

Availability of Thickness Estimation of the Subcutaneous Fat by Using the Near-infrared Ray Measuring Device

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Abstract

Gluteal intramuscular injection requires accurate needle insertion into the specific muscle area for accurate, safe, and efficacious delivery of medication for long-acting anti-psychiatric drugs. With ultrasonography, accurate evaluation of the "Distance from the Epidermis to the Under-Fascia (DEUF)" can be determined. However, a nurse in the clinical settings, ultrasonographic measurements during intramuscular injection is impractical and difficult. The purpose of this study was to estimate the thickness of subcutaneous fat by using a near-infrared ray measuring device. This study was approved by the Ethics Committee of Tokushima University Hospital. There were 39 subjects (21 men and 18 women) aged 20 to 60 years (Mean \pm SD: 44.97 \pm 15.20 years old). Bilateral DEUF at Ventrogluteal and Dorsogluteal sites (AVIUS: Hitachi-Aloka Medical Co.) were evaluated on B-mode scan as the gold standard. At the same sites, the thickness of the subcutaneous fatty tissue was measured using the PoccoStick (HORIC: small-size instrument measuring the thickness of the subcutaneous fat with a near-infrared ray device). The right Ventrogluteal site thickness of the fatty tissue was significantly overestimated by PoccoStick (15.18 \pm 8.77 mm) measurements, as compared to the ultrasonography (12.42 \pm 5.26 mm) ($p < 0.01$) results. The left-side Ventrogluteal site and both the right and left Dorsogluteal sites measurements did not show significant differences. This illustrated and supported the credible use of inexpensive devices such as the PoccoStick in estimating the DEUF. The development of a more highly accurate small-sized instrument is recommended.

Introduction

Intramuscular injection is an essential nursing technological skills with a high risk of arteriovenous injury or nerve injury [1-3]. Intramuscular injections require a deeper insertion into the target muscle, as compared to intracutaneous injections or subcutaneous injections, because the muscular layer is located under subcutaneous fatty tissues. As a result, medication efficacy and administration safety are difficult to control. In cases in which medications are injected into the subcutaneous tissue, manifested side effects, induration, skin redness, and abscesses may arise [4].

In many cases, intramuscular injections are given in the deltoid muscle and the gluteus medius muscle [5]. Anatomically, the gluteus medius muscle is a bulkier muscle compared to the deltoid muscle. When an intramuscular injection is administered using the ventrogluteal and dorsogluteal sites, physicians and nurses need to be aware that these sites are pathways of the sciatic nerve and superior gluteal nerve [3,6,7].

Several studies have been conducted regarding the depth of intramuscular needle insertion. A study with healthy subjects, assessed the depth of needle insertion into the gluteus medius muscle using ultrasonography [8]. Yasuhara et al. [9] and Tanioka et al. [10], used ultrasonography to investigate the optimal length of needle insertion into the dorsogluteal sites particularly for patients with schizophrenia. Furthermore, Takahashi et al. [11], reported that the indication of depth of needle insertion into the ventrogluteal sites via the Hochstetter method in the case of healthy subjects, regardless of gender, which were 15 mm for a body-mass index (BMI) below 18.5 kg/m², and 20 mm for a BMI of 18.5 to 30.0 kg/m². They reported

efficacy of using ultrasonography as an objective and accurate way to assess distances from the epidermis of the gluteus medius muscle to the subfascial sites or iliac bone.

However, the ultrasonographic device is bulky, expensive, and requires an experienced sonographer for accurate measurement thus making this impractical in clinical practice. The delivery of medicine into the intramuscular layers leads to an improved therapeutic efficacy, therefore it is important to establish a practical and economical method to assess hypodermal tissues at the intramuscular injection sites.

Another measuring device which provides a thickness estimation of the subcutaneous fat using the reflection of near-infrared rays [12] are sold to those who want to check the effect of diets or exercises. This inexpensive measurement device may provide an estimate of the exact thickness of subcutaneous tissues, for a more safe and accurate administration of medications intramuscularly. The purpose of this study was to estimate the thickness of subcutaneous fat by using a near-infrared ray measuring device.

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Materials and Methods

Subject

There were 39 subjects (21 men and 18 women) from 20 to 60 years of age (Mean \pm SD: 44.97 \pm 15.20 years old). Inclusion criteria included healthy Japanese subjects aged from 20 to 70 years old with BMI ranged from 17 to 29 kg/m². Exclusion criteria included pregnant or lactating women or use of medications or injection sites in skin disorders known to affect metabolism. The total number of subjects were 35-39 because the study failed to secure measurements on all sites using the device to estimate the subcutaneous fat using the reflection of the near-infrared rays.

