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QUANTITATIVE ASSESSMENT OF MUSCLE ACTIVITY IN MAMMOGRAPHY POSITIONING

Mieko Uchiyama[1], Yongbum Lee[1], Du-Yih Tsai[1], Kiyoko Kazama[2], Yasuko Minagawa[2], Mieko Sadakata[1], Mitsuko Sayama[1]

[1]Graduate School of Health Sciences, Niigata University, Japan
[2]Department of Radiology, Nakajo Central Hospital, Japan
uchiyama@clg.niigata-u.ac.jp

Abstract: The purpose of this study was to measure muscle activity in mammography positioning using surface electromyography. The subjects consisted of 15 females in their 30s-50s, and measurement was performed with positioning for mediolateral oblique view and cranio-caudal view. The sternocleidomastoid, biceps brachii, trapezius, and gastrocnemius muscles were evaluated. A multi-purpose, portable bio-amplifier (Polymate AP1000) was used for measurement. As a result, the activities of not only the muscles directly involved in mammography positioning but also those indirectly involved were high as compared with the normal state.

Keywords: mammography, muscle activity, physical pain, surface electromyography

1. INTRODUCTION

Mammography (MMG) is widely performed as a standard breast cancer screening method in Japan and Western countries. In MMG, after the papillary glands are adequately stretched, the breast is compressed with a radiolucent paddle for fixation and a reduction in the breast thickness. In examinees undergoing MMG, not only breast compression but also fixation with the neck being rotated or the shoulder being flexed is necessary. These imaging techniques reduce X-ray exposure and ensure the image quality necessary for diagnosis [1]. However, such positioning adds to the pain caused by direct breast compression. For effective diagnosis, images with a high quality are required, for which good positioning is important. In the literature on MMG, studies on advances in imaging equipment, appropriate imaging techniques and quality control methods for use of the equipment have been carried out [2-5]. In contrast, there have been few previous studies focusing on the physical burden and pain experienced by the subjects. There have been only rare reports on the effect of pain associated with MMG on the subject's behavior while undergoing the screening test [6-8] , and on the subjective pain in the breast and related sites using a visual analogue scale (VAS) [9,10]. However, there has been no established method to make delicate adjustments and reduce an examinee's physical burden. Therefore, to develop a method that can reduce this burden, we aimed to quantify the burden in MMG positioning, and measured examinees' muscle activity in MMG positioning.

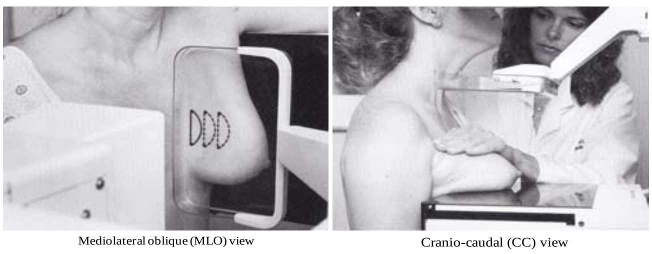
2. METHODS

2.1 Subjects

The subjects consisted of 15 females in their 30s-50s (44.4 ± 6.56 years: mean ± standard deviation, the same hereafter) without heart disease, hypertension, or skin disease. They were 160 ± 6.7 cm tall and weighed 55.08 ± 3.94 kg, and showed a body mass index (BMI) of 21.4 ± 2.21%. In the experiment, a female radiological technologist with rich MMG experience performed positioning. After explaining that no X-ray irradiation was to be performed, written consent for participation was obtained from all subjects.

2.2 Evaluated muscles

During mediolateral oblique (MLO) view and cranio-caudal (CC) view MMG (Fig.1), muscle activity from the initiation to completion of imaging was measured. Those evaluated were the sternocleidomastoid, biceps brachii, and trapezius muscles, which are related to areas showing high levels of physical pain according to Sharp's visual analogue scale (VAS), and the gastrocnemius muscle involved in standing [9]. Measurement was performed only on the right side to evaluate differences in muscle activity between the MMG and non-MMG sides. Thus, when the right breast was examined using MMG, muscle activity on the right side as the direct compassion side was measured. When the left breast was examined using MMG, muscle activity on the right side not directly compressed was measured. Experimental procedure is shown in Fig.2.



