

## Incidence

- Meta analysis- 32 studies 1995-2005 including > 1 million of encounters
- Neuropathy
  - Spinal: 0.04% (4/10,000)
  - Epidural: 0.02%
  - Interscalene: 3%
  - Axillary: 1.5%
  - Femoral: 0.34% (3/1,000)

## Incidence

- Meta analysis- 32 studies 1995-2005 including > 1 million of encounters
- Permanent nerve injury
  - Spinal: 0% to 0.04% (4/10,000)
  - Epidural: 0% to 0.07%
  - Peripheral block: 1 case among 16 studies
- Incidence 1/5 as common among OB patients

– Brull, McCarthy, Chan, El-Beheiry. Neurological complications after regional anesthesia: Contemporary estimates of risk. *Anes Analg*. 2007;104(4):965.

## What are rates of various risks?

- Total of 1.37 million labor epidurals- meta-analysis
- Transient neurologic injury 1:6,700
- Deep infection 1:145,000
- Epidural hematoma 1:168,000
- Persistent neurologic injury 1:240,000

Ruppen, Wilhelm (08/2006). "Incidence of epidural hematoma, infection, and neurologic injury in obstetric patients with epidural analgesia/anesthesia." *Anesthesiology*, 105 (2), p. 394.

## What are rates of various risks?

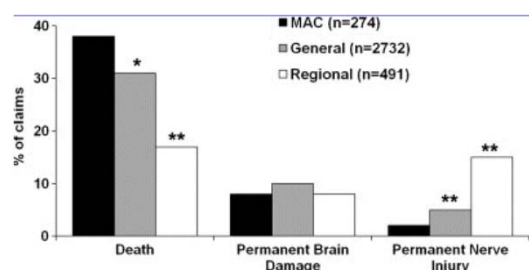
- Reviewed continuous femoral block (catheter) in 1,400 patients
- Three neural lesions (0.21%) were noted after continuous femoral nerve block.
- Nerve damage completely resolved 36 h to 10 weeks later. Cultures from 28.7% of the catheters were positive.

Capdevila, X. et. al. Continuous peripheral nerve blocks in hospital wards after orthopedic surgery: a multicenter prospective analysis of the quality of postoperative analgesia and complications in 1,416 patients. *Anesthesiology*. 103(5):1035-45, 2005.

## Maybe we should stick to general?

- Review closed claims data:
- 22% of all claims related to nerve injury
  - Only 23% of those were permanent
- Historically, 61% of nerve injury claims related to general anesthesia
- 36% were related to regional anesthesia

### Shifting pattern



Metzner, Julia (06/2011). "Closed claims' analysis". Best practice & research. *Clinical anaesthesiology* (1753-3740), 25 (2), p. 263.

### How does pain *therapy* relate to anesthesia injury claims?

- Early issues reflected mainly surgical anesthesia (> 80% of all claims)
- In 1990s, surgical anesthesia claims declined to 72% of all claims; chronic pain (11%) becoming as common as obstetric anesthesia claims (12%)
- Chronic pain management increased to 18% of claims from 2000 to 2007.

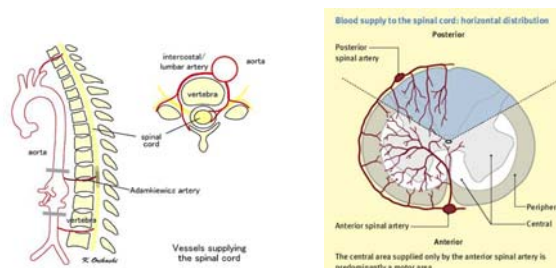
Metzner, Julia (06/2011). "Closed claims' analysis". Best practice & research. *Clinical anaesthesiology* (1753-3740), 25 (2), p. 263.

### Causes of injury

- Infection (Epidural abscess, meningitis)
- Neuronal ischemia (Anterior spinal artery syndrome, Epidural hematoma)
- Direct trauma
- Neurotoxicity (from locals or inadvertant drug)

### Anterior Spinal Artery Syndrome

- Limited, non-collateral perfusion to anterior cord



### Vasoconstrictor-related ischemia

- Widely refuted as a cause of nerve injury



### Epidural Hematoma

- Previous incidence 1/50,000-1/150,000
- Since LMWH, 1/5,000 among at-risk patients.



