

# Effect of Breast Sling Use on Transthoracic Echocardiographic Examination Time and Image Quality in Women with Large Breasts

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**Background:** Transthoracic echocardiographic examinations in women with large breasts are technically demanding and can lead to suboptimal image quality, excessive scan time, and cause pain and discomfort to patients.

**Objective:** Evaluate the effects of self-made breast sling used during transthoracic echocardiographic examination on scanning time, image quality, pain, and satisfaction in women with large breasts.

**Material and Method:** A self-made breast sling was developed by the study team and tested in 26 women with bra cup size of C or larger, who were scheduled for transthoracic echocardiography. Each patient underwent transthoracic echocardiographic examination twice, with and without breast sling use. The sequence of the examinations was determined at random. The primary outcome was scan time in apical views. Secondary outcomes included total scan time, image quality in apical views (qualitative scores), patients' and sonographers' pain (qualitative scores), and patients' satisfaction (qualitative scores). Outcomes were compared within individual subjects.

**Results:** The use of self-made breast sling did not reduce scan time in apical views (mean difference 2.8 minutes,  $p = 0.053$ ), but it reduced total scan time (mean difference 5.9 minutes,  $p = 0.04$ ). Breast sling use was not associated with improvement in image quality scores ( $p = 0.59$ ), patients' pain ( $p = 0.21$ ), and sonographers' shoulder-back-neck pain ( $p = 0.052$ ). It improved patients' satisfaction ( $p = 0.01$ ) and sonographers' wrist pain ( $p = 0.035$ ).

**Conclusion:** In women with large breasts who required transthoracic echocardiographic examination, the use of self-made breast sling did not improve scan time and image quality in apical views. It may improve total scan time, patients' satisfaction, and sonographers' wrist pain.

**Keywords:** Breast sling, Large breast, Transthoracic echocardiography, Scan time, Image quality

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Transthoracic echocardiography, currently one of the most frequently used investigations in cardiology, is a very important imaging modality that helps determine cardiac structures, functions and hemodynamics<sup>(1,2)</sup>. Optimal image quality is a crucial factor for accurate and appropriate interpretation of the examination. However, some certain body habitus of the patient can impair echocardiographic acoustic windows, thereby limiting the usefulness of echocardiography. Women with large breasts pose a particular challenge to cardiac sonographers. In left

lateral decubitus position, excessive and pendulous breast tissue usually overlies cardiac apex, obstructing the areas of chest wall required for apical views of the heart. The sonographer needs to take additional efforts to manipulate the ultrasound probe for proper image acquisition. These efforts, including repositioning of the overlying breast and applying more pressure on the patient's chest wall, not only result in musculoskeletal injury to the sonographer but also discomfort and pain to the patient<sup>(3)</sup>. Despite these manipulations, image quality can still be suboptimal. From our local experience, echocardiographic images in apical views were inadequate in 64% of women with large breasts. In addition, scan time tends to be longer in women with large breasts compared to those with normal body habitus.

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In order to overcome the aforementioned problems associated with echocardiographic examination in women with large breasts, specially-designed apparatus such as breast sling has been developed and is commercially available in the United States<sup>(4)</sup>. The breast sling supports the left breast, preventing it from obstructing the apical window during echocardiographic examination. Disposable breast sling is expensive, however, and is not available in Thailand. In addition, its beneficial effects on echocardiographic examination have never been reported in medical literature. We have developed a self-made breast sling using local materials (Fig. 1), and conducted the present study to evaluate the effects of breast sling use on scan time, image quality, level of satisfaction and pain in patients and cardiac sonographers.

