# Quality Control and Image Quality Comparison according to Ultrasonic Equipment

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**ABSTRACT**

In doing interventional treatment under the guidance of ultrasonography, the medical team detects the legion site with ultrasonic equipment at first, and insert angio needle. In this situation, if the position of legion and the depth of inserted needle on the ultrasonographic screen are different from real position and depth, the needle is likely to damage a major blood vessel or tissue. Accordingly, we had wondered how much such differences between screen image and reality, and so decided to examine them. Using five ultrasonographic equipments manufactured from different companies in different years, this study tried to compare the lengths of the needle on the screen images and real lengths of it, and find out the factors affecting skewness of them. This study used hog meat chunk to mimic human flesh, and sausages as the target of needle. It compared penetrating depths of the needle as the images on the five equipments using single sample t test in the SPSS 22 statistical program. It was found that all the errors were statistically significant(<.05). So, this study decided that it was wrong to evaluate performances of the equipments by the makers and ages of them. It is necessary to do periodic quality controls of equipments and improve the skillfulness of sonographers to reduce error rates between real treatment areas and the images of them.

Keywords: Ultrasonography, Ultrasonographic equipment, Image quality, Biopsy, Angio-needle

## I. INTRODUCTION

Ultrasonography is the examination of soft tissues of human body using reflectance image acquired by projecting ultrasound wave with frequency exceeding the frequencies in the hearing range (20~20,000Hz) to those tissues[1,2]. As ultrasonography provides real-time images, it allows technologist to figure out body structures and continuously identify the legion site[3]. Such a merit of ultrasonography allows technologist to do biopsy of the legion of an internal organ. Under ultrasonography, technologist can detect the legion site, aim at it, and safely cut away a bit of the tissue of the organ without damaging a blood vessel and other organ around it[4,5].

Ultrasonography is used for various disease diagnoses such as fine needle aspiration biopsy, nerve block, ultrasound-induced injection treatment as well as tissue biopsy[6,7]. However, the results of ultrasonography can vary depending on the skills of technologists, and on the conditions of the equipment. The injected needle on the screen can look longer or shorter than the real size of it, or the technologist can mistakenly consider the needle tip as other object, damaging a blood vessel or other organ around the targeted organ[8-10].

Accordingly, to figure out the skewness of measurement in biopsy, this study inserted the needle

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into a hog meat phantom, and measured the depth and length of the needle, and compared them with those in the ultrasonographic screen. This study used five ultrasonographic equipments made from different companies in different years. By analyzing the factors affecting needle skewness per equipment, this study intends to suggest them as the basic data to be used in ultrasonic images.

## II. MATERIALS AND METHODS

### 1. Phantom manufacturing

This study used a hog meat chunk with the size of 15 cm × 15 cm × 10 cm (length×breadth×height), and inserted sausages in the sides of the meat chunk for targets. Fig. 1 show this study inserted sausage with its end pointing to the examiner.

Sausages were inserted at three targets. The first one was inserted at the target of 1 cm; the second one at the target of 2 cm; the third one at the target of 3 cm.

Fig. 1. Sausage on the side of pork.

### 2. Experimental method

#### 2.1. Experimental tools

This study used five ultrasonic equipments manufactured by different companies in different years, and did experiment using linear probe. Fig. 2 show sausage was from Vienna Sausage, and the needle was angio needle 18 G (6.9 cm).

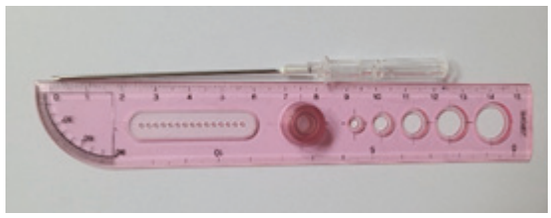


Fig. 2. Angio Needle 18 G (6.9 cm).

#### 2.2. Research method

(1) Setting ultrasonic frequency per equipment

To detect the point where sausage and needle can be clearly visible, this study set the frequency and depth as Table 1, and set them as TGC and gain values.

Table 1. Ultrasonic equipment frequency and depth setting values

| Classification (equipment) | Frequency (MHz) | Depth (cm) |
|---|---|---|
| A (2003) | 23.0 | 5.9 |
| B (2019) | 12.0 | 5.0 |
| C (2012) | 23.0 | 5.0 |
| D (2017) | 11.4 | 5.0 |
| E (2008) | 12.0 | 5.0 |

(2) Measurement

Fig. 3 show this study used the linear probe, and set the points 0.5cm from both end points of the probe as the penetration points. This study penetrated the needle until the endpoint of it touched the sur

Fig. 3. Injection needles are inserted 0.5cm away from both ends of the probe.

