# Atraumatic Lumbar Puncture Needles

## *After All These Years, Are We Still Missing the Point?*

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**Background:** Cutting needles remain the most commonly used needle design for lumbar puncture in the neurology community, although atraumatic (noncutting) needles have become common and popular for anesthesiologists performing spinal anesthesia.

**Review Summary:** The use of atraumatic spinal needles for lumbar puncture has been shown to significantly reduce the incidence of postdural puncture headache compared with cutting needles, without loss of efficacy or ease of use.

**Conclusion:** The use of noncutting or pencil-point spinal needles should become the standard for performing diagnostic lumbar puncture.

**Key Words:** postdural puncture headache, spinal puncture, atraumatic needle, anesthesia spinal, neurology

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In the year 200 AD, the Greek physician Claudius Galen described a clear fluid residue within the neuraxis. In the sixteenth century Antonio Valsalva, an Italian anatomist, described anatomic circulation of the cerebrospinal fluid (CSF). Dr. Heinrich Quincke of Kiel, Germany introduced the concept of diagnostic lumbar puncture in 1891. A student of Dr. Quincke, the German surgeon Karl August Bier and his assistant August Hildebrandt, attempted the first spinal anesthetic in 1898 by subjecting each other to lumbar puncture and injection of cocaine into their intrathecal spaces. Neurologic examination aimed at confirming loss of sensation in the lower extremities included application of burning cigars, strong blows with a hammer, deep needles to the femur, pulling out pubic hairs, and intense pressure on the testicles. A night of revelry with drinks and smokes followed this successful anesthetic. However, the next day, Bier and his assistant suffered the debilitating consequences we now clearly recognize as the syndrome of postdural puncture headache (PDPH). According to a historical account, "Bier found Hildebrandt looking wane, he had not slept, and was able to stand only with great effort. Later that morning, Hildebrandt had a severe headache, followed by an attack of vomiting. By midafternoon he was forced to go to bed." The headache required 9 days to fully resolve.[1]

Over the subsequent century, anesthesiologists saw spinal anesthesia plagued with complications such as drug-induced neurotoxicity, infectious and chemical contamination, hemodynamic aberrations, permanent neurologic deficits, and other drawbacks. However, refinements over the years in a variety of aspects of spinal anesthesia have rendered most of these complications to now only of historical interest, and this anesthetic technique has become standard practice for lower extremity and abdominal surgery worldwide, with a remarkable safety record. Although PDPH is still a frustrating and unpleasant complication, when optimal spinal needles are used, this syndrome has an estimated incidence from less than 1% to about 5% of patients undergoing spinal anesthesia, even in the highest risk subset–young, female, and pregnant.[2–4] How did anesthesiologists address this complication and achieve such success in containment?

PDPH is postulated to be a consequence of 1 of 2 nonmutually exclusive mechanisms, both involving CSF leaking through a needle-induced dural hole. One hypothesis is that this decrease in CSF results in an increase blood volume from vasodilation secondary to the Monro-Kellie doctrine—the sum of the volumes of the brain matter, CSF, and blood must remain the same. The second hypothesis is that the decrease in CSF volume results in sagging of the brain in the cranial vault when the patient assumes the upright position—pulling on the falx cerebri, cerebral blood vessels and tentorium resulting in excruciating positional head pain. This headache may be accompanied by occiput, neck and shoulder pain, upper limb pains or paresthesias, nausea and vomiting, photophobia or cranial nerve palsies including but not limited to diplopia, visual blurring, and hearing loss.

Interestingly, hearing loss is common after lumbar puncture even if no overt headache develops.[5,6] Vestibulocochlear malfunction is attributed to decreased inner ear pressure as fluid drains from the inner ear chamber through the cochlear aqueduct to the lower pressure CSF. It is believed that the greater the CSF loss, the greater the hearing loss. Moreover, the magnitude of hearing loss has been quantified to be directly related to spinal needle gauge and to cutting tip design.[7,8]

Risk factors for PDPH include young age, lesser body mass index, female gender, pregnancy and labor, history of recurrent headaches or previous PDPH, size of the needle, direction of the cutting needle bevel when puncturing the dura, and other technical factors in the performance of lumbar puncture.[9–11] Some populations, such as extremes of age or obtunded patients are less likely to experience PDPH, and in these clinical circumstances needle selection may be less of an issue.

