Obstetrical and Pediatric Anesthesia

PDPH is a common complication of neuraxial blockade in parturients: a meta-analysis of obstetrical studies

[Les céphalées post-ponction durale sont une complication courante du bloc neuraxial chez les parturientes : une méta-analyse d'études obstétricales]

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Purpose: Postdural puncture headache (PDPH) is an iatrogenic complication of neuraxial blockade. We systematically reviewed the literature on parturients to determine the frequency, onset, and duration of PDPH.

Methods: Citations on PDPH in the obstetrical population were identified by computerized searches, citation review, and hand searches of abstracts and conference proceedings. Citations were included if they contained extractable data on frequency, onset, or duration of PDPH. Using meta-analysis, we calculated pooled estimates of the frequency of accidental dural puncture for epidural needles and pooled estimates of the frequencies of PDPH for epidural and spinal needles.

Results: Parturients have approximately a 1.5% [95% confidence interval (CI) 1.5% to 1.5%) risk of accidental dural puncture with epidural insertion. Of these, approximately half (52.1%; 95% CI, 51.4% to 52.8%) will result in PDPH. The risk of PDPH from spinal needles diminishes with small diameter, atraumatic needles, but is still appreciable (Whitacre 27-gauge needle 1.7%; 95% CI, 1.6% to 1.8%). PDPH occurs as early as one day and as late as seven days after dural puncture and lasts 12 hr to seven days.

Conclusion: PDPH is a common complication for parturients undergoing neuraxial blockade.

Objectif : *Les céphalées post-ponction durale (CPPD) sont une complication iatrogène du bloc neuraxial. Une revue systématique des publications sur les parturientes a permis de déterminer la fréquence, le délai d'installation et la durée des CPPD.*

Méthode : *Les citations sur les CPPD dans la population obstétricale ont été repérées par des recherches informatisées, la revue des références et des recherches manuelles de résumés et de comptes rendus de conférences. Les références retenues devaient comporter des données sur la fréquence, le délai d'installation et la durée des CPPD. Nous avons calculé, par méta-analyse, les estimations groupées de la fréquence de ponction durale accidentelle par aiguilles péridurales et celles de la fréquence de CPPD par aiguilles péridurales et rachidiennes.*

Résultats : *Chez les parturientes, le risque de subir une ponction durale accidentelle avec une aiguille péridurale est d'environ 1,5 % [intervalle de confiance de 95 % (IC) 1,5 % à 1,5 %]. Environ la moitié de ces ponctions (52,1 % ; IC de 95 %, 51,4 % à 52,8 %) va provoquer des CPPD. Le risque de CPPD avec les aiguilles rachidiennes diminue pour des aiguilles atraumatiques de petit diamètre, mais demeure appréciable (aiguille Whitacre 27 G 1,7 % ; IC de 95 %, 1,6 % à 1,8 %). Les CPPD surviennent parfois aussi tôt qu'un jour, et aussi tard que sept jours, après la ponction durale et durent de 12 h à sept jours.*

Conclusion : *Les CPPD sont une complication courante chez les parturientes qui subissent un bloc neuraxial.*

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POSTDURAL puncture headache (PDPH) is an iatrogenic complication of neuraxial anesthesia and results from the puncture of the dura mater. The signs and symptoms of PDPH result from loss of cerebrospinal fluid, traction on the cranial contents, and reflex cerebral vasodilation.[1] As female sex and young age are purported risk factors,[1] the complication is common in the obstetrical population, who frequently receives epidural or spinal analgesia and anesthesia during labour and delivery.

The frequency, onset, and duration of PDPH have been evaluated by numerous researchers. Using meta-analysis, Halpern and Preston[2] examined the influence of spinal needle design on the frequency of PDPH in all populations. Atraumatic needles and smaller diameter needles were associated with lower frequencies of PDPH compared to cutting needles and larger diameter needles respectively. The authors recommended that small diameter, atraumatic needles be used for spinal anesthesia. Onset and duration have been reported in a number of case series and comparative studies; however, commonly quoted figures for onset and duration are often based on data from mixed or non-obstetrical populations.

In this report, based on the existing research data from obstetrical populations, we present pooled estimates of accidental dural puncture (ADP) risk for epidural needles and PDPH risk for epidural and spinal needles and systematically review the literature on onset and duration of PDPH in this population. Our report extends the information provided by Halpern and Preston[2] by providing percentages rather than odds ratios for PDPH frequency for both epidural and spinal needles and by reviewing the data on onset and duration of PDPH specific to the obstetrical population.

Methods

Literature search and study identification

The initial literature search was completed in February 1999 as part of the development of an obstetrical PDPH bibliographic database,[3] utilizing a previously described search strategy and inclusion criteria.[4] The literature search was repeated in February 2002. Citations on PDPH in the obstetrical population were identified by computerized searches (MEDLINE 1966 to February 2002, CINAHL® 1982 to February 2002, HealthSTAR 1975 to February 2002, Cochrane Library 2002 Issue 1), citation review, and hand searches of abstracts and proceedings of major anesthesia conferences. Any citation, regardless of study design and language, was included in this review if it contained extractable data on frequency, onset, or duration of PDPH. We evaluated the methodological quality of randomized controlled trials (RCT) and observational studies (cohort or case-control studies) using the Jadad scale[5] and the Quality Index[6] respectively.

Data extraction

Information on the intervention (epidural, spinal), needle design, co-interventions, the number and frequency of ADP (if epidural) and PDPH, and the duration and onset of PDPH were extracted from each citation by two independent reviewers. Disagreements were resolved by consensus.

