Increased risk of unintentional dural puncture in night-time obstetric epidural anesthesia

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Purpose: To evaluate the experience of the operator and the time of epidural anesthesia as factors contributing to unintentional dural puncture (UDP).

Methods: In a prospective analysis of recorded cases of UDP the following variables were recorded: maternal height, weight, and weight gain, type of personnel providing epidural analgesia, number of attempts, and hour of the epidural procedure. Work time was divided into day-time (8 AM to 7 PM) and night-time (7 PM to 8 AM), according to the change of coverage of the delivery suite. Night-time was divided into first (7 PM to midnight) and second parts (midnight to 8 AM). Relative risk was used to compare the incidence of UDP among different work-times.

Results: A total of 1489 consecutive epidural procedures were considered. The incidence of dural puncture was 0.8% (12 cases). The relative risk was higher for night-time than day-time (risk ratio 6.33; 95% confidence interval, 1.39 to 28.80; $P = 0.006$). Seven cases were caused by three operators with poor expertise, and five by two skilled obstetric anesthesiologists.

Conclusion: Operator experience and hour of procedure appear to be two important risk factors of UDP. The increased risk of UDP in night-work could result from human factors such as fatigue, sleep deprivation or interruption.

Objectifs : Evaluer l'expérience de l'opérateur et l'heure de réalisation de l'anesthésie péridurale comme facteurs favorisant la survenue de brèches durales accidentelles.

Méthode : Analyse de cas de brèche durale accidentelle colligés de manière prospective. Les paramètres suivants ont été relevés : la taille, le poids et la prise de poids de la mère, le type de personnel ayant pratiqué l'analgésie péridurale, le nombre de tentatives, l'heure du repérage de l'espace péridural. La période de travail a été divisée en jour (de 8 h à 19 h), et en nuit (19 h à 8 h), en fonction de l'heure du changement d'anesthésiste. Enfin, la période de nuit a été divisée en première (19 h à minuit) et seconde parties (minuit à 8 h). La comparaison de l'incidence des brèches durales entre les périodes de travail a été faite par calcul du risque relatif.

Résultats : Un total de 1489 procédures péridurales ont été pratiquées. L'incidence globale de la brèche durale accidentelle était de 0,8% (12 cas). Le risque relatif était plus important en période de nuit comparée à la période de jour (risque relatif 6.33; intervalle de confiance à 95% 1.39 à 28.80; $P = 0.006$). Sept cas ont été causés par des opérateurs peu entraînés, et les 5 autres par des anesthésistes exerçant au service d'obstétrique.

Conclusion : L'expérience de l'opérateur et l'heure de la procédure semblent être deux facteurs importants de risque de brèche durale accidentelle. L'accroissement du risque en période de nuit pourrait être dû à des facteurs humains tels que la fatigue, la privation de sommeil ou son interruption.

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SEVERAL studies have demonstrated that most mishaps during general anesthesia are due to human failure.[1] Conversely, human factors contributing to morbidity in regional anesthesia have been poorly studied. Regional anesthetic techniques, such as epidural analgesia, require anesthesiologists to have good motor skills. Although skilled operators may also have mishaps,[2,3] experience and training are generally seen as the main factors that affect the incidence of unintentional dural puncture (UDP). Unavoidable patient-related factors such as obesity may also be involved in the risk of dural puncture. The aim of the present study was to evaluate the experience of the operator and the time of epidural anesthesia as factors contributing to the occurrence of UDP.

Patients and methods

All patients having epidural anesthesia in our obstetric anesthetic unit from January 1996 to December 1997 were considered for the study. All cases of UDP were recorded prospectively. The diagnosis of dural puncture was based on the reflux of cerebro-spinal fluid (CSF) through the Tuohy needle during the procedure, and/or on the onset of postdural puncture headache (PDPH) in the postpartum period. For the case report, all patients having undergone epidural analgesia for labour were seen daily after delivery by obstetric residents and midwives, who were aware of the study and who draw to our attention patients who complained of headache. Thus, patients suffering from headaches severe enough to require analgesics were always checked by an anesthesiologist before any treatment. Postdural puncture headache was recognized on the postural character of headache, and on the successful treatment by epidural blood patch. The following variables were obtained in case of UDP: maternal height, weight, and weight gain, type of personnel providing epidural analgesia (anesthesiologist or resident), number of attempts, and hour of the epidural procedure. For data analysis, the day was divided into day-time (8 AM to 7 PM) and night-time (7 PM to 8 AM), according to the change of coverage. Finally, night-time was subdivided into first (7 PM to midnight) and second parts (midnight to 8 AM), assuming that midnight was an approximate time to go to bed. As this was a cohort study, relative risk was used to compare the incidence of UDP among different work-times. Thus, we considered that the primary outcome was the postdural puncture rate, while the exposures of interest were work-time (night-time *vs* day-time insertion of epidurals), and expertise of personnel providing epidurals. The other variables were considered as potential confounding factors in the incidence of UDP. However, because of the expected low incidence of UDP, no analysis (multivariate or univariate) was performed to assess their association with UDP. A P value < 0.05 was considered to indicate statistical significance.

