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Evaluation of uterine blood flow in recurrent pregnancy loss by using color Doppler

تقويم سريان الدم للرحم بالدوبلر في الإجهاض المتكرر

A thesis submitted for fulfillment of academic requirements for the degree of doctorate of philosophy in medical ultrasound

By

Muna Ahmed Mohamed Ahmed

Supervisor

Dr. Mutasim Ahmed Alseed

Professor

Co-supervisors

Dr Mohamed Elfadil Mohamed

Dr. Mohamed Sidig Mohamed

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DEDICATION

To the SOUL OF MY PARENTS,

TO MY FAMILY,

ELDER BROTHER PROF.ABOSHANAB.

AND SISTERS.

MY COLLEGES.

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I would like to start with thanking ALLAH for granting me the ability to complete this work.

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Abstract

The pregnancy loss was one of the major problems facing the pregnant women in the first trimester. Knowing the causes or the characteristics of the abortion will help in improve the result. The general objective of this study was to evaluate the uterine artery blood flow indices (PI, RI and PSV) of RPL. The data were collected from 600 patients where 300 were study group and 300 as control group. The study group were consisted of three categories; threaten abortion, elective abortion and non pregnant, each of them consisted of 100 patients and all have history of recurrence pregnancy loss. The study was carried out in the department of ultrasound in College of Medical Radiologic Sciences, using general electric Logic 5 ultrasound machine. The data were collected by measuring the PI, RI and PSV values as well as the status of intrauterine condition using a multi-frequency vaginal probe 6-10MHz. The results of this study showed that there is a significant difference in uterine blood flow indices (PI, RI and PSV) for the PRL groups at $p = 0.05$ using ANOVA test with $p < 0.001$ and F equal to 118.9, 152.7 and 3.6 respectively. The result as well showed that; the mean values of PI, RI and PSV was 2.1±0.9, 0.7±0.4 and 47.7±28.7 for threaten abortion and for elective abortion it was 1.0±0.5, 0.5±0.3 and 56.1±24.9, the non pregnant group was 0.8±0.3, 2.7±1.6 and 54.4±23.9 respectively. The classification accuracy result using Fisher linear discriminant analysis approach to discriminates between the three groups in respect to their PI RI and PSV only as input it was 77.7%. The control group showed that the mean value for PI, RI and PSV was equal to 1.4±0.87, 1.0±0.60, and 60.8±25.63 respectively. These values showed that there is a difference between the control group and the study groups. This difference was significant by using *t*-test for the entire group versus the control at $p = 0.05$ except for PSV in the elective group. The *t*- values for PI of the threaten abortion, elective abortion and non pregnant groups was 8.68, 6.60 and 14.19 respectively. As well the *t*-values for RI was 2.16, 9.39 and 11.81 respectively, similarly in respect to PSV the *t*-values was 4.72, 1.73 and 2.90 where the difference was inconclusive in case of elective abortion at $p = 0.05$ with $p = 0.09$. Generally the result showed that the RPL groups were different as well as they were different from the control group.

الخلاصة

خسارة الحمل (الإجهاض) واحدة من المشاكل الرئيسية التي تواجه النساء الحوامل في الأشهر الثلاثة الأولى.
معرفة الأسباب أو الخصائص للإجهاض تساعد في تقليل نسبة الاجهاض الهدف العام في هذه الدراسة تقويم تدفق الدم ومؤشرات الشريان الرحمي و نسب مقاومة سريان الدم في شريان الرحم (PI,) معرفة مقاومة الدم وترددده (RI وسرعة التردد الأعلى لنبض القلب (PSV) في حالات الإجهاض المتكرر (RPL) تم جمع البيانات من 600 حالة حيث كانت 300 مجموعة الدراسة و300 كمجموعة مرجعية . وتتألفحتلات الدراسة من ثلاثة فئات ، حمل مهدد بالإجهاض ، والإجهاض الانتفائء وغير الحوامل ، يتألف كل منها من 100 مريض ، وجميعها لها تاريخ اجهاض متكرر (اكثر من مرتئن) . وقد أجريت هذه الدراسة في قسم الموجات فوق الصوتية في كلية علوم الاشعة الطبية جامعة السودان للعلوم والتكنولوجيا ، باستخدام جهاؤ جنرال إلكتريك logic 5 للموجات فوق الصوتية. تم جمع البيانات عن طريق قياس PI,RI, PSV و ضع مسبار داخل الرحم متعددة التردد 6 - 10MHz. وأظهرت نتائج هذه الدراسة أن هناك اختلاف كبير في مؤشرات تدفق الدم الرحمئ PI و في معامل RI سرعة القصوى لسريان الدم عند تنقباض عضلة القلب ,PSV للمجموعات في PRL ف = 0،05 باستخدام اختبار أنوفاANOVAمعف<0،001وواو يساوي 152،7 ، 118،9 و 3،6 على التوالي. النتيجة كذلك أظهرت إن متوسط قيم وPI RI PSV كان 2،1 ± 0،9 ، 0،7 ± 0،4 و 47،7 ± 28،7 االحمت المهدد بالاجهاض والإجهاض الانتقايء وكان 1،0 ± 0،5 ، 0،5 ± 0،3 56،1 ± 24،9 وكانت مجموعة غير الحوامل 0،8 ± 0،3 ، 2،7 ± 1،6 و 54،4 ± 23،9 على التوالي . نتيجة دقة التصنيف بفيشير لتحليل التمايز الخطي ليميز بين الموجوعات الثلاثة فيما يتعلق السرعة القصوى لسريان الدم عند انقباض عضلة القلب في شريان الرحم فقط كمدخل كانت 77،7٪ . وأظهرت مجموعة المرجعية قيمةPI,PSV,RIيساوي1.4 ± 0،87 ، 1،0 ± 0،60 ، و60،8 ± 25،63 على التوالي . وأظهرت هذه القيم ان هناك فرق بين المجموعة المرجعية ومجموعات الدراسة. وكان هذا فرق معنوي عن طريق استخدام اختبار (ت) للمجموعة بأكملها في مقابل المرجعية على ع = 0،05 باستثناء PSVفي مجموعة الإجهاض الانتقايء . T-value لقيم PI للمجموعات الثلاثة الحمل المهدد باالاجهاض–الإجهاض الانتقايء و مجموعة غير الحوامل هي68 ، 6،60 و 14،19 على التوالي وقيمة RI 2،16 9،39 و 11،81 على التوالي ، وبالمثل في ما يتعلق PSVالقيم 4.72، 1.73 و 2.90 حيث كان الفرق غير حاسمة في حالة الإجهاض الانتقايء في ع = 0.05 مع 0.09 غير حاسمة في حالة الإجهاض الانتقايءفيع=ع=0.05مع0.09.. وأظهرت النتائج عموما أن الإجهاض المتكررRPL للمجموعات الثلاثة فيما بينها كانت مختلفةوكذلك كانت مختلفة مع المجموعة المرجعية

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List of Abbreviations

ANOVA	analysis of variance
ApL(apl)	Antiphospholipid
ART	Androgen Replacement Therapy
ASO	Auto Spectrum Optimization:
ATO	Auto Tissue Optimization:
AUX	Auxiliary
(IVF)	in-vitro fertilization
CBC	Complete Blood Count
CCA	Common Carotid Artery
CFM	Color Flow Mode
COI	Color Doppler imaging
CRL	Crown-rump length
CW	Continuous wave
D&C	Dilatation and curettage
D&E	Dilatation and evacuation
DES	diethylstilbestrol.
DF	Doppler frequency
DICOM	Digital Imaging and Communications in Medicine
ECG	Electrocardiography
FVW	FLOW VELOCITY WAVE
Fvws	Flow velocity Waveform
GA	Gestational age

GE	GENERAL ELECTRIC
HCG	Human chorionic gonadotrophin
HCG(hcG	Human chorionic gonadotrophin
Hz	Hertz
IEM	Inborn error of metabolism
Iup	Intra-uterine pregnancy
IVF	Invetro Fertilization
JPG	(Joint Photographic) image
LCD	liquid crystal display
LMP	Last menstrual period
MB	MEGA BITE
MDV	MINIMUM DIASTOLIC VELOCITY
MOD	Modification
MRI	Magnetic resonance imaging
O&G	Obstetrics and Gynecology
PCMCIA	Personal Computer Memory Card International Association
PCO	Polycystic ovaries
PPI	PEAK TO PEAK PULSATITY INDEX
PRF	Pulse repletion frequency
PSV	Peak systolic velocity
p-value	Probability value
PW	Pulsed wave Doppler
RI	Resistance index

RPOC	PRODUCT OF CONCUPTION
RSA	Recurrent spontaneous abortion
S/D ratio	Systolic /diastolic ratio
SA	spontaneous abortion
SD	Stander deviation
TAMV	TIME AVERAGE MAXIMUM VELOCITY
TBD	Steerable CW Doppler
TOP	Termination of pregnancy
TVS	Transvaginal
TVUS	Transvaginal ultrasonography
US	Ultrasonography
USB	Universal Serial Bus
VMAX&MPSV	VELOCITY MAXIMUM
SUST	SUDAN UNIVERSITY OF SCIENCE &TECHNOLOGY
YS	yolk sac

Contents

Chapter one

1-1 Introduction

Recurrent abortion in its broadest definition is defined as 2 to 3 or more consecutive pregnancy losses before 20 weeks of gestation, each with a fetus weighting less than 500gm approximately 1% of women are habitual aborters. Prognosis for a successful subsequent pregnancy is correlated with the number of previous abortions .The risk of having spontaneous abortion for the first time is about 20%, 28% after two miscarriages and 43% after three or more miscarriages (Regan et al. 1989). Studies have confirmed that the higher rate of adverse pregnancy outcome when a large sub-chorionic hematoma was present although the excess risk attributable to this finding appeared small when compared to a control population with vaginal bleeding in absence of a sub-chorionic hematoma **(**Ball et al. 1996). As well the age of the mother was contribute to the incidence of abortion and the number of pregnancies other factors, includes a history of previous full-term normal pregnancy, the number of previous spontaneous abortions, a previous stillbirth and a previous infant born with malformations of known genetic defects (Uzelac and Garmel 2007). High – risk pregnancy is broadly defined as one on which the mother, fetus or newborn is or may possibly be at increased risk of morbidity, or mortality before, during or after delivery (Mehta and Sokol, 2007).

