1999

The Value of a Chest CT in the Evaluation of a Newly Detected Brain Tumor

Jennifer L. White

John W. Henson

The Value of a Chest CT in the Evaluation of a Newly Detected Brain Tumor

Jennifer L. White*

John W. Henson, M.D.

*Department of Biology, Southern Adventist University
Collegedale, TN 37315

Brain Tumor Center, Massachusetts General Hospital
Boston, MA

Keywords: primary brain tumor, metastatic brain tumor, ancillary test, chest x-ray, chest CT

Running title: CHEST CT USAGE FOR BRAIN TUMOR EVALUATION

ABSTRACT

OBJECTIVE: To create a care pathway for patients with a newly detected brain tumor, by examining common diagnostic pathways for patients diagnosed with a primary brain tumor or a central nervous system metastasis.

MATERIALS AND METHODS: All patients diagnosed at MGH between 1/1/95 and 12/31/97 with a primary brain tumor or a central nervous system metastasis were studied. Only patients who displayed one or two brain lesions and presented to the MGH emergency ward or transferred in from another emergency ward were included in the study. Clinical characteristics, use and results of radiological testing, and final diagnostic procedures were evaluated.

RESULTS: Forty-eight patients were selected for the study. The most common ancillary test performed was a chest x-ray; 97.9% of the patients received a chest x-ray, while only 18.8% received a chest CT. None of the chest CT examinations showed a diagnostically significant different from the chest x-ray. Other ancillary scanning was done infrequently.

DISCUSSION: A relatively small proportion of patients with a newly detected brain lesion received any type of ancillary testing beyond a chest x-ray. A chest x-ray appeared to change the biopsy site from the brain to another site in about 50% of the cases. Not enough chest CT examinations were done to determine their effectiveness. However, the results seem to indicate that the preliminary diagnosis of the admitting physician is not necessarily based upon the results of a chest x-ray or other ancillary testing.

INTRODUCTION

Brain tumors have been diagnosed in about 34,000 people annually in the United States (7). Brain tumors can be classified into two groups, depending upon where the tumor originated in the body. Primary brain tumors originate in the brain, while metastatic brain tumors are formed from cancer cells which travel to the brain from a distant site in the body (3). Although the annual deaths from metastatic brain tumors has been estimated to be at least 2 ½ times greater than those from primary brain tumors (4), both primary and metastatic brain tumors are diagnosed about in equal numbers annually (7). Primary and metastatic tumors can be further classified according to their cellular component. This histological diagnosis is necessary before treatment of the tumor can begin, since the treatments for brain tumors vary depending upon the particular tumor type (1,3,6).

There are a variety of diagnostic methods available to detect these tumors. Clinically, brain tumors display both neurological symptoms, such as seizure, sensory changes, and altered mental status, and systemic symptoms (1,2). Since these symptoms are shared with many other brain abnormalities, radiological imaging is used to distinguish between them (1). Computed tomography scans (CT) and a magnetic resonance imaging (MRI) are the most common devices used for detection of structural brain abnormalities, and can often distinguish between brain tumors, other brain lesions, and occasionally between tumor types (1,5). Less commonly used diagnostic tests include magnetic resonance angiography, electroencephalography (EEG), and cerebral spinal fluid analysis (CSF) (1). In patients with a brain lesion, histological diagnosis from a biopsy is usually needed to confirm the tumor and its classification, as well as to determine the treatment regimen.

Once a brain lesion has been detected in a patient not previously known to have cancer, the initial diagnostic procedures vary greatly. Depending on the nature of the brain lesion, the neurosurgeon may elect to completely remove, or resect, the lesion (6). Alternatively, a biopsy is done when small tissue sample can be removed. Particularly in patients where only a biopsy is indicated, finding a biopsy site other than the brain is often preferable. Thus, some patients may receive ancillary testing to determine if metastatic cancer is present at distant sites in the body. Radiological testing may include a chest x-ray, a chest CT, an abdominal CT, and a radionucleotide bone scan. Since there is no basic pathway by which most of these patients are evaluated, it is not known how often ancillary testing is done, or how useful it is in guiding further diagnosis and treatment of the patient. It is also unknown how often an abnormal result on a particular ancillary test will change the biopsy site from the brain to another organ, i.e. the lung.

