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EDITORIAL

Standards for Assurance of Minimum Entry-Level Competence for the Diagnostic Ultrasound Professional

The document presented below is the result of a 14-month collaborative effort between the Society of Diagnostic Medical Sonography (SDMS) and the Society of Vascular Technology (SVT). During the drafting of this document, multiple persons were involved in the evolution of these standards including legal council, educators, clinical sonographers of all specialties, and vascular technologists. The purpose of the document is to establish the minimum entry-level educational and clinical standards to enter the field of diagnostic ultrasound for all subspecialties. This document will be used in tandem with the Scope of Practice for the Diagnostic Ultrasound Professional to reinforce the parameters of our profession with educational institutions, establishments of clinical practice, and legislative and regulatory agencies. It is anticipated this document will be periodically revised as our profession continues to change. The endorsement from other ultrasound organizations will be sought, as was done with the Scope of Practice.

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PREAMBLE

The purpose of this document is to define the qualifications necessary to become certified and practice as a Diagnostic Ultrasound Professional, which includes Diagnostic Cardiac Sonographers,
Diagnostic Medical Sonographers, and Vascular Technologists. It is expected that this document will change as the needs of the profession evolve in the future. The minimum standards established in this document are to be used in conjunction with the Scope of Practice for the Diagnostic Ultrasound Professional and represent the entry-level threshold for persons to enter the field of diagnostic ultrasound. The Scope of Practice of the Diagnostic Ultrasound Professional includes those procedures, acts, and processes permitted by law for which the individual has received education and clinical experience and in which he or she has demonstrated competency. The field of diagnostic medical ultrasound includes the specialties of Vascular Technology, which encompasses vascular sonology and physiologic testing; Diagnostic Cardiac Sonology, with subspecialties in adult echocardiography and pediatric echocardiography; and Diagnostic Medical Sonology, with subspecialties in breast sonology, general medicine sonology, neurosonology, obstetrics and gynecology, and ophthalmology.

Standards, as described in the Scope of Practice, are designed to reflect behavior and performance levels expected in clinical practice. Clinical practice standards and personnel certification are paramount to ensure quality ultrasound examinations and maximum patient protection.

It is clear that a wide range of both academic and clinical training is prerequisite in order for individuals to meet these standards. The increasing sophistication of ultrasound technologies coupled with the current environment and the level of practice required of the Diagnostic Ultrasound Professional renders on-the-job training inadequate as an educational pathway. While no mechanism exists to unquestionably assure technical competence, national board certification is the standard of practice in ultrasound. The purpose of certification is to provide assurance to the public that persons practicing diagnostic ultrasound have completed specified didactic course work, clinical experience, and possess the knowledge, skills, and experience to deliver high-quality patient care.

**DESCRIPTION OF THE PROFESSION**

Diagnostic Ultrasound Professionals use a varied intellect that requires advanced education specific to the multiple specialties of diagnostic ultrasound. Individuals exercise independent judgment in the practice of diagnostic ultrasound, making the outcome of the examination unique to each patient and not a routine process.

According to the Scope of Practice, Diagnostic Ultrasound Professionals

- perform patient assessments;
- acquire and analyze data obtained using ultrasound and related diagnostic technologies;
- provide a summary of findings to the physician to aid in patient diagnosis and management;
- use independent judgment and systematic problem-solving methods to produce high-quality diagnostic information and optimize patient care.

Competency in performing these critical patient care functions requires advanced education specific to the multiple specialties of diagnostic ultrasound.

**Minimum Standards for the Profession**

**I. DIAGNOSTIC ULTRASOUND MINIMUM ACADEMIC STANDARDS**

These represent the minimum educational requirements identified as necessary for an individual to enter the Diagnostic Ultrasound Profession. The educational structure for the Diagnostic Ultrasound Professional has been evolving over the past 2 decades. It is anticipated that all persons will enter the field with a minimum of an associate degree in ultrasound, other allied health or life sciences and have, at a minimum, the clinical requirements outlined in Section II of this document by 2006; a bachelor of science degree in allied health or life sciences and have, at a minimum, the clinical requirements outlined in Section II of this document by 2008; and a bachelor of science degree in diagnostic ultrasound or one of its specialties by 2012.

**Standard: Educational Program Accreditation**

- All established ultrasound educational programs in the United States must be accredited by the Commission on Accreditation of Allied Health Education Programs (CAAHEP) by 2006.
- All newly established ultrasound educational programs in the United States must be accredited by the CAAHEP within 5 years of initiation.
Standards for the accreditation of an educational program for the Diagnostic Ultrasound Professional should be in conjunction with Section I (Requirements for Accreditation) and III (Maintaining and Administering Accreditation) of the CAAHEP Standards and Guidelines for an Accredited Educational Program.5,6

Multispecialty programs must ensure that all requisite standards for each specialty are met. In the case of diverse specialties, this may require an additional year of didactic training.

Standard: Prerequisite Education per CAAHEP Standards Section IC1 (Admission Policies and Procedures)

Standard: Curriculum per CAAHEP Standards Section IIB

The entry-level curriculum for diagnostic ultrasound provides the foundation of knowledge that will be used before a student enters into clinical training.

Standard: Required Competencies Common to Each Learning Concentration (Section IIC).

• Curriculum should be reviewed to ensure currency of content every 2 years.
• Competencies should be outcomes based.
• Code of Ethics as created by the Sonography Coalition should be adopted.
• Code of Professional Conduct should be established.
• Professional society participation should be promoted.

A. Cardiac Sonology Learning Concentration5,6

• Competencies specific to the cardiac sonology learning concentration (Section IIE)

B. Vascular Technology Learning Concentration5,7

Competencies specific to the vascular technology learning concentration (Section II F)

C. General Medicine Sonology Learning Concentration5

• Competencies specific to the general medicine learning concentration (Sections IID1-3 and 8)

D. Obstetrics and Gynecology Learning Concentration

• Competencies specific to obstetrics and gynecology learning concentration (Sections IID4-8)

E. Neurosonology Learning Concentration8

F. Breast Sonology Learning Concentration

G. Ophthalmology Learning Concentration

II. DIAGNOSTIC ULTRASOUND CLINICAL EDUCATION STANDARDS

Clinical education should be an adjunct to didactic education. The cognitive and psychomotor skills necessary to competently perform any ultrasound specialty require extensive clinical experience. A significant component of any ultrasound educational program is clinical practice. Exposure to a high volume and variance of sonographic procedures is necessary, which permits exposure to a variety of pathologic conditions. Clinical education should be specific for each specialty practiced. Clinical education must be accomplished under the direct supervision of a certified Diagnostic Medical Sonographer, Diagnostic Cardiac Sonographer, or Vascular Technologist experienced in the specialty of clinical focus. The cardiac concentration requires a minimum of 800 procedures annually in the lab of clinical internship. The vascular concentration requires a minimum of 1000 procedures annually in the lab of clinical internship, including both sonographic and indirect physiologic procedures. Multispecialty programs require a minimum of 1500 clinical procedures annually in the lab of clinical internship. This allows for overlap of skill development in clinical education that occurs in the first 4 to 6 months for any single learning concentration.

III. DIAGNOSTIC ULTRASOUND MINIMUM CERTIFICATION STANDARDS

Definition of Certification: Successful completion of a national objective written certification examination that has been independently validated and meets the standards of the National Commission for Certifying Agencies (see Appendix, Part III)
Standard: National Board Certification Is Mandatory to Ensure

- Public protection
- Quality of care

The purpose of certification is to provide assurance to the public that the Diagnostic Ultrasound Professional has completed specified didactic courses, and clinical experience, and possesses the knowledge, skills, and experience to deliver high-quality patient care. Additionally, the provider is able to appropriately evaluate normal and abnormal anatomy with ultrasound images or related technologies, assess patient clinical history, optimize established examination procedures, and communicate findings with physicians.

Competence in one specialty can not, and should not, be construed as competence in any other. Certification in each area of clinical work is required.

Standard: Postcertification Continuing Education

Diagnostic Ultrasound Professionals must adhere to the specific continuing education and/or recertification guidelines as mandated by the organization from which the certification is obtained. Due to rapid advancement in ultrasound practice, the need for continually staying abreast of evolving standards, techniques, and technology is imperative. Without continuing education and exposure to knowledge beyond the undergraduate experience, no professional can stay current in information and skills necessary to provide high-quality care to patients. Ongoing certification is based on a standard that includes successful attainment of continuing professional education and experience with new technologies and modalities. In order to remain current with the development of the field, persons who have passed their certification examinations for ultrasound must demonstrate completion of at least 30 hours of qualified CME every 3 years and a minimum of 15 hours in each specialty in which they are certified.

Standard: Types of Continuing Education

Standards of practice will continue to evolve as technology advances and new procedures and techniques are developed. Ongoing education of current practice is necessary to remain abreast of these changes. Participation in research, scientific publication, and completion of advanced degrees may also be a means of staying current with the profession and/or contributing to continuing professional development.

Standard: Institutional Orientation

Current practice dictates persons practicing diagnostic medical ultrasound assume significant responsibility for obtaining a complete and accurate examination, pertinent to each patient’s condition. Institutional and laboratory-specific protocols and procedures cannot be taught prior to being employed at an institution. Every employer of ultrasound professionals must provide comprehensive institutional orientation about its philosophy, standards and methods of practice, the range of patients to be encountered, and all protocols and procedures. The length of this orientation will vary depending on many factors, including the size of the institution, but would generally be a minimum of 6 months.

Standard: Continuing Professional Development

Participation in research, scientific publication, and completion of advanced degrees in order to stay current with the profession is strongly encouraged and supported by the field. However, clinically relevant continuing education is still mandatory.

Appendix

I. Commission on Accreditation of Allied Health Education Programs (CAAHEP), Standards and Guidelines for an Accredited Education Program for the Diagnostic Medical Sonographer, www.caahep.org/standards/dms-st.htm

II. CAAHEP, Standards and Guidelines for an Accredited Program for the Cardiovascular Technologist, www.caahep.org/standards/cvt-st.htm

Notes

2. The minimum educational and clinical standards within this document are supported by the precedent set in the U.S. district court for the eastern district of Pennsylvania (Civil Action No. 98-CV-4076).
5. SVT Guidelines for Educational Programs in Vascular Technology.
6. Because the standards for the learning concentrations related to neurosonology, breast sonology, and ophthalmology have not been created by the CAAHEP, the SDMS and SVT will jointly approach the CAAHEP to request creation of these standards. The SDMS and SVT seek endorsement from the American Society of Ophthalmology.
Sonographers and Occupational Overuse Syndrome: Cause, Effect, and Solutions

CATHY JAKES, BS

Due to remarkable advances in technology, sonographers today are working more efficiently, serving considerably more patients per day. One would assume this to be a benefit, when in fact a new problem has surfaced directly related to these achievements. Ultrasound exams require a peculiar type of muscular effort on the part of the sonographer. Tiny muscle tears that are the result of repetitive manipulations of the transducer, without adequate rest between exams, progress to more extensive muscular damage. The muscular damage can lead to career-ending injury. The purpose of this article is to examine the causes of overuse injuries brought on by repetitive muscle stresses associated with the performance of ultrasound exams and to discuss the changes necessary to combat this ergonomic crisis. Change is difficult, but with the combined efforts of equipment designers, employers, and sonographers, change is possible and an auspicious future can be envisioned.

Key words: ultrasound, sonographer, overuse, musculoskeletal, injury, ergonomics

The technology of ultrasound is improving exponentially. The advantages of real time plus improved imaging capabilities of ultrasound have made ultrasound the diagnostic tool of choice for detecting a variety of medical conditions. It is an exciting field to be in, and one with growing opportunity. A student of ultrasound has much to look forward to.

Unfortunately, there is a down side to these advances. The improved technology not only provides higher quality images but also faster processing of those images. This means more time spent scanning patients and less time in between patients. Although seemingly advantageous, this is ultimately detrimental to both the employer and the sonographer. More scanning time means more time in damaging activity, and less time between patients means less time for damaged muscle fibers to repair. Eventually, the sonographer misses work due to work-related injury,
which has a dramatic impact on the sonographer, the employer, and the quality of care available to patients.

Eighty percent of sonographers are working in pain; 40% label their pain as severe, and 20% have lost their careers due to this insidious process. Unfortunately, the incidence of overuse injuries in the profession is increasing.\(^1\,^3\,^4\) The purpose of this article is to examine the causes and physiological processes of overuse injuries brought on by repetitive muscle stresses associated with the performance of ultrasound exams, and to discuss the changes necessary to combat this ergonomic crisis. Solutions and preventative measures have been offered, but it will take the combined cooperation of equipment manufacturers, employers, and sonographers to implement those solutions.

**Causes of Overuse Injury in Sonographers**

There is a tapestry of factors (involving both the sonographer and the workplace ergonomics) that, in combination and over time, lead to musculoskeletal injury. Numerous researchers\(^2\,^3\,^5\,^6\) agree on the following causes:

1. Minute movements of the transducer (the instrument held against the patient’s skin during the exam) and gripping the transducer tightly cause insult to the small muscle fibers of the fingers, hand, and forearm.
2. Twisting and bending the wrist while applying pressure against the patient’s skin exacerbates the strain in the wrist.
3. Holding the elbow away from the body (shoulder abduction) while pressing against the skin for a sustained period of time compromises the muscles of the shoulder joint, neck, and back. According to Gregory, “The arm should not be abducted more than 20 degrees and ideally no more than 8 degrees. Sonographers nearly always exceed this angle of abduction.”\(^3\,^p(3)\)
4. Performing these muscular activities in a compromised posture, such as leaning over the patient and twisting the torso and neck to see the monitor, leads to back and neck strain.
5. Poor workplace ergonomics (height of system keyboard, height and direction of monitor, sonographer’s chair height, exam table height and width, transducer shape and size, and improper room lighting) contribute significantly to forcing sonographers into compromising positions while performing exams.

6. Increased number of exams and less time between exams leads to the slow progressive process of muscle strain referred to as overuse injury.
7. Height, age, and gender of the sonographer as they relate to shoulder abduction and muscle strength, respectively.

The muscular stresses and postural compromises provoked by a sonographer during a typical exam result in discomfort throughout all parts of the body. However, the majority of insult and pain is located above the waist as depicted in Figure 1.\(^5\)

Because ultrasound is, for many, a second or third career, currently 80% of sonographers are in their 30s and 40s. As muscles age, they are more prone to injury. Muscle fibers in a younger person are stronger and can withstand longer and more forceful stresses than those of an older person. This is not to imply that younger sonographers will not eventually be afflicted with
occupational overuse injuries, just that it may take a little longer. The benefits of strength training to increase muscle strength will be discussed later.

Reflecting on why women tend to experience more injuries than men, Vanderpool et al explained, “A stronger person may be able to hold the ultrasound transducer against the patient with less perceivable hand grip pressure than a weaker person.”

Another factor contributing to the problem of overuse injury in the ultrasound profession is the typical nature, or personality, of most sonographers. It has been my observation as a student of diagnostic ultrasound that sonographers are more concerned with serving the patient than they are with their own well-being. I have heard sonographers refer to work-related injury as just part of the job, something you endure because you love your work.

But testimonies from those who have lost their jobs due to work-related injury exposes the destructive nature of such devotion. The testimony of Susan L. Murphey, who worked 18 years as a sonographer, reveals some of the brutal realities of the current profession:

The practice of medicine has changed dramatically, too. The focus has shifted to issues concerning reimbursement, increased productivity and minimizing expenses. . . . Many recommendations were made to improve the ergonomic situation. . . . Instead, managers were pressured to increase the number of scanned. . . . As a result, our patient volumes went up, and our rest breaks between exams went down. Sonographers were now increasing the time spent in positions of postural dysfunction with little or no rest break available throughout the day.

