AJNR

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AJNR Am J Neuroradiol 1996, 17 (7) 1259-1263
http://www.ajnr.org/content/17/7/1259

Utility of Repeat Brain Imaging in Stroke

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PURPOSE: To determine the utility of repeat brain imaging in patients with stroke. **METHODS:** We reviewed the medical records of 98 consecutive patients in whom stroke was diagnosed between January 1 and December 31, 1991. We noted the number of brain scans performed, the indications cited, and whether repeat imaging changed the therapeutic decisions or final diagnosis. **RESULTS:** Ninety-eight patients underwent 221 procedures, with 123 repeat imaging studies (98 CT scans and 25 MR images). Sixteen patients had only one scan; 51 had two, and 31 had three or more. Indications for repeat imaging were explicitly documented in 62 (50%) of 123 repeated scans and inferred in another 41 (33%). In 20 (16%), no definite indication could be determined. Indications included lack of acute abnormal imaging findings on the initial scan (n = 48, 39%); compliance with stroke research protocol (n = 24, 20%); lack of correlation between clinical examination and initial radiologic findings or concern that tumor was mimicking infarction (n = 20, 16%); and neurologic deterioration (n = 11, 9%). In none of the 82 patients did the repeated scan change the diagnosis; therapy was changed in only two (2%) of 82 patients (aspirin was discontinued). **CONCLUSIONS:** Repeat imaging in patients rarely results in changes in the initial diagnosis or the therapeutic plan; indications for repeat imaging are frequently not clearly stated; in certain groups of patients with stroke, repeat imaging may not be useful.

Index terms: Brain, computed tomography; Brain, infarction; Brain, magnetic resonance; Efficacy studies

AJNR Am J Neuroradiol 17:1259–1263, August 1996

Computed tomographic (CT) scans of the brain are routinely done in the work-up of patients who appear clinically to have had a stroke. Within 48 hours of the ictus, findings on the CT scans may look completely normal (1–5). As a result, it has become common practice for many physicians to repeat the CT scan 48 to 72 hours after the ictus, or to obtain a magnetic resonance (MR) image. In addition, serial head CT and MR studies are commonly used to document the evolution of brain hemorrhage and to rule out underlying tumor. The purpose of this study was to explore this common practice and to determine its impact on the diagnosis and treatment of patients with stroke.

Received October 17, 1995; accepted after revision February 13, 1996.

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AJNR 17:1259–1263, Aug 1996 0195-6108/96/1707–1259

Materials and Methods

In this retrospective study, we reviewed the medical records of 98 consecutive patients admitted to the neurology service at our institution between January 1 and December 31, 1991, with the diagnosis of acute stroke. Patients were included if they had an acute neurologic deficit that lasted more than 24 hours. Patients with traumatic intracranial hemorrhage were excluded. The diagnosis of stroke was based on clinical presentation as documented by the admitting attending neurologist and the results of initial brain imaging, and included 91 patients with infarcts and seven patients with intracerebral hemorrhage. The use of antiplatelet agents or anticoagulants was recorded in each case. All repeat imaging studies were ordered by the treating attending neurologist, and imaging interpretation was based on the official attending neuroradiologist's report. Our review focused on the number and type of scans performed, the indications cited for the follow-up scans, and whether repeat imaging changed the therapeutic course or diagnosis. A clinically important change in imaging findings was defined as, for example, a negative scan's becoming positive; that is, evidence of new or progressive hydrocephalus, hemorrhage, or mass effect. A change in therapy was defined as the addition or discontinuation of an anticoagulant or antiplatelet medication. A change in diagnosis was defined as the diagnosis of

stroke's being changed to, for example, brain tumor or some other intracerebral disorder.