A threatened abortion is presumed when any blood vaginal discharge or vaginal bleeding appears during the first half of pregnancy. Doppler ultrasound is relatively a new method of studying vascular resistance in gynecology (Kremkau , 1992). B mode ultrasound gives information about morphology .but Doppler ultrasound gives information about blood flow (kurjak and Kupesic, 1998).

Doppler assessment of the placental circulation plays an important role in screening for impaired placenta and its complications of pre-eclampsia .intrauterine growth restriction and prenatal death .Assessment of the fetal circulation is essential in the better understanding of the patho-physiology of a wide range of pathological pregnancies and their management (Evans et al, 1989).

An assessment of early placentation could be useful for predicting pregnancy outcome in In such cases information regarding the uteroplacental circulation obtained with the of color Doppler ultrasound could provide prognostic information (Pellizari, et al. 2002). Uterine receptivity is likely to be regulated by a number of factors including uterine Perfusion and of great importance in achieving a normal pregnancy, studies suggest that uterine artery perfusion may regulate endometrial receptivity and, that poor uterine perfusion could be one of the causes of unexplained abortions and ,probably ,of faulty implantation (Habra et al. 2002). uterine blood flow is an important factor contributing to uterine receptivity (Goswamy et al. 1988) and which can be studied by means of transvaginal pulsed and color Doppler (Tekay et al. 1995) this new approach allows closer proximately at the probe to the structures of interest and thus, the use of higher frequencies which results in substantially better resolution, In addition, the relative absence of intervening fat improves the image by reducing artifacts formation (Callen, 2008). This technique has been so widely accepted that endovaginal imaging is now the method of choice in evaluating many conditions

The pulsatility index (Pi) requires computer assisted calculation of mean velocity, which still may be suspected to very large experimental error. So (RI) is considered the ideal parameter as a Doppler index (Kuriak and Kupestic, 1999). The resistance index (RI) approaches 1.00 when diastolic velocities are abnormal low and therefore it reflects the relative impairment of flow by its high values (Kurjak and Kupesic, 1998). However the (RI) must not be considered independent of changes in physiologic variables such as heart rate, cardiac

contractility ,blood pressure ,and the other many determinations of flow (Kuriak &Kupestic 1999)

Thaler et al. (1990) they used a transvaginal duplex Doppler ultrasonography system to compare the blood flow characteristics in the ascending uterine artery before and during pregnancy in the same patient and determined that there was a 3.5-fold increase in blood flow, a still a significant increase in total blood flow to the gravid uterus. Elective termination of pregnancy (therapeutic abortion) is widely performed throughout much of the world in United States .approximately 1.4 million abortions are performed each year (88%) of these are performed during the first trimester (Centers for Disease Control ,1990)s .The most maternal medical conditions that carry significant risks in pregnancy include severe diabetes with retinopathy ,cardiac or renal complications.

The most common fetal anomalies encountered in abortion counseling include most cardiac anomalies trisomy 21; open and closed neural tube defects. To interpret these ultrasound examinations correctly, the normal appearance of the uterus after an elective termination of pregnancy needs to be known (Wang et al; 2002**)**

1-2 State of the problem

The unexplained recurrent pregnancy loss (RPL) among women is high. Vascular changes in the uterine artery of women with RPL have not been thoroughly studied. Study of the indices of uterine artery might reveal useful information which highlights the causes as well as the classification of the RPL into different groups according to the severity of their conditions.

1-3 Objective of the study is

The general objective of this study was to evaluate the uterine artery blood flow in a recurrent pregnancy loss using Doppler indices. PI ,RI &PSV.

Specific objectives

- To classify the RPL into groups according to their condition(threaten abortion, elective abortion and non pregnant)

- To compare the uterine artery blood flow of the PRL groups (threaten abortion, elective abortion and non pregnant)

- To evaluate and compare the uterine artery blood flow of RPL patients and control group (normal).

- To evaluate the uterine artery blood flow before and after elective abortion.

-To detect the effect of hematoma on uterine artery blood flow.

-To detect the effect of presence of yolk sac on uterine artery blood flow.

1-4 Significance of the study

This study will provide rich information about the uterine artery blood flow of RPL and the associated groups, and hence the study can differentiate between the threaten abortion, elective abortion and non pregnancy. Therefore the incidence and severity of the abortion can be evaluated objectively. In general the study can help in diagnosis and management of the pregnancy outcome by using a non invasive tool.

1-5 Overview of the study

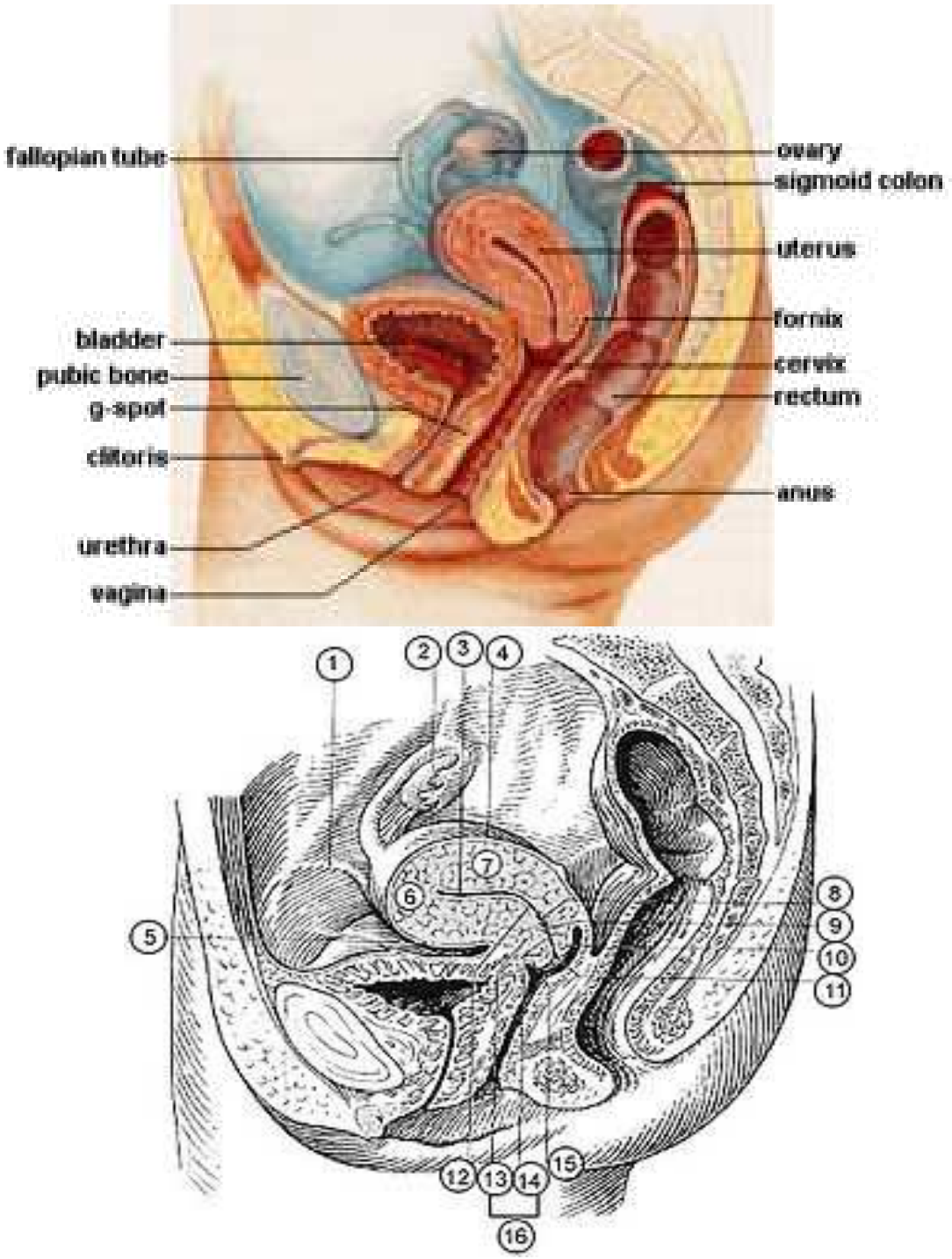
This study falls into five chapters, with chapter one is an introduction, which includes the problem of the study, objective, significant of the study and overview. Chapter two is a literature review which includes theoretical background and previous study. While chapter three is a methodology that includes material and methods, and chapter four include results presentation and finally chapter five includes discussion, conclusion and recommendation.

