

Effectiveness of Epidural Blood Patch in the Management of Post-Dural Puncture Headache

Valérie Safa-Tisseront, M.D.,* Françoise Thormann, M.D.,* Patrick Malassiné, M.D.,* Michel Henry, M.D.,* Bruno Riou, M.D., Ph.D.,† Pierre Coriat, M.D.,‡ Jeanne Seebacher, M.D.*

Background: Lumbar epidural blood patch (EBP) is a common treatment of post-dural puncture headache, but its effectiveness and mode of action remain a matter of debate. The aim of this study was to assess both the effectiveness and the predictive factors of failure of EBP on severe post-dural puncture headache.

Methods: This prospective observational study includes all patients treated in the authors' hospital with EBP for incapacitating post-dural puncture headache, from 1988 to 2000. The EBP effect was classified into complete relief (disappearance of all symptoms), incomplete relief of symptoms (clinically improved patients who recovered sufficiently to perform normal daily activity), and failure (persistence of severe symptoms). The following data were analyzed using a logistic regression to identify predictive factors of failure of EBP: (1) patient characteristics; (2) circumstances of dural puncture; (3) delay between dural puncture and EBP; and (4) the volume of blood injected for EBP.

Results: A total of 504 patients were analyzed. The frequency rates of complete relief, incomplete relief of symptoms, and failure after EBP were 75% ($n = 377$), 18% ($n = 93$), and 7% ($n = 34$), respectively. In a multivariate analysis, only the diameter of the needle used to perform dura mater puncture (odds ratio = 5.96; 95% confidence interval, 2.63–13.47; $P < 0.001$) and a delay in EBP less than 4 days (odds ratio = 2.63; 95% confidence interval, 1.06–6.51; $P = 0.037$) were independent significant risk factors for a failure of EBP.

Conclusions: Epidural blood patch is an effective treatment of severe post-dural puncture headache. Its effectiveness is decreased if dura mater puncture is caused by a large bore needle.

POST-dural puncture headache (PDPH) is frequently associated with neck, vestibular, cochlear, and ocular symptoms. These clinical signs can be observed after diagnostic or therapeutic lumbar puncture, spinal anesthesia, or accidental puncture during epidural anesthesia.¹ They are typically orthostatic, aggravated or provoked by a sitting or standing position, and can be relieved by lying flat. These symptoms result from a cerebrospinal fluid (CSF) leak, leading to decreased CSF

pressure, volume of CSF, or both, which provokes a shift of intracranial contents and traction on pain-sensitive structures in the upright position.² Cerebrovascular changes may also be implicated.³ The diagnosis is clinical but can sometimes be helped with ophthalmic color Doppler flow imaging or magnetic resonance imaging with gadolinium injection.^{4,5} Spontaneous evolution of PDPH results mainly in recovery within a few days, but many cases are very incapacitating and may persist for several months. Severe and even fatal complications have been observed.^{2,6,7}

Many modalities of treatment have been proposed, but only lumbar epidural blood patch (EBP) has apparent benefit, although this has not previously been rigorously assessed.⁸⁻¹⁰ The injection of autologous blood in the lumbar epidural space was initially suggested in 1960 by Gormley¹¹ and later introduced by DiGiovanni and Dunbar.¹² Two theories have been proposed to explain EBP efficiency in PDPH.¹³⁻¹⁵ The first one suggests that the injected blood creates a clot particularly adherent to the dura mater, directly patching the hole in the dura and thus preventing CSF leak.^{15,16} The second theory suggests that the volume of blood injected in the epidural space increases CSF pressure, thus reducing traction on brain and meningeal structures, leading to the relief of symptoms.^{13,14,17,18} These two theories are probably both correct. The first one probably explains the long-lasting effectiveness of the EBP, whereas the second one probably explains the rapid onset of symptom relief after EBP. EBP indications and modes of action remain a matter of debate. Some investigators advise using EBP after a few days of persistent PDPH,¹⁹ whereas others have suggested early or even prophylactic EBP.²⁰⁻²³ The optimal volume to be injected in the epidural space remains also controversial.^{11,24-27} The aim of this observational single-center study was to assess both the effectiveness and the predictive factors of failure of EBP on severe PDPH.