Clinicians who have cared for patients with PDPHs understand that this headache can be excruciating and intolerable. But the morbidity associated with PDPH can be more significant than just this debilitating pain. PDPH has been blamed for peripartum seizures through the mechanism of CSF hypotension resulting in anatomic brain displacement inciting intense vasospasm.[12] Cranial subdural hematoma from decreased CSF pressure after lumbar puncture in a patient with an arteriovenous malformation has been described.[13] Subdural hematomas and subdural fluid collections after lumbar puncture have also been described in patients with no risk factors, at times resulting in death.[14–16]

Considering the significant morbidity associated with CSF leak after lumbar puncture, anesthesiologists and neurologists alike should take all practical precautions to ensure prevention. Numerous

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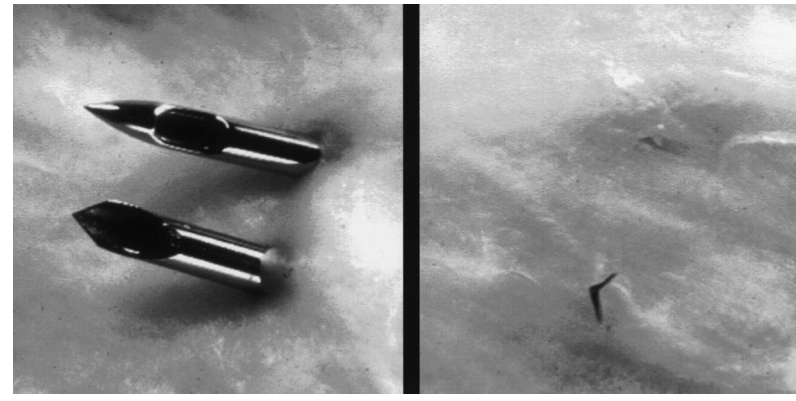

**FIGURE 1.** Dural puncture holes made by cutting and noncutting needles (Reproduced with permission from Strupp, et al. *Neurology*. 2001; 57:2310–2312).

