Non-invasive screening for surgical intracranial lesions

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SYNOPSIS The value and reliability of the combined results of skull radiographs, electroencephalography, isotope angiography, and brain scanning in 147 patients suspected of having an intracranial space occupying lesion are analysed. The overall accuracy of the technique was 79%. No false negatives were found. The advantages of adopting the system proposed by the authors in everyday clinical work is discussed.

The value of skull radiographs (Taveras and Wood, 1964; Zimmer and Caplan, 1966; Pawl and Walter, 1969), electroencephalography (EEG) (Daly and Thomas, 1958; Bagchi et al., 1961; Magnus et al., 1961; Sidell and Daly, 1961; Small et al., 1961; Silverman, 1964; Murphy et al., 1967), echoencephalography (Leksell, 1955, 1958; Lithander, 1961; Brinker et al., 1965; Kurze et al., 1965; Lapayowker and Christen, 1965), and brain scanning (Cowan et al., 1970; Moreno and DeLand, 1971; O'Mara and Mozley, 1971; Scheinberg and Taylor, 1971; Gilday and Reba, 1972), in the investigation and diagnosis of intracranial space occupying lesions is well established. The results produced by each one of these techniques have been compared with those obtained with neuroradiological contrast studies as well as operative and necropsy findings (Wang et al., 1965; Decker and Knott, 1972).

We undertook this study to determine if a given combination of these non-invasive procedures would securely demonstrate or exclude an intracranial mass lesion.

METHODS

Over 800 patients suspected of harbouring an intracranial mass lesion were investigated at the Mount Sinai Hospital, Toronto, Canada, during the period 1 January 1970 to 15 December 1972.

Only the records of those patients who had skull radiographs, electroencephalography, echoencephalography, isotope angiography, and brain scan in addition to at least one neuroradiological contrast study were selected. There were 147 cases available for final analysis; 75 females and 72 males. The youngest patient was 13 and the oldest 78 years, with an average age of 46.8 years.

The skull radiograph series consisted of five films as follows: one posteroanterior, one anteroposterior, one each right and left laterals, and subaxial (Towne's) views. The radiographs were read as normal or abnormal. The borderline cases in which further views were suggested for clarification were considered abnormal irrespective of the result of such views.

The electroencephalograms were recorded with an 8-channel Grass electroencephalograph. Standard mono- and bipolar montages were obtained. Stroboscopic stimulation was always carried out and hyperventilation when possible. For the purpose of our study the electroencephalograms were classified as positive if a focal abnormality was found. Diffuse abnormal tracings were considered negative unless the electroencephalographer in his report suggested the possibility of either a midline or a posterior fossa lesion.

The echoencephalograms were obtained with a Hoffrel ultrasonoscope, model 101. Echoencephalograms were regarded as normal when showing 2 mm or less midline shift. A shift above 2 mm was considered abnormal.

Isotope angiography and brain scanning were obtained on a Nuclear Chicago Pho-Gamma scintillation camera. Anterior, posterior, both right and left lateral, and both right and left oblique views were recorded immediately and two to three hours later (delayed scan). In 20% of the cases vertex
views were also recorded. Asymmetrical perfusion as well as a focal 'hot spot' on early or delayed scans were considered abnormal.

RESULTS

The patients could be divided into four groups according to result:

GROUP A: TRUE POSITIVE In this group we included those patients in whom a space occupying lesion was shown by the non-invasive investigations. The existence of such a lesion was later confirmed by contrast studies and, in some cases, by operation and/or necropsy.

GROUP B: TRUE NEGATIVE In this group all the non-invasive investigations were negative. Further investigation of these patients by neuroradiological procedures failed to show any abnormality.

GROUP C: FALSE POSITIVE In the cases included here, one or more of the preliminary studies suggested a space occupying lesion but their existence could not be demonstrated by a neuroradiological investigation.

