Introduction to Echocardiography

Over the past several decades, echocardiography has become a major tool in the diagnosis and management of people of all ages with heart disease. Echocardiography has gained particular importance in pediatric cardiac disease because of the excellent definition of intracardiac structures that can be obtained with high-resolution transducers. This article is intended as a brief introduction to echocardiography in children.

A pediatric echocardiography laboratory differs from an adult laboratory in several key features. The equipment must be appropriate for the entire spectrum of ages and sizes. This involves a broad selection of transducers, which will allow for high resolution imaging in small babies and adequate penetration in the adolescent patient. The most important components of the pediatric ultrasound laboratory are the sonographer who performs the studies and the physician who interprets the test. The physician must understand the intricacies of congenital heart disease. The sonographers must truly enjoy working with children and their families and the challenge of congenital heart disease. Complete echocardiograms require a minimum of 30 minutes to perform and frequently can take much longer. The patients must lie relatively still for that time period which can be quite difficult for the curious 2 year old. The sonographer uses many techniques to distract the children while performing the echocardiogram. Videos and blowing bubbles play a particularly important role. Occasionally, conscious sedation is required.

There are several components to the standard transthoracic echocardiogram including m-mode, gray scale imaging, and Doppler. M-mode echocardiography is a diagnostic ultrasound modality introduced in the 1960s that significantly influenced the practice of cardiology. M-mode evaluates the information obtained along one scan line of ultrasound and displays this information over time. With the introduction of m-mode echocardiography, cardiac structure and function could be assessed non-invasively. As new ultrasound techniques have developed, the utility of m-mode echocardiography has diminished but it still has a role particularly in the evaluation of wall thickness, chamber dimensions and ventricular function. Gray scale or two-dimensional imaging became clinically available in the 1970s and revolutionized the evaluation of congenital heart disease. Anatomic features that cannot be fully appreciated with angiography such as valve morphology could now be evaluated. Two-dimensional imaging is the current standard for evaluation of intracardiac structure and can provide excellent detail in simple and complex anomalies. Harmonic imaging has developed in the past several years and vastly improves the imaging in individuals with poor acoustic windows. Doppler evaluates hemodynamics by measuring the frequency shift of an emitted ultrasound pulse striking a moving region of blood. This measured frequency shift is then converted to velocity. The velocity of blood flow can be converted to pressure gradient utilizing the simplified Bernoulli equation. The estimated pressure gradient across valves aids in the evaluation of valve obstruction while the gradient between cardiac chambers can estimate pulmonary artery pressure. Color flow imaging, pulsed wave and continuous wave are all Doppler techniques available on ultrasound machines each having different clinical applications.

New techniques are frequently introduced in the clinical ultrasound arena. In the past several years, contrast echocardiography using micro bubbles that pass through the pulmonary circulation, new Doppler techniques such as Doppler tissue imaging, and three dimensional reconstruction have been developed. These techniques are still finding their clinical utility in the day-to-day evaluation of pediatric patients.

The question, "Who needs echocardiography?" has evolved over the years much as echocardiography itself. Early in our experience, a pediatric cardiologist was the only person who could order an echocardiogram in the pediatric laboratory. This led to some patients being referred to adult

echocardiography laboratories where the specialized approach to pediatric patients was not necessarily utilized resulting in an increase in the number of diagnostic errors. Many pediatric echocardiography laboratories now are "open" meaning any qualified caregiver may order an echocardiogram without consulting a cardiologist. The American College of Cardiology (www.acc.org) has clinical guidelines recommending when an echocardiogram should be done. In the pediatric population, age and condition are considered in determining the appropriateness of the test. Echocardiograms are not recommended in asymptomatic functional murmurs, musculoskeletal chest pain, isolated extrasystoles, or common syncope. The distinction of a murmur as pathologic or functional may be difficult prompting some caregivers to order echocardiograms to "rule out" heart disease. This practice has led to several interesting dilemmas in pediatric cardiology. As the echocardiographic equipment becomes more sensitive, flows are detected for which their significance is unknown. As an example, early in the Doppler experience, tricuspid insufficiency was considered pathologic. As more experience was gained, it became apparent that most healthy individuals have tricuspid insufficiency detected by Doppler prompting us to reevaluate its significance. It is now recognized that tricuspid insufficiency is detected in most echocardiograms and is considered a normal finding. Interestingly, flows in the pulmonary artery from a tiny ductus arteriosus are sometimes identified in asymptomatic patients with normal cardiovascular exams. There is no generalized consensus in the pediatric cardiology community how to treat this finding. The opinions vary from considering this is be within the normal range and discharging the patient from cardiac follow-up to closure of the ductus arteriosus in the surgical or catheterization suite.

Transthoracic echocardiography is the most widely used echocardiogram in the pediatric age range but other echocardiographic studies are done depending upon the clinical indication. Fetal echocardiography is the evaluation of the fetal heart in-utero. This is usually performed from the maternal abdomen from 16weeks gestation to term but can be done transvaginally. Fetal echocardiography differs from the routine fetal scan in that it is a focused study to evaluate the structure and flow in the fetal heart. Many types of congenital heart disease can be diagnosed in-utero but fetal echocardiography remains a challenging area. Transesophageal echocardiography (TEE) is done through the esophagus with the ultrasound transducer positioned behind the heart. We routinely use this technique in the operating room and catheterization laboratory to evaluate procedures. TEE can be done as an in- or outpatient procedure in patients that for some reason have poor acoustic windows. In contrast to the adult patient, it is unusual for a pediatric patient to require TEE for poor acoustic windows. Transesophageal probes are available for patients as small as ~3.0 kilograms. Stress echocardiography images the heart while the patient is being stressed, either with exercise or pharmacologically. Left ventricular function is most commonly evaluated. Stress echocardiography may demonstrate regional wall or global left ventricular dysfunction that is not present at rest. The most frequent indications for stress echocardiography in pediatric patients are history of coronary artery involvement with Kawasaki Disease, adriamycin toxicity, and repaired congenital heart disease.

Echocardiography is an extremely dynamic and technology driven area of cardiovascular medicine. Miniaturization has allowed the ultrasound machine to become smaller and smaller. Historically, ultrasound machines could fill small rooms and were not portable. Now affordable machines are available which weigh less than twenty pounds and can easily be carried in a handbag. The availability of such equipment makes the possibility of mass screening echocardiography a reality.

Through The Children's Heart Clinic, the entire spectrum of cardiac ultrasound imaging is available. We also offer portable transthoracic echocardiograms at our outreach sites and area hospitals requesting echocardiography.