

Musculoskeletal Disorders

Case studies involving cardiac echosonographers

By Marian Swinker and Stephen B. Randall

WORK-RELATED MUSCULOSKELETAL disorders have been reported among echosonographers worldwide. Scanning requires the repeated application of manual force and maintenance of prolonged postures. In the study described in this article, the use of force and prolonged postures in the neck and upper extremities during scanning were observed risk factors; equipment modifications were instituted in response. In addition to the physical factors, work practices and administrative controls were reviewed and a work-load pattern was recognized and addressed.

Background: The Concerns

Various noninvasive medical imaging techniques have emerged in recent decades. Diagnostic ultrasound procedures are used in a variety of cardiac, vascular and obstetrical applications. As technology and diagnostic capabilities have improved, the numbers and types of sonographic studies performed have multiplied.

At the same time, professional sonographers have raised concerns about ergonomic hazards in their work. Surveys reveal a prevalence of current and/or past pain involving the neck, upper extremity and hand among those performing studies lasting longer than 45 minutes (Vanderpool, et al 607). In a survey of Alberta sonographers, 88.5 percent reported symptoms attributed to work (Wihlidahl and Kumar 211). In a survey of the membership of the American Registry of Diagnostic Medical Sonographers, respondents reported an average workday of 8.3 hours with six to eight hours spent in active scanning (Pike, et al 221). Echocardiograms were the most frequently performed procedure; echocardiographers reported performing an average of 22.5 scans per week, spending 35.9 minutes per scan. Activities significantly correlated with pain

included sustained or repeated twisting of the neck and trunk, and performing mobile studies.

An American Society of Echocardiography (ASE) survey found an 80-percent prevalence of back/neck and shoulder pain among respondents, which was associated with performing more than 100 scans per month or spending more than 25 minutes per scan (Smith, et al 361). Working conditions that involve prolonged standing and maintaining an uncomfortable position have been recognized as risk factors for musculoskeletal disorders (MSDs) in healthcare workers (Estryng-Behar, et al 48). A survey of sonographers in Great Britain reported a significant correlation between the intensity of back pain during scanning and total weekly scanning time, with increased pain intensity reported when scanning more than 30 hours per week (Solanki, et al 24). Respondents working more than 11 years had three times greater risk for back pain than those with less than two years' experience.

In most studies, being female and lacking control of workflow are associated with symptoms; however, a survey in Italy, where most sonography is performed by physicians, found that one-third had current back and/or neck pain and two-thirds experienced such pain in the past (Magnavita, et al 983). This population was 73.5 percent male and the majority scanned only part-time. This survey also found increasing age (over 40) and duration of full-time ultrasound work over four years to be associated with musculoskeletal complaints. Other studies have not identified age as a risk factor (Wihlidahl and Kumar 210). Other surveys have found work in ultrasound to be associated with an increased rate of reported symptoms after five years. Fewer symptoms were reported by sonographers performing fewer than 40 scans per week. Most symptomatic persons (86 percent) reported having less than three 10-minute breaks per day (Necas 230).

Methods: Case Reports & Investigation

Over a 12-month period, three full-time echosonographers employed in Cardiac Graphics at a 730-bed

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Case A

A 33-year-old female, who had worked as a cardiac sonographer for seven years, presented with left shoulder and neck pain, and muscle contraction headaches aggravated by fixed postures during scanning. Her neck and upper extremity range of motion were limited, and she was treated with analgesics and work modification. Physical therapy rapidly corrected cervical and thoracic facet joint dysfunctions, but she continued to experience persistent trapezius and rhomboid spasms with palpable thickening and nodularity in these muscles. Over a period of several months, these responded to myofascial release (a physical therapy technique used to treat patients with soft-tissue problems) and neuromuscular re-education.