C K SreeHarsha, S Rajasekaran and P Dhanasekara Raja Spontaneous complete recovery of paraplegia caused by epidural hematoma complicating epidural anesthesia: a case report and review of literature *Spinal Cord* (2006) 44, 514-517.

## Epidural Hematoma

- Weakness
- Back pain with radicular component
- Sensory deficit
- Prompt recognition (MRI) and treatment are crucial

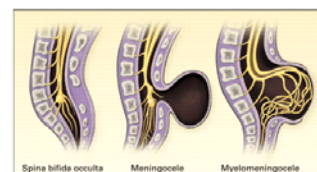
Regionals and Anticoagulants	
Warfarin	Discontinue chronic warfarin therapy 4–5 days before spinal procedure and evaluate INR. INR should be within the normal range at time of procedure to ensure adequate levels of all vitamin K-dependent factors. Postoperatively, daily INR assessment with catheter removal occurring with INR <1.5
Antiplatelet agents	No contraindications with aspirin or other NSAIDs. Thienopyridine derivatives (clopidogrel and ticlopidine) should be discontinued 7 d and 14 d, respectively, before procedure. GP IIb/IIIa inhibitors should be discontinued to allow recovery of platelet function before procedure (8 h for tirofiban and eptifibatide, 24–48 h for abciximab).
Thrombolytics /fibrinolytics	Run away!
Unfractionated SQ heparin	No problem with "minidose" (<10K units)
LMWH	Delay needle/catheter placement 2–4 hours after last dose, document normal aPTT. Heparin may be restarted 1 h following procedure. Sustained heparinization with an indwelling neuraxial catheter associated with increased risk; monitor neurologic status aggressively.

## Direct Needle Trauma



## Predisposing Factors- Low-lying cord or tethered cord

- Conus below L1 in 20% of patients
  - Broadbent, Anaesthesia 2000;55:1006
- Look for signs of spina bifida occulta- dimple, hairy tuft, fatty pad



## Case report

- 26-year-old female THIN, elective caesarean section.
- Spinal anesthesia at L3-4 with 22-gauge Quincke, 1 attempt, and 1.2 mL of 0.5% bupivacaine
- No leg pain or paraesthesia; no resistance to injection
- Post-op, unable to move her right ankle.
- Presented one month later with right foot drop and numbness in the right lateral aspect of her ankle. No urinary or bowel complaints.
- Hypotonia and motor power grade 1/5 in the dorsiflexors of right ankle.
- MRI = cord with tip at L4, tethered to intradural cyst at S3 and syrinx at L1-L3.
- Almost complete recovery over 6 months.
- Ahmada F.U., Pandeya P., Sharma, B.S., and Garga A. Foot drop after spinal anesthesia in a patient with a low-lying cord. *I/OA*. 2006;15(3):233.236.



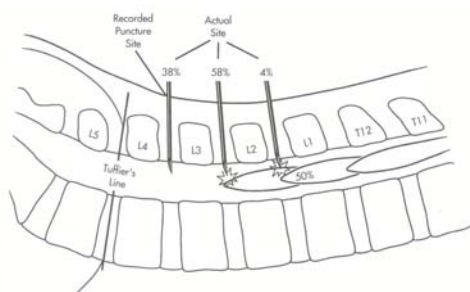
## Predisposing Factors- High Placement

- Difficult to identify specific interspace
- Anesthesia providers tend to be higher than estimated
- Broadbent et. al.:
  - Correct space 29%
  - One space higher 51%
  - Two spaces higher 15%
  - Three spaces higher 1%
  - Four spaces higher 0.5%
- Broadbent, Maxwell, Ferrie, et al. Ability of anaesthetists to identify a marked lumbar interspace. *Anaesthesia* 2000;55:1006-1026.

Anaesthetists' opinions of vertebral level compared with actual marker levels (determined by radiologists) in 100 patients undergoing magnetic resonance imaging scans. Correct identification of the vertebral level is indicated by underlined type.