Study design and period

A comparative descriptive design was used and the period of data collection was between July 11 and 12, 2015.

Measures and statistical methods

Measurement by ultrasonography and the PoccoStick

Ultrasonography was used to measure the "Distance from the Epidermis to the Under-Fascia (DEUF)" at Ventrogluteal and Dorsogluteal sites (AVIUS: Hitachi-Aloka Medical Co.) and the PoccoStick (HORIC: small-size instrument measuring the thickness of the subcutaneous fat using near-infrared ray device) [12]. All ultrasonographic measurements were performed by an experienced sonographer using a 7.5 MHz linear and convex array transducer and ultrasonograph diagnostic system (Hitachi Medical Corporation, Japan). However, the PoccoStick measurements were performed by researchers trained how to measure subcutaneous fat. PoccoStick measured value was added 1 mm by ultrasonographic observed gluteal muscle fascia thickness [8,9,10], in order to match to the DEUF. PoccoStick value was measured twice to calculate the average of measured values.

Ventrogluteal sites were measured with the person lying in a lateral position with angles of an articulation was approximately 90 to 100 degree: To identify the injection site by the "point of Clark" is located at the anterior one of the points trisecting the line connecting an antero-superior iliac spine and posterior superior iliac spine.

Dorsogluteal sites were measured with the person lying in a prone position: To identify the injection site using the "Double Cross" method divides the buttocks with an imaginary cross then divide the upper outer quadrant by another imaginary cross.

Analysis method

The overall scores were statistically analyzed using descriptive statistics and the Wilcoxon-signed rank tests. The level of significance was set at $\alpha < 0.01\%$.

Ethical consideration

This research was conducted with the approval of the Ethical Committee of the Tokushima University Hospital. The study purpose, procedure, methodology and any risks were provided in writing and verbally explained to the subjects. In addition, the subjects were informed that participation was voluntary and they could discontinue it at any time with no detrimental impact.

Results

Table 1 describes the demographic characteristics of subjects of the study. The BMI of the subjects ranged from 21.92 \pm 2.99 kg/m², while their percent of body fat were 22.97 \pm 7.28 % on the left leg and 22.59 \pm 7.14 % on the right leg. As for both legs, the minimum value was 10% and the maximum value was 34%. The difference between them was 24%. The muscle masses of the left legs were 8.32 \pm 2.21 kg, while those of the right legs were 8.41 \pm 2.23 kg. As for both legs, the minimum values were 5 kg, while the maximum values were 14 kg. The difference in muscle mass between the legs was 9 kg.

	Mean	S.D.	Median	Minimum	Maximum
Age	44.97	15.20	48.00	20.00	68.00
Height (CM)	165.77	8.44	165.00	148.00	184.00
Weight (kg)	60.75	12.49	59.20	40.50	94.70
BMI (kg/m ²)	21.92	2.99	21.37	17.07	29.00
Body fat Percentage					
Left Leg (%)	22.94	7.28	22.80	10.60	34.30
Right Leg	22.59	7.14	22.20	10.30	34.30
Body muscle mass (kg)					
Left Leg	8.32	2.21	7.85	5.15	14.30
Right Leg	8.41	2.23	8.00	5.30	14.35

Table 1: Demographic characteristics (n=39)

In the right ventrogluteal site, the thickness of fatty tissue was significantly overestimated by PoccoStick (16.18 \pm 8.77mm), compared with ultrasonography (12.42 \pm 5.26mm) ($p < 0.01$) (Figure 1 right). The left-side of the ventrogluteal site (Figure 1 left) and both the right and left dorsogluteal sites (Figure 2, left and right) did not show significant differences.

In the left ventrogluteal site, seven subjects' PoccoStick values showed differences of more than 10 mm, while others showed differences of less than 2 mm, or more than 20 mm, compared to the ultrasonographic value.

Discussion

The subject's BMI was 21.92 \pm 2.99 kg/m², which showed the typical body type of Japanese people [13]. In the right side of the ventrogluteal site, measured DEUF values using an ultrasonography were 12.42 \pm 5.26 mm, while those using a PoccoStick were 15.18 \pm 8.77 mm. The latter showed significantly longer values. As for the left side, there was no significant difference. But in the dorsogluteal site, there were measurement values with differences of less than 2 mm, nine subjects on the left side and eight subjects on the right side showed a difference of more than 10 mm.

