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June 1998 A SERVICE OF American Echo, Inc Vol. 8 No. 3

Advantages of Utilizing a Specialized Table for Routine Echocardiography

This study was undertaken to determine if utilizing a specialized imaging table with a drop section will: 1) improve apical image quality, 2) reduce imaging time, 3) improve sonographer comfort and ease of image acquisition, and 4) impact patient comfort. Four-chamber (4C) and two-chamber (2C) images were obtained and digitized on 64 consecutive patients undergoing routine echocardiography while using a specialized echocardiography table equipped with a drop section. Images were obtained with and without the drop-section engaged. Image acquisition ease, acquisition time, sonographer comfort and patient comfort were rated and/or recorded for each patient. Image quality was assessed using a predetermined rating scale by three blinded observers possessing varying degrees of experience. Image quality was rated as significantly better when utilizing the drop-section to obtain apical images. Imaging was easier, the sonographer more comfortable, and the study time shorter when utilizing the drop-section. Patient comfort was the same.

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The American Society of Echocardiography (ASE) has long recommended utilizing an exam surface with an excavation at the point where the apex impulse is located when quantifying the left ventricle by two-dimensional (2D) echocardiography.[1] The assumption always has been made that image quality is improved when access to the apical window is unlimited. While specialized echocardiographic examination tables equipped with an apical drop section have been shown to reduce post-exercise acquisition time during stress echocardiograms,[2] no studies have been undertaken to show if specialized drop-section tables improve apical image quality during routine echocardiograms.

This study was designed to determine if utilizing a specialized echocardiography table equipped with a drop section (Echo™ Bed from American Echo Inc.) would indeed improve routine echocardiography, and a number of end points were predetermined to establish the outcome. First, did utilization of a drop section improve apical image quality. It is well recognized that imaging different patients requires varying degrees of difficulty and different individuals reading the exams have varying degrees of skill. To account for these differences, patient data was reviewed in total and patients were grouped by body mass index to recognize differences. Two different sonographers obtained the images, with all images from any one patient being selected and recorded by the same sonographer. Three physicians read each echo. The physicians

TABLE 1

IMAGE PREFERENCE

All Patients, All Views, 3 Observers

IMAGE QUALITY	Number of Images Preferred			
	Observer One	**Observer Two**	**Observer Three**	**Total** (p=0.003)
Drop-section open better than closed	53	48	57	158
Equivalent	46	45	29	120
Drop-section closed better than open	29	35	42	106

participating in the study were deliberately chosen to represent a wide range of experience in interpreting echo studies.

The second parameter measured was the time required to complete a study with and without utilizing an exam surface with a drop section. And finally, the sonographer recorded any preference for drop section/no drop section for each patient, and each patient was asked whether they had a preference for being scanned with the drop section open or closed.

The approach taken in this study was to test 64 consecutive patients undergoing routine echocardiography for various cardiac disorders in a private practice setting. The study group consisted of 33 male and 31 female patients, aged 61 ± 19.7 years, undergoing routine echocardiography for various cardiac disorders in a private practice setting. Patient height averaged 66.9 ± 4.5 inches and weight averaged 172.7 ± 44.3 pounds. The mean calculated body mass index (BMI), which is a measure of fatness, was 27.8 ± 5.4 kg/m^2. With the patient lying in a left lateral decubitus position apical images (apical four chamber (4C) and apical two chamber (2C) were obtained and digitized. This was done for each patient with the drop section of the table open, and additional apical images were obtained and digitized with the drop section of the table closed (conventional exam table). The order (open first or closed first) in which the drop section was utilized for each patient study was randomized.

Each patient study was performed by one of two experienced cardiac sonographers using a Sonos 1000™ (Hewlett Packard, Andover, PA) echocardiography system interfaced with a PreVue III™ (NovaMicrosonics, Mahwah, NJ) digitizing system. A 2.5 MHz transducer was utilized on each study. All images were obtained with the patient lying in a left lateral decubitus position on an Echo™ Bed Dual, (American Echo, Inc., Kansas City, MO). Each completed digital study was stored to floppy disc for later review and analysis.

The resulting digital display consisted of one 8-cell ciné-loop for each of the four views obtained for each patient (two 4C views - one with and one without the drop section opened, and two 2C views - one with and one without the drop section opened). Each ciné-loop was randomly displayed within a quad-screen format.