Because radiologic and laboratory procedures are very costly, it is desirable to know what imaging is necessary to bring about a decision for definitive diagnosis and treatment of a suspected brain tumor. This initial treatment process alone has been shown to require an estimated 75% of the total cost of treatment of high-grade astrocytomas, a common primary brain cancer (6). By eliminating unnecessary diagnostic testing, the money and time spend to diagnose a newly detected brain mass could be significantly reduced, which would help reduce the overall costs of treating brain tumors. To facilitate this, care pathways or algorithms are often created to determine the best method of diagnosing or treating a patient, with the least amount of wasted resources.

The purpose of this preliminary study is to attempt to create a care pathway for patients with a newly detected brain mass, by examining common diagnostic pathways from the case histories of such patients seen at the Massachusetts General Hospital (MGH) between 1995-1997. More specifically, this study will attempt to examine how often a chest CT changes the biopsy site away from the brain, as opposed to a chest x-ray, in patients displaying one or two brain lesions. Patient cases will be retrospectively reviewed to identify all diagnostic testing done and their final diagnostic procedure.

MATERIALS AND METHODS

Patient Selection

Patients diagnosed at MGH with first-time primary brain tumor or central nervous system (CNS) metastasis between January 1, 1995 to December 31, 1997 were obtained from the Cancer Data Registry at MGH. The cases were retrospectively examined to select patients who either presented directly, or transferred in to the MGH emergency ward (EW) at the time of their brain lesion detection, and had only one or two brain lesions. The following factors were used as patient exclusion criteria: (1) patients who already had diagnosed cancer; (2) patients who did not have an intracranial brain lesion; (3) patients who had a previous histological diagnosis done previous to admission to MGH; (4) patients with three or more brain lesions; (5) patients who did not admit to MGH EW or transfer in from another EW; and (6) patients diagnosed with acquired immune deficiency syndrome.

Data Collection

For each of the patients, clinical and diagnostic data were abstracted: date of birth, gender, date of symptom onset, neurological and systemic symptoms, results of the EW physical exam. Neurological symptoms included altered mental status, language, vision or sensory changes, weakness or paralysis, clumsiness, and gait changes. Systemic symptoms included weight loss, abnormal cough, pain, vaginal bleeding, nausea/vomiting, fever, and fatigue. The date and result of all initial diagnostic testing was recorded, including the first CT and MRI scan, chest x-ray, chest CT, abdomen/pelvic CT, RN bone scan, including the final diagnostic procedure, site and results. The radiographic test results were reported as abnormal when the image indicated possible cancerous nodules or lesions, or an air-space disease, such as pneumonia.

RESULTS

A total of 442 patients were diagnosed with a primary brain tumor or CNS metastasis at MGH from January 1, 1995 to December 31,1997. Two hundred ninety-five were diagnosed with primary brain tumors, while 147 were diagnosed with CNS metastases. To date, 349 files have been reviewed: all 147 metastatic brain tumors files and 202 primary brain tumor files. Of these, a total of 48 (13.8%) patients fit the study selection criteria. Thirty-eight patients (72.9%) were ultimately diagnosed with a primary brain tumor, and 10 (20.8%) were diagnosed with a metastatic brain tumor.

Of the 48 selected patients, the mean age of the patients was 53 and median age was 60 (range 5-90 years). Thirty-three (68.8%) were male, fifteen (31.3%) were female. The most commonly presented symptoms were neurological in nature; only one patient did not present with neurological symptoms. However, the majority of the patients (75.0%) did not present with systemic symptoms. Table 1 indicates the frequency of ancillary testing done. A chest x-ray was done the most frequently, while only nine patients received a chest CT (Table 1). Abdominal CTs were done even less frequently, and no patients had radionucleotide bone scanning done (Table 1).

Table 2 shows the distribution of ancillary scanning and final diagnosis among the 47 patients receiving a chest x-ray. Thirty-five (74.5%) of the chest x-rays revealed normal chest examinations, while 12 (25.5%) showed possible lung masses or air-space diseases. Nine patients also received a chest CT; seven of these exams were for further characterization of an abnormal chest x-ray (Table 2). Only two patients with a normal chest x-ray received a chest CT and both resulted in a normal chest examination (Table 2). Five patients received an abdominal CT of which these were positive for an abnormality and all three also had normal chest x-ray examinations (Table 2). All patients who had a normal chest x-ray had a brain procedure, or craniotomy, done for diagnosis (Table 2). However, the diagnosis site for those who had abnormal chest x-rays showed greater variation (Table 2). Of the 35 patients who had a normal chest x-ray, only four had metastatic cancer. Of the 12 patients with abnormal chest x-rays, half had metastatic cancer.

