

The usefulness of CBF brain SPECT in forensic medicine.

A description of four cases

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Abstract

BACKGROUND: The aim of this study was to show the applications of cerebral blood flow SPECT scanning in forensic medicine using four cases: two suspects and two victims of crime.

MATERIAL AND METHODS: Cerebral blood flow studies were performed with the use of ^{99m}Tc-ECD and a triple head gammacamera. Qualitative and quantitative analysis was performed, utilising an asymmetry index for unilateral perfusion deficits and a comparison to cerebellar perfusion for assessing the regional cerebral perfusion. For assessing the normal values, a control group of 30 patients was studied.

RESULTS: In these cases CBF SPECT scanning proved its usefulness in medico-legal argument and played an important role in formulating the final forensic expert's opinion.

CONCLUSIONS: Radionuclide cerebral blood flow studies may play a role in forensic medicine, where this method it is mostly under-utilised at present.

Key words: cerebral blood flow, forensic medicine, single photon emission computed tomography

Introduction

The misfortune of cerebral blood flow imaging is that despite two decades of brain SPECT imaging it has not gained popularity

among clinicians. In 1996 the Report of the Therapeutic and Technology Assessment Subcommittee of the American Academy of Neurology qualified only fresh brain ischaemia, seeking of epileptogenic foci and differentiation of Alzheimer's disease as the "established" applications of cerebral blood flow (CBF) SPECT scanning. The remaining applications were classified as "investigational" (Assessment, 1996). This judgement may seem severe, but it seems to be largely justified, with the nuclear medicine community itself to blame.

In our opinion, however, there are some other areas of practical CBF SPECT scanning and one of them could be the assessment of patients after cranio-cerebral trauma (Abdel-Dayem, 1998, Abu-Judeh, 2000, Lass, 1999, Lass, 1999).

Cranio-cerebral trauma, called the "silent epidemic" (Goldstein, 1990), is a domain not only of medical but also of legal professionals. Cranio-cerebral trauma is frequently a result of car accidents or criminal activity, including assault, and therefore the results of cranial trauma are frequently the object of legal considerations, originating from both the penal and civil codes. Regrettably, neuroradiology as a whole, and brain SPECT in particular, plays little role in forensic expertise.

In our University Hospital, the Department of Nuclear Medicine started regular cooperation with the Department of Forensic Medicine about two years ago and until now we have performed about 20 CBF SPECT studies in forensic cases. We would like to present below four cases of forensic CBF SPECT applications.

Material and methods

Brain SPECT scanning was performed approximately 1 h following the intravenous injection of 740 MBq (20.0 mCi) of ^{99m}Tc-ECD (FAM, Łódź, Poland). Scanning was performed on a triple-head gammacamera Multispect-3 (Siemens, Erlangen, Germany) using a low-energy, ultra-high resolution collimator.

Focal perfusion abnormalities were assessed utilising an asymmetry index (AI): $AI = R - L / (R + L) / 2 \times 100\%$, where R and L are mean counts/pixel values in the respective ROIs of right and left hemisphere. Regional cerebral blood flow was assessed semiquantitatively by calculating the cerebellar index.

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Figure 1. SPECT scanning of pt. 1.

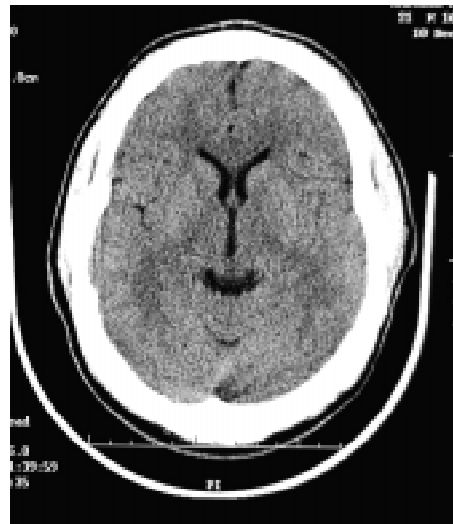


Figure 2. CT scanning of pt. 3.

Results

Case 1

A suspect, aged 32 years, was accused of rape and murder (art. 148 and 197 of the Polish Penal Code). During his psychiatric observation, NMR scanning revealed the arterio-venous (A-V) malformation in the right frontal lobe. His defence applied for acquittal of the suspect, arguing that during the crime he had disturbed ability to judge his actions and had no ability to foresee their consequences. The question was whether this A-V malformation induced significant cerebral blood flow disturbances. CBF SPECT scanning revealed a normal pattern of cerebral blood flow (Fig. 1) and played an important role in the opinion of a specialist of forensic medicine. The suspect was sentenced.

Case 2

A suspect, aged 36, was accused of paedophilia (Art. 200 of the Polish Penal Code). His defence applied for acquittal of the suspect, arguing that his behaviour was the result of organic damage to the frontal lobes after a car accident. Frontal syndrome may give personality disturbances, especially in the spheres of mood control and sexual disinhibition. The prosecution asked for a forensic expert opinion. Psychiatric observation, CT and SPECT scanning revealed no signs of organic brain lesion. In particular, beside the lack of focal perfusion deficits, no diffuse hypoperfusion of the frontal lobes (bilateral hypofrontality) was shown, by normalisation to the cerebellar perfusion. The suspect was sentenced.

Two next cases concern the victims of criminal accidents.

