

Impact of Sevoflurane and Propofol Anesthesia on Quality of [¹⁸F] FDG-PET Scan Image

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Abstract

Background: Profound sedation or general anesthesia is required in pediatric patients when performing positron emission tomography to identify epileptic foci. We investigated the effect of sevoflurane and propofol anesthesia on both the [¹⁸F] FDG-PET scan image quality and sensitivity of localizing epileptic foci in pediatric patients with epilepsy.

Methods: After IRB approval, a retrospective single institutional study of PET Scans from 55 patients (April 2012 - April 2014) was conducted. Patients received [¹⁸F] FDG-PET scan under general anesthesia by either propofol (n=25) or sevoflurane (n=30). All patients were kept spontaneously breathing and anesthesia levels titrated to lack of patient movement during positioning for scan. The patients were injected with 18F-FDG (0.15 mCi/Kg) and after a 30-minute circulation time a PET/CT brain was performed on a GE Discovery 690 scanner. SPM (Statistical Parametric Mapping) of specific regions of brain activity were obtained with Hermes' BRASS software. For each patient, the percent of activity within the right and left cerebellum, frontal lobes, thalami, posterior central gyrus, and brainstem was compared to a standard adult brain control provided by the software package. Visual Rating Score (VRS) of the quality of the PET/CT scan was performed by a Nuclear Medicine physician using the Likert scale. Positive PET-scan diagnosis of epileptic foci was calculated for comparison. The Mann-Whitney U test was used to compare the SPM and VRS between anesthesia groups. Pearson's Chi square test was used for detection sensitivity comparison.

Results: There were no statistical differences in demographic data and pre-scan physiologic data (BP, HR, RR, blood glucose, etc) in both groups. The SPM value was significantly higher in patients treated with propofol (P < 0.05), with the exception of the right frontal area (P=.07). VRS was 2.88 019 in the propofol group and 2.73 016 in the sevoflurane group (P= 0.484). The percentage of detection of epileptic foci in the propofol group (19/25, 76%) was significantly higher than in the sevoflurane group (14/30, 46.67%) (P=0.028).

Conclusion: Pediatric patients with propofol anesthesia had higher SPM values in the majority of the brain, indicating less metabolic brain depression. However, the PET-scan image quality by VRS did not differentiate by anesthetic type. The PET-scan was able to identify epileptic foci more effectively in pediatric patients under propofol anesthesia than under sevoflurane anesthesia.

Keywords: Epilepsy; Sevoflurane; Propofol; PET scans;

Introduction

[¹⁸F] FDG-PET scan has an established role in the noninvasive localization of epileptogenic foci before surgical intervention in children. The epileptic focus in the interictal phase appears as hypometabolic area on [¹⁸F] FDG-PET scan [1, 2]. PET scans consist of computer-generated cross-sectional images of the distribution of 18F-deoxyglucose, [¹⁸F FDG], the most commonly used radiotracer. PET scanning is advantageous because of its versatility of providing in vivo information regarding a patient's glucose metabolism and brain function. Images of different areas of the brain are compared to a standard adult control.

Young children with epilepsy who undergo PET imaging usually require profound sedation or general anesthesia to minimize the patient movements to avoid artifact. Both

sevoflurane and propofol are commonly used anesthetics for PET imaging procedure. It has been known that both sevoflurane and propofol decrease glucose metabolic rate (GMR) in the brain, but suppression in regional glucose metabolic rate (rGMR) varies in different regions [3-6]. Thus, anesthetics can cause hypometabolic area on [¹⁸F] FDG-PET scan and may affect the quality of PET scan image [7]. A recent study by Wagner suggested both propofol and sevoflurane are suitable to detect epileptic lesion by visual assessment in pediatric patients [8]. However, this study did not use Statistical Parametric Mapping (SPM) analysis to evaluate the PET scan image quality. SPM analysis was recently introduced into [¹⁸F] FDG-PET scan analysis. SPM procedure is an objective tool to analyze [¹⁸F] FDG-PET images and useful complement to visual analysis [9]. Comparing to visual analysis, SPM in [¹⁸F]

FDG-PET scan improves the accuracy of diagnostic imaging by eliminating some subjectivity and expertise required by visual assessment [10].

We investigated the effect of sevoflurane and propofol anesthesia on both the [¹⁸F] FDG-PET scan image quality and sensitivity of detecting epileptic foci in pediatric patients with epilepsy.

Methods

After Institutional Review Board [IRB] approval, a retrospective single institutional study using chart review of PET scans from 55 consecutive patients (28 males, 27 females) from April, 2012 to April 2014 was conducted. All patients had clinically significant epilepsy and received [¹⁸F] FDG-PET scan under general anesthesia by using either propofol or sevoflurane. Patient’s demographic data, body weight and height, pre-scan diagnosis, type of anesthesia, preoperative vital signs and blood glucose level were recorded. The PET scan suite was warmed to minimize heat loss in patients, and warming blankets were used to keep patients normothermic. Each patient continued their antiepileptic regimen the day of the PET scan. No premedication was given.

