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DIAGNOSTIC VALUE OF BRAIN SCANNING IN CHILDREN

BY

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ABSTRACT

Ninety five brain scans were carried out on 70 infants and children. Technetium 99 m pertechnetate was used exclusively, because of its energy level and short physical half-life. Brain scanning provides valuable information regarding the presence of many kinds of neoplastic as well as non-neoplastic lesions. Positive scan results related to the nature of the lesions are; infections 67%, vascular lesions 66%, tumors 75%, trauma 67%, subdural hematoma 88%, congenital diseases 59%, degenerative diseases 0% and convulsive disorders 33%. Scan findings were compared with the findings of plain X-rays of skull, cerebral angiography, pneumoencephalography and electroencephalography. The accuracy of scanning does not necessarily exceed that of other methods of investigation, but it provides a valuable information and increases the accuracy of diagnosis in most cases in children. The possible mechanism of positive scanning in subdural hematoma was studied. The interval between the injection and the timing of scanning was found to be an important factor in diagnosis. Brain scanning should have a place of primary importance for the work-up of children in neurosurgical practice.

INTRODUCTION

Scintilation scanning for intracranial lesions is a relatively new procedure which has rapidly become a valuable diagnostic adjunct. Although brain scanning in the adult has been extensively reviewed, reports on the use of this technique in infants and children, especially of non-neoplastic lesions, are relatively scant. This paper summarizes the results of brain scans performed on infants and children at the Tokyo Medical and Dental University hospital. We also compared the results with the findings of other diagnostic neurologic procedures to define its place as a neuroradio-

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logic adjunct in pediatric neurosurgery.

Materials and Methods

Ninety five brain scans were carried out in 70 infants and children during a one-year period (Table 1). There were more of males, the ratio of males to females being 63 to 37. Approximately one-quarter of the patients was under one year old. Technetium 99 m pertechnetate at a dose of 2 to 10 mCi was used exclusively, because of its energy level and short physical half-life[1]. Potassium perchlorate was given before scanning to reduce the uptake of Tc-99 m in the choroid plexus, thyroid gland and gastrointestinal tract[2]. A scintillation scanning instrument with NaI (Tl) crystal detector, 5 inches in diameter, and 85-hole collimator with a 11-cm focal length was used, which produces simultaneously a photoscan and a paper dot scan. A sandcast was utilized to immobilize the child's head. Sedation was needed for the younger or less cooperative children. Anterior view and lateral views on both sides were done routinely and a posterior view was obtained if a posterior fossa lesion was suspected. Scanning was repeatedly done in selected cases to follow up the course. All of the brain scans were reviewed in random order and classified as positive, suggestive and negative by the authors.

Results

Table 2 shows the results of scanning in relation to the nature of the lesion. The following entities were studied.

Infections

Meningoencephalitis with focal signs showed a positive scan. In sub-

Table 1. Diagnosis of 70 cases with intracranial lesions

	Number of cases	Number of scans
Infections	3	6
Vascular lesions	6	6
Tumors	12	16
Trauma	6	6
Subdural hematomas	17	29
Congenital disorders	15	19
Degenerative diseases	1	1
Convulsive disorders	7	9
Others	3	3
Total	70	95

Table 2. Scan results related to nature of lesions

	No. of scans	Scan results (%)		
		Positive	Suggestive	Accuracy
Infections	6	50	17	67
Vascular lesions	6	33	33	66
Tumors	16	44	31	75
Trauma	6	50	17	67
Subdural hematomas	27	70	18	88
Congenital disorders	19	42	17	59
Degenerative diseases	1	0	0	0
Convulsive disorders	9	0	33	33
Others	5	0	0	0

dural empyema, increased peripheral activity and so-called doughnut sign were noted. In addition to these findings, the crescent-shaped activity in the midline from the posterior view indicated a posterior interhemispheric extension of the empyema and provided a strong evidence for its existence, which otherwise might be overlooked.

Vascular lesions

Arteriovenous malformation and hemorrhage due to hemophilia were positive. It is of interest that one case with acute infantile hemiplegia suggested a diffuse increase in radioactivity on the affected side. Scanning was negative for venous aneurysm of the scalp.

