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ORIGINAL ARTICLE

Artificial-coloring in ultrasound-guided regional anesthesia

Ultrasonografi eşliğinde bölgesel anestezi sırasında yapay-renklendirme

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Summary

Objectives: Ultrasonography (US) is an important visualization technique in regional anesthesia. Increasing in quality of images may lead to better conclusions. Our aim in this study was to evaluate the effect of artificial-coloring on image quality and practitioner's preferences.

Methods: Ultrasound images of five block regions, interscalene, supraclavicular, infraclavicular, femoral, and popliteal were taken on a volunteer using gray scale. Then, the images were colored in seven different color scales using artificial-coloring technique. All participants were asked to fill in the structured questionnaire.

Results: All created images were assessed by three specialist and 14 resident anesthesiologists. The highest scores about nerve recognition, distinguishing nerve from surrounding tissues, and visual clarity of fascicles were obtained with blue scale images; however, these findings were not significant compared to gray scale (p>0.05). Blue scale was chosen as a favorite scale by 53% of participants.

Conclusion: Increasing the image quality and resolution while performing regional anesthesia under ultrasound guidance increases success and reduces complications. Artificial-coloring is one of the adjustments that can improve image quality. In our study, the results of coloring with blue were remarkable. However, more importantly than the color chosen, we believe that routine adjustments such as gain, depth, and focusing will bring important advantages.

Keywords: Artificial-coloring; regional anesthesia; ultrasonography.

Özet

Amaç: Ultrasonografi bölgesel anestezi sırasında kullanılan önemli bir görüntüleme tekniğidir. Görüntü kalitesinin artması sonuçları iyileştirir. Bu çalışmanın amacı, yapay renklendirmenin görüntü kalitesine ve uygulayıcı seçimlerine etkisini değerlendirmektir.

Gereç ve Yöntem: İnterskalen, supraklaviküler, infraklaviküler, femoral ve popliteal bölge olmak üzere beş blok bölgesine ait ultrasonografi görüntüleri gri skalada alındı. Takiben görüntüler yapay renklendirme kullanılarak yedi farklı renge çevrilerek katılımcılar tarafından yapılandırılmış anket kullanılarak değerlendirildi.

Bulgular: Görüntüler üç uzman ve 14 araştırma görevlisi tarafından değerlendirildi. Sinirin tanınması, çevre dokudan ayırt edilebilmesi ve fasiküllerin görülmesinin netliği hakkında en yüksek skor mavi skalayla oldu. Ancak bulgular gri skaladan istatistiksel olarak farklı değildi (p>0,05). Mavi skala katılımcıların %53'ü tarafından favori renk olarak tercih edildi.

Sonuç: Ultrason eşliğinde bölgesel anestezi yapılırken görüntü kalitesi ve çözünürlüğün artması başarıyı artırır, komplikasyonları azaltır. Yapay renklendirme görüntü kalitesini artırabilecek ayarlamalardan biridir. Çalışmamızda mavi renk ile renklendirmenin sonuçları dikkat çekiciydi. Ancak, seçilen renkten daha önemlisi bu ayarın kazanç, derinlik ve odaklama gibi rutin yapılmasının önemli avantajları da beraberinde getireceği kanaatindeyiz.

Anahtar sözcükler: Yapay renklendirme; bölgesel anestezi; ultrasonografi.

Introduction

Real-time ultrasonography (US) has become an important and an essential part of regional anesthesia and increasingly of pain management practice.[1] Limited interventional block procedures previously performed using blind techniques and anatomical landmarks, rapidly progressed, and became widespread and diversified after the use of US due to increased success rate of blocks with decreased rate of complication all of which resulted

