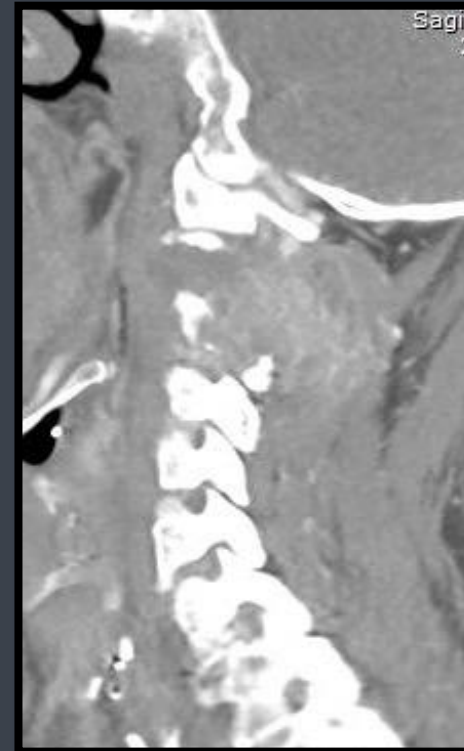
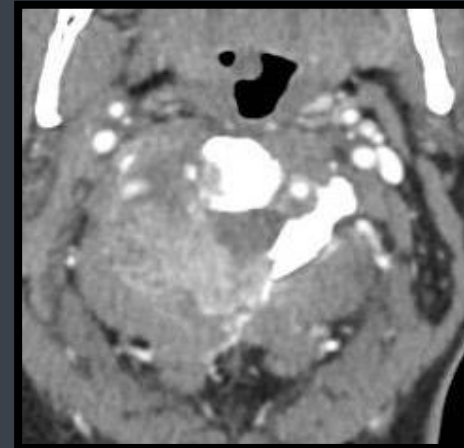
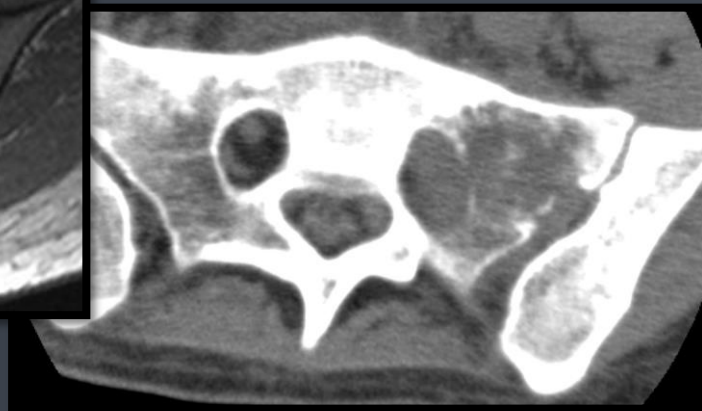
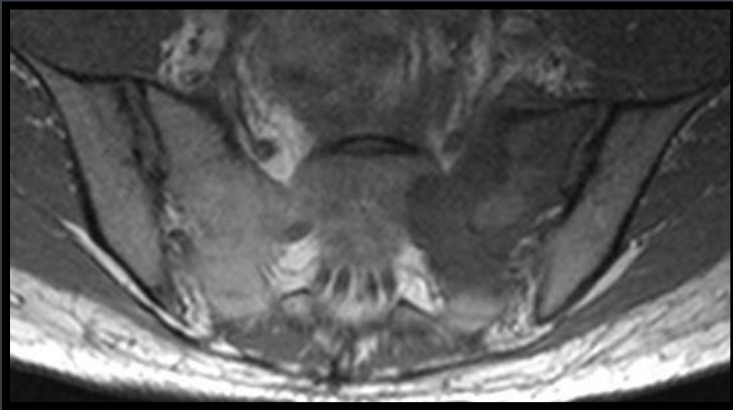
Questions	Answers (Point assignment)				
	4	3	2	1	0
Location		Junctional	Mobile	Semi-rigid	Rigid
Quality			Lytic	Mixed	Blastic
Alignment	Subluxation		Deformity		Preserved
Collapse		> 50%	< 50%	< 50% but > 50% body involved	None
Posterior Elements		Bilateral		Unilateral	None
Pain (Mechanical)		Yes		Occasional, not mechanical	No
<b>Score</b>	<b>13-18 = Unstable</b>		<b>7-12 = Indeterminate</b>		<b>0-6 = Stable</b>
<b>Recommendation</b>	<b>Urgent surgical consult</b>		<b>Surgical consult</b>		

*Modified from Fisher CG, Spine 2010.*



# Location

SPINE LOCATION	Score
Junctional (Occ-C2, C7-T2, T11-L1, L5-S1)	3
Mobile (C3-6, L2-4)	2
Semi-rigid (T3-10)	1
Rigid (S2-5)	0



Level
Location
Quality
Alignment
Collapse
Posterior elements
Pain
SCORE
Recommendation

