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Dilution by Physiological Saline Deteriorates Color Discrimination of Arterial and Venous Blood

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Abstract

We investigated differences in color when distinguishing arterial blood and venous blood with or without the use of physiological saline. The study samples were comprised of undiluted blood samples, blood samples diluted with physiological saline, blood samples from patients with decreased hemoglobin levels, and blood samples from patients with normal hemoglobin levels. Initially, four sample types (arterial blood, venous blood, 2-fold dilution of venous blood with physiological saline, and 3-fold dilution of venous blood with physiological saline) were observed and judged as arterial or venous samples by anesthesiologists under operating light and indoor light. Thereafter, the density of three colors (red, green, and blue) was investigated by a computer. Two-fold dilution of venous blood with physiological saline was most frequently misjuged as arterial blood. Computerized analysis showed that a 2-fold dilution of venous blood had a higher density of red than an arterial blood sample. The red color of a 2-fold dilution of venous blood appeared stronger than that of an arterial blood sample, thereby making it difficult to distinguish between the two samples. Accordingly, we consider that dilutions with physiological saline makes it difficult to distinguish between arterial and venous blood.

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Introduction

The use of physiological saline on central venous puncture is controversial[1,2]. When a syringe containing physiological saline is used, blood entering the syringe occasionally appears as arterial blood by its color. Accordingly, we examined possible differences when distinguishing blood in the presence or absence of physiological saline, based on the macroscopic observations of anesthesiologists.

Blood samples underwent image processing by a computer to analyze and compare the color tone of the three colors (red, green, and blue).

Subjects, Materials and Methods

Ten patients requiring central venous catheterization were investigated (Hb levels: 8.7-14.8 g/dL). We explained the purpose of this investigation, and received informed consent from all of them.

Preparation of samples

Venous blood was collected through a central venous catheter, and arterial blood from the radial artery, and prepared the following four sample types: 1) arterial blood samples, 2) venous blood samples, undiluted, 3) venous blood samples diluted to 2-fold with physiological saline (2-fold dilution of venous blood), and 4) venous blood sample diluted to 3-fold with physiological saline (3-fold dilution of venous blood). Each two mL of arterial blood and venous blood was withdrawn using a 5 mL syringe which

inside was moistened with heparin for samples 1) and 2). For sample 3), one mL of venous blood was withdrawn into a syringe containing one mL of physiological saline, and for sample 4), one mL of blood was withdrawn into a syringe containing two mL of physiological saline, and one mL of this mixture was discarded to leave two mL of 3-fold dilution. The physiological saline used for dilution contained heparin at one mL (1,000 U) per 500 mL of physiological saline.

Test to distinguish between arterial blood and venous blood

Fifteen anesthesiologists (8 staff anesthesiologists and 7 first-year residents) participated in the tests. They determined whether each of samples 1) to 4) was arterial or venous blood by macroscopic examination under operating light and indoor light. Thereafter, the rate of correct answers (rate of accuracy) for each of samples 1) to 4) was estimated.

Color (red, green, and blue) density analysis by computer

Each blood sample was photographed under operating light and indoor light with a CCD camera (Cyber-Shot 2.21 pixel, SONY Co. Ltd.). The images were input into a personal computer, and the density of the three colors was analyzed using Photoshop 5.0. Fig. 1 shows an image being analyzed. This figure shows an arterial blood sample, a venous blood sample, 2-fold dilution of venous blood, and 3-fold dilution of venous blood (from left to right). The density of each of red (R), green (G), and blue (B) in each sample is shown at top right. Since each of the three colors is expressed in 256 levels of density, the color density of each sample is determined by comparison with the color table and expressed by the number indicated in the table. We measured color density at the sites (arrows), and estimated the proportion of each color. This measurement was performed at 5 sites (or points) on the image of each sample, and the mean density and standard deviation were calculated.