Actual level	Anaesthetists' opinions						
	T <sub>12</sub> -L <sub>1</sub>	L <sub>1</sub> -2	L <sub>2</sub> -3	L <sub>3</sub> -4	L <sub>4</sub> -5	L <sub>5</sub> -S <sub>1</sub>	S <sub>1</sub> -2
T <sub>12</sub> -L <sub>1</sub>	<u>2</u>	3		1			
T <sub>12</sub> -L <sub>1</sub>		10	4	2			
L <sub>1</sub> -2	1	<u>16</u>	39	24			
L <sub>2</sub> -3		5	<u>26</u>	45			
L <sub>3</sub> -4				<u>13</u>	5		
L <sub>4</sub> -5					<u>2</u>		
L <sub>5</sub> -S <sub>1</sub>						<u>1</u>	1

## Actual vs. assumed puncture site



## Avoiding the wrong interspace

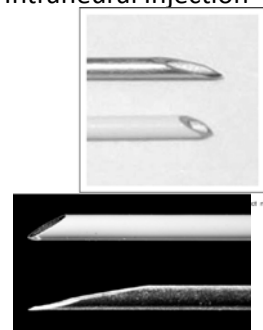
- Seven cases of conus damage
  - Usually estimated to be at L2-3
  - All women
  - Unilateral sensory deficit, 6/7 had foot drop, 3/7 had urinary symptoms.
  - Normal cord length in all. 6/7 had syrinx.
  - Rec: never perform spinal > L3
    - Reynolds Damage to conus medullaris following spinal anaesthesia. *Anaesthesia* 2001;56:235-247.
- Tuffier's line is always below the conus.
  - Kim et. al. *Anesthesiology* 2003;99:1359.

## But why would it be difficult to find landmarks?



## Predisposing Factors- Intraneural Injection

- Blunt ("B-bevel") needle will displace mobile nerve fibers and less likely puncture them.



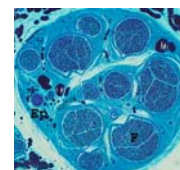
### Intraneural Injection

- Fascicular injury more likely with a long (14°) beveled needle than with a short (45°) beveled needle.
- However, while overall frequency of nerve injury is less with short-beveled needles, injury severity is greater if the fasicle is punctured



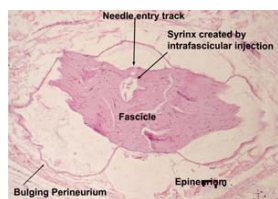
### Predisposing Factors- Intraneural Injection

- May be bad only if also intrafascicular
- Stimulation at very low current
- Immediate onset of block
- High pressure, followed by "give"



### Intraneural Injection

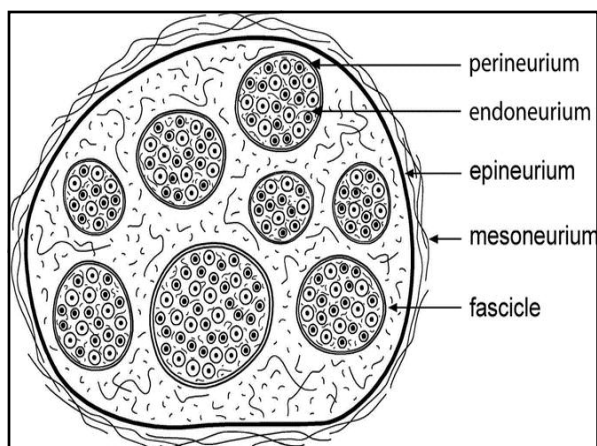
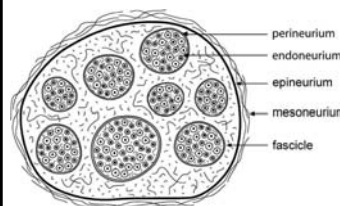
- Local anesthetic (not just needle) is the big offender.
- Fascicle entry by a needle and saline injection causes little damage



### Predisposing Factors- Intraneural Injection

- 26 intraneural injections using ultrasound, and low volumes LA without permanent injury

Bigeleisen, Paul E. "Nerve puncture and apparent intraneural injection during ultrasound-guided axillary block does not invariably result in neurologic injury." *Anesthesiology* 2006;105 (4), p. 779.



### Signs of needle injury

- Paresthesia
- However, 15% with subsequent nerve injury do not experience pain in injection.
  - Does local immediately mask paresthesia?
- Once paresthesia occurs, damage may already be done.



