Sudan University of Science and Technology

College of Graduate Studies

Study of fetal anomalies using ultrasonography

دراسة التشوهات الخلقيه في الأجنه باستخدام الموجات فوق الصوتيه

A thesis submitted as partial fulfillment of M. Sc. in medical diagnostic ultrasound

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بسم الله الرحمن الرحيم

قال الله تعالى : (ولقد خلقنا الانسان من سلالة من طين *ثم جعلناه نطفة في قرار مكين * ثم خلقنا النطفة علقة فخلقنا العلقة مضغة فخلقنا المضغة عظاما فكسونا العظام لحما "ثم انشأناه خلقا" آخر فتبارك الله أحسن الخالقين)

صدق الله العظيم

سورة المؤمنون :14

Dedication

This work is dedicated to my beloved family who stood by me throughout this way

Thank you all.

Acknowledgements

First of all, I would like to express my gratitude to ALLAH.

Special thanks to my supervisor Dr. Ikhlas Abdelaziz Hassan Mohamed for her continuous support, guidance and unlimited assistance during this research.

I would also like to express my appreciation to dr Amad Abu konah for his advices, and sincere gratitude to my family and friends for all support and encouragement they provided.

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Abstract

The main objective of this thesis is to show the role of ultrasound scan performed in the second trimester of pregnancy in detecting congenital malformations with an increasing diagnostic sensitivity.

A prospective health facility (Ibrahim Malik and Omdurman Military hospital) based study, conducted during the period April 2018 – December 2018.

The data was collected from 200 pregnant ladies having at least one of the known risk factors, the study was retro-prospective in which the data was collected to determine age, obstetric and gynecological history, gestational age a, risk factors, etc.

Two dimensions' ultrasound machine were used Mindary (Japanese Company) with convex probe. Mindray DP-10 is a very easy to use, it is a portable ultrasound system.

The distribution of representing female according to age is as follow;

17%between 20-25 years of age; 35% between 26-30 years, 25% between 31-35 years and the least representing age was the ladies above 40 years with7% .

Highest percentage of the women 57.5% screened by ultrasound for congenital abnormalities ate third trimester, 27% at second trimester and 9.5% at first trimester

The incidence of fetal anomalies was found to be 12.5% in the northern population ; 11.5% in the central population , 35.5% in the western population , 33.5% in the eastern population and the southern represents only 7% .

Head and neural tube anomalies 26.5%, anterior abdominal wall defects 12%, face and neck 5.5% and genitourinary system (renal) 1%. spina bifeda, hydrocephalus, anencephaly, microcephaly and cephalocel were reported in 45.3%, 20.8%, 17%, 9.4% and 1.9% respectively within the subgroup (head neural tube), and in 12%, 5.5%, 4.5%, 2.5% and 0.5% within the total sample. cystic hydroma, frontonasal dysplasia and mictonasia were reported in 54.5%, 36.4%, and 9.1% respectively. In the anterior abdominal wall the reported defects were omphalocele 50%, followed by gastroschisis 29.2%, umbilical hernia 16.7% and amniotic bands syndrome 4.2% (within the

subgroup: anterior abdominal wall). In these defects were reported in 6%, 3.5%, 2% and 0.5% of the total sample respectively.

Maternal age more than 40 years and lack of iron supplement were found to be the major risk factor to develop congenital malformations.

That's way antenatal visits & follow up are very important to avoid and detect the anomalies.

الملخص

إن الهدف الرئيسي من هذه الرسالة هو إظهار دور الفحص بالموجات فوق الصوتية التي أجريت في الثلث الثاني من الحمل في الكشف عن التشوهات الخلقية مع زيادة حساسية التشخيص.

الدراسة أقيمت في منشأة صحية (مستشفى ابراهيم مالك ومستشفى امدرمان العسكري) ، و قد أجريت خلال الفترة من أبريل 2018 وحتى ديسمبر 2018.
تم جمع البيانات من 200 سيدة حامل لديهن واحدة على الأقل من عوامل الخطر المعروفة ، وكانت الدراسة رجعية , تم فيها جمع البيانات لتحديد العمر وتاريخ أمراض النساء ، وعمر الحمل ، وعوامل الخطر ، إلخ.

تم استخدام آلة الموجات فوق الصوتية ثنائية الأبعاد (Mindaryلشركة اليابانية) ذات المسبار المحدب.
Mindray DP-10 هو سهل جدا للاستخدام ، وهو نظام الموجات فوق الصوتية المحمولة
توزيع تمثيل النساء حسب العمر هو على النحو التالي ؛
17٪ بين 20-25 سنة من العمر ؛ 35٪ بين 26-30 سنة ، 25٪ بين 31-35 سنة وأقل عمر كان السيدات فوق 40 سنة بنسبة 7٪.
أعلى نسبة من النساء 57.5٪ تم فحصهن بالموجات فوق الصوتية للتشوهات الخلقية في الأثلوث الثالث ، 27٪ في الأثلوث الثاني و 9.5٪ في الأثلوث الأول.
تم العثور على وقوع حالات الشذوذ الجنيني ليكون 12.5 ٪ في السكان الشماليين. 11.5 ٪ في وسط السكان ، و 35.5 ٪ في السكان الغربيين ، و 33.5 ٪ في السكان الشرقية والجنوبية تمثل 7 ٪ فقط.
شذوذات الرأس والأنبوب العصبي 26.5٪ ، جدار البطن الأمامي يتعرّض إلى 12٪ ، الوجه والرقبة 5.5٪ والجهاز البولي التناسلي (الكلوي) 1٪. تم الإبلاغ عن السنسنة المشقوقة ، استسقاء الرأس ، عدم وجود الدماغ ، صغر الرأس و cephalocel في 45.3 ٪ ، 20.8 ٪ ، 17 ٪ ، 9.4 ٪ و 1.9 ٪ على التوالي داخل المجموعة الفرعية (رأس الأنبوب العصبي) ، وفي 12 ٪ ، 5.5 ٪ ، 4.5 ٪ ، 2.5 ٪ و 0.5 ٪ في العينة الإجمالية. تم الإبلاغ عن ورم خبيث كيسي وخَلَلُسُلَّجَّذِ الخَلْطِيّ والميكونيا في 54.5٪ و 36.4٪ و 9.1٪ على التوالي. في جدار البطن الأمامي ، كانت العيوب المبلغ عنها هي omphalocele 50 ٪ ، تليها gastroschisis 29.2 ٪ ، فتق السرة 16.7 ٪ ومتلازمة العصب الأمنيوسي 4.2 ٪ (داخل المجموعة الفرعية: جدار البطن الأمامي). في هذه العيوب سجلت في 6 ٪ ، 3.5 ٪ ، 2 ٪ و 0.5 ٪ من إجمالي العينة على التوالي.
عمر الأم أكثر من 40 سنة و عدم وجود مكملات الحديد يشكلان اهم عوامل الخطر لحدوث التشوهات الخلقية.

من المهم جدًا القيام بزيارات المتابعه والزيارات قبل الولادة لتجنب و اكتشاف الحالات التشوهات الخلقيه .

Chapter One

Introduction

Chapter One

1.1 Introduction

The progress that has been made in the field of ultrasonography has contributed to an increase in the detection of fetuses with structural anomalies both among low-risk and high-risk populations .[2-4] The great potential of ultrasonography for screening for morphological abnormalities throughout all trimesters of the pregnancy has meant that its use with obstetric patients is becoming a routine part of prenatal care.[5] Thornton JG, Lilford R J, Newcombe RG: Tables for estimation of individual risks for neural tube and ventral wall defects, incorporating prior probability, maternal serum alpha-fetoprotein, and ultrasonic examination results. Am J Obstet Gynecol 164: 154, 1991

Recent hospital-based research, covering a short time period, reported a 2.6% prevalence of congenital anomalies among the study population.[4] Although the accuracy of ultrasound for the diagnosis of congenital malformations has been the subject of many studies, it has been found that low sensitivity in combination with low rates of false-positives was associated with tracking low-risk pregnancies, leading to the belief that ultrasonography is most applicable to pregnancies involving fetal abnormalities and/or high levels of risk.[4] Sabbagha RE, DalCompo SA, Shuhaibar L: Targeted imaging for fetal anomalies. In Sabbagha RE (ed): Ultrasound Applied to Obstetrics and Gynecology, 3rd ed. Philadelphia. JB Lippincott, 1994

The majority of studies located were carried out with patients in hospital and reported high rates of detection and an elevated incidence of major malformations.

However, a population study carried out over a long period found a low level of sensitivity (28.4%), although detection of certain structural anomalies was relatively good.The morphological ultrasound scan, performed in the second trimester of the pregnancy, and the continuing specialization of sonographists, have increased the likelihood that congenital malformations will be detected, increasing diagnostic

sensitivity.[9] In certain studies, the sensitivity of detection of fetal anomalies, before the 24th week of gestation, was 93% for the central nervous system, 45.2% for the circulatory system, 85.2% for the digestive system, 85.7% for the urinary system, 84.6% for the musculoskeletal system and 95.2% for other anomalies found. Therefore, it is suggested that ultrasonography between the 20th and 22nd weeks of pregnancy can detect the majority of congenital anomalies.[10]Hegge FN: Letter to the editor. N Engl J Med 330: 570, 1994

1.2 problem of the study:

The RADIUS studies found evidence that, when compared with basic healthcare centers, centers specialized in fetal medicine had a better diagnostic approach to fetal anomalies before the 24th week of gestation. That's why; collaborative studies are needed to establish the true levels of sensitivity and specificity achieved by ultrasound diagnosis at a large number of hospitals.[11] Saari-Kamppainen A, Karjalainen O, Heinonen OP: Ultrasound screening and perinatal mortality: Controlled trial of systematic one-stage screening in pregnancy: The Helsinki Ultrasound Trial. Lancet 336: 387, 1990

1.3 Objectives

1.3.1 General objective;

To study congenital anomalies using ultrasound .

1.3.2 Specific objectives

1. To find out the most common congenital anomalies using ultrasound.
2. To determine the common risk factors of congenital anomalies.

1..4 Over all of the study;

1- Chapter one; introduction.
2- Chapter two; literature review.
3- Chapter three; materials and methodology.
4- Chapter four; results.

5- Chapter five; discussion, conclusion and recommendations.
6- References
7- Appendices

Chapter two

Literature Review

Literature Review

2.1. Theoretical background OF Embryological development

2.1.1 Neaural tube

There are two major ways of forming a neural tube. In **primary neurulation**, the cells surrounding the neural plate direct the neural plate cells to proliferate, invaginate, and pinch off from the surface to form a hollow tube. In **secondary neurulation**, the neural tube arises from a solid cord of cells that sinks into the embryo and subsequently hollows out (cavitates) to form a hollow tube. The extent to which these modes of construction are used varies among vertebrate classes. Neurulation in fishes is exclusively secondary. In birds, the anterior portions of the neural tube are constructed by primary neurulation, while the neural tube caudal to the twenty-seventh somite pair (i.e., everything posterior to the hindlimbs) is made by secondary neurulation (Pasteels 1937; Catala et al. 1996). In amphibians, such as *Xenopus,* most of the tadpole neural tube is made by primary neurulation, but the tail neural tube is derived from secondary neurulation (Gont et al. 1993). In mice (and probably humans, too), secondary neurulation begins at or around the level of somite 35 (Schoenwolf 1984; Nievelstein et al. 1993).

In frogs and chicks, secondary neurulation is usually seen in the neural tube of the lumbar (abdominal) and tail vertebrae. In both cases, it can be seen as a continuation of gastrulation. In the frog, instead of involuting into the embryo, the cells of the dorsal blastopore lip keep growing ventrally (Figure 12.9A, B). The growing region at the tip of the lip is called the **chordoneural hinge** (Pasteels 1937), and it contains precursors for both the posteriormost portion of the neural plate and the posterior portion of the notochord. The growth of this region converts the roughly spherical gastrula, 1.2 mm in diameter, into a linear tadpole some 9 mm long. The tip of the tail is the direct descendant of the dorsal blastopore lip, and the cells lining the blastopore form the **neurenteric canal**. The proximal part of the neurenteric canal fuses with the anus, while the distal portion becomes the **ependymal canal** (i.e., the lumen of the neural tube) (Figure 12.9C; Gont et al. 1993).

2.1.2 Head

At the time when the head region begins to form, the embryo is composed of three layers of tissue, the ectoderm, mesoderm and endoderm. These three germ layers become distinct during gastrulation in the third week of development. The neural folds fuse and form the neural tube, a process known as

neurulation. The process of neurulation is completed in distinct steps that include the forming, shaping and bending of the neural plate and then the closing of the neural groove. If this process does not occur correctly, major Central Nervous System abnormalities can result. In humans, the process of neurulation can be divided into the primary neurulation and secondary neurulation. In the first part of this two-stage process, the neural tube forms, which ultimately will become the brain and a large part of the spinal cord. The neuroepithelium is folded and shaped so that there can be fusion at the midline and a tube can be formed. In an extremely different process, secondary neurulation "involves condensation of a population of mesenchymal cells in the tail bud, to form an epithelial rod". The formation of the secondary neural tube results in a canal whose lumen "is continuous with that of the primary neural tube" (Greene & Copp, 2009).

ormation of the head is defined by the migration of neural crest cells that arise from the rhombomeres, segments of the forming hindbrain which will give rise to differentiated neurons (Sanes, Reh & Harris, 2006). The two streams of neural crest cells come from the first two rhombomeres and aid in the development of the face and branchial arch system. Migrating as the first stream, the crest cells "intermingle and reinforce the mesenchyme situated beneath the expanding forebrain". This first stream of cells becomes the connective tissue that is important for the development of the face, while the second is incorporated in the first branchial arch. The Hox family of Homeobox genes expressed in the rhombomeres are important in this stage for determining the pattern of development (Nanci, 2003).

Facial Formation

The stomodeum is the rudimentary mouth that forms between the first pharyngeal arches around the fourth week of development in the center of the area that will become the face. The neural crest cells of the arches contribute to the development of the skeleton, while the mesoderm will provide the musculature for the face and neck. Around the fifth week of fetal development the face begins to take shape starting with the nasal placodes that will become the nasal pits after evagination. The frontal nasal prominences form above the stomodeum like a primordial lip. When the mandibular prominences merge they will form the beginnings of lower lip, chin and mandible. The nose is actually the result of a fusion of five separate prominences: "the frontal prominence forms the bridge of the nose; the two medial nasal prominences form the crest, tip and central portion of the lip, or intermaxillary segment; and the lateral nasal prominences form the sides Complete fusion of the medial nasal prominences is important because this is where cleft lip and palate can occur (Nybery, et al, 2003). Next, the nasolacrimal groove and duct develop in the seventh week. The nasolacrimal duct is important in the "drainage of excess tears from the conjunctiva of the eye into the nasal cavity" (Larsen, 1997).