Initially, her workday was limited to six hours of scanning and two hours of clerical work; eventually, she was able to tolerate clinical activities for eight hours per day. Performing transthoracic echocardiograms was noted to be the most pain-provoking activity; during such procedures, she maintained a prolonged static posture, holding the transducer against the patient's chest and turning her neck to observe the monitor. In her procedure log, the duration of a transthoracic echocardiogram varied from 15 to 80 minutes, although on one occasion 170 minutes of scan time were required to obtain a satisfactory study of a difficult patient. In general, obese patients weighing more than 350 pounds presented the greatest difficulty.

While she was able to perform other procedures without exacerbating the shoulder and neck pain, transthoracic procedures remained problematic. Eventually, this technician was able to perform seven to eight procedures per day, but could not advance beyond this without recurrence of muscle symptoms. She was discharged from care after 12 months of treatment with a permanent preventive restriction of performing no more than seven to eight transthoracic studies per day, but with no restriction on performing other types of studies.

Case B

A 36-year-old female had been a sonographer for 18 years. She presented with left arm and shoulder pain due to rotator cuff tendonitis. She responded well to steroid injection and was released to full duty. Case B was ambidextrous and did not require formal work restrictions as she used her right hand to hold the transducer until the left shoulder tendonitis improved. She continues to alternate hands during work.

Case C

This 40-year-old female, who had been a sonographer for 11 years, presented with left neck, shoulder and arm discomfort. She was diagnosed with left trapezius myofascial pain and was treated with physical therapy and work modification with a positive response. As she improved clinically, work restrictions were liberalized. She was eventually able to perform eight transthoracic ultrasound procedures per day on a regular basis with no restrictions for other types of studies. On some days, she was able to tolerate one or two additional transthoracic echoes, especially when she had performed few prolonged or difficult studies. This employee was released from care with a permanent preventive restriction of performing no more than eight transthoracic ultrasounds per day, with a provision that she may perform an additional one or two per day as tolerated.

A fourth sonographer was added to the department during the year when the three cases presented were treated. This young male, newly trained and working in his first sonography position, has not reported any problems. This fourth position had been planned prior to the occurrence of this "cluster" of cases in response to an increased demand for services.



teaching and referral hospital presented to the Occupational Health Service with neck, shoulder or upper extremity pain. They were treated medically on-site. The case reports (left) summarize their medical histories and treatment courses. Cardiac Graphics performs transthoracic echocardiograms, transesophageal echocardiograms, stress echocardiograms and ambulatory echocardiograms. Assignments are made on a rotating basis, until all work requests are completed each day; therefore, a sonographer's workday is comprised of whatever combination of procedures is needed.

This temporal "clustering" of cases among experienced, long-term employees resulted in a review of the facility's ergonomic conditions and work practices. (The remainder of this article deals with echosonographers, but the generic term "sonographer" may be used as well.)

Ergonomic Risk Factor Analysis

A formal ergonomic risk factor analysis identified several issues that could contribute to the development or exacerbation of existing work-related MSDs. The sonographer's right hand actively manipulated equipment controls on the echo console, with

Photo 1: Echosonographer with risk of work-related MSD due to extreme hand/wrist postures, static muscle loading and utilization of a pinch grip can be seen with respect to the left upper extremity.

Photo 2a, before (above, right): Performing a sonograph with the right hand, the echosonographer twists head and neck, bends spine, and statically loads the right arm while obtaining and holding an image. This posture may be held for several minutes at a stretch and may result in muscle fatigue.



Photo 2b, after: The operator repositions the patient and equipment relative to herself. The improved proximity promotes more neutral postures of the head and neck, eliminates medial bending of the trunk and allows the echosonographer to rest her right forearm while maneuvering the transducer in order to reduce static muscle loading.



the wrist in its mid-range of motion, making 15 to 30 motions per minute. Right-hand activities varied with the study performed and patient characteristics (weight, body build, level of cooperation). Cumulative exposure to repetitive motion in the right hand occurred for longer than four hours per day. Intermittently, the technician reached above shoulder level with the right hand to adjust or activate console controls when working from a seated position. Cumulative reaching above shoulder level occurred for one to four hours per day.