### A cautionary tale

- Dr. Y, a retired orthopedic surgeon, suffered a spinal injury during knee replacement surgery. Plaintiff alleged that his injuries resulted from the improper administration of a combined spinal epidural anesthesia.
- When anesthesiologist, Dr. G inserted the first needle into plaintiff's back, plaintiff expressed that he felt excruciating pain in his right hip, knee and leg, and that his right thigh cramped and his right calf swelled. When Dr. G inserted the second needle, plaintiff experienced additional severe pain radiating down his right leg, resulting in his right leg losing all sensation.
- After the knee surgery, it was discovered that plaintiff could neither feel nor move his right leg. In addition, plaintiff had lost bladder and bowel control and also experienced sexual dysfunction. Although plaintiff underwent extensive rehabilitation, he had only partial success in his recovery.
- The jury awarded plaintiff damages in the amount of \$12,600,000.00. The appellate court affirmed the verdict against all defendants.

### Neurotoxicity of local anesthetics

### Neurotoxicity- Mechanism

- Disruption of cytoplasmic calcium signaling
- Activation of kinases
- Altered energy metabolism
- Apoptosis linked to calcium alterations
- Mitochondrial damage may be contributing factor (?)

### Neurotoxicity- Mechanism

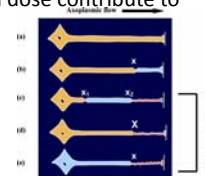
- Direct neuronal membrane damage by local anesthetics, inhibition of axonal transport
- Evidence of damage from the generation of oxygen free radicals.

### Predisposing Factors- Neurotoxicity

- Various substances associated with direct neurotoxicity.
- 5% Lidocaine in spinal microcatheters, chloroprocaine are noted examples
- Addition of epinephrine associated with higher rates of neurotoxicity, particularly with long-acting locals
- Use catheter technique instead

### Predisposing Factors- Neurotoxicity

- Local anesthetics known to be neurotoxic.
- Concentration, mixing, total dose contribute to toxicity.
- Pre-existing neuropathy is risk factor for nerve injury from regional.



### Predisposing Factors- Neurotoxicity

- diabetes mellitus
- hypothyroidism
- alcoholism
- pre-existing neuropathy
- herpes zoster
- peripheral vascular disease
- coagulopathy

### Diabetic Patients

- Case Report:
  - Patient with diabetes mellitus
  - Total knee arthroplasty performed under spinal anesthesia
  - Developed bilaterally symmetrical lower limb neurological deficit
- Highlight:
  - Patients with longstanding comorbidities (peripheral vascular disease and diabetes mellitus) may be at an increased risk of neurological injury following regional anesthesia
- Conclusion:
  - Preoperative evaluation of diabetic patients should include neurophysiological studies to identify subclinical neuropathy and minimize the risk of nerve injury

### Avoiding LA neurotoxicity after failed spinal

- Sacral dermatomes should always be included in an evaluation of the presence of a spinal block.
- If CSF is aspirated after anesthetic injection, total anesthetic dosage should be limited
- If an injection is repeated, the technique should be modified to avoid reinforcing the same restricted.
- If CSF cannot be aspirated after injection, repeat injection of a full dose of local anesthetic...only if no evidence of block.

Drasner K. Local anesthetic neurotoxicity: clinical injury and strategies that may minimize risk. *Reg Anesth Pain Med* 2002;27:576–80

### Ultrasound-guided

- Safe injection and the absence of neurologic damage is likely as long as the needle is placed intraneurally but in an extrafascicular fashion
- However, if nerve fascicles are affected neurologic dysfunction can occur
- A notable reduction of injected volume was still achieved by intentionally applying the local anesthetic circumferentially around the outermost nerve layer rather than injecting it into neural structures
- Conclusion: circumferential administration of local anesthetic rather than creating a single point injection appears to be advantageous

### Ultrasound-guided

- Less time to perform than nerve-stimulator guided blocks
- Fewer needle insertions were required
- Fewer blood vessel punctures

### Ultrasound-guided

- Clear depiction of the target tissues
- Facilitates accurate needle placement during interscalene brachial-plexus blocks
- Minimizes risk of direct puncture-related complications, as well as accidental intravascular injection of LA
- Avoids: central nervous toxicity caused by intravascular injection or resorption of inadequately high dosages (nerve blocks in neck region)

### Ultrasound-guided: local anesthetic dose reduction

- Patients undergoing hand surgery <90 min in duration
- Ultrasound-guided axillary brachial plexus block
- 5 consecutive patients had successful blocks using 1 ml of 2% LidoEpi per nerve
- All had surgical anesthesia within 10 min
- Conclusion: successful ultrasound-guided axillary brachial plexus block may be performed with 1 ml per nerve of 2% LidoEpi