Patient demographic data and the time required to complete each study (i.e., with and without the drop section opened) was recorded for each patient. The ease/difficulty in obtaining each view as well as the sonographer comfort level and the patient comfort level were rated using a 5-point scale. Both the sonographer comfort and the patient comfort were rated on a 4-point scale. The

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ease/difficulty rating and the sonographer and patient comfort ratings were subsequently recorded for each patient.

Interpretation

The digital images from each patient were reviewed for image quality by three blinded observers of differing levels of expertise for image quality ranging from highly skilled to new at reading echocardiograms. Image quality was assessed using a pre-determined scale.

An image was considered excellent if it met the following criteria: the image was "lined up" so that the interventricular septum in the 4C view was in the center of the image and was oriented parallel to the sound source; the 2C view included all of the anterior and inferior walls; the endocardium was visualized (in both the 4C and 2C view); and the image was not foreshortened.

An image was considered good if it met the following criteria: the image was "lined up" so that the interventricular septum in the 4C view was in the center of the image and oriented parallel to the sound source; the 2C view included the anterior and inferior walls; the endocardium was difficult to see; and the image was not foreshortened.

An image was considered fair if it met the following criteria: all of the walls were visualized, even if the interventricular septum wasn't "lined up" in center of the image in the 4C view and was not oriented parallel to the sound source; the endocardium was not easily identified; and the image was slightly foreshortened.

An image was considered poor if it met the following criteria: the interventricular septum (4C) wasn't "lined up" in the center of the image and was not oriented parallel to the sound source; the endocardium was not easily identified; there was some dropout of information in either the lateral wall (4C) or the anterior wall (2C); the apex was not adequately visualized; and the images were foreshortened.

...the images obtained with the drop section opened were significantly better ($p<0.003$) than the images obtained without the use of a drop section...

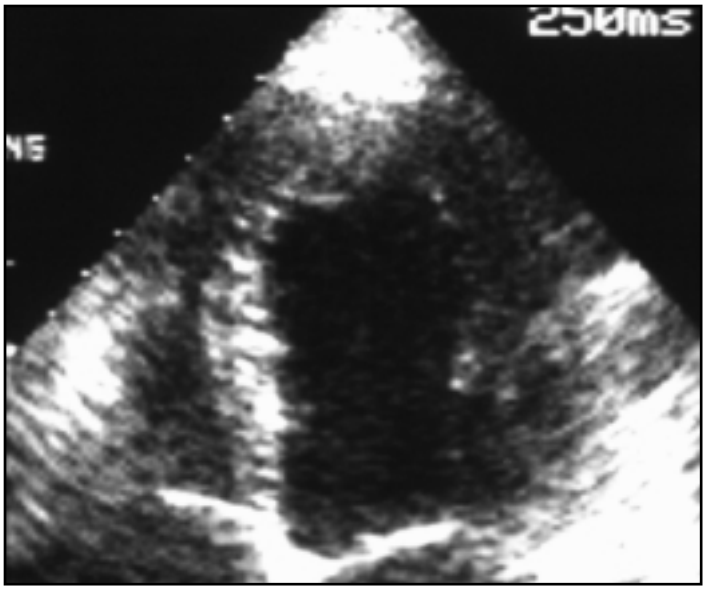
An image was considered technically difficult (TDS) if more than 50% of the walls were not seen; if no endocardium could be distinguished; if the apex wasn't visualized and/or if the image was foreshortened; if the image was generally too "fuzzy" for wall motion to be properly analyzed.

Any time an image was foreshortened, it could not be rated any better than fair and any time the 2C view included the aorta, it was rated as TDS.

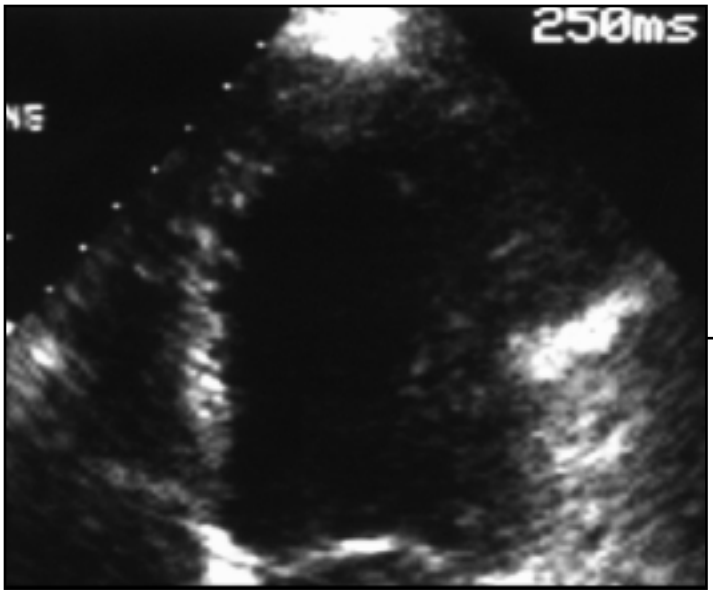
The observers first reviewed, compared and graded the images, and then a determination as to which of the two 4C images and 2C images were of higher quality was made. No difference in image quality also was noted.