This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 5A.

* Staff Anesthesiologist, † Professor of Anesthesiology and Chairman, Department of Emergency Medicine and Surgery, ‡ Professor of Anesthesiology and Chairman, Department of Anesthesiology.

Received from the Department of Anesthesiology and Critical Care and the Department of Emergency Medicine and Surgery, Groupe Hospitalier Pitié-Salpêtrière, Université Pierre et Marie Curie, Paris, France. Submitted for publication August 25, 2000. Accepted for publication January 4, 2001. Support was provided solely from institutional and/or departmental sources.

Address reprint requests to Dr. Safa-Tisseront: Department of Anesthesiology and Critical Care, Groupe Hospitalier Pitié-Salpêtrière, 47 Boulevard de l'hôpital, 75651 Paris Cedex 13, France. Address electronic mail to: valerie.safa@psl-hop-paris.fr. Individual article reprints may be purchased through the Journal Web site, www.anesthesiology.org.

Patients and Methods

Patients

Between December 1988 and October 2000, all patients treated in our hospital with EBP for incapacitating PDPH were included in our prospective observational study. Diagnosis criteria of severe PDPH were a clinical history of dural puncture associated with severe postural symptoms in patients who were disabled in their daily activities and needed to stay in bed for a part of the day.

Every patient accepted the EBP technique offered by the attending physician.

Contraindications to autologous EBP were determined by interrogation, examination, and blood-sample analysis (blood cell count, prothrombin time, partial thromboplastin time, fibrinogen). Patients with defective hemostasis or suspected infection were not treated with the technique. Because the use of autologous EBP in treating PDPH is controversial in subjects with severely a immunocompromised state, we preferred not to use the technique in these patients, and they were therefore not included in our study.²⁸

Epidural Blood Patch Technique

Epidural blood patch was conducted by experienced staff anesthesiologists, during strict surgical aseptic conditions, on a patient in a sitting position with the legs dependent. The lumbar epidural space was located using a 17-gauge (Vygon®, Ecouen, France) or 18-gauge (Portex®, Hythe Kent, United Kingdom) Tuohy needle, by the loss-of-resistance technique with fluid. The puncture level of the EBP was as close as possible to the vertebral level, when known, underlying the site of the dural puncture.^{13–15,29} Otherwise, the level of EBP was chosen by the operator. When the epidural space had been localized, an autologous venous blood sample was drawn (by a second operator) from an antecubital vein into a plastic syringe using strict aseptic technique. This blood was slowly injected into the epidural space through the Tuohy needle at a speed of approximately 0.3 ml/s. The injection was always stopped 2 ml after the appearance of pain in the back, buttocks, or legs. In absence of any pain, the injected volume chosen by the operator was at least 20 ml.²⁶ The cannula was then removed, and the patient was asked to stay lying for 1 h in dorsal decubitus.³⁰ One hour after performing an EBP, its effectiveness was evaluated by asking the patient to stand up and walk. Treatment effectiveness was again assessed at day 1 by the attending physician and at day 15 by a telephone interview with the patient, who was reinterviewed regarding the various symptoms of PDPH through a standard interview. The results of the EBP treatment on clinical signs were then classified into complete relief, incomplete relief of symptoms, or failure. Complete relief was defined as disappearance of all symptoms after the EBP. Incomplete relief of symptoms included clinically improved patients who recovered a correct daily activity and did not need to repeat the EBP. Failure included all patients with persistence of severe PDPH who were restricted in their daily physical activities and had to stay in bed part of the day. In cases of failure, a second EBP was offered to the patient after consultation with a neurologist.

For each EBP, the following data were recorded: (1) age, height, and sex of the patient; (2) circumstances of the dural puncture; (3) size and type of the needle used

and the level of the dural puncture; (4) difficulties encountered in performing dural puncture; (5) delay in appearance of CSF leak symptoms; and (6) clinical symptoms (headache, neck pain, and vestibular, cochlear, and ocular symptoms). The delay between dural puncture and EBP, EBP level of puncture and difficulties encountered, the volume injected when back, buttock, or leg discomfort or pain appeared, and the total blood volume injected were also recorded.

