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Pediatric Spinal Cord Injury and Spinal Shock

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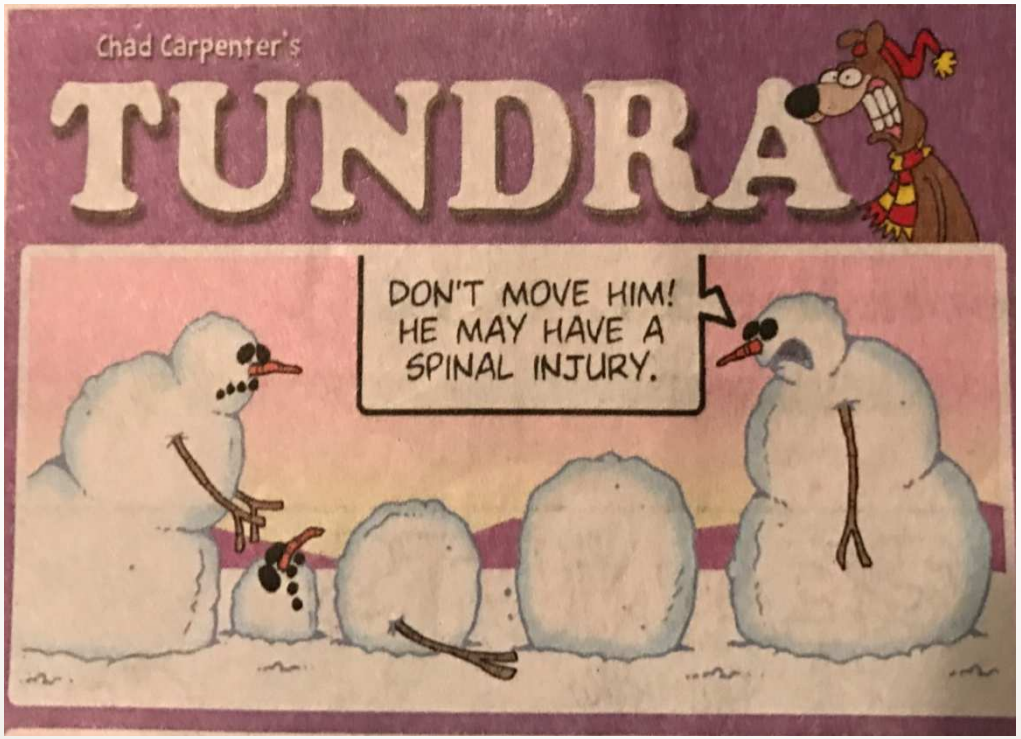
Disclosures

- None



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Outline

- Epidemiology
- Biomechanics
- SCIWORA
- Shock
- Outcomes
- Deformity

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Epidemiology

- Overall incidence in USA: 1.99/100,000
- 60%-80% cervical spine
- Males > Females (2:1)
- Most common mechanism: Motor vehicle accidents (48%-61%)
  - 70%-80% not properly restrained
- Other mechanisms: Falls (18%-30% in younger age), sports injuries (20%-38% in older age), pedestrian accidents, non-accidental trauma (age <2)
- Seasonal peaks during summer and around winter holiday
- Risk for neurologic injury: Cervical > thoracic > lumbar
- Mortality rate: 16%-18%, higher in upper cervical injuries (AOD), and younger age
  - Increased rate of head injuries with higher injuries as well

