Study of the Difference in Residual Amounts according to the Method of Securing Intravenous Injections and the Dose of Physiological Saline during ^{18}F-FDG Administration

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ABSTRACT

This study compares the difference between the remaining amount in syringes according to injection method and the dose of physiological saline when the radiopharmaceutical ^{18}F-FDG isotope is injected into patients who visited the hospital for PET examination. After performing a CT or MRI using a contrast medium when ^{18}F-FDG was injected into 40 patients who came to the hospital for PET examination without removing the 3-way, the radioactivity remaining in the syringe and the 3-way was measured and the dose of radioactivity confirmed. At this time, 20 patients were divided into different dose groups of physiological saline. Another injection method was used to compare the remaining amount of the syringe and the difference in the remaining amount according to the amount of physiological saline when the injection was performed with an extension. After an injection of ^{18}F-FDG, the actual administered dose was confirmed by measuring the radioactivity remaining in the syringe and the 3-way or extension with a calibrator. As a result of measuring the radioactivity of the syringe before administering the radiopharmaceutical and the radioactivity of the syringe and the 3-way or extension after administration, the 3-way injection method in 10 cc's of physiological saline had the lowest residual amount. The remaining amount increased in the order of the extension to 10 cc's of saline and the 3-way to 5 cc's of saline. Likewise, the 5 cc's saline solution and the extension injection method demonstrated the highest residual amounts. The residual difference with the lowest level of remaining injection method was found to be 0.053 mCi. It was found that in a PET examination, by considering the radioactivity remaining in the 3-way and extension and by adjusting the dose of physiological saline, if the intended dose to be administered to the actual patient is determined, it is possible to administer the radiopharmaceutical to the patient more accurately.

Keywords: Residual activity, ^{18}F-Fluorodeoxyglucose, IV (Intravenous line) method, standardized uptake value

I. INTRODUCTION

In a PET (Positron Emission Tomography) scan, the administered dose of ^{18}F-FDG is 0.14 mCi per kg of body weight[1]. The dose before ^{18}F-FDG administration is measured using a dose calibrator and is measured after administration. The dose administered quantitatively to the patient is then calculated by subtracting the measured value after administration[2-3]. Thus, when performing an imaging test the dose administered to the patient is inputted into the test equipment in order to perform a more accurate test[4]. A diagnostic image can be obtained only when radiopharmaceuticals according to the patient's weight are administered quantitatively, and quantitative analyses such as measuring the average standardized uptake value (SUVmean) is possible[5-6].

Therefore, quantitative administration of radio pharmaceuticals is highly important in order to quantitatively administer

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radiopharmaceuticals to patients through an IV. It is then necessary to distribute in consideration of the amount of the remaining in route[7]. In this study, an IV was used to accurately distribute the amount of radiopharmaceuticals according to the patient's weight by finding out the difference between the remaining amount of radiopharmaceuticals according to the route securing method and the amount of physiological saline solution. As a result, the amount of radiopharmaceuticals is then administered to the patient[8-9].

II. MATERIAL AND METHODS

1. Materials

From May 1 to December 31, 2021, two methods were used to secure intravenous infusion lines among outpatients and sick ward patients for PET examination in the Department of Nuclear Medicine. As shown in Fig. 1, for patients who also require a combined CT or MRI examination, 40 syringes with a 3-way stopcock were connected to an angiographic injection and 40 syringes were secured with an injection line. Next, 40 syringes connected with an extension line to the angiographic injection were tested. According to the two methods of securing the injection line, 20 patients were further divided and the saline dose was changed to 5 cc's and 10 cc's.

2. Methods

The radiopharmaceutical used in PET imaging for this study was ^{18}F-FDG (Fluorodeoxyglucose). During the administration process, after measuring the weight of the patient an injection line was secured to a blood vessel. Before injecting the radiopharmaceutical into the patient, the dispensed dose (Pre-Dose[mCi]) of the syringe was measured using a CRC- 25R dose calibrator (CAPINTEC INC. USA) and recorded[10].

