Nursing Benefits of Using an Automated Injection System for Ictal Brain Single Photon Emission Computed Tomography

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ABSTRACT

The traditional method of administering radioactive isotopes to pediatric patients undergoing ictal brain single photon emission computed tomography testing has been by manual injections. This method presents certain challenges for nursing, including time requirements and safety risks. This quality improvement project discusses the implementation of an automated injection system for isotope administration and its impact on staffing, safety, and nursing satisfaction. It was conducted in an epilepsy monitoring unit at a large urban pediatric facility. Results of this project showed a decrease in the number of nurses exposed to radiation and improved nursing satisfaction with the use of the automated injection system. In addition, there was a decrease in the number of nursing hours required during ictal brain single photon emission computed tomography testing.

Review of Literature

Seizures are a result of abnormal cerebral discharge of neurons. A generalized tonic clonic seizure originates in both cerebral hemispheres. Complex partial seizures usually originate in one cerebral hemisphere (Neidermeyer, Schomer, & Lopes da Silva, 2011). The seizure focus in patients with complex partial epilepsy may be further localized to a specific area of the brain. After a proper diagnostic workup and consideration of potential future neurologic sequelae, the removal of this area of the brain could potentially result in cessation of the patient's seizures. Because complex partial seizures in children are usually medically refractory (Kottamasu, 1997), surgical treatment may be an option. Ictal brain single photon emission computed tomography (SPECT) testing is a diagnostic test that identifies and maps the actual location of the seizure focus by showing a focal alteration in cerebral blood flow and metabolism associated with a seizure focus (Kottamasu, 1997; Patil, Biassoni, & Borgwardt, 2007).

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Radioactive isotope is injected during the seizure to identify localization of seizure focus (Kottamasu, 1997; Patil et al., 2007). Children are monitored with video electroencephalography (EEG) to identify the onset of a seizure (Patil et al., 2007). It is necessary to provide accurate documentation regarding the onset, duration, and end of seizure activity, either clinically or on video EEG, in correlation to the injection of the radioactive isotope. This method of ictal brain SPECT testing is cost effective and sensitive in the identification of presurgical localization of seizure focus in children (Kottamasu, 1997, p. 579).

Radioactive isotope concentrates in the section of the brain that experiences increased blood flow during a seizure. Thus, it is necessary to inject the isotope immediately upon seizure onset. With an injection at the onset of a seizure, the isotope is likely to concentrate in the brain at the site of the seizure focus. With a delayed injection, the isotope may disperse over several areas of the brain, demonstrating the propagation of the seizure rather than the starting point (Patil et al., 2007). Traditionally, the injection of the isotope falls within the purview of the nurse. Therefore, nursing plays a pivotal role in this process. The nurse remains at the patient's bedside with the isotope syringe and waits to inject the isotope upon initiation of seizure activity. This method has yielded excellent scans in the identification of a seizure focus (Huntington, 1999).

Because medical personnel are responsible for the injection of the radioactive isotope, this may lead to a delay between the injection of isotope and seizure onset (Van Paesschen et al., 2000). This could result in a false identification of seizure focus. Van Paesschen et al. (2000) invited patients who had undergone a

SPECT test 30 hours previously to participate in another SPECT test using a self-injection method of isotope injection with their next seizure. The results showed that patients who were able to press the button and self-inject the radioactive isotope did so 24.5 seconds earlier than if the injection was performed by medical personnel (Van Paesschen et al., 2000). However, this is not a feasible option in the pediatric population. A manual injection system was compared with an automated injection system, with the results displaying more efficient use of staff, shortened injection times, and a true ictal injection with the use of an automated injection system (Sepkuty et al., 1998). It was reported that the longer the injection of isotope is after the onset of seizure activity, the less there was local hyperperfusion (Sepkuty et al., 1998, p. 1353) and the more likely the scan will show multiple variably perfused areas (Patil et al., 2007).