Fig. 4 show face of the highest part of the sausage on ultrasonographic screen.

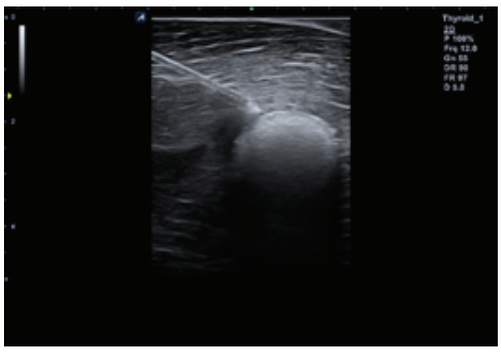


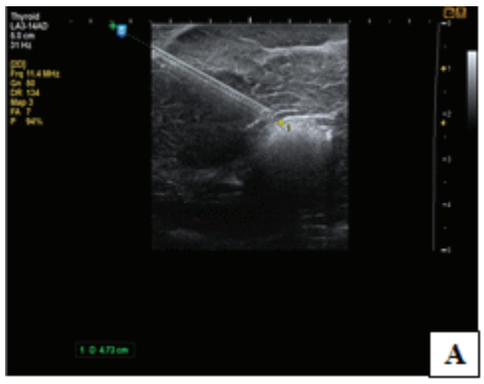
Fig. 4. The tip of the needle touches the highest surface of the sausage.

After penetrating the needle, this study measured the length of it. Fig. 5 show it compared the two kinds of length, real length and the length on the screen. It measured the length of penetrated needle on the screen and the real length from the surface of the meat chunk to the sausage.

Fig. 6 show as it was difficult to observe the needle near the surface of the chunk, this study began to measure it from the needle end, and drew the extension line to the surface.

Fig. 6. Measure the length of the needle by drawing a straight extension line from the tip of the needle.

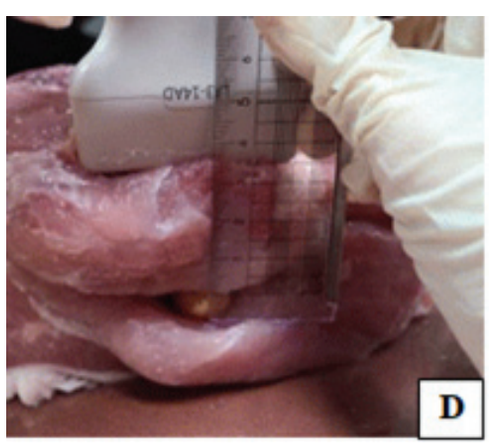
This study got two images from three sausages from five equipments. Thus, it came to get 30 images in total. And, it calculated error rates between the real lengths and those in screen images.




(A) Measuring the length of the needle inserted on the ultrasound


(B) Measurement of the actual inserted needle length


(C) Ultrasonic depth measurement




(D) Actual depth measurement

Fig. 5. Ultrasound image and measurement methods

(3) Data analysis

For statistical analysis of the measured values, a single sample t-test was performed. As a statistical program, SPSS (version 22.0, Chicago, IL, USA) was used, and a significance probability p-value of less than 0.05 was set as statistically significant.

## III. RESULT

Table 2 show the error rates in the real and screen image distances between the surface of the hog meat chunk and the surface of sausage on the images of five equipments are as follows.

The error rate of equipment A was 0.14~0.20 cm;

That of equipment B was 0.21~0.24 cm, that of equipment C was 0.26~0.30 cm, that of equipment D was 0.02~0.05 cm, that of equipment D was 0.02~0.07 cm.

The differences of those rates were statistically significant.

Table 3 show the error rates between the real lengths of the needle which penetrated from the surface of the meat chunk to the surface of the sausage and the lengths of the needle on the screen image were as follows.

The error rate of equipment A was 0.12~0.21 cm, that of equipment B was 0.18~0.20 cm, that of equipment C was 0.24~0.28 cm, that of equipment D was 0.01~0.04 cm, that of equipment D was 0.03~0.07 cm.

The differences of those rates were statistically significant.