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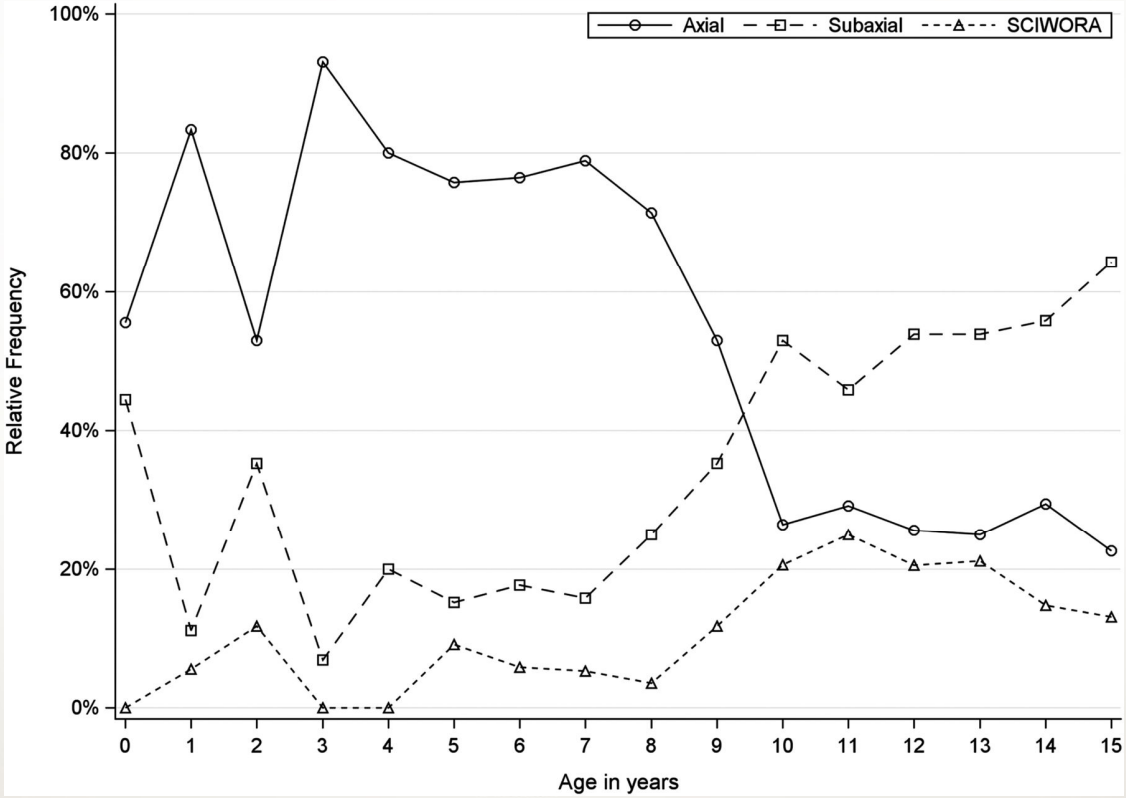
Epidemiology

- Age <8: upper cervical injuries, ligamentous injuries, severe and complete injuries
- Age >8: subaxial injuries, fractures, T-L injuries



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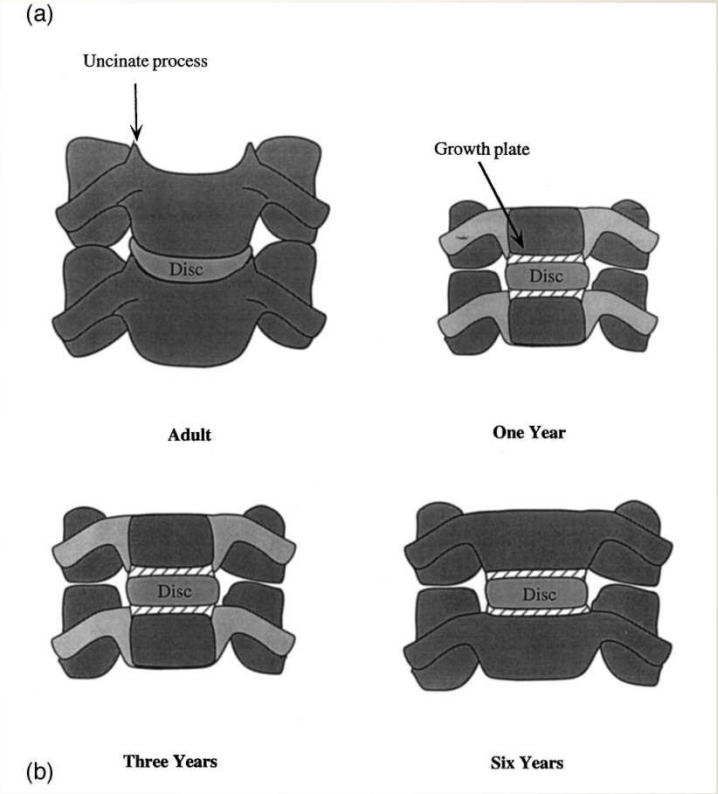
Biomechanics

- Overall: increased elasticity, hypermobility
  - Expansile ligaments, joints, discs, annulus fibrosis
  - Shallow and more horizontally oriented facet joints (30 deg at birth)
  - Wedge-shaped vertebral bodies
  - Absent uncinate process (which limits lateral and rotational movement)
  - Large head to body ratio
  - Underdeveloped neck musculature



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SCIWORA (Spinal Cord Injury Without Radiographic Abnormality)

- **Causes:** High-energy injury with hypermobility of spine and lack of tolerance of the spinal cord to handle stretch.
- **Most common in children under 8**
- **Cervical spine location:** Cervical > Thoracic
- **Risk of neurologic injury:** ranges from complete to partial neurologic injury.
- **Prognosis:** predicted by neurologic status at presentation vs MRI findings (edema, hemorrhage, etc.)
- **Acute treatment:** spine precautions, determination of instability, blood pressure control, steroids (?)
- **Conservative management:** The main treatment of SCIWORA is external immobilization (12 weeks) with activity modification.