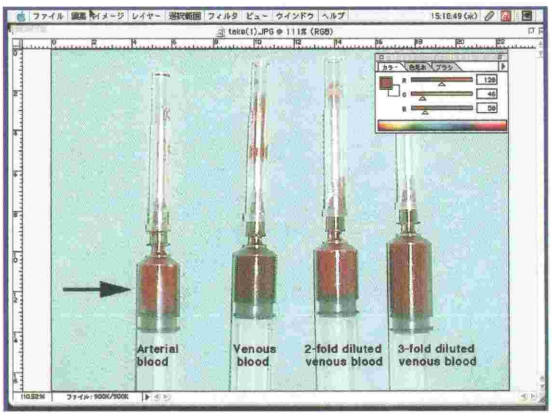

Fig-1. RGB-density was shown at upper right. Red, green, blue-density is divided 256 degrees.

Results

1) Test to distinguish between arterial blood and venous blood

Figs. 2 and 3 show the results under operating light and under indoor light, respectively. The rate of correct answers (rate of accuracy) is plotted on the y-axis against all patients (n=10, shaded box), a patient with decreased hemoglobin levels (n=1, striped box), and a patient with normal hemoglobin levels (n=1, diagonally striped box).

1. Testing under operating light

The rate of accuracy for distinguishing between arterial blood and venous blood was high under operating light. However, the rate of accuracy for identifying the 2-fold dilution of venous blood as venous blood was 0% in patients with decreased and normal hemoglobin levels. The rate of accuracy for identifying the 3-fold dilution of venous blood as venous blood was 20-30%.

2. Testing under indoor light

The rate of accuracy for identifying venous blood as venous blood was 100%. The rate of accuracy for identifying arterial blood was lower under indoor light than under operating light. The rate of accuracy for identifying the 2-fold dilution of venous blood was as low as approximately 7～11%, and that for identifying the 3-fold dilution of venous blood was in excess of 50% under indoor light.

2) Computerized color density analysis

Figs.4 and 5 show the density ratio of the three

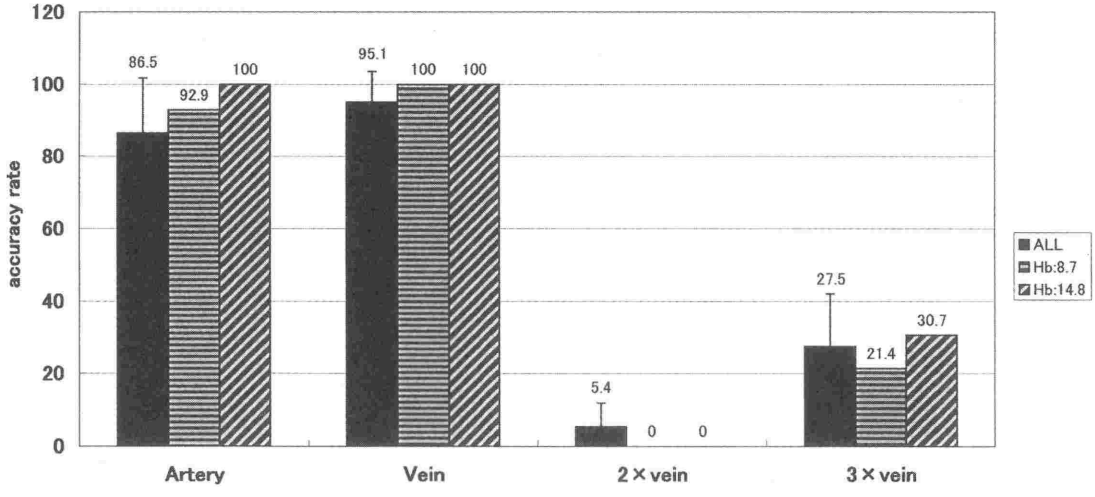

Fig-2. The accuracy rate of all, Hb:8.7,and 14.8g/dl (under operation-light)

