Proceedings of the Society of British Neurological Surgeons

The 100th meeting of the Society of British Neurological Surgeons was held in Cork, Eire, 31 March–2 April 1982

GIANT ANEURYSMS
JR Padilla, TF Buckley (Cork)
The authors had conducted a retrospective study to determine if there were any unusual features in the presentation, investigation or treatment of patients with a giant intracranial aneurysm, defined as having a diameter of 2.5 cm or more. Fourteen patients were reported. Subarachnoid haemorrhage was the common initial event (eight patients), but dementia was also common (six patients). Nine of the aneurysms were extracavernous, five intracavernous, and one was in the vertebrobasilar system. The appearances on CT scanning and at angiography were compared; the true size of the lesion was more likely to be shown by the CT scan. Management was either by exploratory craniotomy with a view to clipping or excising an extracavernous aneurysm or by proximal ligation of the carotid artery in the neck in the case of intracavernous aneurysms. One of the latter was treated by intraluminal wiring. Thirteen of the patients had survived; nine of these were well, but three needed care at home and one required institutional care.

ANEURYSMAL SUBARACHNOID HAEschorrhage: HAVE WE BEEN CONFUSING SPASM AND REBLEEDING?
RS Maurice Williams (London)
The author considered that the pioneer studies of the natural history of ruptured aneurysm, still generally used as a basis for decision making, had over-estimated the incidence of early recurrent haemorrhage. This was because many of the patients who reached hospital in good condition after an aneurysmal subarachnoid haemorrhage and who then deteriorated, did so from a cause other than recurrent bleeding. His observations on a consecutive series of 110 patients supported this view. During the period of study every patient under the age of 65 yr referred with a subarachnoid haemorrhage was admitted as soon as possible and regardless of clinical condition. Only 23 patients underwent surgery within 10 days of the presenting haemorrhage. Patients who deteriorated were subjected to repeat lumbar punctures, repeat CT scan and, if appropriate, autopsy, in an attempt to establish whether the episode of deterioration was due to rebleeding. Forty-nine patients underwent delayed neurological deterioration, involving 57 episodes in all. There were 21 episodes of confirmed rebleeding and 36 of “non-haemorrhagic deterioration”. During the first three weeks, less than a third of the episodes of deterioration were due to confirmed rebleeding. Rebleeding episodes had a “flat” distribution in relation to time but episodes of non-haemorrhagic deterioration showed a marked peak between days 4–12. Rebleeding and non-haemorrhagic deterioration were indistinguishable clinically. No case of non-haemorrhagic deterioration occurred after the 16th day, but cases of rebleeding occurred much later. Most cases were thought to be due to delayed vasospasm and 10 of the 36 episodes began within 48 hours of angiography. In six of the remaining cases focal swelling from a haematoma or oedema may have played a part. The peaking in time of non-haemorrhagic deterioration coincided with the peak which early studies found for rebleeding and the total number of episodes of non-haemorrhagic deterioration and rebleeding was almost exactly that which would have been predicted for “rebleeding” alone from the findings of the Co-operative Study. We may have previously over-estimated by a considerable margin the incidence of early rebleeding from aneurysms. Many surgeons defer direct operations on aneurysm for 10 days or more because of the high risks of early surgery; the author concluded that his findings made such a policy more rational.

THE STRESS RESPONSE AND NEUROLOGICAL DETERIORATION IN ANEURYSMAL SUBARACHNOID HAEOMORRHAGE
KVR Sastry, AJ Strong (Newcastle)
The authors had studied whether components of the systemic metabolic response to stress might play a part in producing neurological deterioration in patients with subarachnoid haemorrhage. They studied 99 patients who had undergone direct surgery for ruptured intracranial aneurysm. The patients’ neurological state was assessed daily according to the Hunt and Hess scale but without modification for systemic factors. Forty-one patients developed progressive neurological deterioration, 11 before operation. In each patient an average of six measurements of plasma and whole blood viscosity (measured with the Coulter Harkness viscometer), fasting blood sugar, ESR, packed cell volume, and white blood cell count, were made on separate days. Three to four measurements of 24 hour urinary free catecholamine excretion were also made. Glucose was excluded from the intravenous infusion during the assessment period.

The analysis showed that several factors correlated significantly with the development of neurological deterioration. These were the presence of a swollen brain at operation, an elevated fasting blood sugar, the application of a temporary proximal clip during dissection, difficult operative dissection, increased mean whole blood viscosity (at days 5–8), and neurological grade 3–4 before operation. On the other hand, some of the factors that had been proposed to be important aetologically were not significantly more common in patients who deteriorated: angiographic vasospasm, surgery performed within 10 days after bleeding, PCV greater than 45%, WBC greater than 10 x 10^9/L, and increased urinary catecholamine excretion. The conclusion drawn was that while neurological deterioration following aneurysmal subarachnoid haemorrhage had many causes, systemic metabolic and rheological disturbances, as well as pre-operative grading, were related to its development.

EFFECT OF PROSTACYCLIN ON THE HUMAN BASILAR ARTERY IN VITRO: RELEVANCE TO TREATMENT OF CEREBRAL ARTERIAL SPASM
KS Paul, R Lye, ET Whalley, J Dutton (Manchester)
The authors had investigated the ability of...
Proceedings of the Society of British Neurological Surgeons

**Prostacyclin (PGI2); (a physiological cerebral vasodilator) to reverse the effects of various agents implicated in the aetiology of cerebral vasospasm. They had used human basilar arteries and constructed concentration/response curves to prostaglandin (PG)F2α, the stable endoperoxide analogue U-46619, 5-hydroxytryptamine (5-HT), angiotensin II, noradrenaline (NA) and cerebrospinal fluid from patients with vasospasm. Thromboxane (TXA2) was generated from guinea-pig lung and investigated by a super-fusion technique. Prostacyclin produced concentration-dependent relaxation of the maximum concentration that was produced by each agonist. The maximum percentage relaxation obtained was as follows: PGE2 (62.2 ± 11.1), U46619 (3.7 ± 5.6), 5-HT (117.4 ± 14.8), Ang II (13.5 ± 6.5), and CSF (81.0 ± 16.1). Prostacyclin also reversed the contractile effects of the product of guinea-pig lung. It was concluded that prostacyclin was a potent antagonist of a wide range of the agents that may be implicated in the aetiology of cerebral arterial spasm. The extent of the antagonism appeared to depend upon the degree of pre-contraction and it was considered that prostacyclin might be of use in the treatment of cerebral arterial spasm in patients.