The left hand held the transducer in a static position, forcefully applying it to the patient's chest. The transducer was usually grasped in a power grip, with fingers wrapped around it, pulling it into the palm. Less often, the pads of the fingertips held the transducer in a pinch grip. Cumulative static gripping of the transducer exceeded four hours a day. The force of the work of the left hand was characterized as "somewhat hard" to "hard" depending on a patient's shape, size and level of cooperation. The

left wrist was repeatedly or persistently flexed and extended, approaching the extremes of the wrist range of motion. Ulnar and radial wrist deviation was less frequent and not as extreme.

The technician frequently pushed and twisted her left forearm to reposition the transducer on the patient and improve the screen image; this involved abducting the left shoulder and holding the newly acquired image for up to five minutes while freezing the left hand, arm and shoulder in a particular posture. The left upper extremity forces and postures described exceeded a duration of four hours per day. The technician also bent and twisted her head, neck and trunk as she switched between two disparate visual targets to monitor the left- and right-hand activities during the study. Cumulative exposure to bending and twisting the neck exceeded four hours per day.

Echosonographers are exposed to other hazards during manual materials handling tasks such as transferring or positioning the patient for the study. These tasks may exceed 50 pounds of force in lifting, pushing or pulling, but their total duration does not exceed one hour per day. Approximately half of all studies are performed within various hospital units, which requires the technician to push the echo cart from the lab to the patient's room. Push/pull tests were conducted with the carts rolling over carpeted and linoleum flooring. Maximum breaking force was 47 pounds on carpet, with an average breaking force of 34 pounds and average sustaining force of eight pounds. On linoleum, maximum breaking force was 26 pounds, average breaking force was 19 pounds and sustaining force was five pounds. Cumulative daily exposure to pushing/pulling was one to four hours.

Ergonomic Interventions

Due to concerns about the hand/tool interface of the transducer, the researchers contacted the manufacturer of the sonography equipment to discuss its design. The wired leads between transducer and the central processing unit required that continuous force be maintained to overcome the directional resistance of the leads and position the transducer on the patient. The manufacturer reported that newer transducers require less force to obtain a clear image and are smaller and lighter in weight than those in use at this institution. The manufacturer had no plans to motorize any of the echo cart product line, but stated that mobility improvements had been made.

Closed-cell neoprene grips were installed over the cart handles to improve the manual interface. The padding softens the interface and reduces the potential for hand trauma during pushing and while overcoming the cart's breaking resistance. Spreading the push/pull forces over a greater, softer area should also reduce the potential for soft-tissue contact stress. Abductor pillows were implemented to support the left forearm during echo studies and to reduce static muscle loading of the left arm. Closed-cell foam tool grips were installed on the transducers to increase the diameter of the tool and the contact surface and to reduce the force required to grasp it. Increasing the diameter of the transducer to about 1.25 inches also



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improved muscle efficiency during manipulation by allowing the operator to use larger muscle groups.

Administrative Interventions

A review of transthoracic echocardiograms performed during the prior year revealed that each technician performed an average of 6.7 such studies per day. In conducting this analysis, an effective presence of 2.5 full-time sonographers was assumed to account for vacations and other leave among the three technicians employed at the time. Marked variation in workload was evident by day of the week, with a high demand for studies at the beginning of the week (12 or more per technician on Mondays), declining to five or six by week's end. Cardiac Graphics operates on a five-day work week, with one technician "on call" for weekend emergencies. This resulted in an accumulation of nonemergency requests over the weekend and a predictable backlog of cases each Monday. After recognizing this pattern, a part-time sonographer was hired to work two days at the beginning of each week. The long-planned fourth sonographer was added as well, reducing the average number of studies performed by each sonographer and, thus, overall ergonomic exposures.