Chapter two
Section one
Theoretical background

2-1 Anatomy

2-1-1 Uterus

The uterus is a hollow, thick-walled, pear-shaped muscular organ in the female reproductive system. During pregnancy the uterus expands to accommodate a developing embryo. It is located between the urinary bladder in front and the rectum behind, and sits above the vagina. The lower narrow portion of the uterus is called the cervix and it protrudes downward into the opening of the vaginal canal. The vaginal canal extends downward to the external female genitalia (The American heritage Science Dictionary, 2005)



igure 2-1(A and B) shows the anatomy of the uterus where 1. Round ligament, 2. Uterus, 3. Uterine cavity, 4. Intestinal surface of Uterus, 5. Versical surface (toward bladder), 6. Fundus of uterus, 7. Body of uterus, 8. Palmate folds of cervical canal, 9. Cervical canal, 10. Posterior lip, 11. Cervical os (external), 12. Isthmus of uterus, 13. Supravaginal portion of cervix, 14. Vaginal portion of cervix, 15. Anterior lip, 16. Cervix The American heritage Science Dictionary, 2005)

2-1-2 Layers

The layers, from innermost to outermost, are as follows:

Endometrium, The lining of the uterine cavity is called the "endometrial". It consists of the functional endometrium and the basal endometrium from which the former arises. Damage to the basal endometrium results in adhesion formation and/or fibrosis (Asherman's syndrome). In most mammals, including humans, the endometrium builds a lining periodically which is shed or reabsorbed if no pregnancy occurs. Shedding of the functional endometrial lining in humans is responsible for menstrual bleeding (known colloquially as a woman's "period") throughout the fertile years of a female and for some time beyond. In other mammals there may be cycles set as widely apart as six months or as frequently as a few days. *Myometrium*: The uterus mostly consists of smooth muscle, known as "myometrium." The innermost layer of myometrium is known as the functional zone, which becomes thickened in adenomyosis. peritoneum: The loose surrounding tissue is called the peritoneum the uterus is surrounded by peritoneum.

2-1-3 Support

The uterus is primarily supported by the pelvic diaphragm,perineal body and the urogenital diaphragm. Secondarily, it is supported by ligaments and the peritoneum (broad ligament of uterus, Gray's Anatomy**).** The uterus **is** held in place by several peritoneal ligaments **'**Major ligaments

utrosacral ligament from the posterior cervix to the sacrum of pelvis cardinal ligaments from the side of the cervix to the ischial spines pub cervical ligament from the side of the cervix to the pubic symphysis.

Other named ligaments near the uterus, i.e. the broad ligament, the round ligament, the suspensory ligament of the ovary, the infundibulopelvic ligament, have no role in the support of the uterus.

2-1-4 Position

Under normal circumstances the uterus is both "anteflexed" and "anteverted." The meaning of these terms are described below:

Table 2-1 the description of the uterus

Distinction	More common	Less common
Position tipped	*anteverted*: tipped forward	*retroverted*: tipped backwards
Position of funds	*anteflexed*: the fundus is pointing forward relative to the cervix	*retroflexed*: the fundus is pointing backwards

.

2-2 Function

The uterus provides structural integrity and support to the bladder, bowel, pelvic bones and other organs. The uterus helps separate and keep the bladder in its natural position above the pubic bone and the bowel in its natural configuration behind the uterus. The uterus is continuous with the cervix, which is continuous with the vagina, much in the way that the head is continuous with the neck, which is continuous with the shoulders. It is attached to bundles of nerves, and networks of arteries and veins, and broad bands of ligaments such as round ligaments, cardinal ligaments, broad ligaments, and uterosacral ligaments (Gray's 1977.

The uterus is essential in sexual response by directing blood flow to the pelvis and to the external genitalia, including the ovaries, vagina, labia, and clitoris. The uterus is needed for uterine orgasm to occur (Gray's 1977).

The reproductive function of the uterus is to accept a fertilized ovum which passes through the utero-tubal junction from the fallopian tube. It then becomes implanted into the endometrium, and derives nourishment from blood vessels which develop exclusively for this purpose. The fertilized ovum becomes an embryo, develops into a fetus and gestates until childbirth. Due to anatomical barriers such as the pelvis, the uterus is pushed partially into the abdomen due to its expansion during pregnancy. Even during pregnancy the mass of a human uterus amounts to only about a kilogram (2.2 pounds).

2-3 Blood supply

The blood supply of the uterus is by the *uterine artery*, a branch of the internal iliac artery. The uterine artery passes inferiorly from its origin into the pelvic fascia. It reaches the junction of the body and cervix of the uterus by passing superiorly. This route takes the uterine artery over the *ureter* as it passes to the bladder from the pelvic brim where it crosses the bifurcation of the common iliac artery. This relationship of the uterine artery and the ureter is important in that surgical manipulation of the uterus and its blood supply may put the ureter at risk. As the uterine artery reaches the uterus it supplies a branch to the cervix which anatomizes below with the *vaginal artery* while the main vessel supplies the body and continues to the fallopian tube where it anatomizes with the *ovarian artery*. The uterine vein communicates in a similar fashion to the uterine artery and drains following the route of the uterine artery to the internal iliac vein (Wikipedia, 2006)

2-3-1 uterine artery aneurysms

Uterine artery aneurysms are rare but are well-recognized complications of pregnancy or previous surgery. There have been previous reports of uterine artery pseudo aneurysms rupturing during pregnancy, and immediately post-partum [Pelage et al 1999], after trauma or following pelvic surgery [Lee WC,et al 2001] and there is a single report of a true aneurysm misdiagnosed radiologically as a pelvic sarcoma and subsequently detected at

laparotomy [Raslan WF, et al 2001]. We present the first case of a spontaneous rupture of a true uterine artery aneurysm presenting as an unusual cause of anemia, abdominal pain, left iliac fossa mass and a retroperitoneal hematoma.

The diagnosis of a uterine artery aneurysm can be made with ultrasound but when small, and when rupture has occurred, visualization may be difficult. Both ultrasound and CT scanning may be useful in identifying the presence of a retroperitoneal hematoma but an underlying arterial abnormality is often best demonstrated by angiography; this imaging modality has the obvious added advantage that, if the anatomy is suitable, treatment by embolisation may be performed at the same time. This should be considered as the treatment of first choice of uterine artery aneurismal disease as it is relatively non-invasive when compared with open surgical techniques and has been proven to be both safe and effective [Pelage JP , et al 1999]. The surgical option of ligation of the internal iliac artery should be reserved for cases when embolisation is not possible. It may itself fail, however, as the aneurysm is not completely excluded from the circulation and may continue to be perfused via collaterals arising from the contra lateral internal iliac artery thus remaining at risk of hemorrhage.

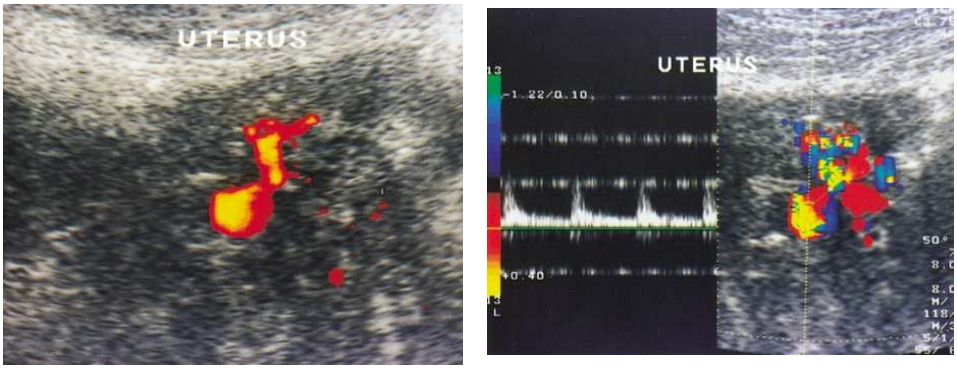


Figure 2-2 uterine aneurysm Left uterine artery aneurysm in an 18-year-old woman with habitual abortion Left uterine artery aneurysm in an 18-year-old woman with habitual abortion Left uterine artery aneurysm in an 18-year-old woman with habitual abortion (British Journal of Radiology)

2-3-2 Arteriosclerosis

Arteriosclerosis is vascular disease characterized by thickening, hardening and remodeling of the arterial wall and classified into following three categories: atherosclerosis, Monck berg's medial calcific sclerosis, and arteriolosclerosis. Fibro muscular intimal thickening starts its

development in the fetal age of the 6th month and continues to grow with aging. The specific topography of early atherosclerotic lesions is primarily attributed to wall shear stress, one of hemodynamic forces. The lesion will proliferate to form atherosclerosis when complicated by hyperlipidemia, hypertension, and/or other clinical risk factors. The major complications of atherosclerosis, stenosis of the arterial lumen and thrombus formation at ulcerated arterial walls, frequently cause such lethal diseases as ischemia of various pivotal organs or rupture of aneurysms Nippon Rinsho (1993) .

2-4 Lymphatic drainage

The lymphatic drainage of the uterus varies according to the source. While all lymphatic of the uterus are in communication, the cervix drains towards *sacral nodes* while the body, funds and fallopian tubes drain towards the *external iliac nodes*. There is some drainage towards *internal iliac nodes*. Lymphatic may also reach the *superficial inguinal nodes* along the round ligament. (Romer et al. 1977)

2-5 Physiology and Embryological Background

2-5-1 Embryo development.

Fertilization most often occurs within 1 day of ovulation (day 15 of the 28 day cycle) in the ampulla, with subsequent development of the morula, blastocyst and bilaminar ,Over the next 2 days m the cell mass transgresses the tube while dividing repeatedly to form a solid ball of 12 or more cells (Callen 2008).