Background

The traditional method used in our epilepsy monitoring unit (EMU) for ictal brain SPECT testing consisted of the nurse manually injecting the radioactive isotope at the onset of seizure activity. This process required the nurse to remain at the patient's bedside for multiple shifts over several days until a seizure could be obtained. Once the patient experienced a seizure, either clinically or electrographically, the nurse and EEG technologist would communicate via an intercom system to verify that the patient's EEG displayed an electrographic correlate and it was appropriate to inject the isotope. The nurse would remove the isotope from the lead shield and inject the isotope into the patient's peripheral intravenous site. This action could potentially increase the risk of radiation exposure to the nurse (Sans-Merce et al., 2011).

Potential safety issues can be identified using this process, one of which is accidental spillage of radioactive material when attempting to inject an isotope during a seizure that involves clinical changes and movement. In addition, maintaining a 1:1 nursing ratio during an 8-hour shift is stressful and labor intensive. This negatively affects nursing satisfaction when providing care to patients and families.

Implementation

In an effort to implement process improvement, an automated injection system already utilized in the magnetic resonance imaging (MRI) department was adapted for remote injection of isotope in patients undergoing ictal brain SPECT testing in the EMU. The automated injection system was intended to take the place of the bedside nurse who would otherwise be waiting to inject the isotope for the ictal brain SPECT. This process change was evaluated and approved by the hospital's Quality Outcomes Committee. Because it was a quality improvement project and not a research project, it required no institutional review board approval. A multidisciplinary team composed of staff from the EMU, nuclear medicine, and radiation safety departments was brought together to develop this new process.

> The authors of this study compare a manual radioactive isotope injection system with one that is automated; they were able to demonstrate more efficient deployment of staff, decreased injection time, and a true "ictal" injection with the automated system.

The patient population consisted of refractory epilepsy patients referred by their neurologists for epilepsy surgery evaluations and who underwent ictal brain SPECT testing from March 2009 to February 2011. These patients ranged in age from 2 to 19 years (M = 11.2 years) and were almost equally divided in gender (male = 35/female = 36). Patient care before and after injection was unaffected and remained consistent with established unit standards of care.

The existing MRI injector system was adapted to the new specifications required for use in the EMU. These adaptations included such items as the intravenous drip rate, injection speed, needle bore size, and length of intravenous tubing, all of which were different from those used in the MRI setting. A custom-built lead shield was constructed to encase the radioactive isotope syringe. Prior to implementing the new process, training on the automated system was conducted by the EMU nurse supervisor, the nurse educator, and a company representative for the injection system. Multiple training sessions were conducted with the EMU nurses, EEG technologists, and nuclear medicine staff, providing the opportunity for review and hands-on return demonstration of the automated injection system. Ultimately, the new process enabled the injector system to function efficiently, safely, and with consistent, reproducible results in its new setting. The system was first utilized in March 2010.

The new process required two nurses (one in the patient room and one in the technologist control room) who coordinated the injector settings on the automated pump (in the patient room) with those on the injector monitor (in the technologist control room). This was done at the beginning of the day prior to the inception of ictal SPECT monitoring and again at the halfway point of the ictal SPECT monitoring period. The nurse in the control room entered all data (including amount of isotope, amount of flush, drip rate, and date/time verification) into the injector monitor. The pump was armed by the nurse, and the EEG technologist then assumed responsibility for initiating the injection at seizure onset. The nurse was then able to provide care to the patient undergoing SPECT monitoring as well as to the other patients on her assignment. Prior to the use of the automated injector system, the nurse would sit at the bedside of the patient undergoing SPECT throughout the entire shift, often for multiple days, without any other patient assignments.

The new process was relatively seamless; however, minor issues were noted related to the setup of the new pump. The EMU nursing staff is composed of 15 staff nurses, and all were required to become proficient with the automated injection system. The new process also required the EEG technologist staff to activate the injector upon proper identification and verification of a seizure. Technologist staffing levels were adjusted to accommodate this process change. No additional technologist salary cost was associated with this process change. As with most new systems, we identified a learning curve. To assist in the learning process, a list of helpful tips was developed for staff reference.

