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Assessment of Sensitivity and Specificity of Modern Screening for Gynecologic Pathology

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Abstract: Diagnostic ultrasound (DUS) is, arguably, the most common technique used in obstetrical practice. From A mode, first described by Ian Donald for gynecology in the late 1950s, to B mode in the 1970s, real-time and gray-scale in the early 1980s, Doppler a little later, sophisticated color Doppler in the 1990s and three dimensional/four-dimensional ultrasound in the 2000s, DUS has not ceased to be closely associated with the practice of obstetrics. The latest innovation is the use of artificial intelligence which will, undoubtedly, take an increasing role in all aspects of our lives, including medicine and, specifically, obstetric ultrasound. In addition, in the future, new visualization methods may be developed, training methods expanded, and workflow and ergonomics improved.

Keywords: Artificial intelligence, Doppler, 3-D, 4-D, Obstetrics, training, ultrasound.

Ultrasound (US) is a portable and safe imaging method that uses high frequency sound waves to visualize structures within the body. While most US examinations are done outside the body there is an emerging field which uses US devices within the body during surgery to aid complex procedures. This review examines the published literature on this technique in benign gynecology and in gynecological oncology. This review demonstrates the use of intraoperative US improves visualization and minimizes surgical complications.

Ultrasound is widely used in obstetric practice to detect fetal abnormalities with a view to provide prenatal opportunities for further investigations including genetic testing and discussion of management options. In 2010, International Societies of Ultrasound in Obstetrics and Gynecology (ISUOG) published the practice guidelines on the minimal and optional requirements for a routine mid-trimester ultrasound scan. Recently, The American Institute of Ultrasound in Medicine (AIUM) suggests a detailed diagnostic second/third trimester scan for high-risk pregnancies, and fetal echocardiography for at-risk pregnancies. ISUOG has published recent guidelines on indications and practice of targeted neurosonography. Although the introduction of prenatal cell-free DNA-based screening for Down syndrome has changed the role of the first trimester scan, the latter should still be offered to women. Around 50% of major structural abnormalities can be detected in the first trimester. In addition, a recent study showed that a routine scan at around 36 weeks' gestation can detect around 0.5% of previously undetected fetal abnormalities, as well as fetal growth restriction (FGR).

High-resolution ultrasonography includes the use of a high-frequency transducer, and the means of enhancing image and signal processing including harmonic imaging (HI), spatial compound imaging (SCI), and speckle reduction imaging (SRI). Compared to a transducer with the low-frequency range (2 to 5 MHz), a transducer with the high-frequency range (5 to 9 MHz) can allow for improved resolution though with limited tissue penetration. HI, utilizing the physics of non-linear propagation of ultrasound through the body tissues, can produce high-resolution images with few artifacts. SCI, combining multiple lines of sight to form a single composite image at real-time frame rates, can reduce angle-dependent artifacts. The use of SRI can reduce speckles or disturbances that result from the echo, which is projected from an ultrasound transducer.

ISUOG recommends the use of the highest possible transducer frequency to perform fetal echocardiography with a view to improve the likelihood of detecting subtle heart defects, albeit at the expense of reduced acoustic penetration (Figure 1a–d and Video S1). The use of HI can improve the quality of ultrasound images, especially when the maternal abdominal wall is thick during the third trimester of pregnancy.

Figure 1. High-resolution ultrasonography of the fetal heart at 20 weeks' gestation showing (a) a four-chamber view showing right atrium (RA), left atrium (LA), right ventricle (RV), and left ventricle (LV), (b) five-chamber view showing ascending aorta (AAo) arising from the left ventricle, the right and left superior pulmonary veins (RSPV, LSPV) enter the left atrium (LA), and descending aorta (DAo) behind the LA (c) Three-vessel view showing the PA dividing into the left (LPA) and right (RPA) PA, AAo, and the superior vena cava (SVC), (d) three-vessel and trachea view showing PA with the ductal branch (DA) joining the DAo, AAo, SVC, and trachea (T); Thymus is anterior to the three vessels.