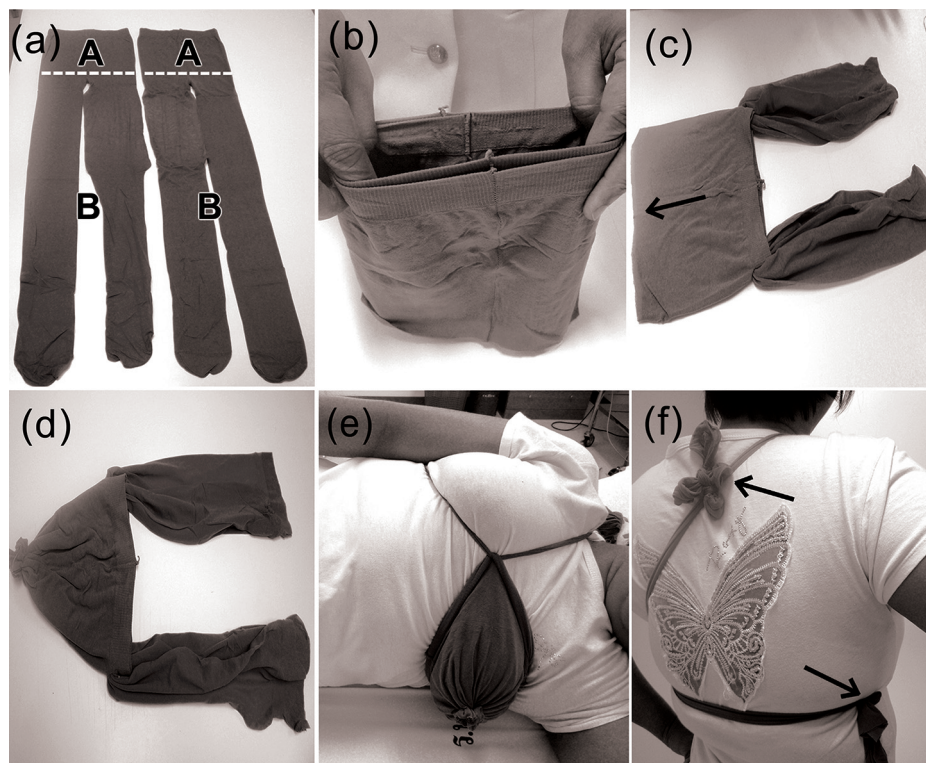
#### Material and Method

The study protocol was approved by the Institutional Review Board of the Faculty of Medicine

Siriraj Hospital, Mahidol University. All patients provided written informed consent before enrollment into the study. The study was conducted between October 1, 2010 and August 31, 2011.

#### Study population

Female patients who were scheduled for transthoracic echocardiography were eligible for the study if they had bra cup size of C or larger, and skinfold thickness below the breasts of at least 30 millimeters. A member of the study team verified the patient's bra cup size by measuring chest circumferences at two levels in horizontal plane, one at the level of both nipples and the other just below the breasts. The difference between the two figures determined the bra cup size according to the standard bra size assessment table<sup>(5)</sup>. The skinfold thickness below the breasts was measured using a pair of skinfold calipers. Patients were excluded if they were unable to remain in left lateral decubitus position for a required period or if they were allergic to nylon.



**Fig. 1** Production of a self-made breast sling. (a) Two pairs of pantyhose, each is cut into 2 parts (A and B) along the dotted line. (b) Put 2 pieces of part A together to form a 2-ply open sack. (c) Make a small hole on each side of the sack just below the rim. Put a piece of part B into each hole to make a cord. Sew the open end of the sack (arrow) to close it. (d) The finished breast sling. (e) The breast sling is put on over the left breast. (f) The cords are tied together at the back (arrows).

### **Study intervention**

The breast sling used in the present study was locally designed and made by cardiac sonographers and members of nursing team at our echocardiography laboratory. It was designed to support and suspend the left breast during the examination in left lateral decubitus position. Two new pairs of pantyhose were used to make a breast sling (Fig. 1), which was discarded after a single use.

After enrollment, an experienced cardiac sonographer performed transthoracic echocardiographic examination twice for each patient on the same day, one with and the other without a breast sling. The period when the breast sling was used was randomly determined for each patient. The same echocardiographic protocol, determined by each patient's indications and conditions, was used during both examinations. The time interval between the two echocardiographic examinations ranged between 1 and 3 hours for each patient. When a breast sling was used, a well-trained nurse assistance put it on and set the posture of the patient before the examination.

