3-2003

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Muhammad Imran Omar

Saba Sohail

RECENT APPLICATIONS OF ULTRASOUND TECHNOLOGY

Saba Sohail and Muhammad Imran Omar*

Before the widespread use of ultrasound imaging the first glance any mother got of her child was the day he or she was born. Three decades ago doctors began using ultrasound to sneak a peek at babies before they are born.[1] Today ultrasound is a common imaging test, requested by the clinicians, in conjunction with X-rays and other diagnostic tests. It has become an advanced imaging and screening option. It is widely available and cost-effective, which tends to overshadow the fact of being operator dependent.

For a long time the clinical applications remained confined to diagnosis of abdominopelvic pathologies and fetal evaluation and monitoring. Further advancement led to neurosonography and cardiovascular sonography as well as imaging soft tissue components of the musculo skeletal systems. However, the application range of ultrasound is growing very fast which is supported by technologic advancements. These applications include power doppler, contrast enhanced ultrasound, 3D and now 4D ultrasound, tissue harmonics ultrasound, intravascular and endosonography and bone assessment techniques. Interventional ultrasound is no more restricted to providing biopsy guidance alone as discussed later. Innovations in teleultrasound have made it possible for remote centers to obtain expert help from larger centers.[2] With the advent of information technology, radiologists can be approached from all over the world for their expert opinion with the click of a button.

Power doppler is one of the most significant technologic advancement in diagnostic ultrasound. It is three times more sensitive as standard doppler and focuses on detecting the power (total energy) of the ultrasound beam thereby detecting minimum critical flows which are seen as areas of absent flow on conventional doppler. The particular fields of application are carotid arteries, musculo-skeletal inflammations, ovarian pathologies, organ transplants and reduced endometrial flows which lead to implantation failure and embryonal deaths.

Contrast agents in ultrasound are offering a new promise and growth potential. Contrast agents used in ultrasound are small particles 7μs in size (less than the size of RBCs), encapsulating absorbable gas or galactose, which can leak out of capillaries and retain long enough in the tissues to increase the sharpness of gray scale imaging as well as to map out the microvascularity of a region.[3] So far, the primary utility is the cardiologic ultrasound (echocardiography) to obtain endocardial border detection, perfusion studies for infarcted organs, imaging highly vascular lesions such as tumors or angiomas and thrombus detection. The most popular extra cardiovascular use of these agents is contrast enhanced sonohysterosalpingography (HyCoSy), where the technique offers the advantage of being relatively less traumatic and painful. Again the agent is costly and the procedure is highly dependent on the skill of operator. An oral contrast agent (Oralex- developed by Molecular Biosystems, USA) for gastrointestinal ultrasound is undergoing phase II trials.

3D ultrasound, and now the newly introduced 4D ultrasound stores a large number of B mode pictures in the computer memory of the machine and the software integration later allows reconstruction of 3D volume allowing analysis of different views from one recording. Despite its great potential, it has stayed in the research phase for an undue long time. The key factor, which will ultimately determine its utility, would be cost effective, real time 3D imaging able to provide quality care to patients. 3D ultrasound is particularly suitable for imaging complex structure such as fetal heart. Other applications include measurements of organs e.g. prostate's volume, prostatic urethral lesions and obstetric anomaly scan[4] and may even show hidden plaque ruptures in major coronary arteries.[5]

Tissue harmonic imaging perceives ultrasound signals returned from the tissues as harmonic multiples of the incident signals. These are filtered as noise in the conventional ultrasound equipment but the high tech unit picks it displaying an image of much higher resolution than was previously possible at the same depth.[6] It is particularly useful in assessing the abdominal and pelvic mass and traumatic injuries, in the obese.[6] It is also under evaluation for echocardiography.
Intravascular ultrasound is currently the most sensitive in vivo modality complementing diagnostic catheterization in providing real time tomographic assessment of luminal patency, atherosclerotic plaque size, distribution and composition particularly in detecting the calcium content.[7]

