EFFECT OF POSTURE ON EXTRADURAL PRESSURE

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SUMMARY

Extradural pressure was measured in the lateral and the supine positions in three groups of patients using the extradural catheter as a manometer. The groups consisted of 20 pregnant patients at or near term, 10 patients in the period after childbirth and 10 male surgical patients. In every patient, the extradural pressure in the supine position was greater than that in the lateral position. The mean extradural pressures in the lateral and the supine positions were similar in the three groups. It is suggested that the difference between the extradural pressures in the lateral and the supine positions is physiological and occurs irrespective of vena caval compression. Extradural pressure changes are probably the result of postural changes in the cerebrospinal fluid (CSF) pressure. The influence of CSF pressure on extradural pressure was confirmed further by measuring the extradural pressure in the prone position in five pregnant patients.

Compression of the inferior vena cava occurs in the supine pregnant patient (Kerr, Scott and Samuel, 1964) and it is thought that the subsequent engorgement of the extradural veins causes a decrease in the size of the extradural space and an increase in the pressure within it (Bromage, 1961). During pregnancy the extradural pressure is greater in the supine position than in the lateral position (Galbert and Marx, 1974).

In the lumbar region the distance between the vena cava and the spinal canal is 7–8 cm. As there are no valves between the vena cava and the extradural veins, in the supine position blood must gravitate into the latter and produce a hydrostatic pressure of 7–8 cm of blood additional to the inferior vena caval pressure. A pressure of 6–9 mm Hg is required to keep a vein fully rounded; at a lower pressure it is ellipsoid (Folkow and Neil, 1971). In the supine position the hydrostatic pressure of blood should cause engorgement of extradural veins in all subjects. Therefore, the extradural pressure should be greater in the supine position than in the lateral position.

The present study was designed to ascertain whether posture or caval compression predominates in determining extradural pressure.

PATIENTS AND METHODS

Extradural pressure was measured in three groups of patients. Group one consisted of 20 women aged 17–37 yr receiving extradural analgesia for labour.

Twelve of the women were not in labour at the time of the study and eight were in the early stages of spontaneous labour with cervical dilatation of less than 4 cm. These eight patients received 10 ml of 0.25% plain bupivacaine and the extradural pressure was measured approximately 30 min later when they were unaware of their contractions. To avoid the effect of uterine contractions on extradural pressure, the pressure in these eight patients was measured in the interval between contractions. Group two consisted of 10 women aged 19–34 yr who had received extradural analgesia during labour and had delivered the child 45–120 min before the study. Group three consisted of 10 male patients aged 20–82 yr about to undergo either genito-urinary or orthopaedic surgery. The extradural pressure in this group was measured before the local anaesthetic drug was administered. All patients gave informed consent before inclusion in the study.

The extradural puncture was performed with a Tuohy needle at the L2–3 or L3–4 space with the patient in the lateral position. Entry into the extradural space was identified by a Macintosh balloon. Between 4 and 5 cm of a 16-gauge Portex extradural catheter was inserted and secured by adhesive plaster. A small ink mark was made on the plaster at the site of the skin puncture to enable all measurements to be referred to the same point.

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The extradural pressure was measured using the catheter as a manometer, held against a vertical measuring rule (Shah, 1981). Bupivacaine 0.25 ml was injected to the vertically held catheter via a bacterial filter so as to fill the catheter completely. When the syringe and the filter were disconnected from the vertically held catheter, the bupivacaine
meniscus dropped rapidly and came to rest in approximately 1 min when the hydrostatic pressure of bupivacaine in the catheter equalled the extradural pressure. With the patient in the lateral position the vertical distance (in cm) between the bupivacaine meniscus and the extradural puncture was assumed to be equal to the extradural pressure. Pressure in the supine position was measured from the surface of the delivery bed or the operating table to the bupivacaine meniscus and 5 cm deducted from the reading (5 cm being the approximate distance of the extradural space from the skin puncture). The extradural pressure was measured in the prone position in five pregnant patients. They were placed on their hands and knees with the back nearly horizontal. This position avoided the effect of abdominal compression on the extradural pressure. A loop of the catheter was held over the side of the patient a few centimetres below the level of the skin puncture because it was found that, in the prone position, the bupivacaine meniscus was often below the skin level (fig. 1).