As the morula enters the uterine cavity on day 18 or 19 of the cycle , endometrial fluid penetrates the cell mass to create a central cavity .When this occurs , the morula is transformed into a blastocyst and its tissue is divided into two important layers. The outer cell layer , or trophblasts, will ultimately create the chorionic membranes and the fetal contribution to the placenta The inner cell layer will develop into the embryo, amnion ,umbilical cord and the primary and secondary yolk sacs.

By the end of the 3 week, the blast cyst begins to implant into decasualized endometrium, a term applied to functional layer of the thickened and edematous gravid endometrium (Moore, 2007) .The 4 week is a time of rapid cell proliferation and differentiation. Affecting multiple primordial structures .The primary yolk sac shrinks and disappears gradually while the secondary yolk sac forms. The latter structure plays a critical role by providing nutrients for the embryo, serving as the site for initial hematopoiesis, and contributing to the developing gut and reproductive systems (Moore, 2007).

A tiny bilaminar embryo also forms between the secondary yolk sac and developing amnion and a primitive uteroplacental circulation is established .By the end of the 4 weeks the gestational sac has attained a diameter of 2 to 3mm and is at the threshold of detection by transvaginal ultrasound transducers (Callen ,2008).

The products of conception continue to enlarge primarily as a result of expansion of the chorionic cavity , which attains a diameter of 5mm .This cavity is identified by sinologists as fluid within the gestational sac The secondary yolk sac is variably identified by sonographic examination and the developing bilaminar embryonic disk undergoes the process of gastrulating ,which transforms it into a trilaminar disk with three germs layers (endoderm ,mesoderm and ectoderm).Despite these transformations , the embryo remains undetectable by sonography (Moore,2007).

Weeks 6 through 10 constitute the embryonic stage ,during which time all major internal and external structures begin to form .Although most organ function remains minimal , the cardiovascular system develops rapidly and the primordial heart starts to beat at the beginning of the 6’th week. The appearance of the embryo changes dramatically as it is transformed from its flat disk-like configuration to a C-shaped structure and it develops a human-like appearance

.During embryogenesis ,crown rump length (CRL)grows rapidly ,measuring 30 mm by the end of the 10^{th} week.

The final 2 weeks of the trimester (11 and 12 weeks GA) are known as the fetal period, during which there is continued rapid growth and ongoing organ development (Moore, 2007)

2-5-2 Development of uteroplacental circulation;

Blood to the uterus is form the paired uterine arteries, which are branches of the anterior division of the internal iliac artery .as each uterine artery enters the uterus at uterocervical junction, it ascends along the lateral uterine wall and produces multiple penetrating arcuate branches .When these branches pierce the endometrium, they become the spiral arteries. With early embryonic development, the spiral arteries located within the decidual basalis become increasingly prominent .Side-by-side maternal and embryonic circulations are established initially as trophoblastic cells form chorionic villi that invade into portions of the decidualized endometrium (Moore.2007)

2-6 Abortion

Abortion is the termination of pregnancy by any means, resulting in the expulsion of an immature, non –viable fetus of less than 20 weeks (or 139 days) gestation, counting from the first day of the last menstrual period, or a fetus weighting less than 500 grams is considered an abortion. The term miscarriage has been used for all pregnancy losses. Although imprecise, its use is preferred to discussion with patients, as the word abortion is not liked by many (Cunningham et al. 2001).

It is estimated that around 40% of early pregnancies result in miscarriage .A large majority of these are lost before the menstrual period is missed and they are sometimes referred to as

biochemical pregnancies .More than 80% of abortions in the first 12 weeks of pregnancy, and the rate decreases rapidly thereafter (Eskild et al. 2009).

2-6-1 Etiology

Fetal wastage has many causes, but genetic factors are by far the most common / the earlier the pregnancy loss occurs, the greater the like hood genetic causation. A among the non-genetic causes of the first trimester fetal wastage ,the best established are thyroid abnormalities ,ant fetal anti bodies and the inherited and acquired thrombophilia .The later are more established in the second trimester .Uterine anomalies can lead to second trimester losses .Infections seen uncommon and autoimmune causes are not validated. A after a thoroughly evaluation .the potential cause in 60% of cases remains unexplained **(**Hill, 1994 and Simpson et al. 2007).

2-6-2 Threatened abortion

Is a clinically descriptive term that applies to women during the first 20 weeks of pregnancy who have any bloody vaginal discharge or vaginal bleeding and a closed internal cervical os.

of those women who bleed in early pregnancy, approximately one half will be aborted (Nyberg et al. 1992 and Cunningham et al. 2001).

2-6-3 Incomplete Abortion

The fetus and placenta are likely to be expelled together in abortions occurring before 10 weeks ,but separately thereafter .When the placenta in whole or in a part, is retained in the uterus bleeding ensues sooner or later to produce the main sign of incomplete abortion (Cunningham et al. 993).

2-6-4 Miss Abortion

It is defined as retention of dead products of conception in uterus for several weeks, the rationale for an exact time period is not clear. After fetal death ,there may or may not be vaginal bleeding or other symptoms denoting a threatened abortion .For a time the uterus to remain stationary in size but mammary changes usually regress. If the missed abortion terminates spontaneously, the process of expulsion is the same as any abortion, if the products are retained for several weeks after death they become shriveled containing a macerated fetus (Cunninghom et al .2001)

2-6-5-Therapeutic abortion

It is the termination of pregnancy before the time of fetal viability for the purpose of safe guarding the health of the mother. The American collage of O &G established guideline for therapeutic abortion and according to this policy therapeutic abortion may be formed for the following:

When continuation of pregnancy may threaten the life of the women or seriously impair her health.

When pregnancy has resulted from rape or incest.

When continuation of pregnancy is likely to result in the birth of a child with severe physical deformities or mental retardation. While septic abortion; is the occurrence of infection on top of any of the types of abortions (Cunningham et al, 2001)

2-7 Recurrent Pregnancy Loss

Pregnancy loss before 20 weeks of gestation (4 completed months) is called an abortion. It is further divided into: Early losses (Embryonic i.e. before 9 weeks or one month after missed period) embryonic losses occur before the full development of baby and are associated with

genetic abnormalities in the baby. This type of abortion is generally associated with a small or delayed appearance of gestational sac in ultrasound, empty gestational sac or non-appearance of cardiac pulse. Late abortions (fetal i.e. from 9 weeks to 20 weeks of pregnancy, late abortions more commonly occur due to other factors like abnormalities in the uterus or immunological factors (Umesh, 2007).

2-7-1 Causes of Recurrent abortion

Genetic Factor: Genetic causes of RSA are over 90 % other causes of RSA should be ruled out before genetic investigations. As far as possible test couples not individuals, couples with 2 or more abortions, couples with one abortion, with a still born child or with a malformed child should be investigated. Prenatal diagnosis is indicated whenever there is a chromosomal anomaly in the parent. Only major Chromosomal abnormality i.e., translocations, sex chromosomal mosaicism and, inversions, should be taken as abnormality causing abortions. Prenatal diagnosis in chromosomally normal couples is cont-roversial. Molecular studies should be done to find minute rearrangements. Preimplantation molecular studies in the future, could be used as a screening method, so far only one gene has been located, responsible for recurrent abortions at Xq 28. Role of Inborn errors of metabolism, especially galactosemia, Phenylketonuria, Tyrosinemia and Homocystinuria, Biotinidase deficiency should always be kept in mind. If we have an index case (one affected child in the family), the diagnosis becomes easier otherwise a systematic approach to IEM may be useful in certain cases with high index of suspicion (Gila, 1999).

Counseling and advise: The obstetrician faced with a couple experiencing spontaneous abortion has several responsibilities. He or she must inform the couple concerning the frequency of fetal wastage (12 - 20 %) of recognized pregnancies , and its usual cause (at least 50 % cytogenetic) , provide recurrence risks , determine whether evaluation for

repetitative abortion is necessary , and if so either perform the necessary evaluations or refer the patient to an appropriate centre. Those first trimester abortuses that do not show chromosomal abnormalities could still have undergone fetal demise from other genetic causes, Mendelian or polygenic / multifactorial. The first obligation, education, can be fulfilled by summarizing the salient facts about RSA described above. Of relevance is the fact that spontaneous abortion rates are positively correlated with advancing maternal age. Women over age 40 have twice the likelihood of experiencing a fetal loss than women 2 decades younger. This increase is due to following reasons: 1) Increase in embryos with trisomies. 2) Cumulative exposure to toxins. 3) Greater opportunity to acquire chronic infections. 4) Diminished leutel response. 5) Poorly vascualried endometrium. This fact of advancing age should also be discussed with couple and prenatal testing for chromosomal abnormalities (trisomies etc.) should be suggested: Deficiency of progesterone or luteal phase deficiency is a common problem especially in patients who conceive with the help of ovulation inducing agents and ART. Hormonal support is very important during first three months of pregnancy. Abnormalities in thyroid status and diabetes can also lead to abortion. However these are treatable causes and with appropriate control of thyroid and diabetes pregnancy outcome is almost normal (Simpson and Golbus 2000 and Manorama 1999).

2-7-2The anatomic factor :

it include uterine malformation; a uterine malformation is the result of an abnormal development of the Mullerian duct(s) during embryogenesis. Symptoms range from amenorrhea, infertility, recurrent pregnancy loss, and pain, to normal functioning depending on the nature of the defect (Johannes, 1830).

