EFFECT OF CRANIOTOMY ON THE BRAIN SCAN RELATED TO TIME ELAPSED AFTER SURGERY

Peter J. Hurley

The Johns Hopkins Medical Institutions, Baltimore, Maryland

It is well recognized that surgical lesions of the skull can result in long-standing abnormalities of the cerebral scan (*1–6*). The typical finding is a peripheral increase in radioactivity corresponding to the shape of the skull defect and thought to represent uptake of tracer by extracerebral tissues and not the brain itself. This can cause difficulties in interpreting the postoperative scan. At times it is impossible to decide whether an abnormal appearance is due to a recurrence of the original lesion or merely to postcraniotomy residua in the skull and extracerebral soft tissues. Interpretation would be facilitated if one knew the probability of visualizing skull and scalp uptake based on the time elapsed between surgery and scanning. This is the basis of the present study.

PATIENTS AND METHODS

Brain scans or Anger camera images obtained since 1966 in 115 patients who had brain surgery were examined, together with skull x-rays and case histories. There were 100 adults and 15 children (14 years old or younger). In 80 of the adults and all the children, the skull bone flap had been replaced; these have been classified as the "craniotomy" group.

TABLE 1. REASONS FOR SURGERY IN 115 PATIENTS UNDERGOING CRANIOTOMY

	No. of patients	
	Adults	Children
Cerebral tumor	29	5
Pituitary region tumor	7	4
Meningioma	16	1
Posterior fossa tumor	3	4
Subdural accumulation	9	—
Vascular abnormality	8	—
Epilepsy	7	—
Abscess	7	—
Skull lesion	5	—
Other	9	1
	100	15

In 15 adults, part or all of the flap was not replaced ("craniectomy" group); the remaining five adults had had a steel or Teflon skull prosthesis inserted ("cranioplasty" group). None of the 115 patients had burr holes alone: all had had an actual bone flap. The patients' diagnoses are summarized in Table 1.

In all studies the radiopharmaceutical was ^{99m}Tc-pertechnetate, usually with intravenous atropine and oral potassium perchlorate. Rectilinear scans were obtained with the use of one of a number of single- or dual-probe 5-in. scanners, all with focused collimators of 3½-in. focal depth. For gamma camera studies a Nuclear-Chicago Pho/Gamma III instrument with a 4,000-parallel-hole collimator was used. At least four views (anterior, posterior, right, and left lateral), and usually a vertex view as well, were obtained in all cases.

Studies were included in this series only (A) if there was no clinical evidence of a recurrence of the original lesion at the time of scanning, or (B) if all brain abnormalities in the scan could be clearly distinguished and separated from any skull abnormality. The large majority of patients fell into the first category. If the brain scan showed a peripheral accumulation of activity corresponding in size and shape to the skull defect, it was classified "abnormal"; if there was increased uptake which corresponded to only part of the skull defect, the scan was classified "abnormal—partial"; if the scan showed no abnormality in the region of the bony defect, it was classified "normal", regardless of whether a lesion was visible elsewhere or not.

RESULTS

These studies are summarized in Fig. 1 and Table 2. In the "craniotomy" group, adults and children were analyzed separately, but their results

Received June 18, 1971; revision accepted Sept. 30, 1971.

For reprints contact: Peter J. Hurley, Dept. of Radiological Science, The Johns Hopkins Medical Institutions, 615 N. Wolfe St., Baltimore, Md. 21205.

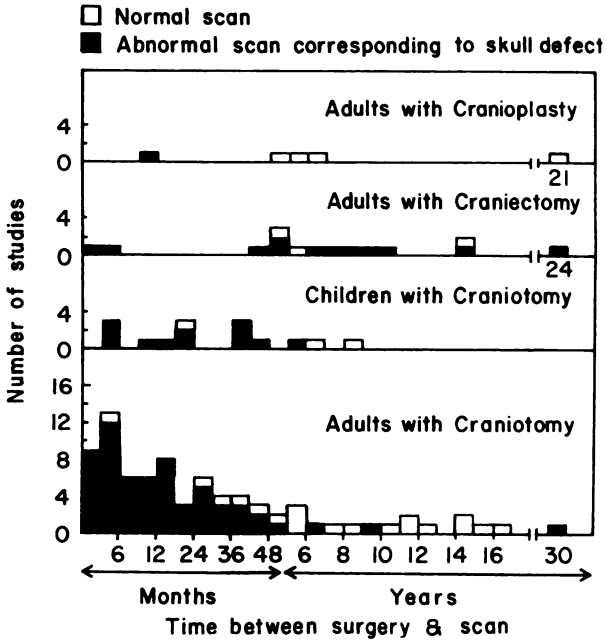

FIG. 1. Histograms showing number of cases classified as abnormal or normal, related to time elapsed between surgery and brain scan. ("Abnormal" and "abnormal—partial" cases have been combined.) Note that time scale on abscissa is not linear.

