Brain Magnetic Resonance Imaging Scans for Asymptomatic Patients: Role in Medical Screening

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In a medical era governed by managed health care and scientific advances, physicians have increasingly emphasized disease prevention and early diagnosis. Such a strategy both reduces costs, as it is generally much more cost-effective to prevent a disease than it is to treat its manifestations, and increases treatment efficacy, as most diseases are more easily cured or ameliorated earlier in their progression. Examples of asymptomatic screening programs that have reduced morbidity and mortality are colorectal cancer with fecal occult blood analysis, cervical cancer with Papanicolaou smears, breast cancer with mammography, prostate cancer with digital rectal examinations and serum levels of prostate-specific antigen, and coronary artery disease with cholesterol measurements. Whereas these successful programs have created optimism about developing other screening protocols, it is important to realize that early detection programs can have negative consequences, and only in circumstances in which such sequelae are outweighed by benefits should such programs be implemented.

Vernooij et al[1] reviewed the incidental findings on brain magnetic resonance imaging (MRI) of 2000 patients. They found clinically unremarkable brain infarcts in 7.2%, cerebral aneurysms in 1.8%, and benign primary tumors in 1.6% of the cohort (Table). Performing brain MRI when patients have no symptoms moves policy toward preventive medicine and gives patients a large amount of responsibility. In response to consumer demand and financial benefits, many imaging companies have begun to advertise and offer brain MRI scans to the general public. In New York City, brain MRI screening can be performed for less than $200, regardless of age or medical history, so that brain lesions can be detected at an earlier stage. Although this program appears to have great benefits, closer analysis shows that brain MRI scans should not be recommended for screening healthy populations because of unequal accessibility, disproportionate allocation of health care resources, screening bias, low prevalence, poor predictive value, and limited need and effectiveness of intervention. Further, early detection programs often have negative consequences, and benefit that justifies possible sequelae has not been demonstrated.

Access to brain MRI scans is limited for some patients. Advertisements target metropolitan areas and people with high socioeconomic status. In contrast to the aforementioned heart disease and colorectal, breast, prostate, and cervical cancer screening programs, which are generally and uniformly implemented throughout the United States,[2] promoting asymptomatic brain MRI screening creates an ethical dilemma by providing regionalized health care that counters the social responsibility for medical professionals to care for patients equally. Many private insurance companies and Medicare also do not cover the expenses incurred by screening tests.[2,3] This restriction not only makes screening services disproportionately available to those of higher socioeconomic status, but also drains financial resources that should be allocated toward proven and life-saving screening programs.

When analyzing a medical screening program, one must be aware of several confounding factors that can affect survival, such as lead, length, and overdiagnosis bias. Lead bias occurs when screening detects the disease earlier but does not alter its course. Patients live longer with the disease, and mean survival numbers rise. The increased chance that screening programs will preferentially detect slower, more indolent forms of disease causes length bias, which increases survival and cure rates. Overdiagnosis occurs when a "pseudodisease" is discovered that would have remained clinically insignificant throughout the remainder of the patient's life.[4] Overdiagnosis effectively changes a healthy person into a diseased one, causing overestimations of the sensitivity, specificity, and positive predictive value of screening tests and the incidence of disease. Overdiagnosis also markedly increases the length of survival, regardless of whether screening or associated treatments are actually effective. However, overdiagnosis does not reduce disease-specific mortality because treating people who have pseudodisease does not help those who have real disease. Consequently, disease-specific mortality is the most valid end point for evaluating screening effectiveness. Each of these factors applies to screening pro-

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TABLE. **Incidental Findings on 2000 MRI Scans**

Finding[a]	No. (%)
Tumors	
Meningioma	18 (0.9)
Pituitary adenoma	6 (0.3)
Vestibular schwannoma	4 (0.2)
Trigeminal schwannoma	1 (<0.1)
Intracranial lipoma	2 (0.1)
High- or low-grade glioma	1 (0.1)
Metastases	1 (0.1)
Vascular findings	
Asymptomatic brain infarct	145 (7.2)
Aneurysm	35 (1.8)
Cavernous angioma	7 (0.4)
Major vessel stenosis	9 (0.5)
Subdural hematoma	1 (<0.1)
Other findings	
Arachnoid cyst	22 (1.1)
Dermoid cyst	1 (<0.1)
Type I Chiari malformation	18 (0.9)
Fibrous dysplasia	1 (<0.1)

[a] Diagnoses were based on imaging only, without histologic confirmation. Data from reference 1.

grams and must be seriously considered when judging their efficacy.

Although intracranial diseases often carry a grave prognosis, they are uncommon. For example, experts conclude that cerebral aneurysms and brain tumors are present in only 1% to 2% and 0.0094% to 0.0104% of the adult population, respectively.[5,6] This conclusion must be compared with the relatively high frequency of colorectal, breast, prostate, and cervical cancer, as well as coronary heart disease. The low prevalence of brain lesions makes effective early detection difficult even with accurate diagnostic techniques.