Statistical analysis

In order to provide estimates of dural puncture (DP) and PDPH risk by needle type and size, combination of single-measurement proportions was necessary. We assumed that the studies would be heterogeneous and that between-study variance and within-study variance would both contribute to the total variance of the pooled event rate; therefore, a random effects model was chosen. Laird and Mosteller[7] have described the statistics; calculations were performed using a Microsoft Excel 97 spreadsheet. Frequencies of events were reported with their 95% confidence intervals (CI). For studies with zero events, the upper 95% CI was calculated as described in Ho *et al.*[8] Because DP and PDPH could be caused by either the epidural needle or the spinal needle when combined spinal epidural procedures are performed, events from combined spinal epidural procedures were examined separately from events caused by epidural or spinal needles.

Two sensitivity analyses were planned *a priori*. First, we compared estimates generated from retrospective *vs* prospective studies. Second, we compared estimates generated from RCT with those generated from all studies. These analyses were conducted when two or more studies contributed to each arm of the comparisons. The Z-statistic was used with P values calculated using SOLO Probability Calculator© (BMDP Statistical Software). A P value of less than 0.10 was considered significant.

A preliminary survey of the eligible studies suggested that quantitative pooling of data on onset and duration would be statistically difficult due to the variability in the reporting of temporal data. For onset, some authors reported the number of PDPH for each postpartum day; other authors reported the number of PDPH over a range of days. Most authors reported duration of PDPH as a range. Because of the wide differences in data presentation, we did not perform meta-analyses of onset or duration of PDPH but report our findings in a narrative fashion.

Results

We identified 87 citations of primary studies containing information on PDPH frequency, onset, or duration. Thirty-six were excluded: 21 were abstracts, one was a duplicate publication, and 14 did not contain extractable data on PDPH. A total of 51 articles (full manuscripts)[9–60] were included in this review (Table A, available at www.cja-jca.org).

Methodological quality

Twenty-two RCT[9–30] and 13 cohort studies[31–43] were evaluated (Table I). There were no case-control studies. Inter-rater reliability was 0.58 and 0.68 for the Jadad scale and the Quality Index respectively. RCT had a median quality score of 2 (range 1–5) out of a maximum score of 5 on the Jadad scale. Cohort studies had a median quality score of 15 (range 5–20) out of a maximum score of 30 on the Quality Index.

DP and PDPH rates

Thirty-nine studies (16 RCT,[10–12,14,16–21,23,24,26,28–30] ten cohort studies,[33–36,38–43] and 13 case series[45,47–51,53–60]) contained data on frequency of ADP or PDPH (Table I). Figures 1 to 3 summarize the meta-analyses of ADP and PDPH risks for different epidural and spinal needles. The pooled risk for ADP for all epidural needles was 1.5% (95% CI, 1.5% to 1.5%; Figure 1). Once DP occurred, the risk of PDPH was 52.1% (95% CI, 51.4% to 52.8%; Figure 2). The risk of PDPH varied amongst spinal needles and ranged from 1.5% to 11.2% (Figure 3). We did not find a statistically significant difference in PDPH risk between the different diameters of Whitacre needles nor between the different diameters of Quincke needles. Whitacre 25-gauge (G) and 27-G atraumatic needles had lower PDPH risk compared to Quincke cutting needles of the same diameters (25-G, 2.2% *vs* 6.3%, $P < 0.001$; 27-G, 1.7% *vs* 2.9%, $P = 0.008$). Sprotte 24-G atraumatic needles had a lower PDPH risk than Quincke 24-G needles but the difference was not statistically significant (3.5% *vs* 11.2%, $P = 0.17$).

Reports of PDPH risk with combined spinal epidural procedures varied in the types of epidural and spinal needles used (Table A).[10,20,25,29,46] Therefore, the data were not pooled. With the exception of one study,[46] these studies examined few (15 to 35) patients and reported no events. Brownridge reported 38 PDPH in 442 patients for an 8.6% (95% CI, 6.0% to 11.2%) risk of PDPH.[46]

Only five needle groups ("all epidural needles", Hustead 18-G, Whitacre 25-G, Sprotte 24-G, and Quincke 25-G) had sufficient studies to undergo sensitivity analysis (Table III). We found statistically significant differences for "all epidural needles" in the ADP risk obtained from RCT compared to the risk obtained from all studies and for Whitacre 25-G needles and Sprotte 24-G needles in their PDPH risks obtained from prospective studies compared to the risk obtained from retrospective studies (Table II). The estimates of risk obtained by RCT for the first case and prospective studies for the other two cases were higher than estimates of risk from all studies in the first case and from retrospective studies in the other two cases.

TABLE I Methodological quality of randomized controlled trials and cohort studies included in this systematic review

