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Perioperative nerve injuries and risk management

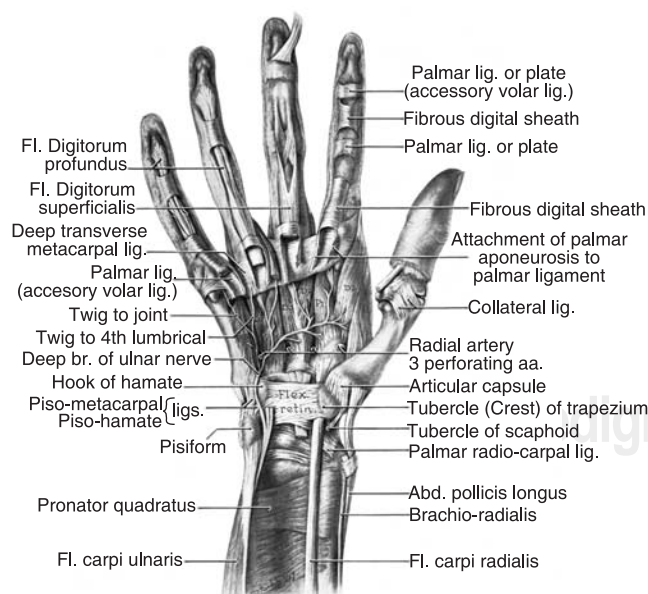
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Objectives:

- List the most common adverse outcomes in the OR
- Know the anatomy and vulnerable zones of the ulnar nerve
- Understand conditions associated with perioperative nerve injury
- Explore factors associated with positioning in the OR
- Recognize differences and similarities for upper and lower extremity neuropathies
- Be familiar with important documentation required for the medical record and risk management
- Review recent nerve injury research
- Be aware of medico-legal considerations and implications

The ASA closed claims database demographics of adverse outcomes



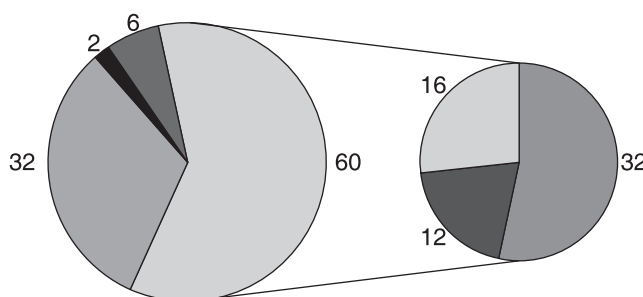
Demographics

Percent (%)

Age > 18 years	90
Elective (vs urgent or emergent)	73
ASA Class 1 or 2	70
General anesthesia	70
Male	41

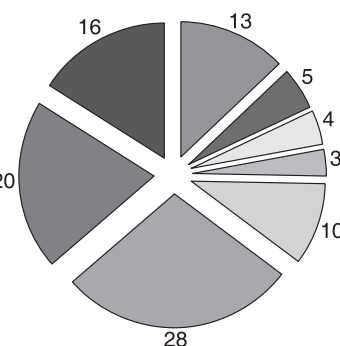
Adverse outcomes: ASA Closed claims data base

Note: Over half (60%) of these claims continue to involve death, brain injury, or nerve injury.



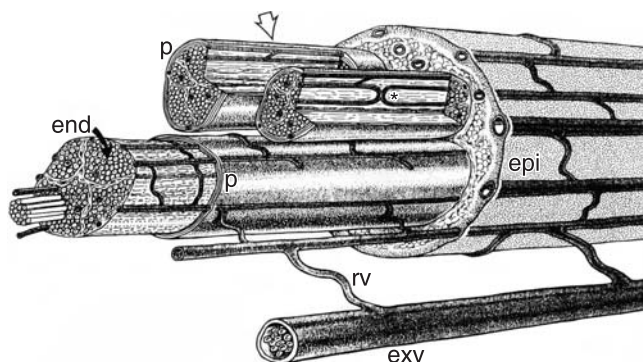
ASA closed claims:

Of all closed claims in the database, 16% involve nerve injuries, and the ulnar nerve (bottom wedge in the pie chart below) is by far the most common cause of litigation (and presumably injured).