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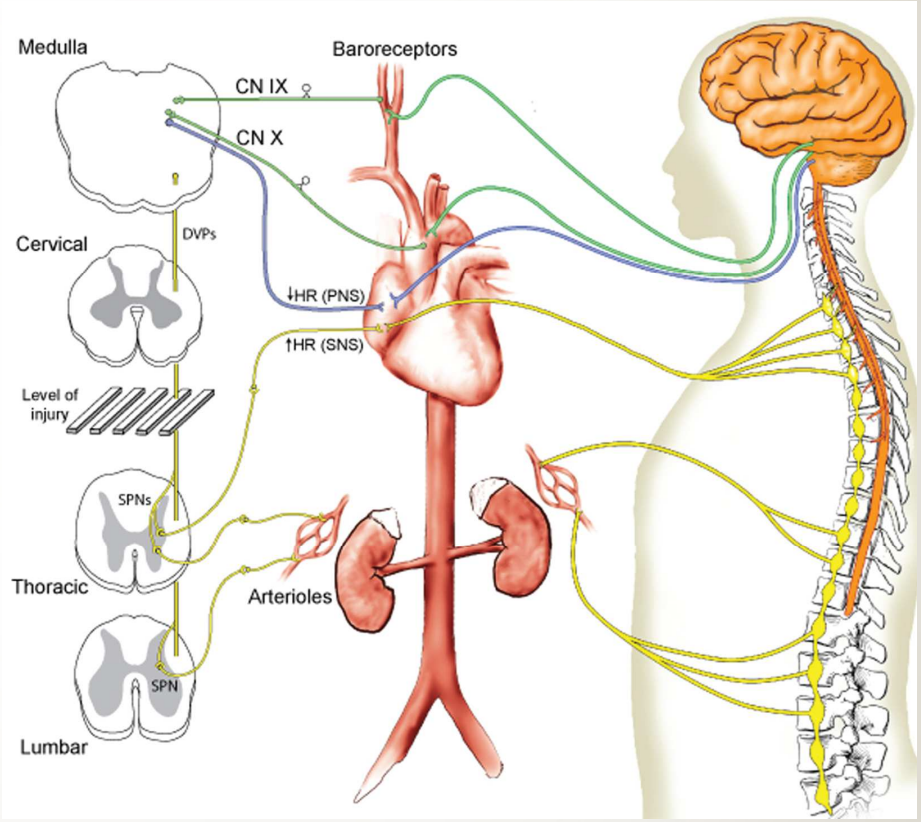
Neurogenic Shock - Pathophysiology

- Most common with injury above T6
- Sudden loss of autonomic tone due to SCI
- Disruption of the descending sympathetic pathways results in unopposed vagal tone in the vascular smooth muscle, causing decreased systemic vascular resistance and vasodilation
- Hypotension that results from neurogenic shock places patients at increased risk of secondary spinal cord ischemia
- May occur anytime after the onset of injury or illness, ranging from the time of presentation to several weeks after presentation



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Neurogenic Shock - Presentation

- Respiratory insufficiency and pulmonary dysfunction
- Systemic hypotension and relative bradycardia
- Other
  - Skin is often warm and flushed initially
  - Hypothermia may develop because of profound vasodilation and heat loss.
  - Central venous pressure is low due to decreased systemic vascular resistance

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Neurogenic Shock - Management

- ICU care and Cardiopulmonary support
  - Hypotension must be treated immediately in order to avoid secondary ischemic SCI (especially in patients with concurrent brain injury)
  - Management of patients with an acute SCI in an intensive care unit or similar monitored setting is recommended
  - Use of cardiac, hemodynamic, and respiratory monitoring devices to detect cardiovascular dysfunction and respiratory insufficiency in patients following acute spinal cord injury is recommended
  - The blood pressure goals in pediatric patients with SCI are unknown, however, it is recommended to maintain a MAP goal (MAP >85-90 mm Hg for 7 days) in adults according to Neurosurgery guidelines

