#12. Viewing the functional consequences of traumatic brain injury by using brain SPECT

D. Pavel, T. Jobe, S. Devore-Best, G. Davis, P. Epstein, S. Sinha, R. Kohn, I. Craita, P. Liu, Y. Chang

High-resolution brain SPECT is increasingly benefiting from improved image processing software and multiple complementary display capabilities. This enables detailed functional mapping of the disturbances in relative perfusion occurring after TBI.

The patient population consisted of 26 cases (ages 8–61 years) between 3 months and 6 years after traumatic brain injury.

A very strong case can be made for the routine use of Brain SPECT in TBI. Indeed it can provide a detailed evaluation of multiple functional consequences after TBI and is thus capable of supplementing the clinical evaluation and tailoring the therapeutic strategies needed. In so doing it also provides significant additional information beyond that available from MRI/CT.

The critical factor for Brain SPECT's clinical relevance is a carefully designed technical protocol, including displays which should enable a comprehensive description of the patterns found, in a user friendly mode.

Report

High resolution brain SPECT with 99mTc_HMPAO is increasingly benefiting from improved image processing software and multiple complementary display capabilities. This has added significantly to the possibility of mapping the disturbances in relative perfusion occurring after Traumatic Brain Injury as well as their changes at longitudinal follow-up and/or after various therapeutic regimens.

Materials and methods

The radiopharmaceutical used was 99mTc_HMPAO in doses adjusted for patient weight (15–30 mci). The acquisition was done with a triple head gamma camera with ultra high resolution fan beam collimators. The processing is based on reconstruction, filtering, and reorientation leading to the three standard orthogonal cuts based on the longest anterior–posterior axis of the brain. In addition a fourth axial display is obtained along the temporal axis. The slices are displayed with a threshold of 40% and a discrete color code of 21 shades. Multiple thresholded volume displays at 55, 65, 85, and 90%, respectively, are then obtained. In addition each study is processed via the automatic Neurostat algorithm (Minoshima et al., 1992) which displays 8 surface views, after normalization to the Talairach space.

Results

Twenty-six cases (ages 8–61 years) between 3 months and 6 years after Traumatic Brain Injury. MRI was available in 40% of cases and Neuropsychiatric tests in 34%. The following areas were evaluated in a semi-quantitative mode: (1) hemispheres (general) and specifically: frontal (DLPF, mesial, lateral); parietal (vertex, lateral, and parieto-occipital; precuneus); occipital (lateral, occipital poles, primary visual area, and cuneus) (2) orbito-frontal areas; (3) insula-s (anterior and posterior); (4) cingulate: anterior (subgenual, rostral, and dorsal) and posterior (dorsal, retro-splenial); temporal (apical, mesial, and lateral); subcortical: striatum (putamen, caudate head) and thalamus; cerebellum (hemispheres and central vermis); pons. The patterns found included (A) Decreases: 1. global hemispheric; 2. regional: vertex; fronto-parietals; frontal pole with or without extension to orbito-frontal; DLPFC; orbito-frontal; temporal apex, mesial temporal; occipital poles, lateral occipital and (B) Increases: Most often in: cortex (focal); mesial aspect of frontal poles; anterior cingulate; lateral temporal; thalamus; and striatum. The combination of features found in 80% of cases was not only explaining most of the patient's symptoms but, also provided the substrate for treatment of the varied comorbidity associated with Traumatic Brain Injury. In all cases where MRI was available the changes were significantly less extensive than on SPECT and in 28% of the cases there was no morphologic change at all.

Discussion

The cases to be presented (Fig. 1) fall in one of the following categories which represent some of the more common sets of situations that can be considered as strong indications for Brain SPECT and attest to its clinical relevance:

(A) The longitudinal follow-up post-treatment (case # 1): this is not just a simple matter of identifying changes happening to a specific area of underperfusion post-accident. While this can prove occasionally useful, the most important aspect of a follow-up is to visualize the continuous changes (local and/or distant) of the relative perfusion levels, in different areas of the brain. This in turn corresponds most likely to a continuing process of restructuring of compensatory network connections. This type of information may have direct therapeutic implications which in time will only get further refined as a better understanding of the clinical significance of various patterns seen on Brain SPECT will emerge.

(B) A focal abnormality can be accompanied by numerous other abnormal features resulting from the same trauma occurrence or superimposed on previous comorbidity (case # 2). Brain SPECT enables the Psychiatrist to become aware of concurrent abnormalities and thus to treat based on the most salient features susceptible to explain the dominant symptoms.