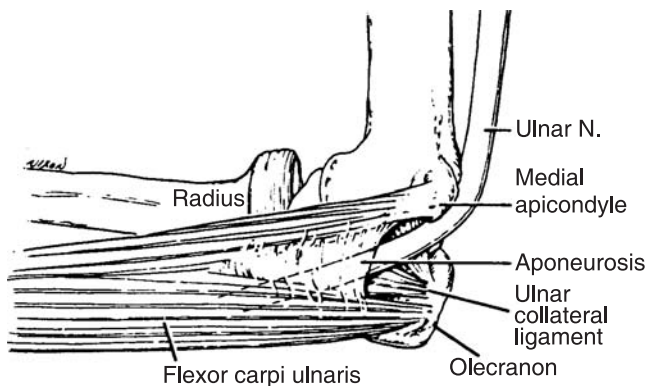
Understanding mechanisms of nerve injury: Possibilities include:

- Pressure
 - compression
- Stretch
 - 10% limit
- Ischemia
- Direct trauma
 - Surgical
- Metabolic
- Other, yet unknown, factors!



Why is the ulnar nerve especially vulnerable?

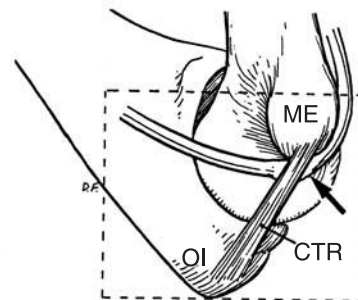
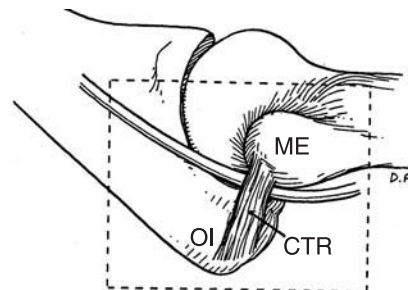
- Superficial course of nerve in olecranon groove, as illustrated here.



Why is the ulnar nerve especially vulnerable?

Additional reasons include:

- retinaculum (CTR in diagram) compression in ulnar groove

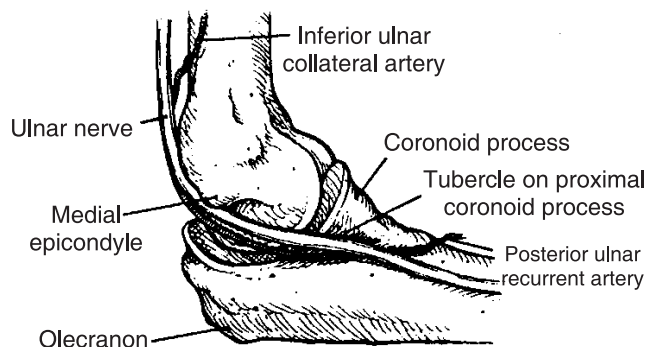


and . . .
ulnar n stretch
around olecranon

Why is the ulnar nerve especially vulnerable?

Also remember the

- gender-based anatomical differences of the elbow
 - Tubercle of coronoid 50% larger in men
 - 2 – 19x less fat to «cushion» the ulnar nerve in males
 - The size and thickness of the CTR in men makes nerve compression more likely



Why is the ulnar nerve especially vulnerable? Anatomical variants also exist

- CTR may be absent, which increases likelihood of
 - nerve dislocation during flexion
 - present in up to 16% of patients
 - many, many specific variations have been described.

Ulnar neuropathy: demographics routinely demonstrate a ratio of males: females = 3:1

- 75% or more occur in men
- Despite more surgery for women
 - median age = 50 yrs
 - very low or high BMI
 - occurs in all types of anesthesia
- 8 claims in SAB or MAC anesthesia
 - bilateral in 14% of cases
 - incidence 0.5% non-cardiac surgery (probably the highest single risk category).

Why are men more vulnerable to ulnar nerve injury?