Mediolateral oblique (MLO) view   Cranio-caudal (CC) view

Fig.1 Positioning of MMG [1]

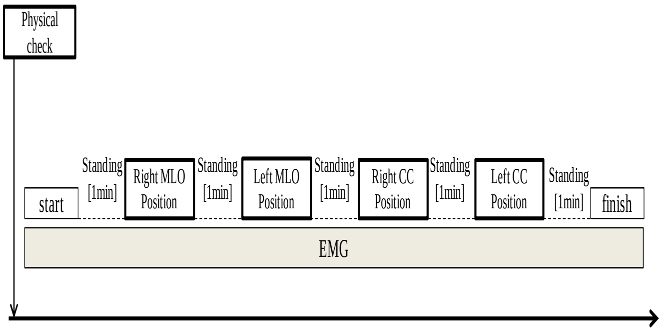


Fig.2 Experimental procedure

2.3 Electromyography

Electromyography (EMG), which is a technique for recording action potentials generated during skeletal muscle contraction as biological signals, is widely used for the evaluation and analysis of physical movements. In particular, EMG using surface electrodes attached to the skin surface is called surface EMG.

In this study, muscle activity was measured using surface EMG employing a small multi-purpose portable bio-amplifier (Polymate AP1000: Degitex Lab. Co., Ltd.) (Fig.3). As an EMG sensor, active electrodes were used in a bipolar arrangement at each measurement site. Electrodes were placed at the middle of the uppermost border of the trapezius running from the acromion and the middles of the bellies of the biceps brachii, sternocleidomastoid, and gastrocnemius muscles. The placement of electrodes is shown in Fig. 4. Before electrode placement, areas were wiped with a pretreatment agent (Skin pure) to reduce the skin-electrode contact resistance. In addition, a conductive paste was applied to the electrodes for a secure connection. The earthing pad was placed on the skin of each subject's wrist.

Fig.3 Illustrations of mammography equipment and biological amplifier used in this study

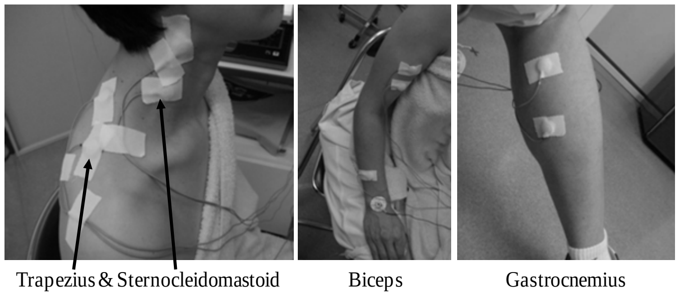


Fig.4 Active EMG sensors placed around muscles.

2.4 Data analysis

Obtained EMG data were analyzed using a surface EMG analysis program (Surface EMG Analysis: NoruPro Light Systems, Inc.) The main frequency range of EMG signals was 5-100 Hz. For EMG data, background noise was eliminated using a notch filter, and filtering was performed using a low cut (cutoff frequency, 5 Hz) and high cut (cutoff frequency, 100 Hz) filter. From waves after filtering, the integrated EMG signal (iEMG) was obtained. The amplitude of EMG waves is determined by the number of muscle fibers involved in muscle contraction and the potential occurring in these fibers. The integrated value as the sum of these potentials is proportional to the strength of muscle contraction.

The state before positioning was defined as the relaxation phase (RP). The iEMG value in this phase was expressed as iEMGrp and used as a reference. The period from the initiation of positioning to the completion of imaging was divided into two phases. The first phase was from the initiation of positioning to breast fixation and defined as the keep phase (KP), while the second phase was from breast fixation to the completion of imaging and defined as the pressure phase (PP). An example of recorded EMG waves in each phase is shown in Fig. 5. In each phase, iEMG was obtained and divided by the phase duration (seconds) (Equation 1, 2, 3).

$$iEMG_{rp} = \int_{t_1}^{t_2} EMG(t)\,dt \Big/ (t_2 - t_1) \qquad (1)$$

$$iEMG_{kp} = \int_{t_2}^{t_3} EMG(t)\,dt \Big/ (t_3 - t_2) \qquad (2)$$

$$iEMG_{pp} = \int_{t_3}^{t_4} EMG(t)\,dt \Big/ (t_4 - t_3) \qquad (3)$$

The value in the KP or PP was compared with that in the RP as the reference. For statistical processing, a software package, SPSS19.J for Windows was used, and one-way analysis of variance was performed. In addition, comparison between the PR and KP or PP was performed using the Dunnett test for multiple comparisons. The mean KP duration was 55.5 seconds, and the mean PP duration was 10.9 seconds. In positioning, the mean breast compression Pressure was 122 N, and the mean compressed breast thickness was 3.44 cm.