Case 3

A victim, aged 22, was attacked by a group of hooligans. He was heavily beaten and kicked. He suffered loss of consciousness. He suffered an open wound in the left occipital area with an additional contusion wound in mandible and right frontal area. At the moment of examination by the forensic medicine expert, he reported memory and sleep disturbances, headaches and vertigo, physical weakness, although he was a well-trained sportsman before the accident. His neurological examination was normal. Psychological ex-

amination (Wechler's test, Benton's, Bender's, MMPI and AVLT tests) suggested an organic lesion of the brain. CT scanning was normal (Fig. 2). CBF SPECT scanning revealed a sharp-edged perfusion deficit in the lower part of the right frontal lobe with an asymmetry index (AI) of 20%, second diffuse perfusion deficit with AI of 15% in the left temporal and occipital lobe, also a diffuse perfusion deficit in the right cerebellar hemisphere (Fig. 3). This was accompanied by diffuse hypoperfusion of the frontal lobes (bilateral hypofrontality) of 69/75% of frontal perfusion normalised versus cerebellar perfusion (normal values in control group were more than 82%). On the basis of psychological testing and SPECT scanning, the forensic medicine expert concluded the organic lesion of the brain lasting longer than 7 days, however not presenting grave impairment of health (art. 156 of the Polish Penal Code).

Case 4

A victim, aged 18, was attacked by two hooligans. He was hit in his face, pushed and the back of his head was struck against a wall. He claimed that following this, he was hit on the right side of his



Figure 3. SPECT scanning of pt. 3.

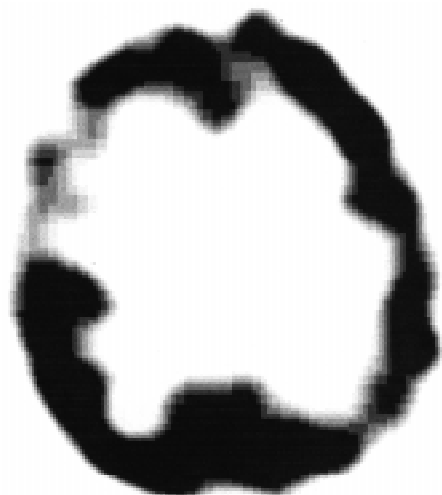


Figure 4. SPECT scanning of pt. 4.

head with a metal object, probably a knuckle-duster. He was hospitalised for 12 days. At the moment of examination he often suffered stubborn headaches, localised in the frontal and occipital areas of the head. As he claims, he became nervous, morose, he performed worse at school. His neurological examination was normal. In CT scanning there was seen a small hypodense area in the right prefrontal cortex, 4 cm wide, up to 5 mm thick, as well as a similar hypodense area, 2 cm wide, less than 5 mm thick, in the left frontal lobe — probably contusion areas. In brain SPECT scanning there was shown a narrow area of cerebral hypoperfusion extending from the frontal pole of the right temporal lobe through the posterior part of the right frontal lobe to the upper parts of this lobe (Fig. 4) with AI of 12–20%.

The crucial point in this patient's case is that his version of this accident and the one given by the attackers (the accused in the case) varied. The victim claimed a dual head injury — one by being struck against the wall and the second one by being hit with a metal object the right fronto-temporal area. The accused admitted that they had pushed him against the wall, but strongly denied using any metal object. It should be mentioned that the use of any dangerous object during an assault is usually followed by a higher penalty. Brain lesion revealed by CT scanning seemed to confirm the accused's version, showing lesions only in the frontal lobes, probably by *contre-coup* mechanism. CBF SPECT scanning revealed additional lesion in the right temporal and occipital lobe, i.e. it supported the version of the victim.

In conclusion, the forensic medicine expert stated:

— post-contusion organic lesion of the brain lasting longer than 7 days, however not presenting grave impairment of health (art. 156 of the Polish Penal Code);

— the expert supported the version of events given by the victim, i.e. not only the blow in the occipital area, but also in the right fronto-temporal area.

Discussion

Cranial trauma and its remote sequelae present an important problem in forensic medicine. The victims' claims aim at obtaining com-

penensation. In penal expertise the defence frequently aims to utilise the facts of past cranial trauma either for extending the judicial process or for obtaining milder conditions of punishment (milder regime of imprisonment or earlier discharge from prison). Last not least, not infrequently patients after head trauma sue the hospitals for, in their opinion, improper care. A key proof in such cases is radiological documentation (Jennett, 1976)

Most often the forensic expert's opinion is raised when long-lasting health impairment or organ disability follows the trauma. Neuroradiological techniques are not over-utilised in medico-legal expertise. In our own material (841 cases of head trauma, unpublished data) neuroradiological techniques (CT, MRI, and SPECT) have an important impact on medico-legal reasoning in 41 cases. Also, in the neuroradiological literature known to the authors, papers on its forensic medicine applications are rare (Jennett, 1976; Boyko, 1986; Valle, 1994; Soderstrom, 2000), although the use of neuroradiology in forensic medicine is postulated (Jennett, 1976, Ricker, 2000).

In diagnosing head trauma, CBF SPECT scanning may be a valuable tool, as sometimes it can be more sensitive than CT/MRI because of its ability to show areas of incomplete infarction (selective neuronal loss) (Marcoux, 1985, Garcia, 1996) and also the area of penumbra (Skyhoj, 1983). Several studies have proved the high sensitivity of CBF SPECT scanning in head trauma (Gray, 1992; Prayer, 1993; Masdeu, 1993; Chambers, 1996; Jacobs, 1996; Abdel-Dayem, 1998; Abu-Judeh, 2000; Lass, 1999; Lass, 1999) and there seems to be no reason why this valuable tool should not be used on a broader scale in forensic medicine.

The four cases given above show the different applications of CBF SPECT scanning and two main advantages of this technique: exclusion ability when the other tests are positive or conflicting, and confirmation ability when the other tests are negative or conflicting. The problem is insufficient specificity of SPECT and the lack of standardisation of this method (Catafau, 1999), which, together with insufficient knowledge about this method among the clinicians and forensic medicine experts, are probably the main reasons for the under-utilisation of this method in forensic expertise.

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