Table 3 compares the results of patients who received both a chest x-ray and a chest CT examination. All of the patients who had metastatic cancer had an abnormal chest x-ray and chest CT, while only one patient who had a primary brain tumor had an abnormal chest x-ray and chest CT (Table 3). Out of all 9 patients who received both a chest x-ray and a chest CT, none of them had conflicting test results (Table 3).

Table 4 shows the diagnostic history of four patients who had a normal chest x-ray had metastatic cancer. The specific ancillary testing and diagnostic test for each of these patients is listed in Table 4. None of these patients received any further ancillary testing. Three out of the four had a brain resection, while only one received a brain biopsy. Table 5 shows the type of diagnostic testing done for patients who had an abnormal chest x-ray. All patients whose final diagnosis was a primary brain tumor had their first diagnostic procedure done in the brain (excluding one patient who did not have any further diagnostic testing for their brain lesion except a head scan). Likewise all patients whose final diagnosis was metastatic cancer had their first diagnostic procedure perform at a location other than the brain (excluding one patient who did not have any further diagnostic testing).

Table 6 shows the differences in ancillary testing and diagnosis based on the number of lesions each patient had. Forty patients (83.3%) had a single brain lesion, while 8 (16.7%) had two brain lesions. Six people from each category had an abnormal chest x-ray. This shows a much higher percentage of abnormal chest x-rays for patients with two brain lesions (75.0%) as compared to patients with only one lesion (15.0%). There is a much higher percentage of diagnostic procedures done in the brain for patients with only one brain lesion (95.0%), than for patients with two brain lesions (37.5%). Half of the patients with two brain lesions had a diagnostic test done outside of the brain, while only one patient with one brain lesion had a diagnostic test done outside of the brain. The majority of patients with only one brain lesion had a primary brain tumor, while the majority of patients with two brain lesions had metastatic cancer.

DISCUSSION

From the data collected so far, over seventy-five percent, it appears that a relatively small proportion of patients with a newly detected brain lesion received any type of ancillary testing further than a chest x-ray. A normal chest x-ray was more common for patients with primary brain tumors; however an equal number of patients with primary brain tumors and metastatic brain tumors had abnormal chest x-rays (Table 2). Of these, two patients required brain resection. Thus, five out of ten patients with an abnormal chest x-ray, who were eligible for a brain biopsy, had a biopsy done at a non-brain site. So in 50% of patients with an abnormal chest x-ray, the biopsy site moved away from the brain.

The other ancillary scanning was not done enough to determine any significant trends. Only nine patients received both a chest x-ray and chest CT, and none of the chest CT examinations showed a diagnostically significant difference (Table 3). Seven patients with abnormal chest x-rays also had a chest CT done to characterize the x-ray results further. Of the seven patients who had abnormal chest CT results, five (71.4%) had a diagnostic procedure done at a non-brain site (Table 2). This percentage is misleading though, because so few patients received both chest x-ray and chest CT examinations. It is possible that though the additional information provided by the chest CT influenced the selection of a non-brain biopsy site more than the chest x-ray did. However, the relative value of a chest x-ray versus a chest CT can not be compared from this data, because not all patients received both a chest x-ray and CT exam. Three patients who had an abnormal chest x-rays, and did not require brain resection, did not have a chest CT done, so it is not known how this test might have influenced the selection of a biopsy site.

Interestingly, the results seem to indicate that the preliminary diagnosis of the admitting physician is not necessarily based upon the results of a chest x-ray or other ancillary testing. The data indicate that only four patients who had a normal chest x-ray had a craniotomy procedure whose resulting diagnosis was metastatic cancer (Table 2). Three of these were a resection procedure, rather than a biopsy procedure (Table 4). Thus only one patient had received a craniotomy when a less invasive procedure might have been able to be done. None of the patients who received an abnormal chest x-ray, and were ultimately diagnosed with metastatic cancer, had a craniotomy procedure done (Table 5). However, an equal number of patients receiving an abnormal chest x-ray result, and were ultimately diagnosed with a primary brain tumor, received a craniotomy (Table 5).