**Oedema in Severe Ischaemic Brain Following Restoration of Flow**

SF Avery, HA Crockard, RW Ross Russell (London)

The authors had performed an experimental study to discover the patterns of oedema formation and cerebrovascular autoregulation during reperfusion and following an episode of severe ischaemia (CBF less than 10 ml/min/100 g). Temporary bilateral carotid clips had been applied for 60 min to 134 gerbils under barbiturate anaesthesia. Flow had then been restored. The procedure resulted in 50% mortality by 3½ hours. Animals were killed at intervals and water accumulation assessed in six areas by a specific gravity technique. In some animals Evans Blue was used to indicate protein leakage, in others regional blood flow (rCBF) was measured serially using the hydrogen clearance technique. In some animals hypertension was maintained with aramine for an hour after reperfusion. The mean CBF was 30 ml/min/100 g initially and fell to 3–10 ml/min/100 g during occlusion. After the clips were removed hyperaemia and oedema increased rapidly, were maximum at one hour, but returned towards control by three hours. The changes were greatest in areas with CBF less than 3–5 ml/min/100 g (parietal cortex; corpus striatum; hippocampus). Areas with very low flow (frontal) or values over 8–10 ml/min/100 g during occlusion (occipital cortex and thalamus) showed less changes. Autoregulation returned in the occipital area. Evans Blue leakage was rare at one hour, but occurred in half the animals at three hours. It was most pronounced in the thalamus. Hypertension produced immediate hyperaemia and very early leakage of Evans Blue. The authors noted that a similar rapid increase and then decrease in water was reported to follow restoration of flow after shorter periods of occlusion (15 minutes). The latter, on the other hand, was followed by 100% survival at 24 hours, whereas in their preparation 96% of animals died by that time. Paradoxically, their animals were dying when oedema appeared to be resolving. They therefore proposed that early "cytotoxic" oedema might be only a para-phenomenon of the biochemical consequences of restoration of aerobic metabolism and reperfusion hyperaemia. The Evans Blue leakage (vasogenic oedema) was altered markedly by induction of hypertension, indicating that the blood brain barrier was vulnerable in the post-ischaemic phase. The return of autoregulation in the occipital area was an indication that the ischaemia had been insufficient to cause irreversible damage in this region.

**Anterior Discisectomy Without Inter-Body Grafting in Central Prolapase of Cervical Intervertebral Disc**

SA O'Laoire, DGT Thomas (London)

The results of anterior cervical discectomy alone have been reported to equal those obtained when bone grafting is added. However, the authors noted that previous series referred only to patients with nerve root compression or with spondylotic myelopathy. Because only isolated cases of cord compression by a prolapsed cervical disc had been reported, they had reviewed 25 such patients whom they had treated by anterior discectomy without fusion. The patients' ages ranged from 27 to 71 yr. The history was three months or less in 50% of cases. Three patients were considered to be mildly disabled, 14 moderately, and eight patients were severely affected (unable to care for themselves). The disc prolapse was at a single level in 19 patients and at two adjacent levels in the remainder. The levels involved were C3/4 (10), C4/5 (5), C5/6 (9) and C6/7 (1). Review three months to four years after operation showed that all patients had improved symptomatically and objectively. Mild to moderate disability had been followed by full functional recovery but with persisting reflex abnormality. All severely disabled patients had become independent but with some persisting disability. There were no complications, post-operative radiographs showed good alignment and bony fusion in many patients. Discectomy alone without formal fusion was recommended as a simple and effective treatment of spinal canal and root compression due to prolapsed cervical disc.

**Arnold Chiari Malformation—a Review of 71 Cases**

KS Paul, RH Lye, FA Strang, J Dutton (Manchester)

The authors emphasised that the natural history of symptomatic adult Type I Arnold-Chiari Malformation (ACM) was variable and therefore the value of surgery in its management difficult to assess. A retrospective series of 71 patients in whom a diagnosis of Type I ACM was confirmed at operation was presented and the progress of the patients following posterior fossa decompression was analysed. The series consisted of 35 males and 36 females, ages 15–66 yr (mean 43). Length of history varied greatly (6 weeks–50 yr; mean 9 yr). Pain, including headache, was the commonest symptom (69% of patients); other symptoms included weakness of one or more limbs (56%), numbness (52%) and unsteadiness (40%). In almost all cases, the presenting physical signs could be classified as a foramen magnum compression syndrome (22%), central cord syndrome (65%) or a cerebellar syndrome (11%). Myelography (68 patients) was the most useful investigation with only 6% false negatives; however, at operation the tonsils were lower than suggested by myelography in over a third of patients. Only 24% of plain radiographs were abnormal. Experience with whole body CT scanning was limited but it appeared to be a useful investigation. In addition to tonsillar descent, the operative findings included arachnoid adhesions (41%) and syringomyelia (32%). Other, rare anomalies were described. All patients underwent suboccipital craniectomy and C1–C3 laminectomy, usually with insertion of a dural graft for decompression. Respiratory depression was the most frequent post-operative complication (14%) and one patient died from sleep apnoea. A further death was considered to be unrelated to surgery. There was good early post-operative improvement of both symptoms (82%) and signs (70%). However, at latest review (6 months–9 yr; mean 4 yr) relapse...
had occurred, usually within 2–3 yr, in 21% of patients showing initial benefit following surgery. None of those patients with a cerebellar syndrome deteriorated, while 56% of patients with evidence of foramen magnum compression and 66% of those with a central cord syndrome maintained their initial improvement. The authors concluded that posterior fossa decompression appeared to benefit some patients although a significant proportion might be expected to relapse within 2–3 yr after operation, depending upon the presenting syndrome.

CERVICAL SPINAL INJURY: WHAT IS THE ROLE OF MYELOGRAPHY?