Tumors

There are several reports on the scan results of the brain tumor in children and the accuracy of this test in the tumor is 50 to 80 per cent of overall pediatric cases[3-11]. We do not have any further comment on the brain scan of tumors from our limited experience, except for the positive scan in the brain stem glioma with extraaxial involvement and in the eosinophilic granuloma of the skull. By Tefft[7], the accuracy of positive scans is 90% with low grade cerebellar astrocytomas, 45% with medulloblastoma, 10% with brain stem glioma, 85 to 90% with highly malignant gliomas and 15 to 20% with low grade glioma in the supratentorial region, 65% with optic glioma and 30% with infiltration by acute leukemia.

Trauma

Six patients with trauma were examined. Trauma of the soft tissue and bone showed increased radioactivity which obscured the increased activity within the intracranial cavity itself. This phenomenon may decrease the value of brain scan in head injuries in the acute phase. Brain

Table 3. Relationship of abnormal brain scan to subdural membrane in 9 cases

Scan result	Well developed	Thin	None at surgery
Convincingly positive	3		
Positive	1	2	
Suggestive		2	
Negative			1

scan was useful, however, in traumatic lesions in the chronic stage, especially in brain contusion.

Subdural hematoma

Seventeen patients with this diagnosis were examined. The accuracy of positive scans was 88%. We studied the mechanism of positive scans in subdural hematoma with Tc-99 m in relation to the thickness of the membrane and the isotope concentration in the subdural content. We selected nine cases whose membranes were observed at the time of operation. There was a close relationship between the abnormal brain scan and the thickness of the membrane (Table 3). The isotope activity of the subdural fluid counted by a well type scintillation counter reached the maximum between three to six hours after the injection (Fig. 1). The relative density of the uptake at the region of the subdural hematoma compared with that of the

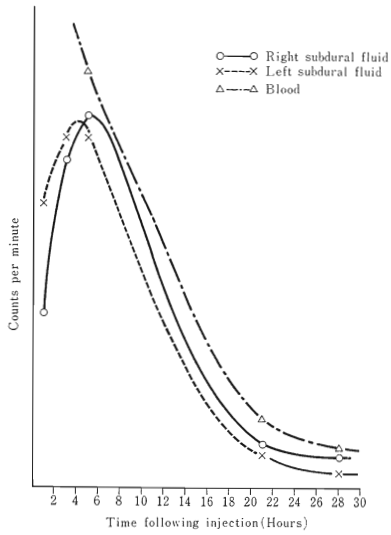

Fig. 1. Concentration of radioactive substance in the blood and subdural fluid.

normal hemisphere studied by a multiplier photometer increases by 50% when the scan is taken three hours after the injection. We performed, therefore, a delayed scan at three hours, if the early scan was negative or equivocal. In this respect, the thickness of the membrane and the interval between the injection of the radioisotope and the time of scanning were found to be essential and important factors for a positive scan.

Congenital malformations

We examined 15 patients with congenital lesions, such as hydrocephalus, porencephaly, congenital skull defect, craniostenosis, etc. We diagnosed these lesions by the brain scan with findings of displacement of the major dural sinus, decrease or increase in radioactivity, etc. Although isotope cisternography or ventriculography is sometimes much more informative in congenital malformations such as hydrocephalus[12,13], approximately one-half of the routine brain scans mentioned above gave some positive or suggestive information for the diagnosis.

Degenerative disease

Although we have only one case with cerebellar degeneration, brain scan was negative as reported in the adult cases.

Convulsive disorder

Convulsive disorders usually give a normal brain scan, but rarely are positive scans found in patients with repetitive seizures. We have experienced three such cases. A transitory breakdown in the blood-brain barrier might be responsible for the increased uptake of radionuclides in the region of the epileptogenic cortex. In addition, it is important to perform it on patients with seizure disorder to rule out any focal lesions, if localizing neurologic signs are suspected.

Other Diagnostic Procedures

We have tried to compare the accuracy of our brain scans with those of other diagnostic studies performed on these patients. Table 4 shows the investigations which were carried out in addition to the scanning for the localization of the lesions. The most common precedures were skull radiography and electroencephalography. Angiography was also carried out in over 60%.

