Original Paper

Optimization of Exposure Condition and Photographic Techniques for Specimen and Devices in Neuroangiographic Suites

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Purpose: We analyzed factors related to quality of photographs taken at neuroangiographic suites to optimize exposure condition.

Materials and Methods: We used a camera (EOS-300D, Canon Inc., Tokyo) with a standard- (EF-S 18−55 mm F3.5−5.6 USM, Canon, Inc., Tokyo) and a macro-lens (EF 100 mm f/2.8 Macro USM, Canon Inc., Tokyo). Photographs were taken at a light-booth (1000 lux) and 2 neuroangiographic suites (988 and 856 lux) under ordinary intensity of illumination. We took photographs of a test chart (ColorChecker, X-rite, Michigan) and Kodak Q-13 Grey Scale Card at different values of aperture and shutter speed with fixed ISO of 400 and assessed the quality of photographs by Blade Pro (V1.1, Image group, Seoul). We analyzed photographs of a device at 1/25−1/80 shutter speed and F12 - 20 apertures and compared the result and also made visual assessment.

Results: Photographs of test chart and Grey Scale Card revealed that the best images chosen by Blade Pro were distributed in scattered range of quality which could help understand the range of optimum exposure condition but was not suitable for practical usage. We obtained reasonable quality photograph at shutter speed of 1/40 and aperture of F16 that can be used in 3 places.

Conclusion: The most appropriate exposure condition when taking photographs in neuroangiographic suites could be explored. To get an optimal image in limited illumination, it is mandatory to select a fast enough shutter speed to avoid motion artifacts and a sufficient aperture to actualize the subject depth.

Key Words : Digital camera; Medical photography; Intraoperative photography; Education

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Since the digital camera replaces the conventional filming analogue camera, it is easy to check the quality of photographs taken at neuroangiographic suite because immediate feedback of the quality assessment became possible after taking pictures. Usage of automatic mode of camera made users to get the most appropriate image quality under different environment.

Advent of rapidly evolving neurointerventional field requires a rapid and accurate recording of specimen, device, and even patients (1−11). However, taking good photographs is not always easy because it requires an excessive time and costs to obtain suitable ones in ideal condition.

In addition to the necessity of photographs for communication, investigation, education and presentation, we have uploaded the photograph to PACS in our institute because photographs of specimen and patients become as integral part of the patient's record (12−15). In the mean time, we have faced some difficulties in taking quality photographs in a good quality. Moreover, our neurointerventional photographs showed varying quality of images even though the pictures were acquired with the same camera in the same places.

To obtain quality photographs it may require equipment (camera and lens), standardization of subject position and environment, appropriate camera setting and type of flash, etc (16, 17). Among those factors which contribute to quality, appropriate camera setting would be the most important practical issue in daily practice when photographs were taken under standardized environment by using a certain camera and lens without using flash. Therefore, we intended to setup the camera condition which can be applied in neuroangiographic suite and investigated the best photographic condition of viewing the specimen and neurointerventional materials by analyzing dynamic range, color reproduction, white balance, signal to noise ratio with the use of picture quality test chart and image quality assess program, Blade pro. (V1.1, Image group, Seoul, Korea). We also evaluated the optimal shutter speed and aperture which is suitable to obtain the best quality image in available range of exposure condition.

MATERIALS AND METHODS

Photographs were taken in 3 places, that is, a light-booth in which standard light was provided, and neuroangiographic suite 1 and 2. In neuroangiographic suites, photographs were taken with all the lights on, which was an usual illumination status in neuroangiographic suites. All the light sources were fluorescent light which may not have an ideal white balance for photograph, but was ordinary exposure condition of neuroangiography suite. The surgical lights on the angiotable were not used. Illuminometer (X-rite) was used to measure the intensity of illumination. Intensity of illumination revealed 1000 lux in light-booth and 988 and 856 lux in neuroangiographic suite 1 and 2, respectively. The photograph spot on the angio-support table in neuroangiographic suites was located about 160 cm away from the light source of the ceiling and was the usual distance in our neuroangiographic suites. The distance of the object were about 76 cm for test chart, 22cm for specimen and devices, and 40 cm for other close-up photographings. Camera angle was set perpendicular to the objects being photographed.