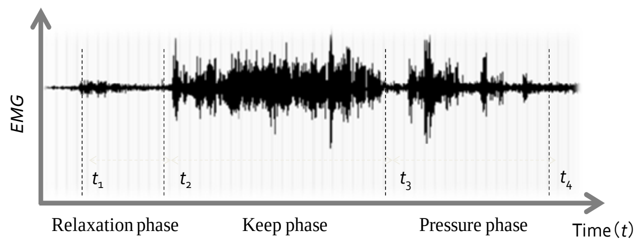


Fig.5 Waves of surface EMG with three phases for analysis

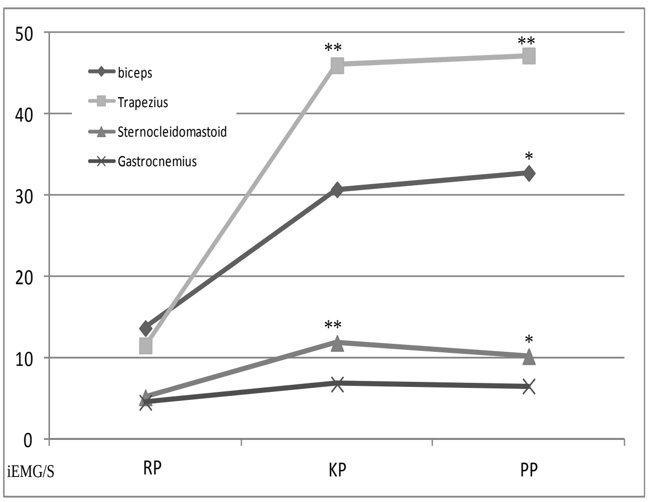
3. RESULTS

3.1 Muscle activity on right breast MLO positioning

The mean value for each muscle on the imaging side was compared among the 3 phases shown in Fig. 6. One-way analysis of variance showed significant differences in the values for the trapezius and sternocleidomastoid muscles between the RP as the reference and KP as well as the PP (trapezius, $F = 12.06$, $p < 0.000$; sternocleidomastoid, $F = 8.155$, $p < 0.001$). Multiple comparison analysis revealed a significantly higher value for the biceps brachii in the PP than the RP and significantly higher values for the trapezius and sternocleidomastoid muscles in the KP and PP than in the RP.

3.2 Muscle activity on left breast MLO positioning

Fig. 7 compares the mean value for each muscle on the non-imaging side among the 3 phases. One-way analysis of variance showed significant differences in the values for biceps brachii, sternocleidomastoid, and gastrocnemius muscles between the RP and KP as well as the PP (biceps brachii, $F = 22.50$, $p < 0.000$; sternocleidomastoid, $F = 9.183$, $p < 0.001$; gastrocnemius, $F = 4.804$, $p < 0.013$). Multiple comparison analysis revealed a significantly higher value for the biceps brachii in the PP than RP and significantly higher values for the trapezius and sternocleidomastoid muscles in the KP and PP than in the RP.



＊＊p<0.01 ＊p<0.05 Dunnett's test（Comparison of the RP）

Fig.6 Muscle activity during right breast MLO positioning

3.3 Muscle activity on right breast CC positioning

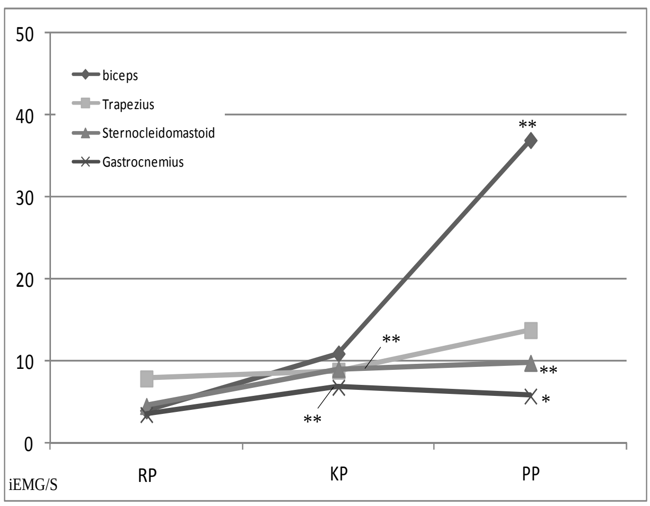
The mean value for each muscle on the imaging side was compared among the 3 phases in Fig. 8. One-way analysis of variance showed a significant difference in the values for the sternocleidomastoid muscle between the RP as the reference and the PP ($F = 3.792$, $p < 0.031$). Multiple comparison analysis revealed a significantly higher value for the sternocleidomastoid muscle in the PP than in the RP.