Ultrasound previously thought to be limited to visualize soft tissues alone is now used for bone status assessment examinations. Ultrasound systems are being developed (e.g. Soundscan 2000, Myriad Ultrasound Systems, Rehovot, Israel), which carry out quantitative measurement of the transmitted signal within the bone only with no distortion from the surrounding soft tissue. Previously utilized in industry for non-destructive evaluation of mechanical properties of solid material, the technique of quantitative ultrasound is finding applications in detecting osteoporosis[8], arthritis, fracture healing and hip replacements providing information about bone density, architecture and elasticity.

Researchers at the Massachusetts Institute of Technology (MIT) are investigating the use of an ultrasound-based method for non-invasive monitoring of glucose levels in diabetics. The researchers envision a battery-powered device about the size of a cigarette pack for making the glucose measurement. According to Robert Langer, Professor of chemical and biomedical engineering at MIT, "Blood tests for any number of things, such as cholesterol and bilirubin, could someday be replaced with this technique.[9]"

Department of Radiology and Civil Hospital, Karachi.
* Department of Publication, CPSP, Karachi.

Correspondence: Dr. Muhammad Imran Omar, Assistant Editor, JCPSP, College of Physicians and Surgeons Pakistan, 7th Central Street, Phase II, DHA, Karachi-75500, Pakistan.
E-mail: drimran@yahoo.com

The technical innovations have also made possible the promotion of ultrasound from a guiding technique for biopsies and sampling to therapeutics. Procedures which previously relied on fluoroscopic localization or other techniques are now done under ultrasound guidance. These procedures are indicated from all branches of medicine. Some of these procedures are mass biopsy, abscess drainage, biliary duct drainage, percutaneous nephrostomy, percutaneous gastrostomy, chorionic villus sampling, amniocentesis and percutaneous umbilical cord blood sampling. Intra-operative ultrasound enhances a surgeon's skill and is exceedingly used in hepatobiliary, pancreatic, neuro, renal and gynecologic surgery. Minimally invasive surgery under ultrasound guidance is evolving rapidly due to alleviated patient pain, reduced recovery time and increased patient safety. Earliest cases of minimally invasive in-utero surgery under ultrasound guidance were carried out to relieve amniotic band syndrome and hence prevent fetal deformities .[10]

Transrectal probes now provide cryosurgical treatment for prostatic cancer using carefully monitored cryoprobes.[11] Ultrasound guided radiotherapy (the ER7B biplane transducer manufactured by Acuson) and chemotherapy implants radioactive and medicine pallets in a target area releasing contents on ultrasound exposure, targeting the tumor with precision and sparing the surrounding normal tissues which reduces complication rate.

Endosonography (performed by 20 MHz probe passed through biopsy channels of endoscopes) is a simple and effective procedure for objective confirmation of sub mucosal separation during endoscopic resection and prevents iatrogenic perforation.

Ultrasound therapy is also used in cosmetic surgery. New and current uses of ultrasound include facial and body skin rejuvenating treatments, reduction of stretch marks, treatment of contracture and scar tissue such as around breast implants and the pre and postoperative treatment of plastic surgery patients to accelerate healing and recovery after procedures such as face lifts, tummy tuck and lipo suction.[12]

Tele ultrasound or image management refers to dissemination of ultrasound pictures from one site to another e.g. The Teleconsulta and MUSTPAC I systems. The later is a portable 3D unit developed by Pacific Northwest Research Laboratory and Frankhoter Center for research in computer graphics in association with the US Army and Defence Department and was first used in Bosnia in September 1997.

All these advancements have given momentum to the development of ultrasound, making it the most dynamically growing imaging modality, according to a market survey report in 1998, published by the Richmond group in Clinica Experta. Undoubtedly, ultrasound is the most valuable and extremely reliable diagnostic technique of the present era.

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