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Retention of Tc-99m ECD in delayed SPECT of the brain

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We determined the effect of retention on the changes in regional biodistribution of Tc-99m ECD in the brain. A total of 14 cases, 7 normal volunteers and 7 patients with various diagnoses but with very minimal radiologic findings or none were included in the study. SPECT images were taken at 30 min, 1, 2, 3, 4 and 6 hrs after an intravenous injection. Retention rates were calculated in various regions and were corrected according to the time decay of technetium. There was a tendency for the retention rate to increase up to three hours of imaging and then a decrease was noted in most regions of the brain. In the thalamus, increasing retention was noted. In conclusion, Tc-99m ECD retention in the different regions of the brain varies with time. These differences should always be considered when planning and interpreting SPECT quantitative studies.

Key words: Tc-99m ECD, SPECT, retention rate

INTRODUCTION

CEREBRAL PERFUSION TRACERS DIFFER in their retention mechanisms. Iodine-123 isopropyliodoamphetamine (IMP) retention is related to amine binding and deamination. Tc-99m hexamethylpropylene-amine oxime (HMPAO) is retained by a stearic transformation of the chelate perhaps linked to glutathione activity. Tc-99m ethyl cysteinate dimer (ECD) is hydrolyzed in polar metabolites after crossing the blood brain barrier.[1]

In addition to other characteristics, an ideal brain imaging for single photon emission computed tomography (SPECT) must not only have good brain uptake but also prolonged retention in the brain tissue with fixed distribution.[2] The prolonged *in vitro* stability and the high cerebral retention of Tc-99m ECD has made it a radiotracer of choice.[1] The lack of differential clearance of a radiotracer from the brain suggests that SPECT images obtained several hours after the injection can still reflect the initial activity pattern.[3] Recently there are varying reports on *in vivo* stability of Tc-ECD. In this study, we would like to determine the effect of retention on the changes in regional biodistribution of Tc-99m ECD in the brain.

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METHODS

Patients

A total of 14 cases, 7 normal volunteers and 7 patients with various diagnoses but with very minimal radiologic findings or none were included in the study. The age range was 17–79 and the Male/Female ratio was 9 : 5.

Imaging

SPECT imaging was performed with a triple-head system (Prism 3000) equipped with ultrahigh resolution fan beam collimators and interfaced to an ODYSSEY super computer. ECD was prepared and quality control measures were performed according to the manufacturer's instruction. Each subject received 740 MBq of Tc-99m ECD in a quite room with subject's eyes open and ears unplugged. A total of 6 serial scans were acquired starting 30, 60, 120, 180, 240 and 360 min after the injection. For each scan, image data were acquired with 40 steps at the rate of 30 sec/step with a 128 × 128 matrix.

One-pixel thick transaxial slice from the vertex of the brain to the level of the orbito-meatal line (OML) was reconstructed with a Butterworth-Low-Pass post reconstruction filter (order-8.1, cutoff frequency-0.24) after

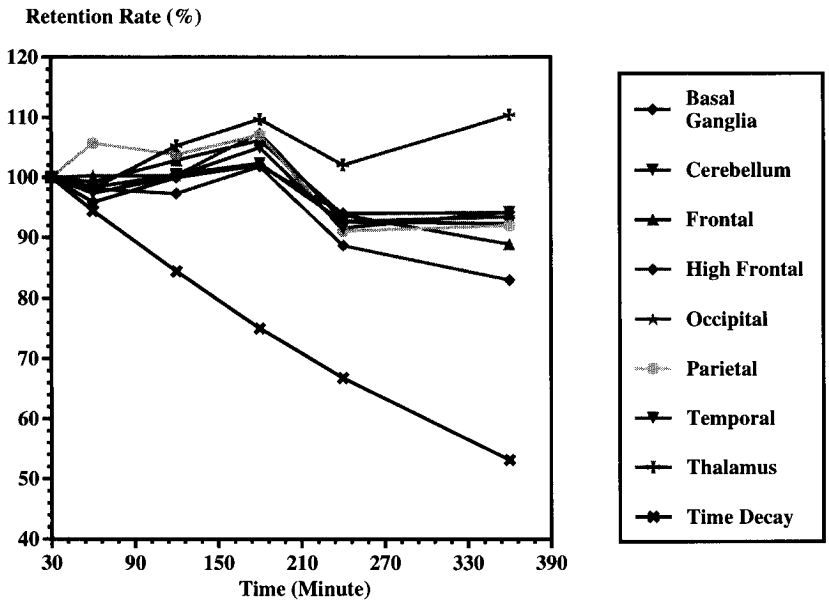


Fig. 1 Retention rates of Tc-99m ECD in the various regions of the brain compared with the time decay of technetium.