After administering the radiopharmaceutical to the patient via syringe and IV, all routes were removed and the remaining capacity (Post-Dose[mCi]) was measured using a calibrator and recorded. Based on this, it is possible to obtain the actual dose rate injected into the patient, as in Eq. (1).[11]

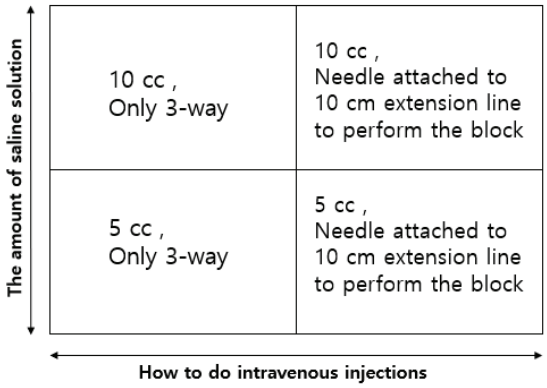


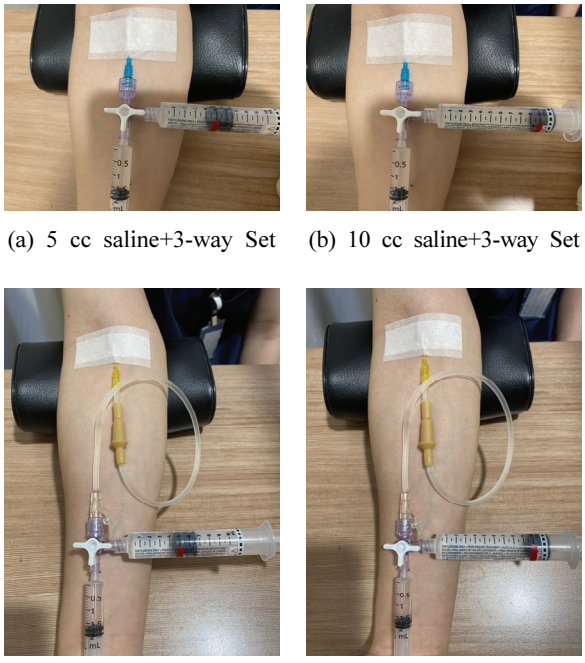
Fig. 1. 4 elements of physiological saline and injection method.

$$ActualDosingRate(\%) = \frac{Pre-Dose[mCi] - Post-Dose[mCi]}{Pre-Dose[mCi]} X\,100 \quad (1)$$

In this study, the method of securing the injection line as shown in Fig. 2 was divided into (1) using a 3-way stopcock (Insung medical, KOREA) connected to the angiographic needle and (2) using a 10cm extension line connected to the angiographic needle. At this point, according to the method of how each injection line was secured, the volume of normal saline was divided into 5 cc's and 10 cc's. Next, the volume of the syringe dispensed was 2 cc's, with the volume of radiopharmaceuticals unified to 1.5 cc's. Capacity was selected considering the length of the 10 cm extension line. In addition, the distributed syringe was administered into the injection line once and the one-time saline solution was pulled to the amount of 1 cc's in the direction of the syringe distributed from the saline connected to the 3-way, then pushed again until the saline solution remaining in the saline syringe was injected.

3. Statistical analysis

The Statistical Package for the Social Sciences (SPSS) 27.0 program was used for data processing to compare the injection method to reduce the remaining amount of radiopharmaceutical in the syringe and the dose rate according to the dose of the physiological saline. Next, Analysis of Variance (ANOVA) and paired sample t-test analysis were performed with the result of the analysis verified at a significance level of 5 %.



(a) 5 cc saline+3-way Set (b) 10 cc saline+3-way Set

(c) 5 cc saline+extension (d) 10 cc saline+extension

Fig. 2. How to secure saline solution and injection.

III. RESULT

1. Comparing administration rates according to the 3-way stopcock and extension in dilution of the same dose of 5 cc's of the physiological saline

When the method of connecting a 3-way stopcock to an angiographic needle was used in 20 out of 40 of the patients, the amount of physiological saline was diluted to 5 cc's and the radioactivity was measured before and after administering the radioisotope to the patient. As a result, the average of the radioactivity before administration was 8.546±1.943 mCi, and the average radioactivity administered to the actual patient was 8.517±1.935 mCi, as shown in Table 1. On average, 0.029±0.009 mCi were administered to the patient, which was less than the initial dose intended to be administered. If the ratio of the radioactivity of the dose to be administered to the first patient was 100%, the ratio of the radioactivity administered to the actual patient was about 99.66%, with the ratio of the radioactivity remaining in the syringe and 3-way stopcock around 0.34%. As a result of measuring the radioactivity before and after administering the radioisotope to the patient by linking the extension to the angiographic in the same 5 cc's saline dilution in another 20 patients, the mean radioactivity before administration was 9.016±1.854 mCi, and the mean dose of radioactivity administered to subjects was 8.956±1.842 mCi, as shown in Table 1. On average, 0.057±0.014 mCi less was administered to the patient, which was less than the initial dose intended to be administered. The proportion of radioactivity administered to the actual patient was about 99.36 % and the proportion of radioactivity remaining in the syringe and extension was around 0.64 %. In the same dose of 5 cc's, the difference in the remaining amount according to injection method was verified, as seen in Table 2. First, in Levene's test for equal variances, the significance probability was over 0.05, so looking at the corresponding value for "equal variance is assumed," the next significance probability was .000, which was, significantly, ($p<0.01$).