Pick List Choices
Rigid spine[S2-S5] (0)
Semi-rigid spine [T3-T10] (1)
Mobile spine [C3-C6, L2-L4] (2)
Junctional spine [occiput-C2, C7-T2, T11-L1, L5-S1] (3)

Pick List Choices
None (0)
Unilateral (1)
Bilateral (3)

Spinal Instability Neoplastic Score
[C7]
-Location: <input type="checkbox"/>
-Lesion quality: <input type="checkbox"/>
-Alignment: <input type="checkbox"/>
-Collapse: <input type="checkbox"/>
-Posterior elements: <input type="checkbox"/>
-Pain (mechanical)(if known): <input type="checkbox"/>
SINS score: <input type="checkbox"/>
Category and recommendation: <input type="checkbox"/>

## MACRO FOR PS360

EXAM: MRI THORACIC SPINE WITHOUT CONTRAST

INDICATION: Back pain.

COMPARISON: None.

TECHNIQUE: MR imaging of the thoracic spine without contrast per protocol.

FINDINGS:

T12 metastasis with complete infiltration of the vertebral body and pathologic fracture compressing the conus. No cord signal abnormality.

SINS: T12
Location: Junctional 3
Lesion: Lytic 2
Alignment: Preserved 0
Collapse: >50% 3
Posterior Elements: Bilateral 3
Pain: Severe mechanical 3
Total: 14 Unstable
ESCC: Grade 1C (Low grade)

Macro SINS

Macro ESCC

Remaining levels normal. Preserved alignment.  
Normal visualized soft tissues.

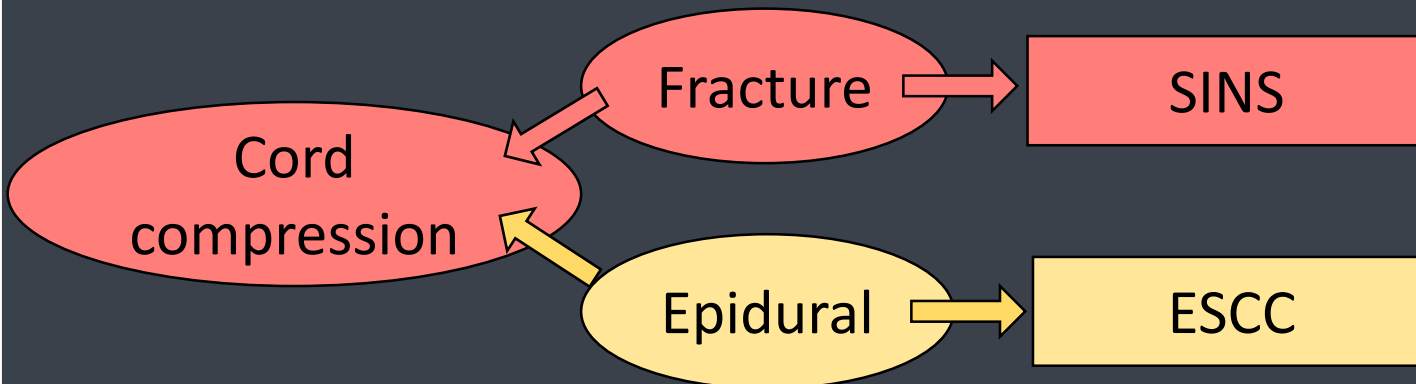
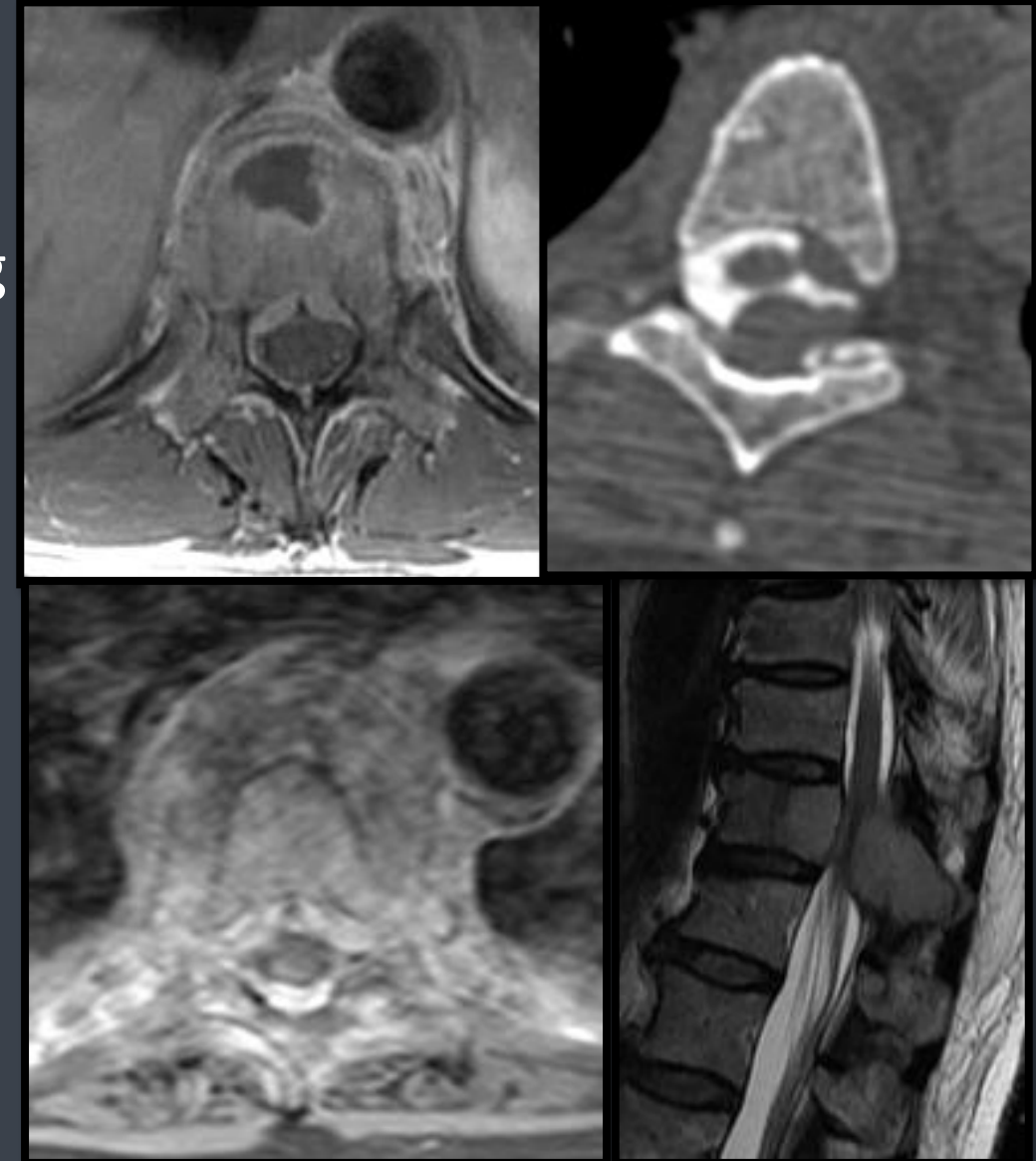
IMPRESSION:

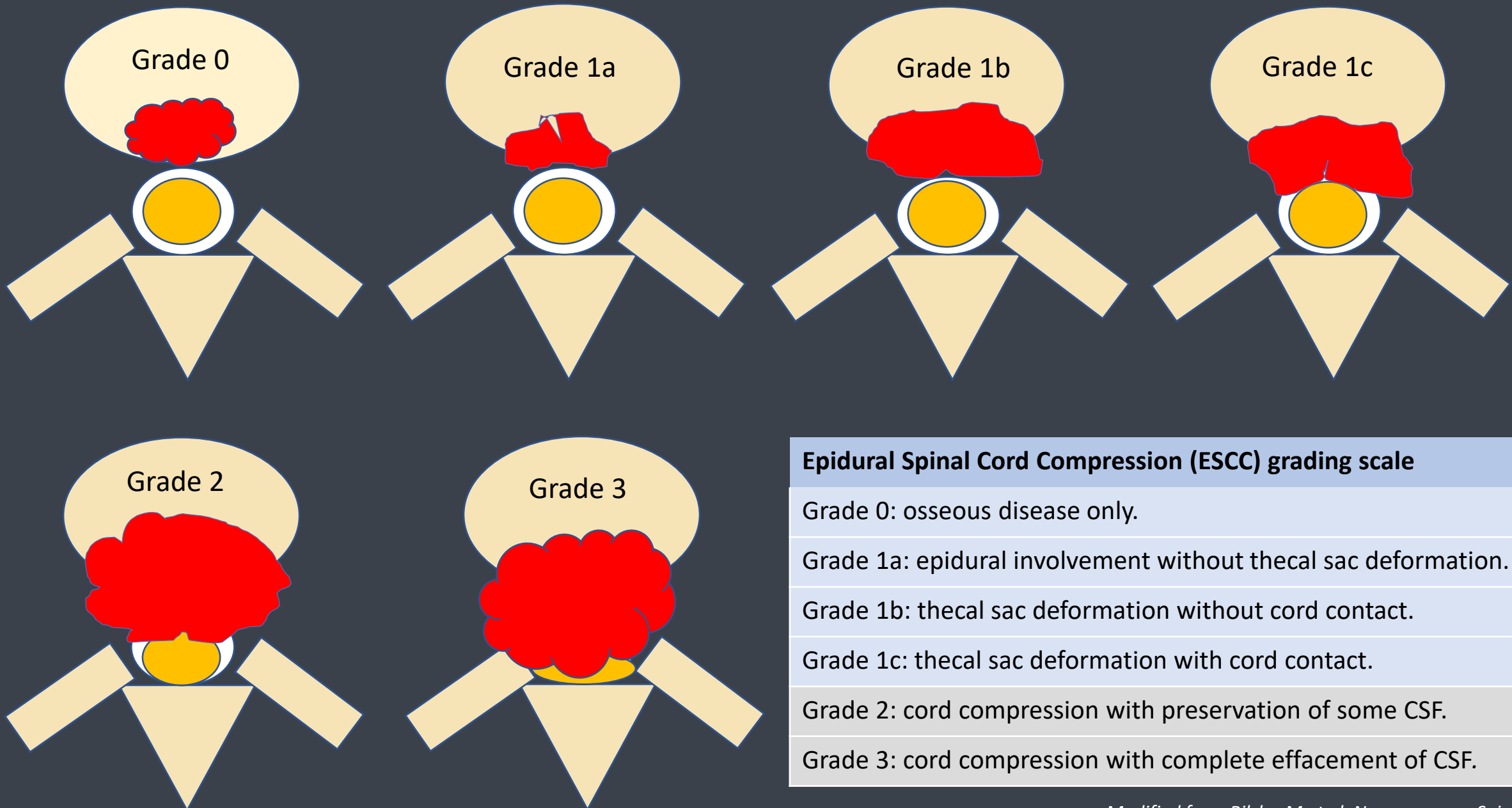
1. Unstable spine. SINS score 14. Recommend urgent surgical consultation.
2. Metastatic disease with pathologic fracture T12 producing severe conus compression.
3. Epidural disease without conus compression (ESCC Grade 1c).

