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# Bevel Direction and Postdural Puncture Headache

## A Meta-Analysis

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**Background:** The effect of lumbar puncture needle bevel direction on the incidence of postdural puncture headache (PDPH) is somewhat controversial. We performed a meta-analysis of available trials to determine if bevel direction during lumbar puncture would influence the incidence of PDPH.

**Review Summary:** Studies were identified primarily by searching the National Library of Medicine's PubMed database (1966 to November 29, 2004) and abstracts from several national meetings (American Society of Anesthesiology, International Anesthesia Research Society, American Society of Regional Anesthesia, Society of Obstetric Anesthesia and Perinatology) for terms related to needle and bevel direction. Inclusion criteria were assessment of the incidence of PDPH after lumbar puncture with a cutting needle (eg, Quincke, Tuohy), comparison of a "parallel" (bevel oriented in a longitudinal or cephalad to caudad direction) to "perpendicular" (bevel oriented in a transverse direction) orientation during needle insertion, randomized trials, and trials primarily in adult populations. Data on study characteristics and incidence of PDPH were abstracted from qualified studies and subsequently analyzed. The search resulted in 52 abstracts from which the original articles were obtained and data abstracted, with ultimately a total of 5 articles meeting all inclusion criteria. Insertion of a non-pencil-point/cutting needle with the bevel oriented in a parallel/longitudinal fashion resulted in a significantly lower incidence of PDPH compared with that oriented in a perpendicular/transverse fashion (unadjusted rates of 10.9% versus 25.8%; odds ratio = 0.29 [95% CI = 0.17–0.50]).

**Conclusions:** Our meta-analysis indicates that with use of a cutting needle, insertion in a parallel/longitudinal fashion may significantly reduce the incidence of PDPH, although the reasons for this decrease are unclear.

**Key Words:** postdural puncture headache, bevel, dura, lumbar puncture, spinal, epidural

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The incidence of postdural puncture headache (PDPH) after diagnostic lumbar puncture may be quite high (23.3% to 62.5%).<sup>1,2</sup> Traditionally, it was thought that the dural fibers were oriented primarily in a longitudinal (cephalad to caudad) fashion and that insertion of the bevel "parallel" rather than "perpendicular" (or transverse) with respect to the dural fibers would result in a lower incidence of PDPH due to fewer dural fibers being cut.<sup>3</sup> Some experimental data also suggest that a parallel rather than perpendicular insertion of a cutting needle might result in a lower rate of cerebrospinal fluid (CSF) leakage (and presumably a lower rate of PDPH).<sup>4</sup> It is unclear whether the bevel direction with a cutting (eg, Quincke) needle during needle insertion for a lumbar puncture is a risk factor for the development of PDPH. Current American Academy of Neurology (AAN) guidelines indicate that there is class I evidence that when using a cutting needle, ensuring the bevel direction is parallel to the dural fibers reduces the frequency of PDPH.<sup>5</sup> These recommendations are based on 5 articles, of which 1 was not randomized,<sup>6</sup> 1 was retrospective,<sup>7</sup> 1 had an improper randomization,<sup>3</sup> and 1 showed a strong trend towards a decrease in headache incidence (11/21 for parallel versus 16/20 perpendicular bevel) but in which the confidence interval includes 1.<sup>8</sup> Two additional randomized controlled trials not cited in the guidelines failed to show a statistically significant difference in the incidence of PDPH based on bevel direction with a cutting needle.

Subsequent anatomic studies indicate that the structure of the dural fibers is much more complex and that the dural fibers may not necessarily run in a longitudinal or cephalad to caudad fashion.<sup>9</sup> In addition, recent experimental studies do not confirm earlier impressions that a parallel rather than perpendicular insertion of a cutting needle results in a lower rate of CSF leakage.<sup>10</sup> We performed a meta-analysis of the available literature to determine if the bevel direction of a cutting needle during lumbar puncture would influence the incidence of PDPH.