During the sixth and seventh week the nasal and maxillary processes begin to expand and fuse to form the upper lip. The lower lip begins to form earlier when the mandibular swellings become continuous and the mandibular depression is filled in "by proliferation of mesenchyme". The buccopharyngeal membrane "ruptures to form a broad, slitlike embryonic mouth" and will not take its mature shape until well into the second month of development when the "maxillary and mandibular swellings creates the cheeks" (Larsen, 1997). Robinow Syndrome, or fetal face syndrome, is a rare genetic disorder that results in children with facial abnormalities that makes them appear like they have not completely gone through full fetal development. The head is enlarged and the forehead appears to be abnormally shaped and bulging. The nose is small and malformed with flared nostrils and a sunken bridge. The eyes are very widespread. There are other abnormalities that occur that are associated with other parts of the body (CIGNA, 2007).

Development of the Nasal Cavities and Sinuses

The nasal prominences form around the nasal placodes and will "form the floors of depressions called nasal pits" which fuse during the sixth week to become one single sac. At first the oronasal membrane separates the oral and nasal cavities, but when this ruptures the two spaces will become connected. The primordial choanae are"the openings between the nasal cavity and nasopharynx" (Moore & Persaud, 1993). At the same time that the secondary palate is forming, the nasal septum begins to take shape, arising from the frontonasal process and the medial nasal processes. The septum grows downwards toward the primary and secondary palates so that the nasal cavity is divided into two passages, "which open into the pharynx behind the secondary palate through an opening called the definitive choana" (Larsen, 1997). In order for the olfactory epithelium to form, epithelial cells on the roof of the nasal cavities must specialize. "Some epithelial cells differentiate into olfactory receptor cells (neurons). The axons of these cells constitute the olfactory nerves (Cranial Nerve I), which grow into the olfactory nerves of the brain" (Moore & Persaud, 1993). There are four distinct types of sinuses that will form, though only two will develop before birth. In the third fetal month the maxillary sinuses, those that are present in the maxillary bones, form "as invaginations of the nasal sac that slowly expand in the maxillary bones". They will be very small at birth but will continue to grow during 18 the first few years of life. Two months later the ethmoid sinuses, those that sit between the eyes, will form in the ethmoid bone. They will continue to grow until approximately the time that the child reaches puberty. At birth the sinuses are so small they cannot even be detected by radiographs and this can make diagnosing infection more difficult (Rosin, 1998). In the first few years after birth, the sphenoid and frontal sinuses will form within the bones of the same name (Larsen, 1997). Surprisingly, the development of the sinus passageways plays one of the greatest roles in determining the size and shape of the face. Their growth during

fetal development and through puberty will alter appearance and result in the changing of the voice later in life.

2.1.3. The heart

The heart is the first functional organ to develop and starts to beat and pump blood at around 21 or 22 days.[19] Cardiac myoblasts and blood islands in the splanchnopleuric mesenchyme on each side of the neural plate, give rise to the cardiogenic region .This is a horseshoe-shaped area near to the head of the embryo. By day 19, following cell signaling, two strands begin to form as tubes in this region, as a lumen develops within them. These two endocardial tubes grow and by day 21 have migrated towards each other and fused to form a single primitive heart tube, the tubular heart. This is enabled by the folding of the embryo which pushes the tubes into the thoracic cavity.*[20]* Vergani P, Mariani S, 1992.

Also at the same time that the endocardial tubes are forming, vasculogenesis (the development of the circulatory system) has begun. This starts on day 18 with cells in the splanchnopleuric mesoderm differentiating into angioblasts that develop into flattened endothelial cells. These join to form small vesicles called angiocysts which join up to form long vessels called angioblastic cords. These cords develop into a pervasive network of plexuses in the formation of the vascular network. This network grows by the additional budding and sprouting of new vessels in the process of angiogenesis.[20] Vergani P, Mariani S, Ghidini A et al: Screening for congenital heart disease with the four chamber view of the heart. Am J Obstet Gynecol 167: 1000, 1992

Following vasculogenesis and the development of an early vasculature, a stage of vascular remodelling takes place.

The tubular heart quickly forms five distinct regions. From head to tail, these are the infundibulum, bulbus cordis, primitive ventricle, primitive atrium, and the sinus venosus. Initially, all venous blood flows into the sinus venosus, and is propelled from tail to head to the truncus arteriosus. This will divide to form the aorta and pulmonary artery; the bulbus cordis will develop into the right (primitive) ventricle; the primitive ventricle will form the left ventricle; the primitive atrium will become the front parts of the left and right atria and their appendages, and the sinus venosus will develop into the posterior part of the right atrium, the sinoatrial nodeand the coronary sinus.[19]

Cardiac looping begins to shape the heart as one of the processes of morphogenesis, and this completes by the end of the fourth week. Programmed cell deathin the process of apoptosis is involved in this stage, taking place at the joining surfaces enabling fusion to take place.[20] Vergani P, Mariani S, Ghidini A et al: Screening for congenital heart disease with the four chamber view of the heart. Am J Obstet Gynecol 167: 1000, 1992

In the middle of the fourth week, the sinus venosus receives blood from the three major veins: the vitelline, the umbilical and the common cardinal veins.

During the first two months of development, the interatrial septum begins to form. This septum divides the primitive atrium into a right and a left atrium. Firstly it starts as a crescent-shaped piece of tissue which grows downwards as the septum primum. The crescent shape prevents the complete closure of the atria allowing blood to be shunted from the right to the left atrium through the opening known as the ostium primum. This closes with further development of the system but before it does, a second opening (the ostium secundum) begins to form in the upper atrium enabling the continued shunting of blood.[20] Vergani P, Mariani S, Ghidini A et al: Screening for congenital heart disease with the four chamber view of the heart. Am J Obstet Gynecol 167: 1000, 1992

A second septum (the septum secundum) begins to form to the right of the septum primum. This also leaves a small opening, the foramen ovale which is continuous with the previous opening of the ostium secundum. The septum primum is reduced to a small flap that acts as the valve of the foramen ovale and this remains until its closure at birth. Between the ventricles the septum inferius also forms which develops into the muscular interventricular septum.

2.1.4 Respiratory system

The respiratory system develops from the lung bud, which appears in the ventral wall of the foregut about four weeks into development. The lung bud forms the trachea and two lateral growths known as the bronchial buds, which enlarge at the beginning of the fifth week to form the left and right main bronchi. These bronchi in turn form secondary (lobar) bronchi; three on the right and two on the left (reflecting the number of lung lobes). Tertiary bronchi form from secondary bronchi.

While the internal lining of the larynx originates from the lung bud, its cartilages and muscles originate from the fourth and sixth pharyngeal arches.[21] Sharland GK, Allan LD: Screening for congenital heart disease prenatally: Results of 2 1/2 year study in the south east Thames region. Br J Obstet Gynaecol 99: 220, 1992

Three different kidney systems form in the developing embryo: the pronephros, the mesonephros and the metanephros. Only the metanephros develops into the permanent kidney. All three are derived from the intermediate mesoderm.

Pronephros

The pronephros derives from the intermediate mesoderm in the cervical region. It is not functional and degenerates before the end of the fourth week.

Mesonephros

The mesonephros derives from intermediate mesoderm in the upper thoracic to upper lumbar segments. Excretory tubules are formed and enter the mesonephric duct, which ends in the cloaca. The mesonephric duct atrophies in females, but participate in development of the reproductive system in males.

Metanephros

The metanephros appears in the fifth week of development. An outgrowth of the mesonephric duct, the ureteric bud, penetrates metanephric tissue to form the primitive renal pelvis, renal calyces and renal pyramids. The ureter is also formed.

2.1.5 Bladder and urethra

Between the fourth and seventh weeks of development, the urorectal septum divides the cloaca into the urogenital sinus and the anal canal.

The upper part of the urogenital sinus forms the bladder, while the lower part forms the urethra.[21] Sharland GK, Allan LD;Screening for congenital heart disease prenatally: Results of 2 1/2 year study in the south east Thames region. Br J Obstet Gynaecol 99: 220, 1992

The superficial layer of the skin, the epidermis, is derived from the ectoderm. The deeper layer, the dermis, is derived from mesenchyme.

The formation of the epidermis begins in the second month of development and it acquires its definitive arrangement at the end of the fourth month. The ectoderm divides to form a flat layer of cells on the surface known as the periderm. Further division forms the individual layers of the epidermis.

The mesenchyme that will form the dermis is derived from three sources:

- The mesenchyme that forms the dermis in the limbs and body wall derives from the lateral plate mesoderm
- The mesenchyme that forms the dermis in the back derives from paraxial mesoderm
- The mesenchyme that forms the dermis in the face and neck derives from neural crest cells.[21] Sharland GK, Allan LD: Screening for congenital heart disease prenatally: Results of 2 1/2 year study in the south east Thames region. Br J Obstet Gynaecol 99: 220, 1992

2.1.6 Gastrointestinal anomalies

Congenital anomalies are anatomical or functional aberrations from the normal spectrum, which are conditioned by genetic, chromosomal, infectious, chemical physical or other harmful agents during intrauterine development. They represent a significant cause of perinatal morbidity and mortality[8]. Congenital GIA are associated in more than 50% of cases with other anomalies which complicate treatment of these patients[9]. Even GIA are complicated by them and long term prognosis is related to the associated anomalies [10]. Correct and timely diagnosis and appropriate treatment reduce morbidity, mortality and the occurrence of complications after operative treatment[11]. Sharland GK, Allan LD: Screening for congenital heart disease prenatally: Results of 2 1/2 year study in the south east Thames region. Br J Obstet Gynaecol 99: 220, 1992

Cleft lip palate

Cleft lip and palate (CLP) is the most common orofacial congenital malformation in live births. CLP can occur individually or in combination with other congenital deformities. Affected patients experience a number of dental, aesthetic, speech, hearing, and psychological complications and have a higher incidence of severe dental conditions[29]. Chitkara U. Rosenburg J. Chervenak FA et al: Prenatal sonographic assessment of the fetal thorax: Normal values. Am J Obstet Gynecol 156: 1069, 1987

The most common craniofacial malformation identified in the newborn is the orofacial cleft, which consists of cleft lip with or without cleft palate (CL/P) or isolated cleft palate (CP). They can occur as part of a syndrome involving multiple other organs or as an isolated malformation. Most studies suggest that about 70 percent of cases of CL/P and 50 percent of CP are nonsyndromic [30]. Fong K,

Ohlsson A, Zaber A: Fetal thoracic circumference: A prospective cross sectional study with real time ultrasound. Am J Obstet Gynecol 158: 1154, 1988

Duodenal obstruction

Congenital duodenal obstruction (CDO) is a frequent cause of congenital intestinal obstruction, which occurs in 1 per 5000−10,000 live births, commonly affecting boys more than girls[35]. Gray DL, Martin CM, Crane JP: Differential diagnosis of first trimester ventral wall defect. J Ultrasound Med 8: 255, 1989

Several embryological defects in foregut development, canalization, or rotation lead to congenital duodenal obstruction. Abnormal embryologic relationships between the duodenum and other structures in close anatomic proximity, such as the pancreas and portal vein, may also lead to CDO[36] Benacerraf BR, Saltzman DH, Esteroff JA, Frigoletto FD: Abnormal karyotype of fetuses with omphalocele: Prediction based on omphalocele contents. Obstet Gynecol 75: 317, 1990

. Thus, CDO can be classified into either intrinsic or extrinsic defects. Intrinsic lesions include duodenal atresia, duodenal stenosis, or duodenal web; whereas, annular pancreas, mal rotation, peritoneal bands, and anterior portal vein result in extrinsic lesions[37]. Nyberg DAS, Fitzsimmons J, Mack LA et al: Chromosomal abnormalities in fetuses with omphalocele: Significance of omphalocele contents. J Ultrasound Med 8: 299, 1989

Imperforate anus

An imperforate anus or anorectal malformations (ARMs) are birth defects in which the rectum is malformed. ARMs are a spectrum of different congenital anomalies in males and females, that varies from fairly minor lesions to complex anomalies.[41] The cause of ARMs is unknown; the genetic basis of these anomalies is very complex because of their anatomical variability. In 8% of patients genetic factors are clearly associated with ARMs.

Anorectal malformation in Currarino syndromerepresents the only association for which the gene HLXB9 has been identified[42]. Pretorius D, Budorick N, Cahill T et al: Midtrimester echogenic bowel and chromosomal abnormalities (SPO abstract 20). Am J Obstet Gynecol 166: 283, 1992

Congenital anomalies of the kidney

Congenital anomalies of the kidney and urinary tract (CAKUT) constitute approximately 20 to 30 percent of all anomalies identified in the prenatal period [1]. An overview of the congenital anomalies of the kidney and urinary tract (CAKUT) Congenital anomalies of the kidney and urinary

tract (CAKUT) represent a broad range of disorders that result from the following abnormal renal developmental processes:

- Malformation of the renal parenchyma resulting in failure of normal nephron development as seen in renal dysplasia, renal agenesis, renal tubular dysgenesis, and polycystic renal diseases.
- Abnormalities of embryonic migration of the kidneys as seen in renal ectopy (eg, pelvic kidney) and fusion anomalies, such as horseshoe kidney.
- Abnormalities of the developing urinary collecting system as seen in duplicate collecting systems, posterior urethral valves, and ureteropelvic junction obstruction.

Defects can be bilateral or unilateral, and different defects often coexist in an individual child.

Because CAKUT play a causative role in 30 to 50 percent of cases of end-stage renal disease (ESRD) [2], it is important to diagnose and initiate therapy to minimize renal damage, prevent or delay the onset of ESRD, and provide supportive care to avoid complications of ESRD. Patients with malformations with a reduction in kidney numbers or size are the most likely to have a poor renal prognosis [3]. Sabbagha RE, Sheikh Z, Tamura RK et al: Predictive value, sensitivity, and specificity of ultrasonic targeted imaging for fetal anomalies in gravid women at high risk for birth defects. Am J Obstet Gynecol 152: 822, 1985

2.1.2 Pathology of congenital anomalies;

Neural tube anomalies central nervous system (CNS) malformations are the second most frequent category of congenital anomaly, after congenital heart disease. Ultrasound examination is an effective modality for the prenatal diagnosis of these anomalies. An accurate fetal diagnosis depends upon a precise description of the sonographic appearance of the CNS and careful evaluation for associated malformations, which are often present [1]. Johnson P, Sharland G, Maxwell D, Allan L: The role of transvaginal sonography in the early detection of congenital heart disease. Ultrasound Obstet Gynecol 2: 2481, 1992

A thorough understanding of the normal sonographic appearance of the CNS at different gestational ages is crucial for accurate diagnosis because the presence or absence of a structure may be deemed normal or abnormal depending upon the age of the fetus.