We used a camera (EOS-300D, Canon Inc., Tokyo, Japan), with standard-lens (EF-S 18−55 mm F3.5−5.6 USM, Canon, Inc., Tokyo, Japan), macro-lens (EF 100 mm f/2.8 Macro USM, Canon Inc., Tokyo, Japan), test chart (ColorChecker, X-rite, Michigan, USA), Kodak Q-13 Grey Scale Card and tripod.

We used a Manual mode at first but it was too difficult to control the various exposure conditions. Among camera modes of aperture (A), manual (M), programmed (P), and shutter speed (S), we adopted shutter speed (S) mode and took phototograph of a test chart and Kodak Q-13 Grey Scale Card by using standard lens at shutter speeds of 1/25, 1/40, 1/60, 1/80, 1/100 sec when aperture was fixed at F8.0. White balance was adjusted 3 times to each light source in 2 neuroangiographic suites and in a light-booth. ISO was 400. We could not compensate corrected values which was displayed on the camera because the displayed values were not reproducible probably due to inconsistent exposure condition in 3 different environments. The inconsistency of especially prominent when the test chart was repositioned at 45 degree angle to the table bottom to make at least 30 degree angle to the light source.

All photographs were taken by only one person (OKL) to obtain better reproducibility (18). We modulated shutter speed at fixed aperture to find out appropriate shutter speed range in our camera as well as in our exposure environment. Four parameters of dynamic range, color reproduction, white balance, signal to noise ratio were compared (Table 1) by using image quality analysis program (Blade pro. V1.1, Image group, Seoul, Korea) to obtain appropriate exposure ranges.

To find appropriate shutter speed and aperture

number, we took photographs of a stent with a macro-lens (EF 100mm F/2.8 Macro USM, Canon Inc., Tokyo, Japan) in 3 places and assessed the quality by Blade Pro and compared results of visual assessment obtained by two observers (SP, OKL). While each value was obtained at the fixed other value, the negotiation point in assessing the quality of photographs was decided to minimize motion artifact and maximize subject depth. We obtained and assessed the images at the ranges of shutter speed 1/25−1/60 and aperture F14−F22.

RESULTS

Analysis of photographs by test chart (ColorChecker, X-rite, Michigan, USA) and Kodak Q-13 Grey Scale Card at automatic revealed that signal to noise ratio and color reproduction were better in light-booth followed by neuroangiographic suite 1 and 2. The reason of the quality difference seemed mainly to be in the stable illumination condition in light-booth which has a constant environment. Neuroangiographic suite 1 was a newly built facility with better illumination than suite 2. The best images chosen by Blade Pro were distributed in scattered range of quality and were difficult to be applied to practical usage (Table 1). There was a trend but no optimal exposure condition in this result could be selected probably due to insufficient illumination or inappropriate aperture number or even inappropriate shutter speed.

Visual assessment of photographs taken with macro-lens, the most reasonable quality image was obtained at shutter speed of 1/40 and aperture of F16 (Fig. 1).

DISCUSSION

During nearly 150 years of history of medical photography, there always have been difficulties in standardizing photographs in our daily practice without having a well-equipped medical portrait studio (19). Photographs of the specimen and devices are important in neuroangiographic suites especially in neurointerventional field. Although photographic education improves quality of images, higher quality and more consistent images can be obtained by the same photographer (20, 21).

As in table 1, signal to noise ratio and color reproduction were best in a light-booth. We think that is because of homogeneous light and relatively greater intensity of illumination of the light booth. In our experiments using test chart and Kodak Q-13 Grey Scale Card, we thought that shutter speed of S1/25, S1/40, and S1/60 would provide better images. However, it was impossible to use manual shutter speed exposure mode because there were many exposure conditions to control. It is certainly easy to use automatic shutter speed exposure mode when we take pictures of the specimen and devices at a neuroangiography suite.

