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Evaluation of the Usability of Transillumination Technique for Finding Venous Access in Pediatric Cases, in Palma-plantar and Cubital Region in Infants: Clinical Study

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Abstract: ***Introduction:*** Providing pediatric vascular access can pose serious challenges to anesthetists. Alternatives are available to provide a vascular access other than the peripheral venous route. However, it may not be as useful as the peripheral venous route due to the risks of complications. Transillumination is used as a cheaper and accessible method. Although the veins are seen in red hues, the venous structures are slightly darker due to the carboxyhemoglobin carried inside. For these reasons, it was thought that the red light and/or beam would pass through the tissue more effectively, create contrast and transfer less energy, and our hypothesis was formed. ***Materials and Method:*** In the study, by obtaining the necessary ethics committee approval, institutional permission and parental consent of the infants included in the study, the cubital area anteroposterior thickness in both arms and palma-plantar thickness of both hands were measured using a clamped ruler and has been recorded. ***Results:*** When we look at the average age, weight, and height of those whose palma-plantar thicknesses are 11 mm or less; For those 29 days and below, we can say that the right wrist thickness is 11 and below. The same statement is 3252 grams for weight and less than 50 cm for height. When we consider the same assessment for the left wrist; When we look at the average age, weight, and height of the wrist thickness of 11 and below; For those who are 32 days and below, we can say that the left wrist thickness is 11 and below. The same statement is 3226 grams for weight and under 50 cm for height. ***Conclusion:*** For the right palma-plantar thickness; For those 29 days and below, the right wrist thickness is 11, and below, for the left palma-plantar thickness; Those under 32 days are 11 or less. This limit is 3226 grams for weight and 50 cm for height.

Keywords: Transillumination, Venous, Access, Pediatric, Infant.

INTRODUCTION

Providing pediatric vascular access can pose serious challenges to anesthetists(Kuensting, L. L. *et al.*, 2009; & Black, K. J. *et al.*, 2005). Alternatives are available to provide a vascular access other than the peripheral venous route. However, it may not be as useful as the peripheral venous route due to the risks of complications. For these reasons, different methods and devices are used to find peripheral venous paths (Black, K. J. *et al.*, 2005; & Yen, K. *et al.*, 2008). These include devices such as Accuvein®, Veinviever®. Although it contributes to finding venous access, no method provides 100% vascular access (Kuensting, L. L. *et al.*, 2009). Although they are technically advanced devices, there are studies showing that they are inadequate in infants, and they have high cost disadvantages (Kim, M. J. *et al.*, 2012).

Transillumination is used as a cheaper and accessible method. In the transillumination method, light is sent to the tissue, after the light passes through the tissue, the shadows of the vascular structures are followed and venous access is attempted. In order for the transillumination technique to be used, the transmitted light and / or beam must reach the other side of the tissue, create contrast between the tissue and vascular structures, and be perceived by the user / practitioner eye. Light beams of different wavelengths produced from different light sources can be used (white light, light emitting diods (LED) light, etc.), even laser beams can be used for this purpose. However, the light and/or beam to fulfill the mentioned conditions must transmit energy that is strong enough to pass through the tissue but not to damage the tissue, and the temperature of the energy it transmits must be lower than the body temperature. Fiberoptic light sources can be used to meet these criteria. Still, in fiberoptic light sources, even though the temperature is low at the point where the light comes out, the energy transferred is high, and this energy directly reaches the tissue, it can cause burns even in a short time such as a few seconds. It limits its use. Another point is the color (wavelength) of the light and/or beam. Wavelength affects the color, visibility of the light and/or the beam, and the amount of energy it carries. Although the veins are seen in red hues, the venous structures are slightly darker due to the carboxyhemoglobin carried inside. For these reasons, it was thought that the red light and/or beam would pass through the tissue more effectively, create contrast and transfer less energy, and our hypothesis was formed.

According to our hypothesis; The wavelength of 640 nanometers (nm) (red) of the light and/or beam will pass through the tissue more effectively, create contrast and transfer less energy. It is predicted that using a red wavelength, low-energy laser beam to provide more effective tissue penetration will increase the success. To verify the hypothesis, our work has been planned gradually. To demonstrate the suitability of this approach for clinical use, it is imperative to evaluate the efficacy and safety of each phase. At this stage, the data of tissue thickness, age-height-weight correlation of tissue thickness, tissue thickness of the body region used, and the suitability of the technique in question were discussed.

The laser beam can penetrate tissues in the range of 5.5 mm (Ash, C. *et al.*, 2017) -14 mm (Kampa, N. *et al.*, 2020), but this depth can be changed by changing the wavelength and power. In different studies, although the results were variable, 9 mm penetration was obtained with a wavelength of 640 nm and 130 mW power (Arslan, H. *et al.*, 2018) and another study reported that 8-10 mm penetration with 35% scattering value was obtained (Douplik, A. *et al.*, 2013). The measured penetration values may be sufficient for transillumination. However, it has been reported that there may be a deviation of up to 20%, so the maximum range of 11 mm was taken as a reference in our study. (9x1.2 = 10.8 mm) (0.2 mm palmaplantar thickness measurement accuracy is not applicable in children)

MATERIALS AND METHOD

In our study, in order to determine the usability of transillumination in infants, measuring the anteroposterior thickness of the body parts most used to provide vascular access in this age group and the longest distance (11 mm -640 nm red light laser) that a beam of light can pass through living tissue (in days) It was planned to determine (the smallest and the largest) and to investigate the relationship between this distance and the height and weight of the infant. For this purpose, by obtaining the necessary ethics committee approval, institutional permission and parental consent of the infants included in the study, the cubital area anteroposterior thickness in both arms and palma-plantar thickness of both hands were measured using a clamped ruler (caliper-image 1, image 2) and has been recorded. Patients with ASA (American Society of Anesthesiologists) risk classification 1 were included in the study. Patients with any detected disease, malnourished infants, and patients under treatment due to low birth weight were excluded from the study.