Plain skull X-rays

The correlation between plain skull x-rays and brain scanning is shown

Table 4. Other diagnostic investigations

Examination	No. of cases	Percentage
Skull radiography	52	74
Electroencephalography	50	71
Angiography	42	60
Pneumoencephalography	20	29

Table 5. Scan results compared with skull X-rays

Scan	X-Rays	Agreement	Percentage
Positive	Positive	Good	30
Negative	Positive	Poor	2
Positive	Negative	Poor	20
Negative	Negative	Good	18
Positive	Doubtful	Doubtful	16
Negative	Doubtful	Doubtful	12

in Table 5. There was a close correlation between skull x-rays and scanning in 30% and the accuracy of both of these procedures in combination was 52%.

Electroencephalography (EEG)

Electroencephalography was carried out in 50 patients. The correlation between EEG and brain scanning is shown in Table 6. Although agreement in the results of the investigation for focal diagnosis is only 22%, a combination of the two, including the hemispherical or diffuse abnormality of EEG, led to an accuracy of 88%.

Angiography

Angiograms were performed on 42 patients. As shown in Table 7, the scanning gave positive results in 64% and angiography in 60% of the patients. In 50% there was a close agreement between the results obtained by the two methods. The total accuracy was 74%, in other words diagnostic

Table 6. Scan results compared with EEG

Scan	EEG	Agreement	Percentage
Positive	Focal abn.	Good	22
Negative	Focal abn.	Poor	10
Positive	Hemisph. abn.	Good	14
Negative	Hemisph. abn.	Poor	2
Positive	Diffuse abn.	Doubtful	14
Negative	Diffuse abn.	Poor	12
Positive	Normal	Poor	14
Negative	Normal	Good	12

Table 7. Scan results compared with angiography

Scan	Angiography	Agreement	Percentage
Positive	Positive	Good	50
Negative	Positive	Poor	10
Positive	Negative	Poor	10
Negative	Negative	Good	19
Positive	Doubtful	Doubtful	4
Negative	Doubtful	Doubtful	7

Table 8. Scan results compared with PEG

Scan	PEG	Agreement	Percentage
Positive	Positive	Good	65
Negative	Positive	Poor	10
Positive	Negative	Poor	5
Negative	Negative	Good	10
Negative	Doubtful	Doubtful	10

accuracy was increased by 10% by scanning and 14% by angiography.

Pneumoencephalography (PEG)

PEG was performed on only 20 patients. Scanning led to an accurate localization in 70% and PEG in 75%. The total accuracy was 80%, in other words diagnostic accuracy was increased by 10% by PEG and 5% by scanning (Table 8).

Comment

Brain scanning in the children offers several advantages. The complete absence of morbidity and the apparent negligible radiation hazard are the major reasons for the preference in children. It is easy to perform this compared to angiography or air studies and is adaptable for outpatient use. Because of its low energy and short physical half-life, scanning may be repeated on the same patient at frequent intervals if desired. For example, we performed this four times on one patient with subdural hematoma to follow the course. Repeated serial studies were also useful in patients after surgery and/or irradiation for intracranial neoplasms. Finally, in brain scanning the radioactive isotope is accumulated in the pathological tissue and therefore it accurately defines the location and size of the intracranial lesions. Since the work of Moore with a Geiger-Müller counter and I 131 diiodofluorescein[14], the clinical use of isotopes to detect tumors of the brain developed rapidly. Chlormeldrin Hg 197 was reported to be useful

in pediatrics by Tefft et al.[3] Recently, sodium pertechnetate Tc-99 m has been used exclusively in most institutions because of its lower energy level (140 KeV) and shorter physical half-life (six hours). In-113 m may be used in children, but there remains the problem of the radiation dose for the critical organ, the bladder[15].

To obtain a positive scan, the interval between the injection of the radioisotope and the time of scanning may be an important factor. The importance of delayed scan in various pathological conditions such as subdural hematomas and posterior fossa tumors is stressed[16,17]. Our study on subdural hematomas in children confirms this fact. The optimal interval between the injection and scanning is at least three hours by Tauxe[18]. Further study is needed to determine the interval from injection to scan according to the type of lesion and physical and physiological characteristics of the isotope. There are several reports concerning the comparison of scanning with cerebral angiography, air studies and EEG, especially in the brain tumor[19–22]. Although such an analysis should be made in each type of lesions, we do not have sufficient cases to do this with validity. However, we obtained a rough idea from our study that the diagnostic accuracy of brain scan favorably compares with the conventional more hazardous neurological studies. In addition to its accuracy, because of several advantages listed above, brain scanning should have a place of primary importance for the work-up of children in neurosurgical practice.

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