As an example, a sonogram of the fetal brain at 14 weeks of gestation cannot detect agenesis of the corpus callosum since this structure does not become sonographically apparent until 18 to 20 weeks

of gestation and does not acquire its final form until 28 to 30 weeks. In another example, a population-based study of 55,226 pregnancies reported 143 infants with CNS defects, 85 of whom had a prenatal sonogram at 16 to 20 weeks of gestation [2] Johnson P, Sharland G, Maxwell D, Allan L: The role of transvaginal sonography in the early detection of congenital heart disease. Ultrasound Obstet Gynecol 2: 2481, 1992. The diagnosis of CNS abnormality was made prenatally in 64 (75 percent), not made in 17 (20 percent), and was questionable in 4 (5 percent). Poor timing of the examination, rather than poor sensitivity, was the most important factor in failing to detect a CNS defect.

Three-dimensional (3D) ultrasound plays an important role in the evaluation of brain anomalies since it has the potential for further characterization of these defects. Multiplanar imaging of the brain, as well as use of a variety of display modalities, such as tomographic imaging, inversion, maximum-mode, surface rendering, and volume scanning, allows the sonologist to obtain planes and sections not possible with conventional two-dimensional (2D) sonography. The pediatric neurologist or neurosurgeon can use this additional information when counseling parents about prognosis and clinical management options.

Fast magnetic resonance imaging (MRI) can also be used to image the fetus. However, we feel that ultrasonography continues to be the modality of choice in the evaluation of a fetus at risk for a neural tube defect (NTD), given its high detection rates.

Genetic amniocentesis should be offered when NTDs are identified, as there is a 5 to 7 percent rate of aneuploidy in these fetuses [3-6]. The incidence of chromosomal abnormalities is as high as 20 percent in fetuses with major CNS abnormalities plus other congenital anomalies; however, the incidence falls to about 1 to 2 percent when NTDs are isolated.

EXENCEPHALY — Exencephaly refers to absence of the entire or a significant portion of the cranium, but brain tissue is present. It appears to be the embryologic predecessor of anencephaly [7-13]. In-utero diagnosis requires careful examination of both the fetal cranium and brain.

The integrity of the fetal cranium can be assessed with transvaginal sonography (TVS) from the first trimester since ossification of cranial bone has begun [14,15]. The first trimester exencephalic fetus has an abnormal head shape with sonolucent spaces within disintegrating brain. The outer shape of the head is bilobed; this appearance has been called "Mickey Mouse" head [16-18]. Exencephaly has been detected as early as the 10th postmenstrual week.

In the second trimester, the usual appearance of the brain is lost. It is heterogeneous and is not covered by the cranium. The fetal facial bones, however, can be clearly visualized.

ANENCEPHALY — Anencephaly is the most common NTD, occurring in approximately 1 per 1000 births prior to the era of routine prenatal screening .More recently, anencephaly has been reported in only 1 in 10,000 births in the United States [21]. It is characterized by absence of the brain and lack of the cranial vault due to failure of the rostral neuropore to close during the 24th to 26th day post conception [7]. Ewigman BG, Crane JP, Frigoletto FD et al: A randomized trial of prenatal ultrasound screening in a low risk population: Impact on perinatal outcome. N Engl J Med 329: 821, 1993

The anencephalic fetus can be definitively identified by the 12th postmenstrual week by TVS, although in some cases this diagnosis has been

made at 9 to 10 postmenstrual weeks [22]. Bromley B, Estroff JA, Sanders SP et al: Fetal echocardiography: Accuracy and limitations in a population at high risk for heart defects. Am J Obstet Gynecol 166: 1473, 1992

Dystrophic brain tissue may be observed early in pregnancy, but disappears later in gestation. The fetal face from the orbits to the chin is usually normal, but there is no skull above the orbits anteriorly and above the cervical spine posteriorly. Polyhydramnios develops in up to 50 percent of the cases during the second and third trimester due to decreased fetal swallowing, but is not present during the first trimester [8,23-25]. Craniorachischisis (congenital incomplete closure of the skull and spine) is observed in less than 10 percent of cases [25]. Faarant P: The antenatal diagnosis of esophageal atresia by ultrasound. Br J Radiol 53: 1202, 1988

Fetal activity is not significantly impaired.

A relatively early and indirect sonographic sign of anencephaly/exencephaly sequence is a significant amount of low-level-echogenic, particulate matter containing amniotic fluid. This results from the "rubbing off" of the exposed neural tissue [26]. Measurement of the crown-chin length and the ratio of the crown-chin to crown-rump length (CRL) at 10 to 14 postmenstrual weeks is also useful in the early recognition of anencephaly [27]. Mariona F, McAlpin G, Zador I et al: Sonographic detection of fetal extrathoracic pulmonary sequestration. J Ultrasound Med 5: 283, 1986

Up to 75 percent of anencephalic fetuses are stillborn with the remainder dying shortly after birth [28,29]. Preterm labor and delivery may occur due to uterine over distention from polyhydramnios or the pregnancy may extend postterm because absence of fetal brain precludes normal pathways in

the fetus' initiation of labor [30]. Fong K, Ohlsson A, Zaber A: Fetal thoracic circumference: A prospective cross sectional study with real time ultrasound. Am J Obstet Gynecol 158: 1154, 1988

Delivery is usually induced given the uniformly lethal prognosis [32]. Sabbagha RE, Comstock CH: Abnormalities of the chest and gastrointestinal tract. In Sabbagha RE (ed): Ultrasound Applied to Obstetrics and Gynecology, 2nd ed. Philadelphia, JB Lippincott, 1987

Management of twins where one twin is anencephalic is more complicated.

CEPHALOCELE — Cephaloceles (eg, encephalocele) are usually, but not exclusively, midline cranial defects through which the brainand/or meninges have herniated outside of the skull. The occipital, frontal, parietal, orbital, nasal, or nasopharyngeal region of the head can be involved, but most occur posteriorly.

The typical sonographic appearance of cephalocele is a defect of the bony skull with a protruding sac-like structure. The sac may be sonolucent and contain cerebrospinal fluid (meningocele) [33] Wenstrom KD, Weiner CP, Hanson J W: A five-year state-wide experience with congenital diaphragmatic hernia. Am J Obstet Gynecol 165: 838, 1991 , brain tissue (encephalocele), or a combination of both [34]. Green JJ, Hobbins JC: Abdominal ultrasound examination of the first trimester fetus. Am J Obstet Gynecol 159: 165, 1988

Very early in the pregnancy, ultrasound may provide more information about the CNS than MRI, but MRI is better than ultrasound for evaluating the brain parenchyma in the late second and third trimesters and in situations in which the intracranial component of the malformation is not clear. For example, MRI is better at visualizing some brain malformations, such as migrational anomalies, which are not seen well on ultrasound.

Posterior cephalocele has been diagnosed as early as 12 postmenstrual weeks [37] Nyberg DAS, Fitzsimmons J, Mack LA et al: Chromosomal abnormalities in fetuses with omphalocele: Significance of omphalocele contents. J Ultrasound Med 8: 299, 1989 , but early diagnosis is usually made from 13 to 14 postmenstrual weeks .

Cephalocele usually occurs as an isolated lesion, but may be a part of a syndrome such as Meckel (or Meckel-Gruber) or Walker-Warburg syndrome in a small percentage of cases. Both syndromes are autosomal recessive. Cephaloceles also can occur in association with aneuploidy; therefore, fetal karyotype should be offered.

- The classical triad of Meckel syndrome is occipital cephalocele (present in 80 percent), bilateral polycystic kidneys, and post-axial polydactyly .Prenatal diagnosis of Meckel-Gruber syndrome has been made in the first and early second trimesters .These abnormalities may be difficult to visualize since renal dysfunction results in severe oligohydramnios.
- Walker-Warburg syndrome is characterized by lissencephaly, cerebellar hypoplasia, Dandy-Walker cyst, and ocular abnormalities .
- Cephalocele can also be due to amniotic band syndrome, in which case they can involve any part of the skull.

Maternal serum alpha-fetoprotein levels are usually highly elevated; exceptions occur when the defect is covered by scalp. There is an increased risk of chromosomal abnormalities with NTDs so determining the fetal karyotype should be offered.

INIENCEPHALY — Iniencephaly is a rare, lethal developmental anomaly with three major features [48-54] Estes JM, Adzick NS, Harrison MR: Antenatal open surgery for the abnormal fetus. In Sabbagha RE (ed): Ultrasound Applied to Obstetrics and Gynecology, 3rd ed. Philadelphia, JB Lippincott, 1994 :

- A defect in the occiput involving the foramen magnum
- Retroflexion of the entire spine, which forces the fetus to look upwards with its occiput directed towards the lumbar region
- Open spinal defects of variable degrees present in up to 50 percent of the cases [55]. Potter EL: Type II cystic kidney: Early ampullary inhibition in normal and abnormal development of the kidney, p 154. Chicago, Year Book Medical, 1972

This is technically not an NTD, but many textbooks list it in the CNS section.

The malformation results from developmental arrest of the embryo during the third postmenstrual week This results in persistence of embryonic cervical retroflexion and leads to failure of the neural groove to close in the area of the cervical spine or upper thorax Associated malformations occur in up to 84 percent of cases and include hydrocephaly, microcephaly, ventricular atresia, holoprosencephaly, polymicrogyria, agenesis of the cerebellar vermis, occipital encephalocele, diaphragmatic hernia, thoracic cage deformities, urinary tract anomalies, cleft lip and palate, omphalocele, and polyhydramnios . The sonographic diagnosis has been made as early as 12.5 to 13 postmenstrual weeks [35,49]. Young ID, Mckeever PA, Brown LA et al: Prenatal diagnosis of the megacystis-microcolon-intestinal hypoperistalsis syndrome. J Med Genet 26: 403, 1989

Hydrocephalus

Hydrocephalus is a disorder in which an excessive amount of cerebrospinal fluid (CSF) accumulates within the cerebral ventricles and/or subarachnoid spaces, which are dilated .

In children, hydrocephalus is almost always associated with increased intracranial pressure (ICP). In most cases, this is caused by excess CSF accumulating in the cerebral ventricles due to disturbances of CSF circulation (known as obstructive or non-communicating hydrocephalus). Less often, the CSF accumulates because of impaired absorption (known as communicating hydrocephalus).

By contrast, in normal pressure hydrocephalus, the cerebral ventricles are pathologically enlarged, but the ICP is within the normal range. This condition is usually caused by impaired CSF absorption.

These forms of hydrocephalus are distinct from two radiographic findings that include the same word. The term “hydrocephalus ex-vacuo” refers to dilatation of the ventricles secondary to brain atrophy or loss of brain tissue secondary to an insult; hydrocephalus ex-vacuo is not accompanied by increased ICP. The term “external hydrocephalus” or “benign enlargement of the extra-axial spaces” refers to excessive fluid, usually CSF, in the subarachnoid spaces and is associated with familial macrocephaly [3,4]. Chervenak FA, Rosenberg J, Brightman RC et al: A prospective study of the accuracy of ultrasound in predicting fetal microcephaly. Obstet Gynecol 69: 908, 1987

2.1.3 Epidemiology of congenital anomalies

Twenty years elapsed since the advent of fetal echocardiography. To date, almost every structural congenital heart disease (CHD) described in postnatal life has been detected in utero by fetal cardiac ultrasound.

Prenatal diagnosis has allowed new insights into the epidemiology of CHD. From published series of structural cardiac anomalies detected during fetal life it is apparent that the closest figure to the true incidence of CHD in the general population of fetuses is 1 percent.[30] Discrepancy between prenatal and postnatal series can be partly explained by the unexpectedly high tendency towards spontaneous intra-uterine demise and early postnatal death of fetuses with cardiac abnormalities.

It is clear that there is a strong association between the presence of fetal cardiac disease, extracardiac abnormalities and aneuplodies.[32] While the incidence of chromosomal abnormalities in fetuses with CHD ranges from 17 to 48 per cent,[32–35] only 5-10 per cent of infants with congenital heart disease are found to be chromosomically abnormal.[36] Associated extracardiac structural malformations are more frequent as well, i.e. 19% prenatally compared to 13% at birth in the largest Italian series.[31] This discrepancy is likely to be due to the tendency toward spontaneous fetal loss of pregnancies carrying chromosomically and/or structurally abnormal fetuses; however it is difficult to prove it, because of the high pregnancy termination rate altering the natural history of disease. We recently reported on 67 cases of anomalies of ventricular outlets which were diagnosed prenatally: chromosomal aberrations and extracardiac malformations were found in 18% and 37%, respectively.[37] There were 48% livebirths in isolated cases and 15% in cases with extracardiac anomalies. The frequency of association with aneuploidies and/or extracardiac anomalies is different for differing congenital heart diseases, being highest for atrio-ventricular septal defects (48%) and lowest for complete transposition of the great arteries i.e. concordant atrioventricular connections with discordant ventriculoarterial connections (0-2.6%).[31,32] Vintzileos AM, Campbell WA, Rodis JF et al: Comparison of six different ultrasonographic methods for predicting lethal fetal pulmonary hypoplasia. Am J Obstet Gynecol 161: 606, 1989

2.1.4 Risk factors for congenital anomalies ;

Alcohol exposure

The mother's consumption of alcohol during pregnancy can cause a continuum of various permanent birth defects : craniofacial abnormalities,[18] brain damage,[19] intellectual disability, heart disease, kidney abnormality, skeletal anomalies, ocular abnormalities.[21] Sharland GK, Allan LD: Screening for congenital heart disease prenatally: Results of 2 1/2 year study in the south east Thames region. Br J Obstet Gynaecol 99: 220, 1992

Toxic substances

Substances whose toxicity can cause congenital disorders are called teratogens, and include certain pharmaceutical and recreational drugs in pregnancy as well as many environmental toxins in pregnancy.[26]

A review published in 2010 identified 6 main teratogenic mechanisms associated with congenital anomalies.