In the subjects with the measurement values using the PoccoStick was shorter compared to the ultrasonography, the injection solution might have been injected into subcutaneous layer onto the muscular fascia. In such situations, it is possible that this may impact the efficacy of the medicine and be one of the causes of induration, skin redness, and abscesses on injection sites [4]. In the subjects in which the measurement values using the PoccoStick was longer than that of the ultrasonographic value, caution is raised as the needle tip might reach the muscle layers, and/or it is at risk for damaging the iliac bone.

Generally, in Japan, injection needles are selected, between 21-23 gauge (G) when using the gluteus medius muscle, and in the case of oil-based solutions of long acting injectable the selected needle gauge

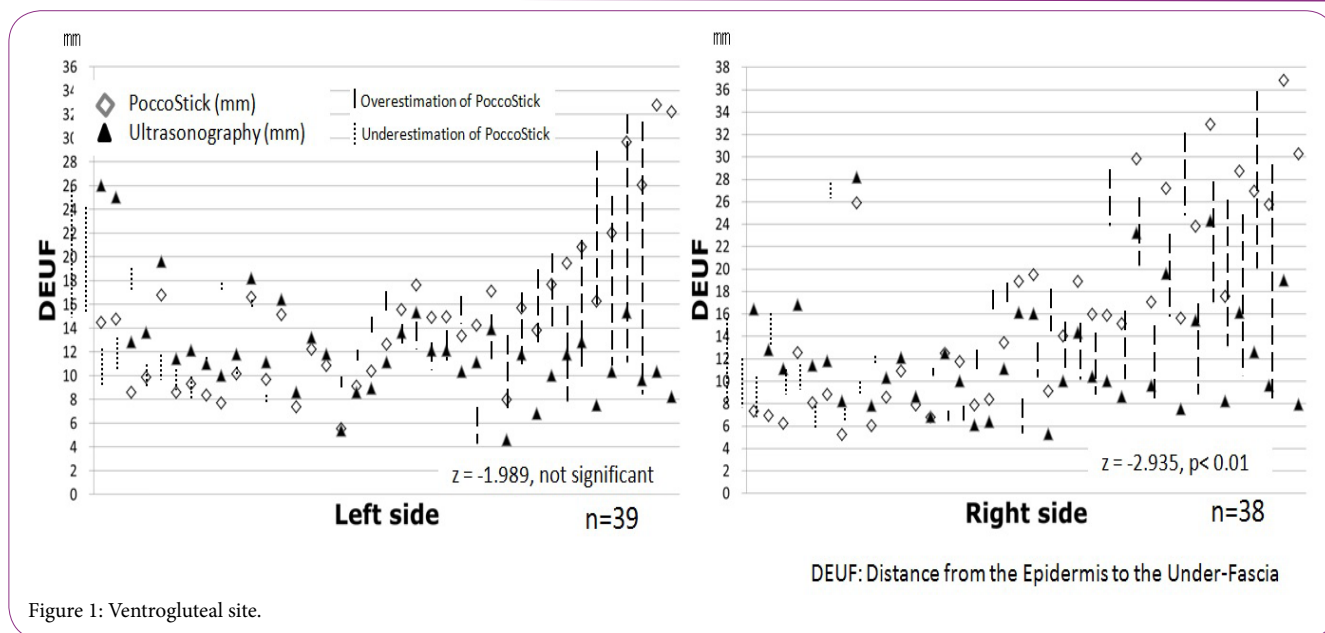


Figure 1: Ventrogluteal site.