Statistical Analysis

Data are expressed as mean \pm SD or median (extremes) for non-Gaussian variables (delays). Main percentages are shown with their 95% confidence intervals (CIs). Univariate comparisons between patients with or without incomplete relief (including failures) of their symptoms after blood patch, and patients with or without failure of blood patch as defined above, were performed using the unpaired Student *t* test, the Mann-Whitney test, or the Fisher exact method when appropriate. For continuous variables, the receiver operator characteristic curve was analyzed to determine the best threshold that maximized the sum of sensitivity and specificity. All dichotomous variables were then analyzed using a stepwise forward logistic regression (*P* value of entry = 0.10). The odds ratios and their 95% CIs were calculated. All comparisons were two-sided, and *P* < 0.05 was considered significant. Statistical analysis was performed on a computer using NCSS 6.0 software (Statistical Solutions Ltd, Cork, Ireland).

Results

During a 12-yr period, 527 patients were included in this observational study. Twenty-three patients were excluded because of missing data (fig. 1). Therefore, 504 patients were analyzed, 372 (74%) female and 132 (26%) male. Dural puncture leading to PDPH occurred during anesthesia in 87 cases (17%), of which 21 were spinal anesthesia and 66 were epidural anesthesia. Among these patients, regional anesthesia was provided for delivery in 78 women and for surgery in 9 patients. The remaining patients underwent diagnostic lumbar puncture in 363 cases (72%), therapeutic lumbar puncture for corticosteroid administration in 31 cases (6%), and lumbar puncture for imaging procedures in 23 cases (5%). Sixty-eight cases (13%) occurred after use of a Tuohy needle (17–18 gauge), but the precise type of the needle used could only be ascertained in 342 of the remaining cases, namely the Quincke type (18–26 gauge) in 326 cases and the Pen type (22–26 gauge) in 16 cases. The vertebral space where the dural puncture was performed or occurred is shown in figure 2. Information concerning the difficulties encountered in performing lumbar procedure could be ascertained in only 157

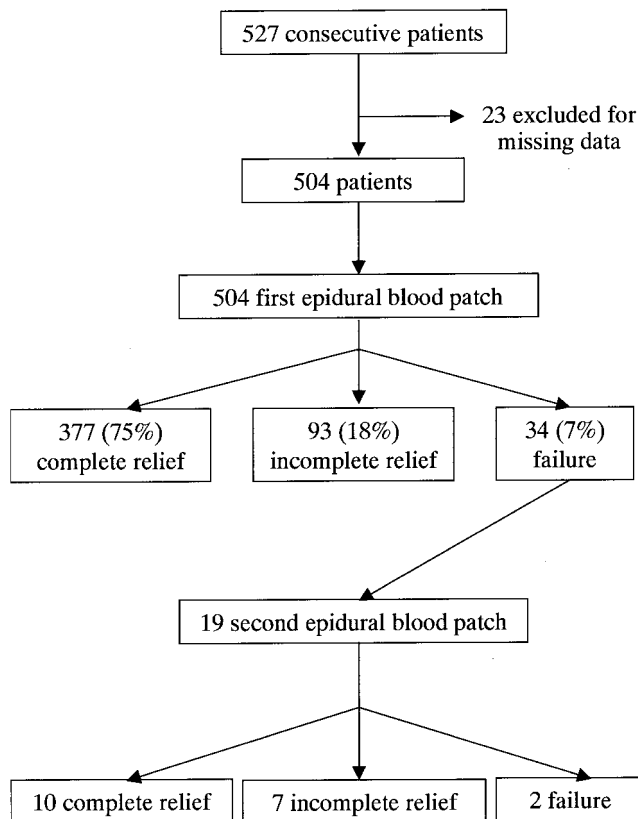


Fig. 1. Trial profile.

cases, and the procedure was recorded as difficult in 109 (69%) of these cases.

Symptoms of CSF leak were noted after a median delay of 1 day (range, 1–10 days) after dural puncture. Headache occurred in 490 cases (97%), neck pain in 438 (87%), vestibular signs (nausea and vomiting) in 347 (69%), cochlear symptoms in 182 (36%), and ocular symptoms in 181 (36%).