# Epidural Spinal Cord Compression

- ESCC scale (2010)
  - 6 point scale for surgical/radiation planning
  - Uniform reporting for standardized treatment (and research, trials)

How would you describe this?





### Epidural Spinal Cord Compression (ESCC) grading scale

Grade 0: osseous disease only.

Grade 1a: epidural involvement without thecal sac deformation.

Grade 1b: thecal sac deformation without cord contact.

Grade 1c: thecal sac deformation with cord contact.

Grade 2: cord compression with preservation of some CSF.

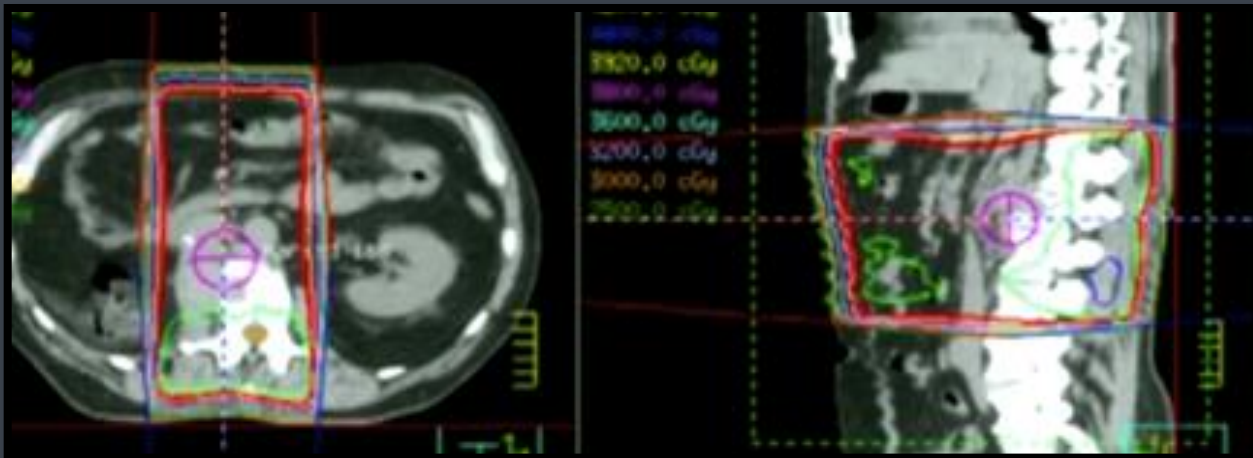