As the specific gravity of 0.25% bupivacaine at 20 °C is 1.003, the results were expressed in cm H$_2$O. The pressure measurements were repeated by refilling the catheter with bupivacaine and a mean of three readings (to the nearest 0.5 cm H$_2$O) was taken in each position. Because of the effect of capillarity, 2 cm H$_2$O was deducted from the results (Appendix).

In an additional patient after childbirth, the changes in extradural pressure between supine and lateral positions were monitored using a central venous pressure transducer (Hewlett-Packard, Model No. 1280 C-02) and recorded on an X-Y recorder (Hewlett-Packard, 7004 A X-Y recorder). At the end of the recording the extradural pressure was measured in the lateral position using the catheter as a manometer, and the reading compared with that obtained with the pressure transducer.

RESULTS
Injection of bupivacaine 0.25 ml to the extradural
EXTRADURAL PRESSURES

space produced a sustained positive pressure in all subjects. The variation in the successive measurements in any one position was less than ± 1 cm H₂O. Respiratory and cardiac oscillations were observed in the bupivacaine meniscus in most patients. The largest cardiac oscillations (when the amplitude was 2–3 mm H₂O) were seen in the elderly patients in group 3. When the patients were turned from the lateral to the supine position, some of the injected fluid tended to be squeezed out of the extradural space into the vertically held catheter. This fluid re-entered the extradural space when the patients were turned from the supine to the lateral position.

The extradural pressure was greatest in the supine position than in the lateral position in every patient. The mean (± SD) pressure of the 40 patients was 14.4 (± 3.6) cm H₂O in the lateral position and 20.9 (± 4) cm H₂O in the supine position. The relation between the lateral and supine pressure is illustrated graphically in figure 2. There was no statistically significant differences in the mean extradural pressures in the supine and the lateral positions between the three groups (table I).

The extradural pressure was greatest in the supine position and least in the prone position in the five pregnant patients, the mean pressures being 22.6, 14.8, and 2.2 cm H₂O in the supine, lateral and prone positions, respectively.

The rapid alterations in extradural pressure during movement from the lateral to the supine positions in a postpartum patient are shown in figure 3. At the end of the pressure recording, the extradural pressures in the lateral position in this patient, measured with the pressure transducer and the catheter manometer were 7 mm Hg (approximately 10 cm H₂O) and 10.5 cm H₂O, respectively.

DISCUSSION

In a supine pregnant patient the inferior vena cava is compressed by the gravid uterus and blood flow is diverted to the valveless paravertebral venous plexuses. It is assumed that the extradural veins also

FIG. 2. Differences between extradural pressures in the supine and lateral positions in 40 patients.

FIG. 3. Postural changes in extradural pressure. L lat = left lateral, sup = supine.

Table I. Mean (SD) extradural pressures in lateral and supine position and the differences between the two pressures in the three groups. n.s. = N significant

<table>
<thead>
<tr>
<th>Group</th>
<th>1 (n = 20)</th>
<th>2 (n = 10)</th>
<th>3 (n = 10)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supine</td>
<td>21.5(3.3)</td>
<td>18.5(2.9)</td>
<td>22.2(5.3)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Lateral</td>
<td>14.6(3.3)</td>
<td>13.1(3.0)</td>
<td>15.5(4.6)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Supine–lateral</td>
<td>6.9(2.1)</td>
<td>5.4(2.0)</td>
<td>6.7(2.9)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>
become markedly engorged, causing an increase in extradural pressure.

In the supine position the vena cava lies 7-8 cm above the spinal canal and the extradural space. Blood must gravitate into the extradural veins and exert a hydrostatic pressure of 7-8 cm blood additional to the inferior vena caval pressure.

The calibre of the extradural veins depends on the pressure of blood within them. At low pressures the veins are ellipsoid, but they become rounded as the amount of blood increases. At a pressure of 6-9 mm Hg the veins become fully rounded and a further increase in the venous pressure produces very little increase in size as the “true” distensibility of the venous wall is low (Folkow and Neil, 1971). An additional hydrostatic pressure of 7-8 cm blood above the inferior vena caval pressure should make the extradural veins fully rounded and engorged in all subjects in the supine position. Any further increase in extradural venous pressure consequent upon vena caval compression should cause only a slight further increase in the size of the already engorged extradural veins. The extradural veins should be engorged in the supine position in all subjects and, therefore, the postural changes in extradural pressure of non-pregnant patients should be similar to those reported for pregnant patients. The results of the study confirm this.