Drinking water is often a medium through which harmful toxins travel. Studies have shown that heavy metals, elements, nitrates, nitrites, fluoride can be carried through water and cause congenital disorders. Nitrate, which is found mostly in drinking water from ground sources, is a powerful teratogen. A case-control study in rural Australia that was conducted following frequent reports of prenatal mortality and congenital malformations found that those who drank the nitrate-infected groundwater, as opposed to rain water, ran the risk of giving birth to children with central nervous system disorders, muscoskeletal defects, and cardiac defects.[39] Sipes SL, Weiner CP. Sipes DR II et al: Gastroschisis and omphalocele: Does either antenatal diagnosis or route of delivery make a difference in perinatal outcome? Obstet Gynecol 76: 195, 1990

Medications and supplements

Probably, the most well-known teratogenic drug is thalidomide. And Vitamin A, is the sole vitamin which is embryotoxic even in a therapeutic dose, for example in multivitamins, because its metabolite retinoic acid, plays an important role as a signal molecule in the development of several tisues and organs. Its natural precursor, β-carotene, is considered safe, whereas the consumption of animal liver can lead to malformation, as the liver stores lipophile vitamins, including retinol.[35] Isotretinoin (13-cis-retinoic-acid; brand name Roaccutane), vitamine A analog, which is often used to treat severe acne, is such a strong teratogen that just a single dose taken by a pregnant woman (even transdermally) may result in serious birth defects. Because of this effect, most

countries have systems in place to ensure that it is not given to pregnant women, and that the patient is aware of how important it is to prevent pregnancy during and at least one month after treatment. Medical guidelines also suggest that pregnant women should limit vitamin A intake to about 700 µg/day, as it has teratogenic potential when consumed in excess.[36][37] Nyberg DAS, Fitzsimmons J, Mack LA et al: Chromosomal abnormalities in fetuses with omphalocele: Significance of omphalocele contents. J Ultrasound Med 8: 299, 1989

Vitamine A and similar substances can induce spontaneous abortions, premature births, defects of eyes (microphthalmia), ears, thymus, face deformities, neurological (hydrocephalus, microcephalia) and cardiovascular defects, as well as mental retardation.[35] Gray DL, Martin CM, Crane JP: Differential diagnosis of first trimester ventral wall defect. J Ultrasound Med 8: 255, 1989

Several anticonvulsants are known to be highly teratogenic. Phenytoin, also known as diphenylhydantoin, along with carbamazepine is responsible for the fetal hydantoin syndrome, which may typically include broad nose base, cleft lip and/or palate, microcephalia, nails and fingers hypoplasia, intrauterine growth restriction and mental retardation. Trimethadione taken during pregnancy is responsible for the fetal trimethadione syndrome, characterized by craniofacial, cardiovascular, renal and spine malformations, along with a delay in mental and physical development. Valproate has antifolate effects, leading to neural tubeclosure-related defects such as spina bifida. Lower IQ and autism have recently also been reported as a result of intrauterine valproate exposure

Hormonal contraception is considered as harmless for the embryo. Peterka and Novotnádo however state that syntethic progestines used to prevent miscarriage in the past frequently caused masculinization of the outer reproductive organs of female newborns due to their androgenic activity.

Smoking

Paternal smoking prior to conception has been linked with the increased risk of congenital abnormalities in offspring.[23] Smoking causes DNA mutations in the germline of the father, which can be inherited by the offspring. Cigarette smoke acts as a chemical mutagen on germ cell DNA. The germ cells suffer oxidative damage, and the effects can be seen in altered mRNA production, infertility issues, and side effects in the embryonic and fetal stages of development. This oxidative damage may result in epigenetic or genetic modifications of the father's germline. Research has shown that fetal lymphocytes have been damaged as a result of a father's smoking habits prior to conception.

Infections

A vertically transmitted infection is an infection caused by bacteria, viruses or, in rare cases, parasites transmitted directly from the mother to an embryo, fetus or baby during pregnancy or childbirth. It can occur when the mother gets an infection as an intercurrent disease in pregnancy.

Rubella is known to cause abnormalities of the eye, internal ear, heart, and sometimes the teeth. More specifically, fetal exposure to rubella during weeks five to ten of development (the sixth week particularly) can cause cataracts and microphthalmia in the eyes. If the mother is infected with rubella during the ninth week, a crucial week for internal ear development, there can be destruction of the organ of Corti, causing deafness.

Other infectious agents include cytomegalovirus, the herpes simplex virus, hyperthermia, toxoplasmosis, and syphilis. Mother exposure to cytomegalovirus can cause microcephaly, cerebral calcifications, blindness, chorioretinitis (which can cause blindness), hepatosplenomegaly, and meningoencephalitis in fetuses.[48]

Genetics

Genetic causes of birth defects include inheritance of abnormal genes from the mother or the father, as well as new mutations in one of the germ cells that gave rise to the fetus. Male germ cells mutate at a much faster rate than female germ cells, and as the father ages, the DNA of the germ cells mutates quickly. If an egg is fertilized with sperm that has damaged DNA, there is a possibility that the fetus could develop abnormally.

Radiation

For the survivors of the atomic bombing of Hiroshima and Nagasaki, who are known as the *Hibakusha*, no statistically demonstrable increase of birth defects/congenital malformations was found among their later conceived children, or found in the later conceived children of cancer survivors who had previously received radiotherapy. The surviving women of Hiroshima and Nagasaki who were able to conceive, though exposed to substantial amounts of radiation, later had children with no higher incidence of abnormalities/birth defects than in the Japanese population as a whole.

Parent's age

Certain birth complications can occur more often in advanced maternal age (greater than 35 years). Complications include fetal growth restriction, preeclampsia, placental abruption, pre-mature births, and stillbirth. These complications not only may put the child at risk, but also the mother.

The effects of the fathers age on offspring are not yet well understood and are studied far less extensively than the effects of the mother's age.[75] Fathers contribute proportionally more DNA mutations to their offspring via their germ cells than the mother, with the paternal age governing how many mutations are passed on. This is because, as humans age, male germ cells acquire mutations at a much faster rate than female germ cells.

2.1.5 Ultrasound screening

Ultrasound imaging is now routinely used in most European countries for the purpose of screening pregnancies for fetal malformations. The modalities, reliability and value of such screening, however, are controversial.

As to the time in pregnancy at which ultrasound screening should be performed, it should be first noted that most structural anomalies are increasingly detected with advancing gestation.[11] In early pregnancy, it is possible to recognise with confidence certain types of fetal malformations, like anencephaly, which can be reliably diagnosed at 10-14 weeks of pregnancy. In some cases omphalocele and limb anomalies are also definable using ultrasound in the first trimester, while other structural anomalies, like urinary tract abnormalities, are detectable later in pregnancy

Screening for neural tube defects may ideally involve ultrasound examination in conjunction with maternal serum alpha-fetoprotein screen. On comparison of the two methods, maternal serum screening was found to have a slightly greater sensitivity compared to ultrasound.

Ultrasound screening for fetal structural abnormalities is generally recommended at 19-21 weeks of gestational age. The accuracy in detecting malformations by ultrasound, however, shows great variability among centres and operators. In one multicenter study, the accuracy of ultrasonographic studies performed before 24 gestational weeks was compared between tertiary versus nontertiary ultrasound laboratories involved, all of which were equipped with state-of-the-art equipment and were provided with in-service training, review and additional training conducted as necessary. Nonetheless, the overall sensitivity for ultrasonographically detectable fetal malformations was 35% in tertiary facilities significantly higher compared to 13% in community hospitals, suggesting that operator experience, skills, and training are important determinants. Other factors affecting sensitivity are: single vs multicentre study, type of malformation (major vs minor, single vs multiple,

natural history of the disease during fetal life), gestational age at ultrasound examination, length and accuracy of follow-up (some malformations are detected in early or even late infancy). In a European multicenter study involving 3686 malformed fetuses the overall detection rate was 56%, but only 44% of the cases were diagnosed before 24 weeks. As shown in Table 1, sensitivity was higher for some and lower for other malformations.

Table 1

Sensitivity of ultrasound by type of anomaly in 4615 malformations[11]

Anomaly	Prevalence (%) of all anomalies	Sensitivity (%)
Central nervous system	16	88
Cardiovascular	21	28
Muscoloskeletal	23	37
Urinary tract	21	88
Digestive system	5	54
Cleft lip and palate	7	18
Total	100	56

Therefore, prevalence data of specific malformations in different studies also affect overall sensitivity of ultrasound within a given population. (Table 2).

Diagnostic potential of ultrasound

Initial data on the potential of ultrasound for detecting structural malformations were derived from populations at specific risk investigated at centers of excellence by expert operators, with sensitivities as high as 85-90% (Fig (Fig11–4). Those promising data could not be replicated in the general population. Indeed, data on detection rates using ultrasound for screening for fetal malformations do vary widely, showing a range from 8.7% to 85%.Such wide differences reflect varying criteria for definition of malformation, postnatal examination, selection of study population, prevalence of specific anomalies within a population, and other methodology issues (e.g., single hospital versus multicenter setting, expertise and skills of operators, use of standardized protocols for ultrasonographic examination).

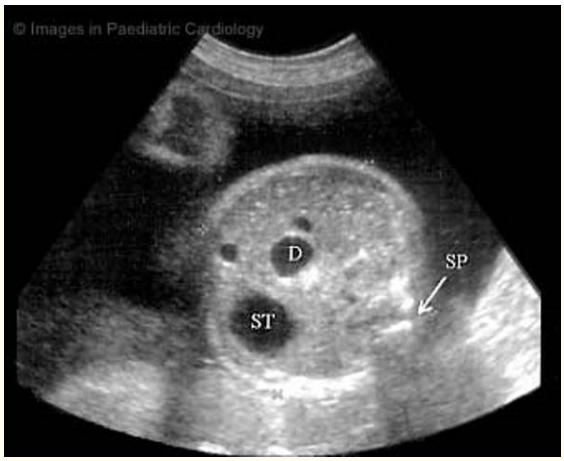


Fig. 1 Duodenal atresia at 28 weeks of gestational age. Transverse scan of the abdomen (ST, stomach;D, dilatated duodenal bulb; SP, fetal spine),

TW. Sadler Medical Embryology (chapter 2.6 Ultrasound finding)

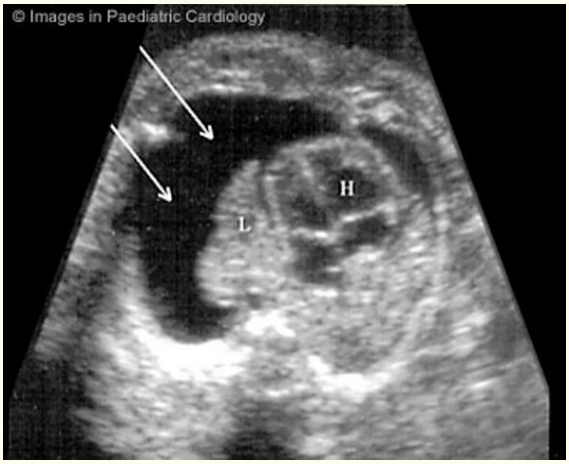


Fig 4 Cross section of a fetal thorax with hydrothorax (arrows); L, lung; H, heart

TW. Sadler Medical Embryology (chapter 2.6 Ultrasound finding)

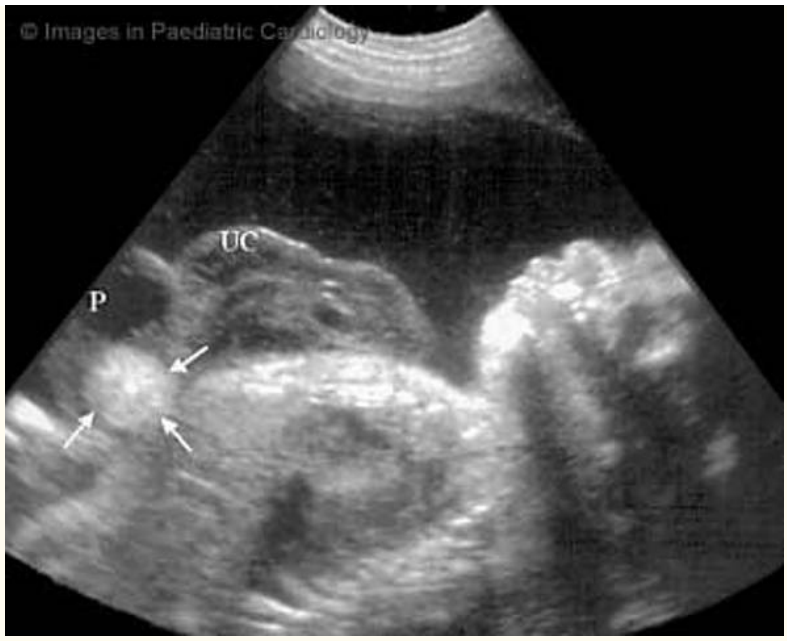


Fig. 2 Umbilical cord at the level of insertion into the fetal abdomen. Hemangioma (arrows); UC, umbilical cord; P, pseudocyst

(Kuideep Sngh &Ashok khurana , ultrasound of fetal anomalies .1st ed 2002 , chapter 6)

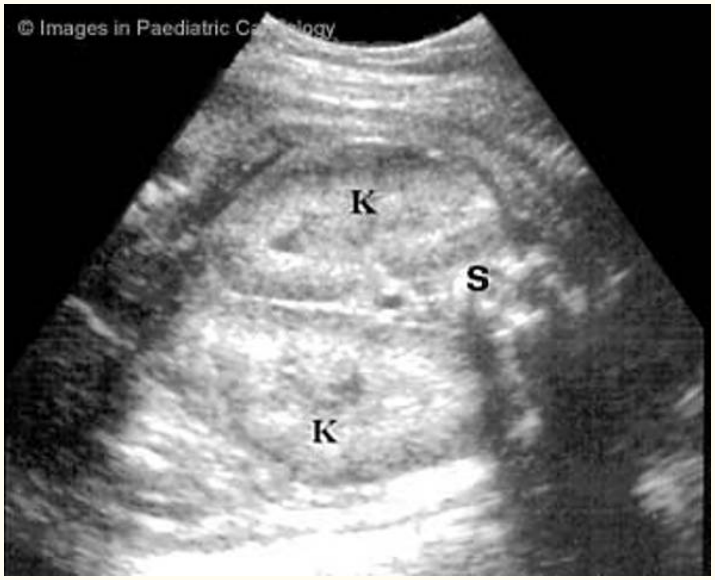
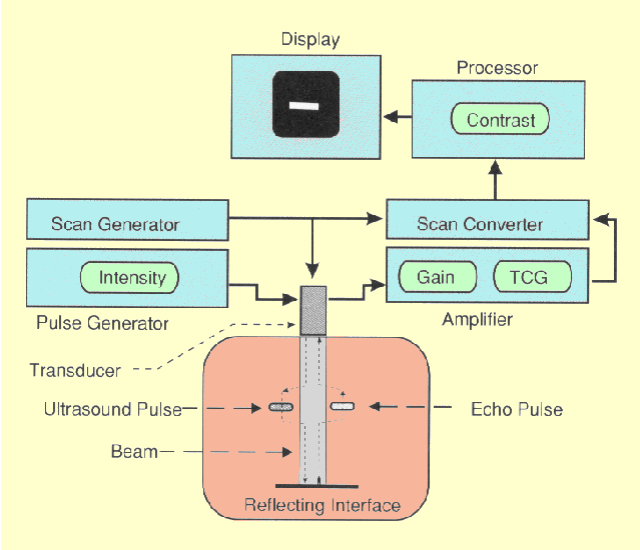


Fig. 3 Bilateral polycystic kidney. Transverse section of the abdomen at 28 weeks (K, kidney; S, fetal spine) *Kuideep Sngh &Ashok khurana , ultrasound of fetal anomalies .1st ed 2002 , chapter 6)*

2.5.2 Ultrasound imaging system

The basic functional components of an ultrasound imaging system are shown below.