Echocardiographic images were digitally recorded and stored in a remote workstation under aliases for blind image analyses. To avoid bias during examination, cardiac sonographers were not allowed to directly observe the scan time. Any device that displayed time (e.g., watch, wall clock, or system clock in echocardiographic machine) was removed or turned off. During the examination, a study nurse in a separate audiovisual control room monitored the echocardiographic images directly sent from the echocardiographic machine, and recorded the scan time. A cardiologist reviewed and analyzed all digital images offline later. Both the study nurse and the cardiologist were not aware of the status of breast sling use when they viewed the echocardiographic images.

### **Study outcomes**

The primary outcome of the study was the scan time in apical views, measured from the first appearance of image in apical views until the completion of image acquisition and echocardiographic measurements in apical views. Secondary outcomes included total scan time, image quality in apical views, patients' satisfaction concerning duration of examination, patients' pain, and sonographers' pain in wrist and back-shoulder-neck areas.

Total scan time was recorded from the first appearance of echocardiographic image until the completion of the examination. The cardiologist

assessed image quality in apical two- and apical four-chamber views. In each view, the left ventricular wall was divided into seven segments. In each segment, the cardiologist assigned a score of 0 if the endocardium was not seen, 1 if the endocardium was partially seen, and 2 if the endocardium was clearly seen. The sum of all segment scores in both views made up the total score for each patient, which ranged from 0 to 28. Higher scores represented better image quality.

Patients rated satisfaction after each examination from 1 (very dissatisfied) to 5 (very satisfied). Patients and sonographers also rated pain from 1 (no pain at all) to 5 (very severe pain). After completion of both examinations, patients were also asked if they would agree to use a breast sling during their next transthoracic echocardiographic examinations.

### **Statistical analysis**

Our preliminary data indicated that the standard deviation of the difference in scan time in apical views between usual transthoracic echocardiographic examination and examination with breast sling use in the same subject was 8 minutes. At the significance level of 0.05 and the power of 80%, at least 23 subjects were required to demonstrate at least 5-minute difference in scan time in apical views between examination without and with breast sling use. To compensate for expected rate of incomplete data of 10%, we enrolled 26 subjects into the study.

Comparisons of outcomes between usual transthoracic echocardiographic examination and examination with breast sling use were performed within the same subject, using Wilcoxon signed-rank test. We did a post hoc subgroup analysis of the primary outcome based on bra cup size using Kruskal-Wallis test. All analyses were carried out at the significance level of 0.05.

## **Results**

### **Patients**

Twenty-six women participated in the study and underwent transthoracic echocardiographic examination twice as required. A breast sling was used during the first examination in 13 patients and during the second examination in the remaining patients. Most of the patients had bra cup size of D or larger. All patients were considered either overweight or obese according to the normal body mass index reference for Thai population. Patient characteristics are shown in Table 1.

### Primary and secondary outcomes

Table 2 displayed the outcomes of the study. The scan time in apical views, the primary outcome, was slightly shorter when a breast sling was used than when it was not, but the difference was not statistically significant (mean difference 2.8 minutes,  $p = 0.053$ ). A post hoc subgroup analysis demonstrated a non-significant trend of increasing magnitude of effect on the primary outcome according to bra cup size (mean difference in scan time in apical views, usual echocardiographic examination, compared to that with

breast sling use, -0.14, 1.82, and 6.88 minutes for cup size C, D, and E or larger, respectively,  $p = 0.132$  for interaction).

The total scan time was significantly shorter with breast sling use (mean difference 5.9 minutes,  $p = 0.04$ ). Echocardiographic image quality in apical views did not improve significantly with breast sling use ( $p = 0.69$ ). Patient satisfaction assessment demonstrated significantly higher level of satisfaction with breast sling use with regards to duration of examination ( $p = 0.01$ ). Patients experienced less pain with breast sling use when compared to usual examination, but the difference was not statistically significant ( $p = 0.21$ ). Sonographers reported significantly less wrist discomfort during examination with breast sling use compared to usual examination ( $p = 0.04$ ). After completion of both examinations, 23 patients (88.5%) exhibited the willingness to use a breast sling during their next echocardiographic examinations. There were no adverse events associated with breast sling use.