DP Byrnes (Belfast)

The management of acute cervical spinal cord injury is surrounded by controversy and lack of consistency. The author’s study concerned the value of a prone cervical contrast myelogram, performed with the aim of detecting continued compression of the cord by conditions such as bony fragments, herniated discs, cord swelling, or haematoma. He had found this investigation more safe and practical than conventional myelography. The study had been performed in Baltimore and Belfast. The subjects were 65 patients who had abnormal neurological signs following an acute cervical spine injury. After reduction of any displacement all had the radiological examination—the mini myelogram. With the patient prone and in traction, 6 ml of contrast, either oil or water soluble, was injected. Usually a lateral C1/2 puncture was used. Little or no manipulation was needed to fill the subarachnoid space. The supine position was unsuitable because the contrast medium was usually lost into the intracranial cavity. Most patients showed a free flow or minimal filling defect at the area of injury. Six patients had either a complete block or a major filling defect in the contrast. This was considered to indicate continuing cord compression and these patients underwent immediate operation. Five patients who had an apparent anterior filling defect underwent anterior dissection and fusion. Four were found to have a significant disc protrusion; one, although completely blocked, was not found to have an abnormality and the appearances were thought to be due to cord swelling. Three of the four patients with disc protrusions improved rapidly and dramatically within 72 hours after operation. One patient had suffered a hyper-extension injury with collapse of the laminae and his myelogram showed a complete block which was due to in-driven bone. He underwent laminectomy but without obvious immediate benefit. The conclusions drawn were: (1) satisfactory myelography was a practical possibility in these patients, (2) most patients did not have continuing cord compression following reduction and therefore did not need decompression, (3) the most common cause of continuing compression was a traumatically herniated disc. Three of the five patients who had undergone operation appeared to have been improved, but the author noted the need for caution in the interpretation of this as it could not be concluded that spontaneous recovery would have taken place; he believed further studies were necessary.

THE PREVENTION OF NEUROLOGICAL INFECTION BY INTRA-OPERATIVE ANTIBIOTICS

JGeraghty, M Feely (Cork)

Infection occurs in 2–8% of patients undergoing a neurosurgical operation. The authors had performed a controlled clinical trial to determine if intra-operative antibiotics reduced the rate of infection. Actively treated patients received vancomycin (1 g intravenously) and gentamycin (80 mg intravenously); streptomycin 50 mg was added to each litre of irrigating saline. Three hundred and eighty-two patients undergoing an elective clean operation were studied. After operation each wound was inspected daily by an experienced neutral observer who applied standard criteria to the diagnosis of wound infection. The control and study group were well matched, but infection was less frequent in the latter (table: p < 0.05 Fisher’s exact test).

<table>
<thead>
<tr>
<th>Control</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminectomy</td>
<td>124</td>
</tr>
<tr>
<td>Craniotomy</td>
<td>49</td>
</tr>
<tr>
<td>Burr-hole biopsy</td>
<td>13</td>
</tr>
<tr>
<td>Duration of operation</td>
<td>1-8 hours</td>
</tr>
<tr>
<td>Infected wounds</td>
<td>7</td>
</tr>
</tbody>
</table>

Although five patients had inadvertently received post-operative antibiotics, all belonged to the control group. Side-effects were infrequent. There was no nephrotoxicity but one patient had an increase in deafness present before operation. Four patients developed a generalised rash at the induction of anaesthesia, that is on starting vancomycin. The authors concluded that the regimen was safe, easy to implement and reduced the infection rate from 3.5% to less than 1%.

SPECIFIC ACTIVE IMMUNOTHERAPY WITH TISSUE-CULTURED HLA MIS-MATCHED HUMAN GLIOMA CELLS IN MALIGNANT CEREBRAL GLIOMAS

DE Bullard, JL Darling, DD Bigner, DGT Thomas (London)

Despite extensive investigation, the treatment of malignant gliomas remains largely palliative. One proposed reason for this poor response to therapy has been the documented immunological deficits of these patients. The authors had examined the feasibility of utilising allogenic cultured glioma cells in combination with BCG cell wall preparation (BCG-CW) in a trial of adjuvant immunotherapy of malignant cerebral gliomas. Five patients with historically proven malignant gliomas were assessed for immunological status by examining white blood cell count, delayed cutaneous hypersensitivity response to recall antigens, and in vitro responses to recall antigens and brain-derived antigens using a peripheral leukocyte migration inhibition assay. All patients received conventional forms of therapy: surgery, radiotherapy, and adjuvant chemotherapy with CCNU, procarbazine and vincristine. In addition, these patients underwent an active immunotherapy with HLA-mismatched allogenic cultured tumour cells. One week following surgery all patients received 106–107 cells from a well characterised human glioma cell line U251-MG together with BCG-CW as adjuvant. Six weeks later, patients received a booster dose of cells alone, one week prior to initiation of cytotoxic therapy. This cycle of treatments was continued until chemotherapy was completed (approximately 12 cycles over 18 months). No toxicity was observed either locally, at the site of injection, or systemically. Serum samples were taken before immunisation and during chemotherapy and examined for antiglioma antibodies using 3H-nicotinate release or indirect live cell membrane immunofluorescence assays and also for anti-HLA and anti-foetal calf serum antibodies. Two patients begun on this regimen died shortly after surgery with no evidence of sustained antibody responses. One patient failed to tolerate radiation therapy, receiving only an initial immunisation and no chemotherapy. The second patient completed radiotherapy but received only two immunisations and a single chemotherapy treatment. Three other patients had relapse free intervals of 42, 76 and 106 weeks after operation and demonstrated increasing antibody titres against the target cell line over the course of immunisation. Extensive absorption, how-
ever, revealed that this activity was predominantly directed towards HLA of foetal calf serum antigens. The evidence that the regimen was non-toxic and well tolerated, together with an indication that high titre serum antibodies can be generated in patients who are generally regarded as immunologically compromised, should encourage further studies.

CRANIO-ORBITAL TUMOURS
J Garibi, A Caceres, A Diaz (Bilbao)
The purpose of this report was to review 50 patients with unilateral exophthalmos due to a tumour. There were equal numbers of male and female patients and their ages ranged from 12 months to 84 yr, with a peak incidence between 40 and 60 yr. Half the patients complained of headache and 42% of ocular pain. As well as exophthalmos, frequent signs included limited eye movements (34%) and reduced visual acuity (40%). Plain skull radiographs and tomograms were useful in the investigation of the majority of patients. By contrast, carotid angiography and orbital venography showed abnormalities in only half of those patients who had these tests. CT scan was abnormal in each of the 25 patients studied by this technique. Forty per cent of the tumours were in the orbit, 36% periorbital, and 24% intracranial. Benign tumours were found in 25 patients: meningiomas, haemangioblastomas, neuromas, granulomas, pseudotumours, osteomas, mucoceles, fibrous displasia and dermoids. Twenty-four of these patients had an operation, with one operative death. Operation was followed by improvement in proptosis and resolution of symptoms and signs but two tumours recurred, a meningioma and an neurinoma. Twenty patients were proved to have a malignant lesion: metastatic carcinoma, sarcomas, carcinoma of perinasal sinus, retinoblastoma and melanoma. Eleven of these had the lesion excised and in some additional radiotherapy and chemotherapy were given, but all died within a year. The authors concluded that the introduction of CT scanning had enabled earlier and more accurate diagnosis and that angiography was now rarely indicated. They also considered that microsurgical techniques had improved the results of operation.

