QUANTITATIVE ASSESMENT OF SPECT SUBTRACTION METHOD FOR DETECTION OF EPILEPTOGENIC FOCUS

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ABSTRACT

Background and purpose

SPECT using radioactive 99Tc tracers, is a technique which detects blood flow changes associated with some types of epileptic foci. Seizures are associated with dramatic increases in cerebral blood flow, localized in partial seizures and global during generalized seizures, reflected on perfusion SPECT. During a seizure there may be a three to four fold increase in cerebral blood flow. Technetium 99m hexamethyl-propyleneamineoxime (Tc-HMPAO, ceretec^{TM}) and Tc ethyl cysteinate dimmer (Tc-ECD, Neurolite^{TM}), enter the brain following intravenous introduction and have a very slow redistribution once in the brain. This means that a scan done several hours after the injection will reflect blood flow at the time of injection. Tc-ECD is stable for over 6 hours after being prepared [1].

In patients with normal MRI, SPECT can provide fresh information on the locus of the epileptic focus. Ictal SPECT provides a higher diagnostic yield than Interictal SPECT although both should be compared when making an evaluation. It is vital that injection of 99Tc be carried out as soon as seizure onset is detected, as there is a dynamic evolution of blood flow whereby ictal hyperperfusion switches to post-ictal hypoperfusion. However if the injection is delayed, hypoperfusion will be found, leading to potential errors. Practically speaking injection should take place within one minute for optimal results [1].

Objective

Our aim was to assess a subtraction method using phantom images; a method based on subtraction of two SPECT studies. We acquired the image data set on a brain phantom. A lesion was simulated by injecting appropriate amount of activity within the putamen of the phantom. The main problem with registering two sets of image data acquired from two different modalities (or two sets of data acquired from the same modality at different times) is that the images to be registered are never aligned. In general, digital image transforms can be categorized based on the geometric transforms for a planar surface element as translation, rotation, scaling, stretching, and shearing. We are using the subtraction method with a new SPECT/CT scanner that has the advantage that CT and SPECT are automatically registered. Subtraction method is based on the perfusion increase at the focal lesion. Ictal and interictal scans have different perfusion at the lesion.

Integrated visualization of medical images assists the clinician in efficiently presenting information from different sources, usually combining functional data with anatomical data. The key issue for clinical acceptance of novel visualization techniques is whether they can improve diagnosis and facilitate the information transfer to the referral. Traditional side-by-side visual interpretation of ictal and interictal SPECT images is hampered by differences in slice location and tracer activity. Despite progress in neuroimaging technology, identification of an epileptogenic focus in cases of partial epilepsy remains difficult, and between 20% and 50% of focal epilepsy cases are unlocalized by conventional methods [2].

Materials and Methods

Brain Phantom imaging can be done for experimental assessment of co-registration algorithms. Our study was performed on a Striatal Brain Phantom, a fully tissue-equivalent anthropomorphic phantom. This phantom is designed for evaluation of quantitative Striatal imaging in humans using SPECT, PET or MRI. The phantom allows the effects of the imaging system on receptor quantification to be investigated under conditions very similar to those in a patient. The phantom includes a transparent brain shell, contained inside an accurately modeled human head, and a set of fillable external markers. The brain shell has five compartments, which can be filled separately: left and right nucleus caudate, left and right putamen, and the rest of the brain shell. This allows different nucleus caudate to putamen ratios as well as different Striatal to background ratios to be obtained; this also permits differences between left and right Striatal activity to be examined.