**Table 1.** Patient characteristics

Variables	n = 26
Age (years)	59.4±11.1
Bra cup size, n (%)	
C	7 (27.0)
D	11 (42.3)
E or larger	8 (30.7)
Skinfold thickness below breasts (mm)	42.0±7.8
Body weight (kg)	72.7±14.9
Height (cm)	154.8±5.9
Body mass index (kg/m <sup>2</sup> )	30.4±5.8
Diagnosis, n (%)	
Coronary artery disease	9 (34.6)
Valvular heart disease	5 (19.2)
Myocardial disease	10 (38.5)
Congenital heart disease	1 (3.9)
Chronic lung disease	7 (27.0)

Data are presented as mean ± SD, except where otherwise indicated.

### Discussion

Our study results demonstrated that in women with large breasts (bra cup size of C or larger) who underwent transthoracic echocardiographic examination, the use of self-made breast sling neither improved scan time and image quality in apical views, nor did it reduce pain associated with the examination as perceived by the patients, and pain in shoulder-back-neck areas as perceived by the sonographers. The use of a breast sling during transthoracic echocardiography,

**Table 2.** Primary and secondary outcomes

Outcomes	No breast sling (mean ± SD)	Breast sling (mean ± SD)	<i>p</i> -value <sup>a</sup>
Scan time in apical views (minutes)	21.5±7.5	18.6±7.2	0.053
Scan time in apical views by bra cup size (minutes)			0.132 <sup>b</sup>
C (n = 7)	17.0±3.9	17.1±7.6	0.527
D (n = 11)	19.6±6.5	17.8±3.5	0.342
E or larger (n = 8)	27.9±7.4	21.0±10.5	0.093
Total scan time (minutes)	46.8±12.3	40.9±13.2	0.044
Image quality scores in apical 2- and apical 4-chamber views (total = 28)	21.6±5.2	22.0±4.2	0.590
Patient satisfaction score regarding the duration of examination (total = 5)	3.4±0.5	3.7±0.5	0.011
Patients' pain score (total = 5)	2.5±0.7	2.4±0.9	0.206
Sonographers' wrist pain score (total = 5)	2.7±0.9	2.5±0.9	0.035
Sonographer's shoulder-back-neck pain score (total = 5)	2.6±0.8	2.3±0.9	0.052

<sup>a</sup> Wilcoxon signed rank test, except where otherwise indicated

<sup>b</sup> Kruskal-Wallis test

however, might be beneficial regarding total scan time, patients' satisfaction concerning duration of examination, and sonographers' wrist pain.

In women with large breasts, echocardiographic examination can take longer time than usual as the result of technical difficulties associated with breast repositioning and manipulation of the ultrasound probe to obtain proper image quality, especially in apical views. Any maneuver that helps preventing the pendulous breast from overlying the areas required for echocardiographic image acquisition should help reduce the scan time and improve image quality. Our self-made breast sling failed to affect the scan time in apical views. However, a post hoc subgroup analysis suggested a tendency of greater benefit in patients with larger breasts. Breast sling use was associated with a 6.9-minute reduction in scan time in apical views among women with bra cup size of E or larger. Inclusion of patients with bra cup size of C in our study might have diluted the beneficial effect of breast sling use. Another possible reason for the negative result of the present study was that the design of our self-made breast sling might not yet be perfect, resulting in some degree of obstruction and disturbance of ultrasound wave by excessive breast tissues during the examination in the apical views. Yet another possible explanation is that the subcutaneous tissue thickness, represented by the skinfold thickness below the breasts, might be so substantial that the effect of breast sling use could not be demonstrated in our study subjects<sup>(6)</sup>.

