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Review

Fetal biometry: Relevance in obstetrical practice

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ABSTRACT

Ultrasound imaging in obstetrics and gynecology dates back to 1958 when The Lancet published the first article about the use of ultrasonography for fetal and gynecological assessments. It is now almost inconceivable, 60 years later, to think of effective performance in obstetrics and gynecology without the variety of ultrasound, for example, real time imaging, power and color Doppler, 3D/4D ultrasonography, etc. Such examinations facilitate the assessment of intrauterine fetal growth and development during pregnancy, provide alerts about the risk of pre-eclampsia and preterm birth, help identify anatomic reasons for infertility, diagnose ectopic pregnancies, uterine, ovary and tubal pathology. Ultrasonography is also used for diagnostic and treatment procedures during pregnancy or for the treatment of infertility. This article is an overview of the development of fetal ultrasound, the methodology and interpretation of ultrasound in the assessment of intrauterine fetal growth and fetal biometry standards both worldwide and in Lithuania.

1. History of fetal ultrasound biometry

Lack of data or contradictory facts often make it difficult to trace back the precise date of a large number of medical inventions. This is not the case in terms of the history of ultrasound in obstetrics and gynecology.

The use of ultrasound equipment in medicine began in the 1950s (until then it was only used in the military industry). The first medical A-mode (amplitude-mode is a one-dimensional imaging which represents the time required for the ultrasound beam to strike a tissue interface and return its signal to the transducer, the greater the reflection at the tissue interface, the larger the signal amplitude [1]) equipment was created in Japan in 1949, and the first B-mode (brightness-mode is a two-dimensional ultrasound presentation display composed of the bright dots representing the ultrasound echoes, the position of the echo is determined from the position of the transducer and the transit time of the acoustical pulse [2]) ultrasound transducers introduced in 1951 allowed obtaining more accurate anatomic information compared with the earlier equipment and made interpretation of the images easier [3–5].

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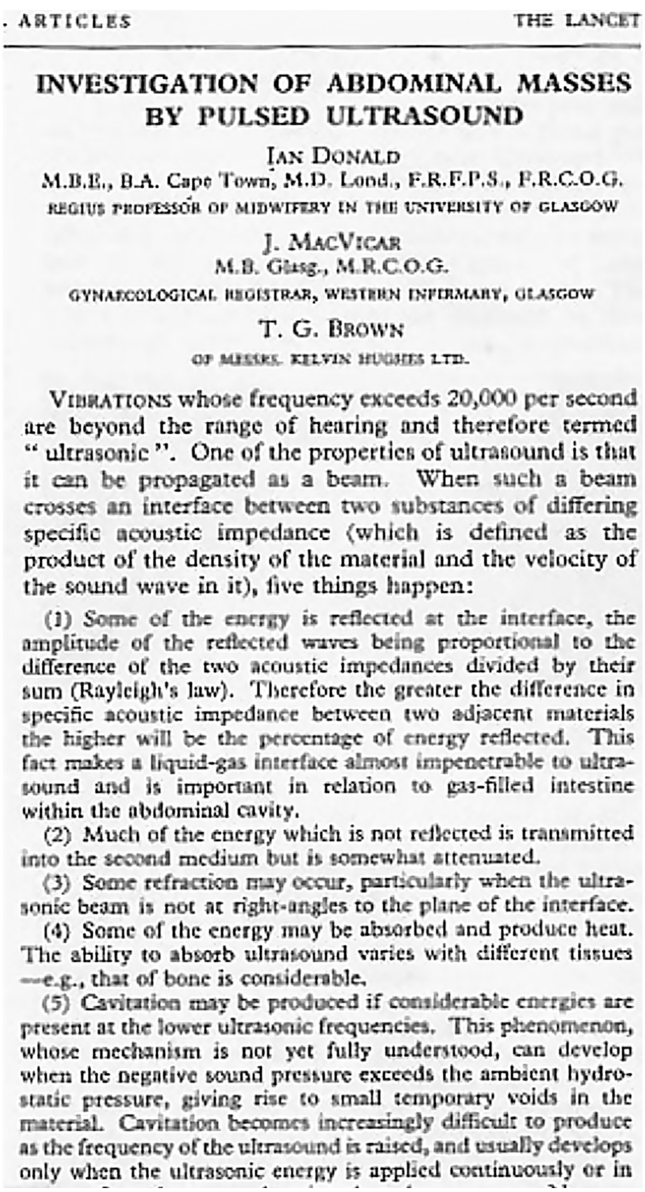
Several years later, in 1958, *The Lancet* published the paper 'Investigation of abdominal masses by pulsed ultrasound' by obstetrician–gynecologist I. Donald, engineer T. Brown and registrar J. MacVicar. This paper is considered to be the reference point in the history of ultrasound use in the practice of obstetrics and gynecology (Fig. 1) [4,6]. In this paper the scholars presented the world's first contact 2D ultrasound Diasonograph scanning machine, which they had developed, and described the opportunities for using B-mode ultrasound in obstetrics and gynecology; they also published the first ultrasound images of the fetus and gynecological formations [6]. Furthermore, this paper detailed the physical characteristics and safety of ultrasound scanning machines, their use for the assessment of prenatal fetal growth and gynecological diseases and outlined further development of these examinations.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INVESTIGATION OF ABDOMINAL MASSES BY PULSED ULTRASOUND