Results

All 98 patients had their initial scan within 24 hours of presentation to the emergency department, with the exception of one patient who had an MR examination at an outside facility. All first scans were performed without intravenous contrast material. One hundred twenty-three repeated studies (96 noncontrast CT scans, two contrast-enhanced CT scans, and 25 MR images) were obtained in 82 patients, with an overall average of 2.2 scans per patient. In those with hemorrhage, the average was 3.1 scans per patient. Sixteen percent of patients had only one scan, 52% had two scans, and 32% had three or more scans (Table 1). In only 50% of cases was the indication for a follow-up scan clearly stated. In another 33% of cases, the indication could be inferred from clinical data on the chart. In 16% of all follow-up scans and 45% of scans obtained in patients with hemorrhage, no clear indication for the scans could be discerned from the charts. Indications for follow-up scans are summarized in Table 2.

Thirty-five percent of patients had a demonstrable lesion on the initial scan, 66% had positive findings on a second scan, and 74% had positive findings on a third scan (Table 3). Of all patients with positive findings on brain scans, 25% had CT evidence of infarction in the right middle cerebral artery distribution, 19% had infarction in the left middle cerebral artery distribution, 2% had an infarction in the anterior cerebral artery distribution, 13% had an infarction in the vertebrobasilar territory, and 10% had a primary intraparenchymal hemorrhage. Twenty-one percent of the total group of patients met clinical criteria for a lacunar infarct (with or without evidence of a small deep infarct on imaging studies). Twenty-one percent of patients did not have radiologic confirmation of an acute stroke (with a clinical presentation highly suggestive of cerebral infarction) despite having had two or more brain scans. Only 21% of patients with positive findings on initial scans had no further imaging procedures.

None of the 82 patients who had repeat imaging had a change in diagnosis as a result of follow-up scans. Only two patients had a therapeutic change, which entailed the discontinuation of aspirin after hemorrhage was seen on the follow-up scan. Thirty-eight percent of second scans and 32% of third scans showed clinically important changes compared with prior scans (Table 4).

One example of questionable use of imaging procedures was in a 66-year-old man with a history of hypertension who presented with acute onset of a pure motor deficit involving his

TABLE 1. Therapeutic and diagnostic changes as a result of follow-up scans in 98 patients

Total No. of Scans per Patient	No. of Patients	No. of Patients with Therapeutic Change after Follow-up Scan	No. of Patients with Change in Diagnosis after Follow-up Scan
1	16	0	0
2	51	2	0
3	23	0	0
4	7	0	0
5	. . .	. . .	. . .
6	1	0	0

TABLE 2. Reasons for 123 repeat scans

Reason	No. (%) of Scans Repeated
Negative findings on prior study	48 (39)
Change in neurologic status	11 (9)
Research protocol	24 (20)
Other (eg, rule out tumor)	20 (16)
No obvious indication	20 (16)

TABLE 3. Breakdown of scan findings and types of scans performed

Finding	Scan					
	1st (%)	2nd (%)	3rd (%)	4th (%)	5th (%)	6th (%)
Negative (no acute disease)	64 (65)	28 (34)	8 (26)	2 (25)	0	0
Positive (acute disease)	34 (35)	54 (66)	23 (74)	6 (75)	1 (100)	1 (100)
Total no. of scans	98	82	31	8	1	1
Noncontrast head CT	97	69	21	4	1	1
Contrast-enhanced head CT	0	1	1	0	0	0
Brain MR imaging	1	12	9	4	0	0

TABLE 4. Clinically important* radiologic changes in follow-up scans

Between				
First and Second Scans	Second and Third Scans	Third and Fourth Scans	Fourth and Fifth Scans	Fifth and Sixth Scans
31/82 (38%)	10/31 (32%)	0/8 (0%)	0/1 (0%)	0/1 (0%)

* Clinically important was defined as a change in imaging findings from negative to positive, new or progressive hydrocephalus, hemorrhage, or mass effect.

left arm and leg equally. The initial impression cited in the chart was a lacunar infarct involving the right hemisphere. Findings on the initial CT scan were negative. The patient remained stable throughout his hospitalization; however, he went on to have two more CT scans and an MR examination, all of which were negative. He was discharged 18 days later with the diagnosis of a right lacunar infarct.