### METHODS

The National Library of Medicine's PubMed database was searched for the time period 1966 to November 29, 2004.

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TABLE 1. Study Characteristics\*

Study, Year	Population (No. Subjects)	Needle Type/Size	PDPH Perpendicular	PDPH Parallel
Ansaloni, 2000	Nonobstetric	Q/22G	9/40 (22.5%)	9/40 (22.5%)
Flaatten, 1998	Nonobstetric	Q/27G	24/106 (22.6%)	4/106 (3.8%)
Norris, 1989	Obstetric	H/17-18G	16/20 (80%)	11/21 (52.4%)
Richardson, 1999	Obstetric	T/18G	2/6 (33.3%)	1/9 (11.1%)
Tarkkila, 1992	Nonobstetric	Q/25G	15/84 (17.9%)	4/89 (4.5%)
Total (unadjusted, not weighted)			66/256 (25.8%)	29/265 (10.9%)

G indicates gauge; H, Hustead; PDPH, postdural puncture headache; Q, Quincke; and T, Tuohy.

\*PDPH data presented as number of PDPH/number of dural punctures followed by the percentage in parentheses.

PubMed was searched for all articles containing text words *transverse* or *perpendicular* (35,174 articles), *parallel* or *longitudinal* (172,685 articles), and *orientation* or *direction* (114,014). These were combined using the usual Boolean meanings of "OR," which yielded a total of 305,397 articles. A second search was performed using the text word *needle* yielded a total of 62,828 articles. These 2 searched were combined using the usual Boolean meanings of "AND," limited to the English language, adult subjects, and randomized controlled trials to yield 52 abstracts. The full article of each abstract was then reviewed by one of the authors for inclusion into the meta-analysis. In addition, the abstract books from 1990 to 2003 for the American Society of Anesthesiology (ASA), International Anesthesia Research Society (IARS), American Society of Regional Anesthesia (ASRA), and the Society of Obstetric Anesthesia and Perinatology (SOAP) were reviewed for any relevant abstracts meeting the inclusion criteria (see below). No minimum sample sizes were invoked for inclusion of studies in the analysis. Any disputes were resolved by agreement of at least 2 reviewers.

For the purposes of this meta-analysis, PDPH was defined as a headache occurring after a single lumbar puncture (continuous spinal catheters excluded) that was postural in nature. Inclusion criteria included assessment of PDPH, studies that used a cutting needle (eg, Quincke, Tuohy) to compare a parallel/longitudinal (bevel oriented in a cephalad to caudad fashion) versus perpendicular/transverse (bevel inserted 90 degrees to the longitudinal axis of the spine) bevel orientation during lumbar puncture, randomized trials, studies evaluating primarily adult patients where the incidence of PDPH was assessed and data available. Exclusion criteria included articles where PDPH was not assessed, a cutting needle was not used for lumbar puncture (eg, pencil-point needle), there was not a comparison of parallel to perpendicular bevel orientation, the patient population was mainly pediatric, or where randomization did not occur.

Data were extracted from each study and extrapolated from figures as needed. The level of significance for all tests was set at an  $\alpha$  level of 0.05, and a fixed-effects model was used. All statistical analyses (ie, determination of pooled estimate) were performed with RevMan 4.2.7 (The Cochrane Collaboration, 2004). We also performed an analysis of the file-drawer problem to determine the number of additional subjects required to invalidate our results.

## RESULTS

The search resulted in 52 abstracts, of which a total of 4 articles met all inclusion criteria. One additional reference was obtained from review of the references of those articles included for analyses from the initial review. Only 1 abstract met the inclusion criteria; however, these data were subsequently published and included in our meta-analysis.<sup>11</sup> A total of 48 articles were rejected for the following reasons: 29 did not assess PDPH, 15 did not compare a parallel to perpendicular bevel orientation, and 4 did not use a cutting-type needle for lumbar puncture.