Randomized controlled trial	*Jadad scale score (max score = 5)*
Sechzer *et al.* 1978[9]	1
Rawal *et al.* 1988[10]	1
Norris *et al.* 1989[11]	1
Barker *et al.* 1990[12]	1
Camann *et al.* 1990[13]	3
Cesarini *et al.* 1990[14]	4
Kestin *et al.* 1991[15]	2
Mayer *et al.* 1992[16]	2
Shutt *et al.* 1992[17]	4
Campbell *et al.* 1993[18]	5
Devcic *et al.* 1993[19]	3
Caldwell *et al.* 1994[20]	1
McKenzie 1994[21]	2
Patel *et al.* 1994[22]	2
Smith *et al.* 1994[23]	4
Hopkinson *et al.* 1997[24]	5
Dunn *et al.* 1998[25]	1
Huffnagle *et al.* 1998[26]	2
Runza *et al.* 1998[27]	2
Richardson *et al.* 1999[28]	1
Choi *et al.* 2000[29]	1
Vallejo *et al.* 2000[30]	3
Cohort studies	*Quality Index score (max score = 30)*
Craft *et al.* 1973[31]	16
Crawford 1979[32]	5
Naulty *et al.* 1990[33]	19
Ross *et al.* 1993[34]	15
Echevarria *et al.* 1994[35]	13
Herpolsheimer *et al.* 1994[36]	12
Bayhi *et al.* 1995[37]	8
Hwang *et al.* 1997a[38]	10
Hwang *et al.* 1997b[39]	10
Lambert *et al.* 1997[40]	18
Birnbach *et al.* 2001[41]	20
Landau *et al.* 2001[42]	16
Rutter *et al.* 2001[43]	17

TABLE II Sensitivity analyses of estimates of DP and PDPH risks

Needle	*Prospective**	*Retrospective**	*P value*
All epidurals (DP)	0.91% (0.91% - 0.92%)	0.85% (0.85% - 0.85%)	*ns*
All epidurals (PDPH)	48.9% (47.1% - 50.8%)	55.6% (54.4% - 56.8%)	*ns*
Hustead 18-G (PDPH)	44.7% (38.2% - 51.3%)	35.8% (33.8% - 37.7%)	ns
Whitacre 25-G	2.7% (2.6% - 2.7%)	0.88% (0.86% - 0.89%)	0.048
Sprotte 24-G	4.0% (3.9% - 4.0%)	1.7% (1.7% - 1.8%)	0.003
Quincke 25-G	6.2% (6.1% - 6.4%)	6.1% (6.0% - 6.3%)	*ns*
Needle	*Randomized trials**	*All studies**	*P value*
All epidurals (DP)	2.9% (2.8% - 2.9%)	1.5% (1.5% - 1.5%)	0.002
All epidurals (PDPH)	61.7% (44.2% - 79.3%)	52.1% (51.4% - 52.8%)	*ns*
Hustead 18-G (PDPH)	44.7% (38.2% - 51.3%)	41.3% (39.1% - 43.5%)	*ns*
Whitacre 25-G	3.0% (2.9% - 3.2%)	2.2% (2.2% - 2.2%)	*ns*
Sprotte 24-G	3.6% (3.6% - 3.7%)	3.5% (3.5% - 3.5%)	*ns*
Quincke 25-G	6.0% (5.7% - 6.4%)	6.3% (6.3% - 6.4%)	*ns*

DP = dural puncture; PDPH = postdural puncture headache; G = gauge; ns = not significant. ***** All values are pooled estimates, which are expressed as percentages and their 95% confidence intervals in parentheses.

Onset and duration of PDPH

Twenty studies reported temporal data on onset or duration of PDPH. Thirteen studies (five RCT,[13,15,17,25,27] two cohort studies,[31,32] and six case series[46,48,49,52,55,59]) reported the onset of PDPH, but six studies[27,31,32,46,48,55] did not provide information on the number of patients for each day on which PDPH began (Table A). For epidural needles, the reported onset of PDPH ranged from less than one day to six days after ADP: 49 began within one day of ADP,[49] 20 began two days after ADP,[49] 15 began within two days,[31] 12 began after two days,[59] 30 began within three days,[31] one began four days after ADP,[25] 55 began within five days,[52] and 226 began within six days.[52] For spinal needles, the reported onset of PDPH ranged from one to seven days after DP: two began one day after DP,[49] 74 began within two days of DP,[15,32] 67 began within three days,[37,48,49] four began within four days,[27] 37 began within five days,[49,55] and 38 began within seven days.[46] The heterogeneous presentation of the data amongst studies prevented us from determining the median or mean time of onset for PDPH.

Ten studies (three RCT,[9,15,22] five cohort studies,[32,34,37–39] and two case series[44,45]) reported the duration of PDPH (Table A). No study reported data on the number of PDPH resolved by PDP day. Only one study[45] reported the duration of PDPH after ADP from epidural needles. In the study by Holdcroft and colleagues, 13 of 1,000 patients experienced a PDPH, which lasted as long as six days.[45] Treatment of PDPH was not reported. For spinal needles, the duration of PDPH ranged from one to seven days.[15,22,32,34,37–39,44] Further analysis of the data on onset and duration was not attempted as the data were confounded by differences in prophylactic and therapeutic interventions between studies and by uncertainty on the length of patient follow-up. Median patient follow-up was six days in the eight studies[9,17,27,31,33,37,39,49] that reported length of follow-up along with data on onset or duration of PDPH. Length of follow-up was unclear in the other 12 studies.

Discussion

In this review, we provide pooled estimates of the risk of ADP for epidural needles and the risk of PDPH for epidural needles and spinal needles. We also summarize the data on onset and duration of PDPH in the obstetrical population.