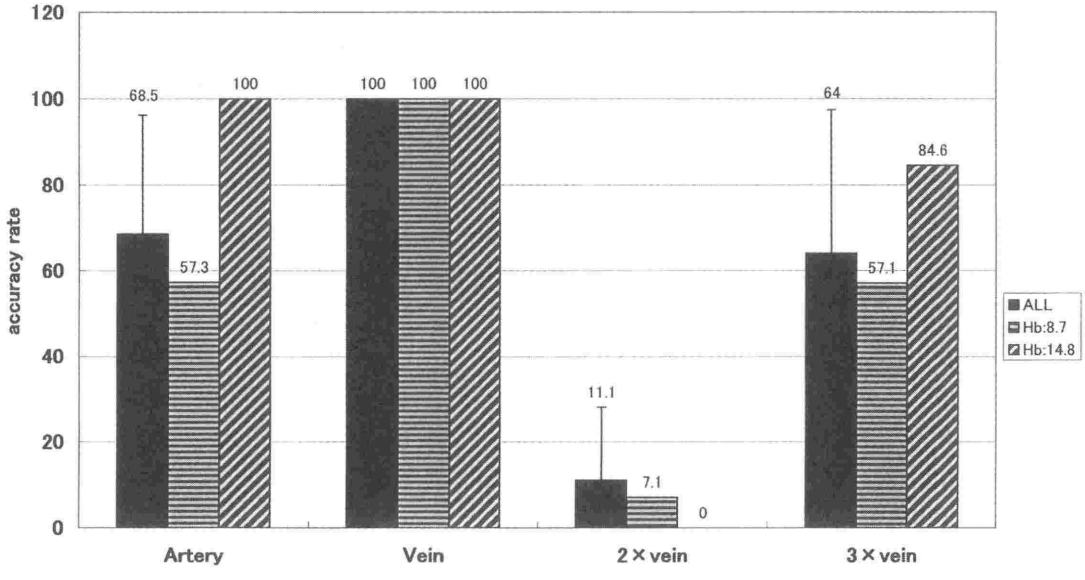

Fig-3. The accuracy rate of all, Hb:8.7, and 14.8g/dl (under room-light)

colors in patients with decreased hemoglobin levels (Hb, 8.7 g/dL) and normal hemoglobin levels (Hb, 14.8 g/dL), respectively. The density of red (red-density) was compared between the patient with decreased hemoglobin levels and the patient with normal hemoglobin levels in Fig. 6.

1. The ratio of the density of red, green, and blue

Red density was higher than that of green density and blue density in the four sample types. The red density of the 2-fold dilution, and 3-fold dilution of venous blood was higher than that of arterial blood. Red density was higher under operating light than under indoor light. The density of green and blue tended to become higher under indoor light than under operating light.

2. Comparison of red density alone

Red density was higher in the four sample types in the patient with normal hemoglobin levels than in the