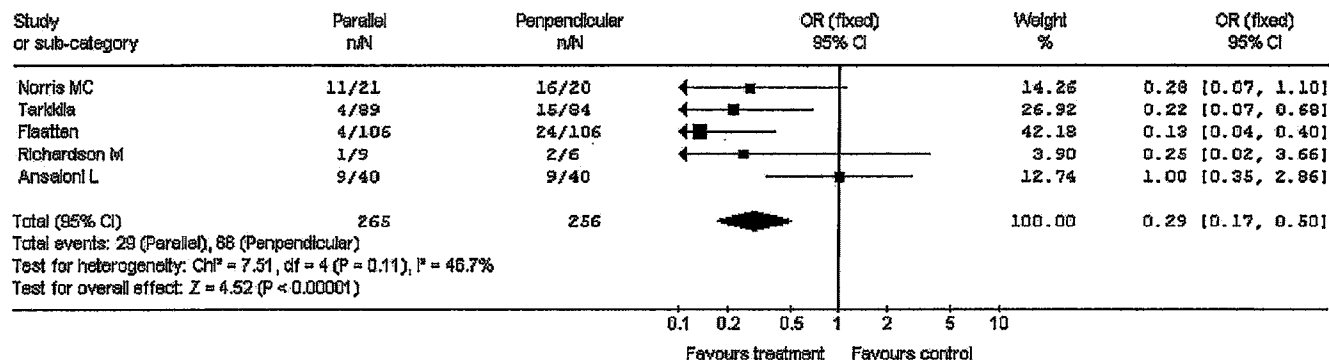
The characteristics of studies used in the analysis are shown in Table 1.<sup>8,11-14</sup> Figure 1 shows the pooled estimate of all included studies. The variation in results across studies (ie, heterogeneity) was not statistically significant ( $I^2 = 46.7$ ,  $P = 0.11$ ). The odds ratio (OR) of developing a PDPH with a parallel (versus perpendicular) beveled needle insertion was 0.29 (95% CI, 0.17-0.50); that is, insertion of a beveled needle in a parallel orientation is associated with three tenths of the odds of developing PDPH than if the needle were inserted in a perpendicular orientation (or the odds of developing a PDPH are approximately 3 times greater when inserting a beveled needle in a perpendicular orientation). Based on the unadjusted PDPH rates (Table 1), the number needed to treat (NNT) is approximately 7 (that is, it would take 7 dural punctures with the beveled needle inserted in a parallel orientation to prevent 1 PDPH).

*A parallel rather than a perpendicular insertion  
of a cutting or beveled needle would result in a  
statistically significant lower incidence of  
postdural puncture headache.*

## DISCUSSION

There are many factors which contribute to the incidence of PDPH; however, many are not related to technique such as gender or age. Mechanical factors, including smaller

Review: Needle bevel direction and postdural puncture headache  
 Comparison: 01 parallel versus perpendicular  
 Outcome: 01 Incidence of PDPH



**FIGURE 1.** Pooled estimate of incidence of postdural puncture headache. This figure shows the weighted (pooled) estimate for the incidence of postdural puncture headache (PDPH). “n” Represents the actual number of PDPHs and “N” represent the actual number of dural punctures. The entire diamond (pooled estimate) lies to the left of the odds ratio (OR) = 1 (which represents “no difference”), suggesting that insertion of a beveled needle in a parallel orientation is associated with a significant lower odds (OR = 0.29; 95% CI, 0.17–0.50) of PDPH than that inserted in a perpendicular orientation.