The detection rate of fetal abnormalities varies, depending on anatomy survey protocol, ultrasound equipment and setting, among other factors [9]. A high-resolution ultrasound can facilitate a detailed diagnostic scan and a first-trimester scan and allow the detection of a small or subtle abnormality [10,11,12]. Although a detailed diagnostic scan is not required for all pregnant women, the indications include family history of congenital malformation, maternal age 35 or above, gestational diabetes mellitus, artificial reproduction technology, body mass index >= 30, teratogen, fetal nuchal translucency >= 3mm, and many other conditions [2]. In the midst of such increasing standards of obstetric ultrasound examination, there is a demand on improving the diagnostic capability, functional analysis, workflow, and ergonomics. Over the years, there have been several improvements in ultrasound technologies including high-resolution ultrasonography, linear transducer, radiant flow, three/four-dimensional (3D/4D) ultrasound, speckle tracking of the fetal heart, and artificial intelligence. The aim of this review is to evaluate the use of these advanced technologies in obstetrics.

Ultrasound is a readily available, safe and portable imaging modality that is widely applied in gynecology. However, there is limited guidance for its use intra-operatively especially with complex gynecological procedures. This narrative review examines the existing literature published on the use of intraoperative ultrasound (IOUS) in benign gynecology and in gynecological oncology. IOUS can minimize complications and facilitate difficult benign gynecological procedures. There is also a role for its use in gynecological oncology surgery and fertility-sparing surgery. The use of IOUS in gynecological surgery is an emerging field which improves visualization in the surgical field and aids completion of minimally invasive techniques.

The initial use of ultrasound in medicine was for therapeutic applications rather than diagnosis. The effect was obtained by heating and disrupting tissues (This is fascinating when one considers that bioeffects of diagnostic ultrasound are based on two mechanisms: thermal and non-thermal or mechanical and that modern ultrasound machines display two on-screen indices, related to these effects: the thermal index [TI] and the mechanical index [MI]. See paragraph on Safety, below). This was based on laboratory work performed in the 1920s by the French physicist Paul Langevin who observed fish dying when in the ultrasonic beam [1], as later confirmed Harvey and Loomis [2]. Only later was ultrasound found to permit "visualizing" internal anatomy [3]. Therapeutic usage was found in various branches of medicine, including gynecology, for instance for the treatment of urinary incontinence or ovarian disorders [4]. While it is well beyond the scope of this article to go into details regarding this huge and burgeoning branch of science, a few principles will be described. In medicine, the idea is that tremendous amounts of information ("big data") together with machine learning can create algorithms that perform as well as, if not better than, and much faster than human physicians [10]. The inspiration is the human brain, hence the designation artificial neuronal networks and machine learning, where the computer automatically recognizes patterns, based on entry of enormous quantities information bits, such as "ideal" ultrasound images of the fetal anatomy. The computer can then perform automatic measurements, for example fetal biometry [6]. In machines from several manufacturers, automatic image recognition is already being used to perform measurement of the fetal BPD, head circumference (HC), abdominal circumference, and femur length. As example, with automatic evaluation, after deep learning, a success rate of 91.43% and 100% for HC and BPD estimations were obtained, respectively, with an accuracy of 87.14% for the plane acceptance check.

Ultrasound imaging is limited in resolution by the wavelength (in general resolution=1/2 wavelength), which depends on the frequency (wavelength=speed of sound/frequency), hence higher frequencies transducers, having smaller wavelength allow for improved resolution. Echoes returning from scanned structures depend on the concentration of scatterers in the tissue, i.e., structures that are "hit" by the ultrasound beam. It is, therefore, difficult to image small blood vessels, because of limited number of slowly (<1 cm/s) moving scatterers. Adding contrast agents (microbubbles) may improve the visualization (see above) but also has limits. Super-resolution ultrasound imaging is a new technique which allows, after introducing a microbubbles visualization of microvascularity at a resolution of tens of microns [11,12]. A major advantage over classic high-frequency techniques, where higher frequency means lower penetration, is that with super-resolution ultrasound there is no penetration trade-off associated with higher frequencies [11]. This may allow in the future precise mapping of placental vasculature or fetal brain, for instance in early stages of fetal growth restriction.

Literature:

1. Salomon, L.J.; Alfirevic, Z.; Berghella, V.; Bilardo, C.; Hernandez-Andrade, E.; Johnsen, S.L.; Kalache, K.; Leung, K.Y.; Malinger, G.; Munoz, H.; et al. ISUOG Clinical Standards Committee. Practice guidelines for performance of the routine mid-trimester fetal ultrasound scan. Ultrasound Obstet. Gynecol. 2011, 37, 116–126.