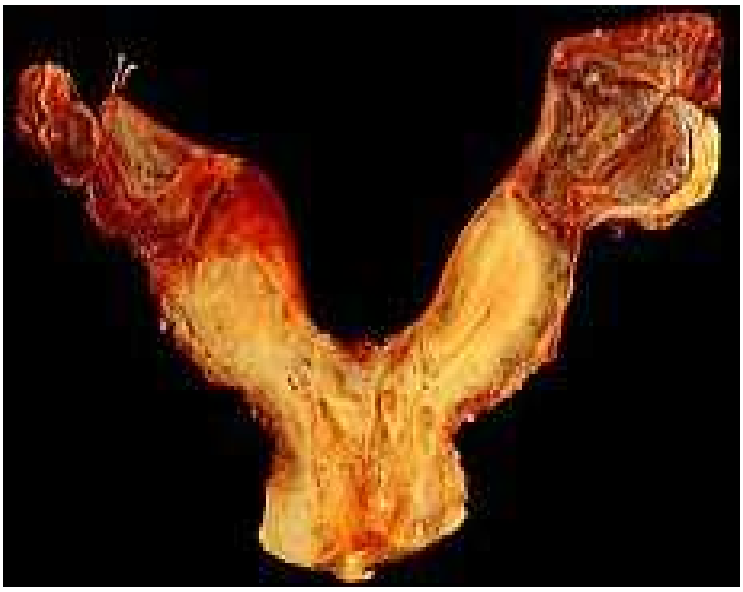


Figure-2-3 A human Bicornuate uterus

2-7-3 Prevalence

The prevalence of uterine malformation is estimated to be 6.7% in the general population, slightly higher 7.3% in the infertility population, and significantly higher in a population of women with a history of recurrent miscarriages 16% (Sotirios, 2008)

2-7-4 Types of prevalence;

The American Society of Reproductive Medicine Classification distinguishes:

Class I: Mullerian agenesis (absent uterus); uterus is not present, vagina only rudimentary or absent. The condition is also called Mayer-Rokitansky-Kuster-Hauser syndrome. The patient with MRKH syndrome will have primary amenorrhea.

Class II: Unicornuate uterus (a one-sided uterus); only one side of the Mullerian duct forms. The uterus has a typical "penis shape" on imaging systems.

Class III: Uterus didelphys, also uterus didelphis (double uterus); Both Mullerian ducts develop but fail to fuse, thus the patient has a "double uterus". This may be a condition with a double cervix and a vaginal partition or the lower Mullerian system fused into its unpaired condition; Triplet-birth with Uterus didelphys for a case of a woman having spontaneous birth in both wombs with twins.

Class IV: Bicornuate uterus (uterus with two horns); Only the upper part of that part of the Mullerian system that forms the uterus fails to fuse, thus the caudal part of the uterus is normal, the cranial part is bifurcated and the uterus is "heart-shaped".

Class V: Septated uterus (uterine septum or partition); The two Mullerian ducts have fused, but the partition between them is still present, splitting the system into two parts. With a complete septum the vagina, cervix and the uterus can be partitioned. Usually the septum affects only the cranial part of the uterus. A uterine septum is the most common uterine malformation and a cause for miscarriages. It is diagnosed by medical image techniques, i.e. ultrasound or an MRI. MRI is considered the preferred modality due to its multiplanar capabilities as well as its ability to evaluate the uterine contour, junctional zone, and other pelvic anatomy. A hysterosalpingogram is not considered as useful due to the inability of the technique to evaluate the exterior contour of the uterus and distinguish between a bicornuate and septate uterus. A uterine septum can be corrected by hysteroscopic surgery

Class VI: DES uterus; the uterine cavity has a "T-shape" as a result of fetal exposure to diethylstilbestrol. An additional variation is the arcuate uterus where there is a concave dimple in the uterine fundus within the cavity. A rudimentary uterus is a uterine remnant not connected to cervix and vagina and may be found on the other side of an unicornuate uterus.

Patients with uterine abnormalities may have associated renal abnormalities including unilateral renal agenesis(.Li et al 2000, Sotirios et al. 2008, Spiezio et al. 2008 and Nouri et al. 2010.)

2-7-5 Double vagina

Main article: Vaginal septum; As the vagina is largely derived from the Mullerian ducts, lack of fusion of the two ducts can lead to the formation of a vaginal duplication and lack of absorption of the wall between the two ducts will leave a residual septum, leading to a "double vagina". This condition may be associated with a uterus didelphys or a uterine septum. A person may not be aware of having a "double vagina;" however, this is unlikely since it is highly visible from the outside and evident to the majority of women. If necessary, the partition can be surgically corrected, however, there is no valid medical reason for such a procedure (Heinonen et al. 2002)

2-7-6 Immunological Factor

Approximately 10–15% of couples desiring children suffer from infertility. However, even after a thorough evaluation, the cause of their inability to conceive remains unknown in at least 10% of the cases. Despite treatment, including IVF, many of these couples remain childless. Both practitioners and patients are seeking answers to direct them towards additional testing and possible treatment options to improve their chances of successful pregnancy. Recently, the search for answers to unexplained infertility has concentrated on the possible role of immunology in reproductive failure. Autoimmune abnormalities (antiphospholipid, antithyroid, antinuclear and antisperm antibodies) have been investigated for possible associations with reproductive failure. The `reproductive autoimmune failure syndrome' was originally described by Gleicher et al. (1989) in women with endometriosis, infertility and increased autoantibodies.

These studies and others led many authors to recommend immunological testing for specific autoantibodies to screen women with infertility. However, after a decade of research, the predictive value of these tests is still questionable and under debate. In the absence of conclusive clinical data, many patients have come to expect (or request) multiple immunological tests. Physicians often feel compelled to perform these tests upon patient request for various reasons. Antiphospholipid antibodies (APA) are acquired antibodies, IgG, IgM and/or IgA against phospholipids which have been associated with a slow progressive thrombosis and infarction in the placenta. The diagnosis of APA syndrome is based on both clinical manifestations and laboratory detection of abnormal antibodies. Several published reports indicate that positive APA are found more frequently in patients undergoing IVF when compared with controls. However, the positive APA do not appear to influence pregnancy outcome in most studies (Gleicher et al. 1994, Birdsall et al. 1996, Denis et al. 1997, Kowalik et al. 1997, Kutteh et al. 1997 and Hornstein et al. 2000).

2-7-7 Hormonal causes

Recurrent pregnancy loss in women at different trimesters is associated with endocrine abnormalities where serum leptin and insulin levels increase in a different way from the increased levels in normal healthy pregnant women. Since insulin elevation during pregnancy seems to be affected by the same process that stimulates leptin production from adiposities, both may serve as markers for detecting and monitoring pregnancy complications specially if cases of RPL have no specific medical cause for pregnancy loss, and can be termed as idiopathic or unexplained RPL. There was no significant correlation between study patients' age and their leptin levels when pregnancy loss occurred during the second and the third trimesters, while it was found that there was a significant correlation when loss occurred during

the first trimester. Because of insufficient number of studies conducted to determine the effect of age on recurrent pregnancy loss at any trimester, there is also a lack of explanation for this finding. Further studies on leptin and its receptors in addition to the other biochemical parameters included in this study in different age groups of women with RPL during the three trimesters are required to strengthen this conclusion. Generally, since most pregnancy losses occurred during the first trimester, it is highly recommended that leptin and insulin hormone evaluation tests are provided within 12-14 weeks of gestation to prevent pregnancy loss (Rayah et al. 2010)

2-7-8 Endocrine disorders

Women with hypothyroidism are at increased risk for pregnancy losses. Unrecognized or poorly treated diabetes mellitus leads to increased miscarriages. Women with polycystic ovary syndrome also have higher loss rates possibly related to hyperinsulinemia or excess androgens. Inadequate production of progesterone in the luteal phase may set the stage for RPL. Thrombophilia. An important example is the possible increased risk of abortion in women with thrombophilia (propensity for blood clots). The most common problem is the factor V Leiden and prothrombin G20210A mutation. Some preliminary studies suggest that anticoagulant medication may improve the chances of carrying pregnancy to term but these studies need to be confirmed before they are adopted in clinical practice Note that many women with thrombophilia go through one or more pregnancies with no difficulties, while others may have pregnancy complications. Thrombophilia may explain up to 15% of recurrent miscarriages (Rodger et al. 2008).

2-7-9 Ovarian factors

Reduced ovarian reserve

The risk for miscarriage increases with age, and women in the advanced reproductive age who have a reduced ovarian reserve are prone to higher risk of repeated miscarriages. Such miscarriages are due to decreased egg quality.

2-7-10 Luteal phase defect

The issue of a luteal phase defect is complex. The theory behind the concept suggests that an inadequate amount of progesterone is produced by the corpus luteum to maintain the early pregnancy. Assessment of this situation was traditionally carried out by an endometrial biopsy, however recent studies have not confirmed that such assessment is valid. Studies about the value of progesterone supplementation remain deficient; however, such supplementation is commonly carried out on an empirical basis (American college O&G 2008**)**

2-7-11 Lifestyle factors

While lifestyle factors have been associated with increased risk for miscarriage in general, and are usually not listed as specific causes for RPL, every effort should be made to address these issues in patients with RPL. Of specific concern are chronic exposures to toxins including smoking, alcohol, and drugs (American college O&G 2008**)**

2-7-12 Infection

A number of maternal infections can lead to a single pregnancy loss, including listeriosis, toxoplasmosis, and certain viral infections (rubella, herpes simplex, measles, cytomegalo virus, coxsackie virus). However, there are no confirmed studies to suggest that specific infections will lead to recurrent pregnancy loss in humans. Malaria, syphilis and brucellosis can also

cause recurrent abortion. *Infections*: There is some evidence that genital infection by Chlamydia and TB can cause recurrent abortion. Co-agulation Disorders: Deficiencies of certain blood clotting factors lead to a thick blood and lead to recurrent loss due to clogging of blood vessels going to the baby (American college O&G 2008)..