Anesthesia type and monitoring

The type of anesthetic was left to anesthesiologist preference. Standard ASA monitors were applied. All patients received mask induction followed by maintenance with propofol infusion (110-350 mcg/kg/min) or sevoflurane inhalation (1.7-2.6% expiratory gas) with laryngeal mask airway after peripheral intravenous catheter was placed. Both anesthetics were titrated to clinical effect with no patient movement during positioning to scan. Patients remained spontaneously breathing and hemodynamically stable throughout the procedure.

PET Scan

The patients were injected with 18F-FDG (0.15 mcg/kg) and after a 30-minute circulation time, a PET scan of the brain was performed on a GE Discovery 690 scanner.

Image Analysis

SPM of specific regions of brain activity was obtained with Hermes’ BRASS software. For each pediatric patient’s brain, the percent of activity within the right and left cerebellum, frontal lobes, thalami, posterior central gyrus, and brainstem was compared to a standard adult brain control, provided by the software package. The subjective review of the quality of the PET scan was analyzed using the Likert scale to rate the image quality by a radiologist specializing in nuclear medicine imaging who was blind to anesthetic type. A simple rating scale of 1, 2, 3, and 4 was used. A value of 1 was considered poor quality, but a diagnostic study with diffusely diminished activity; 2 were the same criteria as 1 but with high activity within basal ganglia. A value of 3 was used to describe a good quality scan of high diagnostic quality and 4 included increased activity noted within basal ganglia in a good quality scan.

Statistical analysis

For the statistical analysis, the Shapiro-Wilk test was used to analyze the patient demographics and vital signs; evaluating for normality of distribution to the general population. To compare the SPM for each group (propofol vs sevoflurane), Mann-Whitney U test was used. Moreover, the significance of the [¹⁸F] FDG-PET scan to identify epileptic foci in the interictal phase was analyzed using the Pearson’s chi square test.

Results

All patients included in this study had an uneventful anesthetic and were discharged the same day after [¹⁸F] FDG-PET scan. There was no statistical difference in the patient’s demographics, vital signs, BMI, and glucose as shown in Table 1.

Table 1: Demographic Data and Vitals Signs with Standard Error Mean for each group

Demographics	Sevoflurane	Propofol	P value
Age (years)	6.32 ± 0.525	7.28 ± 0.765	0.409
Weight (kg)	24.73± 2.701	29.12± 2.924	0.196
Height (cm)	114.5± 3.999	120.6± 4.09	0.335
BS (mg/dL)	75.23± 1.926	81.92± 3.278	0.111
Systolic (mmHg)	113.59 ± 3.676	107 ± 2.34	0.152
Diastolic (mmHg)	71.1 ± 2.92	61.8 ± 3.271	0.055
HR (Beats per min)	97.07± 3.82	97.28± 3.314	0.852
RR (breaths per min)	20.69± 0.589	20.96± 0.716	0.531
Temp (Fahrenheit)	97.53± 0.141	97.89± 0.167	0.156

Anesthetic depth

Both propofol and sevoflurane were titrated to clinical effect with no patient movement during positioning to scan and spontaneously breathing. The average maintenance end tidal sevoflurane concentration was 2.18 ± 0.05%; while the average propofol maintenance concentration was 235.5 ± 17.5 mcg/kg/min. Hemodynamic stability, including blood pressure, heart rate, was maintained within normal limits in both groups patients (data not shown).

The anesthetic effect on brain SPM

The overall mean SPM value was higher in the propofol group, hence; there was less of a depressing effect with propofol and better ability to detect hypometabolic areas on [¹⁸F] FDG-PET

scan. SPM values in brain areas are shown in Table 2. The SPM value in the left frontal brain (p < 0.048), right hippocampus (p < 0.014), left hippocampus (p < 0.007), right thalamus (p < 0.001), left thalamus (p < 0.004), right posterior cingulate gyrus (p < 0.035), left posterior cingulate gyrus (p < 0.015), and the brain stem (p < 0.016) were higher in propofol group than that in sevoflurane group. The SPM of the right frontal brain in both groups was not statistically different and maybe due to confounding factors and sedation specific pharmacodynamic related changes in the brain.

The anesthetic effect on visual rating score (VRS)

VRS was 2.88 019 in propofol group and 2.73 0.15 in sevoflurane group. The difference in visual rating analysis was not statistically significant in both groups (p < 0.484) (Table 2).

Table 2: Statistical parametric mapping (SPM) value across the various regions of the brain and Visual Rating Score (VRS) of PET-scan image quality compared between anesthesia groups.