Meta-analysis enabled the pooling of data to provide estimates of PDPH rates for different needle shapes and sizes. Previous meta-analyses[2] on needle shapes and sizes have expressed results as odds ratios, which are difficult for clinicians and patients to interpret. Our meta-analyses provide numerical estimates of the risks of DP and PDPH (Figures 1 to 3). With the exception of the "all epidural needles" group, the numbers of events, on which the DP and PDPH risks are calculated, are low for the various needle shapes and sizes despite pooling. Even with pooling of data from several studies, the CI for some estimates is large suggesting large differences in the PDPH rate between studies from which the pooled estimate was calculated. Meta-analyses with less than 200 outcome events, like the ones reported in this review, are considered "small" and should be interpreted with caution.[61] Sensitivity analyses are performed to examine

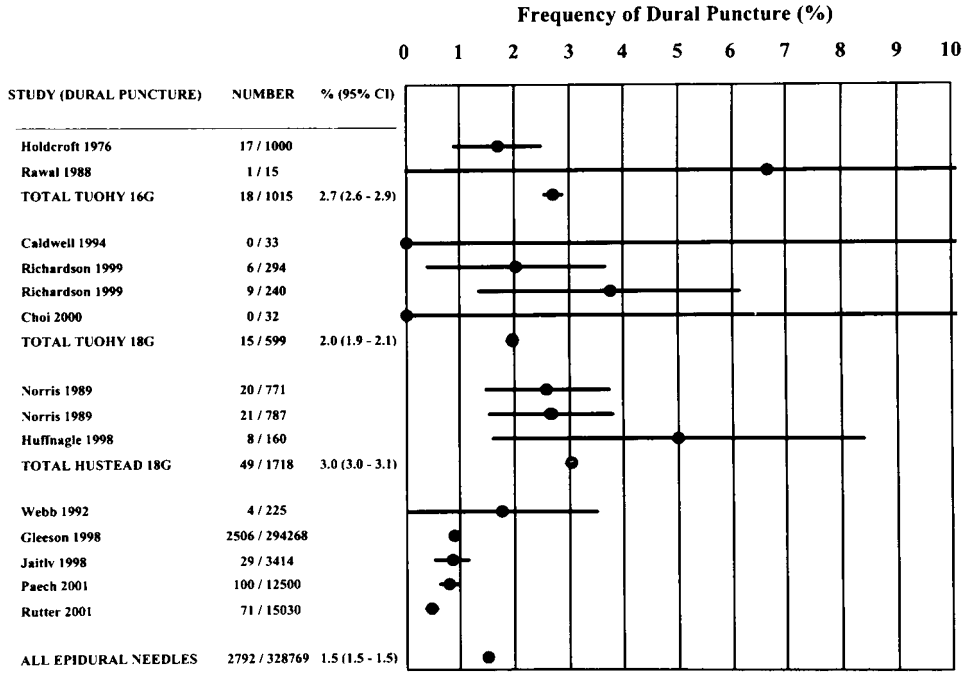

FIGURE 1 Meta-analysis of dural puncture frequencies for epidural needles in the obstetrical population. The dots represent the percentages of patient experiencing the event. The horizontal lines represent the 95% confidence intervals.

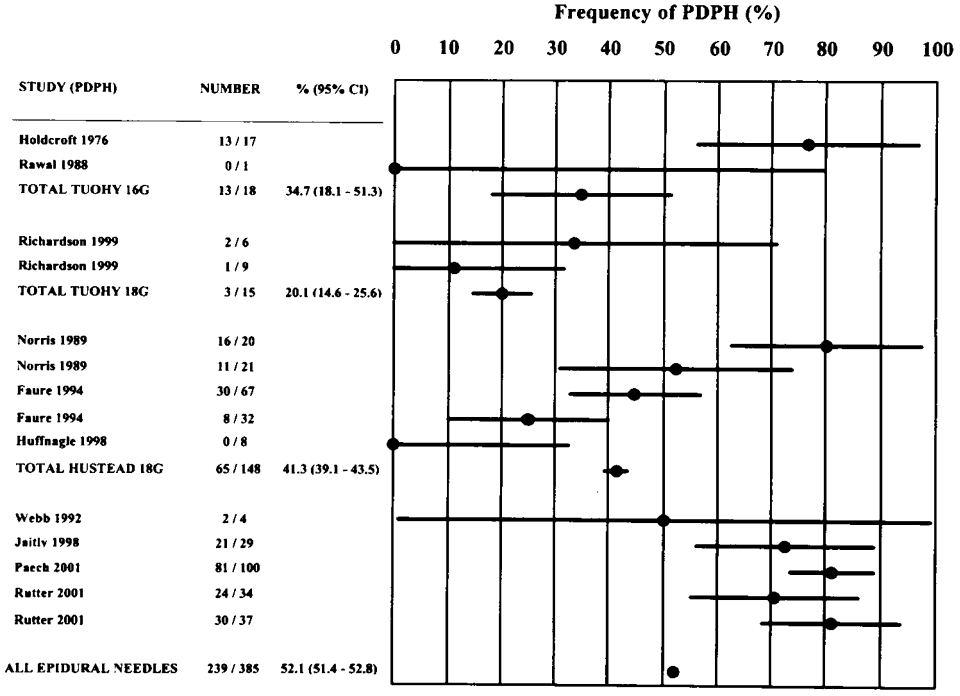

FIGURE 2 Meta-analysis of postdural puncture headache (PDPH) frequencies for epidural needles in the obstetrical population. The dots represent the percentages of patient experiencing the event. The horizontal lines represent the 95% confidence intervals.