The Principal Functional Components of an Ultrasound Imaging System

Modern ultrasound systems use digital computer electronics to control most of the functions in the imaging process. Therefore, the boxes in the illustration above represent functions performed by the computer and other electronic circuits and not individual physical components.

We will now consider some of these functions in more detail and how they contribute to image formation.

Transducer

The transducer is the component of the ultrasound system that is placed in direct contact with the patient's body. It alternates between two major functions: (1) **producing** ultrasound pulses and (2) **receiving** or detecting the returning echoes. Within the transducer there are one or more piezoelectric elements. When an electrical pulse is applied to the piezoelectric element it vibrates and produces the ultrasound. Also, when the piezoelectric element is vibrated by the returning echo pulse it produces a pulse of electricity.

The transducer also **focuses** the beam of pulses to give it a specific size and shape at various depths within the body and also **scans** the beam over the anatomical area that is being imaged.

Pulse Generator

The pulse generator produces the electrical pulses that are applied to the transducer. For conventional ultrasound imaging the pulses are produced at a rate of approximately 1,000 pulses per second. NOTE: This is the pulse rate (pulses per second) and not the frequency which is the number of cycles or vibrations per second within each pulse. The principal control associated with the pulse generator is the size of the electrical pulses that can be used to change the intensity and energy of the ultrasound beam.

Amplification

Amplification is used to increase the size of the electrical pulses coming from the transducer after an echo is received.. The amount of amplification is determined by the gain setting. The principal control associated with the amplifier is the time gain compensation (TGC), which allows the user to adjust the gain in relationship to the depth of echo sites within the body. This function will be considered in much more detail in the next section.

Scan Generator

The scan generator controls the scanning of the ultrasound beam over the body section being imaged. This is usually done by controlling the sequence in which the electrical pulses are applied to the piezoelectric elements within the transducer. This is also considered in more detail later.

Scan Converter

Scan conversion is the function that converts from the format of the scanning ultrasound beam into a digital image matrix format for processing and display.

Image Processor

The digital image is processed to produce the desired characteristics for display. This includes giving it specific contrast characteristics and reformatting the image if necessary.

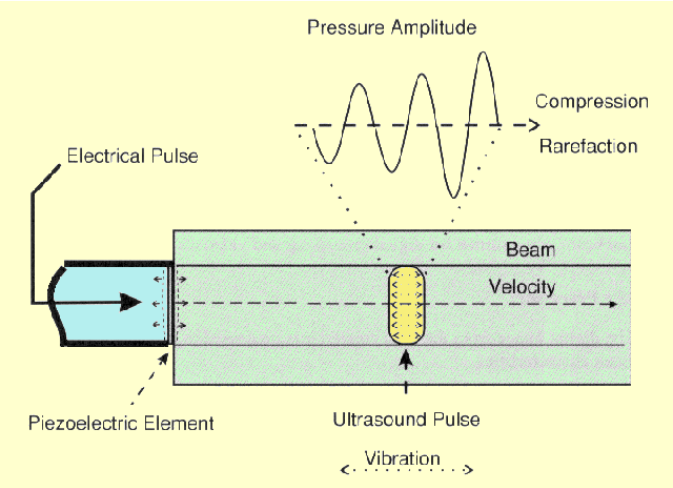
Display

The digital ultrasound images are viewed on the equipment display (monitor) and usually transferred to the physician display or work station.

One component of the ultrasound imaging system that is not shown is the digital storage device that is used to store images for later viewing if that process is used.

THE ULTRASOUND PULSE

The basic principles of ultrasound pulse production and transmission are illustrated below.



The Production of an Ultrasound Pulse

The source of sound is a vibrating object, the piezoelectric transducer element. Since the vibrating source is in contact with the tissue, it is caused to vibrate. The vibrations in the region of tissue next to the transducer are passed on to the adjacent tissue. This process continues, and the vibrations, or sound, is passed along from one region of tissue to another. The rate at which the tissue structures vibrate back and forth is the frequency of the sound. The rate at which the vibrations move through the tissue is the velocity of the sound.

The sound in most diagnostic ultrasound systems is emitted in pulses rather than a continuous stream of vibrations. At any instant, the vibrations are contained within a relatively small volume of the material. It is this volume of vibrating material that is referred to as the ultrasound pulse. As the vibrations are passed from one region of material to another, the ultrasound pulse, but not the material, moves away from the source.

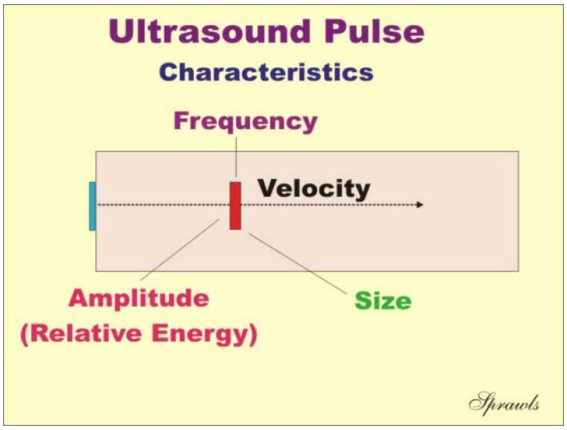
In soft tissue and fluid materials the direction of vibration is the same as the direction of pulse movement away from the transducer. This is characterized as longitudinal vibration as opposed to the transverse vibrations that occur in solid materials. As the longitudinal vibrations pass through a region of tissue, alternating changes in pressure are produced. During one half of the vibration cycle the tissue will be compressed with an increased pressure. During the other half of the cycle there is a reduction in pressure and a condition of rarefaction. Therefore, as an ultrasound pulse moves through tissue, each location is subjected to alternating compression and rarefaction pressures.

As shown above, the space through which the ultrasound pulse moves is the beam. In a diagnostic system, pulses are emitted at a rate of approximately 1,000 per second. The pulse rate (pulses per

second) should not be confused with the frequency, which is the rate of vibration of the tissue within the pulse and is in the range of 2-20 MHz.

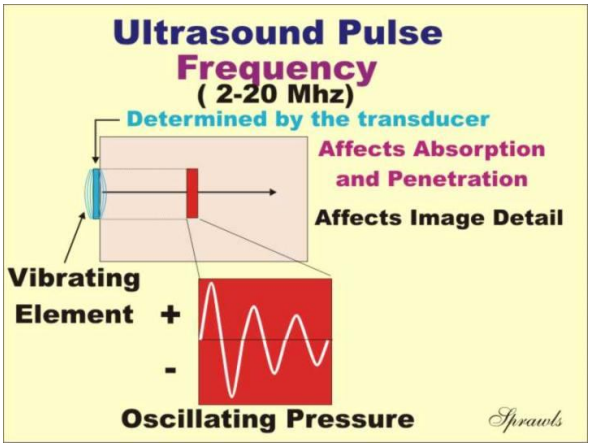
ULTRASOUND CHARACTERISTICS

Ultrasound pulses have several physical characteristics that should be considered by the user in order to adjust the imaging procedure for specific diagnostic applications. The most significant characteristics are illustrated here.



The Characteristics of Ultrasound Pulses That Have an Effect on the Imaging Process

Frequency



Ultrasound Pulse Frequency

The frequency of ultrasound pulses must be carefully selected to provide a proper balance between image detail and depth of penetration. In general, high frequency pulses produce higher quality images but cannot penetrate very far into the body. These issues will be discussed in greater detail later.

The frequency of sound is determined by the source. For example, in a piano, the source of sound is a string that is caused to vibrate by striking it. Each string within the piano is adjusted, or tuned, to vibrate with a specific resonant frequency. In diagnostic ultrasound equipment, the sound is

generated by the transducer. The major element within the transducer is a crystal designed to vibrate with the desired frequency. A special property of the crystal material is that it is piezoelectric. This means that the crystal will deform if electricity is applied to it. Therefore, if an electrical pulse is applied to the crystal it will have essentially the same effect as the striking of a piano string: the crystal will vibrate. If the transducer is activated by a single electrical pulse, the transducer will vibrate, or "ring," for a short period of time. This creates an ultrasound pulse as opposed to a continuous ultrasound wave. The ultrasound pulse travels into the tissue in contact with the transducer and moves away from the transducer surface, as shown in the above figure. A given transducer is often designed to vibrate with only one frequency, called its resonant frequency. Therefore, the only way to change ultrasound frequency is to change transducers. This is a factor that must be considered when selecting a transducer for a specific clinical procedure. Certain frequencies are more appropriate for certain types of examinations than others. Some transducers are capable of producing different frequencies. For these the ultrasound frequency is determined by the electrical pulses applied to the transducer. **Velocity**

Factors Related to Ultrasound Pulse Velocity

The significance of ultrasound velocity is that it is used to determine the depth location of structures in the body. The velocity with which sound travels through a medium is determined by the characteristics of the material and not characteristics of the sound. The velocity of longitudinal sound waves in a liquid type medium like tissue is given by

$$\text{Velocity} = \sqrt{E/r}$$

where **r** is the density of the material, and **E** is a factor related to the elastic properties or "stiffness" of the material. The velocities of sound through several materials of interest are given in the following table.

Approximate Velocity of Sound in Various Materials

Material	*Velocity (m/sec)*
Fat	1450
Water	1480
Soft tissue (average)	1540
Bone	4100

Most ultrasound systems are set up to determine distances using an assumed velocity of 1540 m/sec. This means that displayed depths will not be completely accurate in materials that produce other ultrasound velocities such as fat and fluid.

Wavelength

The distance sound travels during the period of one vibration is known as the wavelength, **l**. Although wavelength is not a unique property of a given ultrasound pulse, it is of some significance because it determines the size (length) of the ultrasound pulse. This has an effect on image quality, as we will see later.

The illustration below shows both temporal and spatial (length) characteristics related to the wavelength. A typical ultrasound pulse consists of several wavelengths or vibration cycles. The number of cycles within a pulse is determined by the damping characteristics of the transducer. Damping is what keeps the transducer element from continuing to vibrate and produce a long pulse. The wavelength is determined by the velocity, **v**, and frequency, **f**, in this relationship:

Wavelength (l) = v/f.

The Temporal and Length Characteristics of an Ultrasound Pulse

The period is the time required for one vibration cycle. It is the reciprocal of the frequency. Increasing the frequency decreases the period. In other words, wavelength is simply the ratio of velocity to frequency or the product of velocity and the period. This means that the wavelength of ultrasound is determined by the characteristics of both the transducer (frequency) and the material through which the sound is passing (velocity).

In ultrasound imaging the significance of wavelength is that short wavelengths are required to produce short pulses for good anatomical detail (in the depth direction) and this requires higher frequencies as illustrated below.

Dependence of Pulse Length on Wavelength and Frequency

Amplitude

The amplitude of an ultrasound pulse is the range of pressure excursions ..

Ultrasound Pulse Amplitude, Intensity, and Energy

The pressure is related to the degree of tissue displacement caused by the vibration. The amplitude is related to the energy content, or "loudness," of the ultrasound pulse. The amplitude of the pulse as it

leaves the transducer is generally determined by how hard the crystal is "struck" by the electrical pulse.

Most systems have a control on the pulse generator that changes the size of the electrical pulse and the ultrasound pulse amplitude. We designate this as the intensity control, although different names are used by various equipment manufacturers.

In diagnostic applications, it is usually necessary to know only the relative amplitude of ultrasound pulses. For example, it is necessary to know how much the amplitude, A, of a pulse decreases as it passes through a given thickness of tissue. The relative amplitude of two ultrasound pulses, or of one pulse after it has undergone an amplitude change, can be expressed by means of a ratio as follows:

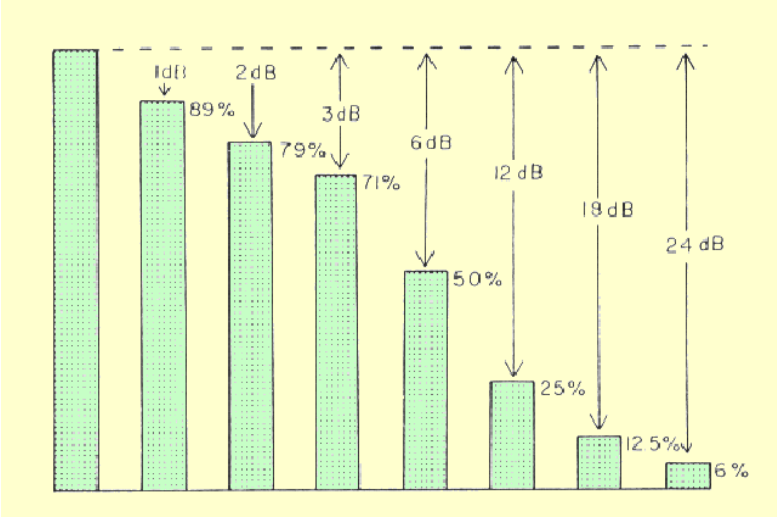
Relative amplitude (ratio) = A_2/A_1.

There are advantages in expressing relative pulse amplitude in terms of the logarithm of the amplitude ratio. When this is done the relative amplitude is specified in units of decibels (dB). The relative pulse amplitude, in decibels, is related to the actual amplitude ratio by

Relative amplitude (dB) = 20 log A_2/A_1

When the amplitude ratio is greater than 1 (comparing a large pulse to a smaller one), the relative pulse amplitude has a positive decibel value; when the ratio is less than 1, the decibel value is negative. In other words, if the amplitude of a pulse is increased by some means, it will gain decibels, and if it is reduced, it will lose decibels.

The following illustration compares decibel values to pulse amplitude ratios and percent values. The first two pulses differ in amplitude by 1 dB. In comparing the second pulse to the first, this corresponds to an amplitude ratio of 0.89, or a reduction of approximately 11%. If the pulse is reduced in amplitude by another 11%, it will be 2 dB smaller than the original pulse. If the pulse is once again reduced in amplitude by 11 % (of 79%), it will have an amplitude ratio (with respect to the first pulse) of 0.71:1, or will be 3 dB smaller.