Susan shared that these work-related injuries became so bad that she was unable to perform simple daily tasks such as laundry, cooking, and cleaning. The fear of losing her job was compounded with the fear of losing her ability to care for her family.

Another woman who lost her career to overuse work-related injury had a testimony similar to Susan’s. This woman, who asked to remain anonymous, felt compelled to share her experience for the purpose of helping other sonographers avoid the same fate: “I loved being a sonographer; I am so very sad to have lost something that I loved so deeply. . . . My physician has told me that these conditions are the permanent result of attempting to compensate [for] the pain, rotator cuff tear and the impingement that I experienced.” Similar to Murphey’s testimony, she reveals, “We often scanned 10 to 12 hours a day without breaks or lunch.” And, like Susan, this woman grieved not only the loss of her job but also the loss of valued family activities: “Even the gentle tug of my grandchildren’s hand was very painful.”

**Physiology and Symptoms: The Progressive Nature of Overuse Injury**

The type of injury that sonographers experience does not happen after one day or one week of work. It is the result of the accumulation of small, repetitive stresses on muscle fibers over time. When repetitive low-level muscle strain is sustained beyond a muscle’s capability, damage occurs. The initial damage may go unnoticed, producing no symptoms. These small muscle fiber tears will heal if given adequate rest time. But small muscle fiber tears, in the absence of adequate rest time, progress to larger groups of fibers being injured. These larger insults to the muscle require longer periods of rest to heal. If not given the required rest time, more serious injuries are incurred.

Another physiologic response to repetitive motion and cumulative trauma is obstruction of venous return, swelling, and compression and demyelination of the nerves supplying the muscles.

Repetitive strain injury will be felt by the sonographer in a variety of ways. Recall that the original insult will most likely not present noticeable symptoms. But, as time passes, the following symptoms are felt: tingling, numbness, shooting sensations, weakness, itching and burning sensations, clumsiness of fingers, swelling, and changes in muscle bulk. Pain is felt in the neck, back, arms, hands, and fingers, as well as shoulder, elbow, and wrist joints. Reduced mobility, freezing of joints, and, eventually, total loss of function are the end stages of this progression.

The fast pace and multiple exams performed daily by the sonographer, plus the “add ons” being squeezed into an already heavy schedule, is a recipe for disaster. If this pace is allowed to continue, the absolute result is severe debilitating pain that will incapacitate the most valued players on the sonographic team.

The industry is losing the most qualified sonographers to this occupational overuse syndrome. The new sonographers miss diseased processes that
the experienced eye can detect. Losing valued
sonographers is a price the health care industry should
not be willing to pay. Solutions have been offered.
Unfortunately, only some are aggressively imple-
menting those solutions.

**Solutions: It Is Up to the Equipment Designers,
Employers, and Sonographers to Work Together**

Many are speaking out passionately for the need for
changes to occur to stop this ergonomic crisis. The
good news is that solutions do exist. The success of
those solutions requires the cooperation and combined
efforts of the equipment designers, the employers, and
the sonographers—each doing his or her part in
implementing the proposed remedies. Joan P. Baker
supports the projected solutions, stating that “all this is
doable, and is not too expensive. In fact it is cheap
when compared to the cost of claims and injuries in
dollars as well as emotional trauma from loss of
careers.”

**RESPONSIBILITIES OF THE EQUIPMENT DESIGNERS**

Addressing the equipment designers, Baker pro-
posed that “the technology and know-how exists to
make ultrasound equipment ‘sonographer friendly.’”

Transducer design has been tagged as a major
contributing factor to hand-wrist strains. The newer,
smaller transducers provide improved imaging but
require additional finger and hand strength to grip and
apply the necessary forces. Proposed changes in
transducer design include incorporating a small
faceplate onto a large transducer or “developing a
transducer that has a handle portion ‘detached’ from
the ‘functioning’ portion, as is the case with most
tools.” Additionally, thinner, lighter-weight trans-
ducer cords would substantially alleviate strain and
torque associated with transducer use.

Another suggestion is to design adjustable chairs,
keyboards, and monitors so that the sonographer can
manipulate their heights to appropriate levels.
Additionally, “Ultrasound equipment should be fitted
with a high resolution screen that has a high refresh
rate (85 Hertz or higher), a non-interlaced monitor and
an easily adjustable brightness control” to reduce eye
strain.

But the best that equipment designers have to offer
cannot help the vulnerable sonographer unless the
employer is willing to purchase the equipment.

**RESPONSIBILITIES OF THE EMPLOYER**

It is the employer’s responsibility to provide a safe
work environment for the sonographer and to supply
adequate rest periods to insure that muscle recovery
time matches muscle trauma. Jonathan Batchelor of
AuntMinnie.com shares statements from Joan Baker
concerning the cost effectiveness of purchasing
ergonomically sound equipment: “An ultrasound
machine that lies idle for one week due to sonographer
injury looses an estimated $10,000 (U.S.) in charge-
able revenue, and 4 weeks of chargeable revenue loss
is equivalent to the average annual salary of a
sonographer”. Baker continues to inculcate that the
cost of support cushions is no more than the cost of a
single exam and that an ergonomic exam table is paid
for in two to three typical work days. Another
suggestion is to provide a separate viewing monitor for
the patient. This addition would alleviate the neck
strain associated with sharing the monitor with the
patient.

Lastly, it is recommended that employers have their
site evaluated by ergonomic professionals followed by
making necessary adjustments, and provide education
to their staff about safe postures and work habits.

**RESPONSIBILITIES OF THE SONOGRAPHER**

Indeed, it has been noted that most of the power to
reduce the incidence of repetitive strain to working
sonographers seems to lie in equipment design and
workplace setups. But does this mean that the
sonographer is powerless to do anything to reduce the
incidence of his or her own injury? There are in fact
many things the sonographer can do, both on and off
the job, to decrease the likelihood of overuse injury.
Recall, the culprits are poor posture, shoulder
abduction, repetitive movements, gripping the
transducer tightly for long periods of time, and
applying static forces with the transducer against the
patient’s body. Sonographers need to focus on these
problems and change their habits. A new sonographer
needs to anticipate how to avoid these injury traps by
establishing good habits to begin with.

On the job, sonographers should do the following:

1. Seek employment at a facility that has height-
adjustable chairs, exam beds, keyboards, and
monitors (with a separate monitor for patient
viewing). Additionally, the chair should rotate freely
and offer easy access to a footrest. Ideally, there are
separate exam rooms for alternating between right- and left-handed scanning. Also, support cushions or pads for arm and elbow should be available.

2. Seek employment at a facility that does not overwork its sonographers but allows time for minibreaks and regular breaks to accommodate muscle recovery.

3. Maintain an upright posture and avoid leaning over the patient as much as possible. Ask patients to move to the edge of the bed so they are closer to you right from the start. Throughout the exam, you may ask them to change positions as needed to scan various parts of the body. When reaching is unavoidable, use a support cushion or a specially designed saddle-type pad to rest the elbow on.

4. Keep updated on new, ergonomically designed equipment and ask employers to provide it if they do not already. Suspended slings for elbow support are currently being developed.

5. Vary your posture so that different muscles are used throughout the day. This could involve standing for some exams and sitting for others. Be sure to adjust the exam bed, keyboard, and monitor accordingly.

6. The keyboard should ideally be at a level that keeps the elbow at a 90° angle and allows the upper arm to hang freely near your side. Monitor viewing height should be slightly lower than looking straight ahead.

7. Alternate between right- and left-handed scanning. This is most easily done if there are separate rooms set up for it. The amount of time spent learning to scan with the untrained hand is well worth reducing muscle strain by one half.

8. Try to do a variety of exams throughout the day so that the muscles are stressed in different ways. This will need to be discussed with the scheduling staff.

9. Keep the elbow as close to the body as possible to reduce shoulder strain caused from abduction. This may require adjusting chair and bed height.

10. Put feet on a footrest to increase stability. An unbalanced posture puts strain on support muscles over time.

11. Lighten your grip on the transducer and periodically release grip to allow muscles short rest periods throughout exam. Wear gloves with a specialized texture that assists gripping the transducer.

12. Reduce the amount of time in sustained downward forces against the patient’s skin. Only press as long as is necessary to get the image, and then release.

13. Keep wrist and neck in a straight position. (Pretend you have a cast on your wrist and you cannot bend it.)

14. Take minibreaks during the exam to stretch and rest muscles. Complete rest, lasting as little as 2 to 3 seconds, can be of tremendous benefit. Ideally, the rest time should at least match the exertion time. As explained by Habes and Baron, “If a sonographer pushes down on the abdomen for a period of 15 seconds to obtain a necessary fetal view, he/she should release the scan head and recover for 15 seconds before proceeding with the examination. For exertion times lasting 1 minute, recovery times of 100 seconds are required.” Also, stretching the neck, upper back, lower back, chest, shoulder, arm, and wrist muscles during minibreaks is effective. Periodically looking away from the monitor will reduce eye strain.

15. Be aware of how your muscles are feeling. Do not ignore early signs of overuse strain. Recall, minute muscle tears will heal with small rest breaks.

16. As a staff, work together to reduce overuse injury. Brainstorm together and share creative ideas for reducing occupational overuse strain.

17. As a group, or individually, learn as much as you can about workplace ergonomics by attending seminars, watching educational video tapes, seeking Internet sources (www.soundergonomics.com), and so on. The more you understand how the muscles are stressed in various positions, the more likely you will discover creative ways to avoid self-injury.

18. Support each other in reporting injury as soon as it is incurred, and do not delay getting immediate help with rehabilitation.

Off the job, sonographers should do the following:

1. Eat a healthy diet including lots of fruits and vegetables.

2. Increase muscle strength and improve overall fitness.

3. Investigate new exercise equipment designed for sonographers (i.e., grip strength putty, available at www.soundergonomics.com).

4. Get adequate rest.

5. Learn effective relaxation exercises and ways to reduce overall stress. Muscle tension due to mental stress will not be noticed unless you are consciously making an effort to check for it. (A good exercise to do periodically is to shrug the shoulders toward the ears. Hold the tension there for a few seconds. Then, slowly relax the neck, allowing the shoulders to lower, until all tension is gone.)

About Exercise
The bottom line for sonographers is that strong muscles hold up under the pressure better than weak muscles.
This should be of particular interest to the older sonographers as they have been targeted as an at-risk population. The good news is that at any age, one can improve their endurance, flexibility, strength and resilience. In other words, given that all other lifestyle habits are similar, an active and fit 40-year-old is at lower risk for occupational overuse injury than a sedentary 30-year-old.

A sonographer from Canada stated that the facility she worked at had set up exercise stations for the employees, and had been working with a physiotherapist to incorporate passive stretching exercises. She further professed that many were taking up strength training to improve upper body strength.³

Specific exercises for sonographers designed by SDMS are available at www.sdms.org (select “workzone” and then “exercises”). Taking the next step and adopting a generalized exercise program into one’s daily routine will substantially reduce the incidence of any type of injury as well as improve overall health and work productivity.

The key to attaining desired results from an exercise program is to start slowly and gradually increase intensity and duration as personal fitness and time allows. Exercise does not need to be intense, neither should it take up all your free time (unless you want it to). Moderation is very effective and consistency is the key.³ Only do what fits into your lifestyle and accommodates your other responsibilities. It is better to be consistent with a little than inconsistent with a lot. Joining a fitness center or getting help initially from a fitness specialist is highly recommended. At the very least, follow these guidelines.

**AEROBIC EXERCISE**

Aerobic exercise should be performed 3 to 5 days per week for a duration of 20 to 40 minutes at a moderate pace (a pace that allows you to hold a conversation). Examples of aerobic exercise, from low to high impact, are as follows: swimming, aerobic rowing machine, water aerobics, bicycling, cross country skiing, elliptical machine, aerobic slide, roller skating, ice skating, roller blading, stair master, hiking, treadmill, walking, jazzercise, floor or step aerobics, jogging, and running (Fig. 2).

**FLEXIBILITY**

Hold each stretch for approximately 15 seconds. Stretching is gentle and pain free and is most effective following a general, whole body warm-up. If you are at your work station and unable to warm up prior to stretching, be especially careful about moving in and out of the stretch slowly and keeping the stretch well within your comfort level (Fig. 3).

**STRENGTH TRAINING**

Work each muscle group 2 to 3 days per week. Never work the same muscle 2 days in a row. One way to avoid working the same muscle 2 days in a row is to do upper-body strength exercises one day followed by lower-body strength exercises the next (Fig. 4).

Always exhale while lifting and inhale while lowering the weight. If standing, keep knees bent slightly and hold abdominals tight. Hips should be directly below shoulders—never sway the hips to assist the lift. Squats and lunges are the highest risk strength exercises; therefore, proper form should be
learned from a professional before attempting these exercises.

**WARNING**

As exercise may be harmful to certain individuals, it is recommended that one see a physician prior to starting an exercise program. Any sonographer with an acute injury should refrain from exercise until consulting a physician/physical therapist about his or her specific needs.

An exercise specialist or personal trainer will be a tremendous asset in getting you started with good habits, proper form, and a balanced workout, which will reduce your chances of injury from any exercise regimen.

If exercise is approached intelligently and conscientiously, preferably with guidance from a professional, at least to get started, the benefits are tremendous and extend beyond the workplace.

**SONOGRAPHERS, FOCUS ON WHAT YOU CAN CONTROL**

For the new sonographer, working in pain is a haunting prospect. For the experienced sonographer, it is likely a blatant reality that he or she is actively battling or choosing to ignore, hoping it will go away. Knowing that cumulative trauma will ultimately lead to career-ending injury is an awesome thought for any sonographer. Unfortunately, there may be some aspects of the work environment that are out of the sonographer’s control. As the testimony from a woman who lost her career to overuse injury discloses, “My employer refused to hire adequate staff to give us the relief and breaks that we needed. . . . My employer did not buy adjustable scanning chairs even though they were requested many times. . . . My employer did not make the necessary room changes to accommodate the equipment, patient and sonographer.”

Similarly, Murphey stated, “A second ergonomic job analysis of my workplace was performed in April of
These women have suffered tremendous pain and numerous surgeries and rehabilitation therapies; yet, cumulative, job-related physical stress eventually took their careers away from them—careers that they worked hard to perfect and both professed to love dearly. They are representative of a majority of sonographers currently working and treading a similar path. Murphey is now an activist for improving the workplace environment and educating professionals in the field about the present hazards of the occupation. As a student of sonography, I take this all very seriously because I believe other sonographers should, whether new or experienced.

Both on and off the job, it is up to the sonographers to do all they can for themselves, not relying solely on the perfect workplace environment. Strength training and overall fitness is one way to take charge of your life and help decrease the incidence and severity of job-related overuse injury.\(^3\)

**Conclusion**

As Gregory so directly states, “All sonographers have the right to be employed in a safe workplace;”\(^3\) But along with employers providing a safe workplace, sonographers need to adopt appropriate body mechanics that will save them from unnecessary suffering.

Experienced sonographers are the ones who can provide the best service to the patient. They are the ones who will discover the hidden pathology states that go undetected by the untrained eye. Diagnostic ultrasound is a difficult and operator-dependent profession. Many pathological states are obscure, and only the experienced sonographers, those who know the tricks from years of experience, will find these destructive processes that lie hidden in the human body. Experience is the sonographer’s, and the patient’s, best friend. To keep the most valuable players on the ultrasound professional team,
sonographers must practice safe postures and scanning habits and employers must provide state-of-the-art, ergonomically designed equipment. As Baker, a pioneer in the field, stated, “In order for patients to have the benefit of this wonderful nonionizing modality, we have to make the changes that will guarantee a productive future for all sonographers.”