The number of brain lesions a patient has showed about the same selectivity that a chest x-ray did in separating patients with a primary brain tumor from those with metastatic cancer (Table 6). If the number of brain lesions a patient had was used as the final diagnostic test, then six people out of 48 would have been misdiagnosed (12.5%). Table 7 combines the criteria of number of brain lesions versus chest x-ray results. This indicates that in this study that 90.9% of patients with a single brain lesion and a normal chest x-ray had a primary brain tumor, and that 83.3% of patients with two brain lesions and an abnormal chest x-ray had a metastatic brain tumor. There were eight patients which had indicators for both primary and metastatic brain lesions. For patients which had a single brain lesion and an abnormal chest x-ray, 83.3% of them had a primary brain tumor. From this it appears that a single brain lesions was a better indicator for a primary brain tumor. These criteria still do not show the accuracy rate observed in the selection of biopsy sites for the patients.

One possibility for why this is the case may be that an MRI or CT scan is sensitive enough to distinguish between primary brain tumors and metastatic brain tumors and other potential brain lesions, so less people are receiving ancillary testing. There appears to be some evidence from the patient files. If a head scan alone is sensitive enough to distinguish a primary lesion from a metastatic lesion, then the admitting physician can be more selective of patients who receive more advanced ancillary testing. In general though, it appears that most patients receive a chest x-ray as a standard diagnostic test, and that this may affect the choice of a biopsy site.

To further compare the value of a chest x-ray and chest CT as ancillary tests, a greater population of patients who have had both scans needs to be obtained. These data need to be interpreted cautiously, as the data is not completely collected yet, and it is possible that the current trends in the data could change. Further plans for the study include finishing data collection as well as retrospective evaluation of the initial head scans for each patient. The initial MRI and CT head scans for each patient have been collected, to allow various diagnosing physicians to predict the final diagnosis based upon the head scan alone, without knowing the actual diagnosis of the patient. This could provide a better understanding of the factors that influence the patient's diagnostic procedure, and what factors allow the accurate preliminary diagnosis of a suspected brain tumor.

Table 1. Prevalence of Ancillary Scanning

Ancillary Test	Patients	
	Number	Percentage[a]
Chest X-Ray	47	97.9
Chest CT	9	18.8
Abdominal CT	5	10.4
Bone Scan	0	0

[a]Total number of patients=48.

Table 2. Distribution of Ancillary Scanning and Diagnosis Among Patients Receiving a Chest X-Ray.

Chest X-ray	Chest CT	Abdominal CT	Diagnostic Test	Final Diagnosis
Normal[a] 35	Normal 2 Abnormal 0 Not Done 33	Normal 1 Abnormal 3 Not Done 31	Brain Biopsy 16 Brain Resection[c] 19 Non-brain Biopsy 0	Primary 31 Metastatic 4
Abnormal[b] 12	Normal 0 Abnormal 7 Not Done 5	Normal 1 Abnormal 0 Not Done 11	Brain Biopsy 3 Brain Resection 2 Non-brain Biopsy 5 Not Done 2	Primary 6 Metastatic 6

[a]Normal radiological examinations showed no indications of nodules, lesions or other irregularities or air-space disease.
[b]Abnormal radiological examinations revealed possible cancerous nodules, lesions or air-space disease.
[c]A complete removal of tumor tissue.

Table 3. Comparison of Final Diagnosis to Results of Chest X-Ray and Chest CT

Final Diagnosis		Chest X-Ray		Chest CT	
		Normal[a]	Abnormal[b]	Normal	Abnormal
Primary Brain Tumor	3	2	1	2	1
Metastatic Brain Tumor	6	0	6	0	6

[a-b]See Table 2.

Table 4. History of Patients with Metastatic Cancer Who Had a Normal Chest X-ray

Patient	Number of Lesions[a]	Chest CT	Abdominal CT	Diagnostic Test
1	1	Not Done	Not Done	Brain Resection[b]
2	1	Not Done	Not Done	Brain Resection
3	2	Not Done	Not Done	Brain Resection
4	1	Not Done	Not Done	Brain Biopsy

[a]The number of brain lesions observed from the patients first CT or MRI brain scan.
[b]See Table 2.

Table 5. Distribution of Diagnostic Tests Among Patients Receiving Abnormal Chest X-Rays

Diagnostic Procedure	Final Diagnosis	
	Primary	Metastatic
Brain Biopsy	3	0
Brain Resection[a]	2	0
Non-brain Biopsy	0	5
Not Done	1	1

[a]See Table 2.

Table 6. Comparison of the Distribution of Chest Scans and Resulting Diagnosis of Patients with One and Two Brain Lesions.