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Day 1	Admission Service:	□ Trauma
	Consults:	□ Spine
	Labs:	□ CBC qam (HCT >21%) □ BMP qam
	Radiology Studies:	□ Follow-up x-rays post halo placement: lateral c-spine
	Immobilization:	□ Aspen collar with cervical collar maintenance
		□ Halo with pin care □ Halo and traction with pin care
	Monitoring:	□ VS □ q1h
		□ Neuro checks □ q1h □ Sensation checks □ q1h
		□ Nursing: please mark the level of abnormal sensation and any changes with the date
		□ MAP Goal x 5 days □ <3yrs: 60 □ 3-12 yrs: 70
		□ 13-16 yrs: 75 □ >16 yrs: 80
		□ Strict I/O □ Arterial line placement
		□ Accuchecks q2-4h □ Glucose control between 80-150
		□ Ventilatory support as needed (normocapnia)
	Vasopressors:	□ Dopamine _____mcg/kg/min □ Norepinephrine ___mcg/kg/min
		□ Epineprhine _____mcg/kg/min □ Neosynephrine ____mcg/kg/min
	Medications:	□ Fentanyl _____mcg/kg/min
		□ Versed _____mg/kg/min □ Remifentanil _____mg/kg/min
	Fluids:	□ D5 1/2 NS with 20 mEq KCl IV @ ____ ml/hr
		□ D5 NS with 20 mEq KCl IV @ ____ ml/hr
	Diet:	□ NPO
	Activity:	□ Bedrest on KenAir Matress □ Strict log rolling only, HOB flat
		□ Turn/ reposition q2h with strict spine precautions maintained
	DVT Prophylaxis:	□ SCD in place (on 2hrs/ off 2hrs) □ T.E.D. hose in place
	Bowel and Bladder:	□ Indwelling catheter x 24-48hrs PI □ NGT

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Day 2	Diet:	□ Enteral Feeds	□ Clear Liquid	□ TF @ ___ ml/hr
	(consider)	□ Regular diet		
	Consults:	□ Physical Therapy	□ Speech Therapy	
	(consider)	□ Occupational Therapy	□ Rehabilitation Services	
	Radiology Studies:	□ Follow-up x-rays post halo placement: lateral c-spine *(If not already obtained)*		
Day 3	Diet:	□ Enteral Feeds	□ Clear Liquid	□ TF @ ___ ml/hr
		□ Regular diet		
	Consults:	□ Physical Therapy	□ Speech Therapy	
		□ Occupational Therapy	□ Rehabilitation Services	
	Bowel and Bladder:	□ Docusate ___mg PO/per tube BID		□ In & Out Cath q6h
		□ Miralax ___ gr PO/per tube BID/TID/QID		
		□ Docusate ___mg PO/per tube BID		
		□ Bisacodyl Suppoitory ___mg PR daily		
Day 6	Monitoring:	□ Disconitue MAP goals		
	DVT Prophylaxis:	□ Convert to LMWH if not contraindicated by plan of care		
	Consult:	□ Hematology prn		

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Neurogenic Shock - Summary

- SCI, regardless of mechanism, may result in neurogenic shock characterized by sudden loss of autonomic tone resulting in hypotension and relative bradycardia
- Higher lesions are associated with more severe deficits
- Peripheral vasoconstrictors, chronotropes, and inotropes may be needed in cases of neurogenic shock
- The hypotension that results from loss of autonomic tone can precipitate further secondary ischemic injury to the spinal cord, and should be managed aggressively
- Treatment in the ICU leads to better outcomes
- Dysautonomia may develop and often persists several weeks after the injury

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Outcomes

	Age <2, N = 27, (%)	Age 2–7, N = 140, (%)	Age 8–15, N = 373, (%)
Outcome			
Death during hospitalization	7 (26)	22 (16)	11 (3)
Normal	10 (37)	84 (60)	292 (78)
Persistent neurologic deficit	10 (37)	34 (24)	70 (19)

Outcome	Direct To Pediatric Trauma Center, n,% (95% CI); n = 180	Via Local Hospital, n,% (95% CI); n = 141
Normal	116, 64% (57–71)	87, 62% (53–70)
Persistent neurologic deficit	51, 28% (22–36)	43, 30% (23–39)
Death during hospitalization	13, 7% (4–12)	43, 30% (23–39)
Unadjusted OR (95% CI)*	1.13 (0.71–1.78)	
Adjusted OR (95% CI)†	1.89 (1.03–3.47)	

*Comparing the odds of normal outcome to persistent neurologic deficit or death for direct to pediatric trauma center compared to via local hospital.
†Adjusting for severity according to altered mental status, focal neurologic findings, substantial comorbid injuries (head, torso, and extremities), and for correlation among patients within a pediatric trauma center.