Despite the failure of breast sling use to affect the scan time in apical views, it significantly reduced the total scan time by 5.9 minutes. It is possible that breast sling use might affect scan time in other views, or this may be just a chance finding, as total scan time was not the primary outcome of this study. However, if the time spent in the process of putting on a breast sling to the patient was included in the total scan time, there was no longer difference in total scan time between usual echocardiographic examination and examination with breast sling use ( $p = 0.78$  by Wilcoxon signed rank test, data not shown).

Image quality in apical views did not improve significantly with the use of a breast sling. In addition to the patient's body habitus and breast size, other factors, including the sonographer's skill and experience, can affect image quality. Cardiac sonographers participating in the present study are well-trained and highly experienced in transthoracic echocardiographic examinations; this may lead to comparable image quality whether or not a breast sling

was used. It is still possible that breast sling use in transthoracic echocardiography performed by less experienced personnel will have some beneficial effects on image quality.

Breast sling use was associated with higher levels of satisfaction regarding the duration of examination as assessed by patients. This was consistent with the associated significant reduction in total scan time. Most patients also agreed to use a breast sling during their next transthoracic echocardiographic examinations. Breast sling use can also help eliminate the weight of patient's breast on sonographer's hands, thereby alleviating wrist pain and discomfort. It may eventually contribute to improvement in quality of life and reduction in musculoskeletal disorders experienced by many cardiac sonographers<sup>(3)</sup>.

We tried to incorporate measures to reduce bias in outcome ascertainment in the design of the present study. The record of scan time and the assessment of image quality were carried out blind of the status of breast sling use. We tried to reduce the influence of sonographers on scan time by removing or turning off devices that display time in the environment of the examination. However, as we could not blind patients and sonographers regarding the status of breast sling use during the examination, subjective assessment of satisfaction and pain may be affected by the awareness of breast sling use.

Our self-made breast sling was designed for easy production, using low-cost materials commonly available in regular stores. We expect that its usage could be applied in echocardiographic laboratories in developing countries, where resources and financial supports are limited. Further improvement in breast sling design is necessary, and additional studies are required to establish the usefulness of a breast sling in transthoracic echocardiographic examination in women with large breasts.

## Conclusion

In women with large breasts who required transthoracic echocardiographic examination, the use of self-made breast sling did not improve scan time and image quality in apical views. However, it may improve total scan time, patients' satisfaction, and sonographers' wrist pain.

## What is already known on this topic?

Transthoracic echocardiographic examinations in women with large breasts frequently result in suboptimal image quality and prolonged scan time.

Patients and sonographers often experienced pain and discomfort during and after the examinations. A breast-supporting device such as breast sling is marketed to help improve image quality and reduce pain and discomfort associated with echocardiographic examination in women with large breasts.

However, the device has never been systematically evaluated for its merits and is not available in Thailand.

#### **What this study adds?**

A self-made breast sling, designed to support and suspend the left breast during echocardiographic examinations did not improve image quality and scan time in apical views. However, it may improve total scan time, patients' satisfaction, and sonographers' wrist pain.

#### **Acknowledgement**

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#### **Potential conflicts of interest**

None.

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## ผลของการใช้เครื่องพุงเต้านมระหว่างการตรวจคลื่นเสียงสะท้อนหัวใจต่อระยะเวลาที่ใช้ในการตรวจและคุณภาพของภาพในสตรีที่มีเต้านมขนาดใหญ่

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**วัตถุประสงค์:** การตรวจคลื่นเสียงสะท้อนหัวใจผ่านผนังทรวงอกในสตรีที่มีเต้านมขนาดใหญ่อาจทำให้คุณภาพของภาพไม่ละเอียดชัดเจนและเสียเวลาในการตรวจนานกว่าปกติ และยังอาจก่อให้เกิดความเจ็บปวดและไม่สบายต่อทั้งผู้ป่วยและผู้ทำการตรวจ