3.4 Muscle activity on left breast CC positioning

Fig. 9 compares the mean value for each muscle on the non-imaging side among the 3 phases. One-way analysis of variance showed no significant differences in the values for all muscles between the RP and KP as well as the PP.

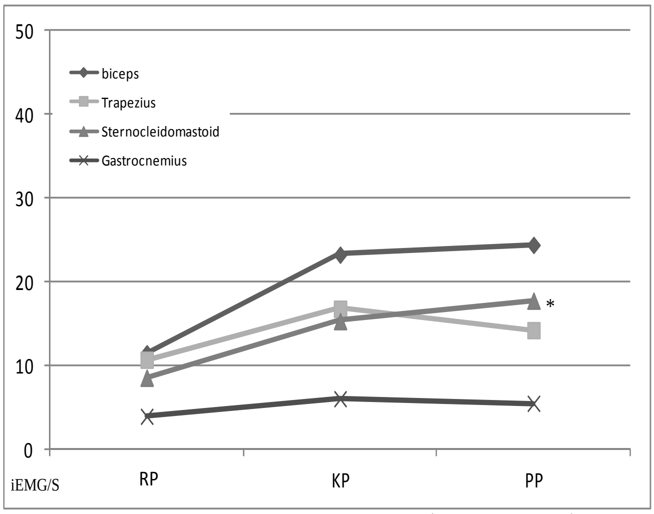
4. CONCLUSION

We quantitatively measured muscle activity in MMG positioning using surface EMG. On the imaging side, the activities of the sternocleidomastoid and trapezius muscles were high in both the "keep phase" and "pressure phase", and the activity of the biceps brachii muscle was high in the pressure phase. On the non-imaging side in MLO, the biceps brachii, sternocleidomastoid, and gastrocnemius muscles showed high activity in both phases. In addition, since MLO is imaged from an oblique direction of the breast, the neck is forced to bend to make it easier to insert the cassette holder at the time of imaging. The opposite breast is pressed out of the way so that it does not interfere with the imaging field, which supposedly increases the muscle activity of the biceps on the opposite side. This indicates that there is an impact not only on the breast directly but also on the surrounding muscle activities during MMG. Therefore, the imaging positioning affects the muscle activities from the start to the end of MMG. These results quantitatively suggest the presence of loads applied on not only muscles directly involved in MMG positioning, but also those not directly involved.



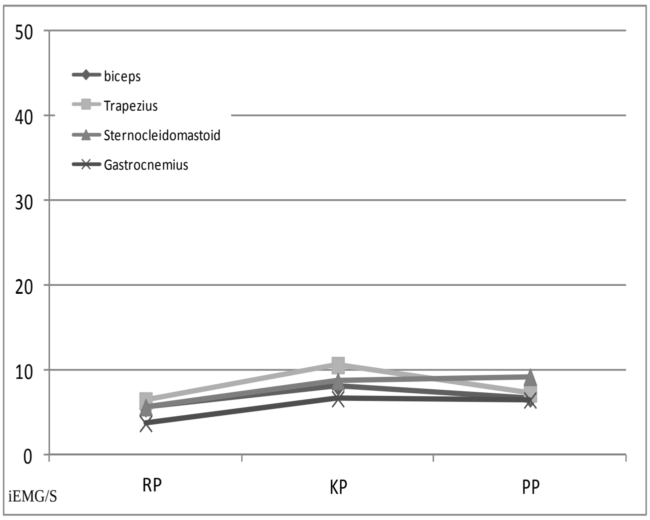
＊＊p<0.01 ＊p<0.05 Dunnett's test（Comparison of the RP）

Fig.7 Muscle activity during left breast MLO positioning



＊p<0.05 Dunnett's test（Comparison of the RP）

Fig.8 Muscle activity during right breast CC positioning



Dunnett's test（Comparison of the RP）

Fig.9 Muscle activity during left breast CC positioning

If muscle loads in body areas in MMG positioning are quantified, obtained data can be effectively used in care to reduce an examinee's pain. Further studies are necessary to evaluate physical and psychological loads in positioning for imaging.

5. ACKNOWLEDGMENTS

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