INTRACRANIAL COMPLIANCE DURING THE POST-OPERATIVE PERIOD AFTER SURGERY FOR INTRACRANIAL ANEURYSMS

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The post-operative course following direct surgery for ruptured intracranial aneurysms is frequently stormy (Azevedo Filho, 1975 [1]). Post-operative generalised cerebral vasospasm has been found to correlate very well with poor outcome and indeed is cause of death in the majoraty of patients (Stornelli & French, 1964 [8]; Losch & Avezedo Filho, 1976 [4]).

Generalised cerebral vasospasm is a major factor in reducing cerebral blood flow and inducing cerebral hipoxia. Hypoxic brain swells and haemorrhagic infarctions may also occur, both processes increasing brain bulk. Under these conditions, intracranial pressure usually increases and further impairs neurological function by compression and distortion of brain substance and cerebral vessels.

Continuous monitoring of intracranial pressure seems to be particularly applicable in patients undergoing direct attack of intracranial aneurysms. When the intracranial pressure is measured through a catheter placed in one of the lateral ventricles the removal of cerebrospinal fluid (CSF) produces an opportunily to study the intracranial compliance (Intracranial Compliance = decrease in mean intracranial pressure per ml of CSF removed).

METHODS AND MATERIAL

Continuous monitoring of intracranial pressure was carried out in 20 patients admitted to the Department of Neurological Surgery. All had craniotomies for direct treatment of ruptured intracranial aneurysms.

This study was performed entirely in the Intensive Therapy Unit, where the patients were admitted immediately after operation and only discharged when close clinical and instrumental observation were considered to be no longer necessary. The intracranial pressure was monitored continuously for periods ranging between 20 and 144 hours, with a mean period of 53 hours.

A rubber catheter was placed in the lateral ventricle for CSF release during the operation and later on used for contiuous monitoring of the intracranial pressure.

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Intracranial pressure was measured by a low pressure transducer (Statham PM 131), whose output was directed into a Hewlett-Packard (780-19) venous amplifier. The paper recording was made on a Devices M4 heated stylus recorder. The zero-reference point for the transducer was established as described by Azevedo Filho & Adams (1977 [2]).

Arterial pressure, ECG, heart rate, temperature, blood gas analysis and neurological status were also continuously monitored. Half-hourly values for mean intracranial pressure (MICP) were extracted from the paper recording and correlated with level of consciousness.

In the investigation of the intracranial volume / pressure responses, the intracranial compliance (→ Y ←) was correlated with resting MICP values (→ X ←). Linear regression analysis was carried out on a Wang electronic calculator (Type 370, Wang Laboatories Inc.) with two card readers which had been previously programmed for the formula of Snedecor & Cochrane (1967 [7]). The readout from this calculation produced values of mean X, mean Y, Standard Deviation (SD) of X, SD of Y, slope, SD of slope, constant term and correlation coefficient.

Microsurgical techniques were employed in all patients with the utilization of the operative microscope, bipolar coagulator and microsurgical instruments. The blood pressure was dropped during the aneurysm manipulation by the use of sodium nitroprusside.

RESULTS

Five ml of CSF were removed on a total of 196 occasions when the resting MICP ranged from 1 to 46 mm Hg. From the change of pressure observed on each occasion, a value for intracranial compliance was calculated with units of mm Hg per ml of CSF removed. A regression line of compliance against resting MICP was calculated with the latter as the independent variable. There was a significant linear relationship between the two values although the coefficient of linear correlation was not high (Fig. 1).

On 70 occasions, 5 ml of CSF were removed from patients when MICP was above 30 mm Hg and the neurological state was stable and on 16 occasions when a high MICP was associated with neurological deterioration. The average calculated compliance under the first circumstances was 2.4 ± 0.58 mm Hg per ml of CSF removed, significantly less than the mean value calculated on the occasions when neurological deterioration had occurred (3.2 ± 0.56 mm Hg per ml of CSF removed) (Table 1).

DISCUSSION

The removal of CSF produced an opportunity to study the intracranial compliance. Several authors (Miller et al., 1973 [5]; Miller & Pickard, 1974 [3]) have been interested in intracranial volume / pressure relationships both clinically and experimentally. Miller & Pickard (1974)[6] reported studies of severe head injuries in which a small change in intracranial pressure (< 2 mm Hg) to a