A second case involved a 75-year-old man with a history of hypertension who presented with acute onset of lethargy and right hemiparesis. The initial CT scan revealed a left putamenal hematoma consistent with hypertensive hemorrhage. During his first 24 hours of hospitalization he became obtunded and was treated with mannitol and hyperventilation. An emergency repeat CT scan revealed hydrocephalus. Over the next 24 hours, the patient responded to conservative treatment and was stable throughout the rest of his hospitalization. However, despite remaining clinically stable, the patient had four additional CT scans during his 45-day hospitalization, none of which changed his diagnosis or treatment.

Discussion

The utility of initial CT examination in the evaluation of stroke, as proposed by Sandercock et al (6), includes being able to differentiate stroke from other, more treatable lesions, to detect cerebellar hemorrhage or infarction, and to exclude hemorrhage in those taking (or likely to need) anticoagulants. CT and MR imaging have had a major impact on modern neurology. Their easy accessibility and relative noninvasiveness and the wealth of information that these tests provide have made them indispensable in many types of diagnostic workups. However, it may be that many physicians order these tests to excess, in a manner that is not necessarily beneficial to patient care or cost effective. The neurologist relies heavily on information obtained from a detailed history and physical examination. The diagnosis of stroke and the location of the lesion can often be made on clinical grounds alone. When used appropriately, brain imaging is a helpful tool that can confirm or disprove an original diagnosis and help guide further workup and management. However, there appears to be a tendency among some neurologists to repeat CT or MR studies automatically. As we have shown in this small study, not one of our 98 patients had a change in diagnosis attributable to a follow-up scan. Only two patients had a change in treatment (discontinuation of aspirin) after hemorrhage was found on the follow-up scan. Moreover, we are unaware of any studies suggesting that aspirin is contraindicated in the presence of hemorrhagic infarction, and even the need to discontinue anticoagulation therapy in this setting has been questioned (7).

Our study has several limitations. Our observations are tempered by the distinct possibility that our sample of patients was not representative of ischemic stroke patients in general, in terms of the risk of hemorrhagic conversion. Only two (2%) of our 82 patients who had repeat scans had evidence of hemorrhagic infarction, a far lower rate than the 43% documented by Hornig et al (8), although their follow-up extended up to 1 month. Since we defined *utility* in large part on the basis of a change in anticoagulant or antiplatelet therapy, our study outcome was overwhelmingly dependent on the frequency of hemorrhagic conversion of ischemic stroke. While the practice of discontinuing anticoagulation therapy in this setting has been debated (7), our sample may for some reason have been biased toward patients with a lower frequency of hemorrhagic conversion, thus underestimating the impact of this finding in conventional neurologic practice. In addition, our criteria for utility, which involved altered diagnosis or therapy, did not consider another benefit frequently cited by practicing neurologists; namely, delineation of the extent of the stroke at baseline should subsequent strokes occur. This rationale may be questioned, but it is possible that it would prove quite useful in subsequent examinations of the patient. We also did not consider the importance of negative

findings seen on repeat imaging studies. For example, the exclusion of some potentially dangerous event, such as subdural hematoma, mass effect, and so forth, would allow the patient's treatment to be continued unchanged. While indications for repeat imaging were frequently not stated, this may reflect the limitations of our retrospective study and a lack of adequate documentation rather than inappropriate decisions made by the treating clinicians.

In these times of health care economic reform, it is clear that medical technology can be used more cost-effectively. As we have suggested in our small study, the outcome in our 98 patients would probably have been the same if they had not undergone the 123 repeated scans. Theoretically, the money spent on these repeated scans might have been allocated to more fruitful ends, such as providing more extensive physical, occupational, and speech therapy; improving and expanding rehabilitation facilities; making home care more readily available; and funding further research on acute stroke intervention and on primary and secondary prevention.

