nuclei produced dissociated sensory loss and there were frequent recurrences of pain.

2. The palaeo-spino-reticulo-thalamic tract terminating in the thalamic intralaminar nuclei including n. centre median and parafascicularis.

3. Fibres passing from the posterior thalamus in the region of the n. limitans portae of Hassler to the second somatosensory cortex in the parietal operculum.

Eleven cases were described in which thermocoagulation lesions were produced stereotactically in either the second or third systems for painful lesions involving the brachial plexus in 10 cases and the sacral plexus bilaterally in one case. Preliminary stimulation studies produced a sensation of heat contralaterally from the posteroventral nuclei and of paraesthesiae from the intralaminar nuclei. Tegmental stimulation and lesions caused diplopia in the two patients so treated. All patients obtained some degree of relief, which in six cases was excellent. Survival time did not exceed six months and no conclusions were drawn in relation to the possible long-term effects of such procedures.

EXPERIMENTAL AND CLINICAL EVALUATION OF A BRITISH CRYOGENIC LESION MAKER

J. W. MCINTOSH (Stoke-on-Trent) described a cryogenic probe designed by H. G. Clark and Brodie Hughes, based on the Joule-Thomson effect, and manufactured by the Hymatic Engineering Company. The instrument consisted of a vacuum insulated probe 1.9 mm in diameter employing B.O.C. nitrogen at 2,000 lb/sq in. The escaping nitrogen gas passed through a heat exchanger to cool the entering gas. A copper-constantin thermocouple at the probe tip recorded temperature and the single control of the instrument was a reducing valve regulating gas pressure. The instrument had been tested by the makers at three times the normal working pressure.

The minimum temperature achieved using nitrogen was -100°C but the gas Argon would produce a lower temperature. The dimensions of the uninsulated tip of the probe were 1.9×2.4 mm, which produced an ellipsoidal volume of frozen tissue. Any application requiring a larger lesion, as in hypophysectomy, would require a probe of larger diameter. As constructed at present the instrument cannot be sterilized by autoclaving because of the low melting point of the solders used in its construction.

The probe was tested in a series of experiments in the cat brain based on a technique described by Mark and his colleagues (1961). This consisted of placing the tip of the probe by a stereotaxic technique at different distances from the Edinger-Westphal nucleus. The effect on the pupil of cooling at various temperatures was observed and recorded photographically. These experiments showed the reversibility of cryogenic lesions related to temperature and range from the surface of the probe and the size and shape of lesions at different rates of cooling. Satisfactory results of this technique using Leksell's stereotaxic instrument were described in 13 patients suffering from Parkinson's disease and one patient suffering from spasmodic torticollis.

REFERENCE

Mark, V. M., Chato, J. C., Eastman, F. G., Aronow, S., and Ervin, F. R. (1961). Localised cooling in the brain. *Science*, **134**, 1520.

VISUAL IMPAIRMENT IN 'LOW PRESSURE' HYDROCEPHALUS

J. BLOCK (Dundee) discussed the possible mechanisms by which visual impairment results from opticochiasmatic arachnoiditis. Two patients were described in detail in whom progressive deterioration of visual acuity and fields, after a severe head injury in the first case and tuberculous meningitis in the second, suggested the diagnosis of arachnoiditis, which was confirmed at operation in the first case. However, in both cases ventriculography showed considerable ventricular dilatation. The first case showed high pressures, of the order of 400 mm CSF and bone changes of raised intracranial pressure, whereas the pressures recorded in the second case were normal. Vision in both patients was significantly improved by ventriculoatrial shunt. It was suggested that the effect was not due to a reduction of slightly raised 'general' intracranial pressure but that there may have been a local pressure effect in relation to the optic chiasm and nerves. Local cystic swellings of two types were described, either a distended third ventricle compressing and distorting these structures from above or an arachnoidal cyst filling from the basal cisterns and causing compression from below. Such an arachnoidal cyst had been demonstrated in the first patient and the residual bitemporal field defect was very suggestive of a lesion compressing the chiasm in the midline.

FIVE MODES OF SUBTRACTION USING ARTIFICIAL SLOW FLOW CAROTID ANGIOGRAPHY

H. VERBIEST (Utrecht) described special aspects of radiographic and photographic subtraction using a recently developed technique of percutaneous artificial slow flow carotid angiography. This method depended upon occlusion of the ipsilateral common carotid artery below the site of puncture by means of digital compression during the injection of the contrast medium and for three seconds thereafter. A distinction was made between angiographic subtraction and photographic (or electronic) subtraction.

Angiographic subtraction was related to the angiographic technique, selective suppression of vascular filling revealed abnormalities in the resulting vascular pattern and might also produce visualization of anastomosing vessels not seen in the routine angiograms. Although the latter was due to angiographic subtraction the result could also be termed an 'addition phenomenon'.

The following photographic subtraction techniques were described:

Subtraction of skull structures from the compression angiograms resulted in better visualization of the angiographic pattern.