INTRACRANIAL METASTASES: MANAGEMENT AND THE CT SCAN
MM Sharr (London)
The main purpose of the study was to analyse the influence of CT scanning on the management of patients with an intracranial metastasis. Out of a total of 553 patients, studied in three neurosurgical units, 318 underwent removal of what appeared to be a solitary metastasis. The analysis took account of the location of the lesion (supratentorial or posterior fossa), the hospital concerned and whether or not CT scanning had been available. After CT scanning there were fewer patients who underwent craniotomy for a supratentorial lesion in one of the units. On the other hand, none of the departments had a reduction of posterior fossa operations after the introduction of scanning. The mean survival varied between two and five months and was not influenced by the introduction of CT scanning. Similarly, the number of patients with prolonged survival (12 months or more) was not significantly higher after CT scanning (10% in the pre-CT era; 8% after CT). Amongst patients who had previously had the primary tumour removed, patients with a breast carcinoma fared better than average (median survival six months as compared with four months). Although CT scanning reduced the excision rate in supratentorial lesions and increased it in posterior fossa lesions, the median survival was unaffected. The data suggested that CT scanning had not improved the outcome of patients with intracranial metastases. The author suggested that a contrast study of metastases should be performed before deciding whether a patient with an apparent solitary intracranial metastasis was in fact in a good risk group. Provided the primary tumour had been eradicated, cranial irradiation might improve survival after operation but the evidence for this was slight.

CHOROID PLEXUS PAPILLOMAS: A MALIGNANT CONDITION?
AJ Kellerman, MM Sharr (London)
The purpose of the report was to review the results of treatment of choroid plexus papilomas. Twenty-four patients were analysed, treated in three neurosurgical centres. The median age at presentation was 11 yr and the history usually of only a few months. Raised intracranial pressure was the usual presentation in patients less than 3 yr old, whereas focal symptoms and signs were more common in older patients. Direct surgery was performed in 23 patients and a shunt procedure in one patient. The tumour was in the lateral ventricle in 10 patients; the fourth ventricle in nine; and in the cerebellopontine angle in four. One patient had a thalamic tumour, probably of third ventricle origin. Two of the intraventricular tumours were malignant. The perioperative mortality, that is death within 24 hours of operation, was 42% but a further 20% of patients were dead within three years. The authors suggested that the high operative mortality was related to the consequences of rapid reduction of ventricular pressure which they considered had particular risks in patients with this tumour. Death could even follow ventriculography and when this occurred post mortem examination usually revealed subependymal and paraventricular haemorrhages with gross engorgement of the tumour. They presumed that the reduction in intracranial pressure had disturbed an equilibrium between the tumour and the CSF, and so caused the tumour, which was highly vascular but with little structural integrity, to expand in response to the increase in perfusion pressure. Another factor might be torsion of the long pedicle of a choroid plexus papilloma. The authors noted that choroid plexus papilomas seemed to respond variably to radiotherapy, although decreases in vascularity and regression had been reported. They hoped that CT scanning, improved hypotensive anaesthesia and microsurgical techniques would improve the disappointing results of the treatment of a tumour that was usually benign by histological criteria.
The otological surgeon removed the posterior wall of the meatus, avoiding the superior semicircular canal and the endolymphatic duct and sac. The CO₂ laser was used to evaporate tumour tissue without retraction or haemorrhage and had proved very useful in removing the dorsal half of the intrameatal tumour. The tumour was removed until only a bridge of capsule covered the seventh and eighth nerves and their entry zone on the pons. After operation one patient had improved hearing in both ears; the other two patients had improvement in one ear. In one patient hearing deteriorated because associated meningioma interfered with the blood supply to the inner ear. Facial nerve function had been preserved in all four patients. The authors concluded that in bilateral eighth nerve tumours, hearing could be improved by subtotal excision with meatal decompression, but considered it too soon to assess the duration of improvement. If hearing loss eventually occurs the remainder of the tumour can be removed with a good chance of retaining facial nerve function.

MULTIPLE MENINGIOMAS
J Sheehy, A Crockard, V Logue (London) Multiple meningiomas were first described in 1889 but cases are rare and the literature mainly concerns isolated examples. The authors believed that the accepted incidence (1–2%) would increase with the more widespread use of computed tomography. They had therefore reviewed the features and outcome of 10 patients, encountered over a 30-year period. Each patient was female; the average age was 50 yr (range 32 to 72). In eight patients all of the tumours were found at the time of initial presentation, in the others the interval was from one to four years. Four patients had lesions involving the hemicranium and in two cases there were lesions above and below the tentorium. Four patients had more than five tumours. Only one patient had the stigmata of von Recklinghausen’s disease. The authors found that the rate of recurrence after excision of multiple lesions was no higher than observed following excision of a single tumour. The histological findings were reviewed; none of the tumours showed malignant features or angioblast-like patterns. The authors concluded that multiple meningiomas occurred in women in the same age range as did single meningiomas and that most lesions were present at the time the patient initially presented. They felt that a conservative approach, based on clinical observation and series CT scanning, would be safe in an elderly asymptomatic patient.

INTRACRANIAL MENINGIOMAS IN THE ELDERLY IN THE CT SCAN ERA
I Papo (Ancona, Italy) The author had noted an increase in the overall incidence of intracranial meningiomas and in the average age of the patients since the CT scanner had become available. He reviewed the consequences. In five years before CT scanning only 76 patients had undergone operation whereas 176 were encountered in the comparable period after CT scanning was introduced. Before CT scanning, 25% of patients were over 60 yr old and 9% over 65 yr; the corresponding figures after CT scanning were 43% and 31%. The most common features in the elderly patients were mental deterioration (57%), epilepsy (40%), and hemiparesis (33%). Signs of raised intracranial pressure were uncommon. Mental disturbances were particularly common (74%) when the CT scan showed severe oedema. One hundred and forty two of the patients diagnosed by CT scanning had an intracranial operation and five had a shunt. The grounds on which elderly patients did not have an operation included age over 72 yr (12 patients), mild non-progressive symptoms (7), heart failure (3), general condition (1), and three patients refused surgery.