2. Comparing administration rates according to 3-way stopcock and extension at the same dilution of 10 cc's of physiological saline

When the method of connecting a 3-way stopcock to an angiographic needle was used in 20 out of 40 of the patients, the amount of physiological saline was diluted to 10 cc's and the radioactivity was measured before and after administering the radioactive isotope

Table 1. Sources Imaging condition and image reconstruction factor

	5 cc						10 cc					
	Angio + 3-way stopcock			Angio + Extension line			Angio + 3-way stopcock			Angio + Extension line		
Number	Pre	3-way	Post	Pre	Extension	Post	Pre	3-way	Post	Pre	Extension	Post
1	5.61	0.012	5.598	7.7	0.054	7.646	5.46	0.002	5.458	5.88	0.005	5.875
2	6.16	0.021	6.139	11.77	0.071	11.699	6.03	0.005	6.025	7.71	0.012	7.698
3	9.38	0.036	9.344	6.83	0.041	6.789	5.55	0.002	5.548	10.95	0.032	10.918
4	7.15	0.021	7.129	7.06	0.050	7.01	6.18	0.006	6.174	8.05	0.007	8.043
5	7.84	0.024	7.816	8.24	0.061	8.179	4.9	0.001	4.899	9.5	0.011	9.489
6	6.30	0.021	6.159	8.27	0.060	8.21	12.38	0.027	12.353	9.92	0.018	9.902
7	7.70	0.024	7.676	8.30	0.061	8.239	5.97	0.003	5.967	9.55	0.011	9.539
8	8.96	0.036	8.924	7.81	0.046	7.764	5.99	0.003	5.987	10.06	0.018	10.042
9	7.56	0.024	7.536	5.74	0.035	5.705	10.73	0.009	10.721	11.46	0.031	11.429
10	11.35	0.041	11.309	7.72	0.052	7.668	4.69	0.001	4.689	9.69	0.015	9.675
11	10.92	0.040	10.88	8.12	0.058	8.062	4.93	0.001	4.929	10.98	0.022	10.958
12	11.76	0.043	11.717	7.98	0.047	7.933	5.02	0.001	5.019	11.57	0.033	11.537
13	11.06	0.038	11.022	12.04	0.083	11.957	5.14	0.001	5.139	9.59	0.026	9.564
14	10.95	0.035	10.915	11.32	0.070	11.25	5.88	0.002	5.878	11.03	0.031	10.999
15	10.91	0.034	10.876	9.06	0.042	9.018	6.01	0.004	6.006	11.78	0.033	11.747
16	8.12	0.027	8.093	12.88	0.091	12.789	6.53	0.005	6.525	11.13	0.032	11.098
17	7.05	0.023	7.027	9.66	0.056	9.604	5.44	0.002	5.438	10.09	0.023	11.067
18	8.68	0.035	8.645	9.15	0.048	9.102	5.67	0.003	5.667	7.76	0.012	7.748
19	7.28	0.026	7.254	9.98	0.052	9.928	6.21	0.004	6.206	9.94	0.031	9.909
20	6.18	0.021	6.159	10.64	0.069	10.571	6.33	0.005	6.325	9.66	0.024	9.636

Table 2. Independent sample t-test according to the residual amount of difference between injection method and physiological saline dose