The spinal canal is a continuation of the skull and forms an enclosure for the fluid filled dura. Extradural veins pass through this enclosed space and, when they dilate, the dura is compressed and the cerebrospinal (CSF) pressure increases. An alteration in the extradural venous pressure causes a directly transmitted change in CSF pressure (Pollock and Boshes, 1936).

In the prone position the blood drains out of the extradural veins, causing a decrease in venous pressure and, consequently, a lower CSF pressure. An increase in CSF pressure in the supine position and a decrease in the prone position have been reported (Loman, Myerson and Goldman, 1935). The data in this study show that similar changes in the extradural pressure occur as a result of changes in posture. It has been claimed that the dura acts as a movable membrane equilibrating the pressure between CSF and fluid injected into the extradural space (Shah, 1981) and, therefore, the extradural pressure is an indirect indicator of the CSF pressure.

In one patient, the extradural pressures recorded with the pressure transducer and the catheter were similar. The catheter can be used as a simple and reliable manometer for studying the changes in the extradural pressure. The effect from capillarity is approximately 2 cm H$_2$O when a 16-gauge Portex extradural catheter is used.

Postural changes in extradural pressure are physiological and occur irrespective of vena caval compression. They are probably the result of changes in CSF pressure caused by the alteration of blood volume within the extradural space.

In the supine position, the CSF and extradural venous pressures are higher and the capacity of the extradural space smaller than in the lateral position. A given volume of local anaesthetic may spread further in the supine than in the lateral position.

**APPENDIX**

Pressure inside a plastic bag filled with distilled water was measured using a wide-bore tube (internal diameter 4 mm), and a 16-gauge Portex extradural catheter as manometers. Readings of the two manometers were compared with different pressures inside the bag. Because of the capillarity effect, the 16-gauge catheter gave a reading 2.2 ± 0.1 cm H$_2$O higher than that given by the wide-bore tube.

The internal diameter of a 16-gauge Portex catheter is 0.58 mm. The calculated capillarity effect in a glass capillary of the same diameter would be 4.7 cm H$_2$O. The smaller capillarity effect in a nylon catheter is attributable to a narrower angle of contact between water and nylon.

**REFERENCES**


EXTRADURAL PRESSURES

EFFET DE LA POSTURE SUR LA PRESSION EXTRADURALE

RESUME
On a mesuré la pression extradurale en position latérale et en décubitus dorsal chez trois groupes de patients au moyen de la sonde extradurale employée comme manomètre. Les groupes consistaient en 20 femmes enceintes à terme ou près d'accoucher, 10 patientes au cours de la période après accouchement et 10 patients mâles en chirurgie. Chez chaque patient, la pression extradurale était plus élevée en décubitus dorsal qu'en position latérale. Les pressions extradurales moyennes en position latérale et en décubitus dorsal étaient analogues chez les trois groupes. On suggère que la différence entre les pressions extradurales en position latérale et en décubitus dorsal est physiologique et qu'elle s'exerce indépendamment de la compression de la veine cave. Les modifications de la pression extradurale sont probablement dues aux changements de posture dont l'effet s'exerce sur la pression du fluide cérébrospinal (CSF). L'influence de la pression CSF sur la pression extradurale a été confirmée en mesurant la pression extradurale en pronation chez cinq patientes enceintes.

EINFLUSS DER KÖRPERLAGE AUF DEN PERIDURALEN DRUCK

ZUSAMMENFASSUNG

EFECTO DE LA POSTURA SOBRE LA PRESION EXTRADURAL

SUMARIO
Se midió la presión extradural en posturas lateral y en decúbito supino en tres grupos de pacientes al usar la sonda extradural como manómetro. Los grupos consistían en 20 pacientes embarazadas cerca del parto o al momento del parto, de 10 pacientes durante el periodo después del parto y de 10 pacientes masculinos sometidos a operaciones. En cada paciente, la presión extradural en decúbito supino era mayor que en postura lateral. Las presiones extradurales promedias en decúbito supino y en postura lateral eran similares en los tres grupos. Se sugiere que la diferencia entre las presiones extradurales en decúbito supino y en postura lateral es fisiológica y que ocurre independientemente de la compresión de la vena cava. Los cambios en la presión extradural resultan probablemente de los cambios de postura en la presión del fluido cerebroespinal (CSF). Se confirmó aún más la influencia de la presión del CSF sobre la presión extradural al medir la presión extradural en la postura de pronación de cinco pacientes embarazadas.