Outcome of intracranial operation for meningioma

<table>
<thead>
<tr>
<th>Category</th>
<th>&lt;65yrs</th>
<th>66-70yrs</th>
<th>&gt;70yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Died</td>
<td>16</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Survived</td>
<td>95</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

The table shows that the mortality rate rose steeply after 65 yr of age. This was mainly due to late complications, against the background of progressive general and neurological deterioration. Those between the ages of 65 and 70 yr who survived operation usually made a moderate or good recovery but all survivors aged over 70 yr were severely disabled. The author urged caution in removing meningiomas in patients over 65 yr unless there were severe and worsening symptoms. He noted that CSF shunting could provide valuable palliation in patients with hydrocephalus.

MICROSURGICAL LUMBAR DISCECTOMY: A PRELIMINARY REPORT
M Feely (Cork) The author had examined the proposition that, using microsurgical techniques, the herniated lumbar disc can be effectively excised with less disturbance to the patient than after a conventional operation. He reviewed the early results in 30 consecutive patients who had undergone micro-lumbar disectomy. All patients had clinical findings of nerve root compression and a minimum of six weeks’ history of leg pain sufficiently severe to prevent them from working. All underwent myelography before surgery. He had used the microsurgical technique and instruments described by Williams. The average stay in hospital after operation was 3-6 days. Twenty-six of the patients had returned to work within two months of operation. The author concluded that, in selected patients, the microsurgical procedure was superior to a standard laminectomy in achieving early discharge from hospital and return to work.

FACIAL NERVE PRESERVATION DURING SURGERY FOR REMOVAL OF ACOUSTIC NERVE TUMOURS
RH Lye, J Dutton, RT Ramsden, JV Occleshaw (Manchester) The authors studied the relationship between the size of acoustic nerve tumours and preservation of the facial nerve at surgery. In addition, the relevance of pre-operative facial weakness to preservation of the facial nerve was considered. A series of 33 patients with acoustic nerve tumours was reviewed. There were 10 males, aged 26–61 yr (mean 43.4) and 23 females, aged 15–69 yr (mean 48.2). Total removal was achieved in 31 of the 35 tumours. A translabyrinthine approach was used for small or medium-sized tumours when no useful hearing remained. The sub-occipital transmeatal approach was used for medium tumours when some useful hearing was present (seven patients) and for 21 large tumours. Post-operatively, there was no patient in whom hearing was preserved. The maximum tumour diameter was measured from CT scans. A system of grading facial function (Grade I—normal, to Grade V—total paralysis) was described. Pre- and post-operative photography enabled comparison with facial function at review. Anatomical preservation of the facial nerve was achieved in 83% of tumour removals of which two were subtotal. Large tumours carried an increased risk of damage to the facial nerve but even in this group the nerve was preserved anatomically in 70% of cases. Damage to the facial nerve occurred more frequently in patients with pre-operative evidence of facial weakness, although post-operative functional recovery of an intact facial nerve appeared independent of the presence of pre-operative facial weakness.
Proceedings of the Society of British Neurological Surgeons

Only 76% of anatomically intact facial nerves showed any evidence of function one month after surgery but facial function improved with time. At the latest review (3 months–48 months; mean 23 months), 45% of all tumour cases had normal facial function or mild facial weakness (Grades I and II). The authors concluded that there was less chance of anatomical preservation or functional recovery of the facial nerve in patients with large tumours. Pre-operative facial weakness was an adverse factor but probably only reflected large tumour size; it did not appear to alter functional recovery of an intact facial nerve.

DORSAL ROOT ENTRY ZONE COAGULATION (NASWOLD’S PROCEDURE) FOR PAIN DUE TO BRACHIAL Plexus AVULSION
DGT Thomas, J Sheehy (London)

Brachial plexus avulsion is an important cause of severe intractable pain, particularly in young motor cyclists. Such pain occurs in the flap, deafferentated limb shortly after injury, and in a minority of cases the pain persists and may worsen over a period of years. It is then particularly resistant to conventional treatment, including stellate ganglion blockage, sympathectomy, cordotomy, rhizotomy, amputation, transcutaneous stimulation, dorsal column stimulation and narcotic analgesic drugs. The authors considered that the three most likely mechanisms responsible for the pain are (1) deafferentated hypersensitive neuronal pools in the injured dorsal root entry zone, (2) injury to spinothalamic and spinoreticular pain pathways, (3) local dysfunction of the neuronal pools of the dorsal root entry zone due to facilitatory or inhibitory influences of the tract of Lissauer. Naswold has recommended intraspinal coagulation of the dorsal root entry zones of the avulsed roots, as a treatment for this type of pain and the authors had evaluated their experience with this procedure. They had treated 15 patients with intractable pain due to brachial plexus avulsion. In 12 patients the brachial plexus lesions were complete. In the majority of patients the pain developed soon after the accident. The pain had a poorly localised dermatomal distribution in the majority of cases, and was frequently described as a burning, crushing or stabbing sensation. All had been treated by conventional methods without success. To perform the lesion a laminectomy was performed from C5–D1. The dura was opened and the intermedio-lateral sulcus of the dorsal spinal column identified. The lesions had been produced with an insulated stainless steel wire electrode 0.45 mm in diameter, with an uninsulated 2 mm tapered tip. After exposure of the cord, the electrode was introduced by hand into the intermedio-lateral sulcus adjacent to the dorsal column at the point where the dorsal roots have been avulsed. The lesion was made with a radio frequency coagulation unit that delivered 40 mA for 15 s, with a spacing of 2 mm between each lesion. The patients were reviewed four to 21 months after operation. In many cases the pain was abolished following surgery. Ten cases had good results (70–100% pain relief); four fair results (30–70% pain relief); and one poor (less than 30% pain relief).

Complications seen in the earlier cases, that is, involvement of the posterior column or lateral corticospinal tract, were reduced with modification of the technique as described by Naswold in 1981. The authors concluded that dorsal root entry zone coagulation can be a safe treatment of pain due to brachial plexus avulsion.