Findings

When all of the images, as evaluated by all of the



with a drop section



without a drop section

observers are treated as a single group, the images obtained with the drop section opened were significantly better ($p<0.003$) than the images obtained without the use of a drop section (see Table 1). That is, in the patient population as a whole, apical image quality was substantially improved when the images were obtained utilizing the drop section. A single set of images is included (on the previous page) to show the type of improvement possible when a drop section is used.

It was also observed that the time to complete resting echo exams was significantly shortened ($p<0.001$), and that the sonographers considered studies utilizing a drop section significantly easier to perform ($p<0.001$). When the comfort of the sonographer and the patient were evaluated the sonographers showed a preference ($p<0.058$) for performing studies using a drop section, and the patients showed no preference either for or against a drop section. The overall findings of this study are summarized in Table 2.

The apical images from each of the patients were evaluated by three blinded observers of varying levels of expertise. The patient population was divided into three groups, by body mass index (BMI). Group one included 26 patients whose BMI was ≤ 24.9 kg/m^2, or those patients considered to be thin. Group two included 18 patients whose BMI was 24.9 - 28.5 kg/m^2, or those patients considered to be of average "fatness". Group three included 20 patients whose BMI was ≥ 28.6 kg/m^2, or those patients considered to be fat. Sonographers commented that the apical window was difficult to reach in one thin patient and one average patient, while the apical window was difficult to reach in 4 fat patients. A fourth group (n=16) was created by deleting the patients where it was difficult to reach the apical window from group three (n=20). Image quality was significantly improved ($p=0.05$) when utilizing the drop section on group one (thin patients); however no significant difference was seen on group two (average) or group three (fat patients). Image quality was significantly improved ($p=0.03$) when utilizing the drop section on the group four patients (fat). These results are summarized on Table 3.

...allows the right-handed sonographer to reach around the patient without twisting or otherwise contorting their body.

The patient population was then divided into two groups: those with chronic obstructive pulmonary disease (COPD) and/or dyspnea and those without COPD and/or dyspnea. Utilizing the drop section in those patients with COPD and/or dyspnea did not significantly impact image quality; however image quality was significantly improved ($p=0.003$) when utilizing the drop section on those patients without COPD and/or dyspnea.

DISCUSSION

Because interpreting physicians, regardless of their level of expertise, are called upon to provide useful diagnostic information from echocardiograms, image quality is a primary concern of transthoracic echocardiography. Image quality includes both how well the walls and other structures of the heart are visualized and how true the echocardiographic views are to the major and minor axis of the heart. In other words, if the heart structures are difficult to see and/or the images are off-axis, the confidence level for an accurate interpretation is lower than it would be if the structures were well visualized and the views were on-axis.

Several factors have generally been recognized to contribute to image quality when performing echocardiography. These include 1) sonographer knowledge and experience, 2) how well the sonographer utilizes various image controls, and 3) the ultrasound system being used. However, even the most knowledgeable and experienced sonographers with the best equipment routinely experience difficulty when obtaining images from "technically difficult" patient exams.

Traditionally, the blame for sub-optimal

TABLE 2

KEY FINDINGS

Drop Section Utilization	Statistical Significance
Apical image quality improved	$p < 0.003$
Time to complete study reduced	$p < 0.001$
Study easier to perform	$p < 0.001$
Sonographer Comfort	$p < 0.058$
Patient Preference	None

TABLE 3

IMAGE PREFERENCE

All Views By Body Size

IMAGE QUALITY	Slim Patients* (n=26) or 52 images				Average Patients* (n=18) or 36 images				Fat Patients* (n=20) or 40 images				Fat Patients * (n=16) or 32 images			
	Observer 1	Observer 2	Observer 3	Observer 4	Observer 1	Observer 2	Observer 3	Observer 4	Observer 1	Observer 2	Observer 3	Observer 4	Observer 1	Observer 2	Observer 3	Observer 4
	Number of Images (4-Chamber and 2-Chamber) Preferred															
Drop-section open better than drop-section closed	21	19	26	66	16	14	16	46	16	15	15	46	15	14	14	43
Equivalent	17	18	11	46	14	10	9	33	15	17	9	41	10	14	6	30
Drop-section closed better than drop-section open	14	15	15	44	6	12	11	29	9	8	16	33	7	4	12	23