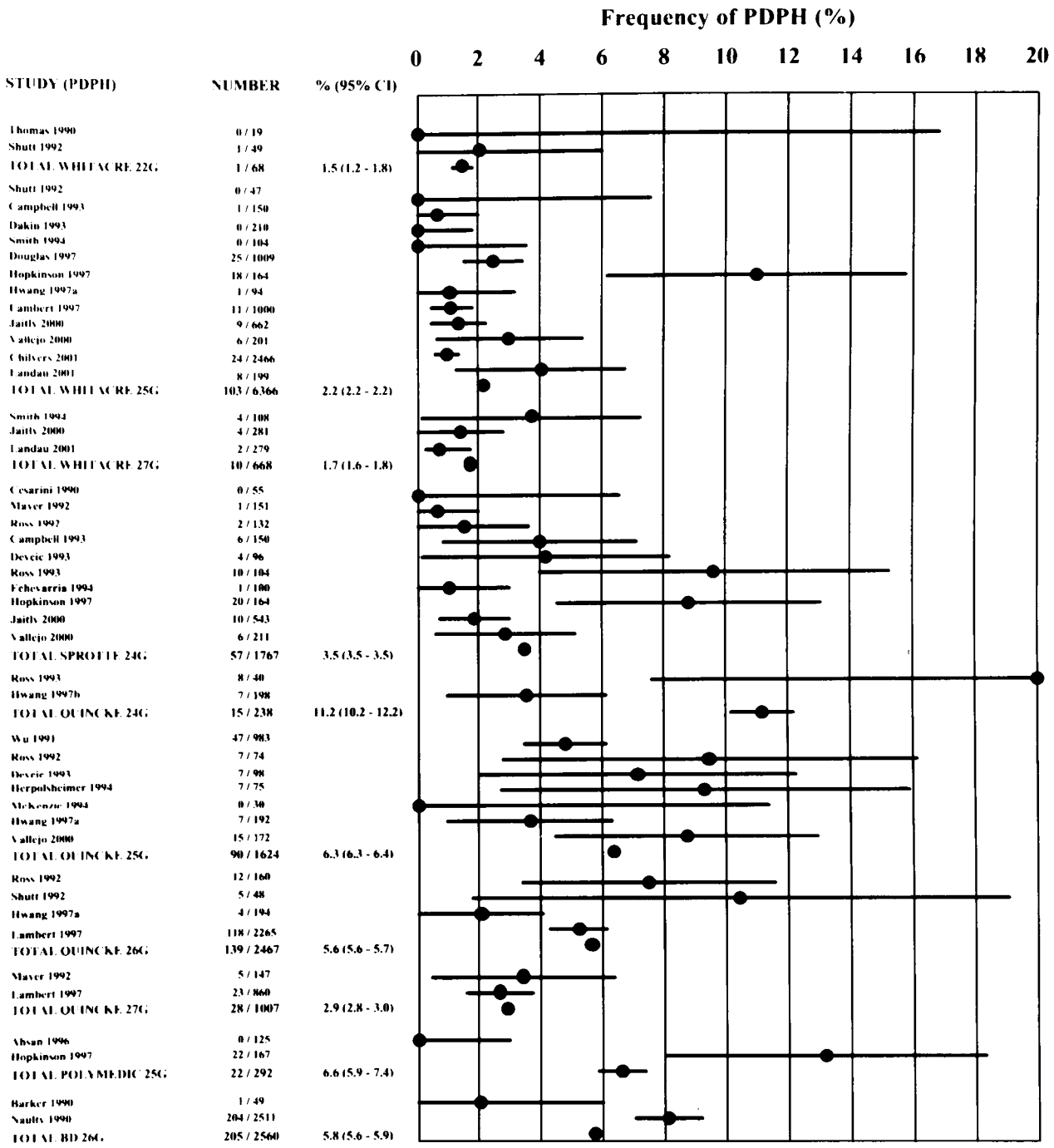

FIGURE 3 Meta-analysis of postdural puncture headache (PDPH) frequencies for spinal needles in the obstetrical population. The dots represent the percentages of patient experiencing the event. The horizontal lines represent the 95% confidence intervals.

the robustness of the estimates. Statistical differences were seen in several analyses. In each case, prospective studies estimated higher risks than retrospective studies or all studies combined. This may suggest underreporting in retrospective studies.

Further attention to the design and reporting of DP and PDPH is merited in future studies. Median quality scores for RCT (2/5) and cohort studies (15/30) were low. Suggestions for improvement have been reported previously.[4]

Attempts to determine the onset and duration of PDPH highlight the challenges and limitations of pooling data. Pooling requires data to be converted into discrete forms (e.g., proportions), continuous forms (e.g., means) or similar probabilities (e.g., *P* values). Conversion of the temporal data to forms amenable to meta-analysis was not possible in this study. Furthermore, the large variations in length of patient follow-up and in prophylactic and therapeutic interventions for PDPH limited the conclusions that we could make. Thus, we presented the information in a descriptive format.

Our pooled risk of DP is similar to risks reported previously.[62] In contrast, the frequency of PDPH following ADP is lower than commonly quoted figures;[62–64] however, the number of reported events, on which we based our pooled estimates, are low. Additional reports of the PDPH risk in parturients receiving epidural analgesia or anesthesia would increase the precision of our pooled estimates. The PDPH risks observed with atraumatic and cutting spinal needles are consistent with previous reports[62,63] and support the recommendations that the smallest diameter atraumatic needle should be used for spinal analgesia or anesthesia.[2] We are unable to provide a pooled estimate of the PDPH risk with combined spinal epidural procedures based on current data.

Although we focused only on the obstetrical population, our observations on the onset and duration of PDPH are consistent with previous reviews, which were based on data from mixed populations. Although female sex and young age may be risk factors for development of PDPH, they are unlikely to affect the onset or duration of the complication. The size of the needle may also influence the onset and duration of PDPH. The heterogeneity of the published data precluded any quantitative analysis of this potential factor.