2-7-13 Chromosomal causes

Many advances have been made in reproductive medicine, yet the spontaneous loss of a pregnancy remains the most common complication of pregnancy. The etiology of spontaneous recurrent pregnancy loss (RPL) is multifactorial. Y chromosome micro deletions are found in ~7% of men with low sperm counts and, compared with the general population, a higher frequency of spontaneous pregnancy loss occurs in infertile couples. Y chromosome micro deletions do not appear to be important in the etiology of RPL. Lifestyle Issues: Smoking, drinking and obesity, the trade of modern life-style do increase the risk of abortions. **(**Tithila, 2010)

2-8- Ultrasound History.

. The modern ultrasonic started about (1917, with Langevin's) use of high-frequency acoustic waves and quartz resonators for submarine detection. Since that time, the field has grown enormously, with applications found in science, industry,

The use of Ultrasonic in the field of medicine had nonetheless started initially with its applications in therapy rather than diagnosis, utilizing its heating and disruptive effects on animal tissues. The destructive ability of high intensity ultrasound had been recognized in the (1920s from the time of Langévin) when he noted destruction of school of fishes in the sea and pain induced in the hand when placed in a water tank insolated with high intensity ultrasound;

and from the seminal work in the late (1920s from Robert Wood and the legendary Alfred Loomis in New York)

In (1944, Lynn and Putnam) successfully used ultrasound waves to destroy brain tissue in animals. William Fry and Russell Meyers performed craniotomies and used ultrasound to destroy parts of the basal ganglia in patients with Parkinsonism.(Peter Lindstrom) reported ablation of frontal lobe tissue in moribund patients to alleviate their pain from carcinomatosis. Ultrasonic was also extensively used in physical and rehabilitation medicine.(Jerome Gersten reported in 1953) the use of ultrasound in the treatment of patients with rheumatic arthritis. Several groups such as the Peter Wells group in Bristol, England, the Mischele Arslan group in Padua, Italy and the Douglas Gordon group in London used ultrasonic energy in the treatment of Meniere's disease.

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Figure 2-4 Medical monographic instruments

2-8-1 From sound to image

The creation of an image from sound is done in three steps - producing a sound wave, receiving echoes, and interpreting those echoes. A sound wave is typically produced by a

piezoelectric transducer encased in a probe. Strong, short electrical \\pulses from the ultrasound machine make the transducer ring at the desired frequency. The frequencies can be anywhere between 2 and 18 MHz The sound is focused either by the shape of the transducer, a lens in front of the transducer, or a complex set of control pulses from the ultrasound scanner machine (Beam forming). This focusing produces an arc-shaped sound wave from the face of the transducer. The wave travels into the body and comes into focus at a desired depth. Older technology transducers focus their beam with physical lenses. Newer technology transducers use phased array techniques to enable the monographic machine to change the direction and depth of focus. Almost all piezoelectric transducers are made of ceramic. Materials on the face of the transducer enable the sound to be transmitted efficiently into the body (usually seeming to be a rubbery coating, a form of impedance matching). In addition, a water-based gel is placed between the patient's skin and the probe. The sound wave is partially reflected from the layers between different tissues. Specifically, sound is reflected anywhere there are density changes in the body: e.g. blood cells in blood plasma, small structures in organs, etc. Some of the reflections return to the transducer (Foster FS, Mehi J,1982)

2-8-2 Receiving the echoes

the return of the sound wave to the transducer results in the same process that it took to send the sound wave, except in reverse. The return sound wave vibrates the transducer, the transducer turns the vibrations into electrical pulses that travel to the ultrasonic scanner where they are processed and transformed into a digital image.

2-8-3 Image Formation

The monographic scanner must determine three things from each received echo:

How long it took the echo to be received from when the sound was transmitted.

From this the focal length for the phased array is deduced, enabling a sharp image of that echo at that depth (this is not possible while producing a sound wave).

How strong the echo was. It could be noted that sound wave is not a click, but a pulse with a specific carrier frequency. Moving objects change this frequency on reflection, so that it is only a matter of electronics to have simultaneous Doppler solography.

Once the ultrasonic scanner determines these three things, it can locate which pixel in the image to light up and to what intensity and at what hue if frequency is processed .Transforming the received signal into a digital image may be explained by using a blank spreadsheet as an analogy. We imagine our transducer is a long, flat transducer at the top of the sheet. We will send pulses down the 'columns' of our spreadsheet (A, B, C, etc.). We listen at each column for any return echoes. When we hear an echo, we note how long it took for the echo to return. The longer the wait, the deeper the row (1,2,3, etc.). The strength of the echo determines the brightness setting for that cell (white for a strong echo, black for a weak echo, and varying shades of grey for everything in between.) When all the echoes are recorded on the sheet, we have a rescale image.(Wikipedia, 2010**)**

2-8-4 Displaying the image

Images from the sonographer scanner can be displayed, captured, and broadcast through a computer using a frame grabber to capture and digitize the analog video signal. The captured signal can then be post-processed on the computer itself. Capture and Store Gynecological Ultrasounds

Figure (2-5) Linear Array Transducer

Ultrasonography (solography) uses a probe containing one or more acoustic transducers to send pulses of sound into a material. Whenever a sound wave encounters a material with a different density (acoustical impedance), part of the sound wave is reflected back to the probe and is detected as an echo. The time it takes for the echo to travel back to the probe is measured and used to calculate the depth of the tissue interface causing the echo. The greater the difference between acoustic impedances, the larger the echo is. If the pulse hits gases or solids, the density difference is so great that most of the acoustic energy is reflected and it becomes impossible to see deeper.

The frequencies used for medical imaging are generally in the range of 1 to 18 MHz's higher frequencies have a correspondingly smaller wavelength, and can be used to make sonograms with smaller details. However, the attenuation of the sound wave is increased at higher frequencies, so in order to have better penetration of deeper tissues, a lower frequency (3-5 MHz) is used. Seeing deep into the body with solography is very difficult. Some acoustic energy is lost every time an echo is formed, but most of it (approximately is lost from acoustic

absorption.)

$$0.3\,\frac{dB}{cm\ depth.MHz}$$

The speed of sound is different in different materials, and is dependent on the acoustical impedance of the material. However, the sonographer instrument assumes that the acoustic velocity is constant at 1540 m/s. An effect of this assumption is that in a real body with non-uniform tissues, the beam becomes somewhat de-focused and image resolution is reduced.

To generate a 2D-image, the ultrasonic beam is swept. A transducer may be swept mechanically by rotating or swinging. Or a 1D phased array transducer may be used to sweep the beam electronically. The received data is processed and used to construct the image. The image is then a 2D representation of the slice into the body. 3D images can be generated by acquiring a series of adjacent 2D images. Commonly a specialized probe that mechanically scans a conventional 2D-image transducer is used. However, since the mechanical scanning is slow, it is difficult to make 3D images of moving tissues. Recently, 2D phased array transducers that can sweep the beam in 3D have been developed. These can image faster and can even be used to make live 3D images of a beating heart. Doppler ultrasonography is used to study blood flow and muscle motion. The different detected speeds are represented in color for ease of interpretation, for example leaky heart valves: the leak shows up as a flash of unique color. Colors may alternatively be used to represent the amplitude of the received echoes

2-8-5 Doppler sonography

- - The Doppler Effect was first described by Austrian physicist Christian (Doppler in 1842.) Doppler postulated that the colored appearance of certain stars was caused by their motion relative to the earth.

- He suggested that if the distance between the source and observer decreases, the wavelength shorten, and vice versa.

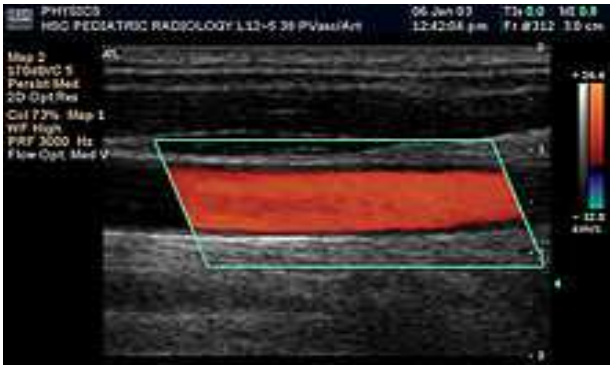

Figure 2-6 Spectral Doppler of Common Carotid Artery

Figure 2-7 Color Doppler of Common Carotid Artery, Computer-enhanced transcranial Doppler.