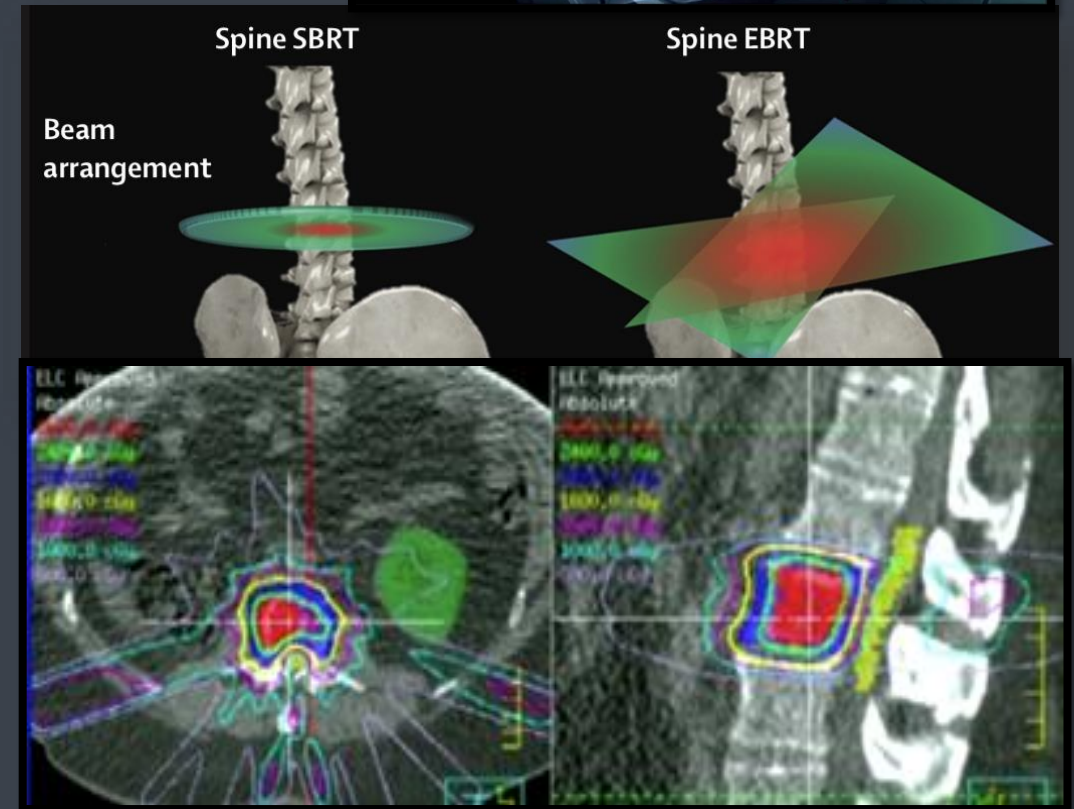
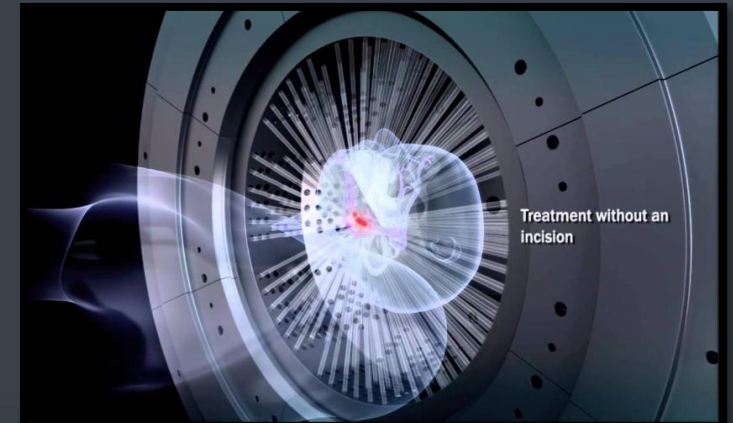
Grade 3: cord compression with complete effacement of CSF.

*Modified from Bilsky, M et al. Neurosurgery: Spine 2010.*

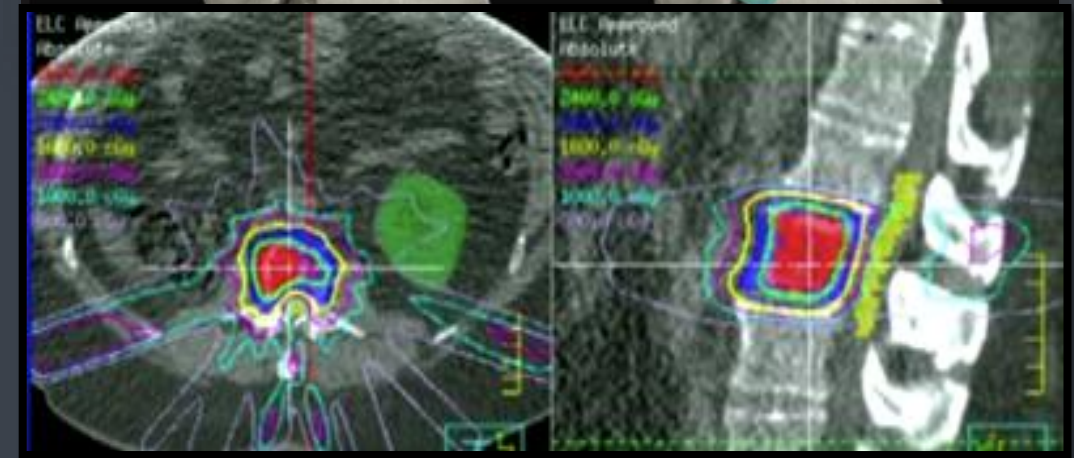


# Spinal metastases: Treatment

- Traditionally based on surgical considerations
- New techniques & technologies:
  - Stereotactic radiosurgery / SBRT
  - Minimally invasive surgical techniques



Conventional external beam radiation



Stereotactic radiosurgery

## Epidural Spinal Cord Compression (ESCC) grading scale

Grade 0: osseous disease only.