In general, the onset of PDPH will occur within the first seven days after a DP and lasts up to seven days. However, symptoms of PDPH can persist beyond this time. MacArthur and colleagues found that 17 of 74 parturients with ADP (23.0%; 95% CI, 14.9% to 33.7%) experienced symptoms for nine weeks to eight years (median 78 weeks).[65] With the current trend towards shorter hospital stays after delivery, PDPH may not occur until the patient has been discharged (and no longer followed by the anesthesiologist). Patients and their caregivers (midwife, family physician, or obstetrician) need to be educated on the signs and symptoms of PDPH so that diagnosis and treatment occurs in a timely fashion.

How can we use these results?

When interpreting these results, we offer the following caveats. First, the pooled estimates in this meta-analysis are unadjusted for operator skill, which may be inversely related to DP risk. Most studies did not provide sufficient information to permit adjustment for operator skill. The risk of DP may be lower if we pooled data only from procedures performed by highly skilled operators.

Second, our estimates of PDPH risk are based on all PDPH. Due to the infrequent reporting of the severity of PDPH and the variation in the definitions used for severity, we did not estimate risks for mild, moderate, and severe PDPH. Knowledge of the risk for moderate or severe PDPH is useful for clinicians as these headaches frequently require treatment from anesthesiologists. We are not aware of any obstetrical study that has examined whether knowing the risk of PDPH *vs* knowing the risk of moderate or severe PDPH influences the patient's decision to receive neuraxial analgesia or not.

Third, our estimates are based on studies of varying sample sizes with different complication rates. Whether the pooled estimates underestimate or overestimate the truth is controversial. On one hand, most studies evaluated less than 1,000 patients. These small studies tended to report high levels of risk or, less frequently, no risk compared to large studies. Thus, the pooled estimates may overestimate the true risk. However, this is unlikely, at least for DP risk, as the small studies contributed only 1.1% of the patients from which our pooled estimate is based. On the other hand, three of the seven large studies used a retrospective design, which may underestimate the frequencies of DP and PDPH.

How can we apply these results? We suggest that PDPH is generally a frequent complication. Parturients have approximately a 1 in 67 risk of an ADP during epidural insertion. Approximately half of all ADP will result in PDPH. With spinal needles, the risk of PDPH diminishes with smaller diameter, atraumatic needles, but the risk is still appreciable (e.g., a 1 in 59 risk for Whitacre 27-G needles). Most parturients with PDPH will experience the onset as early as one day and as late as

seven days following DP. The complication usually lasts from one to seven days. For a hospital with 4,000 vaginal deliveries per year and an epidural rate of 60%, these risks translate into 36 ADP and 18 PDPH per year. If one assumes that one third of all PDPH will begin after two days postpartum and the average length of hospital stay will be two days, the diagnosis of PDPH will not be made in hospital in as many as six of the 18 patients.

These estimates should be interpreted within the context of other perioperative complications also. For example, the estimates are comparable to the frequency of perioperative myocardial infarction reported in prospective cohort studies of all consecutive patients undergoing non-cardiac surgery. In this context, the DP risk with epidural needles and the PDPH risk with spinal needles are still "low".

Finally, these estimates should not be interpreted dogmatically. For the individual clinician, his or her frequency of DP or PDPH will be influenced by other factors such as level of skill and time of day. Prospective follow-up of our own patients, ideally by another individual blinded to our intervention, can provide individualized risk estimates and trends over time.

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References

1 *Morewood GH.* A rational approach to the cause, prevention and treatment of postdural puncture headache. Can Med Assoc J 1993; 149: 1087–93.

2 *Halpern S, Preston R.* Postdural puncture headache and spinal needle design. Metaanalyses. Anesthesiology 1994; 81: 1376–83.

3 *Galinski SE, Choi PT, Lucas S, Takeuchi L.* The quality of PDPH literature in obstetrical anesthesia: results from an obstetrical PDPH bibliographic database. Anesthesiology 1999; 91: 1138 (abstract).

4 *Choi PT, Galinski SE, Lucas S, Takeuchi L, Jadad AR.* Examining the evidence in anesthesia literature: a survey and evaluation of obstetrical postdural puncture headache reports. Can J Anesth 2002; 49: 49–56.

5 *Jadad AR, Moore RA, Carroll D, et al.* Assessing the quality of reports of randomized clinical trials: is blinding necessary? Controlled Clin Trials 1996; 17: 1–12.

6 *Downs SH, Black N.* The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health 1998; 52: 377–84.

7 *Laird NM, Mosteller F.* Some statistical methods for combining experimental results. Int J Technol Assess Health Care 1990; 6: 5–30.

8 *Ho AM, Dion PW, Karmakar MK, Lee A.* Estimating with confidence the risk of rare adverse events, including those with observed event rates of zero. Reg Anesth Pain Med 2002; 27: 207–10.

9 *Sechzer PH, Abel L.* Post-spinal anesthesia headache treated with caffeine. Evaluation with demand method. Part 1. Curr Ther Res 1978; 24: 307–12.

10 *Rawal N, Schollin J, Wesstrom G.* Epidural versus combined spinal epidural block for cesarean section. Acta Anaesthesiol Scand 1988; 32: 61–6.

11 *Norris MC, Leighton BL, DeSimone CA.* Needle bevel direction and headache after inadvertent dural puncture. Anesthesiology 1989; 70: 729–31.

12 *Barker P.* Are obstetric spinal headaches avoidable? Anaesth Intensive Care 1990; 18: 553–4.

