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Influence of sex on cerebrospinal fluid density in adults

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The extent of sensory block during spinal anaesthesia is unpredictable and is influenced by many factors, mainly patient position, site of injection, baricity and the dose of drug injected. Among other factors, cerebrospinal fluid (CSF) density has been advocated to affect subarachnoid distribution of local anaesthetics. In this study, we have investigated the influence of patient characteristics such as sex, age, weight and height on variations in the density of CSF in more than 46 consecutive patients undergoing spinal anaesthesia. CSF 2 ml was obtained after spinal puncture and before injection of local anaesthetic. Mean CSF density measured at 37°C was mean 1.00054 (SD 0.00017) g ml^{-1}, with significantly lower CSF densities in women (1.00049 (0.00011) g ml^{-1}) than in men (1.00058 (0.00011) g ml^{-1}) ($P=0.024$). In contrast, there was no correlation between age, weight or height, and CSF density. These results suggest that sex significantly influenced CSF density and may therefore modify subarachnoid distribution of local anaesthetics.

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Densities of different anaesthetic solutions injected intrathecally are well documented and their impact on the extent of spinal block during hyperbaric or hypobaric spinal anaesthesia is uniformly recognized,[1 2] whereas little is known of inter-individual variation in the density of cerebrospinal fluid (CSF) in humans. Recently, Richardson and Wissler[3] reported significantly lower CSF densities in pregnant compared with non-pregnant women, and Lui, Polis and Cicutti[4] noted a lower CSF density in pregnant and pre-menopausal women compared with post-menopausal women and men. The normal values for the density of human CSF have been studied in two other reports.[5 6] It appears that variability in CSF density depends on mass (constituent concentrations of CSF, such as glucose and proteins), volume and temperature. These vary between individuals and determine the normal variation in CSF density. However, to our knowledge, the possible influence of patient characteristics on CSF density has not been reported. In this study, we have investigated the impact of sex, height, weight and age on variations in CSF density.

Methods and results

After obtaining approval from the Ethics Committee of our institution and patient informed consent, we studied 46 consecutive patients, ASA I–III, undergoing spinal anaesthesia for orthopaedic surgery. Apart from the usual contraindications to spinal anaesthesia, patients with obvious neurological disturbances that could influence CSF composition were excluded. Severe diabetes and dehydration were also exclusion criteria. Moreover, inability to comprehend the basic aspects of this study or difficulty with language, in addition to a psychiatric disease or dementia led to exclusion.

No dextrose was given i.v. for at least 12 h before surgery and patients fasted for a minimum of 8 h before operation. Spinal puncture was performed at L2–3 or L3–4 with the patient in the lateral decubitus position. After observing free CSF reflux, CSF 2 ml was sampled and the spinal anaesthesia performed. Macroscopic blood contamination of the CSF sample led to exclusion. CSF density was measured at 37°C using an Anton PAAR DMA 58 densitometer providing precise measurements to five decimal places. Patient characteristics (weight, height, age and sex) were noted. Mean values of CSF densities were compared using the Student's *t* test for independent samples between men and women. Linear regression was used to correlate age, weight and height to CSF density. Statistical analyses were performed using Statistica for Windows, version 4.5 A, Statsoft, Inc 1993.

Initially we included 48 patients in the study. Two patients were excluded: one diabetic woman treated with oral hypoglycaemic drugs and with an apparently well equili-

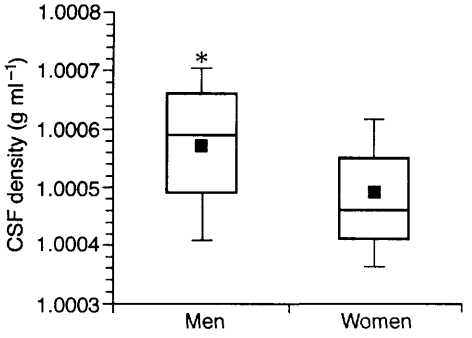

Fig 1 Density of cerebrospinal fluid (CSF) in men and women. Filled squares indicate means, horizontal lines are medians, boxes are 25–75 percentiles and vertical lines are 10–90 percentiles. *$P<0.05$ compared with women.