References

SDMS-JDMS CME TEST

Article: Sonographers and Occupational Overuse Syndrome: Cause, Effect, and Solutions

Author: Cathy Jakes

Category: Other

Objectives: After reading the article, the sonographer will be able to

1. List strategies to avoid hand, wrist, and back injuries.
2. Describe key components of exercise and resources for sonographer-designed exercises.
3. Describe the causes of work-related sonographer injury and the impacts on patient care.
4. Specify the percentage of sonographers reporting career-ending injuries.
5. Specify employer strategies for reducing sonographer injury.
6. Specify actions to take when injury occurs.
7. Describe the physiologic causes of injury.

1. More time spent scanning and less time between patients is the result of all of the following except
  a. technical advances
  b. sonographer shortages
  c. expanding ultrasound uses
  d. injury prevention strategies

2. The percentage of sonographers who have lost their career due to work-related injury is
  a. 10
  b. 20
  c. 40
  d. 80

3. Physiologic responses to repetitive strain injury include all of the following except
  a. venous obstruction
  b. muscle tears
  c. nerve myelination
  d. swelling

4. Hand and wrist strains can be minimized by all of the following except
  a. selecting thinner and lighter transducer cords
  b. using smaller transducers
  c. buying textured gloves
  d. holding the wrist in a straight position

5. Sonographers who are concerned about work-related injury should encourage employers to provide all of the following except
  a. assistants to perform functions between examinations
  b. height-adjustable chairs with footrests
  c. separate monitors for patient viewing
  d. support cushions and pads

6. With respect to exercise, the author emphasizes the importance of which of the following aspects?
  a. intensity
  b. duration
  c. consistency
  d. variety

7. The SDMS Web site (http://www.sdms.org) Workzone link provides exercises designed for all of the following sonographers except
  a. student
  b. young
  c. experienced
  d. injured

8. According to the author, sonographer ergonomic injury directly impacts patient care by
  a. requiring hospitals to invest in ergonomic improvements
  b. removing experienced sonographers from the workforce
  c. increasing “wait times” for sonography examinations
  d. reducing the number of portable examinations

9. Which of the following strategies may reduce back injury?
  a. performing every examination standing
  b. asking the patient to move closer to the sonographer
  c. holding the elbow of the scanning arm away from the body
  d. sharing a monitor with the patient

10. When injury occurs, it is important to
    a. read about ergonomic injury
    b. continue to work as usual
    c. start an exercise program
    d. report the injury to your employer
SDMS-JDMS CME Test Answer Form

Sonographers and Occupational Overuse Syndrome: Cause, Effect, and Solutions
Volume 17, Number 6
November/December 2001
1.0 SDMS CME Credit
Category: Other
SDMS File #: 0001-01367

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Ultrasound of the Carpal Tunnel and Median Nerve: A Reproducibility Study

MAUREEN WILKINSON, DCR(R), DMU, AMS*
KAREN GRIMMER, PhD†
NICOLA MASSY-WESTROPP, BAppSc(OT)†

The authors describe a protocol for measuring the carpal tunnel and median nerve in a reproducible manner using ultrasound, as well as the variability of ultrasound measurements of the median nerve in the carpal tunnel on repeated testing. Measurements of the median nerve in the wrist and carpal tunnel and measurements of the carpal tunnel were taken on 23 wrists using high-resolution ultrasound following a specified protocol. These measurements were repeated a short time later to enable the initial measurements to be tested for reproducibility and stability. The same person obtained all measurements for the purposes of this study; thus, the results represent findings in an intraobserver variability study. Good correlation between the test and retest measurements was demonstrated, with $r^2$ values between 0.72 and 0.98. Paired t test demonstrated no significant difference between the test and retest measurements. The study shows that repeated ultrasound measurements of the cross-sectional areas of the carpal tunnel, median nerve at the proximal edge of the carpal tunnel, distal to the carpal tunnel and at the level of the proximal wrist crease can all be satisfactorily reproduced when a strict ultrasound protocol is adhered to.

Key words: carpal tunnel, median nerve, measurements, stability, reproducibility

The carpal tunnel is defined by four bony prominences. It is defined distally by the hook of the hamate medially and the tubercle of trapezium laterally. Proximally, it is defined by the pisiform medially and the tubercle of the scaphoid laterally. The flexor retinaculum (transverse carpal ligament) connects these four areas and forms a fibrous sheath, which contains the carpal tunnel. The distal volar flexion crease (distal wrist crease) marks the proximal edge of the flexor retinaculum, the proximal end of the scaphoid, and the pisiform. The pisiform is easily palpable at the wrist crease and becomes a landmark for scanning the carpal tunnel. Posteriorly, carpal bones define the floor of the carpal tunnel.
The median nerve is not uniform in its shape as it travels into, through, and out of the carpal tunnel, superficial to the flexor tendons, deep to the flexor retinaculum. This fact is important when planning the placement of the transducer so that reproducibility can occur. In normal patients, the nerve may flatten in the carpal tunnel before it divides into sensory and motor branches distal to the carpal tunnel.\(^1\)

The nerve may slide between tensed flexor tendons,\(^2\) which may distort the shape of the nerve. It follows, therefore, that patient positioning and whether the patient is moving or holding a position will actively affect normal excursion of the nerve. Recognizing this nonuniformity is important when planning the placement of the transducer so that reproducibility can occur.

According to Jeng et al,\(^3\) practical tools in active surveillance programs are needed to detect carpal tunnel syndrome (CTS) with high sensitivity and specificity. Such tools could be used to reveal potential CTS cases before symptoms become established and to monitor the results of surgical, medical, or ergonomic interventions for more established cases.

Ultrasound is a noninvasive, repeatable, inexpensive, and highly sensitive mode of examination of soft tissue, and has been demonstrated to provide useful and reliable information on soft tissue. The carpal tunnel and its contents can be visualized in an efficient and cost-effective manner.\(^4\)

Several authors have discussed the use of ultrasound in examining the carpal tunnel.\(^1,5-9\) Duncan et al\(^9\) demonstrated that ultrasound measurements of the cross-sectional area of the median nerve in the proximal carpal tunnel are sensitive and specific for carpal tunnel syndrome, suggesting that ultrasound may be useful in the diagnosis of carpal tunnel syndrome. They also suggested that standardization of the sonographic technique was necessary before ultrasound could become an accepted procedure. Lee et al\(^10\) found a high degree of correlation between electromyography and ultrasound measurements of the median nerve and recommended the use of ultrasound as the first step in diagnostic testing after physical examination.

Despite the evidence of sensitivity and specificity supporting the use of ultrasound, no studies appear to have tested or demonstrated the reproducibility of measurements in repeated examinations. To test the usefulness of ultrasound in the diagnosis of early carpal tunnel syndrome in later studies, a set protocol with demonstrable reproducibility of measurements is required.

**Method**

**PARTICIPANTS**

A convenience sample of 12 volunteers from colleagues and students participated in the study. Volunteers had no prior history of injury to the wrist, or known carpal tunnel problems. Ethics approval was sought and granted by our institution.

**POSITIONING**

The sonographer sat at a comfortable height and distance from the participant facing the ultrasound machine, so that the controls and participants’ wrists were accessed with ease. Participants were positioned in the same manner at each ultrasound examination for each structure. Participants were seated next to the ultrasound machine facing the sonographer.

The arm for examination was supported on a gurney at a height midway between the elbow and shoulder, with the forearm supinated and the wrist/hand held in slight dorsiflexion. Participants were verbally instructed to allow their fingers to relax completely; thus, the fingers were semiflexed.

Previous pilot studies have indicated the need for strict adherence to protocol, so participants were asked to place both feet flat on the floor and look at a fixed object. A second tester observed each participant to ensure that this standard positioning was maintained at each examination. It is thought that this lessened the effects of the gliding tendencies of the nerve.

**MEASUREMENTS**

**Cross-Sectional Area of Median Nerve at Proximal Carpal Tunnel (Level of Pisiform)**

The proximal carpal tunnel was imaged with the transducer placed midway between the pisiform and the tubercle of the scaphoid at the level of the distal wrist crease. This is usually the point of maximum swelling in patients with carpal tunnel syndrome.\(^9\) The transducer was positioned perpendicular to the median nerve, that is, angled slightly toward the head, the amount of angulation depending on the path of the median nerve as it goes through the carpal tunnel, to
eliminate anisotropy effects. The nerve can be seen as a rounded or oval hypoechoic structure containing punctate bright echoes and with a hyperechoic border. It lies anterior to the flexor tendon of the index finger, which can be detected when the participant is asked to wriggle that finger, and in proximity with the posterior border of the flexor retinaculum. Measurement was obtained by taking the transverse diameter of the nerve and the anteroposterior diameter of the nerve and multiplying them together to find the area. Measurement of the nerve was obtained from the inner borders of the echogenic rim of the nerve (Fig. 1).

**Cross-Sectional Area of Carpal Tunnel (Level of Pisiform)**

With the transducer at right angles to the skin surface, the carpal tunnel was found at the level of the pisiform. The acoustic shadowing and the bright reflective surfaces of the scaphoid and the pisiform could be seen bordering the carpal tunnel.

Measurements were taken from the inner surface of the scaphoid to the inner surface of the pisiform, and from the posterior border of the flexor retinaculum, at a point midway between the scaphoid and the pisiform, to the carpal floor. The measurements were multiplied to obtain the area. It is believed this measurement may serve as an indicator of bulging of the retinaculum (Fig. 2).  

**Cross-Sectional Area of Median Nerve at Proximal Wrist Crease**

The transducer was moved slightly cephalad so that it lay over the proximal wrist crease. The cross-sectional area of the median nerve was measured as before (Fig. 3).

**Anteroposterior Diameter of the Median Nerve at the Level of the Hamate**

The transducer was placed so that a longitudinal section of the median nerve, at its largest diameter, was visualized as it left the carpal tunnel. Only anteroposterior diameter measurement was taken in this position because of the relatively steep angle the median nerve can assume as it leaves the tunnel (Fig. 4).

Both wrists were examined. The first set of measurements was obtained from each of the eight points of interest at the initial examination and recorded by an observer.

A second set of measurements (retest) was taken by the same sonographer after a time lapse, which ranged from 20 minutes to 2 hours. The sonographer did not have access to the first set of measurements before the second set was taken. Participants were asked not to use their hand/wrist excessively in the interim, for example, using a keyboard. The retest was conducted in exactly the same manner as the first test.
FIG. 2. Cross-sectional area of carpal tunnel (level of pisiform). FR = flexor retinaculum, FLEX TEN = flexor tendons, GC = Guyon’s canal, MN = median nerve, PIS = pisiform, SCAP = scaphoid.

FIG. 3. Cross-sectional area at the proximal wrist crease showing the flexor tendons, the fascicles, and the median nerve (MN).

FIG. 4. Anteroposterior diameter of the median nerve at the level of the hamate. CT = carpal tunnel, FT = flexor tendons, MN = median nerve.
STATISTICAL ANALYSIS

The data were entered into Microsoft Excel version 7 for analysis. The measurements of the median nerve cross-sectional area at the level of the proximal wrist crease and at the level of the pisiform and the cross-sectional area of the carpal tunnel at the pisiform level were collated and divided into right and left wrists. Anteroposterior measurements of the median nerve distal to the carpal tunnel were collated. Averages of the right and left initial and retest measurements and standard deviations were calculated. Pearson $r$ and $r^2$ correlations were calculated to test the stability of test and retest measures. Paired $t$ tests were performed to compare the measurements of test 1 with those of test 2. A significance level of $P < .05$ was set. The same tests were performed on the combined right and left median nerves distal to the carpal tunnel. Ninety-five percent confidence intervals were calculated about the mean. These are robust measures of variability and facilitate comparison between means.

Results

Twenty-four wrists were examined on 10 female and 2 male participants. One wrist was excluded from the study because a previous injury to the wrist made visualization of the median nerve difficult.

All measurements of aspects of the carpal tunnel showed no significant differences between test 1 and test 2. The $r^2$'s were greater than 0.7, demonstrating high stability of the test and retest measures. Tables 1 through 4 display the above results, where very small mean differences (95% confidence limit) were found between highly stable repeated measures.

Discussion

Our previous pilot studies indicated that the reproducibility of the measurements of the median nerve in the carpal tunnel at the level of the pisiform had not been consistent. Therefore, rigorous standards for positioning were set in the protocol to prevent any change in the caliber of the median nerve due to different positioning. Based on the reported protocol, confidence can be placed in all measurements of the carpal tunnel, since the 95% confidence limit range shows very little difference between them in the test and retest in all areas measured.

The study demonstrates that with an experienced sonographer, rigorous standardization of patient
position, and quality equipment, a high level of confidence in the measurements can be achieved.

It could be argued that some level of bias was introduced by the fact that one sonographer took all the measurements; however, because there was a time lapse between test and retest measures, and the sonographer did not see the measurements again after they were noted, the likelihood of the sonographer remembering such a volume of numbers is slim. Because this was an intraobserver study, the protocol used shows reproducibility of measures in one person only. Should later studies demonstrate the usefulness of ultrasound using a strict protocol in the demonstration of nerve changes in carpal tunnel syndrome, then a further study to address interobserver reliability will need to be conducted.

**Conclusion**

Repeat ultrasound measures of the cross-sectional areas of the carpal tunnel, median nerve in proximal carpal tunnel and median nerve distal and proximal to the carpal tunnel can be reproduced satisfactorily using a strict protocol. We suggest that following a strict protocol when examining the carpal tunnel for signs of median nerve change will greatly enhance the findings.

**References**

SDMS-JDMS CME TEST

Article: Ultrasound of the Carpal Tunnel and Median Nerve: A Reproducibility Study

Authors: Maureen Wilkinson, Karen Grimmer, and Nicola Massy-Westropp

Category: Other

Objectives: After reading the article, the sonographer will be able to

1. Describe the results of the study and aspects of the scientific methods used.
2. Specify the landmarks that form the boundaries of the carpal tunnel and the structures that lie superficial and deep to the nerve.
3. Specify the location of a carpal tunnel landmark on the surface of the wrist.
4. Describe the course of the median nerve through the carpal tunnel.
5. Specify the location of maximum swelling in patients with carpal tunnel syndrome.
6. Describe the measurement protocol used in this study.
7. Specify reasons that measurements of the cross-sectional diameter of the median nerve may vary.