Epidural blood patch was performed after a median delay of 4 days (range, 1–53 days) after dural puncture. The vertebral space where the EBP was performed is depicted in figure 2. The mean volume of blood injected was 23 ± 5 ml. Discomfort occurred in 391 cases (78%) after administration of a blood volume of 19 ± 5 ml. Pain occurred in 274 cases (54%) after administration of a blood volume of 21 ± 5 ml and was always preceded by discomfort, which was noted after administration of a blood volume of 18 ± 5 ml. Patients who experienced discomfort received a lower blood volume (22 ± 5 vs. 25 ± 4 ml; $P < 0.001$) as well as those who experienced pain (21 ± 4 vs. 24 ± 4 ml; $P < 0.001$). Only one variable was an independent risk factor for pain during EBP: age less than 35 yr (odds ratio, 2.00; 95% CI, 1.55–2.58; $P < 0.001$). The correlation between the height of the patients and the epidural injected blood volume inducing lumbar discomfort or pain is depicted in figure 3.

Complete relief of all symptoms occurred in 377 cases (75%; 95% CI, 73–77%). In the remaining 127 (25%; 95%

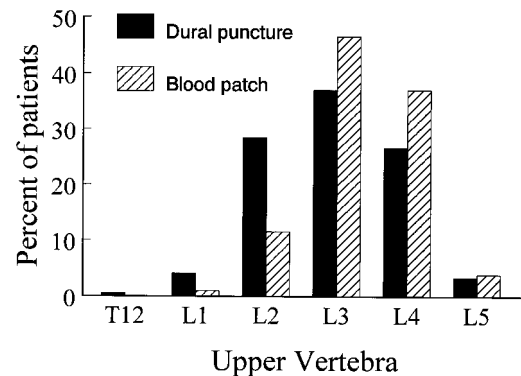


Fig. 2. Levels of initial dural puncture and epidural blood patches.

CI, 23–27%) patients with incomplete relief of symptoms, 34 (7%; 95% CI, 6–8%) were considered as a failure. Table 1 shows the univariate analysis to identify risk factors for either an incomplete relief of symptoms or failure of the EBP. The area under the receiver operator characteristic curve for the diameter of the needle was 0.73 ± 0.17 ($P < 0.05$), and the threshold was 20-gauge (sensitivity, 0.56; specificity, 0.81). The percentage of failure (21 vs. 4%; $P < 0.001$) and the percentage of incomplete relief (including failure; 38 vs. 22%; $P < 0.001$) were significantly greater in patients having received dural puncture with a needle less than 20 gauge. Figure 4 depicts the percentage of incomplete relief of symptoms and failure of EPB according to the size of the needle used for dural puncture. The area under the receiver operator characteristic curve for the delay in EBP was 0.63 ± 0.15 ($P < 0.05$), and the threshold was 4 days (sensitivity, 0.71; specificity, 0.54). The percentage of incomplete relief of symptoms and failure of EBP versus the delay in EBP is depicted in figure 5. In the multivariate analysis, only the diameter of the needle causing the dural puncture and the presence of neck pain were independent risk factors for incomplete relief of symptoms (including failures) after EBP, whereas the diameter of the needle causing the dural puncture and the delay in EBP were independent risk factors for a failure of EBP (table 2).

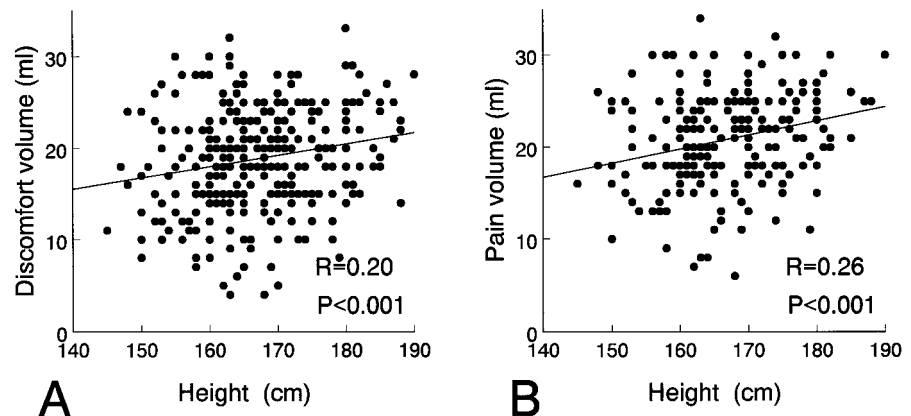
Among the 34 patients with failure of the EBP, 19 underwent a second EBP (22 ± 5 ml) after a median delay of 5 days (range, 4–7 days). Nine patients had an incomplete relief of their symptoms, including two who were considered as treatment failures.