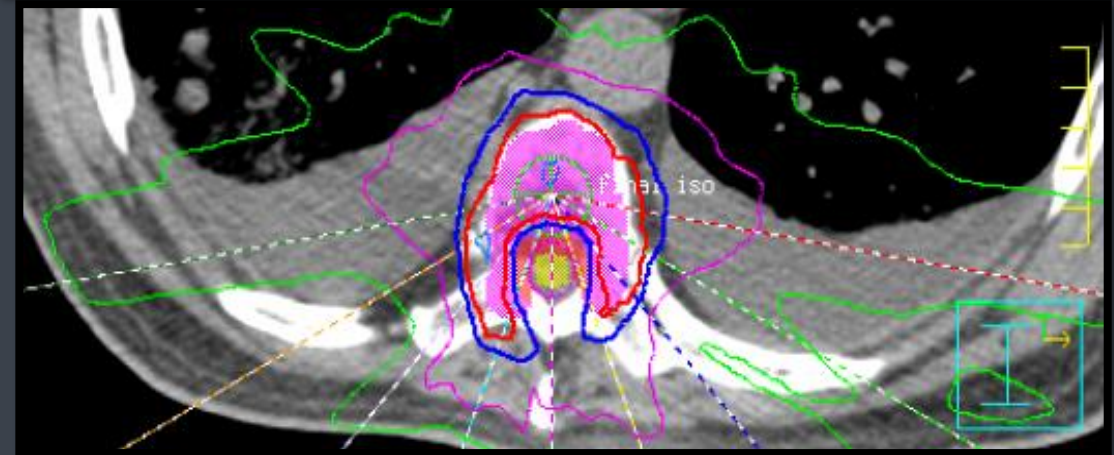
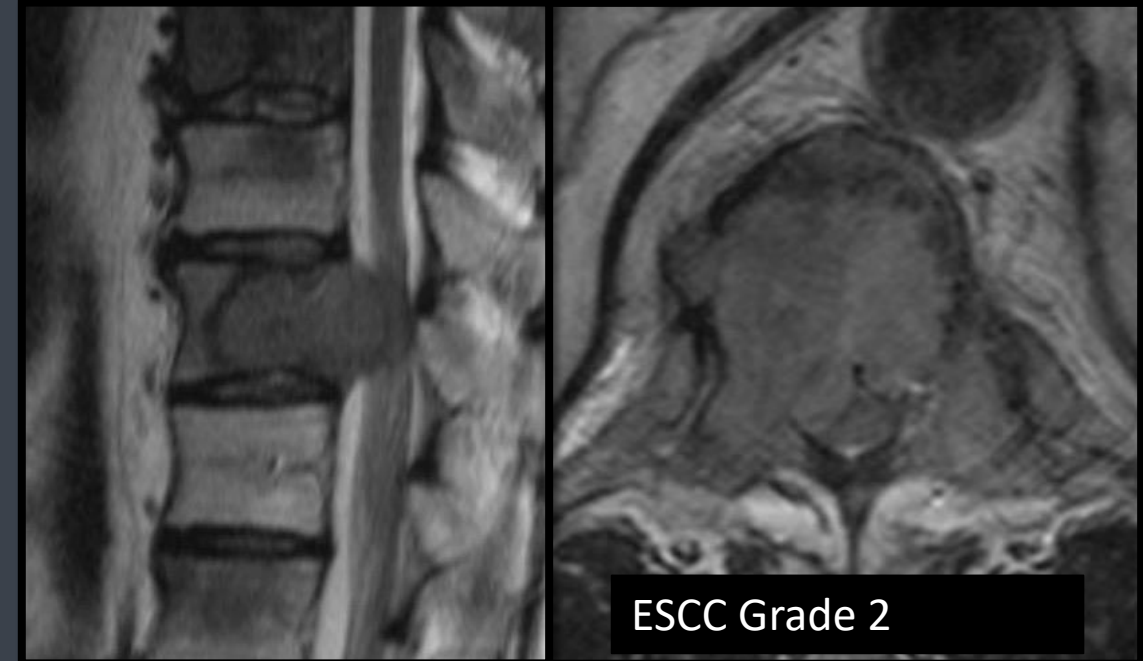
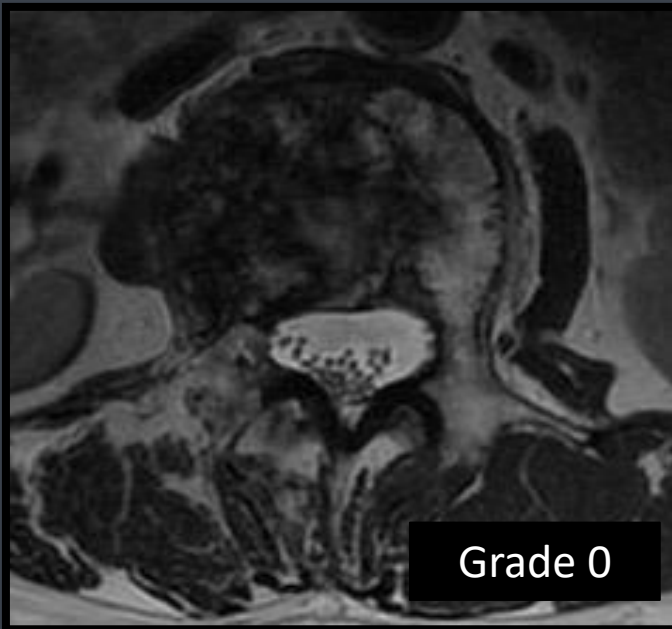
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# Evidence based management (NOMS algorithm)