Brain Region	Sevoflurane	Propofol	P value
Right Cerebellar	79.513 ± 3.91	93.772 ± 3.96	0.009
Left Cerebellar	79.867 ± 3.39	93.036 ± 4.01	0.008
Right Frontal Med	82.29 ± 3.18	90.692 ± 3.83	0.07
Left Frontal Med	78.293 ± 4.17	90.160 ± 4.33	0.048
Right Hippo	82.767 ± 3.77	98.184 ± 4.14	0.048
Left Hippo	80.787 ± 3.97	98.656 ± 4.27	0.07
Right Thalamus	65.69 ± 3.73	85 ± 3.69	0.001
Left Thalamus	66.993 ± 3.84	85.052 ± 4.35	0.004
Right Post CG	80.693 ± 3.13	91.648 ± 3.75	0.035
Left Post CG	81.10 ± 3.27	95.12 ± 4.05	0.015
Brainstem	88.27 ± 3.93	103.36 ± 4.17	0.016
Visual Rating	2.73 ± 0.16	2.88 ± 0.19	0.484

Note: Statistical parametric mapping of pediatric patients in different areas of the brain were compared to a standard adult control.

The anesthetic effect on detection of interictal foci

In propofol group, 19 out of 25 (76%) had positive PET scans in comparison to 14 out of 30 (46.7%) in sevoflurane group. The predictability of the PET scan to detect an interictal epileptic foci in the propofol group was significantly higher (p value < 0.02).

Discussion

Main findings of the present study are 1) both sevoflurane inhalation or propofol infusion provides excellent anesthesia during PET scanning in pediatric population; and 2) Propofol infusion anesthesia is better than sevoflurane inhalation in localizing epileptic foci in pediatric patients with epilepsy. [¹⁸F] FDG-PET scanning has brought innovative changes in managing epileptic patients and preparing them for surgery. Profound sedation or general anesthesia is usually required in the pediatric population to minimize patient movement when performing a PET scan. Inspection of [¹⁸F] FDG-PET image used in pediatric clinical practice is subjective and dependent on observer

experience and expertise. SPM analysis in [¹⁸F] FDG-PET scan improves the accuracy of diagnostic imaging by eliminating some subjectivity required by visual assessment [10].

Wagner et al. [8] compared the impact of propofol and sevoflurane anesthesia on overall quality of PET images, detectability of a hypometabolic lesion and demarcation of the detected lesion in pediatric patients suffering from focal epilepsy. They found that differences in neither single dimension ratings nor in sum scores were statistically significant. They concluded that both, sevoflurane and propofol based anesthetic regimes are suitable to detect hypometabolic cerebral lesions during FDG-PET. Similar to Wagner’s report, our result showed that the type of anesthesia between propofol and sevoflurane did not affect the VRS of the image quality. However, propofol had less depression effect on brain SPM value comparing to sevoflurane. The exact causes are unclear since both agents inhibit the GMR of the brain (5-7). Propofol reduces Cerebral Blood Flow (CBF) while sevoflurane increases it. It is possible that effect on the uptake

of [¹⁸F] FDG in the brain tissue is different among propofol and sevoflurane. One animal study showed that ¹⁸F-fluorodeoxyglucose uptake into the brain was higher compared to other anesthetic including isoflurane and ketamine [11].

Our study also found that PET scan has higher success rate in localizing interictal epileptic foci in pediatric patients with epilepsy under propofol anesthesia when compared to patient with sevoflurane anesthesia. This finding is clinically significant because of its importance in preparation of surgery. Propofol may be a better anesthetic that improves localization of interictal foci.

There are limitations in our study. First, the patient in this study was not selected randomly since it was done retrospectively. Secondary, the clinical depth of anesthesia level was targeted to non-movement of patient and regular spontaneous breathing. The anesthesia depth monitoring such as BIS was not used in patients for both groups due to logistic difficulty in a remote setting. However, the depth of anesthesia may not differ significantly because all patients were titrated to meet the same anesthesia requirement and hemodynamic stability. Third, end-tidal CO₂ (EtCO₂) was monitored in all patients. Since different circular systems were used in two group patients. An open system was used in patients with propofol infusion and a closed circuit system used in patients with sevoflurane inhalation. EtCO₂ value was not comparable in two groups.

In conclusion, pediatric patients with propofol anesthesia had higher SPM values in the majority of the patients, indicating less metabolic brain depression. However, the PET-scan image quality by VRS did not differentiate by anesthetic type. The PET-scan was able to identify epileptic foci more effectively in pediatric patients under propofol anesthesia compared to sevoflurane anesthesia. Further study should be prospective and randomized in nature with those parameters controlled and is needed to validate our results.

Disclosers

The authors report no conflict of interest

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