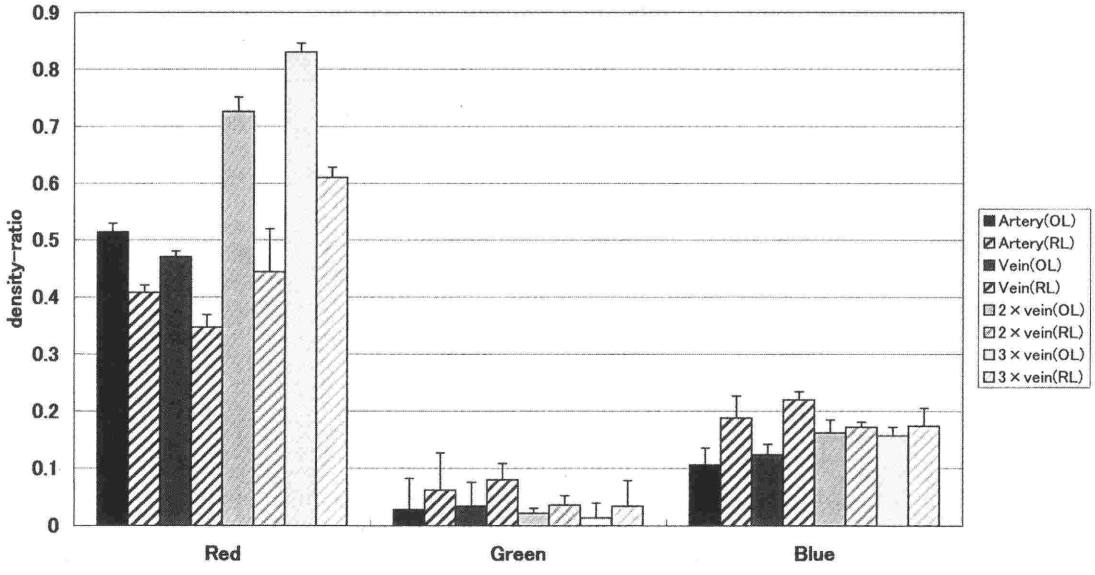

Fig-4. The comparison of RGB-ratio at Hb:8.7 g/dl under operation-light(OL) and room-light(RL)

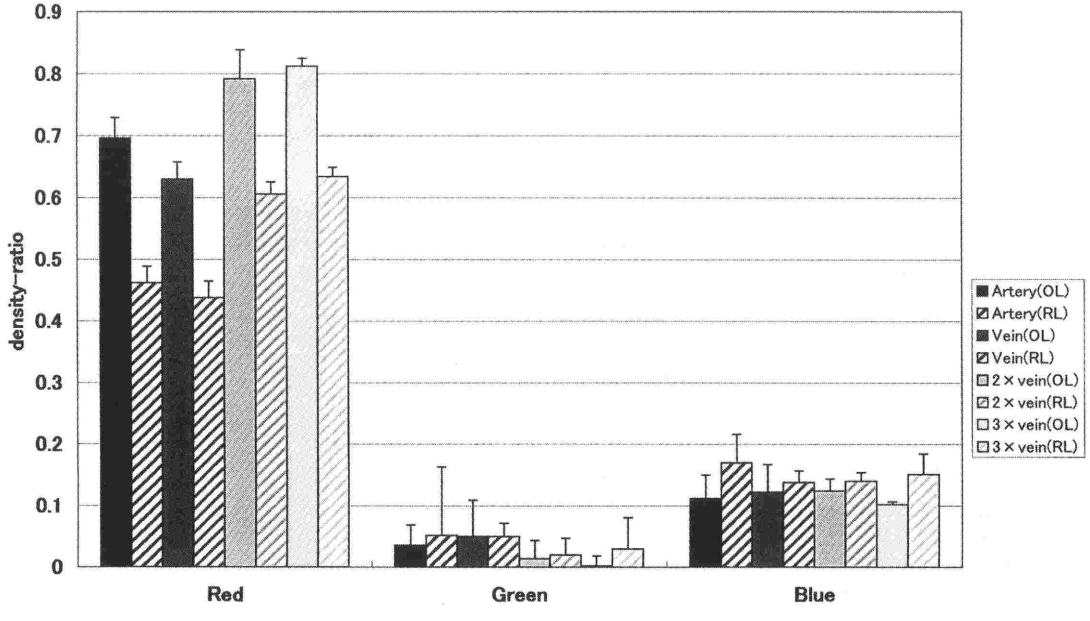

Fig-5. The comparison of RGB-ratio at Hb:14.8 g/dl under operation-light(OL) and room-light(RL)

patient with decreased hemoglobin levels. Red density was higher under operating light than under indoor light.

Discussion

A syringe containing physiological saline is used to perform central venous puncture. When the blood is mixed with the physiological saline, since the red