			Normal	Persistent Deficit	Death
Axial	Injuries involving C1–2	244	62	24	14
	C1 arch fracture	10	90	10	0
	Atlanto-axial rotatory subluxation	55	89	11	0
	Cord injury	10	40	50	10
	C1–2 dislocation	10	10	50	40
	C1–2 subluxation	5	40	40	20
	C2 synchondrosis fracture	15	73	13	13
	C2 vertebral body fracture, other	7	43	14	43
	Hangman's fracture	16	63	38	0
	Jefferson fracture without ligamentous injury	2	100	0	0
	Ligamentous injury C1–2 without fracture	10	40	50	10
	Atlanto-occipital dislocation	30	7	40	53

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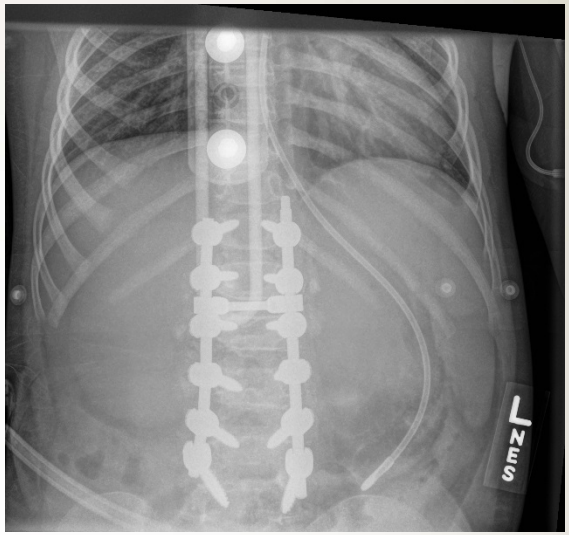
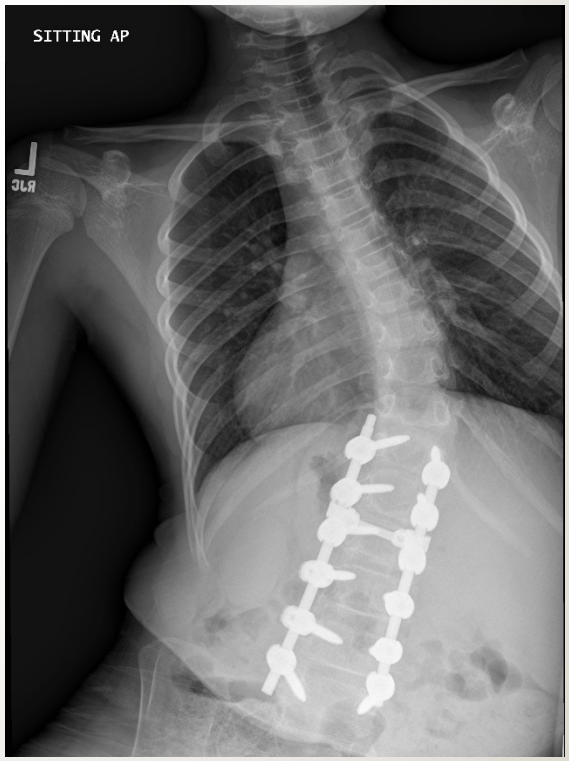
Deformity

- **Deformity:** Progressive deformity can occur in spinal cord injury patients, especially in those injured prior to adolescent growth spurt.
  - Ranges in studies from 46-98%
  - More severe in younger onset of paralysis, age at injury important
- Bracing may be necessary to prevent or delay surgery in growing children with history of spinal cord injury





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Summary

- Pediatric spine is biomechanically unique from an adult, resulting in a different pattern of injuries
- CT and MRI can be useful modalities, especially in SCIWORA
- Management usually consists of external immobilization, but surgical treatments are frequently necessary
- More frequent neurologic deficits and spinal shock in higher injuries
- Deformity can occur after SCI, so proper follow-up is necessary

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