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EDITORIAL

Predicting Outcome in Traumatic Brain Injury: What Role for rCBF/SPECT?

Traumatic brain injury (TBI) represents a major public health problem. According to the National Head Injury Foundation, Inc., there are over two million TBIs annually in the US. Of the survivors, approximately 70,000 to 90,000 will sustain permanent loss of cognitive and/or motor function. The annual costs for dealing with this patient population approaches $25 billion (from *Facts About Traumatic Brain Injury*, distributed by the National Head Injury Foundation, Inc., Washington, DC, undated).

Not all patients suffer severe trauma, many fall into the category of moderate to minor trauma. These patients typically do not require hospitalization, but may have some loss of consciousness and retrograde amnesia, as in the case of moderate traumatic brain injury. Patients with minor TBI will often present with minimal neurological complaints. There are two major issues to consider when dealing with moderate and minor TBI. One is the ability to identify the extent of the brain damage and its relation to the patient's clinical presentation. Another is predicting the resolution of the symptoms. Regional cerebral blood flow/SPECT may provide data relevant to both these questions.

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For correspondence or reprints contact: Ronald S. Tikofsky, PhD, Nuclear Medicine, Medical College of Wisconsin, 8700 W. Wisconsin Ave., Milwaukee, WI 53226.

There is increasing evidence that rCBF/SPECT is a viable technique for detecting cortical lesions following TBI. Regional cerebral blood flow/SPECT imaging frequently reveals a greater number of lesions than either CT or MRI in patients with moderate or minor TBI (*1–5*). The lesions visualized with SPECT in this patient population tend to be larger than those seen on CT or MRI. However, unless it can be shown that the regional changes identified by SPECT, not seen on CT or MRI, better account for the patient's clinical findings, these modality differences are of little value.

Jacobs et al. (*6*) go beyond the question of CT versus SPECT in the evaluation of the TBI patient. Their paper contributes to the assertion that rCBF/SPECT is useful for predicting clinical outcome in moderate and minor TBI based on the initial SPECT scan. In addition, their data make clear that patients with persistent clinical symptoms will continue to have abnormal follow-up SPECT scans. Such findings, if corroborated in other laboratories, are of significance for the future treatment of these patients. For example, it is possible to hypothesize that further rehabilitation for patients with positive clinical and SPECT findings at the end of three months may yield little in the way of continued improvement.

The observation that a negative initial SPECT scan predicts resolution of symptoms within a three mo period is also significant. Jacobs et al. do not indicate whether their patients were involved in head trauma rehabilitation programs. Study designs involving SPECT as a predictor of outcome in TBI should include information regarding treatment and rehabilitative efforts.

A corollary question is whether the greater lesion size and/or number of abnormal regions reported for SPECT is a better indicator of clinical severity than CT or MRI findings. Although Jacobs et al. (*6*) did not address this issue directly, it is possible to make this assertion based on their data. Of particular significance was their finding in patients with minor trauma who had negative CTs. Patients with persistent positive SPECT scans remained symptomatic, and those with negative scans remained negative on follow-up. The situation is less clear for their moderate TBI group. Most patients who were still symptomatic had positive repeat SPECT scans. It is not known if the CTs for these patients were negative.

Much has been made of the observation that SPECT picks up more and larger lesions than anatomic imaging. However, to say that more lesions are detected by SPECT or that these lesions are larger than those seen on CT/MRI is not by itself a sufficient argument in favor of SPECT as the imaging modality of choice in moderate and minor TBI. The perceived characteristics of the lesions detected

by SPECT may be significantly influenced by the imaging system. A multidetector system with high resolution is more likely to show a greater number of lesions than a single-headed rotating gamma camera. One wonders if Jacobs et al.'s (*6*) patient with a negative repeat SPECT scan and persistent positive clinical findings would show an abnormality if the scan were obtained with a higher resolution instrument.

What is needed to make the case for SPECT as a modality of choice for imaging in TBI is a study that directly examines the relationship between findings obtained with CT/MRI and SPECT and clinical status. In addition, this assumes that usable criteria for determining the presence of a lesion and estimating its size and volume can be developed. There is a need to develop standards of interpretation that can be uniformly applied across laboratories and verified by multi-institutional studies. Such clinical research would decrease the frequency of confusing findings currently being reported in the literature.

For example, Jacobs et al. (*6*) did not find any correlation between persistent positive clinical findings and regional cortical abnormalities. This contrasts with findings reported by Ichise et al. (*1*) who report significant regional changes associated with specific neuropsychological deficits. The difference in methodology, patient selection and time, post-TBI, may account for discrepancy in the results. Ichise et al. (*1*) did not have an opportunity to obtain early scans. Their patients were still symptomatic six mo after onset. These and other differences in methodology make it difficult to compare the two studies. However, it seems clear that patients with persistent long term TBI (> 6 mo) clinically differ from those studied by Jacobs et al. (*6*). To fully explore the predictive value of SPECT in TBI, initial and follow-up scans must be obtained on all types of TBI. Visual and quantitative scan findings must be integrated into a data analysis matrix that includes a standard neuropsychological test battery as well as an objective clinical evaluation.

The work of Jacobs et al. (*6*) and the recent Ichise et al. (*1*) paper help make the case for incorporating rCBF/SPECT into the evaluation of the TBI patient. It still remains for the nuclear medicine community to convince our clinical colleagues that we have something of value to offer them. Incorporation of SPECT into outcome studies for this patient population is a logical next step. Research utilizing rCBF/SPECT must be designed and executed in a manner that will satisfy colleagues from other medical disciplines (e.g., physical medicine and rehabilitation). It is also necessary to publish our research findings in journals that are regularly read by these colleagues.

The studies by Ichise et al., Jacobs et al. and others are advancing research for TBI. However, many more such studies need to be performed, particularly in the US where the population of TBI is still growing. Cooperative research studies involving several trauma centers and rehabilitation programs could make a significant contribution to determining the role of rCBF/SPECT in TBI.

The case for using SPECT with TBI should not be overstated. Research strongly suggests that one can show the rCBF changes in patients with moderate and minor head trauma. However, the correlation between outcome and clinical presentation with SPECT findings is not yet well established. The extent of these changes may vary with the timing of rCBF imaging following the onset of the initial insult. Therefore, a conservative approach to SPECT scan interpretation in this patient population is appropriate. This is particularly important as many cases of head trauma end up in litigation. Despite the caveats noted here, the nuclear medicine community must seize the opportunity to make the case for rCBF/SPECT as a cost-effective management tool in TBI.

Ronald S. Tikofsky
Medical College of Wisconsin
Milwaukee, Wisconsin

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