Image 1. Caliper

Image 2. Measurement image (photo is not an infant)

RESULTS

The relationship of the right wrist with age was determined as p = 0.001 with the independent sample t-test, the relationship of the right wrist with the height was determined as p <0.001 with the independent sample t-test, and the relationship of the right wrist with the weight was determined as p <0.001 with the independent sample t-test.

The relation of the left wrist with age was determined as p = 0.001 with the independent sample t-test, the relation of the left wrist with the height was determined as p <0.001 with the independent sample t-test, and the relation of the left wrist with the weight was determined as p <0.001 with the independent sample t-test. Table 1 shows the mean palma-plantar and cubital thickness.

Table 1. Mean palma-plantar and antecubital thickness

n=53	**Right palma-plantar**	**Left palma-plantar**	**Right cubital thickness**	**Left cubital thickness**
Mean (cm)	11,8302	11,7547	23,5283	23,4528
Std. Deviation (±) (cm)	2,39178	2,31970	5,02533	4,97906
Minimum (cm)	6,00	6,00	14,00	16,00
Maximum (cm)	18,00	17,00	36,00	36,00

In addition to the independent sample t-test, the relationship between right wrist thickness and age, height, and weight were found to be p = 0.003 in the logistic regression analysis, while the B value in the relationship with age was 0.001, in the height it was 0.049, and in the relationship with the weight B <0.001. In this sense, the closer the B value is to 1, the more parallel the relationship between the two parameters we are trying to make sense of. In other words, wrist thickness increases as age, height, and weight increase. However, this relationship is weaker in weight and age; partly stronger in height.

If we reveal the relationship between left wrist thickness and age, height and weight with a logistic regression analysis; Basically, while p = 0.215, the B value in relation to age is 0.023, in relation to height it is 0.040, and in relation to weight, B value is <0.001. For the left wrist, like age, height, and weight increase, wrist thickness increases. However, this relationship is still weaker in weight and age; height is stronger.

When we look at the average age, weight, and height of those whose palma-plantar thicknesses are 11 mm or less; For those 29 days and below, we can say that the right wrist thickness is 11 and below. The same statement is 3252 grams for weight and less than 50 cm for height. When we consider the same assessment for the left wrist; When we look at the average age, weight, and height of the wrist thickness of 11 and below; For those who are 32 days and below, we can say that the left wrist thickness is 11 and below. The same statement is 3226 grams for weight and under 50 cm for height.

DISCUSSION

Difficult venous access is still a problem in pediatric patients (Kuensting, L. L. *et al.,* 2009). Although many devices have been developed to overcome this difficulty, their effectiveness is limited in the infant age group, the search for new methods continues. At this point, the transillmunation technique can be as effective as advanced and complex devices (Kim, M. J. *et al.,* 2012).

Palma-plantar thickness correlates with height, weight, and age for both hands. Although the limits determined in our study vary in different study groups, they guide them as a point of view. Apart from pointing to a certain age group for the transillumination technique, it is important that the age group it points to is the age group in which technically advanced devices are inadequate. As a modification of the transillmination technique, it may be possible to increase the effectiveness of the technique with alternative light types that can pass through the tissue. Although different studies have been conducted on this subject, there are no studies in living tissue and in the specified age group. In our study, it has been theoretically shown that palma-plantar thickness can provide sufficient penetration for laser transillmination in the age group younger than 32 days. At this point, it can be expected that the penetration distance in living tissue will be even greater, with reference to studies showing that non-viable tissue penetration is approximately 11 mm. This is enough to investigate efficacy in older age groups. It has been reported in previous studies that accuvein veinviever has limited efficacy in patients younger than 2-3 months. It can also be useful in this age group.

It is essential to emphasize that what is discussed in this study is to provide visibility of the vascular structure. This technique could theoretically increase vascular visibility, but it does not guarantee that it will contribute to the success of the intervention to the same extent. However, despite all these advantages and disadvantages, laser transillumination has laid the groundwork for studies on providing venous access for the age group pointed out in our study. After this stage, what needs to be done and as planned from the beginning of our series of studies, is to carry out a clinical study on the patient, in which the demonstration of the adequacy of the technique is examined.

Limitations

- Percentiles of the infants were not recorded.
- The study was planned with tissue penetration defined for the wavelength of 640 nm, therefore, a 640 nm wavelength laser should be used in the transill setup to be designed using the results of this study. In other wavelengths, for each different wavelength, a separate statistical evaluation should be made according to the depth of tissue penetration.

Conclusion

For the clinical study to be planned with 640 nm laser;

For the right palma-plantar thickness; For those 29 days and below, the right wrist thickness is 11, and below, for the left palma-plantar thickness; Those under 32 days are 11 or less. This limit is 3226 grams for weight and 50 cm for height.

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