Superficial course in olecranon groove retinaculum compression in ulnar groove ulnar n stretch around olecranon

- Gender-based anatomical differences of the elbow
 - Size and thickness of CTR

Additional important observation with ulnar neuropathy

- Onset of ulnar neuropathy is usually delayed!
 - immediate = 21%
 - delayed = 62%
- median = 3 days
- range = 1 - 28 days

Ulnar neuropathy – we now realize this is NOT just a perioperative problem

	Surgical patients (within 48 hours)	Medical patients (within 72 hours)
Prospective incidence	7/1,502	2/986
Percent (%) and C. I.	0.47%	0.2% [0.02 – 0.73%]

Let's look in more detail at just the surgical population:

(Warner et al, Mayo Clinic)

- Six male, one female (N = 1,502 patients)
 - Incidence 0.5%
 - 50 - 75 y.o. men, undergoing abd. surgery
- SSx 2 - 7 days post-op
 - median onset = 4 days
 - pts regularly underestimate time of onset
 - only daily evaluations and documentation clarified this issue
- 3/7 with residual SSx after 2 years

We utilized a new investigation approach> Quantitative modeling of ulnar neuropathy

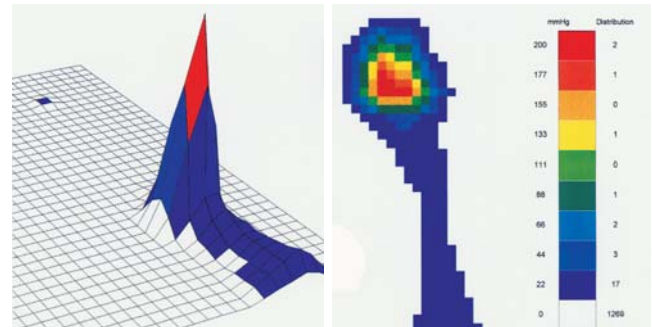
- To avoid assumptions
 - «conventional wisdom»
- Facilitates investigation of key questions:
 - Arm position and nerve pressure
 - Paresthesia and electrophysiological changes
 - Mechanisms of nerve injury
- Ischemia, flexion, and direct pressure

Pressure Monitoring is now feasible

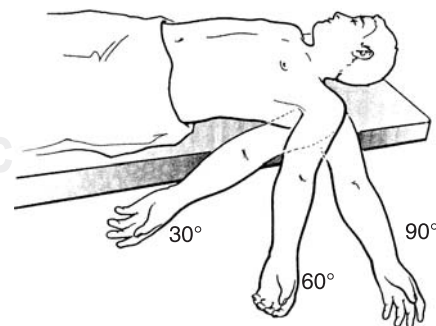
- Pressure sensor mat
 - 1,296 microsensors
 - 5 Hz sampling
 - 0 - 220 mmHg
- Contact surface area to $\leq 1 \text{ cm}^2$ resolution
- Computerized record of all data to reduce bias



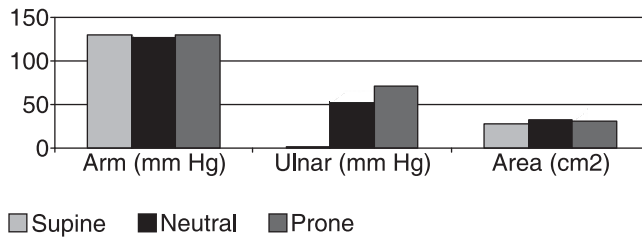
Pressure recording: 3-D and Quantitative look like data maps below >



Abduction & Nerve Pressure were measured under several different experimental positions and conditions >



Phase A: Supination minimizes ulnar nerve pressure (n = 50)



Pressure over the ulnar nerve with arm abduction

Significantly greater pressure is exerted over the ulnar nerve with the arm in 'neutral position' (i.e., with the thumb pointed to the ceiling) at either 30 or 60 degrees of abduction, compared to full 90 degree abduction.

Phase C: Experimental pressure in 16 healthy, male volunteers

- Males ulnar nerve
 - SSEP > Nicolet Viking IV
 - EP latency, amplitude N9 wave (Erb's point)
- Dowel in ulnar groove
 - arm on firm surface
 - mat measures nerve pressure
- SSEP & SSX's every 5 min



Nerve pressure simulation: MRI scan will be shown which simulates the above experimental condition

Results of the experimental paresthesia «stress test»

Paresthesia (+) detected	No paresthesia detected or reported
N = 8	N = 8
SSEP = -44%	SSEP = -44%
Range = - 20% to - 71%	Range = -19% to -72%

More recent ulnar nerve studies (to examine the role of gender in pathophysiology)

- Ulnar current perception thresholds
 - CPT current
- 120 male and 120 female volunteers
- Ischemia, flexion, direct pressure nerve stress
- Baseline CPT
 - then repeat post intervention
 - [Anesth Analg 2003;97:1183]

«Changes in ulnar nerve function occur in the absence of clinical paresthesia in awake, unseated men».