(C) The presence of diffuse abnormalities on brain SPECT may or may not be accompanied anatomically defined abnormalities. As can be seen (cases 3 and 4) such abnormalities can present as diffuse increases, or diffuse decreases. The therapeutic consequences are quite different between these two patterns. In case # 3 there is a clear failure of MRI to detect any morphologic abnormality despite the patient's significant symptoms and the changes found on Brain SPECT.

(D) The short term versus long term consequences of major frontal pole abnormalities sustained during childhood. In case # 5 the clinical consequences continued during teenage years. This is most likely related to the fact that there was concurrent major abnormality in the apex of the right temporal lobe. In case # 6 the network adaptations worked very well for most of the patient's life, till the time (56 years old) when the physiologic changes of the aging brain required additional frontal poles participation.

 213

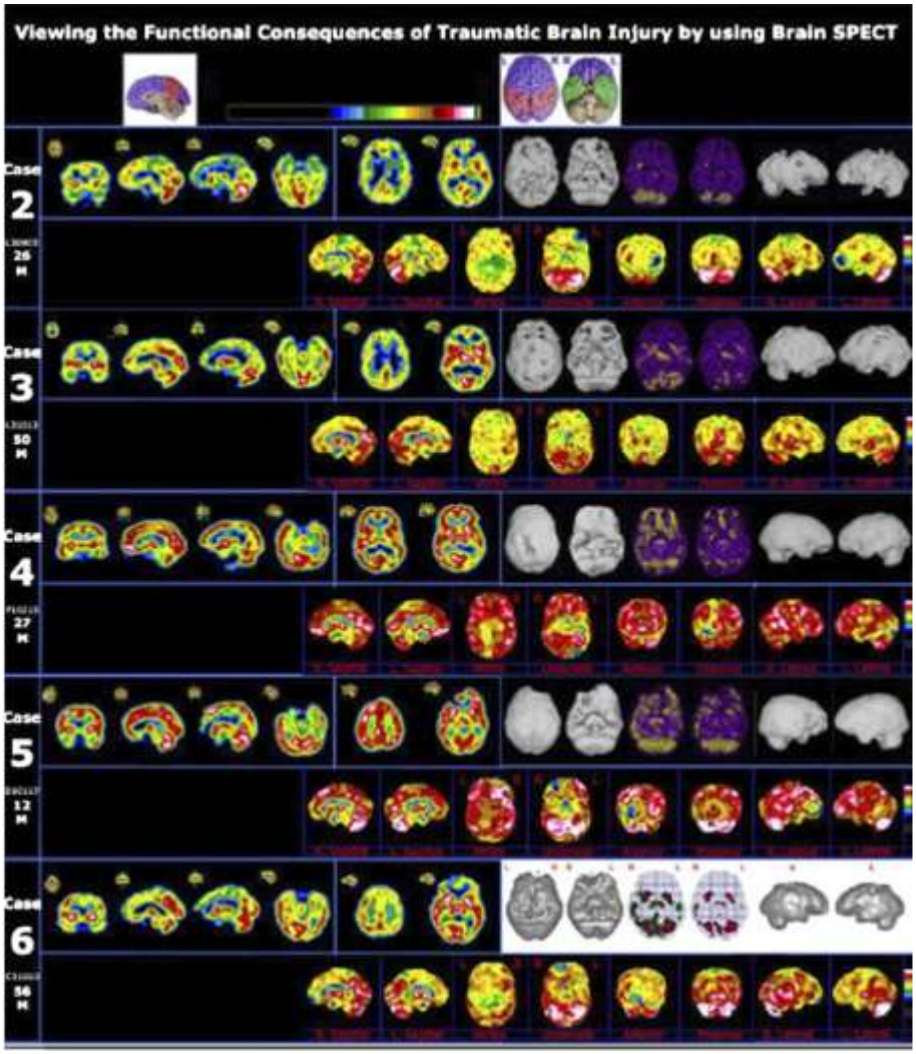

Fig. 1. Synopsis of cases 2–6: the purpose of this type of summary display is to give a clearer idea about the great variability of patterns that can be seen in TBI.

Conclusions

A very strong case can be made for the routine use of Brain SPECT in TBI. Indeed it can provide a detailed evaluation of multiple functional consequences after TBI beyond the simple answer of local perfusion decrease or no decrease and also provides significant additional information beyond that available from MRI/CT. Brain SPECT is thus capable of supplementing the clinical evaluation and to contribute to the tailoring of therapeutic strategies needed to address the complex comorbidity which often accompanies TBI.

The critical factor for Brain SPECT's clinical relevance is a carefully designed technical protocol, including a complete and user friendly set of displays which should enable a comprehensive description of the patterns found.

Reference

Minoshima S., et al. (1992). An automated method for Rotational Correction and Centering of Three-dimensional Functional Brain Image. Journal of Nuclear Medcine, 33, 1579–1585.