Leadership of the EMU explored whether the new injection system affected nursing satisfaction, improved radiation safety, and decreased staffing. A comparison of nursing hours before and after implementation of the system provided data to support a decrease in nursing hours per patient. The dosimetry report, which identifies annual radiation exposure to the nursing staff, showed a decrease in the number of nurses who had a positive radiation exposure after implementation of the automated injection system.

Nursing satisfaction plays an important role in staff retention. When nurses are satisfied with their jobs, there is an increased level of commitment to the organization as well as improved staff morale (Hayes, Bonner, & Pryor, 2010). The 15 nurses on the EMU were invited to participate in a quality improvement project survey. This descriptive survey was developed utilizing the Lickert design to measure the nurses' subjective satisfaction with the new

TABLE 1. Nurse Satisfaction Survey

1. When caring for a patient who is admitted for ictal brain SPECT testing with the use of the automated injection system, how satisfied are you with your patient care assignment?
   a. Very satisfied
   b. Moderately satisfied
   c. Undecided
   d. Moderately dissatisfied
   e. Very dissatisfied
2. When caring for a patient who is admitted for ictal brain SPECT testing with the use of the automated injection system, how satisfied are you with the amount of time you spend in the patient's room?
   a. Very satisfied
   b. Moderately satisfied
   c. Undecided
   d. Moderately dissatisfied
   e. Very dissatisfied
3. To what extent do you feel the ictal brain SPECT automated injector has decreased the risk of isotope exposure to direct care provides?
   a. A great deal
   b. Moderate amount
   c. Somewhat
   d. Very little
   e. Not at all

Note. SPECT = single photon emission computed tomography.

process. Participation in the survey was voluntary. The survey questions were asked 6 months after the implementation of the automated injection system. The participating nurses completed questions related to satisfaction with their patient care assignment, the amount of time spent by them in the patient's room, and if they believed the automated injection system decreased their risk of isotope exposure. Survey questions are shown in Table 1.

Results

In comparing the nurse-to-patient ratio before and after implementation, a decrease in required nursing hours per patient with the use of the automated system was identified. This was directly related to the nurse no longer remaining at the patient's bedside, prepared to manually inject the isotope upon seizure onset. Concomitantly, nursing productivity increased. Prior to inception of the automated injection pump, all patients were assigned 1:1 nursing during SPECT testing time. After implementation of the automated injection pump, the nurse-to-patient ratio gradually increased from 1:1 to 1:3. As usual, all daily patient assignments were made based on the patient's acuity level. Technologist assignments were adjusted to ensure availability of senior technologist staff to activate the injector pump. Results are presented in Figure 1.

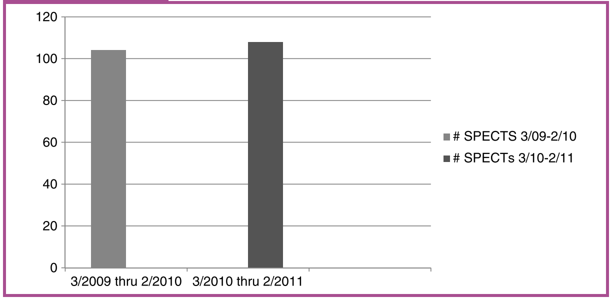
The radiation dosimetry report provided data related to radiation exposure. Each nurse wore a radiation badge that logged the amount of radiation exposure they received during an 8-hour shift. The report was examined for the period of March 2009 through February 2011, before and after injector system implementation. There were 104 SPECT test days from March 2009 through February 2010 during which the manual method of injecting was utilized. From March 2010 through February 2011, there were 108 SPECT test days using the automated method. The results display a decrease in the number of nurses who had a positive radiation exposure reading after the automated system was implemented. The difference in the radiation exposure of the nurses before and after implementation was analyzed using Fisher's exact test with significance indicated at $p < .05$. Although not statistically significant ($p = .109$), the overall decrease in the number of nurse exposures is a clinically significant finding. Results are presented in Figures 2 and 3.