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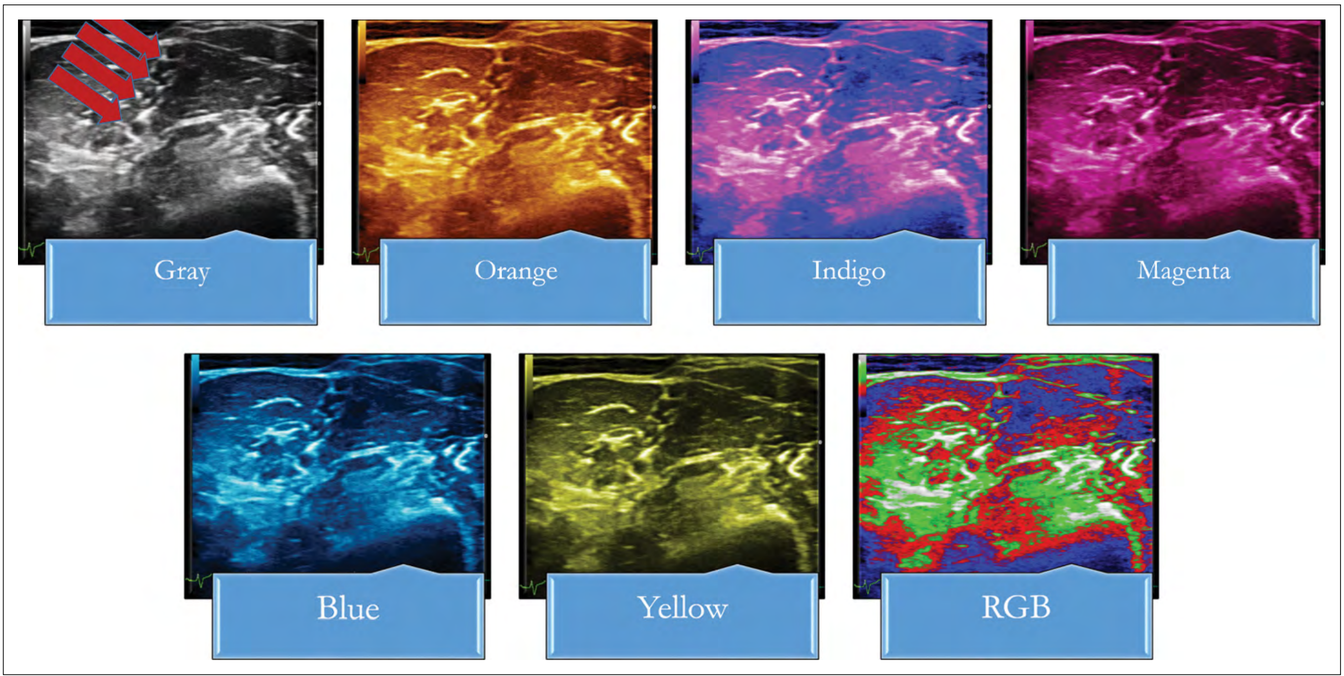

Figure 1. Artificial-color scales used in presentation (Examples illustrate interscalene region and arrows presents interscalene groove).

in increased satisfaction of patients and surgeons.[2] The basis of these important benefits of US lies in the dynamic visibility of anatomy of target tissue and surrounding structures and also real-time visibility of needle movements and injected substance distribution.[1–4]

Continuing research still increases the advantages of US and has clearer and better definable images. The use of 3D and 4D US techniques in regional anesthesia has been reported in recent studies.[5–7] However, these modalities are technically hard to apply and costly, besides the need of a high level of expertise. Artificial-coloring is one of these techniques and is considered to be filtering the color of ultrasound image. The resolution of the human eye in color vision is higher than in black and white. Therefore, it may make sense to view ultrasonographic images in different colors. However, this is highly dependent on the practitioner's adaptation to a color scheme.[8] Ault et al.[9] stated that experienced ultrasound users who already get used to black and white images preferred gray scale, while less experienced practitioners rather had a tendency toward color images.

The aim of this study was to evaluate the effect of artificial-coloring technique on image quality during US-guided peripheral nerve blocking and practitioner's preferences.