needle diameter and the use of “pencil-point” needles, also decrease the incidence of PDPH. Utilizing 21- or 22-gauge Quincke (cutting) needles, an 18.9%–36% incidence of PDPH is reported compared with 3.6%–6.3% for identical gauge Sprotte (pencil-point) needles.<sup>15,16</sup> The question of whether a parallel insertion of a cutting or beveled needle would decrease the development of PDPH compared with that from a perpendicular insertion is still somewhat controversial. Our systematic review of the available literature suggests that a parallel rather than a perpendicular insertion of a cutting or beveled needle would result in a statistically significant lower incidence of PDPH. However, the possible rationale or mechanisms for our findings are not clear. The reduction of PDPH risk with parallel insertion of the needle appears similar to the reduced incidence seen with the use of pencil-point needles.

perpendicular (5% [6/120]) versus parallel (0.7% [1/150]) insertion of a 26-gauge Quincke spinal needle, although this difference was not statistically significant.<sup>17</sup>

*The cells of the arachnoid mater are oriented parallel to the long axis of the spinal cord, and, as such, parallel insertion of a beveled needle may possibly result in less disruption and a consequently lower incidence of postdural puncture headache.*

*The dura mater is a meshwork of collagen and elastic fibers that lack a specific orientation.*

Although there were only 5 studies that qualified for inclusion of our analysis, our results seem to corroborate other nonrandomized data that also indicate that a parallel rather than a perpendicular insertion of a cutting or beveled needle will lower the incidence of PDPH. Multivariate analysis in a prospective study of 1021 spinal anesthetics revealed that direction of the needle bevel when puncturing the dura mater was a significant predictor of PDPH ( $P = 0.022$ ).<sup>6</sup> In addition, a nonrandomized trial using 22- and 25-gauge beveled needles found that the incidence of PDPH was 0.2% (1/420) for patients where the beveled needle was inserted in a parallel orientation versus 16.1% (10/62) for that in a perpendicular orientation.<sup>1</sup> Another study also noted a higher incidence of PDPH with

It is unclear why a parallel rather than a perpendicular insertion of a cutting or beveled needle would result in a lower incidence of PDPH, although many hypotheses have been proposed. Anatomically, the direction of beveled/cutting needle insertion through the dura mater was thought to be an important risk factor for the development of PDPH as initial anatomic and histologic examination of the dura mater showed collagen and elastic fibers running in a longitudinal direction along the axis of the spinal cord.<sup>18,19</sup> Based on these data, it was thought that insertion of a beveled needle parallel to these fibers would result in fewer dural fibers being cut, less leakage of CSF, and consequently, a lower incidence of PDPH.<sup>3</sup> However, more recent light and electron microscopic studies of human dura mater contradict earlier findings and suggest that the dura mater is a meshwork of collagen and elastic fibers that lack a specific orientation.<sup>9,20</sup> Despite the disparity in anatomic studies, it is possible that it is the arachnoid, not the dura, mater that is of

greater importance in the development of PDPH. Unlike that of the dura mater, the cells of the arachnoid mater are oriented parallel to the long axis of the spinal cord, and as such, parallel insertion of a beveled needle may possibly result in less disruption and a consequently lower incidence of PDPH.<sup>21</sup>

The in vitro data on the effect of a parallel or perpendicular insertion of a beveled needle on CSF leakage rates are equivocal.<sup>4,10</sup> Some experimental data indicate that parallel rather than perpendicular insertion of a beveled needle will result in a lower rate of CSF leakage (eg,  $15.5 \pm 3.3$  mL/min perpendicular versus  $11.9 \pm 3.5$  mL/min parallel with a 22-gauge Quincke needle).<sup>4</sup> However, other in vitro data suggest that orientation of the bevel is not a significant factor in determining rate of CSF flow through the dural hole created by a beveled needle.<sup>10,22</sup> Furthermore, the size of the hole (which may influence rate of CSF leakage and incidence of PDPH) created in the dura mater does not appear to be significantly larger with perpendicular rather than parallel insertion of a beveled needle.<sup>23</sup>