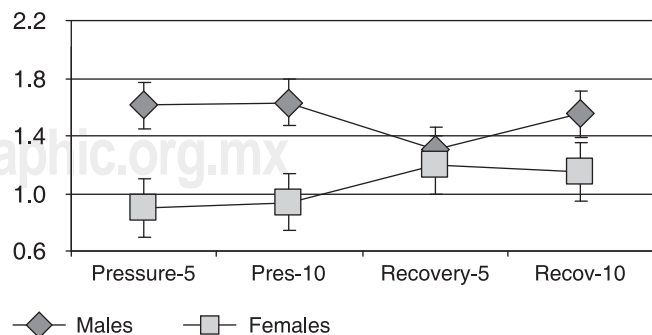


Gender & direct pressure

5 Hz CPT (C unmyelinated = pain fibers)

** Males required significantly greater current after just 5 and 10 min of pressure over the ulnar nerve in the elbow groove.

CPT/CPTbase



Summary: CPT and Intervention

Frequency	Overall effects Fiber type	Function	Type of experimental stress		
			Flexion	Pressure	Ischemia
5 Hz	C-unmyelinated	Slow, sympathetic pain	-	+ (gender specific)	+
250 Hz	A-delta myelinated	Fast pain	-	+	+
2,000 Hz	A- α myelinated	Light touch	-	-	+

Perioperative nerve injuries and potential litigation

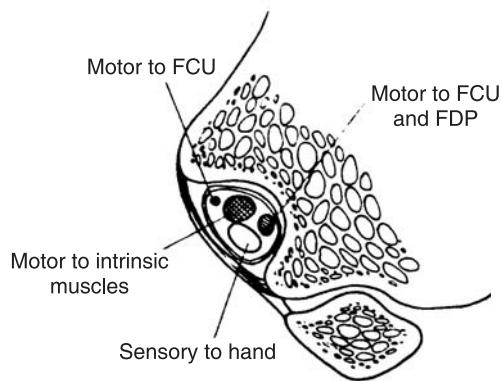
- «What if a neuropathy develops?»

Must ask some key questions: Is neuropathy sensory only?

- Sensory only tends to be transient
- caution against secondary position problems
- frequent patient contact, and follow-up
- if SSx beyond 5 days, probably need official neurology consult.

Ulnar nerve topography

- Sensory fascicles are superficial and vulnerable
- Motor fascicles to extrinsic muscles are deep
 - less vulnerable to compression



If neuropathy has motor component?

- Neurology consult immediately
- EMG/NCS may be needed
 - locate acute lesion
 - may affect treatment plan
- Look for:
 - chronic abnormalities
 - contralateral problems

Neurology Consult —

Can be invaluable! See example of a «good» consult here >

«NCS and EMG studies were completed. These findings are consistent with a longstanding chronic right ulnar nerve lesion, though the location is indeterminate. These findings are at least 6 months in duration. Given the longstanding nature of this disorder, further evaluation/management is unlikely to have any beneficial effect».

Ulnar nerve malpractice:

«In the court of common pleas»
Now come plaintiffs...

- Defendant (your name goes here)...had a duty to Plaintiff
 - Failed to properly prepare for surgery
 - Failed to properly position on OR table
 - Failed to use ulnar nerve protectors
 - Improperly placed pressure on arm, elbow, nerve
 - Failed to assure proper draping and padding
 - Improperly struck or allowed nerve to be struck
 - Failed to properly cushion
 - Failed to take necessary precautions
 - Failed to assure competent personnel in OR
 - Failed to properly supervise OR personnel
 - Failed to assure safety of plaintiff
 - Failure to warn plaintiff
 - Being careless and negligent including other facts found in discovery

Common ulnar nerve legal assumptions

- A nerve injury means someone did something wrong
- Ulnar nerve injury is always preventable

But-for Test: *res ipsa loquitur*

Common knowledge bespeaks negligence must meet the “but-for” test «but for negligence» the (nerve) injury would not have occurred

Procedural effect: res ipsa loquitur

Presumes negligence of defendant

You must rebut the presumption

Specific applications vary a lot from state-to-state (quite conservative in application)

Evidence against these assumptions (Prielipp, Morell, Butterworth et al, 1999)

- Nerve injuries occur in awake patients
- Nerve injuries occur in medical pts
- Bilateral abnormality in NCV in 12/14 patients with unilateral symptoms Alvine, 1987
- Mechanism of injury in only 10/113 patients Cheney, domino et.al. 1999
- 50% of volunteers develop SSEP changes without symptoms

Why do plaintiffs, attorneys, judges, and juries have trouble understanding the quality of your care?