### Ultrasound-guided: Obese Patients

- Study between BMI and 1) time required for block placement, 2) presence of PONV, 3) PACU pain scores, 4) volume of local anesthetic injected, 5) acute complications, 6) opioid administration
- Conclusion: ultrasound-guided interscalene nerve blocks for perioperative analgesia can be safely and effectively performed in the obese patient, but they may be more difficult to perform and analgesia may not be as complete

### Ultrasound-guided: Reducing the Risk of Pneumothorax

- Risk without ultrasound monitoring: 6.1%
- 6366 ultrasound-guided periclavicular plexus blocks
- Clinically symptomatic pneumothorax occurred in 4 patients (0.06%) (3 of which were after a 2-day latency period)
- Conclusion: ultrasound guidance does appear to reduce the risk of pneumothorax
- Risk factors: faulty image-setting, inability to obtain a view of the needle tip, inadequate supervision

### Clinical presentation of nerve injury

- Paresthesias; numbness, tingling, or any abnormality of sensation
- Within the first 24 hours, most likely caused by a hematoma, intraneural edema, or a lesion involving a sufficient number of nerve fibers to allow diagnosis.
- May commonly onset days or weeks later.

### Identification of injury

- Cauda Equina- involves lumbosacral roots. Bowel/bladder dysfunction, perineal sensory loss, lower ext. weakness.
- Neuropathy- sensory/motor deficits, painful paresthesias, hyperreflexia
- Neurapraxia- mild insult; results in impulse conduction failure across affected segment

### Workup of Nerve Injury

Pathophysiology	Key Neurophysiologic Finding
Neuropraxia (conduction block)	MEP/SSEP become altered, but NCS and EMG remain normal over time
Axonotmesis (axonal degeneration)	MEP/SSEP are altered whereas s/mNCS and EMG show signs of partial damage
Neurotmesis (nerve degeneration)	All neurophysiologic recordings become completely abolished

Abbreviations: EMG, electromyography; MEP, motor-evoked potential; NCS, nerve conduction study; SSEP, somatosensory-evoked potential; s/mNCS, sensory/motor nerve conduction study.

Borgeat, Alain (06/2011). "Assessment and treatment of postblock neurologic injury". *Anesthesiology clinics*, 29 (2), p. 243.



### Clinical Presentation

- Common presentation is > 48 hours after block recession.
- Onset: varies with mobility, surgical limitations
- Intensity: varies with severity of injury
- Duration: varies with severity; may become CRPS
- Motor function more reliable to identify particular nerve than are skin dermatomes

### What to do- Approach

- Careful exam for signs of anatomic abnormality
- Stay below Tuffier's line
- Ultrasound
- Slow approach, not too deep, negative pressure LOR technique
- Keep pt. able to respond

### What to do- Approach

- Paresthesia vs. perivascular?
- Ultrasound vs. conventional?
- Nerve stim vs. anatomic?
- Needle gauge & type?

Horlocker T. Complications of Regional Anesthesia and Acute Pain Management. *Anesth Clinics*. 2011;29(2)

### Factors not helpful

- Pencil point needles not found to be significantly protective
- Sitting position- distends CSF/sac?
- Electrical stimulation
  - Tsai found intraneural needle did not produce motor response even at high (1.5mA) current in some.
  - In others, produced response at very low current- 0.1mA.
  - One study of neuropathies found nerve stimulator used in 9 of 12 patients with neuropathies.

### What is clear?

- Stop and back up for any but the most transient paresthesias
- Do not inject if motor response to PNB is < 0.2mA)
- Inject slowly
- Stop injection if high resistance
  - Hadzic A, Dilberovic F, Shah S, et al. Combination of intraneural injection and high injection pressure leads to fascicular injury and neurologic deficits in dogs. *Reg Anesth Pain Med* 2004; 29:417–423
- Limit volume, %, vasoconstrictors, and total dose of local

### Treatment

- No proven method to stimulate nerve regeneration
- physiotherapy to prevent muscle atrophy and preserve range of motion
- functional electric stimulation (FES) has some promise to stimulate functional recovery of motor nerve fibers and alpha motoneurons

Borgeat, Alain (06/2011). "Assessment and treatment of postblock neurologic injury". *Anesthesiology clinics*, 29 (2), p. 243.

Questions?