**วัตถุประสงค์:** ประเมินผลของการใช้เครื่องพุงเต้านมที่ทำขึ้นเองต่อระยะเวลาในการตรวจ คุณภาพของภาพ ความเจ็บปวด และความพึงพอใจต่อการตรวจคลื่นสะท้อนหัวใจผ่านผนังทรวงอกในสตรีที่มีเต้านมขนาดใหญ่

**วัสดุและวิธีการ:** ทำการศึกษาในผู้ป่วยสตรี 26 ราย ที่มีขนาดเต้านมเทียบเท่ากับเสื้อยกทรงตั้งแต่ขนาด C ขึ้นไป ที่มารับการตรวจคลื่นสะท้อนหัวใจผ่านผนังทรวงอกตามนัดหมาย ผู้ป่วยแต่ละรายได้รับการตรวจคลื่นเสียงสะท้อนหัวใจผ่านผนังทรวงอกโดยใช้เครื่องพุงเต้านม 1 ครั้ง และไม่ใช้เครื่องพุงเต้านมอีก 1 ครั้ง ภายในวันเดียวกัน โดยใช้วิธีการสุ่มในการกำหนดว่าการตรวจโดยใช้เครื่องพุงเต้านมจะเป็นการตรวจครั้งแรกหรือครั้งที่ 2 ในผู้ป่วยแต่ละราย ผลลัพธ์หลักของการศึกษาคือระยะเวลาที่ใช้ในการตรวจบริเวณยอดของหัวใจ (apical views) ผลลัพธ์รองได้แก่ระยะเวลาทั้งหมดที่ใช้ในการตรวจ คุณภาพของภาพในการตรวจบริเวณยอดของหัวใจ (apical views) ความเจ็บปวดของผู้ป่วยและผู้ทำการตรวจ และความพึงพอใจต่อการตรวจของผู้ป่วย การเปรียบเทียบผลลัพธ์ทั้งหมดเป็นการเปรียบเทียบในผู้ป่วยรายเดียวกัน

**ผลการศึกษา:** ระยะเวลาที่ใช้ในการตรวจบริเวณยอดของหัวใจ (apical views) ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติระหว่างการตรวจโดยใช้และไม่ใช้เครื่องพุงเต้านม (ความแตกต่างเฉลี่ย 2.8 นาที,  $p = 0.053$ ) การใช้เครื่องพุงเต้านมช่วยลดระยะเวลาทั้งหมดที่ใช้ในการตรวจ (ความแตกต่างเฉลี่ย 5.9 นาที,  $p = 0.04$ ) แต่ไม่ช่วยทำให้คุณภาพของภาพดีขึ้น ( $p = 0.59$ ) ไม่ลดความเจ็บปวดของผู้ป่วย ( $p = 0.21$ ) และไม่ลดความเจ็บปวดบริเวณไหล่-หลัง-คอ ของผู้ทำการตรวจ ( $p = 0.052$ ) การใช้เครื่องพุงเต้านมทำให้ผู้ป่วยมีความพึงพอใจต่อการตรวจมากขึ้น ( $p = 0.01$ ) และช่วยลดความเจ็บปวดบริเวณข้อมือของผู้ทำการตรวจ ( $p = 0.035$ )

**สรุป:** การใช้เครื่องพุงเต้านมระหว่างการตรวจคลื่นสะท้อนหัวใจผ่านผนังทรวงอกในผู้ป่วยสตรีที่มีเต้านมขนาดใหญ่ไม่ช่วยลดระยะเวลาที่ใช้ในการตรวจบริเวณยอดของหัวใจ (apical views) และไม่ทำให้คุณภาพของภาพบริเวณยอดของหัวใจ (apical views) ดีขึ้น แต่การใช้เครื่องพุงเต้านมอาจช่วยลดระยะเวลาที่ใช้ในการตรวจทั้งหมด เพิ่มระดับความพึงพอใจต่อการตรวจของผู้ป่วย และลดความเจ็บปวดบริเวณข้อมือของผู้ทำการตรวจ

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