The only complication, observed in three patients in our series after EBP, was fever without neurologic complication and without any confirmed pathogen, which resolved spontaneously.

Discussion

In a series of 504 patients, we confirmed that EBP is an effective treatment for symptoms of CSF leak after dural

Fig. 3. Correlation between the height of the patients and the epidural injected blood volume inducing (A) lumbar discomfort (n = 389) and (B) lumbar pain (n = 274).



mater puncture, with 75% showing complete relief of symptoms and only 7% failure. Moreover, we observed that the increasing diameter of the needle causing the dural puncture and the decreasing delay between dural puncture and EBP realization were the two predictive factors of failure of EBP.

The effectiveness of a first EBP to treat PDPH was high in our study when both complete and incomplete relief of symptoms (93%) were considered as a success, as previously reported.^{2,25,26} When only complete relief was considered, the success rate of the EBP was of 75% in our series, in accordance with findings reported by Vercauteren *et al.*¹⁰ The reported EBP effectiveness in the literature remains highly variable because some investigators consider only total relief from symptoms as success, whereas others include incomplete relief of

symptoms. Otherwise, the populations of patients and the EBP methods used are different between the studies, and these points can explain different results.

Symptoms of CSF leak appeared after a median delay of 1 day after dural puncture and correspond to a resumption of an erect posture by the patient. Neck symptoms and headache were the most frequently reported symptoms. In the current study, vestibular, cochlear, and ocular symptoms were more frequently observed than is apparent from the literature, where they have not been routinely reported.

Using multivariate analysis, the diameter of the needle causing the dural puncture was a predictive factor of failure or of incomplete relief of symptoms after an EBP. Our finding in patients having dural puncture with needles larger than 20 gauge are similar to those reported by

Table 1. Univariate Analysis of Factors Predicting an Incomplete Relief of Symptoms or a Failure of Epidural Blood Patch (n = 504)

	Relief of Symptoms		Global Result	
	Complete (n = 377)	Incomplete† (n = 127)	Success (n = 470)	Failure (n = 34)
Age (yr)	36 ± 12	35 ± 10	36 ± 12	36 ± 10
Sex (female)	282 (75)	90 (71)	343 (73)	29 (85)*
Height (cm)	167 ± 9	168 ± 8	167 ± 9	167 ± 7
Symptoms				
Delay (days)	1 [1–10]	1 [1–6]	1 [1–10]	1 [1–2]
Neck pain	319 (85)	119 (94)*	405 (86)	33 (97)
Headache	366 (97)	124 (98)	456 (97)	34 (100)
Vestibular signs	262 (69)	85 (67)	327 (70)	20 (59)
Cochlear signs	135 (36)	47 (37)	167 (36)	15 (44)
Ocular signs	136 (36)	43 (34)	169 (36)	10 (29)
Dural puncture				
Surgery/obstetrics	64 (17)	25 (20)	75 (16)	14 (41)*
Tuohy needle	45 (12)	23 (18)	54 (11)	14 (41)*
Needle diameter < 20 gauge	55 (15)	34 (27)*	70 (15)	19 (56)*
Epidural blood patch				
Discomfort	289 (77)	102 (80)	365 (78)	26 (76)
Pain	197 (52)	77 (61)	255 (54)	19 (56)
Delay (days)	4 (1–28)	3 (1–53)	4 (1–53)	3 (1–8)
Delay < 4 days	174 (46)	65 (51)	215 (46)	24 (71)*
Difficulties	37 (10)	13 (10)	47 (10)	3 (9)
Volume (ml)	23 ± 5	22 ± 5	23 ± 5	23 ± 5

Data are mean ± SD, median [extremes], or number (percent). Because of rounding, adding percentages may not provide a sum of 100%.

* $P < 0.05$. † Including failures.