13 *Camann WR, Murray RS, Mushlin PS, Lambert DH.* Effects of oral caffeine on postdural puncture headache. A double-blind, placebo-controlled trial. Anesth Analg 1990; 70: 181–4.

14 *Cesarini M, Torrielli R, Lahaye F, Mene JM, Cabiro C.* Sprotte needle for intrathecal anaesthesia for caesarean section: incidence of postdural puncture headache. Anaesthesia 1990; 45: 656–8.

15 *Kestin IG, Madden AP, Mulvein JT, Goodman NW.* Comparison of incremental spinal anaesthesia using a 32-gauge catheter with extradural anaesthesia for elective caesarean section. Br J Anaesth 1991; 66: 232–6.

16 *Mayer DC, Quance D, Weeks SK.* Headache after spinal anesthesia for cesarean section: a comparison of the 27-gauge Quincke and 24-gauge Sprotte needles. Anesth Analg 1992; 75: 377–80.

17 *Shutt LE, Valentine SJ, Wee MY, Page RJ, Prosser A, Thomas TA.* Spinal anaesthesia for caesarean section: comparison of 22-gauge and 25-gauge Whitacre needles with 26-gauge Quincke needles. Br J Anaesth 1992; 69: 589–94.

18 *Campbell DC, Douglas MJ, Pavy TJ, Merrick P, Flanagan ML, McMorland GH.* Comparison of the 25-gauge Whitacre with the 24-gauge Sprotte spinal needle for elective caesarean section: cost implications. Can J Anaesth 1993; 40: 1131–5.

19 *Devcic A, Sprung J, Patel S, Kettler R, Maitra-D'Cruze A.* PDPH in obstetric anesthesia: comparison of 24-gauge Sprotte and 25-gauge Quincke needles and effect of subarachnoid administration of fentanyl. Reg Anesth 1993; 18: 222–5.

20 *Caldwell LE, Rosen MA, Shnider SM.* Subarachnoid morphine and fentanyl for labor analgesia. Effcicacy

and adverse effects. Reg Anesth 1994; 19: 2–8.
21 *McKenzie AG.* Low incidence of postdural puncture headache in indigenous Zimbabwean obstetric practice – a preliminary study. Int J Obstet Anesth 1994; 3: 178.
22 *Patel M, Samsoon G, Swami A, Morgan BM.* Flow characteristics of long spinal needles. Anaesthesia 1994; 49: 223–5.
23 *Smith EA, Thorburn J, Duckworth RA, Reid JA.* A comparison of 25 G and 27 G Whitacre needles for caesarean section. Anaesthesia 1994; 49: 859–62.
24 *Hopkinson JM, Samaan AK, Russell IF, Birks RJ, Patrick MR.* A comparative multicentre trial of spinal needles for caesarean section. Anaesthesia 1997; 52: 998–1014.
25 *Dunn SM, Connelly NR, Steinberg RB, et al.* Intrathecal sufentanil versus epidural lidocaine with epinephrine and sufentanil for early labor analgesia. Anesth Analg 1998; 87: 331–5.
26 *Huffnagle SL, Norris MC, Arkoosh VA, et al.* The influence of epidural needle bevel orientation on spread of sensory blockade in the laboring parturient. Anesth Analg 1998; 87: 326–30.
27 *Runza M, Albani A, Tagliabue M, Haiek M, LoPresti S, Birnbach DJ.* Spinal anesthesia using hyperbaric 0.75% versus hyperbaric 1% bupivacaine for cesarean section. Anesth Analg 1998; 87: 1099–104.
28 *Richardson MG, Wissler RN.* The effects of needle bevel orientation during epidural catheter insertion in laboring parturients. Anesth Analg 1999; 88: 352–6.
29 *Choi DH, Kim JA, Chung IS.* Comparison of combined spinal epidural anesthesia and epidural anesthesia for cesarean section. Acta Anaesthesiol Scand 2000; 44: 214–9.
30 *Vallejo MC, Mandell GL, Sabo DP, Ramanathan S.* Postdural puncture headache: a randomized comparison of five spinal needles in obstetric patients. Anesth Analg 2000; 91: 916–20.
31 *Craft JB, Epstein BS, Coakley CS.* Prophylaxis of dural-puncture headache with epidural saline. Anesth Analg 1973; 52: 228–31.
32 *Crawford JS.* Experience with spinal analgesia in a British obstetric unit. Br J Anaesth 1979; 51: 531–4.
33 *Naulty JS, Hertwig L, Hunt CO, Datta S, Ostheimer GW, Weiss JB.* Influence of local anesthetic solution on postdural puncture headache. Anesthesiology 1990; 72: 450–4.
34 *Ross AW, Greenhalgh C, McGlade DP, et al.* The Sprotte needle and post dural puncture headache following caesarean section. Anaesth Intensive Care 1993; 21: 280–3.
35 *Echevarria M, Caba F, Olmedo L, Cruz A, Llamas JM, Rodriguez R.* Headache following dural puncture in pregnant patients at term. Comparative study with non-obstetric patients (Spanish). Rev Esp Anesthesiol Reanim 1994; 41: 217–20.
36 *Herpolsheimer A, Schretenthaler J.* The use of intrapartum intrathecal narcotic analgesia in a community-based hospital. Obstet Gynecol 1994; 84: 931–6.
37 *Bayhi D, Cork RC, Heaton JF, Nolan TE.* Prospective survey of continuous versus single-injection spinal anesthesia in obstetrics. Southern Med J 1995; 88: 1043–8.
38 *Hwang JJ, Ho ST, Wang JJ, Liu HS.* Post dural puncture headache in cesarean section: comparison of 25-gauge Whitacre with 25- and 26-gauge Quincke needles. Acta Anaesthesiol Sin 1997; 35: 33–7.
39 *Hwang JJ, Ho ST, Wang JJ, Kuo WS, Liu HS.* The incidence of post dural puncture headache in Taiwanese patients undergoing cesarean section. Acta Anaesthesiol Sin 1997; 35: 1–6.
40 *Lambert DH, Hurley RJ, Hertwig L, Datta S.* Role of needle gauge and tip configuration in the production of lumbar puncture headache. Reg Anesth 1997; 22: 66–72.
41 *Birnbach DJ, Matut J, Stein DJ, et al.* The effect of intrathecal analgesia on the success of external cephalic version. Anesth Analg 2001; 93: 410–3.
42 *Landau R, Ciliberto CF, Goodman SR, Kim-Lo SH, Smiley RM.* Complications with 25-gauge and 27-gauge Whitacre needles during combined spinal-epidural analgesia in labor. Int J Obstet Anesth 2001; 10: 168–71.
43 *Rutter SV, Shields F, Broadbent CR, Popat M, Russell R.* Management of accidental dural puncture in labour with intrathecal catheters: an analysis of 10 years' experience. Int J Obstet Anesth 2001; 10: 177–81.
44 *Cappe BE.* Prevention of postspinal headache with a 22-gauge pencil-point needle and adequate hydration. Anesth Analg 1960; 39: 463–5.
45 *Holdcroft A, Morgan M.* Maternal complications of obstetric epidural analgesia. Anaesth Intensive Care 1976; 4: 108–12.
46 *Brownridge P.* Spinal anaesthesia revisited: an evaluation of subarachnoid block in obstetrics. Anaesth Intensive Care 1984; 12: 334–42.
47 *Thomas TA, Noble HA.* A re-evaluation of the Whitacre spinal needle in obstetric anaesthesia – a pilot study (Letter). Anaesthesia 1990; 45: 489.
48 *Wu ΥW, Hui ΥL, Tan PP.* Incidence of post-dural puncture headache with 25-gauge Quincke spinal needle. Acta Anaesthesiol Sin 1991; 29: 538–41.
49 *Ross BK, Chadwick HS, Mancuso JJ, Benedetti C.* Sprotte needle for obstetric anesthesia: decreased incidence of post dural puncture headache. Reg Anesth 1992; 17: 29–33.
50 *Webb RJ, Kantor GS.* Obstetrical epidural anaesthesia in a rural Canadian hospital. Can J Anaesth 1992; 39: 390–3.