1. This study demonstrates that measurements of the carpal tunnel and median nerve are
   a. reproducible by different sonographers
   b. reproducible by the same sonographer
   c. independent of protocol
   d. independent of measurement location
2. The portion of the bony prominences forming the carpal tunnel that is palpable at the wrist crease is the
   a. hamate
   b. trapezium
   c. pisiform
   d. scaphoid
3. Measurements of the cross-sectional area of the median nerve vary as the result of all of the following except
   a. flattening within the tunnel
   b. nonuniformity in shape
   c. movement of the flexor tendons
   d. sonographer pressure on the transducer
4. The flexor retinaculum forms a fibrous sheath that covers the_________ portion of the carpal tunnel
   a. superficial
   b. posterior
   c. proximal
   d. distal
5. To position the transducer perpendicular to the median nerve, the transducer is angled
   a. toward the patient’s fingers
   b. medial from the patient’s arm
   c. lateral from the patient’s arm
   d. toward the patient’s head
6. Measurements of the median nerve were obtained from
   a. the outer border to the inner border
   b. the outer borders
   c. the inner border to the outer border
   d. the inner borders
7. A strict protocol was adhered to that included all of the following except
   a. patients in standard position
   b. fingers semiflexed and relaxed
   c. observer verification
   d. multiple sonographers
8. Maximum swelling in patients with carpal tunnel is usually
   a. at the distal carpal tunnel (level of the hamate)
   b. at the proximal carpal tunnel (level of the pisiform)
   c. midway between the pisiform and the tubercle of the trapezium
   d. at the level of the proximal wrist crease
9. The subjects in this study were
   a. at high risk for carpal tunnel syndrome
   b. a selected sample
   c. a random sample
   d. a nonrandomized sample
10. The median nerve may assume a relatively steep angle as it leaves the carpal tunnel
    a. proximally
    b. distally
    c. anteriorly
    d. posteriorly
SDMS-JDMS CME Test Answer Form

Ultrasound of the Carpal Tunnel and Median Nerve: A Reproducibility Study

Volume 17, Number 6
November/December 2001

1.0 SDMS CME Credit
Category: Other
SDMS File #: 0001-01509

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The Use of Sonography in the Detection of Bony and Calcific Disorders of the Shoulder

MARK A. STIELER, MS

Sonography is commonly used for the evaluation of shoulder symptoms. This report describes some of the bony and/or calcific changes that may be visualized in the ultrasound examination of the shoulder and may not have been detected by other modalities. Sonography is able to accurately predict the diameter of the acromioclavicular joint as well as determine the presence or absence of osteoarthritis at this joint. The os acromiale is amenable to ultrasonic detection also. Sonography appears to be more sensitive in the detection of rotator cuff calcification than the standard shoulder x-ray series and has the additional advantage of precise localization of the tendon of origin of the calcification. Sonography is able to reliably detect fractures around the greater tuberosity, and the Hill-Sachs lesion may also be seen. Changes of irregularity, cyst formation, and sclerosis around the greater tuberosity may occur in association with the impingement syndrome. These changes lead to irregularity of the greater tuberosity. Sonography can detect these changes and, to some degree, grade their severity.

Key words: shoulder, ultrasound, sonography, shoulder ultrasound, musculoskeletal ultrasound, calcific tendinitis

The painful shoulder is one of the most common musculoskeletal disorders. Traditionally, the painful shoulder has initially been evaluated by plain-film x-ray, followed by specialized techniques such as arthrography, contrast computed tomography (CT), and magnetic resonance imaging (MRI). Sonography is a commonly used application in the evaluation of shoulder symptoms, and its benefits are well recognized, particularly in the assessment of rotator cuff lesions. The diagnostic benefits of the technique are augmented by its noninvasive nature and the absence of ionizing radiation. Additionally, sonography is generally well tolerated by patients and is much less expensive than MRI or CT.
Disorders of periarticular soft tissues (rather than bony structures) are the most common source of shoulder pain. Rotator cuff lesions are the most common soft-tissue disorder encountered in the shoulder region, with rotator cuff tear and calcific tendinitis being the two most important causes of intrinsic rotator cuff tendinopathy. Rotator cuff tears are most often the end stage of the impingement syndrome. Plain-film x-ray findings in the impingement syndrome include subacromial and subclavicular osteophytes, sclerosis, and cystic change around the greater tuberosity and the presence of an os acromiale. Primarily, sonography has been used to evaluate the soft tissue structures of the shoulder, specifically the rotator cuff; however, to maximize the benefits of the technique, it is desirable that the sonographic examination provide information beyond merely confirming or excluding the presence of a rotator cuff tear. In some cases, sonography may detect bony and/or calcific abnormalities in the shoulder region that are not detected or are not optimally demonstrated with other imaging modalities and may be the source of a patient’s symptoms.

The aim of this study was to assess the utility of sonography in the assessment of the greater tuberosity and the acromioclavicular joint (ACJ) as well as in the detection of rotator cuff calcification and the presence of an os acromiale. The ultrasound findings are correlated with plain-film x-ray data.

Materials and Method

Two patient populations were used for the study. The first patient population consisted of 103 consecutive patients who underwent shoulder sonography and x-ray. The second population consisted of 53 consecutive patients who underwent shoulder sonography and x-ray examinations including a special projection of the greater tuberosity. In all cases, the two examinations were undertaken on the same day. All examinations were performed on patients referred for radiological evaluation of shoulder symptoms referable to the rotator cuff.

Because of the very limited availability of MRI in Australia, sonography is almost always used for the evaluation of suspected rotator cuff disorders, with MRI reserved for those cases in which a diagnosis cannot be achieved with sonography, plain-film x-ray, and clinical assessment. Because of this, no patient from this study proceeded to MRI.

CT is most helpful in the evaluation of shoulder trauma but provides limited information about the soft tissues. In particular, CT has a limited role in the evaluation of the rotator cuff. CT arthromograms are useful in demonstrating bony, ligamentous, and cartilaginous structures. One patient from this study proceeded to CT for assessment of a shoulder fracture. No other patient proceeded to CT.

All sonographic examinations were performed by the same sonographer on an HDI 3000 ultrasound system (Advanced Technology Laboratories, Bothell, WA) using a 5- to 10-MHz broad bandwidth linear array transducer. No standoff medium was required.

For the first patient population, the following data were recorded for each sonographic examination:

1. ACJ/acromion (presence or absence of ACJ osteoarthritis, width of the ACJ [measured with electronic calipers from the on-screen sonographic image], and presence or absence of accessory ossification centers around the acromion);
2. Rotator cuff (presence or absence of rotator cuff calcification);
3. Any other findings.

Immediately following the sonographic examination, a standard series of shoulder radiographs was obtained. The radiographs were interpreted by one of 6 radiologists who were blinded to the sonographic findings. The same data were recorded as for the sonographic examination. ACJ diameter was measured directly from the resultant radiograph.

The study performed on the second patient population was an extension of the first wherein the greater tuberosity was specifically evaluated. To allow accurate assessment of the greater tuberosity, a specialized view was performed in the x-ray series (see below), as well as a directed ultrasound examination of the greater tuberosity. Changes seen at the greater tuberosity were graded on a 4-point scale from 0 (normal) to 3 (severe abnormality). Shoulders receiving a grade of 0 or 1 were categorized as “no significant abnormality” and those with a 2 or 3 were categorized as “significant abnormality.” A sonographic image of a markedly irregular greater tuberosity in a patient with a chronic, full-thickness rotator cuff tear is shown in Figure 1.
Immediately following the sonographic examination, a standard series of shoulder radiographs was obtained. Additionally, a specific view of the greater tuberosity was obtained. This view was obtained with the shoulder in external rotation, so that the greater tuberosity was cast into profile. Exposure factors were optimized for the greater tuberosity. Each of 6 radiologists evaluated this view, with no prior knowledge of the sonographic findings. Each patient was categorized in the same manner as in the sonographic examination.

To limit the effect of subjective interpretations on the results of the study, the grading system used was based on a series of reference films, which had been obtained previously and agreed upon by a panel comprising the sonographer and 3 of the 6 radiologists participating in the study. Radiographs of normal (grade 0) and markedly abnormal (grade 3) greater tuberosities are shown in Figures 2 and 3. For each patient in the study, all radiologists directly compared each film with the reference films and then assigned a category. The scores provided by the radiologists were averaged to provide a mean score for each patient. The mean score was used in correlation coefficient calculations. A modal score (i.e., the most frequently assigned score) was also provided for each patient. In cases of a deadlock, the score from the radiologist who had the lowest coefficient of correlation with the mean

**FIG. 1.** Sonographic image of markedly irregular greater tuberosity and humeral head in a patient with a chronic, full-thickness rotator cuff tear. The deltoid muscle is in direct apposition to the markedly irregular humeral head due to the absence of the rotator cuff.

**FIG. 2.** Radiograph of a normal (grade 0) greater tuberosity.
score was disregarded so as to break the deadlock. The mode was used in the construction of frequency tables where an exact value was required.

During the sonographic examination, the sonographer attempted to categorize each shoulder in the same manner as the radiologists. This was also accomplished with reference to the sonographic appearances of the 4 patients who provided the reference films for the radiological classification.

The results were analyzed using the SYSTAT statistical software package (SPSS Inc., Chicago, IL) on an IBM-compatible computer.

**Results**

**ACROMIOCLAVICULAR JOINT**

The sonographically derived ACJ diameter was a very good predictor of the ACJ diameter obtained from the plain shoulder radiograph \( r = 0.86 \). Table 1 shows the correlation between sonography and x-ray in the detection of ACJ osteoarthritis. Agreement between the two modalities was achieved in 79% of cases. The Cohen kappa value was 0.56. Individual case analysis showed that disagreement occurred most frequently in cases of mild osteoarthritis, where only minimal changes were seen on one modality or the other.

**OS ACROMIALE**

There are usually 3 separate ossification centers for the acromion, and they normally unite with the spine of

<table>
<thead>
<tr>
<th>Observed Frequencies of Acromioclavicular Joint Osteoarthritis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X-ray</strong></td>
</tr>
<tr>
<td>Not Present</td>
</tr>
<tr>
<td>Sonography</td>
</tr>
<tr>
<td>Osteoarthritis present</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

the scapula by the 12th year and fuse to each other by the 15th to 18th year. Os acromiale is the result of failure of one of the outer ossification centers to unite with the more medial portion. The os acromiale is usually regarded as an incidental finding, but in recent years it has been implicated as a possible cause of subacromial impingement and, consequently, rotator cuff tear.

Only one os acromiale was detected radiographically during the study, and it was demonstrated sonographically (see Fig. 4). There were no false positives. Since the completion of the study, an additional 4 os acromiales have been detected with sonography, and all were verified with subsequent radiographs.

**ROTATOR CUFF CALCIFICATION**

Table 2 shows the correlation between sonography and x-ray in the demonstration of rotator cuff calcification. There was agreement between the two modalities in 91% of cases. The Cohen kappa value was 0.64.

Radiographically evident calcifications were detected ultrasonically in all but one case. Although this calcification was identified on sonography, it was located very close to a rather irregular greater tuberosity (confirmed on x-ray) and was considered to be part of this irregularity.

There were 8 calcifications detected sonographically that were not visible on initial plain radiographs. Two of these were tiny echogenic foci within the supraspinatus tendon that were presumably too small to be shown radiographically. In each of 2 further cases, a calcific focus was located very close to the surface of an irregular greater tuberosity. Sonography suggested these foci were separate from the bony surface, indicating they were calcifications, whereas they could not be distinguished separately from the
bony irregularity on plain-film x-ray. In another 2 cases, the calcifications were located in the subscapularis tendon and were thus presumably projected over the humeral head and not seen radiographically. In the final 2 cases, sonography showed calcifications within the supraspinatus tendon that could not be shown radiographically with the standard shoulder series and subsequent extra views. These two calcifications were successfully demonstrated under fluoroscopic examination.

FRACTURES/HILL-SACHS LESIONS

Three fractures were successfully demonstrated sonographically. The first of these involved the greater and lesser tuberosities and was not detected on a radiograph performed at an outside institution. The sonographic examination suggested a fracture, which was confirmed on further plain-film x-ray views and on CT. The second fracture was an avulsion fracture of the greater tuberosity on a patient who was initially referred for sonography only. The avulsion was detected sonographically, and upon further questioning a history of trauma 10 days prior was elicited. A plain-film x-ray was obtained immediately, which also showed the fracture. In the third case, an avulsion from the greater tuberosity was detected sonographically. This had not been shown on previous x-rays at an outside institution. Additional views performed following sonography again failed to adequately demonstrate the fracture, but the fracture was eventually demonstrated under fluoroscopic control.

The Hill-Sachs defect (visible as an erosion on the posterior surface of the humeral head) is an important bony sign of previous anterior shoulder dislocation.

FIG. 4. A small bony fragment (arrow) is seen separate to the main body of the acromion. An os acromiale was confirmed on a plain radiograph.

| TABLE 2 |
|---|---|---|
| Observed Frequencies of Rotator Cuff Calcification |

<table>
<thead>
<tr>
<th></th>
<th>X-ray</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Sonography</td>
<td></td>
</tr>
<tr>
<td>No calcification</td>
<td>84</td>
</tr>
<tr>
<td>Calcification</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>92</td>
</tr>
</tbody>
</table>
and instability. Two Hill-Sachs defects were demonstrated sonographically. One of these was shown radiographically, and the other could not be shown despite numerous extra views.

**GREATER TUBEROSITY**

When the changes involving the greater tuberosity were categorized as either significant or not significant, there was a correlation coefficient of 0.70 between sonography and the mean score of the 6 radiologists. Table 3 shows the case-by-case analysis for sonography versus the modal score. There was disagreement in 5 of 53 cases. When the changes involving the greater tuberosity were graded on the 4-point scale, the correlation between sonography and the mean score of the 6 radiologists was 0.62. Table 4 shows the case-by-case analysis for sonography versus the modal score. There was disagreement in 29 of the 53 cases; however, in only 1 case did the disagreement span more than one category. Additionally, a majority of cases of disagreement occurred when sonography showed mild changes whereas no changes were observed radiographically.

**Discussion**

Sonography is of proven value in the assessment of the soft-tissue structures of the shoulder, particularly the rotator cuff tear. Some studies have also assessed the utility of ultrasound in assessing certain disorders of bony structures in the shoulder region, including fractures of the greater tuberosity and irregularity of the greater tuberosity in patients with rotator cuff tear. This study has shown sonography to be of value in the assessment of certain areas traditionally evaluated by plain radiographs. In the assessment of the ACJ, sonography proved to be a reliable predictor of ACJ width. Additionally, sonography was able to predict the presence of osteoarthritis involving the ACJ, particularly cases with more than mild amounts of osteoarthritis. This is important in the context of the impingement syndrome, where ACJ osteoarthritis is recognized as a causative factor. Similarly, the os acromiale has been implicated as a precipitating factor for impingement. Sonography proved capable of demonstrating an os acromiale in this study, although only 1 case was encountered in a population of 103. Subsequent experience has confirmed the usefulness of sonography in the diagnosis of this variant. It is noted, however, that although the os acromiale may be an etiological factor in the impingement syndrome, it is not common, with an incidence of less than 1% in this study.

Rotator cuff calcification is considered by some authors to be related to the impingement process, whereas others believe it to be an entirely separate pathologic process. Possible triggering mechanisms include tissue hypoxia and genetic susceptibility. Whatever the initial causative mechanism, calcific deposits of sufficient size may themselves impinge on the acromion. Whether or not it is related to the impingement process, calcific tendinitis is an important differential diagnosis, and as such it is important to document its presence in individuals suspected of having impingement tendinitis.

In the current study, sonography detected all calcifications detected radiographically except for one. In this one case, the sonographic study suggested

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Frequency Table Comparing Sonography-Graded Greater Tuberosity Changes With Radiologists’ Modal Score: Changes Graded as Significant or Not Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonography</td>
<td>No Significant Abnormality</td>
</tr>
<tr>
<td>No significant abnormality</td>
<td>43</td>
</tr>
<tr>
<td>Significant abnormality</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 4</th>
<th>Frequency Table Comparing Sonography-Graded Greater Tuberosity Changes With Radiologists’ Modal Score: Changes Graded on a 4-Point Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray Grade</td>
<td>Sonography grade</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
</tr>
</tbody>
</table>
the “calcification” was actually bony irregularity whereas the radiologist interpreting the plain-film x-rays thought the calcification was discrete from this irregularity. There were a total of 8 calcifications detected on sonography that were not visible on the standard shoulder x-ray series. It appeared that these calcifications were not seen radiographically for a number of reasons, most commonly the superimposition of the calcifications on adjacent bony structures. Very small calcifications were also missed radiographically. These findings suggest sonography is more sensitive than plain radiography in the detection of rotator cuff calcifications. Additionally, sonography is able to precisely localize the tendon within which the calcification is contained, which can only be inferred from plain-film x-rays.

The small number of fractures (3) that were detected during the course of the study precludes definitive comment; however, the fact that 3 of 3 fractures in the region of the greater tuberosity were successfully demonstrated suggests that sonography has value in this area. These findings are in accordance with those of another study with a larger population of greater tuberosity fractures. Similarly, although only 2 Hill-Sachs defects were encountered in the current study, it would appear that sonography is of value in the detection of these lesions.