BIRTH INJURY AS A CAUSE OF PRIMARY BASILAR IMPRESSION
RDE Battersby, B Williams (Birmingham)

To test the hypothesis that the bony deformities found in the basiocciput and cervical spine of adults with syringomyelia were related to an injury at birth, the authors had compared the birth histories of patients with primary basilar impression with those of a control group. Seventy-seven patients and 205 control subjects had completed a birth history questionnaire. Eighty per cent of the patients studied had syringomyelia. First born children were more common amongst the patients. A scoring system gave points to factors such as high birth weight, prolonged labour, and the use of forceps. Significantly more patients than controls had high birth scores (p < 0.001). The chance of a patient having a positive birth score was four times that of a control subject.

<table>
<thead>
<tr>
<th>Birth Score</th>
<th></th>
<th>&gt; 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>Controls</td>
<td>157</td>
<td>23</td>
</tr>
</tbody>
</table>

The height of the tip of the odontoid process above Chamberlain's line was measured as an index of the degree of primary basilar impression. This did not correlate with the magnitude of a patient's birth score. The authors considered that minor degrees of occipital osteodiastasis may occur more commonly during birth and be survived more often than generally recognised. They referred to experimental evidence to support the view that disruption of normal growth of basioccipital synchondroses during a traumatic labour might produce subsequent deformity of the basiocciput and contribute to the development of syringomyelia.

BRAINSTEM HAEMORRHAGES AND INCREASED INTRACRANIAL PRESSURE: FROM DURET TO COMPUTED TOMOGRAPHY
J Kushner (Maryland)

The author reviewed the contributions of Henri Duret, a French surgeon of the late nineteenth century. He believed that Duret had described merely the ordinary haemorrhage in the brainstem associated with increased intracranial pressure. He noted that Duret was not a pathologist and that, while some pathologists use the term "Duret haemorrhages" others do not. Whether the haemorrhages were arterial or venous in origin or both were still unclear. The case of a 48-year-old man was presented to illustrate CT findings. The patient had remained unconscious, with decerebrate posturing after removal of a subdural haematoma. Small haemorrhages shown on a CT scan on the third and second post-operative day were correlated with the haemorrhages in the brainstem seen at post mortem. The author suggested that the haemorrhages described by Duret might not have been limited to the secondarions lesions with which his name has become connected. Nevertheless, although the association may not be accurate, he considered that Duret's work had been original and pertinent.

THE NATURAL HISTORY OF RAISED INTRACRANIAL PRESSURE AFTER HEAD INJURY IN MAN
S Galbraith, E Cardoso, J Rowan, G Teasdale (Glasgow)

The aim of this study had been to determine the evolution of raised intracranial pressure after head injury. In the authors' institution measures such as hyperventilation, mannitol, steroids, or CSF drainage were used infrequently. This had provided an opportunity to study the natural history of raised intracranial pressure after head injury. They measured the ventricular fluid pressure in three types of head injured patients: those with a diffuse injury who were not localising to painful stimulus; those who had a mass lesion removed; and those with an "occult haematoma". One hundred and twenty-four patients had been studied; 63 had a "diffuse" injury and 61 a mass lesion. During the first day after resuscitation and removal of a significant haematoma there were only 34 patients (27%) whose intracranial pressure...
was greater than 20 mmHg. Only six of these (5%) had an intracranial pressure greater than 40 mmHg. Even in these 34 patients there was a spontaneous reduction of at least 10% in 20 patients within the next 24 hours. Eight other patients were hydropneumatoed; three of these had CSF withdrawal and two received mannitol. Even if the treatment was successful in reducing ICP in these patients, they were regarded along with those whose pressure remained above 20 mmHg because constituting a spontaneously uncontrolled group of 14 patients. Among patients with raised ICP who were not treated, monitoring was continued for at least three days in 15. In these patients the mean ICP fell from 29.5 ± 2.2 mmHg on the first day to 18.7 ± 4.4 mmHg on the third day. The authors' provocative conclusion was that, after resuscitation and removal of significant haematomas, only a minority of head injured patients had a high intracranial pressure and that even when it was elevated there was a tendency for it to resolve spontaneously. They therefore questioned the need for "routine" prophylactic measures aimed at preventing raised intracranial pressure.

BEHAVIOUR OF THE PRESSURE-VOLUME ELASTICITY SLOPE FOLLOWING A CORTICAL COLD LESION
R Johnston, F Sklar (London and Dallas)
The authors had performed experimental studies designed to test if changes in intracranial pressure produced by fluid infusions would predict the enlargement of an intracranial lesion. They produced a cold lesion (−169° C for 15–30 min) in seven anaesthetised adult mongrel dogs. Mock CSF was intermittently infused at a rapid rate into the cisterna magna, in order to generate pressure. Volume curves up to an ICP of 40 mmHg. Blood pressure, ICP and volume data were sampled at 250 ms intervals using a PDP 11/34 computer. An elasticity slope was calculated as a regression slope relating the natural logarithm of pressure to the volume that had been infused. Evan's Blue solution was given at the time of cold lesion and the degree of staining used to estimate the volume of the lesion in sections taken at the end of the experiment. All the animals showed bilateral, transient but statistically significant increases in elasticity slope after the production of a cold lesion. In six dogs this appeared within 20 min, in the remaining animal within 40 min. The elevations in elasticity slope persisted for a mean of 95 min (range 50–150 min) but the values then fell to control level or even below. The cold lesions and the surrounding regions of oedema occupied approximately 5–8% of the total brain volume at 4 h. The results showed that the ICP pressure-volume relationship was altered only transiently by a cortical cold lesion. The initial increase in elasticity slope was thought to be due to cerebrovascular changes and not related to the development of oedema or mass effect. The subsequent return to control values suggested that pressure-volume response estimations may not provide a basis for predicting the enlargement of an intracranial lesion. The authors doubted that elasticity measurements, such as the pressure volume response would be useful in clinical practice.