Despite the uncertainty of the effect of direction of bevel insertion on CSF leakage rates, there is a suggestion that the biomechanical properties of the dura mater may influence the size of the dural puncture and thus possibly CSF leakage. Some of the available experimental data indicate that the tensile strength and stiffness of the dura mater are greater in the longitudinal (parallel) rather than transverse (perpendicular) direction.<sup>19,24</sup> It is also easier to distend the dural sac in a transverse rather than longitudinal direction.<sup>25</sup> Although further studies are needed, it is possible that increased tensile strength/stiffness and decreased distensibility of the dura mater in a longitudinal direction in vivo may result in decreased CSF leakage with a parallel rather than perpendicular insertion of a beveled needle. It has been hypothesized that traction exerted longitudinally tends to close the dural hole created by insertion with the bevel in a parallel orientation (and thus reduce CSF leakage and PDPH) but increase that created by a beveled needle inserted in a perpendicular orientation.<sup>26</sup> Finally, it has been reported that beveled needles when inserted will be deflected to a greater extent than a pencil-point needle of the same caliber and that smaller needles are more likely to have a greater degree of deflection than larger needles.<sup>27</sup> It has been hypothesized that a midline insertion of a beveled needle oriented parallel to the longitudinal axis might result in needle deflection such as to create a tangential entry into the dura, resulting in a tissue "flap" that might overlap the margin of the entry or exit of the dural hole.<sup>28</sup>

There are several limitations to our study. Some of the studies in our analysis had rates of PDPH which may at first glance seem excessive (eg, 22.6% PDPH rate with a 27-gauge Quincke needle); however, the incidence of PDPH generally may be higher than expected and has been reported up to 37% even in patients undergoing outpatient surgery (who presumably would receive smaller-gauge spinal needles).<sup>29</sup> The definitions of PDPH should be reasonably consistent among studies, but not all of the studies examined the incidence of PDPH as a primary outcome. The number of studies included for our analysis was quite small, despite our attempts to seek out other relevant studies (ie, abstract search). Not surprisingly, there was moderate heterogeneity (variation among studies), which may reflect the different age groups and type of procedures examined, but the test for heterogeneity did not demonstrate statistical significance (Fig. 1). Our findings may not extend to excluded populations such as pediatric subjects. We also did not weight by the quality scoring of the RCTs used or assess the articles in a blinded fashion although the effect of these items on pooled estimate in a meta-analysis is uncertain.<sup>30,31</sup> There also may be potential limitations of the meta-analytic technique per se. Discrepancies between meta-analyses and subsequent large randomized, controlled trials have been described, although the reasons for these differences are uncertain.<sup>32,33</sup> This may be related in part to the presence of publication bias where only positive findings are published, primarily in English-language journals.<sup>34,35</sup> There may have been the presence of publication bias since we excluded non-English trials; however, the exclusion of non-English trials may have little effect on the pooled estimate and may actually result in a more conservative estimate.<sup>36</sup>

In summary, our meta-analysis demonstrates that insertion of a beveled or cutting needle oriented parallel or longitudinal to the long axis of the spinal cord is associated with a statistically significant decrease in the incidence of PDPH compared with that inserted in a perpendicular fashion. This provides further support for current AAN guidelines on the prevention of post-lumbar puncture headaches. The substantial decrease in the incidence of PDPH was a bit surprising (OR = 0.29, NNT = 7). The performance of diagnostic lumbar puncture via a beveled spinal needle in a parallel rather than perpendicular orientation is simple, inexpensive, and may diminish the risk (and possibly severity<sup>11,13</sup>) of PDPH, a complication of lumbar puncture which can be debilitating for the patient.<sup>36</sup> Although PDPH is a risk of diagnostic lumbar puncture, our data suggest one method to minimize the risk of PDPH.<sup>37</sup>

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*The performance of diagnostic lumbar puncture via a beveled spinal needle in a parallel rather than perpendicular orientation is simple, inexpensive, and may diminish the risk (and possibly severity) of postdural puncture headache.*

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