showed no obvious differences and have been combined in Table 2. This table and Fig. 1 demonstrate a high incidence of abnormal uptake in the region of the skull defect up till 4 years after surgery. From 5 years postoperatively onwards, normal studies predominated, and most of the abnormal group were of the "partial" variety. "Abnormal" and "abnormal—partial" scans showed similar trends, however, and have been combined in Fig. 1. There were only four abnormal scans (all "partial") out of a total of 19 obtained more than 5 years postoperatively. This included one patient in whom a slight but definite increase in activity persisted 30 years after craniotomy.

In the "craniectomy" group (Fig. 1), there was a higher incidence (7 out of 9) of abnormal scans after 5 years postoperatively. All but one of these was of the "partial" variety, the exception being a fully abnormal scan obtained 24 years after surgery. The "cranioplasty" group (Fig. 1) comprised only five patients, four of whom were classified "normal", although those with skull prostheses had diminished activity at the site of the artificial flap.

TABLE 2. "CRANIOTOMY" GROUP: SCAN CLASSIFICATIONS GROUPED ACCORDING TO TIME ELAPSED BETWEEN SURGERY AND SCAN

Period between surgery and scan (yr)	No. of patients				% Abnormal (including partial	%
	"Abnormal"	"Abnormal—partial"	"Normal"	Total		Normal
0–1	31	6	1	38	97	3
1–2	9	5	1	15	93	7
2–3	8	2	2	12	83	17
3–4	5	2	1	8	88	13
4–5	1	1	1	3	67	33
5–6	0	1	3	4	25	75
6–10	0	2	4	6	33	67
10–20	0	0	8	8	0	100
More than 20	0	1	0	1	100	0
	54	20	21	95		

DISCUSSION

According to these results, a craniotomy flap up to 4–5 years after surgery can be expected with 80–90% certainty to result in accumulation of activity visible in the brain scan. From 5 years onwards, there is about a 75% chance that the scan will not be affected. If a substantial piece of bone is permanently removed, the scan is likely to remain abnormal for longer. Wilkins, Pircher, and Odom (*3*) found no striking difference between the patterns of craniotomy and craniectomy but did not discuss the element of time elapsed postoperatively.

The reasons for these abnormalities are unknown; Maynard, et al (*4*) have suggested the type of surgery, whether the dura were closed, possible subdural accumulations, and brain damage as contributing factors, but none of these seem likely explanations for very long-standing derangements. Possibly the surgery results in a prolonged abnormality in the bone extracellular fluid space (*7*).

Several other series (*2,3*) have also included the occasional patient with abnormal uptakes in the region of the skull defect many years after surgery. In some reports (*2,3,5*) the different patterns of abnormal accumulation have been discussed, but little attempt has been made to correlate these with the time interval between surgery and scans. Van Vliet and associates (*1*) in 1965 found no abnormalities in the postcraniotomy brain scan more than 79 days after surgery, but their radiopharmaceutical was ^{131}I-polyvinylpyrrolidone; there appear to have been no other similar studies using more modern agents. Oldendorf and Iisaka (*7*) have suggested double-isotope subtraction techniques as one method of removing interfering skull and scalp activity during external measurements of brain radionuclide content. This could conceivably be extended to the field of imaging. The present data will hopefully also prove useful in some instances of difficult scan interpretation following cranial surgery.

ACKNOWLEDGMENT

This work was supported by USPHS Grant #GM10548. I wish to thank H. William Strauss and H. N. Wagner, Jr. for their help and advice.

REFERENCES

1. VAN VLIET PD, TAUXE WN, SVIEN HJ, et al: The effect of craniotomy on the brain scan. *J Neurosurg* 23: 425–530, 1965

2. HEISER WJ, QUINN JL, MOLLIHAN WV: The crescent pattern of increased radioactivity in brain scanning. *Radiology* 87: 483–488, 500, 1966

3. WILKINS RH, PIRCHER FJ, ODOM GL: The value of postoperative brain scan in patients with supratentorial intracranial tumors. *J Neurosurg* 27: 111–118, 1967

4. MAYNARD CD, HANNER TG, WITCOFSKI RL: Positive brain scans due to lesions of the skull. *Arch Neurol* 18: 93–97, 1968

5. FORSTER DM, BETHELL AN: The diagnostic value of scintillation brain scanning. *Clin Radiol* 20: 257–268, 1969

6. RASMUSSEN P, BUHL J, BUSCH H, et al: Brain scanning—cerebral scintigraphy. *Acta Neurochir* 23: 103–119, 1970

7. OLDENDORF WH, IISAKA Y: Interference of scalp and skull with external measurements of brain isotope content: Part I. Isotope content of scalp and skull. *J Nucl Med* 10: 177–183, 1969