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VIBRATIONS whose frequency exceeds 20,000 per second are beyond the range of hearing and therefore termed " ultrasonic ". One of the properties of ultrasound is that it can be propagated as a beam. When such a beam crosses an interface between two substances of differing specific acoustic impedance (which is defined as the product of the density of the material and the velocity of the sound wave in it), five things happen:

(1) Some of the energy is reflected at the interface, the amplitude of the reflected waves being proportional to the difference of the two acoustic impedances divided by their sum (Rayleigh's law). Therefore the greater the difference in specific acoustic impedance between two adjacent materials the higher will be the percentage of energy reflected. This fact makes a liquid-gas interface almost impenetrable to ultrasound and is important in relation to gas-filled intestine within the abdominal cavity.

(2) Much of the energy which is not reflected is transmitted into the second medium but is somewhat attenuated.

(3) Some refraction may occur, particularly when the ultrasonic beam is not at right-angles to the plane of the interface.

(4) Some of the energy may be absorbed and produce heat. The ability to absorb ultrasound varies with different tissues —e.g., that of bone is considerable.

(5) Cavitation may be produced if considerable energies are present at the lower ultrasonic frequencies. This phenomenon, whose mechanism is not yet fully understood, can develop when the negative sound pressure exceeds the ambient hydrostatic pressure, giving rise to small temporary voids in the material. Cavitation becomes increasingly difficult to produce as the frequency of the ultrasound is raised, and usually develops only when the ultrasonic energy is applied continuously or in

Fig. 1 – Page 1 of the article "Investigation of abdominal masses by pulsed ultrasound" by Donald et al.

In the mid-1960s other companies – Kretztechnic in Austria and Aloka in Japan – developed commercial transvaginal transducers but the potential of transvaginal scanning was not realized until the advent of real time imaging [4,5]. In Germany, R. Soldner, an engineer who worked for Siemens, developed the first (almost) real time scanner [4,5]. Compared to the Diasonograph, the image resolution was poor yet this machine was purchased widely in German-speaking countries and by the late 1960s was probably the most commonly used machine in Europe [4,5].

I. Donald and the scholars led by him continued their intensive research of ultrasound after the development of the Diasonograph and in 1963 described the early diagnosis of the hydatid mole (in its characteristic snowstorm appearance), identified fetal development anomalies in the period of early pregnancy, offered guidelines for assessment of the growth of the gestation sac (by ultrasound when the bladder of the pregnant woman is full) [4,5,7]. J. Willocks, a colleague of I. Donald, published an article in 1964 about the use of A-mode ultrasound to identify differences in biparietal diameter (BPD) in the third trimester of pregnancy between normal growth and restricted growth fetuses [8]. This publication may be considered as the beginning of fetal ultrasound biometry. Unfortunately, due to the lack of precision, the idea brought forward in 1968 by S. Campbell, another member of I. Donald's team, to use B-mode ultrasound machines for fetal biometry measurements surpassed the A-mode ultrasound transducers several years later [9]. S. Campbell also announced that the midline echo of the fetus could be seen clearly from the thirteenth week of pregnancy and that the second trimester cephalometry of the fetus was a reliable method to identify pregnancy [9]. This introduced a new concept into prenatal medicine – "determination of gestational age by ultrasound". S. Campbell developed the first fetal growth chart in the world that showed changes in the BPD of the fetus between gestation weeks 13 and 40 [9]. Later similar charts were developed by M. Hansmann, A. Kratochwil, R. Sabbagha and many others and they are, with certain corrections, still used [4,5].

The scientists, aware that the brain is the last structure affected in the case of fetal growth restriction, understood that the use of BPD alone to assess fetal growth restriction was not sufficiently accurate as a method. Thus, in 1971, H. Thompson and E. Makowsky also introduced the thoracic circumference (TC) measurement, to be used along with BPD, into fetal growth assessments [4,5]. In 1975 these examinations were supplemented by M. Hansmann with abdominal circumference (AC) measurement [10]. Several years later, L. Grennert and P. Persson demonstrated for the first time, with reference to long-term results of the research that covered the detection of gestational age and twin gestations during the early prenatal period, that routine ultrasound screening was necessary during pregnancy [4].

With further investigations, in 1967 A. Kratochwil used the A-mode transvaginal transducers to identify the fetal heart rate during week 7 of gestation [4,5]. The use of an improved Diasonograph in 1973 enabled H. Robinson to obtain a detailed fetal crown-rump length (CRL) growth chart from weeks 7 to 16 of gestation; this chart is still in use [4,5,7]. Moreover, using A and B mode ultrasound equipment, H. Robinson developed the chart of the fetal heart rate at week 7 of gestation and was the

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