Table 1 Retention rates in various regions of the brain with different time intervals

Time interval	High frontal	Frontal	Parietal	Temporal	Occipital	Thalamus	Basal ganglia	Cerebellum
1 hr	98.2 ± 1.8	101.8 ± 2.8	111.8 ± 27.1	98.9 ± 5.7	100.8 ± 3.1	101.6 ± 4.6	97.7 ± 4.0	100.0 ± 3.7
2 hrs	96.6 ± 4.6	103.5 ± 5.0	101.5 ± 5.6	99.5 ± 3.5	98.6 ± 4.2	107.4 ± 2.4	100.8 ± 4.9	97.9 ± 2.2
3 hrs	96.4 ± 4.1	101.1 ± 7.1	101.6 ± 5.4	98.8 ± 4.6	100.9 ± 1.6	110.9 ± 2.8	97.6 ± 7.9	96.0 ± 3.4
4 hrs	92.1 ± 4.9	97.4 ± 9.2	94.6 ± 7.7	95.1 ± 4.0	96.3 ± 7.5	106.0 ± 8.7	97.6 ± 3.6	96.2 ± 2.4
6 hrs	86.2 ± 1.0	92.4 ± 7.8	95.6 ± 16.6	97.9 ± 4.6	97.0 ± 7.1	114.7 ± 8.9	97.8 ± 5.6	96.0 ± 3.0

applying a ramp back projection filter. Attenuation correction with the first order of Chang was performed by assuming uniform attenuation (μ = 0.09 cm^{-1}). Images were then reformatted to yield one-pixel thick (2.17 mm) transoblique slices parallel to the OML.

Data Analysis

Three elliptical regions of interest (ROIs) were drawn with a 53 pixel size in the following regions: high frontal, frontal, parietal, temporal, occipital lobes, basal ganglia, thalamus and cerebellum in both hemispheres. ROI placement depended on visual identification of anatomical regions with highest activity. All ROIs were applied by the same investigator to eliminate intraoperator variation. The average count per pixel from each region was obtained. No attempt was made to correct for partial volume or scatter effects.

Retention rates were calculated by [B/A(100)]. A is the count for the first image, presumed to be 100%; and B is the count from images obtained at another time. The retention rates were then decay-corrected to the time of the first count.

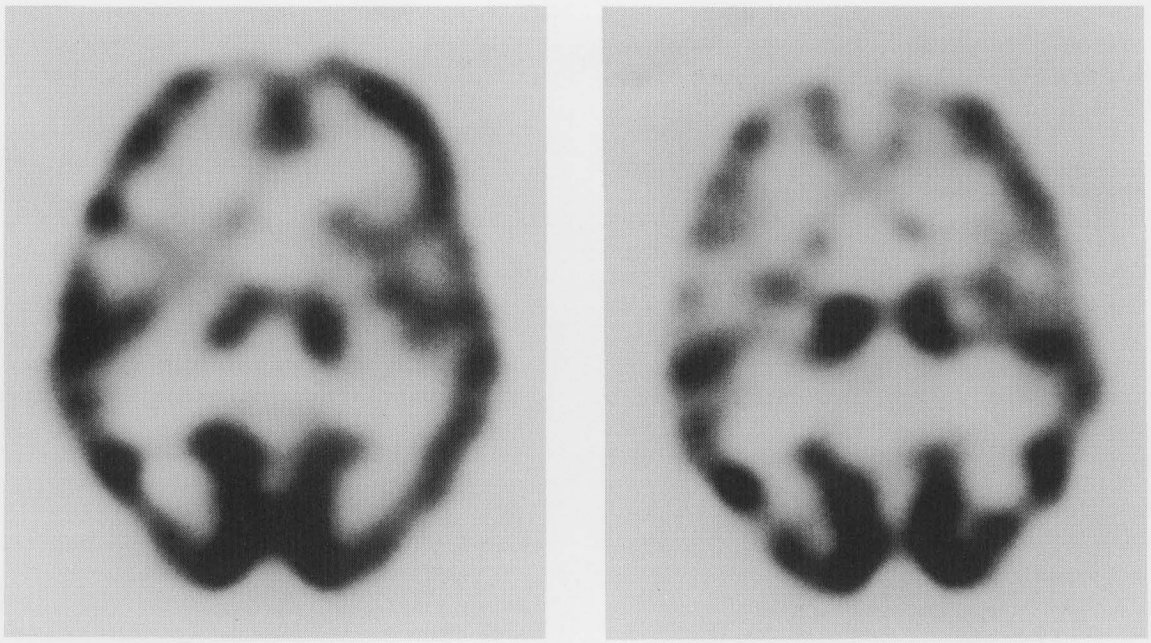
Comparison of retention with time in the various regions of the brain was done by means of Fisher's PLSD ANOVA, Abacus Concept Statview.