		Levene's test for equal variance		t-test for equality of means						
		F	Probability of significance	t	Degree of freedom	Probability of significance (both side)	Standard Deviation	Standard error of mean	95% confidence interval of difference	
									Lower limit	maximum
5 cc +3way, extension	Equal variance is assumed	1.826	.814	-8.053	40	.000	-.02845	.003539	-.03559	-.02130
	Uniform variance is not assumed			-8.053	33.681	.000	-.02845	.003532	-.03563	-.02126
10 cc +3way, extension	Equal variance is assumed	13.243	.001	-6.826	38	.000	-.01700	.002491	-.022042	-.01195
	Uniform variance is not assumed			-6.826	31.082	.000	-.01700	.002491	-.022079	-.01192
5 cc +3way,	Equal variance is assumed	11.929	.001	10.423	38	.000	.02455	.002355	.019782	.029318
10 cc +3way,	Uniform variance is not assumed			10.423	32.544	.000	.02455	.002355	.019755	.029345
5 cc +extension,	Equal variance is assumed	1.301	.261	9.470	38	.000	.03600	.003801	.028305	.043695
10 cc +extension	Uniform variance is not assumed			9.470	33.463	.000	.03600	.003801	.028270	.043730

to the patient. As a result, the average of the radioactivity before administration was 6.252±1.857 mCi, and the mean of the radioactivity administered to actual patients was 6.248±1.852 mCi, as shown in Table 1. An average of 0.004±0.006 mCi less than the intended dose was administered to the first patient. If the ratio of the radioactivity of the dose to be administered to the first patient was 100%, the ratio of the radioactivity administered to the actual patient was about 99.93%, with the ratio of the radioactivity remaining in the syringe and the 3-way was about 0.07%. As a result of measuring the radioactivity before and after administering the radioisotope to another 20 patients by linking the extension to an angiographic needle in the same 10 cc saline dilution, the mean radioactivity before administration was 9.815±1.469 mCi, and the mean dose of radioactivity administered in actual patients was 9.794±1.461 mCi, as shown in Table 1. The average dose was 0.021±0.009 mCi less than the dose originally intended for the patient. The proportion of radioactivity administered to the actual patient was around 99.78% and the proportion of radioactivity remaining in the syringe and extension was about 0.22%. In the same dose of 10 cc's, the difference in the remaining amount according to injection method was verified, as seen in Table 2. First, since the significance probability was less than 0.05 in Levene's test for equal variances, looking at the corresponding value for "equal variance is not assumed," it was .001, so that the next significance probability was .000. Therefore, the difference in the remaining amount in the injection method according to the same dose of 10 cc's of saline was statistically significant at ($p<0.01$).

3. Comparing administration rates according to dilution of different doses (5 cc/10 cc) using the same injection method

When 20 patients were administered radioactive isotopes using the same injection method that connected a 3-way stopcock to an angiographic with different amounts of physiological saline at 5 cc's and 10 cc's, the average radioactivity of each remaining amount was 0.029±0.009 mCi, 0.004±0.006 mCi, respectively, with the difference in the remaining amount being 0.025±0.003 mCi. Whether there was a difference in the residual amount according to the 3-way stopcock injection method in different physiological saline doses was verified, as seen in Table 2. First, in Levene's test for equal variances, the significance probability was less than 0.05, so looking at the corresponding value for "equal variance is not assumed," the value was .001, so that the significance probability was .000, and the residual difference was statistically significant at ($p<0.01$). In another 20 patients, radioactive isotopes were administered by varying the amount of physiological saline to 5 cc's and 10 cc's using the same injection method that connected the extension to the angiographic needle. When comparing the difference in the residual amount, the average radioactivity of each residual amount was 0.057±0.014 mCi and 0.021±0.009 mCi, respectively, with the difference in the remaining amount being 0.036±0.004 mCi. Whether there was a difference in the remaining amount according to the extension injection method at different doses was verified, as seen in Table 2. First, in Levene's test for equal variances, the significance probability was 0.05 or higher, so looking at the corresponding value of "equal variance is assumed", it was .216, so that the next significance probability is .000 and the residual difference is statistically significant at ($p<0.01$).

IV. DISCUSSION

In order to accurately administer ^{18}F-FDG for PET to a patient, it is important to administer the correct amount of radioactivity appropriate to the weight of the patient. We need to accurately administer radiopharmaceuticals at the first desired dose while minimizing patient exposure. This can be managed by measuring the amount of radioactivity a patient's body