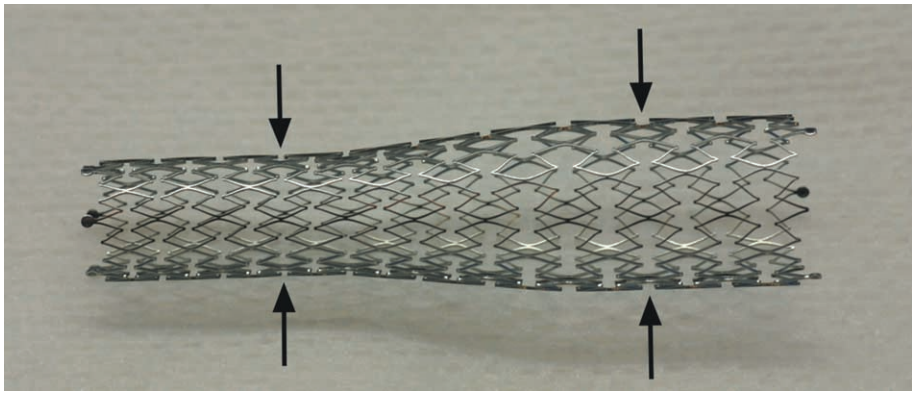
Image quality was good in both the light-booth and neuroangiographic room 1. It may be contributed to high intensity of illumination. If more attention is drawn to room setup, better quality images can be produced under the higher intensity illumination (22). However, white balance should be also considered when fluorescent light is used as in our study, since it is not an ideal light source for photograph.

It is recommended in an automatic shutter speed exposure mode to take photograph with macro-lens at longer distance to objects (40 cm). Because macro lenses magnify object that is close to the camera, they are convenient for photography and documentation of lesions (23). If the light booth is not available, usage of macro-lens with higher intensity of illumination can provide better image quality.

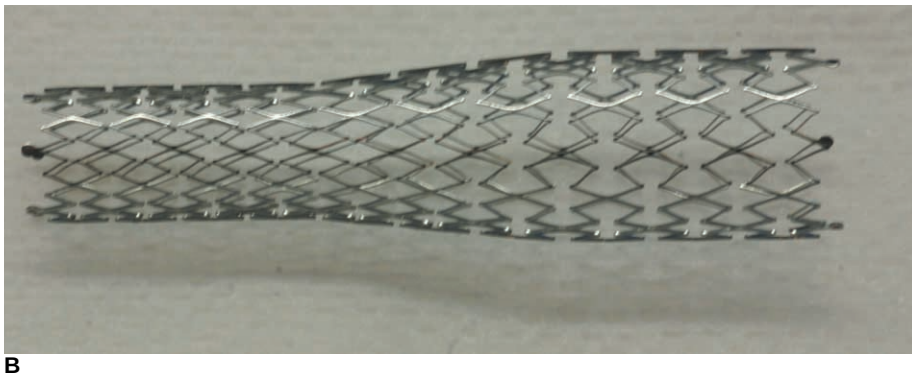
Table 1. Analysis Results of Test Chart Images Provided by Blade Pro

	Light-booth (1000 lux)				Room 1 (988 lux)				Room 2 (856 lux)			
SS	DR	CR	WB	SNR	DR	CR	WB	SNR	DR	CR	WB	SNR
1/25	0.71	31.02	**0.06**	**22.80**	0.96	**12.05**	**0.01**	**20.09**	**0.99**	**14.71**	**0.03**	5.95
1/40	0.93	19.39	0.08	19.18	0.97	23.95	**0.02**	16.84	**0.99**	27.22	0.04	6.64
1/60	**0.98**	**12.82**	0.10	19.42	**0.99**	34.79	**0.03**	12.75	**1.00**	38.05	0.05	9.81
1/80	**0.98**	**12.93**	0.13	19.75	**0.99**	41.28	0.05	10.40	**1.00**	44.23	0.06	7.78
1/100	**0.99**	13.76	0.08	18.58	**0.99**	45.24	0.06	7.95	**0.99**	47.65	0.06	6.88