Magnetic resonance imaging could excel at detecting brain lesions in patients with disease. Studies in healthy participants, however, have shown MRI can be oversensitive and display incidental white-matter foci without underlying pathology.[7] Consequently, the seriousness of the finding, including whether it is within the realm of normal variation, must be evaluated. This translates to a depressed specificity because many individuals without brain tumors require additional follow-up of incidental and nonpathologic images. Most important, as a result of the low prevalence of brain lesions in the general population, the positive predictive value of brain MRI screening, which is strongly dependent on the proportion of people with the disease, will be extremely low, as was demonstrated by Katzman et al[6] in a study of MRI images from 1000 healthy asymptomatic persons. "Abnormal" radiographic images from 180 patients required additional investigation and diagnostic procedures to discover the nature of the abnormality. These procedures confirmed a brain tumor in 2 participants, generating a positive predictive value of only 0.011. False-positive results can cause unnecessary anxiety and further diagnostic testing.

Another potential problem with MRI screening advertised to the public is suboptimal image quality leading to overdiagnosis of "pseudolesions" and increased cost for work-up of these findings. In the study by Vernooij et al,[1] MRI scans were performed with a high-resolution 1.5 T scanner (GE Healthcare, Leiderdorp, the Netherlands) with thin slices and a variety of sequences without contrast. Studies performed for the public might not be done on such specific scanners, and poor-resolution images often require additional testing at extra cost. Further, incidental findings can require invasive imaging and procedures with inherent risks. For example, stereotactic biopsy and catheter angiography have a 0% to 12% and 0.1% to 1.2% risk of major complications, respectively.[8-10]

The limited treatment options after incidental brain findings are another reason asymptomatic brain imaging should not be recommended. In the study by Vernooij et al,[1] 271 of 2000 scans revealed intracranial abnormalities, for which only 2 patients received treatment. Thirty-five patients (1.8%) had intracranial aneurysms; 7 patients (0.4%), cavernous angiomas; and no patients, arteriovenous malformations. No aneurysms were located in the posterior circulation (which is associated with a worse prognosis), and only 3 aneurysms were larger than 7 mm in diameter. At our institution, unruptured aneurysms are treated according to the following guidelines: (1) with rare exceptions, all symptomatic aneurysms should be treated; (2) small, incidental aneurysms less than 5 mm in diameter should be managed conservatively in virtually all cases; (3) aneurysms greater than 5 mm in diameter in patients younger than 60 years should be seriously considered for treatment; and (4) incidental aneurysms larger than 10 mm in diameter should be treated in nearly all patients younger than 70 years.[5] Asymptomatic cavernous angiomas along with asymptomatic Chiari malformations and arachnoid cysts, as reported by Vernooij et al, are rarely treated. Moreover, arteriovenous malformations are rare, thereby greatly decreasing the positive predictive value of screening.

The limited availability and effectiveness of treatment for brain tumors is another reason asymptomatic brain imaging should not be recommended. Even if MRI demonstrates a brain tumor at an early stage of its progression, the options are limited, both in technique and in final outcome. The American Cancer Society states that, in most cases, the type of tumor and its location determines survival of patients with brain cancer, not how early the lesion is detected. In addition, there is no evidence that early diagnosis and treatment of brain tumors increases survival.

Although advances in neuroimaging will increase the detection of incidental brain abnormalities, future studies

could demonstrate a possible role of imaging in carefully selected asymptomatic patients. Brain imaging could be beneficial for assessing patients with risk factors for cerebrovascular disease; recognizing asymptomatic brain infarcts might identify populations at risk for future ischemic events and prompt prophylactic lifestyle modification and medical therapy.

Regardless of incidental findings, many patients who pay for their own MRIs could be worried by subtle symptoms or signs not apparent to physicians who are not neurologists. Consultation with a neurologist or neurosurgeon, pending the radiographic findings, should be mandatory for those electing to undergo MRI to help interpret and plan appropriate follow-up if needed. In the study by Vernooij et al,[1] patients with aneurysms smaller than 7 mm in diameter were not referred for follow-up or medical treatment. Risk-benefit analysis demonstrates that treatment should be considered for a subset of patients with small asymptomatic aneurysms.[5]

The current trend in medicine toward prevention and early diagnosis will continue to improve medical practice. Discovering underlying pathology before overt manifestations has been emphasized to improve cost-effectiveness and reduce morbidity and mortality. Yet for a screening program to be of value to society, it must be applied in the proper context. Brain MRI screening of asymptomatic patients regardless of age, health, or medical history is an example of an ineffective screening program that would produce many inconsequential findings and an exceedingly low rate of clinically relevant findings. Valuable screening programs must either address a highly prevalent disease or be applied to high-risk individuals, and must accurately uncover a treatable disease.

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