The sonographers also received biomechanics training that covered static standing, pushing and pulling tasks, patient handling (turning, positioning and lateral transfers) and positioning of the echo cart relative to the patient. The goal was to improve body segment alignment of the head, neck and back, and hand, wrist and forearm, and to reduce the horizontal work range during studies. Bed and stretcher adjustment was emphasized as a way to improve the vertical work range. Specific strategies to reduce static muscle loading were also discussed. An exercise physiologist instructed the technicians to perform specific stretches during the workday in order to reduce accumulated discomfort or fatigue.

Results

The three sonographers were eventually able to return to work and remain pain-free. However, only



Photo 3a, before (above, left): The echosonographer flexes and extends her wrist when obtaining a quality image. Once an image is found, the technician holds her left hand in place, resulting in static muscle loading.

Photo 3b, after: The echosonographer uses an abduction pillow to support the left forearm while finding and holding the image. This helps to significantly reduce the cumulative effects associated with a sustained posture.

one was able to do so without limiting the number of transthoracic studies performed; this sonographer was ambidextrous and could scan equally well with either hand, effectively dividing the workload between each extremity. The other two could perform only seven to eight transthoracic echoes per day on a regular basis, although this allowed them to perform essential job functions and remain productive. Performance of transesophageal or stress echocardiograms was not observed to be associated with work-related musculoskeletal pain and provided useful variation in work postures and extremity positions for the sonographers during and after treatment.

Discussion

ASE has promulgated guidelines regarding the minimum number of echocardiographic procedures that should be performed in order to maintain competence: 50 transthoracic procedures per month or eight stress echoes (ASE "Recommendations" S-10); however, no formal guidelines are available regarding the maximum number of studies that should be performed in order to prevent work-related MSDs. According to ASE guidelines, a complete cardiac

Photo 4a (before) and 4b (after): A foam grip was installed over the existing handle in order to provide a soft and compressible hand/handle interface when transporting the unit for portable studies.



echo with Doppler will likely take 45 to 60 minutes to perform while a limited study will last 30 to 45 minutes. If the average duration of a study is 45 minutes, a sonographer could perform 10 studies in an eight-hour day, but would have no time for breaks, paperwork, travel or preparation of equipment between patients.

Although actual work practices vary, a recent survey found that 53 percent of ASE membership performed fewer than five studies per day, 42 percent performed up to 10 and only five percent performed more than 10 per day (ASE "Results" 2); thus, 10 studies per day represents the 95th percentile of performance. Ergonomic modifications (as described) can mitigate the risk of work-related MSDs when using existing equipment. Preventive measures such as education on body mechanics and use of stretch breaks may also be helpful, although strong evidence supporting their efficacy is not available (Harris 1-12).

Based on the experience at this institution, it would appear that eight to 10 transthoracic echoes per day should be considered a maximum, based on both time factors and physical factors. Ten studies per day may represent the upper limit of long-term physical tolerance. Although a technician can perform 10 studies in an eight-hour day, such a schedule may not allow time for appropriate rest breaks or for work activities other than hands-on scanning. This conclusion is roughly consistent with the ASE guidelines for average study duration. Clinical observations suggest that the optimal maximum workload to prevent injury or the recurrence of symptoms may be slightly lower—seven to eight per day; this rate would allow for stretching breaks, rest breaks or non-scanning activities. Of note, the scanning method employed here—using the left hand for the transducer—has been suggested to lower risk of back pain compared to a right-handed scanning technique (Solanki 27). Other scanning techniques may be less-well-tolerated on a physical basis.

Conclusion

Performing cardiac ultrasound—especially transthoracic echocardiograms—can result in static postures and loads and subsequent work-related MSDs. Ergonomic factors and work practices, including expected productivity levels, can contribute to these problems. The interventions described for improving the ergonomics of scanning and adjusting work loads may help to prevent or relieve these problems. This experience raises questions about the maximum

long-term work tolerance of sonographers and the optimal number of scans that can be performed per day to maximize productivity and minimize injury risks. These observations are suggestive but require confirmation in other institutions or with additional subjects in controlled studies. ■

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