*Images grouped by body mass index and preference of three blinded observers. Group 1 = Those patients whose body mass index was ≤24.90 kg/m^2 (slim). Group 2 = Those patients whose body mass index was 24.91 - 28.55kg/m^2 (average). Group 3 = Those patients whose body mass index was >28.56 kg/m^2 (fat). Group 4 = Those patients in Group 3 minus 4 patients that the right handed sonographers could not reach around due to the patient size.

imaging has been placed on the sonographer, the current ultrasound technology in use, the body habitus and size of the patient and/or the presence of lung disease. Additional factors influencing image quality are only recently being recognized include access to optimal imaging windows and sonographer comfort.

One method that has proven effective in improving image quality in technically challenging patients is placing the patient in varying positions in order to locate the best window. Generally, when a patient is positioned in a steep left lateral decubitus position, the heart moves away from the lung and closer to the chest wall, improving image quality. Frequently, however, positioning a patient in the steep left lateral decubitus position prevents access to the true apex resulting in off-axis images.

Recent studies show that up to 80% of cardiac sonographers[3] and 81% of all sonographers[4] scan in pain. The pain (occupational in nature) is caused not only by repetitive motion, but also by the repeated abnormal body positions that many sonographers assume in order to reach the best ultrasound window. Although research has not been completed regarding sonographer pain and image quality, it has been postulated that a relationship between the two exists. Depending on the degree of pain and the individual, generally a sonographer who experiences pain while scanning a difficult patient is unable to exhibit the patience and take the time required to obtain the best possible image.

In response to these problems, ultrasound manufacturers continually strive to incorporate new technology. While dramatic technical advances have been made, very little has been done to address imaging difficulties due to individual patient factors and sonographer pain. Clearly, these imaging problems can not be addressed by ultrasound technology alone.

This study shows that utilizing a specialized table with a drop section at the patient's apical window significantly improves apical access, apical 2 chamber and apical 4 chamber images. However, the image problems associated with lung disease is not affected by utilizing the drop

section. Additionally, we found that in the four patients with a very high body mass index, the right-handed sonographer was unable to reach around the patient in order to obtain images from the apex, even when utilizing the drop section. When we eliminated these patients from the group, we found that the image quality improved by using the drop section of the Echo™ Bed. Therefore, we postulate that if the sonographer imaged from the patient's left side, image quality in these morbidly obese patients would improve when utilizing the drop section since improved access to the true apex would be available to the sonographer.

The issue of sonographer pain was studied indirectly by utilizing the Echo™ Bed with Dual Drop Sections. The Dual Echo™ Bed has a drop section on both sides of the table, one at the patient's apical area and the other on the patient's right side (for the sonographer). The sonographer drop section allows the right-handed sonographer to position their body perpendicular to the patient's body. This position allows the right-handed sonographer to reach around the patient without twisting or otherwise contorting their body. As noted earlier, there was a trend for the sonographer to be more comfortable when utilizing the patient drop section and the sonographer drop section. We postulate that this trend is due in part to utilizing the dual drop section and recognize that further studies are needed regarding the scope of sonographer pain and possible solutions to the problem.

CONCLUSIONS

This study reinforces the recommendation of the American Society of Echocardiography standards committee for utilizing an exam surface with an excavation at the point where the apex impulse is located. Image quality is indeed improved as a result of improving access to the true apical window.

The study also demonstrated a clear benefit for the sonographer regarding ease of examination, sonographer comfort while performing the examination, and a decrease in the length of time required to complete the examination.

Benefits to the patient are uncompromised patient comfort while utilizing the drop section and a shortened examination time.

...clear benefit for the sonographer regarding ease of examination, sonographer comfort while performing the examination...

Patient outcomes are improved as a result of technically better images, the potential for increased sonographer productivity exists, and sonographer injuries resulting in a loss of sonographer work time should be reduced. Additional studies are needed regarding utilizing other features of a specialized examination surface and the impact on sonographer work related injuries, and to determine how the results of this study might impact other procedures including stress echocardiography.

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