ACCEPTED ARTICLES TO APPEAR IN UPCOMING ISSUES

Precautions in the Management of Patients Who Have Received Therapeutic Amounts of Radionuclides (Book Review). Accepted 9/24/71.
Gerald J. Hine

Adverse Reactions to Radiopharmaceuticals (Letter to the Editor). Accepted 9/30/71.
H. L. Atkins, W. Hauser, P. Richards, and J. Klopper

A Simple Method for Determining Labeling Efficiency of Technetium Sulphur Colloid (Letter to the Editor). Accepted 10/6/71.
Charles L. Lewis and Roland Bramlet

A Nuclear Medicine Quality Control Program (Letter to the Editor). Accepted 10/6/71.
S. Genna, E. W. Webster, J. C. Brantley, G. L. Brownell, J. A. Cardarelli, F. P. Castronovo, H. L. Chandler, and F. X. Masse

Scintigraphic Visualization of Abdominal Lymph Nodes with ^{99m}Tc-Pertechnetate-Labeled Sulfur Colloid. Accepted 10/14/71.
Virgil F. Fairbanks, W. Newlon Tauxe, Joseph M. Kiely, and W. Eugene Miller

Effect of Line Spacing and Ratemeter Averaging on Lesion Detection. Accepted 10/14/71.
L. G. Knowles, E. F. Hart, and A. G. Schulz

Clinical Evaluation of ^{67}Ga-Citrate Scanning. Accepted 10/14/71.
T. Higasi, Y. Nakayama, A. Murata, K. Nakamura, M. Sugiyama, T. Kawaguchi, and S. Suzuki

Studies of Suprarenal Scintigraphy in Humans Using ^{131}I-DDD (Preliminary Note). Accepted 10/14/71.
Gregorio Skromne-Kadlubik, Jorge Alvarez-Cervera, and Filiberto Cortes-Marmolejo

Temporary Circulatory Arrest in the Extremities to Restrict Distribution of I. V. Isotopes (Letter to the Editor). Accepted 10/14/71.
William H. Oldendorf

Rhenium and Technetium Heptasulfide (Letter to the Editor). Accepted 10/15/71.
Marvin B. Cohen and Leonard Spolter

Reply by J. Szymendera and Maria Radwan

Clinical Applications of Computer Assisted Renography. Accepted 10/28/71.
R. H. Secker-Walker, E. P. Shepherd, and K. J. Cassell

Analytical Pitfalls with ^{99m}Tc Labeled Compounds. Accepted 10/28/71.
William C. Eckelman and Powell Richards

The Kinetics of ^{99m}Tc-, ^{113m}In-, ^{169}Yb-DTPA Compounds in Brain Sarcoma and Kidneys of Mice. Accepted 10/28/71.
Thomas P. Haynie, Tad Konikowski, and Howard J. Glenn

Radioisotopic Studies of Changes in Splenic Size in Response to Epinephrine and Other Stimuli. Accepted 10/28/71.
Richard P. Spencer, Robert C. Lange, Allen D. Schwarz, and Howard A. Pearson

Amebic Pericarditis (Case Report). Accepted 10/28/71.
R. E. Anderson and V. M. Varma

Use of Scintiphotography to Outline Abdominal Masses (Case Report). Accepted 10/28/71.
J. McRae, G. F. Stenig, and P. E. Valk

Separation of Lung-Liver Scintiphotos due to Ascites—A False Positive Test for Subdiaphragmatic Abscess. Accepted 11/8/71.
En-Lin Yeh, Philip P. Ruetz, and Robert C. Meade

Radiotriolein Revisited: A Study of the ^{131}I-Triolein Absorption Test Using Radiochemically Pure Triolein in Man. Accepted 11/8/71.
Gary E. Leinbach, David R. Saunders, and Wil B. Nelp

Biliary Excretion of ^{99m}Tc Albumin Microaggregate Degradation Products—A Method for Measuring Kuper Cell Digestive Function? Accepted 11/8/71.
Kenichi Kitani and George V. Taplin

Intrahepatic Lesion Presenting as an Area of Increased Radiocolloid Uptake on a Liver Scan (Case Report). Accepted 11/8/71.
M. Coel, S. Halpern, N. Alazraki, W. Ashburn, and G. Leopold

Scan Reproduction Made Easier and Simpler (Letter to the Editor). Accepted 11/8/71.
Thomas H. Minnich

Tissue Distribution of ^{125}I-Iodopropamide (1-(p-iodobenzene-sulfonyl)-3-n-propylurea-^{125}I) in the Hamster with Beta Cell Carcinoma of the Pancreas (Concise Communication). Accepted 11/11/71.
Lionel M. Lieberman, William H. Beierwaltes, and Charles M. Boyd

Uptake of ^{18}N-Labeled Ammonia (Concise Communication). Accepted 11/12/71.
W. G. Monahan, R. S. Tilbury, and J. S. Laughlin.