Sonography can be enhanced with Doppler measurements, which employ the Doppler effect to assess whether structures (usually blood) are moving towards or away from the probe,

and its relative velocity. By calculating the frequency shift of a particular sample volume, for example flow in an artery or a jet of blood flow over a heart valve, its speed and direction can be determined and visualized. This is particularly useful in cardiovascular studies (sonography of the vascular system and heart) and essential in many areas such as determining reverse blood flow in the liver vasculature in portal hypertension. The Doppler information is displayed graphically using spectral Doppler, or as an image using color Doppler (directional Doppler) or power Doppler (non directional Doppler). This Doppler shift falls in the audible range and is often presented audibly using stereo speakers: this produces a very distinctive, although synthetic, pulsating sound. Most modern sonographic machines use pulsed Doppler to measure velocity. Pulsed wave machines transmit and receive series of pulses. The frequency shift of each pulse is ignored, however the relative phase changes of the pulses are used to obtain the frequency shift (since frequency is the rate of change of phase). The major advantages of pulsed Doppler over continuous wave is that distance information is obtained (the time between the transmitted and received pulses can be converted into a distance with knowledge of the speed of sound) and gain correction is applied. The disadvantage of pulsed Doppler is that the measurements can suffer from aliasing. The terminology "Doppler ultrasound" or "Doppler sonography", has been accepted to apply to both pulsed and continuous Doppler systems despite the different mechanisms by which the velocity is measured. It should be noted here that there are no standards for the display of color Doppler. Some laboratories insist on showing arteries as red and veins as blue, as medical illustrators usually show them, even though, as a result, a tortuous vessel may have portions with flow toward and away relative to the transducer. This can result in the illogical appearance of blood flow that appears to be in both directions in the same vessel. Other laboratories use red to

indicate flow toward the transducer and blue away from the transducer which is the reverse of 150 years of astronomical literature on the Doppler effect. Still other laboratories prefer to display the sonographic Doppler color map more in accord with the prior published physics with the red shift representing longer waves of echoes (scattered) from blood flowing away from the transducer; and with blue representing the shorter waves of echoes reflecting from blood flowing toward the transducer. Because of this confusion and lack of standards in the various laboratories, the sonographer must understand the underlying acoustic physics of color Doppler and the physiology of normal and abnormal blood flow in the human body. (Wikipedia 2008, Ellis et al. 2000 and DuBose et al. 2009)

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2-8-6 Modes of sonography

Four different modes of ultrasound are used in medical imaging. These are:

-mode: A-mode is the simplest type of ultrasound. A single transducer scans a line through the body with the echoes plotted on screen as a function of depth. Therapeutic ultrasound aimed at a specific tumor or calculus is also A-mode, to allow for pinpoint accurate focus of the destructive wave energy.

B-mode: In B-mode ultrasound, a linear array of transducers simultaneously scans a plane through the body that can be viewed as a two-dimensional image on screen.

M-mode: M stands for motion. In m-mode a rapid sequence of B-mode scans whose images follow each other in sequence on screen enables doctors to see and measure range of motion, as the organ boundaries that produce reflections move relative to the probe.

Doppler mode: This mode makes use of the Doppler effect in measuring and visualizing blood flow **Gale Encycloped)**

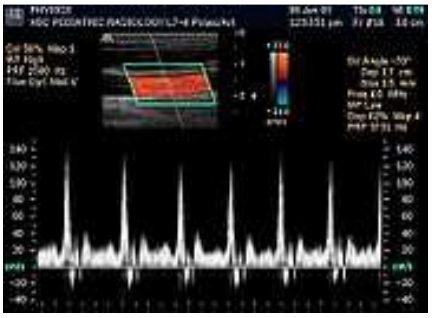


Figure 2-8 Doppler sonography

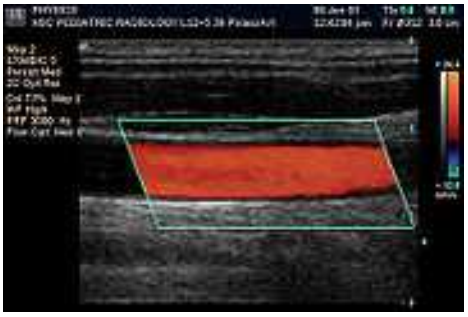


Figure 2-9 Spectral Doppler of Common Carotid Artery

Published physics with the red shift representing longer waves of echoes (scattered) from blood flowing away from the transducer; and with blue representing the shorter waves of echoes reflecting from blood flowing toward the transducer. Because of this confusion and lack of standards in the various laboratories, the sonographer must understand the underlying acoustic physics of (American Journal of Roentgenology, 1989)

2-8-7 Doppler ultrasound in medicine

In recent years, the capabilities of ultrasound flow imaging have increased enormously. Color flow imaging is now commonplace and facilities such as ‘power’ or ‘energy’ Doppler provide new ways of imaging flow. With such versatility, it is tempting to employ the technique for ever more demanding applications and to try to measure increasingly subtle changes in the maternal and fetal circulations. To avoid misinterpretation of results, however, it is essential

for the user of Doppler ultrasound to be aware of the factors that affect the Doppler signal, be it a color flow image or a Doppler sonogram.

Competent use of Doppler ultrasound techniques requires an understanding of three key components:

The capabilities and limitations of Doppler ultrasound

The different parameters which contribute to the flow display;

Blood flow in arteries and veins.(Evans et al. 1989and Goldberg et al. 1997).

2-8-8 Basic principle

Ultrasound images of flow, whether color flow or spectral Doppler, are essentially obtained from measurements of movement. In ultrasound scanners, a series of pulses is transmitted to detect movement of blood. Echoes from stationary tissue are the same from pulse to pulse. Echoes from moving scatterers exhibit slight differences in the time for the signal to be returned to the receiver (Figure 8). These differences can be measured as a direct time difference or, more usually, in terms of a phase shift from which the ‘Doppler frequency’ is obtained (Figure 9). They are then processed to produce either a color flow display or a Doppler sonogram.

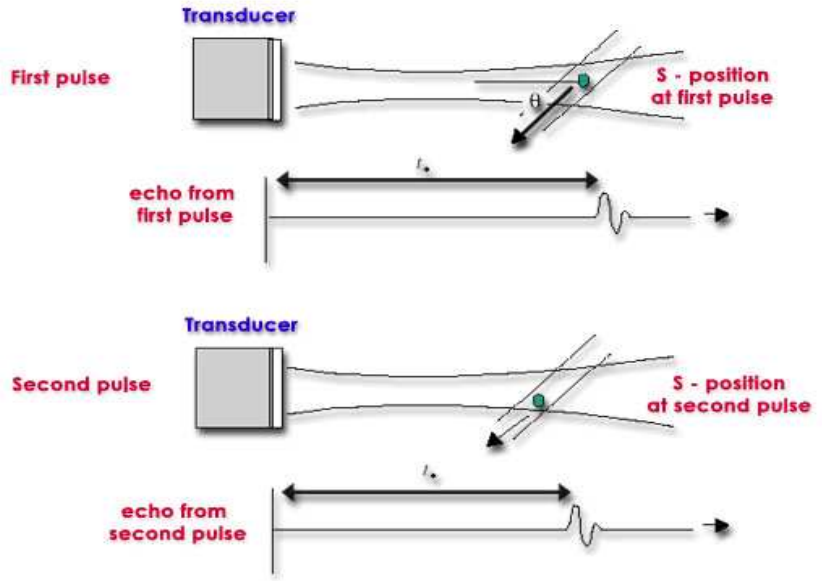


Figure 2-10 Ultrasound velocity measurement. The diagram shows a scattered S moving at velocity V with a beam/flow angle q. The velocity can be calculated by the difference in transmit-to-receive time from the first pulse to the second (t2), as the scattered moves through the beam.

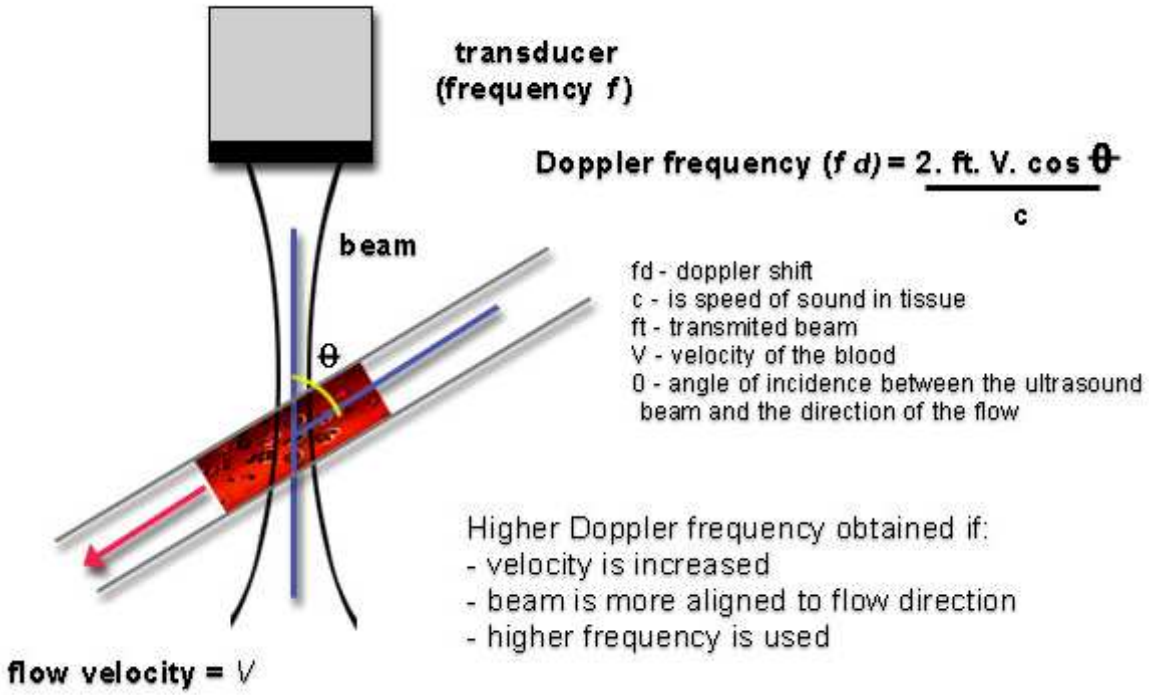


Figure 2-11 Doppler ultrasound. Doppler ultrasound measures the movement of the scatterers through the beam as a phase change in the received signal. The resulting Doppler frequency can be used to measure velocity if the beam/flow angle is known.