51 *Dakin MJ, Carli F.* Post-spinal headaches in parturient women (Letter). Br J Anaesth 1993; 71: 171.
52 *Stride PC, Cooper GM.* Dural taps revisited. A 20-year survey from Birmingham Maternity Hospital. Anaesthesia 1993; 48: 247–55.
53 *Faure E, Moreno R, Thisted R.* Incidence of postdural puncture headache in morbidly obese parturients (Letter). Reg Anesth 1994; 19: 361–3.
54 *Ahsan S, Kitchen N, Jenkins C, Margary J.* Incidence of postdural puncture headache following spinal anaesthesia for lower segment caesarean section with the 25 gauge polymedic spinal needle. J Paki Med Assoc 1996; 46: 278–81.
55 *Douglas MJ, Ward ME, Campbell DC, Bright SB, Merrick PM.* Factors involved in the incidence of postdural puncture headache with the 25 gauge Whitacre needle for obstetric anesthesia. Int J Obstet Anesth 1997; 6: 220–3.
56 *Gleeson CM, Reynolds F.* Accidental dural puncture rates in UK obstetric practice. Int J Obstet Anesth 1998; 7: 242–6.
57 *Jaitly VK, Millns JP.* Postdural puncture headache (Letter). Anaesthesia 1998; 53: 410–1.
58 *Chilvers RJ, Bamber J.* Postdural puncture headache in obstetric patients (Letter). Anesth Analg 2001; 92: 1616.
59 *Paech M, Banks S, Gurrin L.* An audit of accidental dural puncture during epidural insertion of a Tuohy needle in obstetric patients. Int J Obstet Anesth 2001; 10: 162–7.
60 *Rorarius M, Suominen P, Haanpaa M, et al.* Neurologic sequelae after caesarean section. Acta Anaesthesiol Scand 2001; 45: 34–41.
61 *Flather MD, Farkouh ME, Pogue JM, Yusuf S.* Strengths and limitations of meta-analysis: larger studies may be more reliable. Controlled Clin Trials 1997; 18: 568–79.
62 *Schneider MC, Schmid M.* Post-dural puncture headache. *In*: Birnbach DJ, Gatt SP, Datta S (Eds.). Textbook of Obstetric Anesthesia. New York: Churchill Livingstone; 2000: 487–503.
63 *Zakowski MI.* Postoperative complications associated with regional anesthesia in the parturient. *In*: Norris MC (Ed.). Obstetric Anesthesia, 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 1999: 723–48.
64 *Bromage PR.* Neurologic complications of regional anesthesia for obstetrics. *In*: Shnider SM, Levinson G (Eds.). Anesthesia for Obstetrics, 3rd ed. Baltimore: Williams & Wilkins; 1993: 433–53.
65 *MacArthur C, Lewis M, Knox EG.* Accidental dural puncture in obstetric patients and long term symptoms. BMJ 1993; 306: 883–5.