Calcifications, fractures, and Hill-Sachs defects share a common trait in that their demonstration on plain radiographs relies on a view tangential to the abnormality, with even a few degrees of error rendering the lesion undetectable due to superimposition on adjacent bony structures. By its nature, sonography is not constrained by these difficulties, often allowing easier detection of these abnormalities.

Changes around the greater tuberosity are frequently seen in association with the impingement syndrome, and the ability to demonstrate these changes sonographically would add to the diagnostic value of this technique. The main changes that were observed radiographically around the greater tuberosity in the study were sclerosis, bony irregularity, and cyst formation. Although sonography is unable to detect sclerosis, it was uncommon for sclerosis to be an isolated finding, with most cases of significant degeneration showing bony irregularity and, often, cyst formation in association with the sclerotic change. Sonography is capable of demonstrating this bony irregularity. In the study, sonography was quite effective in detecting those greater tuberosities with significant degenerative change, with disagreement in less than 10% of cases when compared with the averaged results of the panel of 6 radiologists. Analysis of agreement between individual radiologists showed that the correlation coefficients ranged between 0.48 and 1.0, illustrating that there is still a large element of subjectivity involved in an assessment such as this, even when relatively objective criteria are developed for interpretation.

Sonography fared slightly less well when the changes were graded into 4 categories, with exact agreement occurring in less than half of the cases; however, in only one case was the sonographic grade more than one category outside of the radiologists’ modal score.

Although the plain radiograph was adopted as the gold standard in this study, there were a number of cases in which sonography clearly showed irregularity in spite of a normal radiograph. As is the case with the other conditions already considered in this report (calcifications, fractures, etc.), changes around the greater tuberosity may be undetected radiographically if they are not shown in profile. Intuitively, this would be more of a problem in the milder degrees of greater tuberosity degeneration and may at least partially account for the 18 cases in which sonography showed mild changes whereas the radiologists reported the greater tuberosity to be normal.

There are a number of potential limitations of this study. Magnification effects were not taken into account for the measurement of ACJ diameter from the plain radiographs; however, these values were used only for the calculation of correlation and not for an absolute measurement.

Only one sonographer interpreted the sonographic results. Further studies will be necessary to assess interobserver variability and factors such as sonographer experience level, equipment level, and so on.

Not all sonographically documented calcifications were verified by other methods. Calcifications that were visualized on sonography but not on radiographs were included in the study if they exhibited typical sonographic characteristics of calcific foci and if the reason for their nonvisualization radiographically
could be explained based on their anatomical location and physical characteristics (ie, size, echodensity). Similarly, the Hill-Sachs lesion, which was visible on sonography but not on radiographs, was included based on the typical ultrasonic appearances of a well-defined indentation within the surface of the humeral head posterolaterally.

In conclusion, this study has shown that sonography has the ability to detect certain bony and calcific changes around the shoulder that have traditionally been the province of plain radiography. Although the plain shoulder radiograph will not become superfluous in the foreseeable future, this information will enhance the value of sonography as a diagnostic test and will occasionally allow sonographers to detect lesions that, for technical reasons, may not have been visible on initial radiographs.

**References**

Sonographic Evaluation of Intraocular Cysticercosis

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S. MALHOTRA, MS

The authors report a case of intravitreal cysticercosis with retinal detachment diagnosed on sonography.

**Key words:** intraocular cysticercosis, ultrasound

Cysticercosis is an infestation caused by the larval stage of *Taenia solium*. Cysticerci lodge in the central nervous system, the eye, and the skeletal muscle.\(^1\) The most frequent and severe manifestation of ocular cysticercosis is involvement of the posterior segment. It often leads to blindness and atrophy of the eye.\(^2,4\)

**Case Presentation**

A 25-year-old woman presented in an ophthalmology outpatient clinic with a 3-month history of diminished vision and photophobia in her left eye.

On examination, there was no perception of light. Slit lamp biomicroscopy with a 90D lens showed exudative retinal detachment with a white-colored cyst along with grade I to grade II cells in flare.

The patient was referred for ultrasound examination for evaluation of the posterior chamber. High-resolution sonography was performed using a 5- to 9-MHz transducer (Ultramark 9 HDI, ATL, Bothell, WA). The sonographic examination of the right eye was normal. In the left eye, the anterior chamber and lens were normal. In the posterior chamber, a Y-shaped retinal detachment was seen. In addition to the retinal detachment, a well-defined round cystic lesion of 5 × 5 mm was seen entrapped within the detached retina. An echogenic nodule suggestive of calcified scolex was seen within the cyst (Fig. 1, Fig. 2). The retrobulbar structures were normal. The diagnosis of intravitreal cysticercosis along with retinal detachment was established. The patient underwent computed tomography of the head region to search for associated intracranial infestation, which was negative.

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Discussion

*T solium* is of worldwide distribution but is considered endemic in Mexico, Africa, Southeast Asia, Eastern Europe, and Central and South America. The frequency of diagnosis of cysticercosis has been increasing in developed countries as a result of increased influx of immigrants from endemic areas and increase in foreign travel to tropical countries. Tapeworm infections are common in developing countries, where the combination of a rural society, crowding, and poor sanitation causes fecal contamination of food and water.

In the regular lifecycle of *T solium*, the definitive host is human. A human’s small intestine may harbor single adult bladeworms, the last segments of which (proglottides) contain thousands of eggs and are eliminated in the feces. The usual intermediary host is the pig, which may ingest the eggs in contaminated food or water. The eggshell is dissolved by gastric or duodenal juices, and the released embryo, aided by its hooks, perforates the gastrointestinal mucosa, thereby reaching the bloodstream. The embryo then localizes in the pig’s various organs and tissues, mainly muscles, heart, and brain. Within 3 months, the parasite loses its hooks, acquires a head, and becomes vesicular and larger, reaching the mature larval stage called *cysticercus cellulosae*. Infrequently, other animals can be infected by the same mechanism. The entire cycle is completed when a human eats contaminated pork that is insufficiently cooked. The *cysticercus* is freed in the gastrointestinal tract and attaches itself to the intestinal mucosa by the suckers, and in a few weeks the parasite becomes an adult tapeworm.

Human cysticercosis occurs when a human acts as an intermediary host instead of a definitive host, most frequently when contaminated vegetables, fruit, or water are ingested or through autoinfestation by reflex peristalsis of eggs from a resident adult parasite. The embryo perforates the gastrointestinal mucosa, invades the bloodstream, and reaches various organs. The organs most infected are the eye (13% to 46%), subcutaneous tissue (24.5%), and brain (13.6%). Cysticercosis usually occurs in individuals between the ages of 10 and 30 years (68%) and has no gender predilection.

Since Sommerring first described ocular cysticercosis in 1930, other investigators have reported on various aspects of the disease. In the eye, *cysticerci* can lodge in any part of the eye or its adnexa. They have been reported in the anterior chamber, vitreous cavity, subretinal space, optic nerve head, subconjunctival space, lids, and lacrimal glands. Involvement of the lens is extremely rare but has also been reported, as has bilateral multifocal intraocular involvement. *Cysticerci* have also been reported to migrate within the eye.
In the posterior segment, access of the parasites is presumably through the posterior ciliary arteries, and they have been found near the posterior pole in the subretinal space, often in the macular area. From this location, however, they usually pass through a rent in the retina into the vitreous.

A rhegmatogenous retinal detachment may develop or the perforation may be sealed by an inflammatory reaction, which leaves a chorioretinal scar. In rare cases, the parasite may pass from the vitreous, through the pupil, into the anterior chamber. Infestation of the ocular adnexa is probably through the anterior ciliary arteries.13,16

In 1992, Cardenas et al17 performed a study in 30 patients with intraocular cysticercosis and observed a 63% incidence of vitreous cavity involvement as compared to 37% of subretinal involvement. No cyst was observed in the anterior segment. Retinal detachment was seen in 6* cases (63%).

When the media are clear, the cysticercus is easily seen by direct ophthalmoscopy or biomicroscopy. However, in the presence of opaque media, ultrasonography may be valuable in detecting the cyst. When the cyst is subretinal, it shows a curvilinear echo corresponding to the cyst wall. Often, the scolex is seen as a round density connected to this curvilinear echo. A V- or Y-shaped echogenic structure representing the detached retina overlies the cyst. When the parasite is intravitreous, sonography shows a curvilinear cystic structure floating freely in the vitreous cavity. The intravitreous inflammatory reaction around the cyst may cause low to medium echoes in the vitreous cavity suggestive of turbid material. An important aspect of the sonography study is the possibility of observing the parasite’s movement in the vitreous chamber. Ultrasound imaging is valuable for demonstration and localization of the cyst.18,19,20

Computed tomography (CT), if properly performed, can detect intraocular cysticercosis in addition to intracranial cysticerci. CT may show pinhead areas of increased attenuation. At times, however, it may be difficult to appreciate the cyst in some patients due to the very low density difference between the cyst fluid and vitreous fluid. Ultrasound imaging is especially useful in such cases.

In conclusion, ultrasound is the investigation of choice for evaluation of intraocular cysticercosis because vitreous fluid acts as good acoustic media to detect subtle difference of density between the cyst wall and vitreous fluid. This added advantage of sonography being noninvasive, nonionizing, and easily available makes it an useful diagnostic tool in investigation of intraocular cysticercosis.

References
Sonographic Appearance of Klippel-Trénaunay-Weber Syndrome Diagnosed at 18 Weeks Gestation

DEBORAH A. HUBACZ, BA, RDMS

Presented is a case of Klippel-Trénaunay-Weber (KTW) syndrome. This rare syndrome is associated with a triad of anomalies including varicose veins, cutaneous hemangiomas, and bony or soft tissue hypertrophy. The prominent sonographic finding is multiple cystic areas or localized edema most often located on the lower torso of the fetus. Findings suggestive of KTW syndrome were noted following an 18-week gestation fetal survey and were later confirmed at autopsy.

Key words: Klippel-Trénaunay-Weber syndrome, hemangioma, port wine stain, hypertrophy, lymphangioma

Klippel-Trénaunay-Weber (KTW) is a rare syndrome consisting of a triad of features including varicose veins, cutaneous hemangiomas, and bone or soft-tissue hypertrophy. One or more cystic areas or localized edema are usually the first sonographic features noted. KTW can affect any part of the fetal anatomy but most often is identified on the torso, buttocks, or lower extremity.Typical presentation of KTW is asymmetric limb hypertrophy usually involving a leg. There is increased arterial flow to the affected area that may be confirmed with color flow Doppler. Symptoms are variably expressed, and each case of KTW is unique.

The inheritance factor of KTW is sporadic, and the etiology has yet to be determined. It has been hypothesized that the condition is linked to abnormalities in the fetal regulation of growth factors.

There are few cases of prenatally diagnosed KTW found in the literature. A majority of reported cases were similar to this case in that they proved to be severe and involved more than one extremity.

Case Presentation

We present a case of KTW syndrome seen in a 32-year-old primagravida presenting at 10 weeks, 2 days gestation with a history significant for breast cancer 5
years prior at age 27. The patient underwent breast conservation surgery and primary breast radiation and received six cycles of adjuvant chemotherapy. Because the patient was premenopausal and expressed a strong desire to have children, tamoxifen therapy was not used.

The patient underwent a brief course of successful infertility treatment. Prenatal genetic counseling was ordered secondary to the patient’s breast cancer and a family history significant for Charcot-Marie-Tooth syndrome (hereditary motor and sensory neuropathy). It was determined that the patient in all probability did not inherit Charcot-Marie-Tooth but did have a family history significant for breast cancer. The patient’s family history for breast disease included her maternal grandmother diagnosed at age 53 with breast cancer, the patient’s mother with benign breast tumors, and a sister diagnosed at age 44, also with breast cancer.

An early ultrasound was ordered to confirm viability. At 12 weeks gestation, the fetus was again monitored with ultrasound to assess growth. Both exams appeared normal for gestational age. Alpha fetoprotein screening had been ordered and was low risk for evidence of neural tube defects.

The patient presented for 18-week ultrasound to assess anatomy and growth. Present antepartum course had been uncomplicated by illness, infection, or vaginal bleeding. Ultrasound revealed a single, viable, active fetus with an anterior grade 0 placenta. Cervix measured within normal range with no evidence of funnelling of membranes or fluid within. Amniotic fluid appeared appropriate for fetal age.

Upon examination, it was noted that a 5.5-cm complex multicystic area arised from the fetal left axilla (Figs. 1, 2). The right axilla showed no similar finding. Evaluation of the lower extremities revealed numerous cystic areas involving the left thigh and questionably the buttock area with marked anasarca of the left foot (Figs. 3, 4). The right leg appeared somewhat edematous but to a lesser degree.

Evaluation of the cranial structures revealed a slightly enlarged biparietal diameter and cranial circumference measurement. The cerebellum, cisterna magna, and nuchal fold were identified and measured within normal limits. The right lateral ventricle measured .86 cm with the left showing slight dilatation at 1.5 cm. The right choroid measured within normal limits, but the left measured 1 cm and appeared dangling within the ventricle, raising the suspicion of hydrocephalus (Fig. 5).

The abdominal circumference measurement proved to be larger than expected for the gestational age of the fetus. Multiple intra-abdominal cystic loculations were noted within the bowel mesentery, the largest measuring 2.8 cm (Figs. 6, 7). All other organs were identified with no apparent abnormalities. Genitalia was male.

A follow-up sonogram with a perinatologist was ordered. The findings were confirmed and indicated a lymphangiomatous dilatation and the question of

![FIG. 1. Loculated cystic mass of 5.5 cm arising from left axilla.](image1)

![FIG. 2. Coronal view of cystic area arising from left axilla.](image2)
KTW syndrome or less likely Proteus syndrome. Genetic counseling was ordered, as well as an amniocentesis. The amniocentesis returned with the impression of a male fetus with no detectable chromosomal anomalies.

Considering the ultrasound findings, it was determined that the mild ventriculomegaly probably represented hydrocephalus with no way to predict whether it would increase over the course of the pregnancy (Fig. 5). Mild cases of KTW can be managed expectantly, but this case appeared to be severe, with three extremities and internal organs affected. The hydrocephalus was an additional factor to consider. It was determined that the prognosis for the fetus would be grim. The couple decided to terminate the pregnancy at 23 weeks.

At autopsy, it was determined that the 24-week-old male fetus had multiple subcutaneous capillary and cavernous hemangiomas involving the chest, right leg, and especially the left leg, buttock, and foot (Fig. 3, Fig. 4). The findings were suggestive of KTW. It was determined that the edema resulted from hemangiomas and not from limb soft-tissue hypertrophy. The cystic areas had evidence of lymph, another characteristic of KTW.
**Discussion**

KTW was first described in 1900 by Klippel and Trénaunay. Later, in 1907, Parkes-Weber added the finding of arteriovenous fistulas. The terms KT and KTW syndrome are often used interchangeably. KT syndrome technically includes the manifestations of hypertrophy of a limb and varicosities associated with port wine staining of the skin. KTW includes these findings but includes the addition of arteriovenous malformations with shunting. Prenatal differentiation between the two syndromes is virtually impossible. When vascular lesions involve the face or central nervous system, the condition is referred to as Sturge-Weber syndrome.

The sonographic findings of this syndrome include three hallmark clinical manifestations that may present in varying degrees: (1) varicose veins, (2) cutaneous hemangiomas, and (3) bone or soft-tissue hypertrophy.

**VENOUS VARICOSITIES AND MALFORMATIONS**

Abnormalities of the deep-vein system include subtle to massive dilatation of deep veins, absent venous valves, hypoplasia of the veins, and complete absence of the deep-vein system.