Results

Over the study period, 1,489 epidural procedures were performed. Twelve patients had an UDP (0.80%). The study variables are reported in Table I. Details of the personnel providing epidural analgesia are shown in Table II. Anesthesiologists 1 and 2 were obstetric anesthetists, while anesthesiologist 3 was a critical care anesthesiologist involved in the rotation of obstetric anesthesia for the night-time, once or twice a month. Residents 1 and 2 were learning obstetric epidural anesthesia for the first time, and each of them contributed for a six-month period. Nine UDPs were caused by anesthesiologists, and the remaining three by residents. Dural puncture occurred at the first attempt in four cases, and after more than two attempts in six cases. In six cases, there was no reflux of CSF during the procedure (Table I), and the diagnosis of UDP was made at the time of occurrence of PDPH. Eleven parturients complained of PDPH, and were treated by blood patching. Ten cases of UDP occurred during night-time: two before midnight and eight between 3 and 8 A.M. Another case (patient #7) occurred on a Sunday mid-afternoon with an anesthesiologist who had been working most of the previous night and morning. The amount of call that the operator had taken prior to each case of UDP (defined as the time interval between 7 PM and the time of UDP) is reported in Table I. As the total number of epidurals performed during daytime, first and second parts of the night were 832, 251, and 406, respectively, the corresponding incidences of UDP were 0.24%, 0.79% and 1.97%. The comparison between night-time and daytime for the incidence of UDP showed that the risk was greater for the night-time work (risk ratio 6.33; 95 % confidence interval, 1.39 to 28.80; $P = 0.006$). When only night-time was considered, the risk was not different between first and second parts (risk ratio 2.47; 95 % confidence interval 0.53 to 11.55; $P = 0.23$).

Discussion

The present study is a survey of near 1,500 consecutive epidurals performed at a single university teaching hospital over two years. The study focused on UDP, the overall incidence of which was consistent with that published previously. The incidence of UDP is believed to vary between 1 and 3%. In a large retrospective study, Tanaka *et al.*[4] reported an overall rate

TABLE I Study variables recorded in 12 cases of unintentional dural puncture

Patient number	*Age (yr)*	*Height (cm)*	*Weight (kg)*	*Weight gain (kg)*	*Operator*	*Hour*	*Number of attempts*	*Reflux of CSF*	*Amount of call (hours)*
1	27	172	70	14	Anesthesiologist #2	07:40 a.m.	1	Yes	12.66
2	31	158	63	14	Anesthesiologist #2	06:00 a.m.	1	No	11.00
3	43	160	65	9	Anesthesiologist #3	05:40 a.m.	3	No	10.66
4	29	164	68	11	Resident #2	07:20 a.m.	1	No	12.33
5	29	168	78	13	Anesthesiologist #1	04:00 a.m.	7	Yes	09.00
6	29	155	71	24	Anesthesiologist #3	06:00 a.m.	6	No	11.00
7	30	156	63	7	Anesthesiologist #2	03:30 p.m.	1	Yes	30.50
8	25	170	62	11	Resident #1	07:00 a.m.	3	No	12.00
9	22	167	89	10	Resident #2	07:25 p.m.	2	Yes	00.41
10	25	162	65	14	Anesthesiologist #3	03:00 a.m.	3	Yes	08.00
11	32	166	71	16	Anesthesiologist #2	05:50 p.m.	2	No	-
12	21	168	109	31	Anesthesiologist #3	08:20 p.m.	8	Yes	01.33