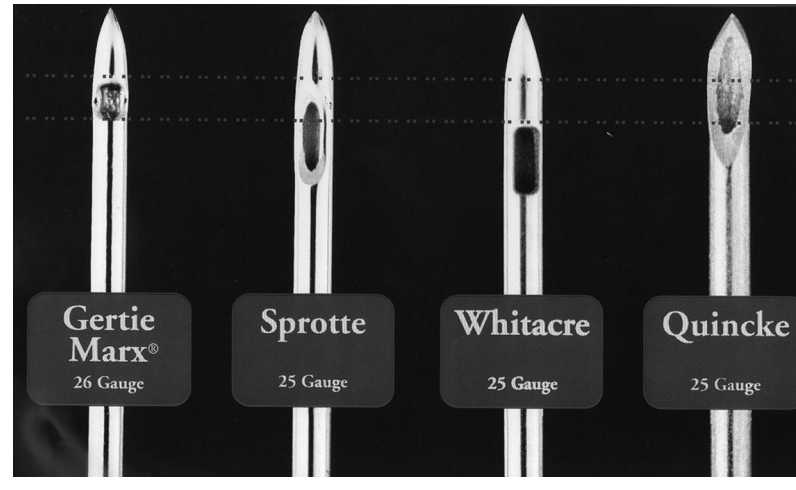


**FIGURE 2.** Atraumatic and cutting needle tips. (Reprinted with permission from IMD Medical, Huntsville, UT).

and convincing clinical investigations confirm decreased rates of PDPH with smaller gauge, noncutting (atraumatic) needles. Modern cutting needles, also called Quincke needles, have an obliquely sliced tip that cuts through the dura. (Figs. 1 and 2) The pencil-point or atraumatic needle was thought to penetrate and then separate the dural fibers, resulting in a less traumatic hole and subsequent less loss of CSF and a lower incidence of PDPH. Electron microscopic evaluations of human cadaveric dura traumatized by either a cutting tip or a pencil-point tip do not substantiate this theory and actually show that pencil-point needles cause more complex lesions than the cutting needles.[17] This led some to wonder whether the decrease in PDPH from "atraumatic" needles leads to increased inflammation and more rapid healing of the hole. Or maybe, simply less CSF leaks through the dural hole made by a pencil-point needle, as shown in an in vitro human cadaveric study comparing flow through holes made by various needle sizes and tips.[18]

Whatever the reason, the concept that atraumatic spinal needles cause fewer PDPHs is not new. The needle was designed with this theory in mind in the 1920s[19] with reduction in PDPH being demonstrated as early as 1951.[20] Modern studies held to current research standards have substantiated the difference between cutting and atraumatic needles.[21] The rate of PDPH for diagnostic lumbar puncture in an ambulatory population with a 20- or 22-gauge cutting needle is estimated to be 36%.[22] In comparison, the rate of PDPH with a 22-gauge atraumatic needle is estimated to be less than 2%.[23] The superiority of the atraumatic needle has also been demonstrated in a randomized trial for myelography, with fewer postmyelogram headaches observed with an atraumatic needle compared with a cutting tip design.[24]

The evidence that atraumatic spinal needles cause fewer PDPHs is so convincing that both the American Society of Anesthesiologists (ASA) and the American Academy of Neurology have published statements encouraging the replacement of cutting needles by atraumatic spinal needles.[25–26] According to the American Academy of Neurology in 2005 "Most studies in the anesthesiology literature, across several needle sizes, and now also one study providing Class I evidence in a patient population undergoing diagnostic LPs with a 22-gauge needle support the use of an atraumatic spinal needle to reduce the frequency of post lumbar puncture headaches (Type A recommendation)." And according to the most recent guidelines for obstetrical anesthesia of the ASA (2007): "The literature supports the use of pencil-point spinal needles compared with cutting-bevel spinal needles to reduce the frequency of post–dural puncture headache. The consultants and ASA members both strongly agree that the use of pencil-point spinal needles reduces maternal complications. Recommendations: Pencil-point spinal needles should be used instead of cutting-bevel spinal needles to minimize the risk of post–dural puncture headache."

Long before these guidelines were published, the data in support of the replacement of atraumatic for cutting needles was evident. Systematic reviews and meta-analyses of randomized controlled trials of atraumatic needles confirm their effectiveness to prevent PDPH.[21] For example, a meta-analysis including 38 trials (8184 patients) revealed that using an atraumatic needle significantly decreased the odds of a PDPH [OR 0.43, 95% confidence interval (CI) 0.37 to 0.51] and decreased the odds of a severe PDPH (OR 0.38, 95% CI, 0.25–0.55).[27] Subgroup analyses demonstrated that using an atraumatic needle significantly decreased the odds of a

PDPH similarly in each of 4 populations: anesthesia (OR 0.49, 95% CI, 0.38–0.64 and NNT 51, 95% CI, 34–100), obstetrical anesthesia (OR 0.49, 95% CI, 0.38–0.64 and NNT 33, 95% CI, 21–79), myelography (OR 0.40, 95% CI, 0.29–0.55 and NNT 9, 95% CI, 6–13), and neurology (OR 0.35, 95% CI, 0.24–0.53 and NNT 6, 95% CI, 4–9). Expressed differently, this evidence reveals that for every 6 neurology patients that undergo a diagnostic dural puncture with an atraumatic needle instead of a standard needle, 1 patient will be prevented from having a PDPH. Further, studies looking specifically at neurology patients undergoing lumbar puncture have shown a decrease from 36% to 3% ($P = 0.002$) and 24% to 12% ($P < 0.05$) when an atraumatic Whitacre or Sprotte needle is used instead of a cutting needle.[28–29]