- Considers four aspects of disease status:

- **N**eurologic (cord compression)
- **O**ncologic (radiosensitivity to cEBRT)

ESCC scale

- **M**echanical stability

SINS score

- **S**ystemic status (life expectancy, comorbidities)

- Integration determines the use of radiation, surgery / cement augmentation, systemic therapy



# Management Algorithm (NOMS)

Neurologic (Cord compression)	Oncologic (Is the tumor radiosensitive (EBRT)?)	Mechanical ( <u>Is the spine stable?</u> )	Systemic (Can the patient tolerate surgery?)	Treatment Decision
Low-grade	Yes	Yes		External beam radiation (EBR)
		No		Surgical stabilization -> EBR
	No	Yes		Stereotactic radiosurgery (SRS)
		No		Stabilization ->SRS
High-grade	Yes	Yes		EBR
		No		Stabilization -> EBR
	No	Yes	Yes	Separation surgery -> SRS
			No	EBR
		No	Yes	Stabilization & Sep surgery ->SRS
			No	Stabilization (cement) -> EBR

*Modified from Laufer, I et al. The Oncologist 2013*

# Common Data Elements

Questions	Pre-defined Answers				
	4	3	2	1	0
Location		Junctional	Mobile	Semi-rigid	Rigid
Quality			Lytic	Mixed	Blastic
Alignment	Subluxation		Deformity		Preserved
Collapse		> 50%	< 50%	< 50% but > 50% body involved	None
Posterior Elements		Bilateral		Unilateral	None
Pain (Mechanical)		Yes		Occasional, not mechanical	No

## The ASNR-ACR-RSNA Common Data Elements Project: What Will It Do for the House of Neuroradiology?

A.E. Flanders and J.E. Jordan

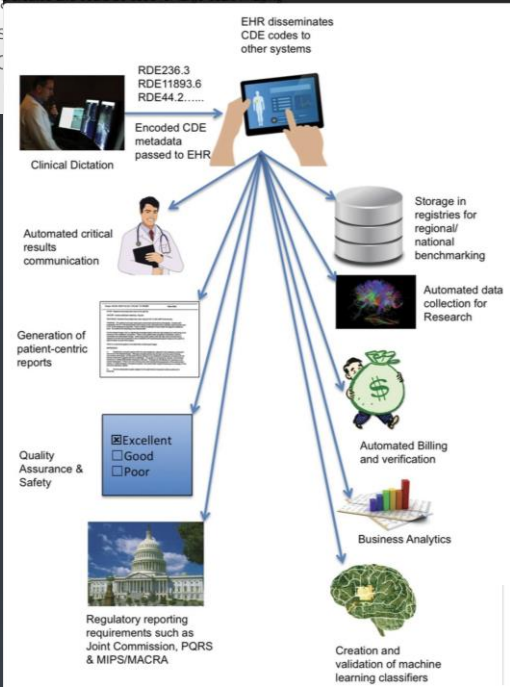
American Journal of Neuroradiology September 2018, DOI: <https://doi.org/10.3174/ajnr.A5780>



The ASNR-ACR-RSNA Common Data Elements (CDE) Neuroradiology Workgroup

Adam Flanders, MD  
Chair, CDE Workgroup

The ASNR has teamed up with the American College of Radiology (ACR) and the Radiological Society of North America (RSNA) to create neuroradiology specific common data elements (CDEs) for specific clinical use cases. CDEs are not reporting templates. Fundamentally a CDE is a question, concept, measurement, or feature with a set of controlled responses. This could take the form of a measurement (e.g. diameter of a pituitary adenoma), a subjective assessment of severity (e.g. mild, moderate, severe foraminal stenosis) or an ordinal value (e.g. ASPECTS score in acute stroke). CDEs can be both machine and human-generated. Rather than redesigning neuroradiology reporting, the goal is to establish the minimum number of "essential" concepts that should be represented in a report to address a clinical question. Examples include a standardized carotid stenosis measurement, use of an ASPECTS score with an acute stroke C schema for root compression in a degenerative lumbar spine MRI.