Venous abnormalities involving the affected extremities may present as superficial varicose veins that may not be apparent immediately at birth.

Appearance of the baby within 1 to 2 weeks of birth will provide a reliable indication with regard to the extent of syndrome. Unaffected organs and extremities will not be subject to the symptomatology in the future.

Those afflicted with KTW may have abnormalities of the lymphatic system. Sonographically, it is often unclear whether the edema of the affected extremity is a result of venous insufficiency, abnormal lymphatic drainage, or a combination of the two. In this case, autopsy results indicated a combination of the two.

**CAPILLARY HEMANGIOMAS AND CUTANEOUS LESIONS**

A broad spectrum of cutaneous symptomatology is seen with KTS. The most common manifestation is port wine stains, which range in color intensity from very light to deep maroon. The lesions may be flat or elevated. The skin covering these lesions also varies. The integrity of the skin in some areas of the lesion may be poor and prone to skin breakdown, bleeding, and infections. Increased blood flow to the hemangioma can often be documented with color, pulsed, or power Doppler.

**BONE OR SOFT-TISSUE HYPERTROPHY**

Bone hypertrophy presents as the affected extremity measuring longer than the other. Along with bone hypertrophy, soft-tissue hypertrophy is a symptom of KTW. Soft-tissue hypertrophy usually presents as asymmetrical swelling around the affected limb that may include a combination of anechoic and echogenic cystic areas. This symptom may be localized or widespread. Sonographically, these areas may appear as a localized mass on the back or chest or involve an entire leg or arm (Figs. 1, 2). Areas usually consist of venous structures and fat. Under ultrasound, a soft-tissue mass on the neck may resemble a cystic hygroma. The lower extremities are affected in three fourths of reported cases (Fig. 3). It is most often the longer, or larger, extremity that exhibits the skin or vascular changes.

Over time, these symptoms have the potential to exhibit change. The port wine staining may become lighter or darker as the child grows. Dark nodules, which may be prone to bleeding, may appear on the affected limb. The limb length discrepancy may also become more pronounced. Some complications of...
more severe cases may include arteriovenous fistula with arterial insufficiency and secondary heart disease, as well as persistent hemorrhage. Cardiomegaly was reported in a prenatal diagnosis of KTW.\(^\text{10}\)

Each case of KTW has its own combination and varying degree of symptomatology. There is a male:female ratio of 1:1 associated with KTW.\(^\text{5}\) The earliest prenatal diagnosis was made at 14 weeks.\(^\text{3}\)

The sonographic findings in this condition may mimic other syndromes and anomalies. Careful observation should be made to rule out large abdominal wall defects and to confirm whether the edema is localized or presenting overall. Ultrasound may reveal other limb findings associated with KTW including syndactyly, clinodactyly, polydactyly, or a split-hand deformity.\(^\text{11}\)

Differential diagnosis would include amniotic band syndrome. Amniotic band syndrome usually manifests with localized limb enlargement but not a substantial increase in arterial flow to the area. Proteus syndrome is another differential diagnosis to consider. This syndrome also manifests with sonographic findings of bone overgrowth and cystic areas involving the limbs and internal organs. Unlike KTW, these areas are not hemangiomas or a vein abnormality but truly cystic areas with lymph fluid often found within. There will be no flow seen with color Doppler. Proteus syndrome often presents with the additional finding of macrocephaly.

There is no known cure for KTW syndrome. Conservative symptom treatment may be used in milder cases. Treatment ranges from compression to relieve the effects of edema and to protect hemangiomas from trauma and bleeding to laser therapy to reduce or eliminate port wine stains. Superficial varicose veins may be removed if the deep-venous structures are unaffected and able to compensate. Surgery in early teen years to correct bone length differences is considered if the length discrepancy is more than 2 cm. Surgery to reduce excessive tissue may be required. Rarely, amputation of the limb is considered.

**Conclusion**

Prognosis depends on the type and extent of involvement. Some small vascular anomalies are amenable to surgical correction.\(^\text{12}\) If the vascular malformations extend from a limb to the trunk, the prognosis is more dismal in that this scenario precludes resection.\(^\text{5}\)

Because the extent of the condition may range from mild to severe, the use of ultrasound to accurately document the affected areas is helpful in the diagnosis and management of each individual case.

**References**

Carotid Anomaly in a Patient With Holt-Oram Syndrome

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The authors present a case of a young man diagnosed with Holt-Oram syndrome. He was found to have an additional anomaly, separate ostia for the entire right carotid system, which has not been associated with Holt-Oram syndrome in the past.

Key words: separate ostia, hand-heart syndrome, carotid artery, carotid bruit

Case Presentation

The patient is a young man with a past history of Holt-Oram syndrome (hand-heart syndrome) who presented for a routine well–young-adult visit. He has had chromosomal analysis and is a 46 XY male karyotype. At a few weeks of life, he had a pulmonary banding on his pulmonary artery secondary to a ventricular septal defect. He had this defect completely repaired at the age of 11 months. His family history is negative for other congenital heart diseases, and his social history is remarkable for normal development and education.

Physical examination revealed a well-developed, well-nourished man with an asymmetric-appearing upper face. Blood pressure was 122/60 mmHg in the left arm and 126/64 mmHg in the right arm. Pulse was 64 bpm, weight was 200 lb, and height was 67 in. His right hand is, in fact, smaller than his left hand (the right hand is 13.6 cm in length, and the left hand is 15.6 cm in length). The right thumb is hypoplastic and finger-like, and the patient has hypoplasia of the thenar and hypothenar regions of the right hand. He has bilateral syndactyly of the second and third toes, with feet that are broad. Neurological exam is nonfocal. Cardiac exam reveals a regular rate and rhythm, S1, S2, without any obvious S3 or S4. There is a I-II/VI systolic ejection murmur loudest at the left upper sternal border second intercostal space. There are no obvious heaves or lifts. He does appear to have bilateral carotid bruits on auscultation, but otherwise the carotids are strong. There is no jugular venous distention. His face, as mentioned above, is rather...
broad and has a mild anti-Mongoloid slant to the eyes. There is hypertelorism, a prominent chin, and a low posterior hairline.

Echocardiogram showed normal chamber sizes with normal left and right ventricular wall motion without any obvious color flow abnormalities or intrachamber communication.

A carotid ultrasound was obtained, given the patient’s bruits, which showed an anomalous origin of the right internal and right external carotid arteries directly from the right innominate artery. The left common carotid arose from the aorta, and the left vertebral arose from the left subclavian (Figs. 1, 2, 3).

**Discussion**

Our patient had been seen by genetic specialists and was diagnosed with Holt-Oram syndrome. He met the criteria proposed by Zhang et al, that is, an inherited disorder with a cardiac defect (in his case the ventricular septal defect) and upper extremity skeletal abnormalities.

Our patient presented with one slightly different finding, that being the lack of a common carotid artery on the right side. He was noted to have no right common carotid artery arising from his innominate vessel on the right side. In place of this, he had separate ostia for the internal and external carotid systems. There have been reports of other vascular abnormalities of the intracerebralcirculation in patients with Holt-Oram syndrome. In reviewing the past and present literature on Holt-Oram syndrome, we have not come across any reference to abnormalities involving the extracranial carotid circulation.1-10

Koutlas et al described a patient who developed an intracerebral hemorrhage due to intracerebral vascular abnormalities. Their patient had no extracranial abnormalities. Our patient, on the other hand, did have extracranial abnormalities, namely, the separate ostia of the external and internal carotid arteries off the right subclavian. Whether these could possibly cause pathological consequences in this patient’s future is unknown. In addition, the presence of the bruit in our patient may be due to the transmission of the cardiac murmur, not to the turbulence within the anomaly. But at least identifying this anatomical variance at his age would help with future disease surveillance.

In addition to a screening echocardiogram for a patient suspected of having Holt-Oram syndrome, we
suggest adding extracranial carotid ultrasound if a carotid bruit is auscultated. Ultrasound of the carotid anatomy is a relatively inexpensive, comfortable, and noninvasive procedure that can help in the management of these patients. However, we realize that this abnormality may not be due to Holt-Oram syndrome. Early diagnosis and identification of such extracranial abnormalities could prevent or assist in the diagnosis of cerebrovascular pathology.

References

Ultrasound Evaluation and Clinical Management of Persistent Gestational Sac in a Cervical Ectopic Pregnancy

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Early diagnosis with vaginal ultrasound is critical to the conservative management of cervical ectopic pregnancy. Ultrasound findings of a persistent gestational sac within the endocervical canal during medical treatments, when accompanied by a continued decline in HCG levels, does not necessarily signal a failure of the medical treatment.

Key words: cervical ectopic pregnancy, methotrexate, potassium chloride, endovaginal

Cervical ectopic pregnancy (CEP) is the rarest form of ectopic gestation. The incidence of cervical ectopic pregnancy is estimated to be 1 in every 2400 live births in the United States. Early diagnosis with vaginal ultrasound is critical to the conservative management of CEP and in preserving future reproductive capacity. Catastrophic consequences can occur at the time of a dilatation and curettage (D&C) in an unsuspected CEP. Massive hemorrhage historically results in rates of hysterectomy as high as 50%. Medical therapy with methotrexate alone or in combination with intrafetal injection of potassium chloride (KCl) is rapidly becoming the treatment of choice in CEP.

This is the first report of sonographic findings and clinical management of a persistent gestational sac in the successful medical management of CEP.

Case Presentation

A woman in her early 30s gravida 2 para 0 with a 6-week history of amenorrhea presented to the emergency room with bright red vaginal bleeding and acute onset of lower abdominal pain. Her history was significant for a cone biopsy more than a decade ago and for treatment of chlamydial cervicitis. Initial quantitative human chorionic gonadotropin (hCG) was 2269 mIU/mL. An endovaginal ultrasound demonstrated a small fluid collection in the cervical canal suspected of being an impending spontaneous abortion. Three days after initial ultrasound, the hCG level rose to 5144 mIU/mL and a transabdominal and endovaginal evaluation was performed. A Siemens
450SI ultrasound unit with a 5-MGz curved linear array and a 5- to 7.5-MGz vaginal probe was used. A gestational sac of 12 mm with a viable crown rump length of 4.8 mm located within the endocervical canal confirmed CEP (Figs. 1, 2, 3). A single dose of methotrexate was given intramuscularly (50 mg/m² body surface area). Endovaginal ultrasound 48 hours after methotrexate injection demonstrated a persistent viable ectopic pregnancy with a quantitative hCG level at 7902 mIU/mL. Two days later, the hCG titer rose to 11,327 mIU/mL. Transabdominal ultrasound guidance was used to pass a 21-gauge needle transcervically into the gestational sac. An injection of 1.6 mL of KCl (40 mEq/mL) was administered, and immediate cessation of fetal cardiac activity and collapsing of gestational sac ensued (Fig. 4). Seventy-two hours after the KCl injection, the hCG level declined to 9357 mIU/mL. Serial hCG levels showed a continual decline (Fig. 5); however, repeated endovaginal ultrasounds demonstrated a persistent and enlarging gestational sac. Thirty-five days after the KCl injection, the gestational sac had increased in size and developed an acute
inflammatory process surrounding the sac now measuring $3.6 \times 2.4 \times 3.2$ cm (Figs. 6, 7). Although the hCG level had declined to 480 mIU/mL, the patient began to experience heavy vaginal bleeding that persisted for 3 days. A suction curettage under general anesthesia was performed with a 10-mm canula. An approximately 1 cm mass of necrotic tissue was removed. Surgical pathology demonstrated products of conception and first trimester type chorionic villi. Estimated blood loss during the surgery was less than 5 mL. Eight days after surgery, the hCG level was < 5 mIU/mL. Follow-up ultrasound 10 days after surgery revealed a normal uterus and normal appearance of the cervix.

FIG. 5. Graph correlating human chorionic gonadotropin levels over a 42-day course of time from discovery, methotrexate injection, potassium chloride procedure, and curettage.


FIG. 7. Coronal endovaginal scan of persistent cervical ectopic pregnancy after methotrexate and potassium chloride injection.
Discussion

Recent conservative medical management treatments that have been reported for use in CEP are methotrexate alone or in combination with KCl injection directly into the gestational sac, cervical cerclage,\(^2,3\) surgical ligation of the cervical branch of the uterine arteries\(^4,6\) followed by use of a large Foley catheter to tamponade intracervical bleeding after D&C.\(^2,6-8\) Bilateral hypogastric artery ligation and percutaneous hypogastric artery embolization\(^10,12\) have also been used to prevent or treat catastrophic hemorrhage. In a review of CEP, Ushakov et al\(^13\) outlined five necessary conditions for the conservative medical management of CEP:

1. A reliable diagnosis of CEP.
3. Menstrual age of < 10 weeks for viable CEP.
4. Absence of active renal or hepatic disease.
5. Absence of thrombocytopenia or leukopenia.

Conditions 1 and 3 require careful and accurate sonographic evaluation of the patient.

Despite current literature on the success of single-dose methotrexate and KCl injections, the viable CEP encountered in this report was complicated by the persistent and enlarging gestational sac with heavy vaginal bleeding in spite of declining hCG levels. Ushakov et al\(^13\) reported that to achieve successful eradication of the aberrant trophoblast tissue, concomitant use of a minor surgical procedure may be necessary under some circumstances.

This report demonstrates that in spite of a persistent and enlarging gestational sac in CEP, methotrexate and KCl therapy was successful. Careful monitoring of falling hCG levels to < 500 mIU/mL provided for an uncomplicated D&C, preserving the patient’s reproductive capacity.

References

Hypochondrogenesis:
A Rare Lethal Skeletal Dysplasia

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A case of achondrogenesis/hypochondrogenesis type II was reported in the fetus of a 24-year-old woman. The sonographic diagnosis was made at 16 and 18 weeks gestation, when shortened long bones and a narrow, hypomineralized spine was observed. Targeted scans at a tertiary high-risk center confirmed the diagnosis. The patient chose to terminate the pregnancy due to the lethal nature of this condition. This case demonstrates the value of routine scanning in the early detection of various fetal abnormalities, including those seen in skeletal dysplasia.

Key words: skeletal dysplasia, achondrogenesis, hypochondrogenesis, dwarfing condition

Skeletal dysplasia occurs with the abnormal development of the cartilaginous and osseous tissues, resulting in bones that appear shortened, thinned, or deformed, or that fall more than two standard deviations below normal.1-4 Evidence of skeletal dysplasia requires a detailed anatomic scan. Skeletal dysplasia, sometimes referred to as a dwarfing condition, is usually suspected because of family history or a short femur measurement. As a group, lethal skeletal dysplasias are rare. Affected fetuses may exhibit normal long-bone growth patterns until 21 to 26 weeks and are not always detected prenatally by ultrasound imaging. A sporadic occurrence of these types of dwarfism may be missed if the patient’s only ultrasound examination occurs before 26 weeks.1

Case Presentation

A patient in her mid 20s (gravida 3, para 1, TAB 1) was referred for pregnancy at approximately 8 weeks gestation. A single intrauterine pregnancy with positive embryonic cardiac motion and a crown-rump length at approximately 8.9 weeks gestation was found. A repeat study approximately 2 months later showed fetal head and abdominal growth consistent with the patient’s menstrual age. The femur and humerus appeared shortened, measuring approxi-
approximately 3 weeks less than the measurements of the head circumference and abdominal circumference. The fetal spine appeared narrow and hypomineralized (Fig. 1). These findings suggested the possibility of skeletal dysplasia. A third study, performed 1 week later, confirmed a lag time in long-bone development with a measurement approximately 4 weeks less than gestational age (Fig. 2). Additionally, a relatively small fetal chest, protuberant abdomen, and mild ventriculomegaly were noted (Fig. 3). The fetus remained in an occiput anterior, transverse lie throughout all studies. This position permitted clear demonstration of nuchal thickening (Fig. 4) but precluded detailed investigation of the fetal face. A differential diagnosis of achondrogenesis or thanatophoric dysplasia was made based on the accumulated abnormal findings.