EFFECT OF MANNITOL ON ICP, CPP AND CBF IN HEAD INJURED PATIENTS
T Russell, AD Mendelow, J Patterson, G Teasdale (Glasgow)
The long term use of mannitol in the management of head injured patients is controversial. The short term effect of mannitol on ICP has been documented, but little is known about the effect of such therapy on CBF. The authors had studied the effect of a single bolus of intravenous mannitol (0.25–0.5 g/kg; 20% w/v soln) on ICP, CPP and CBF in 28 patients. Cerebral blood flow was measured using the Xe133 IV technique which allows simultaneous measurement in both hemispheres. Ten patients had a resting ICP < 25 mmHg the remainder having an ICP > 25 mmHg. The results are summarised in tables 1 and 2. Mannitol significantly increased CPP in head injured patients in this study. Its overall effects on ICP were small but significant in patients with low ICP. The effect on CBF was significant but only in patients whose ICP was high. The authors concluded that mannitol infusion will often increase CBF in patients with head injury, but that this increase is due more to the effect of mannitol on the systemic circulation than its effect on ICP.

ELECTROPHYSIOLOGICAL EVIDENCE FOR DIFFUSE BRAIN DISORDER AFTER MILD HEAD INJURY
BH Cummins, H Curry (Bristol)
The authors drew attention to the importance of the symptoms that frequently follow minor head injury: short term memory loss, fatigue, and difficulty in decision-making. They had devised techniques to demonstrate the electrical activity of the brain while performing tasks which demanded visual concentration, memory for and the editing of auditory and visual information. They compared findings in 56 normal volunteers with those in 15 mildly head injured patients. All the latter had traumatic amnesia (PTA) of less than 24 hours and were free of clinical neurological disorder. They were studied as close to the end of their post-traumatic amnesia as possible and in 10, six months later. Recordings were made while the subjects performed four tasks: (1) auditory target detection: recognition of a target sound in a particular ear (eg high pitch, left ear) while ignoring other sounds in either ear, (2) visual target task: detection of a shape or word presented in random sequence in series with many others, (3) auditory contingent negative variation (Go/No Go): an appropriate warning sound (by pressing a button) while inappropriate sounds required the clicks to proceed unchecked, (4) visual CNV: if the word or pattern presented was the same as a previous signal, an appropriate button was pressed. The event-related electrocerebral potentials in the second ensuing each stimulus were averaged and displayed. Normal patients showed well formed electrical activity: each task produced its own different wave pattern but these were virtually identical from subject to subject. The differences were marked in frontal and occipital areas, where...
little variation occurred after non-specific stimuli but major, predictable deflections followed the target stimulus. In contrast to the normal subjects, the mildly head injured patients showed a wide variation of abnormality. Some were hardly affected at the first recording. Others showed widespread asymmetry at this time but had improved markedly six months later. A minority of patients showed gross disorders both initially and at a later study. The authors had provided novel information which showed that even a head injury that was judged by PTA to be mild, may cause serious and long lasting electrophysiological abnormalities that could be detected by studies which tested the response to editing of information and the taking of decisions. This was consistent with neuropathological evidence of scattered lesions in the brains of apparently mildly head injured patients.

POST-TRAUMATIC INVOLUNTARY MOVEMENTS AND THEIR SURGICAL MANAGEMENT

J Andrew (London)

The purpose of the report was to review the different forms of involuntary movement that may follow trauma and which the author had encountered in 14 patients referred for possible thalamotomy. He related the types of movement to the site of the lesion he believed responsible and discussed the indications and results of operation. The patients fell into two groups: 12 patients with unilateral tremor (resting; postural; and action), and two patients with hemidystonia. In those with tremor it was unilateral and followed a recovering hemiplegia in six patients. Eleven of the patients with tremor, including four with cerebellar dysarthria and ataxic gait, had clinical and radiological evidence of mid-brain damage; all had been unconscious for a long time. All but one was aged under 23 yr at the time of injury—which in each case had been a road traffic accident.

The operation greatly reduced the tremor in each of the 11 patients with mid-brain damage and much improved the usefulness of the affected arm. The twelfth patient, with an identical tremor, had not injured his head but had twisted his neck when falling from his motorcycle. Two weeks later he developed a hemiplegia and, as this recovered, tremor appeared. His CT scan showed a lucency in the right hemisphere and angiography showed an old intimal tear of the corresponding common carotid artery. Thalamotomy relieved this tremor but made his residual hemiparesis rather worse. In the two patients with hemi-torsion dystonia the responsible lesion was in the basal ganglia. These patients were also thought to have vascular lesions, related to damage to the cervical carotid arteries. After thalamotomy the dystonia was reduced, although not abolished and the function of the affected side was improved. Although there was no satisfactory explanation why a stereotaxic lesion centred in the ventralis intermedius (ventralis lateralis) should be effective, there had been clear improvement in the involuntary movements in the majority of patients. Severe dysarthria and ataxia were contraindications but otherwise the operation should be advised if there was no spontaneous recovery from tremor of hemidystonia.

THE USE OF A COMBINED SUPRA- AND INTRATENTORIAL APPROACH TO THE ANTERIOR TENTORIAL HIATUS

L Symon (London)

The author drew attention to the difficulty in the approach to a tumour spreading from the middle to posterior fossa or arising primarily on the clivus in the upper part of the posterior fossa. Over the past 10 years, he had employed a combined supra- and infratentorial approach with division of the tentorium and lateral sinus giving extensive exposure to the clivus from the posterior clinoids to the foramen magnum. He described the technique and presented illustrative cases. Fifteen cases of clivus or apical petrous tumours, six cases of difficult or complicated upper basal aneurysms, and six cases of cholesteatoma of the posterior fossa tentorial hiatus and supratentorial region, had been operated on by the technique, which had also proved useful in angiomas of the upper medial cerebellum or vermis (three cases), or on the superior brain stem itself (two cases). The author recommended that complete angiography was essential in planning the approach. Carefully taken venous phases should be included, because the competence of both lateral sinuses must be assured. Where one lateral sinus is dominant, and particularly if the other is absent, division of the dominant lateral sinus might be unwise. The lateral sinus on either side had been divided without attributable complication except in one case, a complicating recurrent clivus meningioma with an anomalous posterior circulation in which there had been gross asymmetry between the sizes of the lateral sinuses and the larger was divided. Haemorrhagic infarction of the dominant temporo-occipital region followed, although other factors may have contributed.