Level
Location
Quality
Alignment
Collapse
Posterior elements
Pain
SCORE
Recommendation

Pick List Choices
Rigid spine[S2-S5] (0)
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Spinal Instability Neoplastic Score

[C7]

-Location: ☐

-Lesion quality: ☐

-Alignment: ☐

-Collapse: ☐

-Posterior elements: ☐

-Pain (mechanical)(if known): ☐

SINS score: ☐

Category and recommendation: ☐

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Macro SINS  
CDE

Macro ESCC  
CDE

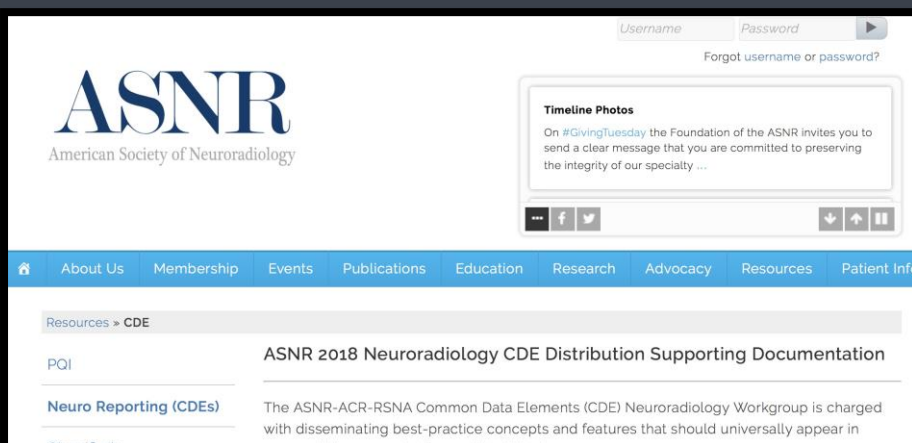
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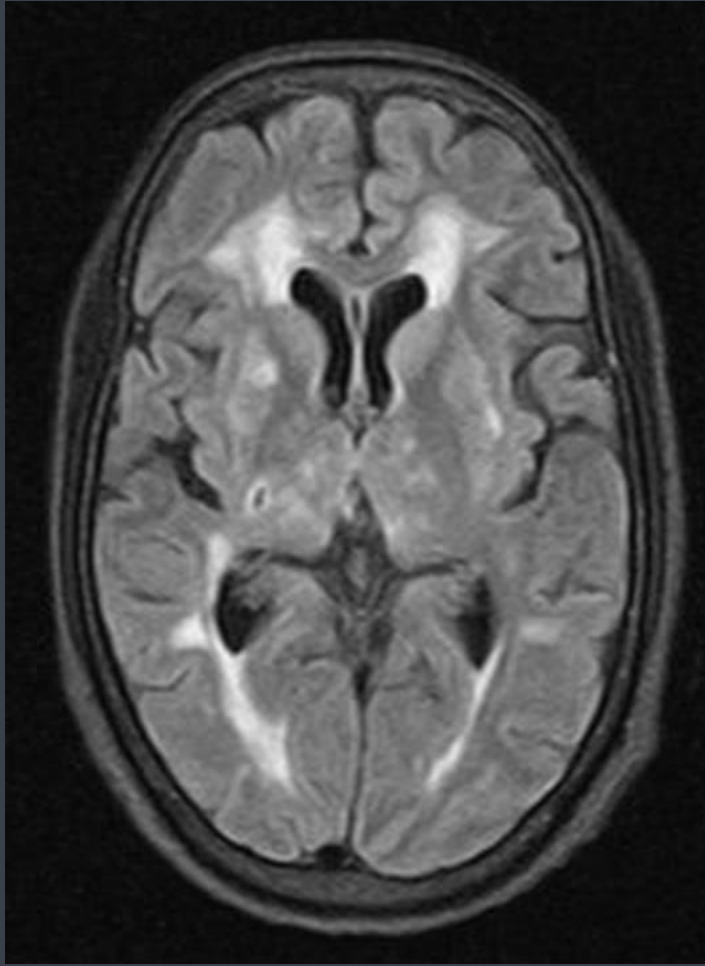
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[www.ASNR.org/Resources/CDE](http://www.ASNR.org/Resources/CDE)



# Standard terminology



Small vessel  
ischemic change

Leukoaraiosis

Small vessel  
disease

White matter  
disease





# Challenges

- Process/ Acceptance
- Guideline changes and advances in knowledge
- Dissemination



# Summary

- Adding structure to our reports has numerous benefits, not the least of which is providing labels for machine learning algorithm training.
- What will convince “regular” radiologists to adopt structure?
- Many are interested, and are contributing in their own way. How can we combine forces?