Pulse Amplitudes Expressed in Decibels and Percentages

Perhaps the best way to establish a "feel" for the relationship between pulse amplitude expressed in decibels and in percentage is to notice that amplitudes that differ by a factor of 2 differ by 6 dB. A reduction in amplitude of -6 dB divides the amplitude by a factor of 2, or 50%. The doubling of a pulse amplitude increases it by +6 dB.

During its lifetime, an ultrasound pulse undergoes many reductions in amplitude as it passes through tissue because of absorption. If the amount of each reduction is known in decibels, the total reduction can be found by simply adding all of the decibel losses. This is much easier than multiplying the various amplitude ratios.

INTENSITY AND POWER

Power is the rate of energy transfer and is expressed in the units of watts. Intensity is the rate at which power passes through a specified area. It is the amount of power per unit area and is expressed in the units of watts per square centimeter. Intensity is the rate at which ultrasound energy is applied to a specific tissue location within the patient's body. It is the quantity that must be considered with respect to producing biological effects and safety. The intensity of most diagnostic ultrasound beams at the transducer surface is on the order of a few milliwatts per square centimeter.

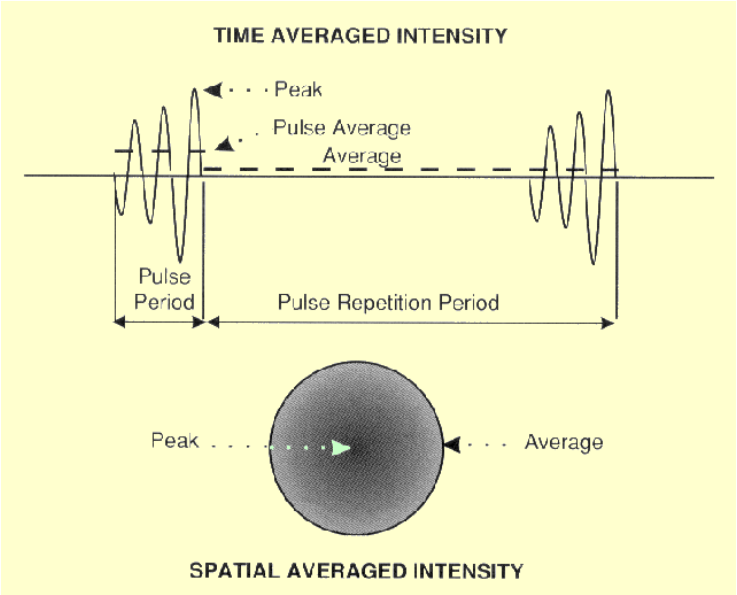
Intensity is related to the pressure amplitude of the individual pulses and the pulse rate. Since the pulse rate is fixed in most systems, the intensity is determined by the pulse amplitude.

The relative intensity of two pulses (I_1 and I_2) can be expressed in the units of decibels by:

Relative Intensity = 10 log I_2/I_1.

Note that when intensities are being considered, a factor of 10 appears in the equation rather than a factor of 20, which is used for relative amplitudes. This is because intensity is proportional to the square of the pressure amplitude, which introduces a factor of 2 in the logarithmic relationship. The

intensity of an ultrasound beam is not constant with respect to time nor uniform with respect to spatial area, as shown in the following figure. This must be taken into consideration when describing intensity. It must be determined if it is the peak intensity or the average intensity that is being considered.



The Temporal and Spatial Characteristics of Ultrasound Pulses That Affect Intensity Values

Temporal Characteristics

The figure above shows two sequential pulses. Two important time intervals are the pulse duration and the pulse repetition period. The ratio of the pulse duration to the pulse repetition period is the duty factor. The duty factor is the fraction of time that an ultrasound pulse is actually being produced. If the ultrasound is produced as a continuous wave (CW), the duty factor will have a value of 1. Intensity and power are proportional to the duty factor. Duty factors are relatively small, less than 0.01, for most pulsed imaging applications.

With respect to time there are three possible power (intensity) values. One is the peak power, which is associated with the time of maximum pressure. Another is the average power within a pulse. The lowest value is the average power over the pulse repetition period for an extended time. This is related to the duty factor.

Spatial Characteristics

The energy or intensity is generally not distributed uniformly over the area of an ultrasound pulse. It can be expressed either as the peak intensity, which is often in the center of the pulse, for as the average intensity over a designated area.

Temporal/Spatial Combinations

There is some significance associated with each of the intensity expressions. However, they are not all used to express the intensity with respect to potential biological effects.

Thermal effects are most closely related to the spatial-peak and temporal-average intensity ($\mathbf{I_{SPTA}}$). This expresses the maximum intensity delivered to any tissue averaged over the duration of the exposure. Thermal effects (increase in temperature) also depend on the duration of the exposure to the ultrasound.

Mechanical effects such as cavitation are more closely related to the spatial-peak, pulse-average intensity ($\mathbf{I_{SPPA}}$).

Three Types of Ultrasound Pulse Interactions Within a Body

As an ultrasound pulse passes through matter, such as human tissue, it interacts in several different ways. Some of these interactions are necessary to form an ultrasound image, whereas others absorb much of the ultrasound energy or produce artifacts and are generally undesirable in diagnostic examinations. The ability to conduct and interpret the results of an ultrasound examination depends on a thorough understanding of these ultrasound interactions.

Absorption and Attenuation

The Reduction of Pulse Amplitude by Absorption of It's Energy

As the ultrasound pulse moves through matter, it continuously loses energy. This is generally referred to as attenuation. Several factors contribute to this reduction in energy. One of the most significant is the absorption of the ultrasound energy by the material and its conversion into heat. Ultrasound pulses lose energy continuously as they move through matter. This is unlike x-ray photons, which lose energy in "one-shot" photoelectric or Compton interactions. Scattering and refraction interactions also remove some of the energy from the pulse and contribute to its overall attenuation, but absorption is the most significant.

The rate at which an ultrasound pulse is absorbed generally depends on two factors: (1) the material through which it is passing, and (2) the frequency of the ultrasound. The attenuation (absorption) rate is specified in terms of an attenuation coefficient in the units of decibels per centimeter. Since the attenuation in tissue increases with frequency, it is necessary to specify the frequency when an attenuation rate is given. The attenuation through a thickness of material, **x**, is given by:

Attenuation (dB) = (a) (f) (x)

where **a** is the attenuation coefficient (in decibels per centimeter at 1 MHz), and **f** is the ultrasound frequency, in megahertz.

Approximate values of the attenuation coefficient for various materials of interest are given in the following table.

Approximate Attenuation Coefficient Values for Various Materials

Material	*Coefficient (dB/cm MHz)*
Water	0.002
Fat	0.66
Soft tissue (average)	0.9
Muscle (average)	2.0
Air	12.0
Bone	20.0
Lung	40.0

From the attenuation coefficient values given in the above table, it is apparent that there is a considerable variation in attenuation rate from material to material. The significance of these values is now considered. Of all the materials listed, water produces by far the least attenuation. This means that water is a very good conductor of ultrasound. Water within the body, such as in cysts and the bladder, forms "windows" through which underlying structures can be easily imaged. Most of the soft tissues of the body have attenuation coefficient values of approximately 1 dB per cm per MHz, with the exception of fat and muscle. Muscle has a range of values that depends on the direction of the ultrasound with respect to the muscle fibers. Lung has a much higher attenuation rate than either air or soft tissue. This is because the small pockets of air in the alveoli are very effective in scattering ultrasound energy. Because of this, the normal lung structure is extremely difficult to penetrate with ultrasound. Compared to the soft tissues of the body, bone has a relatively high attenuation rate. Bone, in effect, shields some parts of the body against easy access by ultrasound.

The following illustration shows the decrease in pulse amplitude as ultrasound passes through various materials found in the human body.

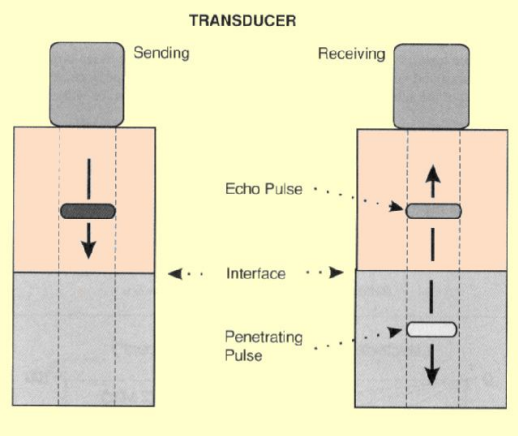
The Effect of Absorption on Ultrasound Pulse Amplitude in Relation to Distance or Depth in the Body

Reflection

The reflection of ultrasound pulses by structures within the body is the interaction that creates the ultrasound image. The reflection of an ultrasound pulse occurs at the interface, or boundary, between two dissimilar materials, as shown in the following figure. In order to form a reflection interface, the two materials must differ in terms of a physical characteristic known as acoustic impedance **Z**. Although the traditional symbol for impedance, **Z**, is the same symbol used for atomic number, the two quantities are in no way related. Acoustic impedance is a characteristic of a material related to its density and elastic properties. Since the velocity is related to the same material characteristics, a

relationship exists between tissue impedance and ultrasound velocity. The relationship is such that the impedance, **Z**, is the product of the velocity, **v**, and the material density, **Y**, which can be written as

Impedance = (Y) (v).



The Production of an Echo and Penetrating Pulse at a Tissue Interface

At most interfaces within the body, only a portion of the ultrasound pulse is reflected. The pulse is divided into two pulses, and one pulse, the echo, is reflected back toward the transducer and the other penetrates into the other material, as shown in the above figure. The brightness of a structure in an ultrasound image depends on the strength of the reflection, or echo. This in turn depends on how much the two materials differ in terms of acoustic impedance. The amplitude ratio of the reflected to the incident pulse is related to the tissue impedance values by

Reflection loss (dB) = 20 log $(Z_2 - Z_1)/(Z_2 + Z_1)$.

At most soft tissue interfaces, only a small fraction of the pulse is reflected. Therefore, the reflection process produces relatively weak echoes. At interfaces between soft tissue and materials such as bone, stones, and gas, strong reflections are produced. The reduction in pulse amplitude during reflection at several different interfaces is given in the following table.

Pulse Amplitude Loss Produced by a Reflection

Interface	*Amplitude Loss (dB)*
Ideal reflector	0.0
Tissue-air	-0.01
Bone-soft tissue	-3.8
Fat-Muscle	-20.0
Tissue-water	-26.0
Muscle-blood	-30.0

The amplitude of a pulse is attenuated both by absorption and reflection losses. Because of this, an echo returning to the transducer is much smaller than the original pulse produced by the transducer.

Refraction

When an ultrasound pulse passes through an interface at a relatively small angle (between the beam direction and interface surface), the penetrating pulse direction will be shifted by the refraction process.

2.2 Previous studies;

Unfortunately, there is no record of any study done in Sudan regarding congenital anomalies neither about incidence nor about courses.

That's why in this research I had to compare the finding with some international results.

For example, the magnitude of congenital anomalies in Asia has been shown to vary with reported incidences of 2.5% in India and 1.3% in China. In the Middle East, where consanguineous marriages are common, the prevalence of major congenital anomalies is reported to be 6.5%.

In the United States of America, congenital anomalies reportedly affect 2-5% of all live births.

In Africa, some of the rare studies on congenital anomalies have reported an incidence between 1.5% and 2.5% in Egypt and East Africa (Kenya and Uganda) respectively.

Findings are similar to those reported in Tanzania and Kenya where CNS, MSS and GIT were the most affected systems. Among the CNS, myelomeningocele was the commonest, anorectal malformation & gastroschisis for GIT.

Likewise, a study from Iran Abdi-Rad et al. stated CNS, musculoskeletal, gastrointestinal, urogenital are the most detected anomalies.

Similarly, Indian studies Gupta et al, showed CNS followed by Musculoskeletal and then CVS related birth defect respectively in descending order of prevalence.

Our study agreed with other literature which noted that Head and neural tube anomalies 26.5%, anterior abdominal wall defects 12%, face and neck 5.5% and genitourinary system (renal) 1%. It should be noted that in 55% of the cases no congenital abnormalities were reported.

head and neural tube defects showed that spinabifeda, and hydrocephalus were the commonest. Distribution of the face and neck defects showed that frontonasal and cleft lip and pallet were reported common.

Fetal thorax & skeletal system anomalies were never detected in this screening study; maybe due to difficulty in diagnosing such cases.

Anterior abdominal wall the reported defects were omphalocele, followed by gastroschisis, then umbilical hernia and amniotic bands syndrome

high pregnancy rates among mothers in more than 40 years' age range could account for increased frequency of congenital anomalies. Other studies reported an incidence of 6.1% in mothers with age >30 years and the incidence of 3.2 % in younger mothers related to other causes rather than their age. More over medication and radiation have shown strong relation with congenital malformation worldwide and in Sudan .

Three million children with congenital anomalies are born annually, among whom 495,000 die in the first year of life (4,5). Despite the great advancements in the etiology and pathogenesis of congenital anomalies Iranian Journal of Neonatology 2018; 9(2) worldwide, still 22% of causes of death among neonates are these abnormalities.

Chapter three

Materials and methodology

Chapter three

Materials and methodology

3.1 Materials

3.1.1 the study population;

Study population includes 200 pregnant ladies of different age group at their 2nd trimester.

All of these ladies have at least **one risk factor** to deliver a baby with an anomaly.

3.1.2 the study Area;

The main hospitals in which the study was accomplished were Inbrahim Malik teaching hospital and Omdurman military hospitals.

The above mentioned hospitals have fine techniques, real scanners and provided services for adequate number of patients per day.

3.1.3 the study design ;

the study was retro-prospective in which the data was collected to determine age, obstetric and gynecological history, term of pregnancy, etc.

3.1.4 the Machine used ;

Two dimensions ultrasound machine were used Mindary (Japanese Company) with convex probe and tranvaginal probe. Mindray DP-10 is a very easy to use and portable ultrasound system with weight about 5.5 kg. It features a built-in 12,1" LED screen and 2 USB ports, ability to store pictures and videos to an external hard disk or USB stick & pperating frequencies of ultrasound: 5.0-10.0Mhz.

A Philips printer was used, a blue aqueous gel applied over the patient abdomen, then removed by clean gauze after the examination.

3.2 Methodology

3.2.1 Technique used;

The patient is positioned lying face-up on an examination table that can be titled or moved.

A clear water-based gel is applied to the patient's abdomen and help the transducer make secure contact with body and eliminate air pockets between the transducer and the skin. The sonographer (ultrasound technologists) or radiologist then presses the transducer firmly against the skin and sweeps it over the abdomen.