GROUP D: FALSE NEGATIVE This group encompasses those cases in which the preliminary investigations were negative but a mass lesion was later found with contrast studies. This was a hypothetical group but none of our patients fell into this category.

The final results are shown in Table 1. There were 17 cases in group A (12%), 99 cases in group B (67%), 31 cases in group C (21%), and none in group D. The overall accuracy of the combined non-invasive techniques to confirm or deny the existence of a mass lesion was 79%. The reliability, however, was absolute in the sense that, whenever all the non-invasive investigations were negative, all neuroradiological procedures were also negative. Conversely, in the cases with proved pathology, one or more of the screening procedures showed the lesion.

In the group A series there were 12 tumours, two arteriovenous malformations, one subdural haematoma, one cerebral abscess, and one intracerebral haematoma (Table 2). The electroencephalogram and the brain scan localized the lesion in 13 cases each (76%) and the skull radiographs, the blood flow study, and the electroencephalogram in nine cases each (52%).

In four cases, only one of the five non-invasive studies was abnormal: the electroencephalogram in a temporal lobe haematoma; the skull radiographs in a craniopharyngioma; the brain scan in an astrocytoma grade III and the electroencephalogram in an astrocytoma grade IV.

In two cases all the studies were abnormal: a meningioma and an arteriovenous malformation.

In the group C series there were 31 cases. The final diagnoses in these were cerebrovascular

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**Table 1**

<table>
<thead>
<tr>
<th>Group</th>
<th>Cases (No.)</th>
<th>(%)</th>
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<tbody>
<tr>
<td>A (true positive)</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>B (true negative)</td>
<td>99</td>
<td>67</td>
</tr>
<tr>
<td>C (false positive)</td>
<td>31</td>
<td>21</td>
</tr>
<tr>
<td>D (false negative)</td>
<td>0</td>
<td>0</td>
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</tbody>
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**Table 2**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tumour</td>
<td>12</td>
</tr>
<tr>
<td>Arteriovenous malformation</td>
<td>2</td>
</tr>
<tr>
<td>Subdural haematoma</td>
<td>1</td>
</tr>
<tr>
<td>Intracerebral haematoma</td>
<td>1</td>
</tr>
<tr>
<td>Cerebral abscess</td>
<td>1</td>
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**Table 3**

<table>
<thead>
<tr>
<th>Final diagnoses of 31 cases in Group C</th>
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<tbody>
<tr>
<td>Diagnosis</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
</tr>
<tr>
<td>Late onset epilepsy</td>
</tr>
<tr>
<td>Cerebral atrophy</td>
</tr>
<tr>
<td>Hypertensive encephalopathy</td>
</tr>
<tr>
<td>Pseudotumor cerebri</td>
</tr>
<tr>
<td>Metastatic carcinoma without brain metastases</td>
</tr>
<tr>
<td>Progressive supranuclear palsy</td>
</tr>
<tr>
<td>Head injury (concussion)</td>
</tr>
<tr>
<td>Arteriovenous malformation of the scalp</td>
</tr>
<tr>
<td>Not yet diagnosed</td>
</tr>
</tbody>
</table>
accident in 10, late onset epilepsy in nine, cerebral atrophy in three, and one case each of hypertensive encephalopathy, pseudotumor cerebri, metastatic carcinoma without cerebral involvement, progressive supranuclear palsy, head injury, and arteriovenous malformation of the scalp (Table 3). Three cases could not be securely diagnosed.

The electroencephalogram gave most false positive results, as it was abnormal in 24 out of 31 cases, and the only abnormality in 16. This represents an overall of 16% false positive results for electroencephalography in the series. The skull radiographs, isotope angiography, and brain scan were falsely positive in six cases each, or 4% for the whole series. There were no false positives for echoencephalography.