2. Anonymous. AIUM Practice Parameter for the Performance of Detailed Second- and Third-Trimester Diagnostic Obstetric Ultrasound Examinations. J. Ultrasound Med. 2019, 38, 3093–3100.

3. Anonymous. AIUM Practice Parameter for the Performance of Fetal Echocardiography. J. Ultrasound Med. 2020, 39, E5–E16.

4. Malinger, G.; Paladini, D.; Haratz, K.K.; Monteagudo, A.; Pilu, G.L.; Timor-Tritsch, I.E. ISUOG Practice Guidelines (updated): Sonographic examination of the fetal central nervous system. Part 1: Performance of screening examination and indications for targeted neurosonography. Ultrasound Obstet. Gynecol. 2020, 56, 476–484.

5. Paladini, D.; Malinger, G.; Birnbaum, R.; Monteagudo, A.; Pilu, G.; Salomon, L.J.; Timor-Tritsch, I.E. ISUOG Practice Guidelines (updated): Sonographic examination of the fetal central nervous system. Part 2: Performance of targeted neurosonography. Ultrasound Obstet. Gynecol. 2021, 57, 661–671.

6. Salomon, L.J.; Alfirevic, Z.; Audibert, F.; Kagan, K.O.; Paladini, D.; Yeo, G.; Raine-Fenning, N.; ISUOG Clinical Standards Committee. ISUOG consensus statement on the impact of non-invasive prenatal testing (NIPT) on prenatal ultrasound practice. Ultrasound Obstet. Gynecol. 2014, 44, 122–123.
7. Kenkhuis, M.J.A.; Bakker, M.; Bardi, F.; Fontanella, F.; Bakker, M.K.; Fleurke-Rozema, J.H.; Bilardo, C.M. Effectiveness of a 12-13-week scan for the early diagnosis of fetal congenital anomalies in the cell-free DNA era. Ultrasound Obstet. Gynecol. 2018, 51, 463–469.
8. Ficara, A.; Syngelaki, A.; Hammami, A.; Akolekar, R.; Nicolaides, K.H. Value of routine ultrasound examination at 35–37 weeks' gestation in diagnosis of fetal abnormalities. Ultrasound Obstet. Gynecol. 2020, 55, 75–80.
9. Edwards, L.; Hui, L. First and second trimester screening for fetal structural anomalies. Semin. Fetal. Neonatal. Med. 2018, 23, 102–111.
10. International Society of Ultrasound in Obstetrics and Gynecology; Carvalho, J.S.; Allan, L.D.; Chaoui, R.; Copel, J.A.; DeVore, G.R.; Hecher, K.; Lee, W.; Munoz, H.; Paladini, D.; et al. ISUOG Practice Guidelines (updated): Sonographic screening examination of the fetal heart. Ultrasound Obstet. Gynecol. 2013, 41, 348–359.
11. Platt, L.D. Should the first trimester ultrasound include anatomy survey? Semin. Perinatol. 2013, 37, 310–322. [Google Scholar] [CrossRef] [PubMed]
12. Pooh, R.K.; Kurjak, A. 3D/4D sonography moved prenatal diagnosis of fetal anomalies from the second to the first trimester of pregnancy. J. Matern. Fetal. Neonatal. Med. 2012, 25, 433–455.
13. Paladini, D.; Vassallo, M.; Tartaglione, A.; Lapadula, C.; Martinelli, P. The role of tissue harmonic imaging in fetal echocardiography. Ultrasound Obstet. Gynecol. 2004, 23, 159–164.
14. Biard, J.-M.; Steenhaut, P.; Bernard, P.; Race, V.; Sznajer, Y. Antenatal diagnosis of cardio-facio-cutaneous syndrome: Prenatal characteristics and contribution of fetal facial dysmorphic signs in utero. About a case and review of literature. Eur. J. Obstet. Gynecol. Reprod. Biol. 2019, 240, 232–241.
15. Mak, A.S.L.; Ma, T.W.L.; Chan, K.Y.K.; Kan, A.S.Y.; Tang, M.H.Y.; Leung, K.Y. Prenatal diagnosis of 5p deletion syndrome: Report of five cases. J. Obstet. Gynaecol. Res. 2019, 45, 923–926.