Number of Lesions[a]		Chest X-Ray		Chest CT		Diagnostic Test		Final Diagnosis	
One	40	Normal[b]	33	Normal	2	Brain Biopsy	17	Primary	36
		Abnormal[c]	6	Abnormal	2	Brain Resection[d]	21		
		Not Done	1	Not Done	36	Non-brain Biopsy	1	Metastatic	4
						Not Done	1		
Two	8	Normal	2	Normal	0	Brain Biopsy	2	Primary	2
		Abnormal	6	Abnormal	5	Brain Resection	1		
		Not Done	0	Not Done	3	Non-brain Biopsy	4	Metastatic	6
						Not Done	1		

[a]See Table 4.
[b-d]See Table 2.

Table 7. Comparison of Lesion Number and Chest X-Ray Results with Final Diagnosis

Number of Lesions[a]		Chest X-Ray		Final Diagnosis	
One	39	Normal[b]	33	Primary	30
				Metastatic	3
		Abnormal[c]	6	Primary	5
				Metastatic	1
Two	8	Normal	2	Primary	1
				Metastatic	1
		Abnormal	6	Primary	1
				Metastatic	5

[a]See Table 4.
[b-c]See Table 2.

REFERENCES

Black, P and Wen, PY. 1995. "Clinical, imaging and laboratory diagnosis of brain tumors." In *Brain Tumors: An Encyclopedic Approach.* Ed. AH Kaye and ER Laws Jr. Churchill, Livingstone: New York, 191-214.

Das, A and Hochberg, FH. 1996. Clinical Presentation of Intracranial Metastases. *Neurosurgery Clinics of North America.* 7(3): 377-391.

Henson, JW. 1999. "Glioblastoma Multiforme and Anaplastic Astrocytoma, Anaplastic Oligodendroglioma: A Guide For Patients." MGH Brain Tumor Center.

Posner, JB. 1995. "Neurologic Complications of Cancer." Contemporary Neurology Series, vol. 45. Davis, Philadelphia, 3-14.

Scaefer, PW, Budzik, RF, and RG Gonzalez. 1996. Imaging of Cerebral Metastases. *Neurosurgery Clinics of North America.* 7(3): 393-423.

Silverstein, MD, Cascino, TL, and WS Harmsen. 1996. High-Grade Astrocytomas: Resource use, Clinical Outcomes, and Cost of Care. *Mayo Clinic Proceedings.* 71(10): 936-944.

Walker, AE, Robins M, and FD Weinfeld. 1985. Epidemiology of brain tumors: The national survey of intracranial neoplasms. *Neurology.* 35(2): 219-226.

SOUTHERN SCHOLARS SENIOR PROJECT

Name: Jennifer White   Date: 9/9/99

Major: Biology

Senior Project

A significant scholarly project, involving research, writing, or special performance, appropriate to the major in question, is ordinarily completed the senior year. Ideally, this project will demonstrate an understanding of the relationship between the student's major field and some other discipline. The project is expected to be of sufficiently high quality to warrant a grade of A and to justify public presentation. The completed project, to be turned in in duplicate, must be approved by the Honors Committee in consultation with the student's supervising professor three weeks prior to graduation. The 2-3 hours of credit for this project is done as directed study or in a research class.

Keeping in mind the above senior project description, please describe in as much detail as you can the project you will undertake:

During summer internship with Dr. John Henson at Massachusetts General Hospital, I ~~wanted~~ did research on the process of diagnosing brain tumors at the MGH. Through a retrospective analysis of patients with a newly detected brain lesion, I created a database of patients and all the types of diagnostic testing they received, the results of certain tests, physical symptoms, admitting diagnosis & dates, and final diagnosis/date. This database can then be sorted to determine the frequency of certain diagnostic testing and its usefulness. The ~~specific~~ purpose of this project is to create a care-pathway for patients with a newly detected brain lesion; specifically, ~~and~~ to determine how often a chest CT changes the biopsy site away from the brain as opposed to a chest X-ray.

Expected date of completion 12/17/99

Signature of faculty advisor Linda Ann Foster

Approval to be signed by faculty advisor when project is completed:

This project has been completed as planned: yes af

This is an "A" project: yes - af

The project is worth 2-3 hours of credit: yes af

Advisor's Final Signature Linda Ann Foster

Chair, Honors Committee ____________ Date Approved: ________