Table 1 Patient characteristics (mean (SD or range)). CSF=Cerebrospinal fluid

	Men ($n=24$)	Women ($n=22$)	P
Height (m)	1.71 (0.06)	1.57 (0.06)	0.021
Weight (kg)	75.5 (10.3)	61.4 (11.3)	0.024
Age (yr)	67.1 (24–89)	71.6 (31–95)	ns
CSF density (g ml^{-1})	1.00058 (0.00011)	1.00049 (0.00011)	0.024

brated diabetes but presenting with an increased CSF glucose measurement (12 mmol $litre^{-1}$) with a CSF density of 1.00097 g ml^{-1}; and a man with myotonic dystrophy (Steinert disease) showing a CSF density of 1.00127 g ml^{-1} and high concentrations of CSF proteins (1.2 g ml^{-1}). In eight patients with high CSF density values (i.e. >1.00065 g ml^{-1}), we measured CSF glucose and protein concentrations which were within the normal range (<4.4 mmol $litre^{-1}$ for CSF glucose and <0.3 g $litre^{-1}$ for CSF proteins) except for the two patients mentioned above. The characteristics of the 46 patients are presented in Table 1. Mean CSF density was 1.00054 (SD 0.00017) g ml^{-1}, with significantly lower CSF densities in women than in men (Fig. 1). In contrast, there was no correlation between height (r=0.45), weight (r=0.48) or age (r=0.38), and CSF density.

Comment

We have demonstrated a difference between men and women in CSF density. Although there were significant morphological differences between men and women in our study (Table 1), we found no evidence that age, weight or height influenced the value of CSF density. Sex differences in CSF density have been suggested recently[4] and it appears that subpopulations of women present differences in CSF density (post-menopausal women have a higher CSF density than pregnant or pre-menopausal women but not men). However, in this former study, the subgroups of women were not uniformly represented as there were only seven pre-menopausal non-pregnant women compared with 22 pregnant and 28 post-menopausal women and the differences were significant only when the subgroups were compared. Of the women in our study, two were pre-menopausal. Their CSF densities were 1.00043 g ml^{-1} (patient age 37 yr) and 1.00046 g ml^{-1} (patient age 31 yr). Although these values were less than the mean of the female group, the mean difference between men and women was still significant ($P=0.042$) when analysed excluding these two cases.

Normal values for the density of human CSF have been reported previously.[5,6] Cells, glucose and proteins are the main determinants of CSF mass and therefore density. These constituents vary between individuals and determine the physiological range of CSF density. We measured protein and glucose CSF concentrations when extreme CSF density values were noted. These measurements showed physiological values except for two patients who were excluded because of specific diseases (see above). Astonishingly, the large inter-individual variation in CSF densities observed[3,4] has never been correlated with CSF composition. In our study, density was measured at 37°C so that differences in patient temperature could not influence our results.

In summary, the importance of our finding and its influence on subarachnoid distribution of local anaesthetic solutions during spinal anaesthesia remains to be determined.

References

1 Van Gessel EF, Forster A, Schweizer A, Gamulin Z. Comparison of hypobaric, hyperbaric, and isobaric solutions of bupivacaine during continuous spinal anesthesia. *Anesth Analg* 1991; **72**: 779–84
2 Greene NM. Distribution of local anesthetic solutions within the subarachnoid space. *Anesth Analg* 1985; **64**: 715–30
3 Richardson MG, Wissler RN. Density of lumbar cerebrospinal fluid in pregnant and non pregnant humans. *Anesthesiology* 1996; **85**: 326–30
4 Lui ACP, Polis TZ, Cicutti NJ. Densities of cerebrospinal fluid and spinal anaesthetic solutions in surgical patients at body temperature *Can J Anaesth* 1998; **45**: 297–303
5 Davis H, King WR. Densities of cerebrospinal fluid of human beings. *Anesthesiology* 1954; **15**: 666–72
6 Levin E, Muravchick S, Gold MI. Density of human cerebrospinal fluid and tetracaine solutions. *Anesth Analg* 1981; **60**: 814–7