can handle and distribute by weight and, before administering it to the patient, if the injection method and residual amount according to physiological saline is known the dose required by the patient can be calculated. As studies on accurate administration preceded, Lee,Wang-Hee et al. measured radioactivity before and after ^{99m}Tc-MDP administration during bone scan, and found that on average, 2.18 mCi was administered to the patient less than the dose initially intended to be administered to the patient.[1] In a similar study, Son,Sang-Jun et al. compared the average residual radioactivity of six types of radiopharmaceutical syringes using ^{99m}Tc.[5] Here, the research results were preceded and the dose rates of radiopharmaceuticals using plastic syringes and Nom-Jek syringes were measured and compared.[6] This study, which looked at previous research on residual doses and injection method according to the administration of radiopharmaceuticals for gamma-cameras and SPECT tests, finding that no analysis has yet been conducted with regard to factors relating to patients' SUV measurements, such as PET, compared and analyzed the difference between physiological saline doses for the administration of ^{18}F-FDG and residual doses according to injection method. It was found that the 3-way stopcock method for 10 cc's of saline solution first had the lowest average residual amount of 0.004 mCi, and secondly, the average residual amount of the extension method connected to 10 cc's of saline was 10 cc's. 0.021 mCi Third, at 0.021 mCi and connecting a 3-way stopcock to 5 cc's of saline, the average amount was found to be 0.029 mCi. The administration method with the highest residual amount was found to be a 5cc saline volume connected in increasing order with an average residual amount of 0.057mCi. The difference in administration method with the smallest residual amount was 0.053 mCi. When administering a radiopharmaceutical to a patient, before determining the correct dosage, if the injection method and amount of saline to be administered to the patient is considered, the residual amount for the patient can be reduced and the initial dose quantified. The end result is that it is possible to administer the radiopharmaceutical to the patient more accurately.

V. CONCLUSION

The dose of physiological saline was different and the remaining amount according to both the administration of radiopharmaceuticals and to the injection method were compared. As the dose of physiological saline was increased, the length of securing the injection line was shorter, and as it got closer to the patient's vein, the remaining amount decreased. The injection method of the 3-way stopcock connection to the physiological saline volume of 10 cc's had the lowest residual amount, while comparing the extension connection method to the physiological saline volume of 10 cc's, the 3-way stopcock connection method to the physiological saline volume of 5 cc's, and the physiological saline solution of 5 cc's, in terms of capacity, the extension connection method had the highest remaining amount. Paired t-test results for the difference in residual amount according to each physiological saline solution and injection method were all significant ($p<0.01$).

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^{18}F-FDG 투여 시 정맥주사 확보 방법 및 생리식염수 용량에 따른 잔류량의 차이에 관한 연구

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요 약

본 연구는 PET(positron emission tomography) 검사를 위해 내원한 환자를 대상으로 방사성의약품 ^{18}F-FDG 동위원소를 주사 할 때, 주사 방법과 생리식염수의 용량에 따른 주사기의 잔량의 차이를 비교하였다. 조영제를 사용하는 CT 혹은 MRI 검사 후, 3-way를 제거하지 않고, PET 검사를 위해 내원한 40명의 환자를 대상으로 ^{18}F-FDG를 주사 할 때, 주사기와 3-way에 남게 되는 방사능을 측정하여, 실제 환자에게 투여된 방사능을 확인했다. 이때 20명의 환자들로 나누어 생리식염수의 용량을 달리하였다. 또 다른 주사 방법은 extension을 이용하여 주사 하였을 때, 주사기의 잔량 비교와 생리식염수 용량에 따른 잔량 차이를 비교하였다. ^{18}F-FDG 를 주사 한 후, 주사기와 3-way 또는 extension에 남아 있는 방사능을 검량기로 측정하여 실제 투여된 용량을 확인 했다. 방사성의약품을 투여하기 전의 주사기의 방사능과 투여한 후 주사기와 3-way 또는 extension 의 방사능을 측정한 결과, 생리식염수 10 cc에 3way 의 주입 방식이 잔류량이 가장 낮았고, 생리식염수 10 cc에 extension, 생리식염수 5 cc에 3way 순으로 잔량이 증가하였다. 5 cc의 생리식염수에 extension 주사 방법이 잔량이 가장 많이 남아 있었다. 잔량이 가장 적게 남은 주사 방법과의 잔량 차이는 0.053 mCi 이다. PET 검사 시, 3-way와 extension에 남게 되는 방사능을 감안하고, 생리식염수의 투여 용량을 조절함에 따라, 실제 환자에게 투여하고자 하는 목적 용량을 고안한다면 좀 더 정확하게 환자에게 방사성의약품을 투여할 수 있을 것이다.

중심단어: 잔여 방사선량, 플루데옥시글루코스, 정맥주사방법, 표준화된 섭취값

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