>>>> our record can be our friend/enemy

Medical (legal) documentation

- ASA Task Force Practice Advisory (2000)
- Chart arm position/care my suggestion = «arms 85° bilaterally, palms up, ulnar grooves clear»
- Use padding

- padded arm boards; extra padding for elbow?
- Document position (re)check
- PACU nerve check?
- Deficits need expert consultation

Summary Task Force Consensus upper extremity positioning

- Ulnar nerve
 - Abduction d" 90° in supine patients
 - Forearms neutral or supine position
 - Prone patients > 90° degrees?
 - Arms at side should routinely place forearms in neutral position
- Radial Nerve
 - Avoid humeral pressure in the spiral groove
- Median nerve
 - Avoid (over) extension of the elbow to avoid stretch

CONCLUSIONS

- Nerve injuries increasing in closed claims
- Ulnar neuropathy most common perioperative nerve injury (1/3 of claims)
 - DELAYED presentation in men
- 94% identify no breach in standard of care
- Therefore, document appropriate care/position of both arms on anesthesia record
- Document, Document, DOCUMENT

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Table I. Incidence of ulnar neuropathy in all hospitalized patients.

Primary diagnosis of hospitalized patients	Prospective incidence of ulnar neuropathy (after 48-72 h)	Percent	Confidence interval
Medical	2/986	0.2	0.02-0.73
Surgical	7/1,502	0.47	0.2-1.0
Summed totals	9/2,488	0.36	—

(Summarized from information in references 10 and 24).

Table II. Data from 16 male subjects with somatosensory evoked potential (SSEP) monitoring during intentional application of pressure to ulnar nerve.*

Paresthesia? (Yes or no)	# Subjects	Parameters	Time to SSX (min)	% SSEP change
Yes	8	Mean	37	-44
		Median	33	-45
		Range	20-59	-20 to -71
No	8	Mean	60	-44
		Median	60	-45
		Range	-	-19 to -72
		P-value	0.0003	0.92

*Subjects are grouped by those who reported («Yes») or denied («No») paresthesia during direct application of pressure to the ulnar nerve during the investigational protocol.

Table III. Position-related upper extremity SSEP changes for five operative positions

Position	Numbers	Pts with changes	Changes - %
Supine, arms tucked	110	2	1.8
Supine, arms out	31	1	3.2
Lateral, decubitus	359	27	7.5
Prone, «superman»	514	36	7.0
Prone, arms tucked	95	2	2.1
Summed totals	1109	68	6.1

(Summarized from information in reference 41).

Practice questions:

1. The clinical presentation and first documentation regarding complaints of perioperative ulnar neuropathy are MOST likely to occur:

- A. In the operating room immediately after tracheal extubation
- B. In the PACU before recovery room discharge
- C. Three days post-operatively during surgical recovery
- D. One to two months after surgery and upon return to employment
- E. Evenly distributed between all time periods noted above

Answer = [C]

Explanation: Data from the ASA closed claims database indicate that only 21% of perioperative ulnar nerve injuries were evident in the immediate postoperative period, while 62% became evident between 1 and 28 days after surgery, with a median of 3 days.

2. Which factor(s) account for perioperative nerve injuries during major surgery?

- a. Stretch
- b. Ischemia
- c. Compression
- d. Direct trauma
- e. All the above

Answer = [E].

Explanation: The etiology of perioperative peripheral nerve injuries is complex, multifactorial and incompletely understood. Metabolic conditions and other factors also contribute.

3. Which patient is MOST at risk for developing a perioperative ULNAR neuropathy?

- A. 22 year-old soccer player having knee arthroscopy under spinal anesthesia
- B. 50 year-old man under general anesthesia for laparoscopic cholecystectomy
- C. 2 year-old boy for repair bilateral inguinal hernias
- D. 36 year-old female for shoulder arthroscopy under general anesthesia
- E. 82 year-old woman for open abdominal hysterectomy with epidural catheter

Answer = [B].

Explanation: Men are 3 times as likely as women to develop a perioperative ulnar nerve injury. This may be due, in part, to anatomical differences with men having a larger tubercle of the coronoid process and women having more fat content at the medial aspect of the elbow.