Nonetheless, use of atraumatic needles has not become standard practice in the neurologic community. A 1996 survey of Departments of Neurology and Neurosurgery in the United Kingdom found that the Quincke (cutting) needle was still being used by over 70% of respondents.[30] A more recent 2001 survey of American Academy of Neurology members discovered that only 2% of neurologists surveyed routinely used atraumatic needles.[31] Almost half of the responding neurologists reported having no knowledge of atraumatic spinal needles. Our correspondences with multiple neurologists confirm that Quincke needles are still being used. The anesthesia community has awoken to the data and nearly eliminated the use of Quincke needles, with some even questioning the ethics of ever using a Quincke needle—even in research.[32]

So why has the neurology community continued to hold on to the cutting needle? It is likely because changes in practice are slow to happen and not because atraumatic needles are more difficult to use. In fact, research indicates that the cutting needle is more difficult to use. A meta-analysis evaluating needle design found the incidence of operator difficulty to be greater (pooled odds ratio 0.48, 95% CI, 0.24–1.00, $P = 0.05$) and the failure rate of spinal anesthesia to be greater (pooled odds ratio 0.52, 95% CI, 0.27–1.01) with cutting needles.[21] The atraumatic spinal needle may require some learning for practitioners who are used to using cutting needles. For example, a small skin nick or an introducer may be required to pass the atraumatic needle through the skin, and the feel of the ligaments may be slightly different (compared with the cutting needle) as the atraumatic needle is advanced into the CSF. Nonetheless, these are minor obstacles and easy to overcome, as documented by the almost universal use of small-gauge atraumatic needles by anesthesiologists performing spinal anesthesia.

Perhaps this anesthesia literature is not applicable to the diagnostic lumbar puncture as practiced by neurologists. After all, anesthesiologists perform lumbar puncture/spinal anesthesia with the aim of injection of a few milliliters of medication into the CSF, whereas neurologists are seeking withdrawal of significantly larger volumes of CSF for diagnostic purposes. This difference in clinical goals allows anesthesiologists to use extremely small-gauge needles for spinal anesthesia—typically 25 gauge or less. However, the choice of needle-tip design does not affect flow rate. In comparing flow rates of saline (which has similar viscosity to CSF) through similarly gauged atraumatic and cutting needles, flow rates were found to be similar, if not greater, in the atraumatic needles.[33] Further, the flow rate and acquisition of opening pressure with a 20 gauge atraumatic needle was deemed adequate by Carson and Serpell who in comparing various needles deemed the 20 gauge Whitacre "the best needle for diagnostic lumbar puncture."[34]

The neurology community should not feel remiss for their continued use of the cutting needle despite overwhelming evidence to do otherwise. The anesthesiology community themselves slept for years through the research and used the cutting needle despite study after study demonstrating its inferiority. It was not until the 1990s that the atraumatic needle became standard practice in the anesthesia community. This change in practice was facilitated by manufacturers of spinal anesthesia products—upon request from the anesthesia community, they began manufacturing virtually all of the commercially available spinal anesthesia kits to include an atraumatic needle for use by the anesthesiologist.

Although it took time, the anesthesiology community did change their practice, and the time has come for the neurology community to do the same. Diagnostic lumbar puncture kits should be manufactured to include atraumatic instead of cutting needles, just as spinal anesthesia kits include atraumatic needles. Until this time, neurology practitioners and departments should consider purchase of atraumatic, noncutting needles, readily available from virtually all major needle manufacturers, for physicians to add to their tray once the kit is opened. In the Neurology Department at the Mayo Clinic Arizona, atraumatic needles were introduced and made available to staff conducting diagnostic lumbar punctures in 2002. Over the course of the year, atraumatic needle use increased from use in 0% of lumbar punctures to use in 37% of lumbar punctures (unpublished quality assurance and quality improvement data). This change in practice is simple; you will be following evidence-based guidelines, practicing evidenced based medicine, and preventing a significant number of excruciating headaches in your patients.

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