Table 2 The actual depth between the pork and sausage surfaces and the depth in the image (cm)

| Ultrasonic Equipment | No | Target - Surface | Target upper - probe (a) | Target upper - probe (image) (b) | a - b | t | p |
|---|---|---|---|---|---|---|---|
| A | 1 | 3.00 | 2.99 | 2.82 | 0.17 | 15.614 | 0.000 |
| | | | 2.92 | 2.76 | 0.16 | | |
| | 2 | 1.00 | 0.80 | 0.60 | 0.20 | | |
| | | | 0.65 | 0.46 | 0.19 | | |
| | 3 | 2.00 | 1.96 | 1.81 | 0.15 | | |
| | | | 1.93 | 1.79 | 0.14 | | |
| B | 1 | 4.00 | 4.05 | 3.84 | 0.21 | 36.888 | 0.000 |
| | | | 4.14 | 3.94 | 0.20 | | |
| | 2 | 2.00 | 1.57 | 1.35 | 0.22 | | |
| | | | 1.43 | 1.20 | 0.23 | | |
| | 3 | 2.00 | 2.35 | 2.12 | 0.23 | | |
| | | | 2.37 | 2.13 | 0.24 | | |
| C | 1 | 1.00 | 1.18 | 0.88 | 0.30 | 9.938 | 0.000 |
| | | | 1.20 | 0.91 | 0.29 | | |
| | 2 | 1.00 | 0.97 | 0.69 | 0.28 | | |
| | | | 1.15 | 0.88 | 0.27 | | |
| | 3 | 2.00 | 2.03 | 1.77 | 0.26 | | |
| | | | 1.9 | 1.77 | 0.25 | | |
| D | 1 | 3.00 | 2.98 | 2.95 | 0.03 | 5.809 | 0.002 |
| | | | 2.99 | 2.95 | 0.04 | | |
| | 2 | 2.00 | 1.79 | 1.77 | 0.04 | | |
| | | | 1.82 | 1.77 | 0.05 | | |
| | 3 | 2.00 | 1.87 | 1.85 | 0.02 | | |
| | | | 1.87 | 1.85 | 0.02 | | |
| E | 1 | 3.00 | 3.05 | 3.06 | 0.01 | -3.639 | 0.015 |
| | | | 3.06 | 3.09 | 0.03 | | |
| | 2 | 1.00 | 1.07 | 1.10 | 0.03 | | |
| | | | 1.32 | 1.42 | 0.10 | | |
| | 3 | 2.00 | 1.91 | 1.97 | 0.06 | | |
| | | | 1.90 | 1.95 | 0.05 | | |

Table 3 The actual needle length transmitted from the pork surface to the sausage surface and the length of the needle in the image (cm)

| Ultrasonic Equipment | Needle length (c) | Needle length (image) (d) | c - d | t | p |
|---|---|---|---|---|---|
| A | 4.86 | 4.72 | 0.14 | 14.627 | 0.000 |
| | 4.63 | 4.50 | 0.13 | | |
| | 3.17 | 3.00 | 0.17 | | |
| | 2.94 | 2.78 | 0.16 | | |
| | 4.06 | 3.94 | 0.12 | | |
| | 3.89 | 3.78 | 0.11 | | |
| B | 4.74 | 4.57 | 0.17 | 39.461 | 0.000 |
| | 4.84 | 4.64 | 0.16 | | |
| | 2.68 | 2.50 | 0.18 | | |
| | 2.48 | 2.29 | 0.19 | | |
| | 4.25 | 4.06 | 0.19 | | |
| | 3.70 | 3.50 | 0.20 | | |
| C | 2.99 | 2.74 | 0.25 | 30.042 | 0.000 |
| | 2.99 | 2.74 | 0.25 | | |
| | 2.69 | 2.45 | 0.24 | | |
| | 2.66 | 2.43 | 0.23 | | |
| | 3.75 | 3.49 | 0.26 | | |
| | 4.20 | 3.91 | 0.29 | | |
| D | 4.75 | 4.73 | 0.02 | 3.322 | 0.021 |
| | 5.00 | 4.96 | 0.04 | | |
| | 3.83 | 3.81 | 0.02 | | |
| | 4.56 | 4.50 | 0.06 | | |
| | 4.26 | 4.25 | 0.01 | | |
| | 4.26 | 4.25 | 0.01 | | |
| E | 3.71 | 3.75 | 0.04 | -5.270 | 0.003 |
| | 3.76 | 3.82 | 0.06 | | |
| | 3.04 | 3.10 | 0.06 | | |
| | 3.03 | 3.12 | 0.09 | | |
| | 3.16 | 3.20 | 0.04 | | |
| | 3.37 | 3.39 | 0.02 | | |

# IV. DISCUSSION

This study tried to compare differences in the real needle lengths and the needle lengths on the screens of five ultrasonographic equipments, and analyze the factors affecting the skewnesses[11].