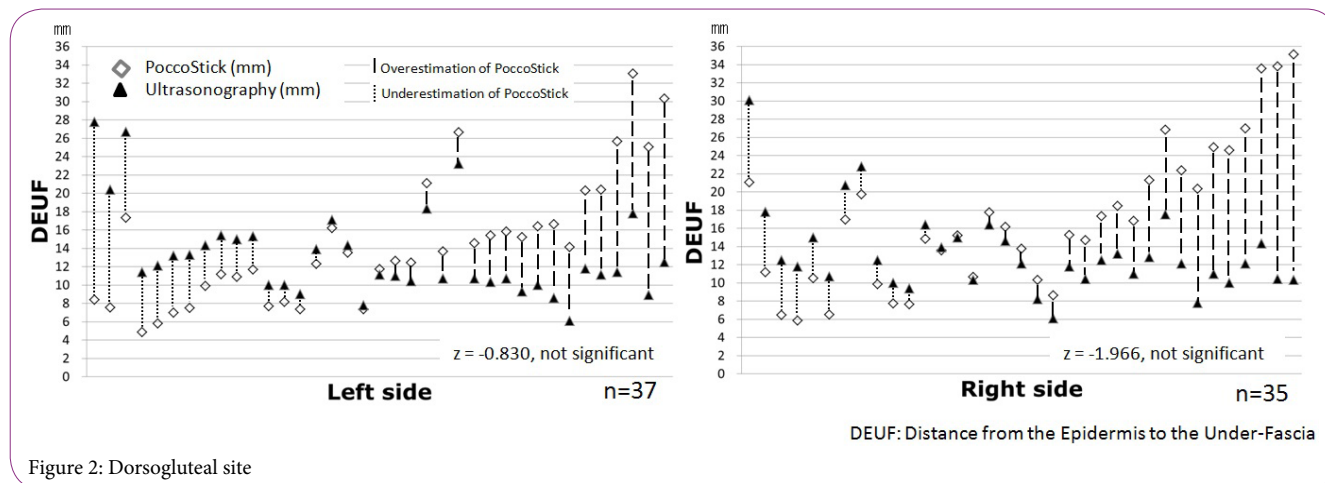


Figure 2: Dorsogluteal site

is 21G [14,15]. The longest of all the injection needles is 1.5 inches (38 mm), excluding the specialized needle and Cathelin needles [2]. The gauge and lengths of injection needles for Risperidone (Risperdal Consta), are 20 G 2 inches (50 mm) as used exclusively [16].

Regarding the measurements using PoccoStick in this study, the longest values of DEUF in the ventrogluteal site were 31.75 mm on the left side and 35.80 mm on the right side, while those in the dorsogluteal site showed 32.05 mm on the left side and 34.10 mm on the right side.

In the study by Tanioka et al. [10], in the case of Japanese persons with schizophrenia, the distance from the epidermis to the iliac bone (DEI) measured by ultrasonography in the dorsogluteal site were 51.3 mm on the left side and 51.6 mm on the right side at their shortest. If the PoccoStick measurement value of skinfold thickness was used for needle insertion there would be little risk of ilium bone injury. However, in the dorsogluteal site, it was considered possible to estimate the approximate distance by measuring using the PoccoStick.

Furthermore, Masuda et al. [17] measured "Distance from the Epidermis to the Iliac bone (DEI)" of the healthy Japanese subjects

at the ventrogluteal site, and they found that the injection depths were 43.8 mm on the left side and 38.1 mm on the right side at their shortest, which were shorter compared to those in the case of those receiving the same medications at the dorsogluteal site. It can be said that inserting the injection needles using the PoccoStick measurement value as a guide might have risks of ilium bone injury. In the ventrogluteal site, it was considered possible to prevent contact with the iliac if nurses assess the DEI by palpation after the measured by PoccoStick.

The study by Ide et al. [18] measuring the thickness of subcutaneous fat by using a near-infrared light, such as PoccoStick, found a positive correlation between the measurement values of the upper arms, thighs, and abdominal areas using ultrasonography and the estimate values using the near-infrared light. However, the findings in this study indicated that the injection site measured by the PoccoStick versus ultrasonography greatly differed. There continues to be studies indicating differences in measurement between the PoccoStick and ultrasonography. Therefore, further research is needed to assess accuracy for clinical use.

Limitation

One limitation of the study related to measurement. The PoccoStick utilizes a near-infrared ray which could be impacted by the following factors: a wet skin site due to ultrasonography gel, lack of sensor adherence to the skin [12], or sensor cleanliness related to skin marking with a felt tip. In addition, there may be variability of measurement using the DEUF depending on the angle of the ultrasonography probe. If the PoccoStick sensor and the angle of the ultrasonography probe are different, there is a possibility that measured value have margin of error.

Another limitation is small sample size, this estimation suitable for adults only. Furthermore, many studies [20,21], have reported a high prevalence of obesity in patients with schizophrenia compared to the general population. In the Japanese male patients, frequency of obesity was lower, and underweight was higher than those in the general population. In female patients, frequency of both obesity and underweight were higher than those in the general population [22]. Also, prevalence of underweight and undernutrition in Japanese inpatients with schizophrenia was higher than in outpatients and the general population [23]. In our finding has not been clarified whether estimation can be applied to these patients with schizophrenia. Therefore, it was considered that additional tests are required for the lean and obese groups.

Conclusion

This study illustrates and supports the credible use of cost effective devices such as the PoccoStick in estimating the DEUF. The development of a more highly accurate small-sized instrument is needed in order to estimate the thickness of subcutaneous fat for safe and effective intramuscular injections and reliable clinical use.

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