DISCUSSION

The purpose of a screening test is to provide a rapid and simple means, with low morbidity, of separating those patients who require further investigation from those in whom the probability of undiagnosed pathology is low. The definitive methods of assessment of patients with intracranial mass lesions such as pneumoencephalography, cerebral angiography, and the like possess some inherent morbidity and occasional mortality (Taveras and Wood, 1964; Fischer, 1968; Abrams, 1971; Natelson et al., 1972; White et al., 1973).

The need for an effective screening system in the investigation of patients suspected of having an intracranial space occupying lesion is obvious. This is particularly true in otherwise asymptomatic patients who are being investigated for headaches, or in symptomatic patients in whom it is necessary to ‘rule out’ rather than confirm the presence of an operable mass lesion such as those suffering from late onset epilepsy, pseudotumor cerebri, multiple sclerosis, etc.

Skull radiography, electroencephalography, echoencephalography, and brain scanning are now routinely used as screening procedures. They have the advantage of being possible to carry out on an outpatient basis, on one short visit. The results are usually available within 24 hours.

It has been shown previously that the combination of a normal EEG with a normal brain scan lessens the likelihood of presence of tumour to 5% (Wang et al., 1965; Murphy et al., 1967; Decker and Knott, 1972). In 147 cases, the combination of the results obtained by these procedures added to those of skull radiographs and echoencephalography, effectively showed or excluded the presence of a space occupying lesion in 79% of them. Furthermore, there were no false negative results and, therefore, no mass lesion was missed. From this point of view, the reliability of the technique is 100%, which compares favourably with any of the neuroradiological investigations in current use. In a previous study, in only two out of 44 histologically proven tumours reported by Wang et al. (1965) were the electroencephalogram, brain scan, and skull radiographs normal. It should be noted that in their study not all patients had all investigations. This, as well as the use of the less sophisticated scanning techniques then available, may account for their false negative results. They also had a lower yield from echoencephalography (41% compared with 52%). We find it rather interesting that in these same two cases angiography also gave negative results.

From our data we conclude that the application of our technique, in the case of a negative result, saves the patient the risks, however minimal, of the more elaborate neuroradiological studies, hospitalization time, and money. The latter consideration is most important in this age of escalating cost in medical care. A total of 228 neuroradiological procedures was carried out in these 147 patients, 77 of them in groups A and C and 151 in group B. In other words, 99 patients underwent 151 ‘unnecessary’ procedures and hospitalization.

When we embarked on this study, our concern was for accuracy of exclusion rather than diagnosis of lesions. Many patients in our original group of 800 who had an intracranial mass had to be excluded from the study. These were the cases with an echoencephalographic shift or a positive brain scan who went directly to angiography or surgery and thus missed some other of the non-invasive investigations. They could have been added to group A on the basis of a positive study alone. This would have increased our apparent percentage of overall accuracy.

The fact that there were 21% false positive
results does not detract from the value of the technique. The criteria of assigning a positive label to any test which was focally abnormal resulted in a higher incidence of false positive results than would have been obtained if a more refined interpretation had been permitted in evaluating statistically this screening protocol. For example, on scanning, a localized area of hypoperfusion in the blood flow study, with or without a positive static image, was considered abnormal in our investigation, although cerebral vascular insufficiency was correctly diagnosed or an infarct could be recognized by assessing the appearance of the abnormal scan image. A number of false positives requiring additional investigation is preferable to missing a potentially treatable intracranial mass. This is emphasized by the 32 cases with abnormal electroencephalograms reported by Decker and Knott (1972) who were not investigated further at the time and were later proved to have an intracranial neoplasm.

In analysing our results we find that isotope angiography was falsely positive six times and did not add any accuracy in diagnosis. We no longer consider it an essential part of our screening technique.

The electroencephalogram was never falsely positive. The importance of proceeding with further studies every time a shifted echo is obtained is stressed.

The institution in which this study was performed is a metropolitan general hospital which does not handle paediatric cases. While our results, we believe, can be extrapolated to any hospital serving a general population, the value and reliability of this technique as applied to children is not known and further investigation in this direction is suggested.

REFERENCES