The scans were done on a CT-SPECT machine “HAWKEYE” at the Baptist Hospital in Miami. HAWKEYE allows you to acquire SPECT and CT images on the same bed, inside the same gantry.
Radiotracer used was Technetium-99, with a predetermined amount of activity being injected in the putamen of the brain phantom for obtaining a set of data with different possible combinations to simulate ictal and interictal studies. A separate set of experiments was performed for correcting the translation and rotation between the two images (intramodality) to be registered.
Automatic Image Registration software (AIR) was used to perform the image registration task. The results were displayed using the MRIcro. This helped in integrated visualization of two different neuroimaging modalities. The functional information from SPECT will be co-registered with an anatomical reference image (CT) in order to provide anatomical framework to functional data. The final goal was to validate the accuracy of SPECT subtraction using the software with the results obtained from the scans done with pre-determined values of activities.

Results

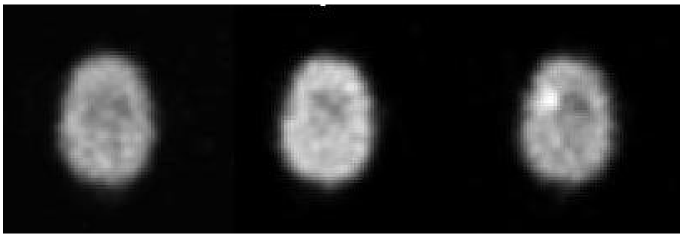

Figure 1. Interictal, Ictal (with 16% Perfusion Increase) and Ictal (with 200% Perfusion Increase), SPECT images of Brain Phantom on a GE Scanner, HAWKEYE

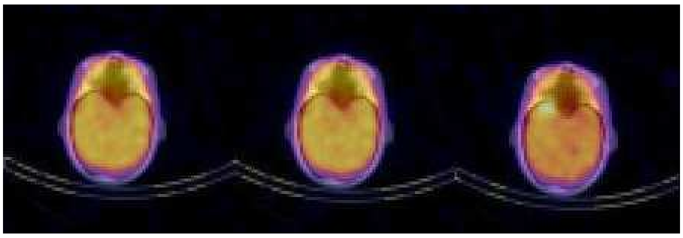

Figure 2. SPECT-CT Registered images of Interictal, Ictal (16% PI) and Ictal (200% PI)

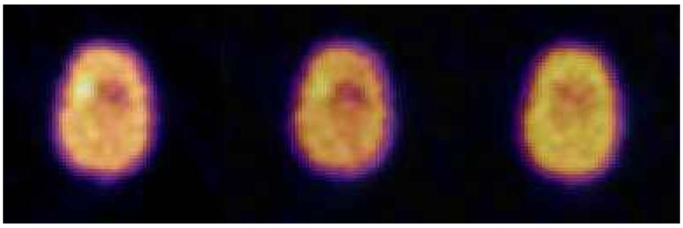

Figure 3. Subtracted Images,

a. Ictal (200% PI) - Interictal

b. Ictal (200% PI) - Ictal (16% PI)

c. Ictal (16% PI) – Interictal

PI : Perfusion Increase

Discussion

Epilepsy is one of the most prevalent neurological disorders-affecting about 1% of the general population [7]. Scalp EEG often fails to accurately localize the seizure focus. Excision of the focus can lead to elimination of the seizures or significantly improved pharmacologic control in 80% of patients. CT and MRI have low sensitivity for seizure foci detection, 17% and 18% respectively. The role of brain SPECT is to localize the seizure focus [8]
Wide range of techniques for sequential image registration can be found in the literature. There are three basic elements of the registration methods: features, search strategies, and similarity measures. At the end, the registration outputs the set of transformations that can be used to correctly map the input image to the reference image. It has been known that there is no single best image registration technique for all types of data. Each technique has its own advantages and disadvantages for particular input data.

Conclusions

It allows us to determine the limit or margin of perfusion increment in the ictal study with respect to the interictal study that can be detected.
The method is reliable and can also be also applied to PET and MRI.
The results indicated that when there is 16% increase in activity with respect to Interictal studies, the subtracted images don’t show a significant amount of difference in perfusion increase. However with a 200% increase in activity, the resulting subtracted images show highly localized area of hyperperfusion.

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