TABLE II Type of personnel involved in dural punctures

	Anesthesiologist #1	*Anesthesiologist #2*	*Anesthesiologist #3*	*Resident #1*	*Resident #2*
Age (yr)	33	32	35	35	32
Experience performing obstetric epidural anesthesia (yr)	6	5	6	0.5	0.5
Number of epidurals in the study period	300	350	20	25	70
Number of dural punctures	1	4	4	1	2
Incidence of UDP per operator (%)	0.33	1.14	20.00	4.00	2.85

of 0.61%, and showed that the rate varied with the site of epidural space identification, reaching 1.16% when the L_{4-5} interspace was used. Similarly, Giebler *et al.*[2] reported an overall rate of 0.72%, and also showed site-dependence, with an increasing incidence of UDP with epidural puncture toward lower thoracic interspaces. In parturients, Norris *et al.*[5,6] reported higher rates (around 2.6%). In our study, the incidence of UDP was 0.80%, with a higher risk of UDP during night-time, with a similar risk in the first and the second parts of the night.

Unintentional dural puncture is the most common complication of epidural procedure. This may have tragic consequences in the setting of obstetric anesthesia: intense and prolonged headache for the mother, risk of malpractice claims for the anesthesiologist. Therefore, risk factors must be identified and avoided. Experience and skill may influence the incidence of UDP, and this appears to be so in the present study. Seven of 12 cases were caused by three operators with poor expertise. Two were residents learning obstetric anesthesia. It has been shown that epidural anesthesia is the most difficult regional procedure, and that a minimal number of procedures is required to achieve experience and skill.[7,8] Given its learning curve,[8] university training programmes are usually associated with an increase in the incidence of UDP. Thus, while an approximate rate of 1% is considered as reasonable,[2,4] Norris *et al.*[5,6] reported incidences of about 2.6% and 2.7% in two studies in which first year anesthesia residents performed the majority of labour epidurals using 17- or 18-g needles. Although the contribution of this factor to the incidence of UDP probably can be reduced, it cannot be suppressed completely. A third operator has been practicing anesthesiology and critical care for six years. Although he learned obstetric epidural anesthesia during his residency, his current practice (20 epidurals over two years) probably is too small to maintain expertise. One could ask why anesthesiologists without expertise in obstetric epidural anesthesia are involved in this practice. The answer is that there are difficulties in finding obstetric anesthesia coverage. The obstetric anesthesia staff is composed of four qualified anesthesiologists and two residents working daily, and covering operating room (gynecologic surgery), labour and delivery suite, gynecological and obstetric anesthetic consultations and services. At night, when residents are on duty in the intensive care unit, they often return to the delivery suite to perform epidurals, with the qualified anesthesiologist in attendance. Because the labour and delivery suite is covered 24 hr a day by a qualified

anesthesiologist present in the hospital, and because of the workload represented by all our tasks, five additional qualified anesthesiologists practicing daily in other units (intensive care unit, digestive surgery, orthopedic surgery) took part in night-time coverage of the labour and delivery suite, each being on call once or twice a month. Given the high incidence of UDP for anesthesiologist 3, it could be suggested that a more frequent practice would be better in term of skill acquisition and maintenance.

The study also shows a higher incidence of UDP at night. Although this is in part due to the involvement of non-experienced operators, as five cases of UDP were caused by two skilled obstetric anesthesiologists, other human factors specific to night-time work probably are involved. Furthermore, although not statistically significant, most cases occurred in the second part of the night. This could result from the circadian changes in performance.[1] It has been shown that the performance of a complex task is best between 10 AM and 3 PM, and then decreases to less than 50% of the maximum attainable between 11 PM and 9 AM, with the worst level between 4 and 6 AM. Thus, studies performed in other settings such as aviation,[1] car driving[9] or industrial work[10] show circadian variation in accident frequency. As in these fields, the anesthesiologist's performance may be altered by factors such as fatigue, sleep deprivation or interruption.[1] Fatigue results from hours of continuous work or work overload. As the anesthesiologist on call at night usually has been working all day, fatigue may occur and further decrease performance at night. Although interrelation may exist with fatigue, sleep loss has been shown to affect performance of skilled cognitive and motor tasks.[1,11,12] Unfortunately, the amount of sleep for each anesthesiologist could not be specified in our study. Sleep interruption disrupts the normal circadian rhythm and induces a shift in peak and minimal performance times. In addition, when the sleep cycle is interrupted during rapid eye movement and/or slow wave sleep, great cognitive performance decrements and increased sensory-motor deficit may occur, briefly. All these factors of decreased performance probably contribute to the apparent difficulty of the epidural procedure accounted for by the number of puncture attempts, as it is not justified by patient characteristics, especially for skilled operators. Fatigue, sleep deprivation or interruption are commonly encountered in obstetric anesthetic practice and, therefore, may contribute to maternal anesthetic morbidity. On the other hand, because of high interpersonal variability of the periodic and rhythmic fluctuation in performance and work efficiency, as monotonous tasks requiring a sustained and prolonged attention are more sensitive to sleep deprivation, the consequences on physicians' work probably are of little extent. This could account for the low incidence of UDP in our survey. Nevertheless, to limit the night-time associated morbidity, it may be suggested that physicians on call at night should be off duty for the preceding day, and that physicians should not work more than 24 hr consecutively.