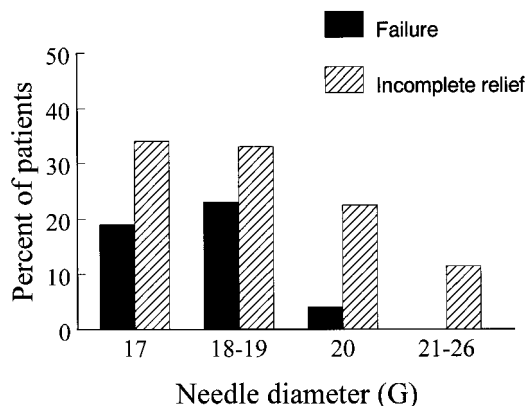


Fig. 4. Percentages of patients with incomplete relief of symptoms (including failures) and failure of epidural blood patch treatment versus the diameter of the needle performing dural puncture.

Stride and Cooper,³¹ who performed EBP after dural tap with 16-gauge Tuohy needles. The clot theory for symptom resolution after EBP can explain that the dural tear is more difficult to plug as its size is bigger. On the other hand, when the size of the dural tap increases, the CSF leak and the decreased CSF volume and pressure are more important. In this case, it is probably more difficult to restore the normal CSF pressure by compressing the dura with the injected blood. The two theories proposed in the literature to explain EBP efficiency are compatible with our finding that failure or incomplete relief of symptoms after EBP was favored by a larger dural opening. As depicted in figure 4, the foreseeable EBP effectiveness was different according to the size of the needle causing dural puncture, with a threshold of 20 gauge.

Epidural blood patch was performed after a median delay of 4 days after dural puncture. We found that the percentage of failure of EBP was significantly increased when EBP was performed within 3 days after dural puncture. In our study, this delay between dural puncture and EBP was uncontrolled, and EBPs were performed when proposed by the patient's attending phy-

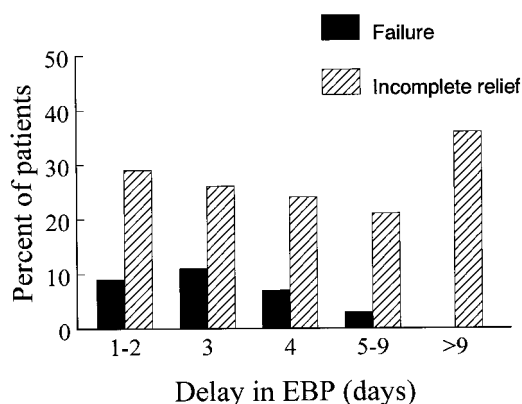


Fig. 5. Percentages of patients with incomplete relief of symptoms (including failures) and failure of epidural blood patch (EBP) treatment versus the delay between dural puncture and EBP.

Table 2. Multivariate Analysis of Risk Factors for an Incomplete Relief of Symptoms or a Failure of Epidural Blood Patch (n = 504)

	Variables	
	Odds Ratio (95% CI)	P Value
Incomplete relief of symptoms* (n = 127)		
Neck pain	2.53 (1.10–5.77)	0.028
Needle diameter < 20 gauge	2.12 (1.24–3.62)	0.006
Failure (n = 34)		
Needle diameter < 20 gauge	5.96 (2.63–13.47)	< 0.001
Delay in EBP < 4 days	2.63 (1.06–6.51)	0.037

* Including failures.

EBP = epidural blood patch; CI = confidence interval.

sician. Symptoms are more severe as the CSF leak is greater, and it is likely that patients experiencing more pain were treated earlier because of the severity of their symptoms. This suggests that the diminished effectiveness of early EBP was more related to the size of the dural puncture and the severity of the CSF leak than with the fact of not delaying EBP. The only report that supports the clinical impression of benefit in delaying EBP after dura mater puncture is a study by Loeser *et al.*¹⁹ These investigators compared, in a retrospective and uncontrolled study, the effectiveness of immediate and late EBP in 48 patients with PDPH. In this work, the reason why some EBPs were performed very early and the others later is not known. As in our study, severity of CSF leak could also explain the diminished effectiveness of early EBP.¹⁹ Moreover, some investigators have reported that early EBP can be effective.^{20–23} Neither our study nor any of these previous uncontrolled observational studies allow reliable recommendations to delay EBP from dural puncture.