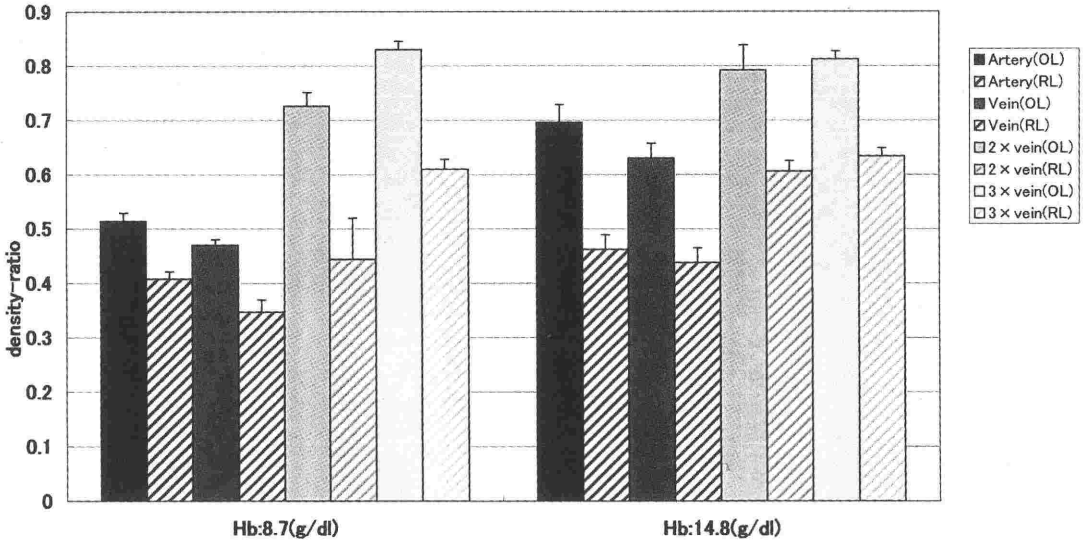

Fig-6. The comparison of red-density between Hb:8.7 and 14.8g/dl under operation-light(OL) and room-light(RL)

color is strengthened, the sample sometimes appears as arterial blood. In patients with reduced blood pressure due to shock, it is hard to distinguish arterial blood and venous blood by the pulsation of reflux blood alone. On such occasions, the use of physiological saline may cause the blood to be diluted, making judgment more difficult. It can occasionally happen that we realize a catheter being mistakenly been inserted in the artery. If distinguishing between the artery and vein by the color of the blood is difficult, we need to confirm the voltage waveform using a pressure transducer, or to measure the oxygen partial pressure of the blood. Dilution, light, hemoglobin and heparin levels may affect the color of the blood. Some investigators consider that operating light should not be used because it makes it more difficult to distinguish between arterial blood and venous blood. In the present study, we demonstrated the effects of the above factors on distinguishing blood objectively by the computerized color analysis. The results of the analysis show that venous blood not diluted has the lowest red density among the four sample types irrespective of hemoglobin levels in patients under operating light and indoor light, and that this provides positive attribution to the high rate of accuracy in identification. The red density of 2-fold, and 3-fold dilutions of venous blood was higher than that of arterial blood under operating light and indoor light. The rate of accuracy for identification of 2-fold dilution of venous blood was almost 0%, probably because 2-fold dilution of venous blood appeared to have a higher red density than arterial blood. The rate of accuracy for identifying 3-fold dilution as venous blood was higher than that for 2-fold dilution, probably because the judgments of the anesthesiologists were based on preconceptions. Illumination intensity and color temperature are involved in the influence of light. The illumination intensity of indoor light (400 lux) is clearly lower than the 100,000 lux of operating light. It is known that the blue color of an object is enhanced under light with a high color temperature, and that red is enhanced under light with low color temperature. The color temperature of indoor light is 4500° K, and that of operating light is 4250° K. Therefore, blood samples may have appeared bluish under indoor light. We consider that this effect is involved in the lower rate of accuracy in identifying arterial blood in the patient with decreased hemoglobin levels under indoor light (Fig. 3), the lower red density in all four sample types under indoor

light (Fig. 6), and the elevated density of green and blue under indoor light (Figs. 4, 5). Red density of arterial blood was lower in patients with decreased hemoglobin levels. The rate of accuracy for discriminating arterial blood from venous blood was lower in the patient with decreased hemoglobin levels. The rate of accuracy of identifying arterial blood with decreased hemoglobin levels as arterial blood may be higher under operating light than under indoor light. It is clear that the color tone of arterial and venous blood is affected by dilution and light. If heparin is added to the heart-lung machine, the red of the blood sometimes appears to be enhanced; however, since a very small amount of heparin was used in the present study, we consider that its addition had little effect on the color tone of the blood.

Conclusion

It is considered risky to determine whether blood is arterial or venous from its color alone, especially when a syringe with physiological saline is used for the puncture.

References

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