Table 1. Questions asked of participants about the images

1.	I clearly recognized the nerve
2.	I was able to clearly distinguish nerves from surrounding tissues
3.	I was able to separate the fascicles clearly
4.	Image is more descriptive than gray scale
5.	I prefer this color when blocking

Table 2. Likert's scale

1.	Strongly disagree
2.	Disagree
3.	Neither agree nor disagree
4.	Agree
5.	Strongly agree

Material and Methods

This study was planned as a small group study following Institutional Review Board and Ethics Committee approval of Baskent University Faculty of Medicine (project no: KA16/289). Initially, five most commonly performed peripheral nerve blocks in the clinic were determined as interscalene, supraclavicular, infraclavicular, femoral, and popliteal blocks. US images of these five regions were taken on a volunteer using gray scale. The same device was used to obtain all the images (Esaote MyLabTM30, Genoa, Italy). Suit-

Table 3. Answers of each questions for each block and different colors (Mean±SD)

	Gray	Blue	Indigo	Magenta	Orange	Yellow	RGB
Question 1							
Interscalene	4.3±0.8	4.5±0.5	2.6±1.2	3.4±0.7	3.9±1.0	4.0±0.6	1.9±0.8
Supraclavicular	4.5±0.8	4.4±0.5	2.9±0.9	3.4±0.9	4.2±0.6	4.1±0.7	2.2±1.0
Infraclavicular	4.2±0.9	4.5±0.5	2.9±1.0	3.5±0.6	3.9±0.9	4.0±0.7	1.8±1.0
Femoral	4.2±0.7	4.4±0.6	2.9±1.1	3.2±0.8	3.9±0.8	3.8±0.8	1.9±0.9
Popliteal	4.1±0.9	4.2±0.7	2.7±0.9	3.1±0.9	3.7±0.8	4.1±0.7	2.1±1.0
Question 2							
Interscalene	4.0±0.9	4.3±0.7	2.2±0.9	2.9±0.7	3.3±1.3	3.7±0.8	1.6±0.6
Supraclavicular	4.1±0.8	3.9±0.9	2.4±0.8	2.9±1.0	3.6±0.8	3.6±0.9	1.8±0.7
Infraclavicular	3.9±1.0	4.2±0.7	2.5±0.8	3.1±0.7	3.5±1.2	3.5±0.9	1.6±0.9
Femoral	3.9±0.9	4.2±0.7	2.5±0.9	2.9±0.8	3.9±1.0	3.5±0.9	1.6±0.7
Popliteal	3.9±0.9	3.9±0.8	2.4±0.8	2.6±0.9	3.4±1.0	3.5±0.7	1.6±0.7
Question 3							
Interscalene	3.4±1.1	3.6±1.1	2.1±1.1	2.6±0.9	3.0±1.5	3.2±1.0	1.6±0.6
Supraclavicular	3.9±1.0	3.9±0.9	2.5±1.1	2.8±1.0	3.6±0.8	3.7±0.9	1.8±0.8
Infraclavicular	3.3±1.1	3.8±1.0	2.1±0.7	2.8±0.7	3.2±1.2	3.2±0.8	1.5±0.8
Femoral	3.8±1.0	3.9±0.8	2.1±0.7	2.8±0.8	3.5±1.1	3.4±0.9	1.6±0.7
Popliteal	3.9±1.1	3.9±1.0	2.3±0.9	2.7±0.9	3.3±0.8	3.6±0.9	1.5±0.5
Question 4							
Interscalene	–	3.4±0.8	1.5±0.6	2.0±0.8	2.6±1.0	3.1±0.8	1.4±0.5
Supraclavicular	–	3.8±0.8	1.9±1.0	2.3±1.0	3.2±1.0	3.1±0.9	1.4±0.7
Infraclavicular	–	3.7±0.7	1.7±0.7	2.2±0.9	2.8±1.2	2.9±0.9	1.3±0.6
Femoral	–	3.9±0.7	1.9±0.7	2.3±1.0	3.1±1.1	3.1±0.9	1.6±0.8
Popliteal	–	3.8±1.0	1.9±1.0	2.2±1.0	2.9±0.9	2.9±0.9	1.3±0.5
Question 5							
Interscalene	4.1±0.9	3.7±0.9	1.5±0.7	1.9±1.0	2.6±1.4	3.1±1.0	1.3±0.5
Supraclavicular	4.4±0.7	3.9±0.6	2.1±1.1	2.2±1.0	3.3±1.0	3.1±1.1	1.5±0.8
Infraclavicular	4.0±0.9	3.7±0.7	1.7±0.7	2.3±0.8	3.1±1.3	3.1±1.0	1.4±0.8
Femoral	4.1±0.7	4.1±0.7	2.0±1.0	2.5±1.1	3.1±1.1	3.3±0.9	1.5±0.7
Popliteal	4.1±0.9	3.8±1.0	1.9±0.9	2.3±1.0	3.0±0.9	3.2±1.0	1.5±0.8