In our study, the mean blood volume injected in the lumbar epidural space was not significantly different in groups of patients with success or failure of the EBP. This suggests that the volume of blood injected does not appear to influence significantly the success of the treatment. The optimal recommended volume of blood that should be injected during an EBP is also controversial and has tended to increase over time. Gormley¹¹ initially injected 2 or 3 ml of blood in the epidural space and reported a success in all seven of his patients. Other studies have reported an increase incidence of failure rate or relapse of the symptoms when EBPs were performed using a volume lower than 10 ml.^{24,25} Taivainen *et al.*²⁷ compared different volumes (10–15 ml) of blood and could not detect any advantage of larger volumes. Using a blood volume of 20 ml, Crawford²⁶ observed a 96% success rate. Although there is no consensus about the optimal EBP volume to inject, the tendency is to use approximately 20 ml. According to proposed EBP mechanisms of action, its efficiency might increase as the

amount of blood injected increases, a small volume being unable to cover the dura mater opening or restore CSF pressure. In our study, the mean volume of blood injected during EBP was effective in the treatment of PDPH. It was a little larger than those reported in the literature and did not explain the cases of EBP failure observed in our patients. Further studies are required to determine if lower volumes are associated with such a high level of success.

Discomfort or pain in the back, buttocks, or legs appeared in 77% and 54% of our population, respectively. According to our methodology, in patients reporting this discomfort, the total injected blood volume was lower than in patients without this signs. These signs indicated the existence of neural or medullary compression as a cause of neurologic symptoms and thus a factor limiting the total injected blood volume. Nevertheless, in our study, the presence of these signs during injection in the epidural space was not a factor predicting better outcome of treatment. These results suggest that the effectiveness of EBP is not decreased when injection of blood is stopped because of the appearance of these signs of compression.

A significant but low correlation was found between the height of the patients and the volume of blood injected into the epidural space when lumbar discomfort or pain occurred. This is in agreement with results of Taivainen *et al.*,²⁷ who compared injected volumes ranging from 10 to 15 ml according to the height of the patient and could not detect any advantage with larger volumes.

In conclusion, lumbar EBP was an effective treatment of severe PDPH, leading to the relief of symptoms in 93% of the patients after one EBP and in 97% of cases after a second EBP. A large diameter (< 20 gauge) of the needle causing dural puncture was a predictive factor of failure of EBP in treating PDPH. In deliberate dural puncture, it is important to use a needle of small diameter to decrease PDPH¹ and potentially EBP effectiveness if the technique is needed.

The authors thank D. J. Baker, M.D., F.R.C.A. (Hôpital Necker Enfants-Malades, Paris, France), for editing the manuscript.

References

1. Halpern S, Preston R: Postdural puncture headache and spinal needle design: Metaanalyses. *ANESTHESIOLOGY* 1994; 81:1376-83