The present study has some limitations. The work schedules in our institution probably are specific, and different from that of many other institutions. Indeed, physicians' work schedules and workload are regulated in some countries, to limit the consequences of fatigue. Thus, great variation may exist among institutions. Another limitation is that many other factors related or not to the experience of the operator and workload probably were not taken into account. However, our results concerning the incidence and risk of UDP, and our conclusions are clinically relevant.

In summary, although the overall incidence of UDP in obstetric epidural anesthesia is low, the risk is higher during night-time. This appears to result from human factors such as fatigue, sleep deprivation or discontinuation. Nevertheless, studies involving many more cases and using multivariate methods are necessary to confirm the present findings. On the other hand, with the increasing use of regional techniques in obstetric anesthesia,[13] and given the decreasing number of anesthesiologists[14] and their aversion for obstetric anesthesia,[15] the problems identified in this study could increase in future.

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References

1 *Weinger MB, Englund CE.* Ergonomic and human factors affecting anesthetic vigilance and monitoring performance in the operating room environment. Anesthesiology 1990; 73: 995–1021.

2 *Giebler RM, Scherer RU, Peters J.* Incidence of neurologic complications related to thoracic epidural catheterization. Anesthesiology 1997; 86: 55–63.

3 *Auroy Y, Narchi P, Messiah A, Litt L, Rouvier B, Samii K.* Serious complications related to regional anesthesia. Anesthesiology 1997; 87: 479–86.

4 *Tanaka K, Watanabe R, Harada T, Dan K.* Extensive application of epidural anesthesia and analgesia in a university hospital: incidence of complications related to technique. Reg Anesth 1993; 18: 34–8.

5 *Norris MC, Leighton BL, DeSimone CA.* Needle bevel direction and headache after inadvertent dural puncture. Anesthesiology 1989; 70: 729–31.
6 *Norris MC, Grieco WM, Borkowski M, et al.* Complications of labor analgesia: epidural versus combined spinal epidural techniques. Anesth Analg 1994; 79: 529–37.
7 *Kopacz DJ, Neal JM, Pollock JE.* The regional anesthesia "learning curve". What is the minimum number of epidural and spinal blocks to reach consistency? Reg Anesth 1996; 21: 182–90.
8 *Konrad C, Schüpfer G, Wietlisbach M, Gerber H.* Learning manual skills in anesthesiology: is there a recommended number of cases for anesthetic procedures? Anesth Analg 1998; 86: 635–9.
9 *Horne JA, Reyner LA.* Sleep related vehicle accidents. BMJ 1995; 310: 565–7.
10 *Laundry BR, Lees REM.* Industrial accident experience of one company on 8- and 12-hour shift systems. J Occup Med 1991; 33: 903–6.
11 *Friedman RC, Bigger JT, Kornfeld DS.* The intern and sleep loss. N Engl J Med 1971; 285: 201–3.
12 *Hart RP, Buchsbaum DG, Wade JB, Hamer RM, Kwentus JA.* Effect of sleep deprivation on first-year residents' response times, memory, and mood. J Med Educ 1987; 62: 940–2.
13 *Hawkins JL, Gibbs CP, Orleans M, Martin-Salvaj G, Beaty B.* Obstetric anesthesia work force survey, 1981 versus 1992. Anesthesiology 1997; 87: 135–43.
14 *Ruhnke GW.* Physician supply and the shifting paradigm of medical student choice. JAMA 1997; 277: 70–1.
15 *Lagasse RS, Santos AC.* Obstetric anesthesia coverage. The problem in perspective. (Editorial). Anesthesiology 1997; 87: 4–5.