To optimize the use of medical resources, we propose the following guidelines for repeat brain imaging in patients whose clinical presentation is consistent with stroke:

1. If treatment with anticoagulants or thrombolytic agents is being considered, a repeat CT scan is indicated to exclude hemorrhage.

2. If history, clinical presentation, or initial CT findings suggest a tumor, the patient should have an MR examination or contrast-enhanced CT study. (We appreciate the study by Wang et al [9], in which three of 530 patients with a clinical diagnosis of stroke were later found to have brain tumors on follow-up scans.)

3. If the neurologist is unable to locate the lesion by means of history and examination, if findings on the initial CT scan are negative for acute abnormalities, and if the location and size of infarct will make a difference in further management (eg, a pial territory infarct consistent with branch occlusion might prompt a more intensive search for the sources of the embolism), the patient should undergo a repeat CT or MR study. While in none of our cases did repeat imaging result in a change in stroke subtype diagnosis, this possibility is increasingly compelling, as ongoing research may suggest optimal therapy for specific stroke subtypes. The repeat scan should not be done for at least 72 hours after the ictus so as to optimize the chance of detecting the infarct (2).

4. If the patient is experiencing neurologic decompensation, and surgical or medical intervention is being contemplated, it is reasonable to repeat the scan in order to differentiate among an evolving infarct, hemorrhage, hydrocephalus, or mass effect. In the case of massive hemorrhagic conversion, for example, repeat imaging may forestall therapy, such as anticoagulation, which is still commonly thought to be hazardous in this situation.

5. If the clinician believes that radiologic confirmation is absolutely necessary in those patients who appear clinically to have had a lacunar or posterior fossa infarct, and results of initial CT are negative, a follow-up MR study should be done rather than a repeat CT scan. MR imaging has been shown to be far superior to CT in depicting strokes of the posterior fossa and lacunae (3, 10–12).

6. If the initial head CT scan reveals an intraparenchymal hemorrhage and the patient is clinically stable, there is no need to document the evolution of the hematoma with serial scans. Further work-up should be gauged according to the index of suspicion of an underlying lesion. If a neoplasm is suspected, an MR study should be postponed for a few weeks after the ictus to allow the hemorrhage to resorb and to optimize the chance of detecting a mass. Clinical deterioration after hypertensive intracerebral hemorrhage can occur for any number of reasons, including recently recognized recurrent or continued bleeding (13), and this development warrants repeat imaging.

7. If the patient is clinically stable, and the initial CT scan reveals an acute infarct consistent with the examination, there is usually no reason to repeat imaging.

Our definition of the term *utility* was quite narrow, and many could argue justifiably that repeat scans have merit beyond these restrictive criteria. Nevertheless, Hazelton and Earnest (14) found no differences in outcome or treatment between two groups of stroke patients, one studied before the advent of CT and the other after CT became available. Recent studies, however, have suggested benefits from treatment with thrombolytic agents and anticoagulants in the acute stroke setting (15, 16). With more frequent use of these agents in the near future, repeat imaging could significantly alter management if hemorrhagic conversion

were seen. Our study did not address the promise of newer techniques, such as MR spectroscopy, in terms of furthering our understanding of the pathophysiology of ischemic stroke and, one hopes, of fostering more effective treatments (17).

On the basis of our limited series of patients, we conclude that repeat brain imaging in stroke patients may not change the initial diagnosis or treatment, and the indications for these tests are often not clearly stated. Standards of practice may, of course, vary widely among institutions and different geographic areas. It is plausible, however, that our observations can be generalized at least to some degree to other institutions in the United States. If our sample is at all representative of those from other institutions, then current practices may be excessive. We hope that our proposed guidelines will help to identify those patients most likely to benefit from follow-up investigations and to minimize fruitless testing on those who will not.

Acknowledgment

We thank Jacques Goldstein for his helpful advice.

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