SD: Standard deviation; RGB: Red-Green-Blue.

ability of the images was verified by three specialists' who have experienced in US-guided regional anesthesia (UGRA). Then, the images were colored in seven different color scales using artificial-coloring technique as gray, orange, indigo, magenta, blue, yellow, and Red-Green-Blue (RGB) (Fig. 1).

A brief information about the method was given to all the participants and they evaluated the images in the same order. Anatomical structures for each block were explained to the participants on the gray scale images that they were familiar with. Participants were, then, shown color images and asked five questions about anatomical structures for each of the seven different color images, including the gray scale (Table 1).

Seven different colors were assessed for each block. Responses were categorized according to the five point Likert's scale (Table 2). There was no time restriction for the evaluation of the participants. Participants were released to change the images as they wish forward or backward. Finally, favorite colors in the study were asked to each participant.

Table 4. Answers of each questions for different colors (Blocks are generalized) (Mean±SD)

	Gray	Orange	Indigo	Magenta	Blue	Yellow	RGB
Question 1	4.2±0.7	3.9±0.7	2.8±0.8	3.3±0.7	4.4±0.5	4.0±0.6	2.0±0.7
Question 2	4.0±0.8	3.5±0.8	2.4±0.7	2.9±0.7	4.1±0.6	3.6±0.7	1.7±0.5
Question 3	3.7±0.9	3.3±0.9	2.2±0.7	2.8±0.7	3.9±0.8	3.4±0.8	1.6±0.5
Question 4	–	2.9±0.8	1.8±0.6	2.2±0.8	3.7±0.6	3.0±0.6	1.4±0.4
Question 5	4.1±0.7	3.0±0.9	1.9±0.7	2.2±0.8	3.8±0.6	3.1±0.8	1.4±0.5

SD: Standard deviation; RGB: Red-Green-Blue.

The presence of color blindness and lack of experience on UGRA was accepted as exclusion criteria from the study.

Statistical Analysis

SPSS for Windows 17.0 (SPSS Inc, Chicago, Ill) was used for statistical analysis. Intergroup comparison of data was done using paired t-test. Values are presented as mean±SD. $p<0.05$ was considered statistically significant.

Results

The resulting images were presented to three specialist and 14 resident anesthesiologists who had experience in UGRA. The average age of the participants was 31.5±4.4 years (25–44 years) and duration of experience in anesthesia was 5.1±4.9 years (2–20 years).

Averages and standard deviations of responses to each question, for each block and for each color, are presented in Table 3. Higher scores compared to gray scale were observed for all images only in blue scale.

The highest scores about nerve recognition, distinguishing nerve from surrounding tissues, and visual clarity of fascicles were obtained with blue scale images except for nerve recognition and separation of nerve from surrounding tissues for supraclavicular block image. However, these were not statistically significant ($p>0.05$). When generalized to all blocks for the first three questions, the highest scores were observed in the Blue scale, these differences were not significant compared to gray scale ($p>0.05$, Table 4).

By the fourth question, it was asked whether the images were clearer compared to gray scale. Although positive answers were seen to this question in Blue scale, responses for other color images were ambivalent or negative.

In the fifth question, the participants were asked which color they would prefer while making blocks. Interestingly, unlike the scores for images, the highest preference was determined to be gray scale. In fact, these participants pointed blue in the first three questions and also in their last election.