2. Gielen M: Post dural puncture headache (PDPH): A review. *Reg Anesth* 1989; 14:101-6
3. Kongstad L, Grände PO: Local vascular response during organ elevation: A model for cerebral effects of upright position and dural puncture. *Acta Anaesthesiol Scand* 1999; 43:438-46
4. Chen CC, Luo CL, Wang SJ, Chern CM, Fuh JL, Lin SH, Hu HH: Colour doppler imaging for diagnosis of intracranial hypotension. *Lancet* 1999; 354: 826-9
5. Pannullo SC, Reich JB, Krol G, Deck MD, Posner JB: MRI changes in intracranial hypotension. *Neurology* 1993; 43:919-26
6. Edelman JD, Wingard DW: Subdural hematomas after lumbar dural puncture. *ANESTHESIOLOGY* 1980; 52:166-7
7. Eerola M, Kaukinen L, Kaukinen S: Fatal brain lesion following spinal anaesthesia: Report of a case. *Acta Anaesthesiol Scand* 1981; 25:115-6
8. Seebacher J, Ribeiro V, LeGuillou JL, Lacomblez L, Henry M, Thormann F, Youl B, Bensimon G, Darbois Y, Bousser MG: Epidural blood patch in the treatment of post dural puncture headache: A double blind study. *Headache* 1989; 29:630-2
9. Carbaat PA, van Crevel H: Lumbar puncture headache: Controlled study on the preventive effect of 24 hours' bed rest. *Lancet* 1981; 2:1133-5
10. Vercauteren MP, Hoffmann VH, Mertens E, Sermeus L, Adriaensens HA: Seven-year review of requests for epidural blood patches for headache after dural puncture: Referral patterns and the effectiveness of blood patches. *Eur J Anaesthesiol* 1999; 16:298-303
11. Gormley JB: Treatment of postspinal headache. *ANESTHESIOLOGY* 1960; 21: 565-6
12. DiGiovanni AJ, Dunbar BS: Epidural injections of autologous blood for postlumbar-puncture headache. *Anesth Analg* 1970; 49:268-71
13. Beards SC, Jackson A, Griffiths AG, Horsman EL: Magnetic resonance imaging of extradural blood patches: Appearances from 30 min to 18 h. *Br J Anaesth* 1993; 71:182-8
14. Vakharia SB, Thomas PS, Rosenbaum AE, Wasenko JJ, Fellows DG: Magnetic resonance imaging of cerebrospinal fluid leak and tamponade effect of blood patch in postdural puncture headache. *Anesth Analg* 1997; 84:585-90
15. Djourhuus H, Rasmussen M, Jensen EH: Epidural blood patch illustrated by CT-epidurography. *Acta Anaesthesiol Scand* 1995; 39:613-7
16. Cook MA, Watkins-Pitchford JM: Epidural blood patch: A rapid coagulation response. *Anesth Analg* 1990; 70:567-8
17. Colonna-Romano P, Linton P: Cervical dural puncture and lumbar extradural blood patch. *Can J Anaesth* 1995; 42:1143-4
18. Griffiths AG, Beards SC, Jackson A, Horsman EL: Visualization of extradural blood patch for post lumbar puncture headache by magnetic resonance imaging. *Br J Anaesth* 1993; 70:223-5
19. Loeser EA, Hill GE, Bennett GM, Sederberg JH: Time vs success rate for epidural blood patch. *ANESTHESIOLOGY* 1978; 49:147-8
20. Quaynor H, Corbey M: Extradural blood-patch: Why delay? *Br J Anaesth* 1985; 57:538-40
21. Colonna-Romano P, Shapiro BE: Unintentional dural puncture and prophylactic epidural blood patch in obstetrics. *Anesth Analg* 1989; 69:522-3
22. Cheek TG, Banner R, Sauter J, Gutsche BB: Prophylactic extradural blood patch is effective: A preliminary communication. *Br J Anaesth* 1988; 61:340-2
23. Christensen FR, Lund J: Accidental dural puncture: Immediate or delayed blood patch. *Br J Anaesth* 1983; 55:89-90
24. Ostheimer GW, Palahniuk RJ, Shnider SM: Epidural blood patch for post-lumbar-puncture headache. *ANESTHESIOLOGY* 1974; 41:307-8
25. Abouleish E, de la Vega S, Blendinger I, Tio TO: Long-term follow-up of epidural blood patch. *Anesth Analg* 1975; 54:459-63
26. Crawford JS: Experiences with epidural blood patch. *Anaesthesia* 1980; 35:513-5
27. Taivainen T, Pitkänen M, Tuominen M, Rosenberg PH: Efficacy of epidural blood patch for postdural puncture headache. *Acta Anaesthesiol Scand* 1993; 37:702-5
28. Bucklin BA, Tinker JH, Smith CV: Clinical dilemma: A patient with post-dural puncture headache and acute leukemia. *Anesth Analg* 1999; 88:166-7
29. Szeinfeld M, Ihmeidan IH, Moser MM, Machado R, Klose KJ, Serafini AN: Epidural blood patch: Evaluation of the volume and spread of blood injected into the epidural space. *ANESTHESIOLOGY* 1986; 64:820-2
30. Martin R, Jourdain S, Clairoux M, Tétrault JP: Duration of decubitus position after epidural blood patch. *Can J Anaesth* 1994; 41:23-5
31. Stride PC, Cooper GM: Dural taps revisited: A 20-year survey from Birmingham Maternity Hospital. *Anaesthesia* 1993; 48:247-55