The patient was referred to a high-risk center for further evaluation and classification of the skeletal dysplasia, and for counseling. A targeted sonographic evaluation at 20 weeks gestation confirmed the previous findings. Also noted was markedly deficient ossification of the distal spine, a smaller than expected thoracic circumference, and clubbing of the feet. The diagnostic conclusions offered to the patient were probable achondrogenesis with a less likely possibility of thanatophoric dysplasia.

**FIG. 1.** Transverse scan of a single fetus in transverse lie demonstrating mild ventriculomegaly and a hypomineralized and narrowed fetal spine.

**FIG. 2.** Demonstration of an abnormally shortened femur.
After counseling, the patient chose to terminate the pregnancy. Postmortem pathology indicated a 330-g female fetus with short limbs, short thorax, micrognathia, bilateral ankle clubbing, hydroptic changes, ascites, cartilaginous vertebral bodies, and a posterior cleft palate. These findings were consistent with the collagen type II disease of hypochondrogenesis.

Discussion

Collagen is a protein component of bone, cartilage, and connective tissue. Several skeletal dysplasias are due to changes in a specific protein called type II collagen. These dysplasias include hypochondrogenesis, spondyloepiphyseal dysplasia congenita, spondyloepimetaphyseal dysplasia, Strudwick spondyloepimetaphyseal dysplasia, and Kneist dysplasia. 5-11

The type II collagen disorders have common clinical and imaging findings including spinal changes resulting in a short-trunk form of dwarfism. This case demonstrated a majority of the sonographic features associated with skeletal dysplasia (Table 1). Babies with hypochondrogenesis show signs of focal hypomineralization; the spine and sacrum are demineralized, and the head may appear large and oval shaped even though the skull is normally ossified.

Flattened facies and hypertelorism are associated findings, and a cleft palate is often present along with micrognathia. The abdomen may appear pear shaped due to shortening of the ribs and narrowing of the chest. Club feet may be present. 3-7

Hypochondrogenesis is inherited as an autosomal dominant manner, and usually there is no prior history of the condition in the family. It is currently thought to be the consequence of a genetic change in the type II collagen gene of normal-sized parents. 6,8 The incidence of hypochondrogenesis is rare, with probably less than 100 cases reported. 1-5
Early diagnosis of hypochondrogenesis provides the patient with the option to terminate. Later diagnosis is also valuable because it allows the patient time for counseling and preparation.

Because sonographers are most often the first to visualize the problem, they must be familiar with the sonographic signs of the anomaly. The importance of understanding the gestational age at which characteristics of the disorder may present and the necessity of careful long-bone measurements cannot be overstated. Each fetal limb should be imaged and measured during routine obstetrical sonographic examinations. Sonographers need to be alert to the fact that true bowing of a limb or artifactual shadowing from overlying limbs may give the appearance of a shortened long bone. The presence of abnormal mineralization may result in a reduction in echogenicity of the bone. The reduced echogenicity may make long-bone imaging difficult or may give a false impression that the long bones are very thin. Calculation of the thoracic circumference/abdominal circumference ratio is equally important to rule out the presence of an abnormally narrow thorax. The normal thoracic circumference/abdominal circumference ratio is 0.89.‡

Sonographers should routinely check for the presence of other associated abnormalities including polyhydramnios, polydactyly, club foot, abnormal nuchal thickening, cleft lip or palate, cardiac defects, and the presence of a two-vessel umbilical cord.

In the hands of skilled operators and interpreters, sonography has proven to be the most accurate imaging modality for the early detection of skeletal dysplasias.

References


| TABLE 1 |
| Sonographically Visible Features Strongly Associated With Lethal Skeletal Dysplasia |
| Abnormal calvarium |
| Abnormal spine |
| Shortened long bones |
| Small thorax |
| Hypomineralization |
| Multiple fractures |
| Polydactyly |
| Nonimmune hydrops |
| Polyhydramnios |
| Abnormal posturing or immobility |
Sonographic Findings in Fetal Alpha Thalassemia Major

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JULIA SHVETSOVA, BS, RDMS, RVT

Alpha thalassemia major is an autosomal recessive disease found mostly in Southern Chinese and Southeast Asians. It is caused by deletion of alpha globin genes. Normally, there are four alpha genes. Some cases lead to lifelong dependence on transfusions, with iron buildup and shortened life duration. Depending on the number of genes affected, the fetus may die in utero or very soon after birth.

Key words: alpha thalassemia, hydrops fetalis, ascites, prenatal ultrasound

Alpha thalassemia may present with several syndromes of differing severity:

1. With a single gene deletion, no abnormality is detected.
2. With two genes affected (alpha thalassemia minor), the clinical consequences are slight anemia and mild to moderate microcytosis.
3. With three genes affected (hemoglobin H disease), the abnormal cells at birth contain a mixture of hemoglobin Bart’s, hemoglobin H (four beta globin chains), and hemoglobin A. The neonate can appear well at birth, but hemolytic anemia develops after infancy.
4. With all four genes affected (alpha thalassemia major), postnatal life is not possible. The hemoglobin in the fetus consists mainly of hemoglobin Bart’s, which has increased affinity to oxygen. The fetus dies in utero or soon after birth.

Alpha thalassemia major is the most severe form of alpha thalassemia. Ultrasound findings associated with the disease are frequently made in the last months of pregnancy and commonly indicate a hydropic fetus. There can be other congenital anomalies, although none are distinctively characteristic for alpha thalassemia major. The mother frequently exhibits toxemia and can develop severe postpartum hemorrhage. Affected infants are usually stillborn. The fetus demonstrates typical features of nonimmune hydrops fetalis. Because alpha globins are required for

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production of fetal and adult hemoglobin, the fetus suffers from hypoxia. These babies can have other complications associated with hydrops, such as heart failure and pulmonary edema.

We report a patient displaying the most severe form of alpha thalassemia, also known as hemoglobin Bart’s hydrops fetalis.

**Case Presentation**

A 19-year-old pregnant woman of Chinese descent (gravida 3, para 0020) was referred for an obstetrical ultrasound. She was a late registrant (26 weeks, 5 days). Review of the patient’s medical records revealed that both the patient and her husband had alpha thalassemia. Her two previous pregnancies ended with embryonic demise at approximately 8 to 9 weeks gestation.

An obstetrical ultrasound demonstrated a single, live, intrauterine gestation, with the fetus in cephalic presentation. Evaluation of the fetal anatomy performed with a 5-MHz transducer revealed multiple abnormalities: fetal hydrops with cardiomegaly (cardiac thoracic ratio > 50%) (Fig. 1); pericardial effusion (Fig. 2), ascites (Fig. 3), and subcutaneous thickening with edema (Fig. 4); and protruding abdomen possibly indicating enlargement of liver and spleen (Fig. 5). These complications are commonly associated with alpha thalassemia major.\(^5\)

The anatomy scan also suggested skeletal dysplasia, that is, abnormally shortened long bones (Figs. 6, 7). The left hand appeared to be abnormal, with short, “stumpy” fingers (Fig. 8), and the right foot appeared to have three toes (Fig. 9). These findings are nondistinctive for characterizing alpha thalassemia major.

**Patient Management**

After ultrasound, the patient was referred for genetic counseling. She was also closely monitored by her obstetrician/gynecologist. At 31+ weeks gestation, the patient developed preeclampsia and underwent induction and vacuum extraction of a stillborn baby boy weighing 2700 g (6 lb). The hydropic infant appeared edematous, skin color was bluish due to subcutaneous edema, ascites was noted in the abdomen, fingers and toes were malformed, and the genital area was maldeveloped. Further evaluation of the fetus was not possible because of the parent’s refusal of autopsy.

**Conclusion**

The diagnosis of alpha thalassemia can be suspected from a thorough maternal history. It is a disease of varying severity depending on the number of gene deletions. In its most severe form (alpha thalassemia major), it usually leads to hydrops fetalis, in utero demise, or perinatal demise. Hemolytic anemia, when suspected, can be evaluated by amniocentesis to check for bilirubin, a by-product of red blood cell breakdown. Cordocentesis can be used to classify the specific hemoglobinopathy that is encountered.\(^5\) In utero transfusions can help treat the anemia and its consequences. There are reports of survival and...
FIG. 3. Coronal scan through the abdomen shows ascites.

FIG. 4. Sagittal scan shows subcutaneous thickening with edema.

FIG. 5. Sagittal scan shows thoracic/abdominal disproportion.

FIG. 6. Graph showing abnormally shortened femur.

FIG. 7. Graph showing abnormally shortened humerus.
chronic transfusions in infants with alpha thalassemia. More of these infants can be saved if the diagnosis is projected based on clinical history and prenatal ultrasound, and treatment is provided.

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DIAGNOSTIC CHALLENGE

BRIANNA M. WHITWORTH

History: A woman in her mid-forties presented with nausea, fever, and severe right upper quadrant pain post cholecystectomy times 2 weeks. Her hemoglobin and hematocrit were decreased. However, her white blood count was at a normal level.

The answer is on page 367.

FIG. 1. Image of the right lobe of the liver. This is a longitudinal view through the right lobe at the level of the portal vein. Note that the anterior section of the liver is hypoechoic with internal echoes. The normal liver parenchyma is in the posterior aspect. The portal vein lies within. It is echogenic because of the oblique angle catching the lining of the portal vein. The hypoechoic lesion on the anterior surface of the liver is encased in the Glisson’s capsule, so it involves the liver. There is fluid superior to the diaphragm, or a pleural effusion.

FIG. 2. Transverse image of the right lobe of the liver. Again, note the hypoechoic area in the anterior aspect of the right lobe. It is anechoic with a few internal echoes representing some debris. The normal liver parenchyma is posterior to this lesion. This is about midway in the liver. The fluid superior to the diaphragm is easily seen, enough to properly diagnose a pleural effusion.

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There was no premonition, no bolt from the blue, when sonographer Sandra Karol awoke that February day. It was simply a day off, to be used to indulge oneself; a day to be enjoyed. All of that was about to change as she tuned into a program about Project V-Day, dedicated to stopping violence against women by empowering them. Viewers were urged to think about how they could use their lives to end the pain and suffering being endured by women throughout the world.

Long after the program ended, Sandy couldn’t stop thinking about what she could do to help. She found herself looking around and taking stock of her life. She had everything she needed: a loving family, good friends, and a satisfying ultrasound career. All in all, it was a very comfortable life. But, a question prompted by the television show kept intruding on her thoughts. What could one lone person do? She recalled the early days of her career, when she had volunteered to go to Africa under the auspices of Africare. Even after political instability and the ensuing violence in the region forced her to put that dream on hold, she felt a special bond with Africa. Random thoughts tumbled through her mind well into the night, but by morning she began putting them down on paper. She listed what she, as an individual, might offer to such a project. She possessed a knowledge and love of ultrasound, time, energy, and a desire to help. Slowly, a new thought began to take form, and by midday she had formulated a plan.

When my phone rang that day, I had no idea that I was about to become a recruit. The caller was my friend, Sandy Karol. After we exchanged pleasantries, she asked me what I knew about Project V-Day. “Not a whole lot,” I said. “I know what it stands for. Why?”

“Because, I’m interested in getting involved and I’d like to run an idea by you. I’ve decided that I want to send a portable ultrasound unit to Africa. In order to make that happen, I figure I need to accomplish four things: secure an ultrasound unit, find someone who needs and will use it, find a sonographer to provide
training, and come up with round-trip travel to Africa. What do you think? Is it doable?"

I recall feeling a little skeptical, but not wanting to discourage her completely, I answered cautiously, “Well, anything is possible . . . but this sounds like a major undertaking. Are you willing to invest the time and energy necessary to actually pull it off? Do you have any resources or even a plan?”

“Yes to the first, no to the second, and, sort of,” she replied. “I contacted someone at Project V-Day and was referred to several women’s groups and humanitarian organizations. They all thought the idea was terrific, but it just isn’t the sort of thing that they are equipped to do.”

“That’s not surprising, Sandy. Think of all the bureaucracy that exists in large organizations. There must be hundreds of stumbling blocks. If your goal is to get aid to the people who need it, you would be better off dealing with them directly. Last year, I wrote about two sonographers from New York who went to teach in Africa for a month, and I know of another sonographer who is there right now developing an educational program. Why not contact them to see if they have any ideas or advice?”

The conversation ended after she had taken down the sonographers’ contact information, and I had politely asked her to keep me informed. I put the matter on my mental back burner, convinced that it would be some time before I would be hearing from Sandra Karol again.

I couldn’t have been more wrong. Sandy phoned or e-mailed me daily to report on her activities or plans, and to occasionally ask for information or opinions about her progress. And, what progress she made! She began her crusade with a campaign of phone calls, faxes, and e-mails. She seemed able to interest and recruit almost everyone she contacted into a rapidly growing network of corporate, professional, sonographer, and lay volunteers. With every call, she received encouragement and often referrals to someone else who might be able to help her.

Acting on my earlier advice, Sandy contacted Ann Polin in Ghana and heard firsthand about the ultrasound program she had developed. Ann gave her many insights and also mentioned the need to find other sonographers who would be willing to take her place when her year in Ghana was up. She then spoke with Kathy Velekkakan and Barbara Rosenberg in New York. Sandy sounded elated when she reported that they were delighted with the prospect of returning to Africa. With the encouragement of their families and employers, the two sonographers had quickly arranged to spend their vacations delivering the equipment and providing 30 days of instruction.

Incredibly, another problem was solved when Kathy Velekkakan suggested that the Medical Missionaries of Mary might be good candidates for the equipment. Sandy wasted no time in making that contact and learned that the organization maintained 60 missions in 14 different countries, Africa among them. The nun she spoke with could hardly believe the offer and assured her that the community would be very grateful for such a magnificent gift. So it was, that in less than a week, half of the necessary goals had been achieved.

Karol then turned her attention to finding someone willing to provide ultrasound equipment. From the outset, she was convinced that a hand-held ultrasound unit was essential. On the strength of that conviction, she dubbed the project Hand-Held Africa. Then, always starting at the top of the corporate ladder, she placed calls to several manufacturers, including Kevin Goodwin, CEO of SonoSite Inc. in Seattle.

To her amazement, her call was put through and she found herself explaining the nature of her call and her request. Goodwin listened patiently as she described the special requirements she thought the setting called for, describing the rigors of transportation by jeep over dusty, almost nonexistent roads. She stressed the need for a battery backup because of the unreliability of power in the remote areas of the country. Goodwin, undaunted by the parameters she had specified, agreed to consider her request and asked her to send him an overview of the project.

In her reply, Sandy described how very differently the many organizations that constituted the Project V-Day coalition were addressing the problems of violence toward women. Whereas one organization gave Afghani women video cameras to film the brutality to which they are subjected; another gives cattle to women or villages as a means of increasing the status of women and to hopefully avoid spousal beatings. She later shared that correspondence with me, and I was particularly impressed with her closing argument:

Little and big things move mountains! My project is simply a way of “giving something back” for the scholarship that brought me into ultrasound. I know
and love ultrasound—especially obstetrical sonography and its ability to save the lives of both mother and child. That’s it. Period. I’ve gathered an angel network to help me find and deliver a very simple one-to-one donation to several hard-working nuns in a small village in Tanzania. With your help, they could see 100 patients a week, 100 babies a week . . . perhaps as many as 5000 women per year!

In mid-April, SonoSite adopted the role of corporate “angel” with its promise of a SonoSite 180 to the Hand-Held Africa project.