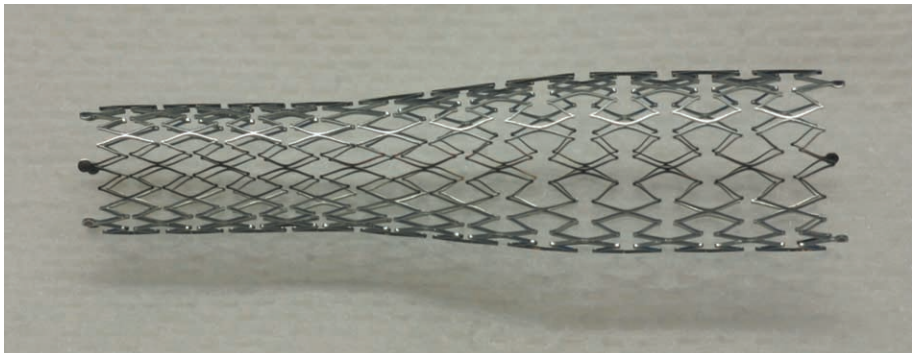
*SS = shutter speed, DR = dynamic range (the better the closer to 1, the better), CR = color reproduction (the smaller the better; less than 5 is recommended), WB = white balance (the better the closer to 0), SNR = signal to noise ratio (the higher the better; more than 40 is recommended). Numbers shown as bold italic letters represent relatively better quality than others. However, WB relatively remained at low values even though there were some differences according to the places.



A



B



C

Fig. 1. Photographs of a carotid stent (7−8 mm diameter, 40 mm length) taken at different range of shutter speed and aperture to reduce motion artifact and to increase subject depth.
A. Image taken at shutter speed 1/60 and aperture F14 reveals blurring of the stent margin (arrows) due to low subject depth.
B. Image taken at shutter speed 1/25 and aperture F22 reveals blurring of the whole stent due to motion artifact.
C. Image taken at shutter speed 1/40 and aperture F16 reveals a good image without motion artifact and rather good subject depth.

It was meaningful that we could get shutter speed 1/40 and aperture F16 as the most optimal exposure condition in our camera when we fixed ISO (400) and ordinary intensity of illumination in neuroangiographic suite. The exposure condition can be changed according to camera, lens and intensity of illumination when it is used in other places.

There are some limitations in our study. First, we used a home-made light-booth which may not provide ideal exposure condition. However, a professional product of light-booth is relatively expensive and voluminous to handle. It is easy to handle our light-booth, to move at a neuroangiographic suite and to put the specimen in it without having to move the specimen. Secondly, we used limited number of digital camera and lens, despite that image quality could vary depending on digital camera and lenses being used. So the study with multiple cameras and lenses is required to consolidate our observations and results.

The most appropriate exposure condition when taking photograph in neuroangiographic suite could be explored. To get an optimal image, it is mandatory to select a fast enough shutter speed to avoid motion artifacts and a sufficient aperture to actualize the subject depth. If the quality is not satisfactory, it is advisable to check if the conditions of taking photographs are within the appropriate range.

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뇌혈관조영실에서 인체추출물이나 기구들의 촬영시 필요한 적정노출조건 및 촬영기술

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목적: 노출조건을 적정화하기 위해 뇌혈관조영실에서 촬영된 사진의 화질에 관련된 인자들을 분석하였다.

대상 및 방법: 카메라(EOS-300D, Canon Inc., Tokyo), 표준 렌즈(EF-S 18~55 mm F3.5~5.6 USM, Canon, Inc., Tokyo)와 접사용렌즈 (EF 100 mm f/2.8 Macro USM, Canon Inc., Tokyo)로 라이트부스(1000 lux)와 2개의 뇌혈관조영실(988와 856 lux)에서 평상시조도하에서 촬영하였다. 적당한 노출조건을 찾기 위해서 테스트차트(ColorChecker, X-rite, Michigan)와 코닥Q-13회색스케일카드를 촬영하였다. 적정노출조건을 얻기 위해 스텐트사진을 1/25-1/80 셔터속도와 F12-20 조리개값의 범위 내에서 촬영하여 시각적 평가를 하였다.

결과: 자동노출조건에서 테스트차트와 회색스케일카드의 사진을 Blade Pro.로 분석하였을 때 적정값의 변화추세는 알 수 있었지만 영상화질이 분산되어 실용적인 값을 얻기 어려웠다. 적정노출범위를 알아내기 위한 실험에서는 3 장소에서 공통적으로 사용될 수 있는 1/40셔터속도와 F16 조리개값을 얻었다.

결론: 저자들은 뇌혈관조영실에서 사진촬영시 필요한 적합한 노출조건을 얻을 수 있었다. 제한된 조도속에서 적절한 영상을 얻기 위해서는 움직임훼손을 초래하지 않으면서 충분한 피사체심도를 구현하는 셔터속도를 얻는 것이 필수적이었다.

Key Words : Digital camera; Medical photography; Intraoperative photography; Education