Intraneural injections in Anesthesia

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Intraneural injections

• The conventional idea:
  “Intraneural injection leads always to injury”

• Actual information:
  “(Un)intentional intraneural injection is not always associated with injury”

• Actual safety procedures minimize the risk of lesions
Technique and occurrence

- Nerve stimulation does not prevent intraneural injections
  - But not necessarily injuries
  - 0.024% neuropathies (Auroy Anesthesiology 2002)
- With US: visualisation of nerves
  - No decrease in neurological injuries, less LAST
    (Barrington RAPM 2013)
• Incidence of neurologic complications
  • 2/3 US-guided PNB
  • 4/10,000 blocks (similar as Auroy, Capdevilla)
  • Power?? Proving statistical differences??
  • 9 times more deficits unrelated to PNB
Most post-operative neurological complications are the result of non-block-related causes

Fredrickson et al. Anaesthesia 2009
Unreported cases

- WHY?
  - Unknown
  - Not willing to report
  - Children do not complain
  - Statistically the true incidence of any unreported event can be as high as 3/n
Figure 1. Type of peripheral nerve blocks associated with nerve injuries.
To understand nerve injury, one must review nerve anatomy
Nerve structure

- More proximal nerves tend to be more solid
- The more distal
  - More stromal tissue
  - More dispersed fascicles
- The perineurium is a tough and resistant tissue
  = unlikely to be easily penetrated by
  a blunt short-bevel needle
Brachial Peripheral Nerve

1. Brachial Plexus Roots
2. Brachial Plexus Trunks
3. Brachial Plexus Divisions
4. Brachial Plexus Cords
5. Peripheral Nerves
6. Anterior Scalene Muscle
7. Middle Scalene Muscle
8. Posterior Scalene muscle
9. Interstitial (extracellular) fluid and endoneurium
10. Fascicle
11. Epineurium
12. Perineurium
13. Nodes of Ranvier
14. Myelin
15. Schwann cell
16. Efferent axon
17. Afferent axon
18. Aα fiber
19. Aγ fiber
20. Aβ fiber
21. C fiber
Causes of nerve lesions

• Direct or indirect lesions to the axons
  • Mechanical: laceration (needle), intraneural injection
  • Vascular: acute ischemia, hematoma
  • Compression: extraneural (n. ulnar), intraneural injection
  • Chemical: injection neurotoxic solution (vasoconstrictor?)

⇒ Disturbed conducting impulses and axonal NT transport
  • temporary or permanent
Puncture of nerve with short bevel needle and injection

Background: Nerve puncture by the block needle and intraneural injection of local anesthetic are thought to be major risk factors leading to neurologic injury after peripheral nerve blocks. In this study, the author sought to determine the needle–nerve relation and location of the injectate during ultrasound-guided axillary plexus block.

Methods: Using ultrasound-guided axillary plexus block (10-MHz linear transducer, SonoSite, Bothell, WA; 22-gauge B-bevel needle, Becton Dickinson, Franklin Parks, NJ), the incidence of apparent nerve puncture and intraneural injection of local anesthetic was prospectively studied in 26 patients. To determine the onset, success rate, and any residual neurologic deficit, qualitative sensory and quantitative motor testing were performed before and 5 and 20 min after block placement. At a follow-up of 6 months after the blocks, the patients were examined for any neurologic deficit.

Results: Twenty-two of 26 patients had nerve puncture of at least one nerve, and 21 of 26 patients had intraneural injection of at least one nerve. In the entire cohort, 72 of a total of 104 nerves had intraneural injection. Sensory and motor testing before and 6 months after the nerve injections were unchanged.

Conclusions: Under the conditions of this study, puncturing of the peripheral nerves and apparent intraneural injection during axillary plexus block did not lead to a neurologic injury.

2–3 ml of anesthetic mixture was injected
No Clinical or Electrophysiologic Evidence of Nerve Injury after Intraneurral Injection during Sciatic Popliteal Block

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PNS, 20 patients

ABSTRACT

Background: Intraneurral injection during nerve-stimulator-guided sciatic block at the popliteal fossa may be a common occurrence. Although intraneurral injections have not resulted in clinically detectable neurologic injury in small studies in human subjects, intraneurral injections result in postinjection inflammation in animal models. This study used clinical, imaging, and electrophysiologic measures to evaluate the occurrence of any subclinical neurologic injury in patients with intraneurral injection during sciatic popliteal block.

What We Already Know about This Topic

- Ultrasonography indicates peripheral nerve blocks often result in intraneurral needle placement, and intraneurral injection results in acute inflammation in animals.

What This Article Tells Us That is New

- In 16 patients, an injection into the epineurium of the sciatic nerve at the popliteal fossa did not lead to postoperative neurologic dysfunction as assessed by serial physical examinations and nerve conduction studies.
Nerve Expansion Seen on Ultrasound Predicts Histologic But Not Functional Nerve Injury After Intraneural Injection in Pigs

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Background and Objectives: Intraneural injection can be seen as nerve expansion during ultrasound-guided regional anesthesia. The purpose of this animal study was to determine if nerve expansion seen on ultrasound during intraneural injection results in nerve injury.

Methods: Ten pigs underwent general anesthesia for this randomized control study. After skin incision, the right and left median nerves for each animal were randomly assigned to the local anesthetic (LA) side or control side. For the LA side, a needle was placed intraneurally under direct vision. Nerve expansion seen on ultrasound was produced by injecting up to 20 mL lidocaine 2% with epinephrine intraneurally. For the control side, no needle puncture or injection was administered. The primary outcome was histologic evidence of nerve injury (axonal retraction balls) on the seventh postoperative day after intraneural injection seen as nerve expansion on ultrasound. Correlation coefficients were calculated between the maximum volume injected, maximum injection pressure, degree of nerve expansion, and histologic and functional nerve injury.