Subtraction of compression angiograms from the routine arteriogram in cases of visualization of the middle and anterior cerebral arteries in the routine angiogram

and visualization of the middle cerebral artery in the compression angiograms facilitated the discrimination of the anterior cerebral artery and its branches from the middle cerebral artery and its branches because of the variation of contrast filling.

Subtraction of compression angiograms one from the other resulted in the presentation of flow patterns in one picture and may add to better identification of particular vessels.

REFERENCE

- Verbiest, H., and Dokkum, Th. A. (1970). Artificial slow flow carotid angiography. Carotid angiography with compression proximal to the site of injection. *J. Neurosurg.*, 32, 180-196.

CORRELATION BETWEEN REGIONAL CEREBRAL BLOOD FLOW AND ANATOMICOPATHOLOGICAL DATA

L. SYMON, J. E. REES, and J. MARSHALL (London) stated that current methods of examining regional cerebral blood flow have given valuable information about physiological mechanisms responsible for maintenance and variation of cerebral blood flow in relation to changing arterial blood pressure and pCO_2 . They described a method of isotope clearance using ^{133}Xe with particular stress on accuracy of collimation to study cerebrovascular disease, especially in relation to subarachnoid haemorrhage. The details of collimation were described and the two-compartmental analysis used to obtain five analytical values for each of 16 regional detectors was outlined. Comparisons of abnormal cases with a group of normal cases in which the standard deviation of each variable for each individual area had been worked out produced valuable information which correlated well with circumstances of cerebral infarction seen either at operation or necropsy. Five illustrative cases were described and the potential of the method for the detailed analysis of regional cerebral blood flow in relation to subarachnoid haemorrhage was outlined. It seemed possible that, with increasing experience, the adequacy of perfusion of areas of brain supplied by branches of the major cerebral vessels might be subject to a reasonable assessment.

INFLUENCE OF THE CIRCULATION ON THE CSF PRESSURE WAVE

H. PONSSEN and G. C. VAN DEN BOS (Amsterdam) had investigated the influence of the pulsatile phenomena of the circulation on the form of the CSF pressure curve recorded in the cisterna magna in anaesthetized dogs. Common carotid artery flow, central arterial pressure, central venous pressure, and CSF pressure in the cisterna magna were recorded. To illustrate the interaction between the circulation and the CSF a simple model was described. The skull was represented by a rigid cylinder with two compartments. One of these represented the intracranial blood volume, the other the CSF space. They were separated by a piston which simulated the blood vessel walls and the surrounding brain tissue. The CSF space continued into the spinal canal, where it was contained in

the expandable dural sac. The spinal canal was simulated by a rigid cylinder also, but with a small cross-sectional area. The dural sac was considered in association with the peridural veins and because both were situated in the spinal canal, expansion of the former was possible only at the expense of the latter. With an increase of intracranial blood volume, the piston drove CSF into the spinal canal with a higher velocity than that of the piston, due to the difference in cross-sectional area of the cylinders. The CSF pressure in the cisterna magna was the result of the intracranial blood volume, the impedance of the spinal canal for the inflow of CSF during systole, and of the pressure in the peridural veins related to the central venous pressure. In the CSF pressure wave an arterial and a venous component could be recognized.

From the relationship between the acceleration and the deceleration phases of the flow velocity in the carotid artery and prominent points in the CSF curve it was concluded that inertial forces occurring when the CSF was driven into the spinal canal were the cause of the form of the curve at these points. These forces could occur because a small change in volume of the brain caused a larger change of the velocity (= acceleration or deceleration) of the CSF. The a-wave of the central venous pressure curve appeared in the CSF pressure curve as a small peak, just before the arterial peak. Transmission of this peak to the CSF occurred via the peridural veins. The venous CSF pressure peak never disappeared, not even when the CSF pressure was higher than the central venous pressure. The authors concluded that the peridural veins never became totally compressed and that the dural sac was always expandable.

MONITORING OF INTRACRANIAL PRESSURE IN NEUROSURGICAL PATIENTS

A. HULME, J. C. CHAWLA, and R. COOPER (Bristol) presented their experiences with continuous monitoring of intracranial pressure (ICP) and described some of its applications in clinical management. Most of the studies had been made with implanted subdural pressure transducers and only a small number of ventricular fluid pressure recordings had been made. Different types of miniature transducers suitable for insertion through a burr hole into the subdural space were described. In many cases additional recordings were made of local cortical blood flow and cortical available oxygen monitored by subdural thermistors and gold electrodes. Data were recorded by means of a modified 16 channel Beckmann EEG machine and also on analogue tape fed into a Link 8 computer.

Recordings for periods between a few hours and several weeks had been investigated by implanted transducers in 75 patients. The largest group consisted of patients with intracranial space occupying lesions, mainly tumours. In conjunction with clinical and other observations these records provided useful information of the patient's progress and the effect of therapeutic measures as they influenced ICP. Examples of such records were shown and the most obvious feature was the large plateau waves which were always pathological and represented a partial breakdown in intracranial compensation, their frequency and amplitude increasing in deteriorating