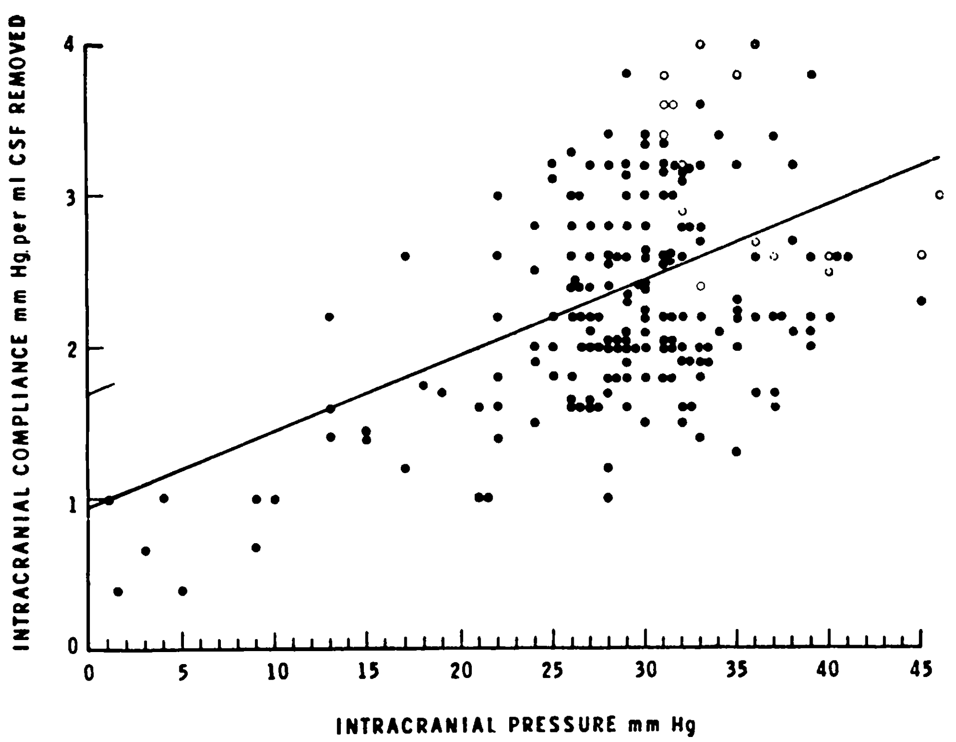

Fig. 1 — Regression line of intracranial compliance values against resting mean intracranial pressure: 0 = values associated with neurological deterioration; ● = values unassociated with neurological deterioration. X = 0.047 (± 0.006) X + 0.96; r = 0.48 on 194 degrees of freedom (P < 0.01).

Intracranial compliance unassociated with neurological deterioration	Intracranial compliance associated with neurological deterioration
Mean = 2.4 mm Hg per ml CSF removed	Mean = 3.2 mm Hg per ml CSF removed
S.D. = 0.58	S.D. = 0.56
Nº observations = 70	Nº observations = 16
T value = 5.121	Po.oo1

Table 1 — Mean intracranial compliance values for resting mean intracranial pressure above 30 mm Hg associated and unassociated with episodes of neurological deterioration.

cerebral volume change induced by the withdrawal of 1 ml of CSF suggested that patients could cope adequately with any small increase of intracranial volume. A change exceeding 5 mm Hg on the other hand, was thought to indicate that compensatory mechanisms were becoming exhausted and that the patient was likely to be at risk from even small increasses of intracranial volume.

The results reported in this series deal with the removal of 5 ml of CSF in situations in which resting MICP ranged between 1 and 46 mm Hg. If the compliance values relating to MICP readings above 30 mm Hg are considered the mean compliance associated with episodes of deterioration of the level of consciousness (3 mm Hg per ml of CSF removed) was significantly greater than that relating to values when level of consciousness was steady (2 mm Hg per ml of CSF removed). These findings suggest that compliance values up to 2 mm Hg per ml of CSF removed indicate that the compensatory mechanims are fairly well equilibrated inside the intracranial cavity. On the other hand, however, values above 3 mm Hg suggest that these mechanisms are under strain and any further increase of intracranial volume is likely to induce hazardous intracranial pressure increases and ultimately neurological deterioration. The smaller volume (3 mm Hg per ml of CSF removed as opposed to 5 mm Hg per ml of CSF removed in the injured patients) for tolerated compliance in the post-operative period following aneurysm surgery is perhaps another indication of the considerable cerebral haemodynamic instability associated with cerebral vasospasm.

Even in the absence of neurological deterioration, intracranial compliance values exceeding 3 mm Hg per ml of CSF removed suggest that special care should be taken to avoid situations likely to produce intracranial volume increases, such as high Pa CO_2 or the inhalation of certain anaesthetics agents. In these circumstances it would perhaps be safer to reduce the cerebral volume at once by infusion of Mannitol, and thereby reduce the likelihood of neurological damage.

SUMMARY

Generalised post-operative cerebral vasospasm is a major factor in delineating poor operative results following direct ruptured intracranial aneurysms. Continuous monitoring of intracranial pressure seems to be particularly helpful on such occasions, and intracranial compliance determination as well. High intracranial compliance values suggest that even small intracranial volume increases may induce rapid intracranial pressure increase and situations likely to produce neurological deterioration.

RESUMO

Complascência intracraniana no periodo post-operatório após cirurgia para abordagem de aneurismas intracranianos.

Vasospasmo cerebral post-operatório é um fator extremamente importante como causa de insucessos cirúrgicos após abordagem direta de aneurismas intracranianos rôtos. Contínua monitorização da pressão intracraniana como também a determinação da complascência intracraniana parecem ser de particular ajuda nessas circunstâncias. Valores de complascência intracraniana elevados sugerem que mesmo pequenos aumentos do volume intracraniano podem ser causa de rápido aumento da pressão intracraniana e ocasionar deterioração do quadro neurológico.

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