Results: Six nerves from the LA side and none from the control side had histologic evidence of injury ($P < 0.01$). All 10 nerves from the LA side exhibited histologic evidence of inflammation compared with 3 from the control side ($P < 0.005$). No pigs exhibited functional nerve injury. We were unable to demonstrate any correlation between the maximum volume injected or pressure generated and the relative increase in nerve cross-sectional area or the graded presence of any histologic nerve damage.

Presently, our ability to detect unintentional needle puncture and/or injection inside a nerve remains limited. Conventional surrogate methods to detect intraneural injection can be misleading. Subjective reports of paresthesia during nerve localization or pain upon LA injection is not a reliable warning signal even in awake patients. Nerve stimulation may be equally unreliable to detect intraneural needle placement because the threshold safety current has not yet been firmly established. Recently, it has been suggested that high injection pressure measurement may predict intraneural needle placement; however, intraneural injection often occurs with lower injection pressures.

A reliable method of detecting intraneural injection to prevent nerve injury during peripheral nerve blockade remains elusive. We recently completed a preliminary animal study (phase 1), which demonstrated that intraneural injection in the smallest amounts reliably produces nerve expansion seen on ultrasound. The present animal study (phase 2) aimed to determine whether nerve expansion seen on ultrasound during intraneural injection of a clinically relevant volume of LA results in nerve injury. We hypothesized that nerve expansion seen on ultrasound leads to histologic nerve injury and functional neuropathy.

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Intraneural injection during nerve stimulator-guided sciatic nerve block at the popliteal fossa

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**Background.** Exact location of the needle tip during nerve stimulation-guided peripheral nerve blocks is unknown. Using high-frequency ultrasound imaging, we tested the hypothesis that intraneural injection is common with nerve stimulator-guided sciatic nerve (SN) block in popliteal fossa.

**Methods.** Forty-two patients scheduled for hallux valgus repair were studied. Sciatic block at
the popliteal fossa was accomplished using nerve stimulation. When a motor response was elicited at <0.5 mA (2 Hz, 0.1 ms), 40 ml of local anaesthetic (LA) was injected. Using ultrasound (Titan, Sonosite, 5–10 MHz), the diameters and area of the SN were measured before and after the injection. The presence of nerve swelling and proximal or distal diffusion of LA were

Motor response at <0.5mA
Injection of 40ml LA
Nerve swelling US controlled (88%)
No neurologic deficits

2009
Combine US, PNS and pressure monitoring for Intraneural puncture

No injection if P>20psi
No motor response doesn’t exclude intraneural injection (16.7%)
Low-current stimulation with response was intraneural puncture
No neurologic deficits
Actual daily practice

Prevention of intraneural injections
Pain on injection

• No reliable sign, present in minority of cases

• Nerve puncture is usual without paresthesia
  (Bigeleisen, Anesthesiology 2006)

• We can touch a nerve without motor response nor paresthesia
  (Peerless RAPM 2006)

• Discomfort while injecting = pressure paresthesia =“normal”

• If pain occurs, stop injecting

• Still avoid heavily sedated patient
Nerve stimulator

- Intensity of the stimulating current
- Nerve localisation!!
- Detection of intraneural puncture??
- Optimal current intensity??
25% no motor response even with high currents

Figure 69–4. Intensity of the electrical current required to obtain a motor response in a sciatic nerve block model in pigs. As the distance of the needle to the nerve decreases from 0.1 mm to the intraneural location of the needle, stimulation can be obtained with a current of progressively lesser intensity (minimum 0.08 mA/0.1 msec with needle intraneurally). However, when the needle was inserted intraneurally, motor response could not be obtained in 25% of the attempts even with currents of 0.5–1.7 mA. (From Hadzic A, et al. 2006. Unpublished data).
Safety rule:

If no motor response at 0.3mA

Intraneural possible, but extrafascicular

(Hadzic 2004)

DO NOT search for a nerve response with currents of 0.3mA or less

(Choquet Anesth Analg 2012)
Pressure monitor
Combination of intraneural injection with high injection pressure leads to fascicular injury and neurologic deficit in dogs
Initial pressure >20psi = STOP injection
What about US?

- Visualisation of
  - Nerve, but not all fasciculi
  - Epineurium? Bigeleisen RAPM 2010
  - Needle penetration into nerve???
  - Intraneural LA during injection = swelling of the nerve
    0.5ml is reliably detected with US N.Moayeri et al.
  - US +PNS: 0.3-0.5mA can not rule out intraneural position
    P.Bigeleisen et al. Anesthesiology 2009
Needle design and direct trauma

• Sharp needles
• Clean cuts, recover faster and more completely
• More likely to penetrate the perineurium

Seelander  Acta Anesthesiol Scand 1997
Macias  Chir Organi Mov 2000
Bigeleisen  J d’Echo et Rad 2009
Needle design and direct trauma

- Blunt needles
  Reduced risk of nerve penetration & fascicular damage

- Minor nerve injury if needle trauma without injection

(Sala-Blanch RAPM 2009)
No pain
No neurologic deficit
Conclusion

- Neurologic complications are rare
- Intrafascicular injection
- Use US and follow the safety algorithm:
  - Pain / paresthesia
  - Motor response at ≤0.3mA
  - Pressure evaluation at start injection
  - Tangential needle approach & blunt needles

Minimizing the risks, but NO ZERO-RISK