TERMING VENTRICULOSTOMY FOR SYRINGOMYELIA

B Williams, G Fahy (Birmingham)

The operation of excision of the filum terminale has been recommended as treatment for syringomyelia and the claim has been made that this procedure, named terminal ventriculostomy by Gardner, may produce improvement in around three-quarters of cases and has a low morbidity rate. Although the theoretical basis for this claim is unclear, the intractable problems of progressive syringomyelia, particularly after craniocerebral decompression has failed to arrest progression, have led to this procedure being tried in many centres. A series of 31 patients was presented, which the authors had collected from several surgeons. Twenty cases had no evidence of a patent central canal at the conus and in only one case was the conus observed to be low. Just over half the cases claimed some amelioration but objective improvement was difficult to verify. The apparent improvement could not be correlated with the number of previous operations, nor with the age of the patients or the age of the syrinx, nor with the observation of a patent central canal or leakage of CSF from the cut end of the conus. Most patients had continued to deteriorate. The authors suggested that terminal ventriculostomy should not be used as a primary treatment for syringomyelia and that when they are indicated, drainage of hydrocephalus, craniocerebral decompression and direct myelotomy all had theoretical and practical advantages.

THE PRESSOR RESPONSE TO TRACHEAL INTUBATION

J Curran, M Crowley, E Glynn, M Nagle (Cork)

Laryngoscopy and tracheal intubation during general anaesthesia cause increases in blood pressure and heart rate. Rarely these may be fatal. The authors had studied two series of patients, most undergoing neurosurgery, in order to document the phenomena and to discover the effects of various forms of pre-treatment. In the first 144 patients, the mean responses (defined as the maximum post-intubation minus the pre-induction value), were an increase of 30-6 mmHg in mean arterial pressure and an increase of 16-7 beats/min in heart rate. Greater than average changes occurred if the patient was a cigarette smoker, or if intubation was either prolonged or difficult. The extent of the cardiovascular effects correlated only weakly with the pre-anaesthetic blood pressure but more strongly with the decrease in blood pressure.
pressure that followed induction. In the second series, 137 patients were given intravenous agents before induction. Ninety-five patients were allocated randomly to pretreatment with either droperidol (100 \( \mu \)g/kg or 150 \( \mu \)g/kg); fentanyl (2.5 \( \mu \)g/kg) or sodium nitroprusside (1 \( \mu \)g/kg). The other 42 patients, because it was deemed that attenuation of cardiovascular changes was desirable, were pre-treated with varying doses of atropine and practolol in combination with either sodium nitroprusside or various doses of fentanyl. The results showed that the most effective combination was atropine 15 \( \mu \)g/kg and practolol 400 \( \mu \)g/kg with fentanyl 5 or 7 \( \mu \)g/kg. The authors noted that this technique had potential dangers and that acceptable degrees of attenuation could be produced by smaller amounts of atropine, practolol or sodium nitroprusside.

SACRAL ANTERIOR ROOT STIMULATORS FOR BLADDER CONTROL IN PARAPLEGIC AND QUADRIPLEGIC PATIENTS
GS Brindley, CE Polkey, DN Rushton (London)
After a major spinal cord injury the bladder becomes reflex and other urinary tract abnormalities arise which cause social inconvenience and late mortality from chronic urinary tract infection. Some anterior sacral roots in man, always S2 and usually S2 and S4 contain both parasympathetic fibres to the detrusor muscle and somatic fibres to the striated muscle to the external sphincter. Voiding of urine can be produced using appropriate stimulus parameters because the detrusor muscle can be made to contract continuously whilst the external sphincter contracts intermittently. A passive electrical system is implanted surgically and activated from an external transmitter which has three independent channels available. The authors had implanted such a device in 10 patients, eight men and two women, all the victims of spinal injury. Ther level of injury varied from C6 to D12 and in eight patients the transaction was clinically complete. All patients had preoperative cystometry which in most showed a large, over distensible bladder, and they had also had an IVU within one year of operation. The implantation was made in two stages, the first involved a lumbar and sacral laminectomy. The nerve roots were identified both anatomically and physiologically. At the second stage a subcutaneous pouch was made in the left costal margin for the receiver. There had been few complications. A special grommet prevents CSF leakage. Minor damage to the nerve roots occurred in five patients and more severe damage which recovered, in two patients. In three patients there had been failure of hardware, this was always remediable. At the time of review, all the implants were working sufficiently well for the patient to be able to empty the bladder at will. Eight patients are continent at night and five by day. All patients had a reduction of their residual urine volume—to between 22% and 1% of the pre-operative amount. In four of the six patients where post-operative urograms were available there had been slight improvement. The authors concluded that an implanted device could give voluntary micturition and an improvement in urinary continence and urinary function for up to four years.

EVALUATION OF TWO SUBDURAL SCREWS FOR THE MEASUREMENT OF INTRACRANIAL PRESSURE
AD Mendelow, JO Rowan, L Murray, A Kerr (Glasgow)
A subdural screw has been widely used to measure intracranial pressure (ICP). It avoids breaching the dura or penetrating the brain and appeals because the incidence of infection, epilepsy and intracerebral haematoma should be lower than with ventricular catheterisation. The aim of this study was to determine the reliability of subdural pressure measurements by comparing readings from two types of subdural screw with those obtained from the ventricular catheter. ICP was measured in 10 patients with a single lumen subdural screw with an open end and in 10 other patients with a Leeds screw, which has four lateral openings. In both series the results were compared with simultaneous intraventricular measurements. Corresponding chart recorder readings were taken every 30 minutes.

<table>
<thead>
<tr>
<th>Open-ended screw (mmHg)</th>
<th>Ventricular catheter (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0–10</td>
</tr>
<tr>
<td></td>
<td>0–10</td>
</tr>
<tr>
<td>10–20</td>
<td>11</td>
</tr>
<tr>
<td>20–30</td>
<td>0</td>
</tr>
<tr>
<td>30–40</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leeds screw (mmHg)</th>
<th>Ventricular catheter (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0–10</td>
</tr>
<tr>
<td>0–10</td>
<td>143</td>
</tr>
<tr>
<td>10–20</td>
<td>66</td>
</tr>
<tr>
<td>20–30</td>
<td>1</td>
</tr>
<tr>
<td>30–40</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
</tr>
</tbody>
</table>

The results showed that above 20 mmHg both types of subdural screw gave lower readings than the ventricular catheter. The tendency to under-read ICP was more common with the open-ended screw. Both screws tended to function poorly after peaks of pressure. The authors concluded that subdural screws might give unreliable results, in particular by under-estimating the occurrence of high ICP.