Biopsy under ultrasonography can be done without the risk of being exposed to radiation, and, as ultrasonography allows technologist to work continuously observing the legion, the results of biopsy tend to be accurate. In addition, the patient is treated in supine position, he or she feels little inconvenience, and there is little vasovagal reaction. Such a biopsy has the merit that it can be done simple with a needle under local anesthesia[12].

Hyeon-seok Song et al. indicated that, considering the depth of the treated part, it is desirable to use the needle of 2.5-10.0cm, that, if the needle is too long[8], it is difficult to operate it, and that the thickness of 18 G allows technologist to have a clear image with bright and thick line. They also mentioned that even the image of the needle with the same thickness can be blurred if it comes near the ultrasonic wave. The tissue the needle penetrates tends to be pushed away by elasticity, which is identifiable on the ultrasonographic screen. That is, when the needle creates small vibration while penetrating the tissue, the tissue surrounding the needle is pushed a little, which allows technologist to indirectly identify the position of the needle[13].

Considering the 15cm depth of the meat chunk, this study used the 18 G needle of 6.9 cm, which was clearly visible on the ultrasonographic screen.

However, this study did not consider the angle between the needle and ultrasonic wave, it had difficulty in differentiating the needle on the screen. Due to such a mistake, it took longer time than expected to work, and repeated penetrations created air artifacts, generating not uniform values for each equipment. In addition, while the meat chunk needs to have elasticity to create small vibration, it came to lose the elasticity over time, which made technologists difficult to find the position of the needle.

This study used angio needle instead of the needle used for biopsy. If this study had used biopsy needle, it would have better results.

The limits of this study may be the unskillfulness of the experimenters and error caused by using hog meat chunk. However, it is meaningful to find out

that, if they are continuously given good quality control, even old equipments make little needle errors compared with the needle of new equipment. So, quality control of equipments are really important.

## V. CONCLUSION

This study compared the depths of sausage and the lengths of the needle on the screens of five ultrasonographic equipments and real depths and lengths, and tested the differences of measurement using the single sample t test of the SPSS statistical program. It was found that, regardless of the equipment makers and equipment ages, all equipments generated errors in measurement, and the findings were statistically significant. Therefore, this study recommends that ultrasonographic equipments should get periodic quality controls, and it is desirable to improve skillfulness of sonographer.

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# 초음파 장비에 따른 정도관리와 화질 비교

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## 요 약

초음파 유도 하 중재적 시술 시 먼저 초음파 장비로 병변의 위치를 파악하며 angio needle을 삽입한다. 이때 실제와 초음파 상 병변의 위치 또는 바늘의 투과 깊이의 차이가 클수록 인체의 주요 혈관이나 조직에 손상을 일으킬 수 있는 위험이 있다. 그러므로 우리는 초음파 장비 업체와 연식에 따라 성능의 차이가 나는지, 이것이 시술의 정확도에 얼마나 영향을 끼치는지 의문이 들어 이를 연구 주제로 삼았다. 본 연구에서는 임의의 초음파 5대의 장비를 사용하여 초음파상 주사침의 길이와 실제 길이를 비교하여 왜곡에 영향을 주는 요인을 분석하고자 하였다. 초음파 유도 하 돼지고기 투과 시 각 연식과 업체가 다른 다섯 대의 초음파 장비로 실제 소시지의 깊이와 바늘의 투과 길이를 영상에서의 값을 측정하여 오차율을 비교하기 위해 spss 22 통계 프로그램의 단일 표본 T 검정을 이용하였다. 그 결과 모두 통계적으로 유의한 범위의 수치가 나왔고, 장비의 연식과 업체만으로 성능을 평가하는 것은 옳지 않다고 판단하였다. 그러므로 초음파 정도관리를 정기적으로 실시하고 시술자의 숙련도를 높여 실제 시술 부위와 영상에서의 오차율을 줄여야한다고 결론을 내리는 바이다.

중심단어: 초음파, 장비, 화질, 생검, 혈관바늘

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