If a transvaginal scan is performed. The technique provides improved, more detailed images of the uterus and ovaries. This method of scanning is especially useful in early pregnancy.

Transvaginal ultrasound is performed very much like a gynecologic exam and involves the insertion of the transceduer into the vagina after the patient empties her bladder. The tip of the transducer is

smaller than the standard speculum used when performing a Pap test. A protective cover is placed over the transducer, lubricated with a small amount of gel, and then inserted into the vagina. Only two to three inches of the transducer end are inserted into the vagina. The images are obtained from different orientations to get the best views of the uterus and ovaries. Transvaginal ultrasound sis usually performed with the patient lying on her back, possibly with her feet in stirrups similar to a gynecologic exam.

When the examination is complete, the patient may be asked to dress and wait while the ultrasound images are reviewed. However, the sonographer or radiologist is often able to review the ultrasound images in real-time as they are acquired and the patient can be released immediately. This ultrasound examination is usually completed within 30 minutes.

3.2.2 Data Collection;

A detailed and structured questionnaire is to be filled directly by the researcher in the office be the ultrasound examination (Women completed pre-coded questionnaires after formal consent). The questionnaires included personal information (age, number of pregnancies, gestational age, ultrasound findings).

3.2.3 Data analysis:

The data will be analyzed by using Statistical Package of Social Science (SPSS). Obtain results will be present in tables and figure. The confidence interval of 95% and the P. value equal to 0.05 is use in this study.

Chapter Four

Results

Chapter Four
Result

The study which cover 200 pregnant ladies present highest percentage of the mothers 35% aged between 26-30 years and lowest percentage 7.5% aged above 40 years (table 1).

According to table (2) the most common tribal origins were eastern tribes 35.5% and western tribes 33.5%.

Highest percentage of the women 57.5% screened by ultrasound for congenital abnormalities ate third trimester, 27% at second trimester and 9.5% at first trimester (Figure 1).

The presenting symptoms were decreased fetal movement 47%, shortness of breath 35.5%, abdominal pain 16% and lower limps edema 1.5% (Figure 2).

The clinical findings were fundal level corresponding with date 63.5%, fundal level > date 31% and fundal level < date 5.5% (Figure 3).

Head and neural tube anomalies 26.5%, anterior abdominal wall defects 12%, face and neck 5.5% and genitourinary system (renal) 1%. It should be noted that in 55% of the cases no congenital abnormalities were reported (table 3).

Distribution of the head and neural tube defects showed that spina bifeda, hydrocephalus, anencephaly, microcephaly and cephalocel were reported in 45.3%, 20.8%, 17%, 9.4% and 1.9% respectively within the subgroup (head neural tube), and in 12%, 5.5%, 4.5%, 2.5% and 0.5% within the total sample of the study (table 4).

Distribution of the face and neck defects showed that cystic hydroma, frontonasal dysplasia and mictonasia were reported in 54.5%, 36.4%, and 9.1% respectively within the subgroup (face and neck), and in 5.5%, 2%, and 0.5% within the total sample of the study (table 5).

In the anterior abdominal wall the reported defects were omphalocele 50%, followed by gastroschisis 29.2%, umbilical hernia 16.7% and amniotic bands syndrome 4.2% (within the subgroup: anterior abdominal wall). In these defects were reported in 6%, 3.5%, 2% and 0.5% of the total sample respectively (table 6).

The risk factors of congenital anomalies were maternal age > 35 years 23%, medication 5%, history of similar conditions 3.5%, smoking 3% and radiation 1.5% .

Tables

Table (1) Distribution of the study sample according to age group .

Age group	N	%
20-25 years	34	17.0%
26-30 years	70	35.0%
31-35 years	50	25.0%
36-40 years	31	15.5%
> 40 years	15	7.5%
total	200	100%

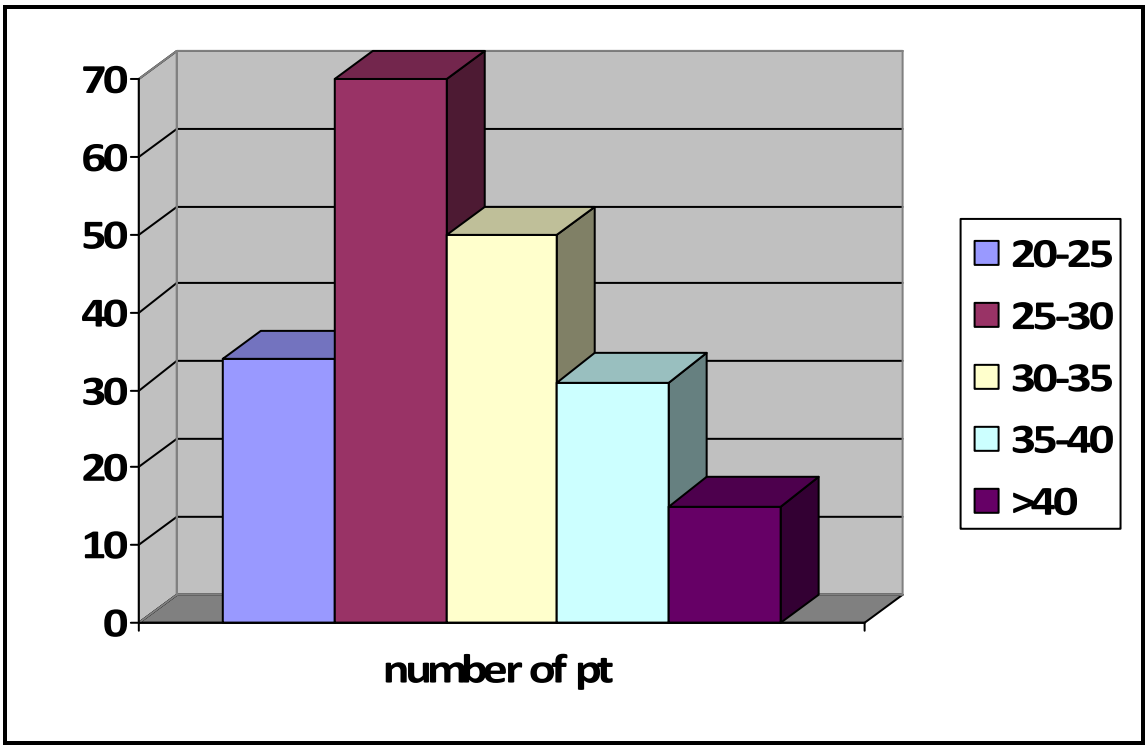
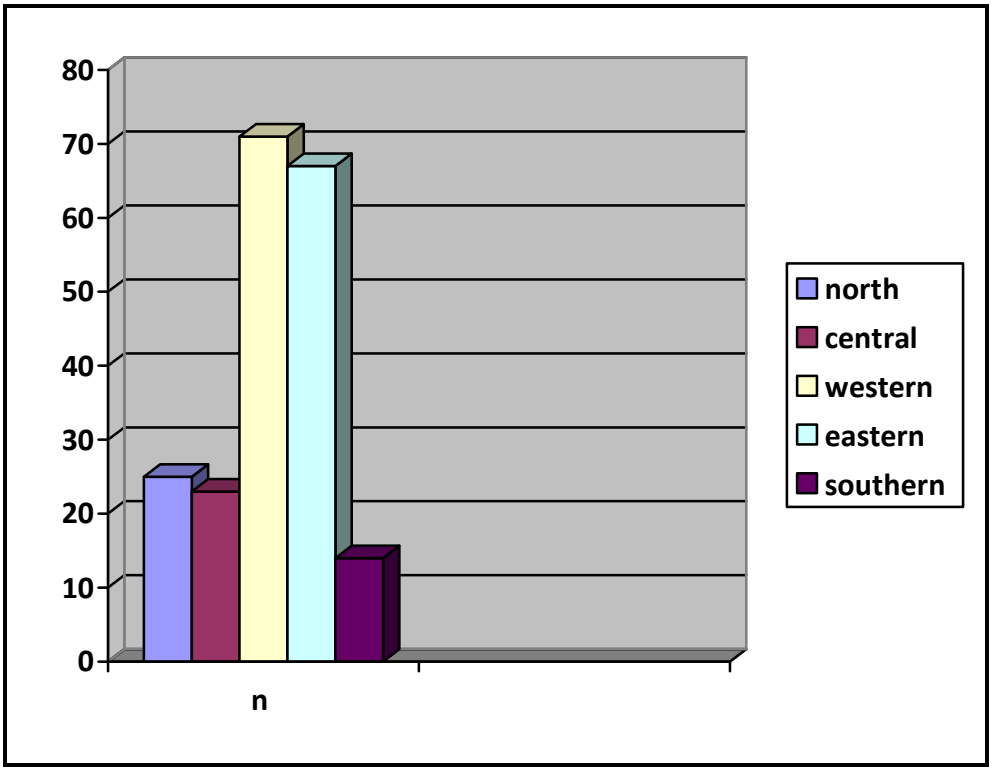


Figure no (1) shows Distribution of the study sample according to age group among 200 pregnant women presented for obstetrical ultrasound investigation.

Table (2) Distribution of the study sample according to tribal origin

Tribal origin	N	%
Northern	25	12.5
Central	23	11.5
Western	71	35.5
Eastern	67	33.5
Southern	14	7.0
Total	200	100.0



Finger no (2) shows the Distribution of the study sample according to tribal origin, among 200 pregnant women presented for obstetrical ultrasound investigation.

Table (3) Distribution of the study sample according to trimester at screening

Trimester	N. patients	%
1st	19	9.5%
2nd	66	33%
3rd	115	57.5%
T0tal	200	100%

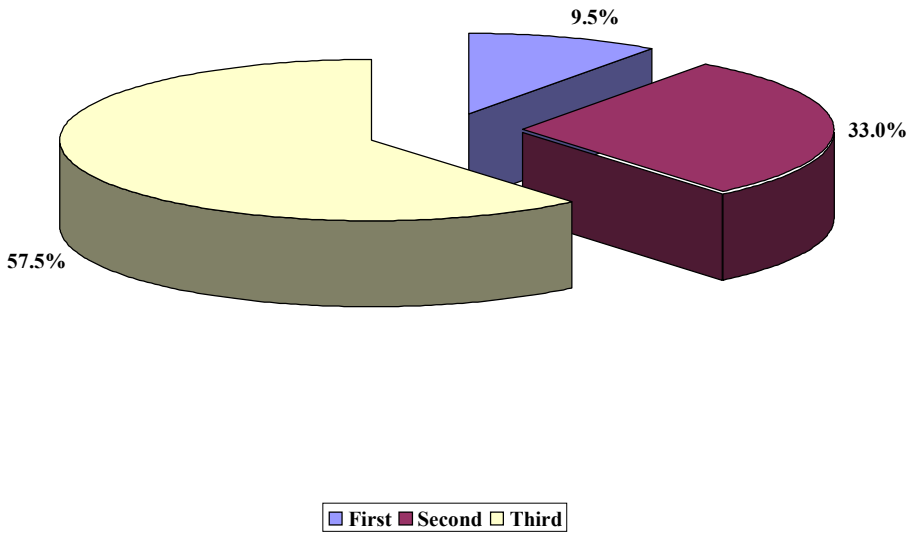


Figure (3) Distribution of the study sample according to trimester at screenin

Table (4) Distribution of the study sample according to risk factors of congenital anomalies;

Risk factors	n. patients	%
Maternal age >40		23%
Pre- existing medical disease		9%
Hx .of similar condition		3.5%
Medication		5%
Smoking		3%
Radiation		1.5%
Total	200	100%

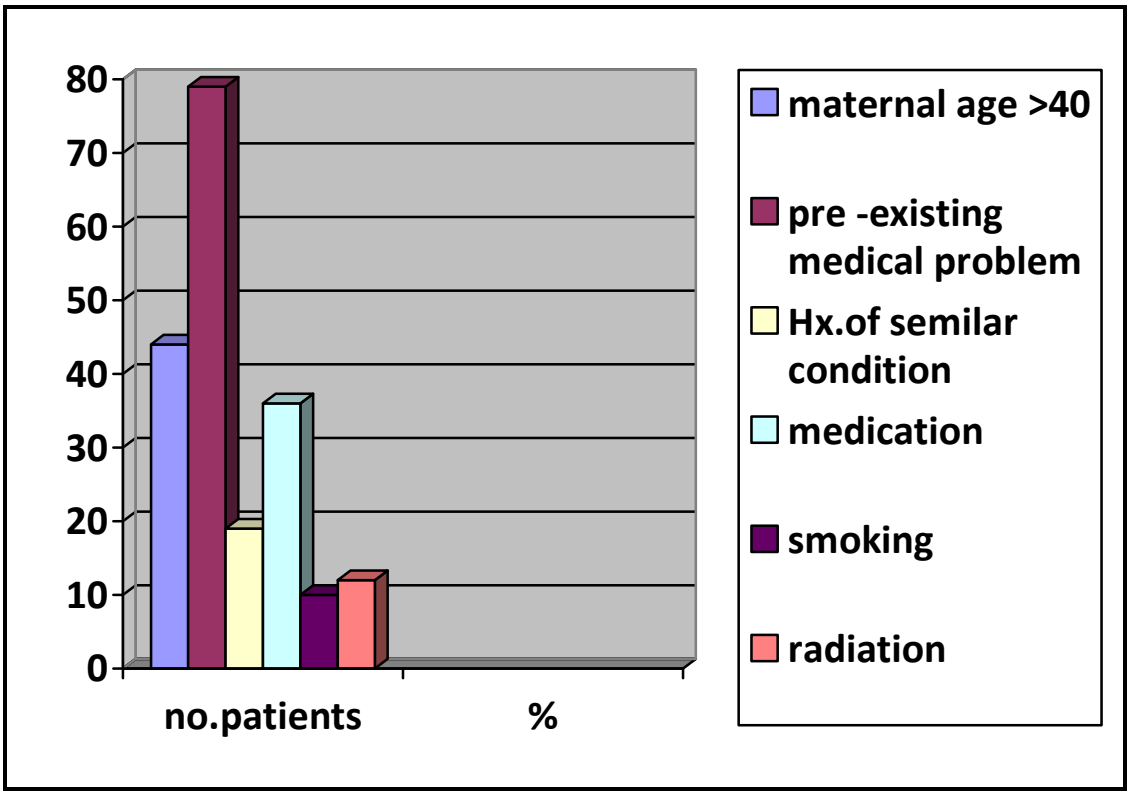
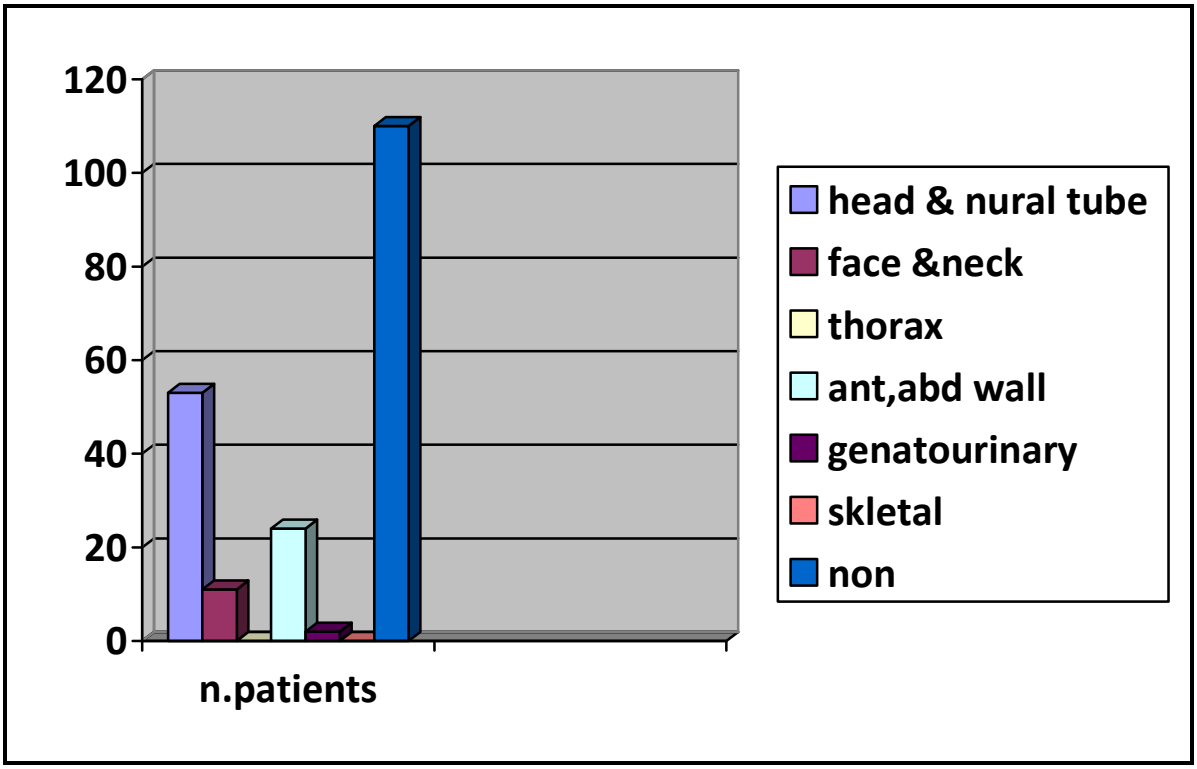