The postimplementation satisfaction survey was sent to a cohort of 15 staff nurses, with a response rate of 11. All responders were very satisfied with their patient care assignment, the amount of time spent with their patient, and the decrease in their potential radiation exposure. The results of the survey support that nursing satisfaction improved due to the automated injection system. Results are presented in Figure 4.

Implications for Practice

During the implementation of the new system, some issues were identified. The nurses were initially reluctant to leave the patient's room once the injector pump was set up and active. There was a definite learning curve and a gradual increase in comfort levels with the equipment and process. During the beginning of the process change, the nurses were observed making numerous, frequent trips back to check on the patient

FIGURE 2 SPECT Testing Days



Note. SPECT = single photon emission computed tomography.

FIGURE 1 Nurse–Patient Ratio During Single Photon Emission Computed Tomography Testing: 7 a.m. to 3 p.m. Shift

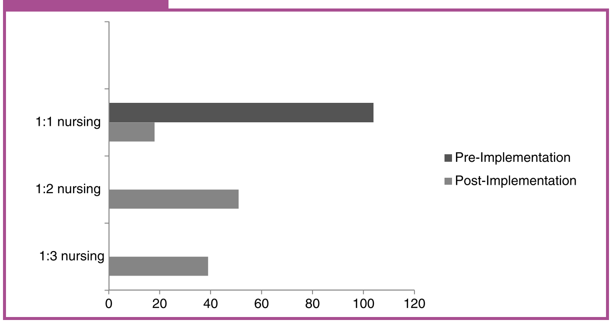


FIGURE 3 Radiation Dosimetry Report: Annual Radiation Exposure ($p = .109$)

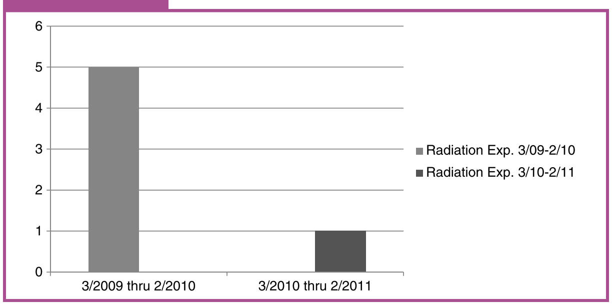
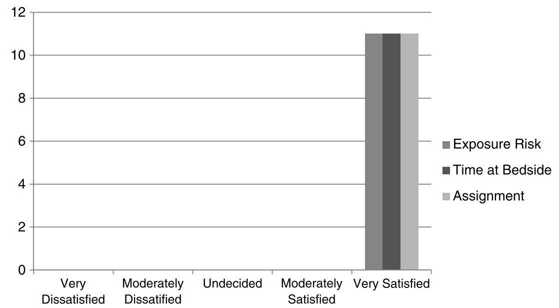


FIGURE 4 Postimplementation Nursing Satisfaction Survey (n = 11)



and pump. As they became more comfortable with the new process, the number of trips decreased. The new process no longer required the nurse to remain at the bedside during testing. As a result, the nurse call system, the event button on the EEG equipment, and an intercom were utilized to notify nursing of seizure onset. Nursing would then immediately respond to the patients needs.

Identifying and troubleshooting the errors that occurred when setting up the injector pump presented an additional opportunity for nursing education. Most errors were linked to incorrectly following all the steps in the setup process. Some errors included syringes not being completely loaded and locked on the unit, low or dead battery indicators, and connection problems with the cables or plugs. The tip sheet was utilized by staff for assistance in troubleshooting. The errors decreased as staff became more experienced with the injection system.

Conclusions

The automated injection system has been beneficial in the EMU of this project facility and could provide the same benefit to other institutions faced with the similar issues of nursing hours, nursing job satisfaction, and safety concerns. The new system has provided this nursing staff with greater satisfaction related to their patient care assignment, decreased nursing hours, and markedly improved safety related to radiation exposure. Further research would be needed to generalize these findings.

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