Ictal SPECT in epilepsy: the advantages of automatic dose injection system

"*Early results using an automated injection system are promising in reducing injection time and improving SPECT accuracy.*"

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Epilepsy is the most prevalent chronic neurological disorder in the field of neurology. It is estimated to affect five out of every 1000 people in the population. The range of drug treatments currently available provides adequate control of the disorder for 75% of patients. However, this leaves 25% of sufferers for whom even the use of polytherapy at maximum dosage is not effective [1]. It is in this latter group that surgery is considered an option to limit the frequency of seizures. Resective epilepsy surgery is based on the premise that if the epileptogenic area is completely removed, the patient will be seizure-free. Presurgical evaluation of patients with drug-resistant epilepsy can identify the epileptogenic area or region and a successful surgical outcome will depend on accurate preoperative localization of the seizure focus. Video-EEG monitoring, with scalp and sphenoidal electrodes, is the method of choice for localizing seizure focus. However, scalp EEG is often inadequate, especially for deep lesions or in rapidly spreading seizures, where it either fails to register or identifies activity as propagation rather than seizure onset [2]. In order to avoid invasive recordings with intracraneal electrodes, structural and functional imaging procedures have been developed to supplement EEG findings. MRI, PET and ictal and interictal SPECT are the most frequently used procedures for localizing seizure focus.

Brain SPECT is a nuclear medicine exploration that can map the distribution of cerebral blood flow at the moment of tracer injection. If a radioactive tracer injection can be given during the epileptic seizure, a brain SPECT will localize the onset zone by showing increased uptake [3]. Ictal SPECT is probably the best imaging procedure to localize the seizure onset zone before surgery in patients with complex partial seizures [4]. A good ictal SPECT is not always easy to obtain, however, because a seizure is a dynamic process in which several brain regions can become involved sequentially [5,6]. As a consequence, ictal SPECT as a technique has been limited to a few specialist epilepsy centers. Its complex methodology means that it is not routinely available in clinical practice in the majority of nuclear medicine departments.

The biggest problem with ictal SPECT is that the radiotracer dose has to be calculated and administered manually, a time-consuming process that requires the constant availability of trained medical staff at the bedside for extended periods. As seizure onset is unpredictable, we must maintain a tracer-filled syringe close to the patient's bed, waiting for a seizure to occur. The urgency of calculating the correct radioactive dose and rapidly administering it to a patient in the middle of an epileptic attack is stressful, complicated and can increase the risk of radioactive contamination. As any delay between seizure onset and tracer injection can seriously compromise results (giving false readings caused by activity spread), it is essential that the injection procedure takes as little time as possible.

"*[The] complex methodology [of ictal SPECT] means it is not routinely available in clinical practice in the majority of nuclear medicine departments.*"

An automatic radioactive isotope injection system would remove some of the pressure on medical staff and increase the accuracy of ictal SPECT in order to localize the seizure focus. No commercially manufactured injection system is currently available, although some epilepsy units are using injection systems of their own manufacture [7–9].

Our center has developed an injector system that calculates the volume of radioactive tracer to be injected over time (allowing for radioactive decay) and then quickly administers the dose automatically, making this procedure much more safe, simple and effective. Technical data of this injection system are described in Setoain *et al.* [10].

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In this article, injection times and seizure focus localization with SPECT were analyzed in 56 patients with drug-resistant complex partial seizures who were undergoing presurgical evaluation at our hospital. Results have demonstrated that the use of such a system significantly reduces the time lag between seizure and injection.

> *"...automated injection systems simplify the methodology for injecting radioactive doses during seizure, making ictal SPECT more accessible."*

The final goal of the automated injection system is to improve SPECT's diagnostic performance. The highest rate of seizure focus localization achieved by trained staff administering manual injection is 65% [10]. This has increased to 78–80% using an automated injection system [9,10].

Nursing staff and technicians appreciate the ability to monitor patients from their workstation room, rather than maintaining a constant vigil at the patient's bedside. The injection is initiated by remote control, allowing them to perform other tasks while the patient is under observation. The degree of stress during injection is noticeably reduced with the automated system and the risk of possible accidental radioactive contamination is eliminated.

With short half-life radioactive tracers, the injected volume needs to be adjusted depending on time lapsed. Checking the time and calculating the correct dose is an added complication in manual injection. The automated system software generates an immediate calculation and guarantees a volume that will administrate 925 MBq with a maximum error of ±3% over a 4 h period [10].

Automated injection system software can be adapted to provide pediatric doses when needed. Other parameters can be changed, such as dead volume, which will vary if the line tube is changed in diameter or length. Expiration time for injection can also be changed, which can be more than 4 h after dose preparation if ethyl cysteinate dimmer (ECD) is used instead of hexamethylpropyleneamine-oxine. ^{99m}Tc-ECD has shown higher stability *in vitro* and may be more appropriate for this type of equipment. Its radiochemical purity is greater than 90% over an 8 h period, which allows tracer availability for ictal SPECT over a longer period of time [11,12].

Finally, it is important to highlight that automated injection systems simplify the methodology for injecting radioactive doses during seizure, making ictal SPECT more accessible. Benefits include the possibility of maintaining the tracer at the patient's bedside for longer, with significantly less stress for the nurses and EEG technicians, and allowing finer adjustment of the injection dose. Early results using an automated injection system are promising in reducing injection time and improving SPECT accuracy. A commercially manufactured injection system would help extend the use of ictal SPECT to more nuclear medicine departments.

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