Finally, at the end of the study, after the presentation, the participants were asked about the color scale they liked most and least on seven scales. Of the 17 participants, 9 (53%) indicated the Blue scale as their favorite scale, and all (100%) stated the RGB scale as the worst scale.

Discussion

US has rapidly entered the medical field and has been widely used, thanks to its features such as being easily accessible, dynamically imaging soft tissues, and having no known side effects. Despite its increasing use, especially in interventional procedures, the desired level has not been reached yet. Today, US has been used with increasing momentum in all medical branches. It has a wide area of use in all interventional and diagnostic procedures, especially in vascular interventions and nerve blockades in anesthesiology and its sub-branches. In intensive care units, it can be used to evaluate the heart walls and great vessels, lung and other thoracic structures, airway, gastric volume and other abdominal structures by echocardiography, or it can guide central or peripheral vascular interventions. It can be used as a primary or supportive imaging method in the treatment of pain and performing many blocks.[10,11]

In addition to the increasing number of applications performed with US, research on improving image quality is also increasing rapidly. Immediately after the development of new and modern equipment such as 3D, 4D, or high-resolution 3D devices, researches on the use of these devices in regional anesthesia procedures have emerged and positive results have been reported. On the other hand, it seems that it will take some time for these techniques to be used routinely due to the high cost of these devices.[1,3,5–7] However, the higher resolution of the human eye in color vision has led researchers to seek new ways to obtain better images in many imaging methods. Coloring in imaging processes is done for reasons such as improving image quality, clearly defining the boundaries of the targeted tissue, or determining functional properties. Narrow-band imaging during gastrointestinal endoscopy, elastography during USG examination, and diffusion mapping during magnetic resonance can be examples of these.[12–14]

While performing US, the image should be optimized by making some changes on the device depending on the characteristics of the tissue to be examined. In this way, diagnosis or intervention can be performed more successfully. Depth, focus, gain, and color are some of these parameters that need to be adjusted.[8] While the first three of the aforementioned are frequently adjusted during initiation of the US-guided procedures, color adjustment is often overlooked. In fact, for image optimization, it is important to make all settings sequentially depending on the characteristics of the devices. However, in daily practice, some potentially useful settings are overlooked due to the inability to abandon routine habits and the ease of use provided by preset presets. In this study, we investigated the effect of coloring ultrasound images of different nerve blocks with color scales on practitioner preferences. The results showed that images colored with blue were mostly preferred by all participants of this study for all blocks in our study.

For high success rates, low complication rates, and low local anesthetic consumption, it is very important to see the nerve clearly and to separate the nerve from the surrounding tissue easily when performing UGRA.[1–4] To achieve the best image optimization in US, it is essential to make some dynamic changes to the settings and appropriate changes can only be achieved with experience. Artificial-coloring is one of the modalities of US to be used for better images. Although a lot of research has been done to get a better image during UGRA, as far as we know, there are no studies on artificial-coloring. In our study, two of the seven colors, gray and especially blue, were the most preferred. It was determined that the most clear identification of the nerve tissue and its separation from the surrounding structures can be achieved, especially with blue coloring. As mentioned earlier, preference for gray scale may be related to habits, more preference for a new color should increase awareness for these adjustments. Blue color may have come to the fore in this study, but it should be kept in mind that there may be individual differences. Therefore, these settings need to be made individually.

We asked the participants what color scale they liked the most among the images shown. While more than half of the participants (n=9, 53%) preferred the blue scale, only four participants (24%) preferred the gray color they routinely use. Unlike the scoring, the participants answered being asked the scale they preferred chose gray scale. We think that this difference may be due to two main reasons. First, the gray scale is the most known and used scale in daily practice, and therefore, it is the most preferred, and second, because the first demo was shown in gray scale, it may have provided familiarity with those images. Both of these explain the habitual behavior mentioned before. However, an overall assessment indicates that blue scale images have better visual clarity both during the initial assessment and at the end of the process in our study.