To overcome the hurdle of transportation, Sandy brainstormed with her growing network. Several ideas were proposed, such as identifying firms that did business in Africa to see whether they would allow our sonographers to “hitch a ride” on their corporate jets. Another thought was to ask for the donation of frequent flier miles from members of the ultrasound community. The final suggestion involved identifying those airlines that provided regular service to Africa and exploring the possibility that they would be willing to provide the transportation as a humanitarian gesture. As luck would have it, one of Sandy’s close friends mentioned that British Airways provided regular service to Africa. She placed a call, and within a matter of days John Lampl at the New York office of British Airways agreed to check on the matter. Her request was granted and confirmed, with a promise to provide round-trip tickets from New York to Africa whenever our sonographers wished to travel.

In only 60 days, Sandy Karol had accomplished the goals necessary to make Hand-Held Africa a reality. From the beginning, everyone who heard about the plan reacted positively. The spread of the news by word of mouth resulted in complete strangers contacting her to offer advice, opinions, and services. One of Sandy’s friends, a private duty nurse in Florida, discussed the project with a patient. That man, Geoffrey Hurt, contacted Sandy with concerns about the need to frequently recharge the ultrasound unit’s lithium batteries using a gas-powered generator. He proposed the less-expensive alternative of using solar power instead, and offered his engineering talents if required. Ben Deeley, the SonoSite sales representative for North Carolina, mentioned the project to a friend who had developed a compression program for use on the Internet. His friend has volunteered his services as a consultant to make it possible to send the African-generated real-time images to any interpretive team or sister hospital back in the United States. A number of sonographers who have heard about the project have contacted Sandy and volunteered to staff any future projects, wherever they might be. To date, 27 “angels” have gathered to ensure that Hand-Held Africa successfully launches in January 2002. And in so doing, they have provided the proof that, indeed, anything is possible.

As I began collecting information for this story, I contacted Kathy Velekkakan and Barbara Rosenberg to get some impressions about their upcoming adventure. Kathy commented:

We are going to Kabanga Hospital in Northwestern Tanzania, close to Lake Tanganyika,” said Kathy. “We will be working with Dr. Nuru, a Tanzanian doctor, and an as-yet-unnamed nurse practitioner. This 155-bed hospital serves the Waha tribe, who speak Kiha and Kiswahili. In addition, because of an influx of refugees from Burundi and the Congo (formerly Zaire), the Akgoma Hospital has set up a clinic at a United Nations refugee camp. Having a small, portable ultrasound unit will be very helpful in this clinic.

I’m so happy to be going back to Africa. When we returned home after our first trip two years ago, we began looking for another opportunity to serve. The Medical Missionaries of Mary is family to me, and having the chance to return, this time to one of their hospitals, is like serving your sister or your mother. I am currently an associate member of the organization. . . . Associate members are individuals who have a close commitment to the community, but who do not take vows.

Twenty-five years ago, as a young woman, I entered this community hoping to make my vows and stay for a lifetime. Hand-Held Africa represents the first time in all of those years that I will have a chance to fulfill that original call. Now that I’m a wife and mother, I’d like my family to feel our responsibility towards the world and our sisters and brothers in places where there is so much need.

The other half of the sonographer team, Barbara, had this to say:

I can’t believe that I’m actually going to have the opportunity to travel to Africa again. Our experience last time was truly life changing. We even hope to be able to see our Kenyan friends, since Tanzania is right next door to Kenya. But I have to keep reminding myself that those are countries, not states, and the
distances are very great in Africa, not to mention the logistics of travel and lodging.

This new adventure will be different from the last, in that the conditions are going to more primitive than before. In Kenya, we were still near city amenities such as automobiles, stores, and an airport. I don’t think that will be the case where we’re going in Tanzania. It is not in an area frequented by tourists, as it is somewhat inaccessible. I’m going into this venture a little more informed than last time, but that just means I’m expecting more surprises, and I understand that I must learn to just go with whatever comes along.

We plan to take some reference books with us for the hospital. I really feel that the books will be indispensable, not only for our students but for us too, since I know we will see things in their patients that we have never encountered in upstate New York.

I also checked in with Sandra Karol to find out what she and her “angels” were going to do with all of their free time:

Hand-Held Africa is pretty much in a holding pattern until January. I don’t know about the rest of my angel team, but as I look back on what we accomplished, I’m still amazed at how everything came together so quickly.

I recently found out that the Medical Missionaries of Mary have several missions in Brazil. Now that we have such a large network and have some experience under our belts, I’ve been thinking . . . A for Africa, B for Brazil. Do you think it’s doable?

During the course of her odyssey, many people have asked Sandra Karol why she decided to tackle such a project. She always gives this reply:

My inspiration is Mother Teresa, who was only 4 feet, 11 inches tall. She worked in the mud. She never asked for a dime, but she changed the world, one good deed at a time.

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Answer to Diagnostic Challenge

Subcapsular hematoma on the anterior surface of the liver

Postoperative complications are rare following a cholecystectomy. However, they do occur occasionally. The complications include common bile duct injury, retained cystic duct stones, hepatic artery injury, and fluid collection due to an abscess or hematoma. A small area of the liver can be punctured, which causes a pooling of blood within the capsule of the liver. The patient’s severe pain was due to the pooled blood that stretched the Glisson’s capsule that surrounds the liver. The hypoechoic area measured $8 \times 15 \times 22$ cm. The common hepatic and common bile ducts measured within normal limits. The surrounding liver parenchyma was of normal echogenicity. This focal lesion may be confused with a biloma, hematoma, or an abscess. A biloma is a collection of bile outside of the ductal system. It can appear as upper abdominal fluid that has collected. An abscess is an area of infection and can cause a fluid buildup in an area. An abscess usually causes the white blood cell count to increase because of the infection, but this patient had a normal white blood cell count. We still cannot rule it out. A hematoma is a pooling of blood in an area that can be septated due to blood coagulation and the blood settling. Fresh blood appears anechoic and becomes more echogenic as it ages. Hematomas can also appear anechoic with aging.

In this patient, sonography could not provide a definitive diagnosis. The primary method of confirmation of a hematoma is to drain the lesion and examine the material. The patient underwent aspiration of the area under computed tomography the following day after the ultrasound. With a guidewire and drainage catheter placement, the area was drained. A 14-French drain 100 cc of old-blood-appearing fluid was removed with a large amount of fibrinous material within. The fluid was not sent for lab tests. This material’s appearance confirmed that it was a hematoma. If the area had been a biloma, the fluid would have been a greenish color. Had the area been an abscess, the fluid would have had a thick pus appearance. The punctured area healed, the pain was relieved, and the patient had no other complications.
LETTER TO THE EDITOR

The case study titled “Pyomyositis: A Differential Diagnosis for Venous Thrombosis” (Journal of Diagnostic Medical Sonography 2001;17:258–262) was interesting from a clinical perspective but contained some significant technical errors that escaped the author’s attention. Figure 1, captioned “Doppler signal taken from dorsalis pedis artery demonstrating normal flow,” is a split-screen image showing a center-steered color box and Doppler sample volume placed perpendicular relative to the plane of the dorsalis pedis artery and vein. The spectral waveform shows what appears to be a low velocity, low resistance arterial waveform that the author interpreted as normal flow. I have two concerns with this presentation.

First, although the ultrasound beam (sample volume) angle is labeled as 60° to the artery on the image, the true angle is clearly closer to 90°. This extremely steep beam-to-vessel angle produced a very poor (low) frequency shift that significantly reduced the system’s sensitivity to (1) detect low-flow states and (2) display subtle but diagnostically important velocity information. The erroneously displayed sample volume angle of 60° adds to the measurement error, resulting in an artificially low arterial velocity. If the sample volume had truly been adjusted to a 60° angle, the cursor “wings” would have been aligned parallel to the vessel walls. Clearly, this image confirms that the angle adjustment cursor is not aligned parallel to the arterial wall.

Second, the arterial waveform is labeled as “normal flow” when, in reality, the waveform does not represent a normal dorsalis pedis artery velocity pattern; nor can we determine whether the flow state is normal. The word flow implies “volume flow.” Blood flow velocity and volume flow are not the same measurement. The relatively high diastolic flow velocity implied by the spectral display would suggest more of a hyperemic state, which is abnormal for a pedal artery. Unfortunately, the 90° sample volume angle “desensitized” the frequency shift to the point where one cannot accurately determine whether a more high-resistant, “normal,” reverse flow component exists. It is logical to assume that the patient could have vascular hyperemia secondary to the initially diagnosed hypervascular mass and staphylococcus aureus infection. Therefore, a relatively high end-diastolic (low-resistance) velocity would be expected.

Misplacement and misalignment of the sample volume relative to the orientation of the blood vessel is the most common source of diagnostic error in vascular sonography. The high precision required to accurately detect and analyze both normal and complex pathological vascular disease states makes it imperative that the sonographic practitioner understand the pitfalls of Doppler beam steering and angle-related velocity estimate errors. It is unfortunate that the angle placement error also escaped the editorial review process.

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Electronic Submission of Journal Articles

RICH DEMPSEY, RDMS, RVT

Many medical journals now accept electronic submissions of material for publication. Recently, the Journal of Diagnostic Medical Sonography (JDMS) has joined this growing list. Each publication has its guidelines for authors, which need to be obtained and reviewed prior to submission. Size, format, image resolution, and the requirement for a hard-copy version vary. This information is readily available on the home page of the publication. Information with regard to JDMS submission is available through the Society of Diagnostic Medical Sonographers (SDMS) Web site (http://www.sdms.org). An e-mail to the editor at jdmseditor@sdms.org can be used for additional questions or to quickly clarify the publication’s requirements.

JDMS is fortunate to be one of only a few journals with access to a Web-based submission and review process. At the peer connect Web site (http://212.58.231.10/jdms), authors may submit on-line, review the progress of their submission, and even access reviewer suggestions and comments. Sonographers can now submit an article at home, at their convenience, without purchasing blank disks, copying documents, or even making a trip to the post office.

On-line submission requires Internet access, as well as the document, a separate title page, and images in digital format. Once the article is submitted on-line, it will be given an identification number and converted to a pdf file on the Web site that will be available for review. Because the review process must be anonymous, authors are requested not to include their name on the source manuscript itself.

There are many excuses for failing to submit interesting case reports to a professional journal. Reluctance to undertake the task of converting a sonographic image into a publishable format is certainly a major factor. In the past, preparation of ultrasound images from film format to publisher-usable prints was both time consuming and expensive. However, recent advances in computer technology have lessened the daunting task of image...

Editor’s Note. Staying e-Connected will provide Web site and software reviews and information on the innovative use of digital resources in sonography. The format will vary from single reviews to multiple short descriptions. Sonographers may contribute to this symposium by submitting to the editor descriptive narratives and analyses of digital resources. Submissions may range from single paragraphs to multiple pages in length. Selection of material for publication is at the discretion of the editor and editorial board.
preparation. Some degree of computer skill is required; however, many sonographers are already comfortable scanning images into home computers for personal home pages or family use. Any image acquired on film can be converted into an electronic format, edited, and labeled—ready for publication. Illustrations and drawings are also easy to modify to the task at hand. The size of the original image is important. Most radiology departments print either 12 or 16 images per sheet of 14 × 17 in. film, which is sufficient for creating a digital image. Making a duplicate copy at the time of printing saves time; alternatively, images can be saved to the ultrasound unit hard drive for later retrieval. If a filmless PACS system is in use, there is usually a provision for making a hard copy, often a color print. If the image is originally saved as a color print, a one-on-one format is required for optimal resolution.

To convert an ultrasound image from a filmed format to electronic format, one needs the following:

- Flat bed scanner
- Computer (PC or Macintosh)
- Photo-editing program (Corel Photo Paint, Adobe Photo Shop, Microsoft Photo Editor, and others) (most scanners come with a rudimentary photo editing program suitable for this task).

If the image was saved as color print, it may be scanned normally as for any photograph. For laser printer images, use the following technique.

Select the film image to be converted and carefully cut it out from the parent sheet, if it is a duplicate print. If it is the original, position the image of interest in the center of the scanning bed. Use dark cardboard or paper to cover or mask the remainder of the scanner bed. Leave the scanner lid open. Place a stationary 60- to 100-W light source such as a table or floor lamp nearby. The lighting level should be similar to what would be required for reading, sewing, or other close-up work.

The image should be scanned at 400 dots per inch (dpi) resolution on a color setting. Depending on scanner capability, a preview scan should be obtained, the image area of interest selected and cropped, and a magnification factor of 125% used. Image alignment in the xy-axis is important at this stage because postprocessing corrections may result in image degradation. However, do not worry if the image is flipped either vertically or right to left. The overall density of the image can be adjusted by moving the external light source closer to or farther from the scanner. This may take a few minutes of experimentation. Alternatively, the scanner controls can be adjusted to alter the scanned image’s brightness. All other adjustments to the image may be made after the image is transferred to the computer.

After the scan, when the image is transferred to the computer, save it in Joint Photographic Experts Group (JPEG) format. A midrange compression setting is adequate. Proper image compression will result in a smaller image file without an appreciable loss of image quality from the original. See Figures 1 through 3 for an example of the relationship between compression, image quality, and file size. For a complete discussion of image compression in medical imaging, see the Society for Computer Applications in Radiology White Paper released November 2000 (http://www.scarnet.org/publications.html).

There is a bewildering number of file formats.

- Graphics Interchange Format (GIF) is best suited for line drawings or simple illustrations. It supports eight bits and 256 colors.
- Windows Bit Map (BMP) is mapped pixel by pixel to the page. It cannot be enlarged without becoming “pixellated” or “jaggy.” A large BMP image can result in a very large electronic file.
- Tagged Image File Format (TIFF) is a bitmap file format used by many digital scanners.
- Portable Network Graphics (PNG) is a newer standard for graphic exchange. It permits the lossless, well-compressed storage of raster or bitmapped images. PNG can replace the older GIF and TIFF formats. Indexed-color, gray-scale, and true-color images are supported.

Each of these methods has its merits and weaknesses, beyond the scope of this discussion. There is a trade-off between resolution, file size and degree of compression possible, and ease of display inherent in each method. A format suitable for a black-and-white line drawing would not be of use in saving a color microphotograph of a pathology specimen. The JPEG format is a suitable compromise for all image types in which a large range of shades of gray or color need to be displayed.
Color depth (a bit depth) refers to the number of colors that can be supported in a file. A 1-bit file supports 2 colors (usually black and white), a 2-bit file supports 4 colors, a 4-bit file supports 16 colors, an 8-bit file supports 256 colors, and a 24-bit file supports 16 million colors. An ultrasound image is a gray-scale image or an 8-bit file, with 256 increments between black and white. The higher the color depth or bit depth, supported by a file type, the larger the electronic file (see Figs. 4-6).

It is important to submit electronic images in the format that the journal editor and publisher are able to work with. For our purposes, the preparation of images for a case report, the JPEG format is adequate.
The following parameters may be adjusted within the photo editor program: image orientation, brightness, contrast, intensity, overall gamma, and sharpness. The image can be cropped to remove identifying information and unnecessary details. Many programs permit text labels and arrows to be drawn on the image. However, it is suggested that one clearly named master copy of the image be backed up on disk, before performing extensive modifications or labeling. If authors want arrows on their images, they need to be added by the authors to the digital files submitted. The publisher will not add arrows.

For those without Internet access, the completed article and images can be transmitted by e-mail as an attachment. However, if there are numerous large image files, transmission becomes unwieldy.

An alternative method is to save the article to a floppy disk or CD-ROM and send it by conventional mail. With proper compression, a 1.44-MB floppy will hold five or six JPEG images, as well as all the text files for an article of approximately 2000 words. Floppies are inexpensive and are in universal use.

For authors with Internet access, the new JDMS Web site offers a stream-lined method for electronic submission, editing, and review.

**References**