RESULTS

Figure 1 shows that Tc-99m ECD activity does not decrease with the time decay of Tc-99m in various regions of the brain. There was a tendency for the retention rates to increase until the three hour image. Decrease in the retention rate was noted in most regions of the brain in the six hour image except for the thalamus where an increase was noted.

Retention rates were initially high in the high frontal, and occipital regions and cerebellum, and especially the parietal region in the one hour image. The retention rates either tapered off or increase slightly until the three hour image. A decrease was noted in most regions of the brain in the six hour image. Minimal changes were noted in temporal region, basal ganglia and cerebellum, but an increase was noted in the thalamus (Table 1).

One hour after IV administration, the high frontal lobe ($p = 0.04$), temporal ($p = 0.03$) region, basal ganglia ($p = 0.01$) and thalamus ($p = 0.05$) showed a significant differ-



A B

Fig. 2 Transaxial images 10 minutes (A) and 6 hours (B) after IV administration of Tc-99m ECD about 3.5 cm from orbitomeatal line.

ence in their retention rates from the parietal region. In the four and six hour images a significant difference was noted between the various areas of the brain and the thalamus.

Representative Case

In a 45-year-old male volunteer, 30 minutes after IV administration of Tc-99m ECD good delineation of white and gray matter with low background uptake was noted (Figure 2A). One hour after IV administration, a decrease in retention was noted in most areas of the brain except in thalamus (Figure 2B).

DISCUSSION

In most reports the rate of clearance of Tc-99m ECD was slow and similar in all of areas of the brain. There was also no difference between the clearance rates for the high and low flow areas of the brain.[4–6] Our study showed a variation in Tc-99m ECD retention leading to regional variation in Tc-99m ECD clearance which was in agreement with other reports.[3,7,8] We agree that the difference between the retention rates in various studies could be partly due to differences in methods, such as instruments, scan timing, image reconstruction parameters, filters and methods of quantitative measurement and data analysis.[3]

Another major factor is the difference in anatomic and metabolic properties of various regions in the brain. Esterase activity is the major determinant of Tc-99m ECD retention[9] and regional difference in intracranial metabolic activity was noted.[10] The distribution of Tc-99m ECD in the brain may be related to the density of neurons.[11] We noted higher retention in high flow areas, such as the cerebellum and basal ganglia and highest in the thalamus. Delayed images may provide a mix of information that reflects both metabolism and CBF.[12]

In the protocol of Takeuchi et al., scan time was 53 minutes and for the detection of abnormality of hemodynamic reserve in cerebrovascular disease, the increase ratio was calculated from the post acetazolamide rCBF/baseline rCBF.[13] In the study by Noachtar et al., images were acquired 1–2 hours after Tc-99m ECD injection and an increase of more than 10% compared with the respective ROI in the contralateral hemisphere was considered significant.[14] In both studies, prolonged retention in the brain tissue with fixed distribution of Tc-99m ECD is necessary. Our study shows that as early as one hour after injection of Tc-99m ECD, differences in retention occurred. Holm et al. recommended proper correction of two images for regional wash-out of tracer and strict timing of the injection/imaging sequence.[15]

In conclusion, Tc-99m ECD retention in the regions of the brain varies with time. These differences should always be taken into account when planning for delayed studies and also when analyzing quantitative studies.

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