There are some limitations in our study. The images were prepared by the designers of the study, because the participants could not adjust the device settings according to their own preferences, their eye familiarity may have changed. Since the images are only shown as images, dynamic evaluation could not be made. This may have affected the individual concentrations of the participants. We did not evaluate individuals' visual impairments other than color blindness, but we allowed people to wear the glasses they wear in daily life. Moreover, we only used the five most commonly used blocks.

Artificial-coloring is one of the important part of ultrasound settings to adjust. Artificial-coloring with different colors may improve or worsen the image optimization of nerves and surrounding structures during ultrasound-guided regional anesthesia. We think that, clearer images can be obtained if it becomes part of the routine setting when using ultrasound, such as gain, depth or focus. This can help increase the security and quality of the blocks. However, this analysis should be done separately for each brand, as the coloring features may vary for each device.

Ethics Committee Approval: The Başkent University Clinical Research Ethics Committee granted approval for this study (date: 25.10.2016, number: KA16/289).

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References

1. Marhofer P, Greher M, Kapral S. Ultrasound guidance in regional anaesthesia. Br J Anaesth 2005;94:7–17. [CrossRef]
2. Barrington MJ, Kluger R. Ultrasound guidance reduces the risk of local anesthetic systemic toxicity following peripheral nerve blockade. Reg Anesth Pain Med 2013;38:289–99.
3. Swenson JD, Davis JJ, DeCou JA. A novel approach for assessing catheter position after ultrasound-guided placement of continuous interscalene block. Anesth Analg 2008;106:1015–6. [CrossRef]
4. Yamamoto H, Sakura S, Wada M, Shido A. A prospective, randomized comparison between single- and multiple-injection techniques for ultrasound-guided subgluteal sciatic nerve block. Anesth Analg 2014;119:1442–8. [CrossRef]
5. Clendenen NJ, Robards CB, Clendenen SR. A standardized method for 4D ultrasound-guided peripheral nerve blockade and catheter placement. Biomed Res Int 2014;2014:920538. [CrossRef]
6. Clendenen SR, Robards CB, Clendenen NJ, Freidenstein JE, Greengrass RA. Real-time 3-dimensional ultrasound-assisted infraclavicular brachial plexus catheter placement: Implications of a new technology. Anesthesiol Res Pract 2010;2010:208025. [CrossRef]
7. Choquet O, Capdevila X. Case report: Three-dimensional high-resolution ultrasound-guided nerve blocks: A new panoramic vision of local anesthetic spread and perineural catheter tip location. Anesth Analg 2013;116:1176–81.
8. Zander D, Hüske S, Hoffmann B, Cui XW, Dong Y, Lim A, et al. Ultrasound image optimization ("Knobology"): B-mode. Ultrasound Int Open 2020;6:E14–24. [CrossRef]
9. Ault MJ, Rosen BT. Portable ultrasound: The next generation arrives. Crit Ultrasound J 2010;2:39–42. [CrossRef]
10. Akelma FK, Altinsoy S, Akkus IB, Aslan H, Ergil J. Evaluation of the attitudes of anesthesiologists to the use of clinical ultrasonography. JARSS [Article in Turkish] 2019;27:258–64.
11. Bainbridge D, McConnell B, Royse C. A review of diagnostic accuracy and clinical impact from the focused use of perioperative ultrasound. Can J Anaesth 2018;65:371–80.
12. Asztalos IB, Colling CA, Buchner AM, Chandrasekhara V. Development of a narrow-band imaging classification to reduce the need for routine biopsies of gastric polyps. Gastroenterol Rep (Oxf) 2020;9:219–25. [CrossRef]
13. McQueen AS, Bhatia KS. Thyroid nodule ultrasound: Technical advances and future horizons. Insights Imaging 2015;6:173–88. [CrossRef]
14. Arbabi A, Kai J, Khan AR, Baron CA. Diffusion dispersion imaging: Mapping oscillating gradient spin-echo frequency dependence in the human brain. Magn Reson Med 2020;83:2197–208. [CrossRef]