Splenic Displacement Due to Gastric Dilatation (Concise Communication). Accepted 11/14/71.
Steven Landgarten and Richard P. Spencer

Persistent Neutrophilic Leukocytosis Associated with Idiopathic Functional Asplenia (Case Report). Accepted 11/14/71.
Richard P. Spencer, Peter McPhedran, Stuart C. Finch, and Walter S. Morgan

Aneurysmal Dilatation of the Superior Vena Cava (Case Report). Accepted 11/14/71.
Anthony R. Gabriele, Luceil North, Felix J. Pircher, and S. F. Boushy

Preparation of High Purity Carrier-Free ^{123}I-Monochloride as an Iodination Reagent for the Synthesis of Radiopharmaceuticals IV. Accepted 11/15/71.
Richard M. Lambrecht, Constance Mantescu, Carol Redvanly, and Alfred P. Wolf

Neutron Activation Analysis of Calcium in Biological Samples. Accepted 11/15/71.
David A. Weber and Howard L. Andrews

Stereo Cisternography (Letter to the Editor). Accepted 11/15/71.
Robert J. Lull

Feasibility of ^{133m}Ba as a Bone Scanning Agent (Letter to the Editor). Accepted 11/22/71.
Robert C. Lange and Richard P. Spencer

Hepatic Phagocytic, Metabolic and Blood Flow Evaluation by Dynamic Scintigraphy. Accepted 11/22/71.
Thomas M. Saba, Ervin Kaplan, Leonard Graham, and Robert P. Cornell

Clinical Feasibility of Myocardial Imaging with ^{13}NH$_3$ (Concise Communication). Accepted 11/22/71.
P. V. Harper, K. A. Lathrop, H, Krizek, N. Lembares, V. Stark, and P. B. Hoffer

Synthesis and Distribution of a Radiolabeled Antitumor Agent: cis-Diamminedichloroplatinum (II) (Concise Communication). Accepted 11/22/71.
Robert C. Lange, Richard P. Spencer, and Harold C. Harder

Simple Technique for Recording Anterior Landmarks on a Prone Patient in Dual-Crystal Scanning (Concise Communication). Accepted 11/22/71.
Ann Nelis and Gunes N. Ege

Diagnosis of Splenic Abscess by Radionuclide Scanning and Selective Arteriography (Case Report). Accepted 11/22/71.
James R. LePage, Avery D. Pratt, Jr., August Miale, and William P. Calvert

A Simpler Method for Optimizing the Window of the Anger Camera for ^{99m}Tc (Letter to the Editor). Accepted 11/22/71.
Robert C. Lange

Agglutination of Labeled RBC (Letter to the Editor). Accepted 11/22/71.
Johannes F. Klopper, Harold L. Atkins, and William C. Eckelman

^{51}Cr-EDTA Biological Half-Life as an Index of Renal Function (Letter to the Editor). Accepted 11/22/71.
T. G. Brien and J. A. Fay

Field Uniformity Distortion with the Pinhole Collimator on the Scintillation Camera (Letter to the Editor). Accepted 11/22/71.
Donald W. Fink and F. Wes Wilcox

Impurities in ^{99m}Tc-Sodium Pertechnetate Produced by Methyl-Ethyl-Ketone Extraction. Accepted 12/2/71.
G. D. Robinson, Jr.

Shortcomings of ^{99m}Tc-Pertechnetate as a Tracer for Brain Tumor Detection as Shown by Well Scintillation Counting of Human Brain Tumors and a Mouse Ependymoblastoma. Accepted 12/2/71.
Michael L. Schwartz and Charles H. Tator

Catabolic Pathway Differences Between ^{131}I and ^{99m}Tc Labeled Albumin Colloids and Microaggregates. Accepted 12/2/71.
Kenichi Kitani and George V. Taplin

Analysis and Correction of Spatial Distortions Produced by the Gamma Camera. Accepted 12/2/71.
Steve S. Spector, Valerie A. Brookeman, Chester D. Kylstra, and Nils J. Diaz.

Scintiphotographic Demonstration of Rupture of an Accessory Spleen (Case Report). Accepted 12/3/71.
Donald W. Fink

Metastatic Thyroid Carcinoma Evaluated with Rapid Scintiphotography (Case Report). Accepted 12/9/71.
Leonard M. Freeman and Peter Mehnert