Figure (4) shows Distribution of the study sample according to risk factors of congenital anomalies

Table (5) Distribution of the study sample according to the presence of congenital anomalies or not; among the 200 pregnant ladies;

Anomalies	N	%
Head and neural tube	53	26.5
Face and neck	11	5.5
Thorax	0	0.0
Anterior abdominal wall defects	24	12.0
Genitourinary system	2	1.0
Skeletal system	0	0.0
Non	110	55.0
Total	200	100.0



Fieger (5) shows Distribution of the study sample according to the presence of congenital anomalies or not; among the 200 pregnant ladies

Table (6) Distribution of the study sample according to presenting symptoms;

Symptoms	N. patients	%
Increase fetal movement	12	6%
Decreased fetal movement	51	25.5%
Shortness of breath	24	12%
Abdominal pain	18	9%
Lower limp edema	86	43%
Normal	9	4.5%
Total	200	100%

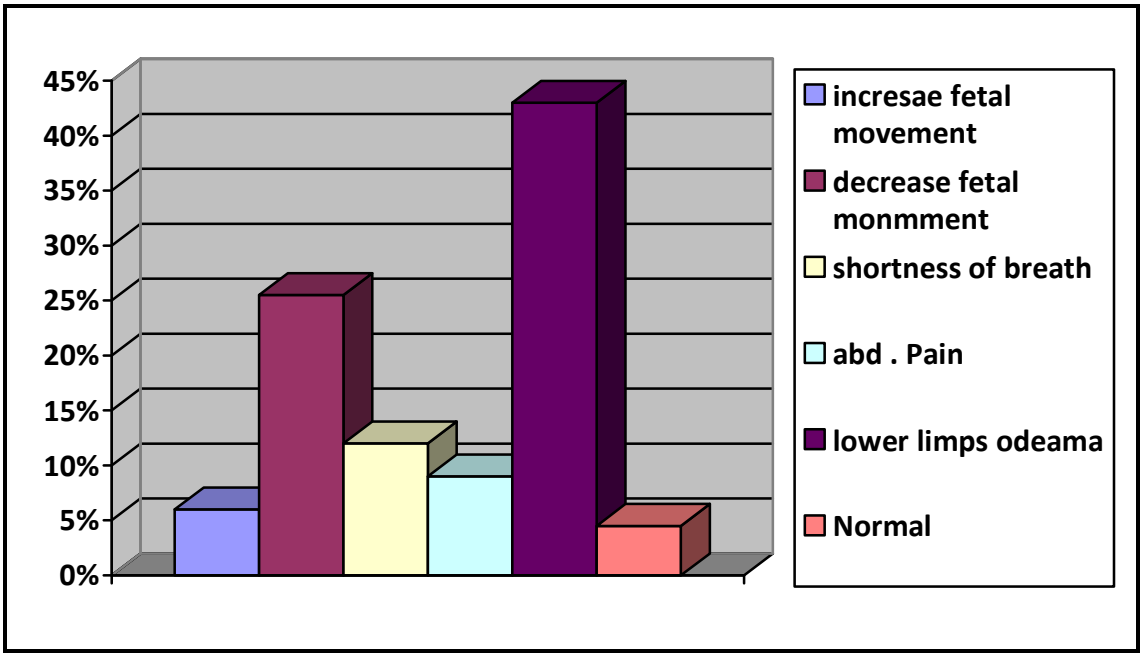


Figure (4) Distribution of the study sample according to presenting symptoms

Table (7) Distribution of the study sample according to head and neural tube anomalies

Head and neural tube	Within subgroup		Within total sample
	N	% within subgroup	% of total sample (n=200)
Anencephaly	9	17.0	4.5
Cephalocel	1	1.9	0.5
Microcephaly	5	9.4	2.5
Hydocepahlus	11	20.8	5.5
Spina Bifida	24	45.3	12.0
Total	53	100.0	26.5

Table (8) Distribution of the study sample according to face and neck anomalies

Face and neck	Within subgroup		Within total sample
	N	% within subgroup	% of total sample (n=200)
Fronotnasal dysplsia	4	36.4	2.0
Mictonasia	1	9.1	0.5
Orbital defect	0	0.0	0.0
Cleft lip / cleft palate	6	54.5	3.0
Total	11	100.0	5.5

Table (9) Distribution of the study sample according to anterior abdominal wall anomalies

Anterior abdominal wall defects	Within subgroup		Within total sample
	N	% within subgroup	% of total sample (n=200)
Omphalocele	12	50.0	6.0
Gastroschisis	7	29.2	3.5
Amniotic bands syndrom	1	4.2	0.5
Ubmlical hernia	4	16.7	2.0
Total	24	100.0	12.0

Table (10) Distribution of the study sample according to Genitourinary anomalies

Genitourinary anomalies	NO. patients	%
Infantile polycystic kidney disease	0	0
hypospadias	2	1%
Renal agenesis	0	0
Ambiguous genitalia	0	0
Total	2	100%

Chapter five
Discussion, conclusion and recommendation

Chapter five

Discussion, conclusion & recommendation

5.1 Discussion;

The study shows that out of 200 women from different parts of Sudan presented for obstetrical ultrasound examination, 35% aged between 26-30 years while the lowest percentage 7.5% aged above 40 years.

The regional distribution of patients mentioned above was characterized by western majority 35.5% followed by 33.5% in the eastern population and the southern represents only 7% and this is probably due to their migration

Highest percentage of the women screened by ultrasound for congenital abnormalities at the third trimester was 57.5 % then 27% at second trimester and 9.5% at first trimester; this is attributed to poverty, restricted knowledge about antenatal care and most important Couse is limited sonographic facilities especially in countryside.

Symptoms such as decrease fetal movement were complained by 51 patient 22 of them were due to oligohydramnios associated with IUGR for women known to have long standing high blood pressure (hypertension) also 10 women with hypothyroidism having the same complain. Others due to associated anomalies that prevent fetal free movement such as; hydrocephalus and gastroschisis, while the rest were found to be normal.

Increased fetal movement was complained by 12 of patients 7 of them were due to polyhydramnios which was found to be associated with diabetic patients.

Other complains like SOB & LLO are described as normal variation in pregnancy due to physiological changes.

Head and neural tube anomalies 26.5%, anterior abdominal wall defects 12%, face and neck 5.5% and genitourinary system (renal) 1%. It should be noted that in 55% of the cases no congenital abnormalities were reported.

Distribution of the head and neural tube defects showed that spinabifeda, and hydrocephalus were the commonest. Distribution of the face and neck defects showed that frontonasal dysplasia and cleft lip and pallet were reported common.

Fetal thorax & skeletal system anomalies were never detected in this screening study; maybe due to difficulty in diagnosing such cases.

Anterior abdominal wall the reported defects were omphalocele, followed by gastroschisis, then umbilical hernia and amniotic bands syndrome.

The only genitourinary malformation to be detected was Hypospadias in 2 cases of the whole study. These two babies mother were prim gravidas on hormonal therapy (induction), both was complaining of primary infertility due to hypothyroidism.

The risk factors of congenital anomalies were maternal age > 40 years, medication, history of similar conditions, smoking, radiation etc.

But the strongest theory was lack of iron supplement intake which found to have a strong association with neural tube defect (spina befida) .

5.2 Conclusion;

The incidence of fetal anomalies in Sudan was found almost near with that mentioned in previous studies, except for genitourinary which found less than international.

The Head and neural tube anomalies 26.5%, anterior abdominal wall defects 12%, face and neck 5.5% and genitourinary system 1% of all anomalies detected .

It should be noted that in 55% of the cases no congenital abnormalities were reported.

Head and neural tube defects showed that spina bifeda and hydrocephalus were reported the commonest; this is my be due to poverty associated with malnutrition & lack of maternal knowledge regarding the antenatal visits.

Maternal age > 40 years, medication, and medical disease such as DM, HTN, hypothyroidism and epilepsy were strongest factor to develop anomalies.

That's why, routine ultrasound scanning in the 2nd trimester is a safe , noninvasive and useful diagnostic tool for early detection of congenital malformation especially for high risk group of women .

5.3 Recommendations;

1- Maternal knowledge regarding the importance of antenatal visit should be improved.

2- continued ultrasound scanning should be done to all pregnant ladies; at least three times during their pregnancy and that will be scheduled one in every trimester. But for women with risk factors more frequent visits should be encourage for early detection of the malformation.

3-All pregnant women should avoid unnecessary medication and review her doctor regarding chronic medication for adjustment of the dose or to stop a specific drug which can be contraindicated in case of HTN, DM and epilepsy.

4- proper nutritional supplies & iron supplement are very important for maternal % fetal wellbeing.

Final point is that; ultrasonography is an operator dependent skill that's why untrained or less skilled operator may Couse hazards to the mother & her baby by missing an important finding which may affect her plan of managements (to continue with pregnancy or for early termination) .

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Appendix

1. Data sheet (questionnaire) ;

Serial No / ……. hospital name / ……

1- Age? A. <20 b. 20 – 30 c. 31 – 40 d. > 40

2- Education? a. primary b. Secondary c. University d. Illiterates

3- Socio economic status? a. Low b. High c. Moderate

4- Parity? a. prim gravida b. multipara (2 - 4) c. grandmultipara (>5)

5- Estimated length of gestational age?

a. < 13 weeks b. 13-26 weeks c. > 28 weeks

5- State of ANC? a. Regular b. Irregular c. No ANC

6- Is she taking (vit / supplements) ? a. yes b. no

7- Any complain regarding the pregnancy?

a. Shortness of breath b. abd. Pain c. lower limp oedema

8- Abdominal examination findings?

a. Movement(Increased or decreased) Abdomen (>date /< date)

9- Any chronic disease?

DM b. HTN C. Epilepsy d. thyroid e. ca-of any type

10- Drug hx.?

a. Pre- conception b. 1st trimester c. throughout the pregnancy

d. chronic medications

If yes name it ? …….

11- Past medical hx of a baby with any type of congenital anomalies, or similar condition in the family ?

a. Yes b. No name it ? ……..

12- Exposure to toxic substance (during 1st trimester) ?

a. Chemo therapy b. radiotherapy c. radiation e. metals

13 - Social habits?

a. Smoking b. alcohol consuming c. narcotics

Appendix

2. Consent

التاريخ : ……/……/……

إقرار

إقرار بالموافقة على المشاركة فى البحث:

أنا .....بعد أن تم شرح لي طبيعة الدراسة وأعطيت فرصة كافية للإستفسار عنها وقد تم الإجابة على كل أسئلتى بصورة كافية، وفهمت أن لى الحق فى التوقف عن هذه الدراسة فى أى وقت من غير أن أفقد الحق فى الرعاية الطبية أو أي حقوق أخرى .أوافق طوعية على المشاركة فى هذه الدراسة.

اسم المريض:

التوقيع :

Appendix

3.pictutrs with ultrasound finding ;

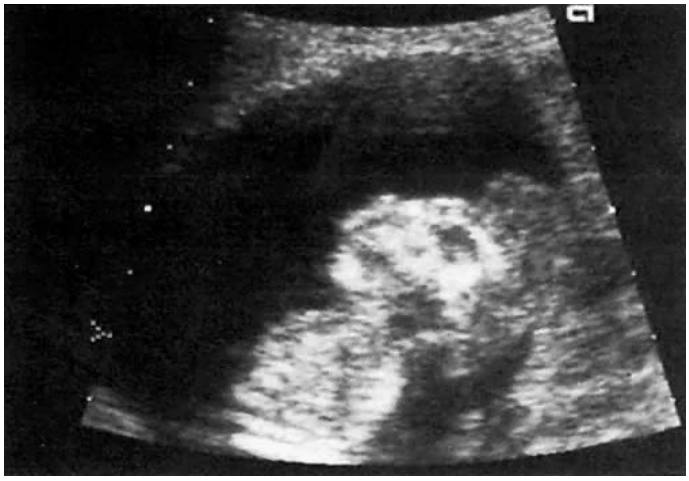

Fig. (1) Acrania (exencephaly) , in 19week fetus of 22yers old PG , at Ibrahem Malic teaching hospital .