A subarachnoid screw for monitoring intracranial pressure

Technical note

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A new technique for monitoring intracranial pressure is presented. It is based on a hollow screw in the skull whose tip projects through the dura into the subarachnoid space. The screw can be easily inserted under local anesthesia. Pressure is monitored isovolumetrically by connecting the screw to a transducer. The system can be calibrated in situ and has been successfully used in 56 patients during a 6-month period.

KEY WORDS intracranial pressure • monitoring systems • subarachnoid space

For the past 2 years it has been our policy to monitor intracranial pressure (ICP) in all patients with severe brain injuries. This has generally been done by means of a ventricular catheter using the technique of Lundberg. Unfortunately we have experienced a high rate of infection with these catheters. Moreover, we have had difficulty placing them in the ventricle in many traumatic cases because of small ventricular size. These factors led us to develop a new system for monitoring ICP which we are describing in this report.

Method

The screw that we developed is shown in Fig. 1. The proximal end consists of a standard luer lock and a hexagonal collar for insertion. The threads on the distal end fit a ⅛ in. twist drill hole. A glass wool wick is placed in the lumen of each screw before insertion to prevent occlusion of the tip, using the steps illustrated in Fig. 2.

To insert the screw, a ⅛ in. twist drill hole is made in the skull through a 1 cm scalp incision under local anesthesia. The exposed dura is nicked with a knife under direct vision and removed with a small angled curette. This maneuver also opens the arachnoid, and a small amount of CSF is usually seen. The screw is threaded into the twist drill hole with a hexagonal screwdriver to a point that places the tip of the screw 1 mm below the surface of the dura. The 1 cm incision is closed around the shaft of the screw with 2-0 silk sutures, and a small sterile dressing is placed around the shaft. Figure 3 shows the subarachnoid screw in place in a patient after craniotomy.
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Fig. 1. Close-up of the subarachnoid screw showing details of the hexagonal collar, tip, and anchoring threads for the skull.

To monitor the ICP, the screw is connected to a stopcock assembly via a saline-filled extension tube. The stopcock connections include a P-37 Statham transducer, a 20 cc syringe filled with saline, and a water manometer which is open to the air through a bacteriologic filter. The output of the transducer is displayed on an oscilloscope and written out on chart paper. The system is calibrated by zero balancing the transducer to the water manometer after matching the height of the water manometer to the level of the end of the screw in the subarachnoid space. The transducer is then opened to the subarachnoid space via the saline-filled extension tube, and a calibrated ICP is recorded. The system can be recalibrated at any time by repeating the above steps.

Results

Animal Studies

Twelve cats under nembutal anesthesia were used to determine the reliability of the new system under a variety of ICP conditions. The animals were immobilized in a stereotaxic frame. Eight animals had screws inserted bilaterally at the level of the coronal suture. The remaining four had a screw inserted on one side and a 2 cc epidural balloon placed on the opposite side. The animal system was identical to the one described for humans except the screws were smaller to fit the cat skull. In the first four animals a cisternal needle was inserted and the cisternal ICP was compared to the right and left subarachnoid ICP in the normal ICP range. The three ICP's were found to be equal in all four animals. In the next four animals one screw was used for ICP monitoring while the other screw was used to infuse saline via a Harvard infusion pump. All four animals maintained satisfactory ICP tracings to 100 mm Hg. In the final four animals, subarachnoid ICP was monitored while inflating the epidural bal-

Fig. 3. X-ray showing the subarachnoid screw in place in a postoperative craniotomy patient.

Fig. 2. Steps in fashioning the glass wool wick. From left to right: glass wool, wisp of glass wool with suture tied around the middle, subarachnoid screw, wisp being pulled through the screw, and final appearance before insertion after trimming excess glass wool from the proximal end.

Fig. 4. Simultaneous recordings of BP, ICP, and CVP from a cat with a subarachnoid screw. ICP fluctuations are synchronous with blood pressure and CVP fluctuations are readily seen.
TABLE I

Disorders monitored

<table>
<thead>
<tr>
<th>Disorder</th>
<th>No. of Cases</th>
</tr>
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<tbody>
<tr>
<td>brain tumors</td>
<td>10</td>
</tr>
<tr>
<td>trauma</td>
<td>33</td>
</tr>
<tr>
<td>aneurysm</td>
<td>7</td>
</tr>
<tr>
<td>miscellaneous*</td>
<td>6</td>
</tr>
<tr>
<td>total</td>
<td>56</td>
</tr>
</tbody>
</table>

* CVA, hepatic coma, brain abscess.

loon on the opposite side in 0.01 cc increments. Satisfactory ICP recording was obtained in all 12 animals. Good respiratory and blood pressure fluctuations were present in all tracings. A record from one of the animals showing the correlation of ICP with arterial blood pressure and central venous pressure is shown in Fig. 4.

Human Studies

The subarachnoid screw has been used to monitor ICP in 56 cases since November, 1972. It was initially used to monitor ICP in cases of severe trauma, but its use has subsequently been extended to pre- and postoperative patients with aneurysms or brain tumors. A summary of the disorders monitored is shown in Table 1. Satisfactory records have been obtained in all cases as judged by blood pressure and respiratory fluctuations. Lundberg waves and the ICP events surrounding the rupture of an aneurysm have been recorded. Twelve of the patients have had simultaneous measurements of ICP made by ventricular tap which were identical to the values recorded by the subarachnoid screw. An excerpt from the record of a patient with traumatic cerebral edema recorded during an episode of Cheyne-Stokes breathing is shown in Fig. 5 to illustrate the type of ICP record obtained with the subarachnoid screw. A trace from another patient correlating ICP from a subarachnoid screw with blood pressure, central venous pressure, and electrocardiogram is shown in Fig. 6. The

Fig. 5. ICP tracing from a subarachnoid screw in a patient with traumatic cerebral edema. Marked variations in ICP are recorded with changing respiratory rhythms.

Fig. 6. Correlation of ICP from a subarachnoid screw with simultaneous tracings of BP, CVP, and EKG.
A subarachnoid screw for monitoring intracranial pressure

length of monitoring varied from 1 day to 3 weeks, the average being 7 days. ICP was successfully recorded up to 150 mm Hg. The wicks did not become occluded during monitoring. Occasionally the records damped out during recording. This could usually be traced to a slow leak in the stopcock assembly. The traces were restored by correcting the leaks and flushing 0.25 to 0.50 cc of saline through the subarachnoid screw via the stopcock. We have subsequently discovered that the screws will function well without the wicks if the system is free of slow leaks.

At the end of the period of monitoring the area around the shaft of each screw was cleaned with peroxide and prepped with betadine after which the screw was unscrewed and removed. One or two sutures were used to close the opening in the skin left by the shaft of the screw. To date there have been no instances of infection or CSF leak. The only complication has been a subdural hematoma in a patient with cerebral edema and liver failure who developed a severe bleeding disorder several days after insertion of the screw.

If an ICP monitoring system is to be widely used, it must be simple, inexpensive, safe, and reliable. This monitoring system based on the subarachnoid screw appears to meet these requirements.

References


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