As can be seen from Figures 2-5 and 2-6, there has to be motion in the direction of the beam; if the flow is perpendicular to the beam, there is no relative motion from pulse to pulse. The size of the Doppler signal is dependent on:

Blood velocity: as velocity increases, so does the Doppler frequency.) Ultrasound frequency: higher ultrasound frequencies give increased Doppler frequency. As in B-mode, lower ultrasound frequencies have better penetration.) The choice of frequency is a compromise between better sensitivity to flow or better

The angle of insonation: the Doppler frequency increases as the Doppler ultrasound beam becomes more aligned to the flow direction (the angle *q* between the beam and the direction of flow becomes smaller). This is of the utmost importance in the use of Doppler ultrasound. The implications are illustrated schematically in Figure 2-7.

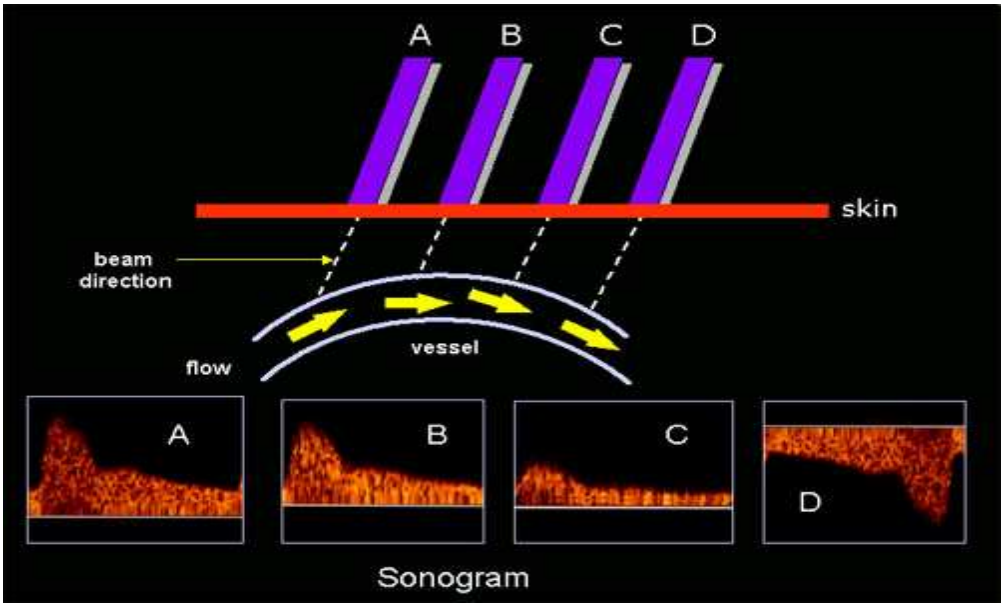


Figure 2-12 - Effect of the Doppler angle in the sonogram. (A) higher-frequency Doppler signal is obtained if the beam is aligned more to the direction of flow. In the diagram, beam (A) is more aligned than (B) and produces higher-frequency Doppler signals. The beam/flow angle at (C) is almost 90° and there is a very poor Doppler signal. The flow at (D) is away from the beam and there is a negative signal.

All types of Doppler ultrasound equipment employ filters to cut out the high amplitude, low-frequency Doppler signals resulting from tissue movement, for instance due to vessel wall motion. Filter frequency can usually be altered by the user, for example, to exclude frequencies below 50, 100 or 200 Hz. This filter frequency limits the minimum flow velocities that can be measured.(Evans et al. 1989)

2-8-9 Continuous wave and pulsed wave

As the name suggests, continuous wave systems use continuous transmission and reception of ultrasound. Doppler signals are obtained from all vessels in the path of the ultrasound beam (until the ultrasound beam becomes sufficiently attenuated due to depth). Continuous wave Doppler ultrasound is unable to determine the specific location of velocities within the beam and cannot be used to produce color flow images. Relatively inexpensive Doppler ultrasound systems are available which employ continuous wave probes to give Doppler output without the addition of B-mode images. Continuous wave Doppler is also used in adult cardiac scanners to investigate the high velocities in the aorta.

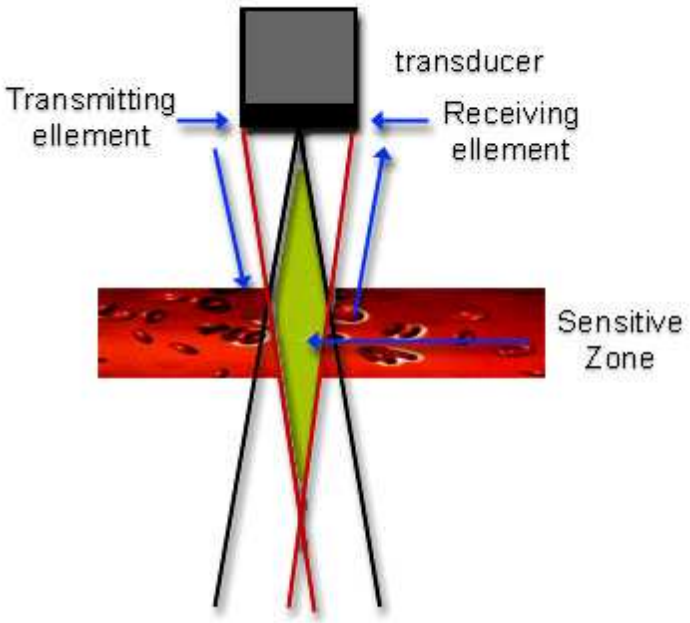


Figure 2-13 Continuous-wave Doppler transducer

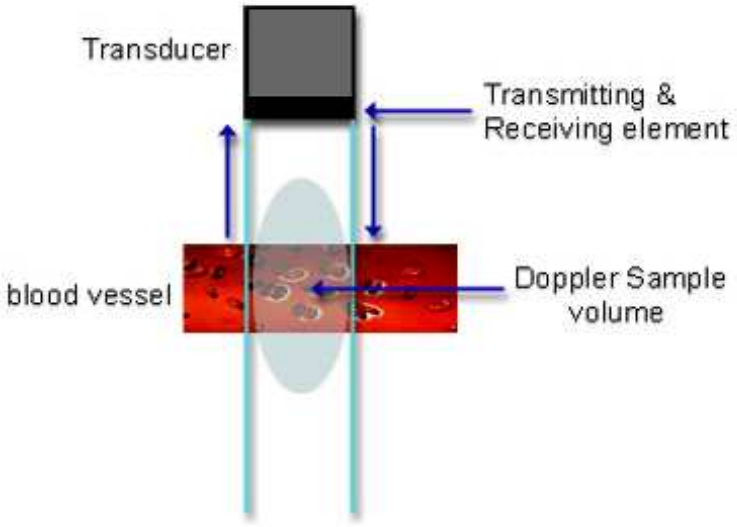


Figure 2-14 Pulsed-wave Doppler transducers

Doppler ultrasound in general and obstetric ultrasound scanners uses pulsed wave ultrasound. This allows measurement of the depth (or range) of the flow site. Additionally, the size of the sample volume (or range gate) can be changed. Pulsed wave ultrasound is used to provide data for Doppler sonograms and color flow images.(Powis et al. 1991)

2-8-10 Aliasing

Pulsed wave systems suffer from a fundamental limitation. When pulses are transmitted at a given sampling frequency (known as the pulse repetition frequency), the maximum Doppler frequency fd that can be measured unambiguously is half the pulse repetition frequency. If the blood velocity and beam/flow angle being measured combine to give a value greater than half of the pulse repetition frequency, ambiguity in the Doppler signal occurs. This ambiguity is

known as aliasing. A similar effect is seen in films where wagon wheels can appear to be going backwards due to the low frame rate of the film causing misinterpretation of the movement of the wheel spokes.

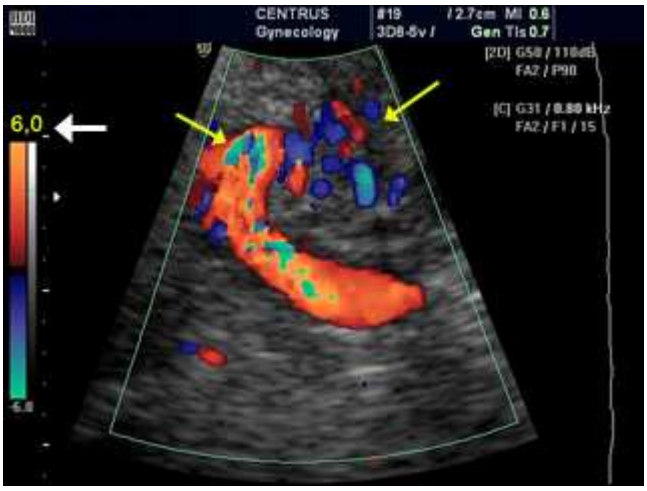


Figure 2-15: Aliasing of color Doppler imaging and artifacts of color. Color image

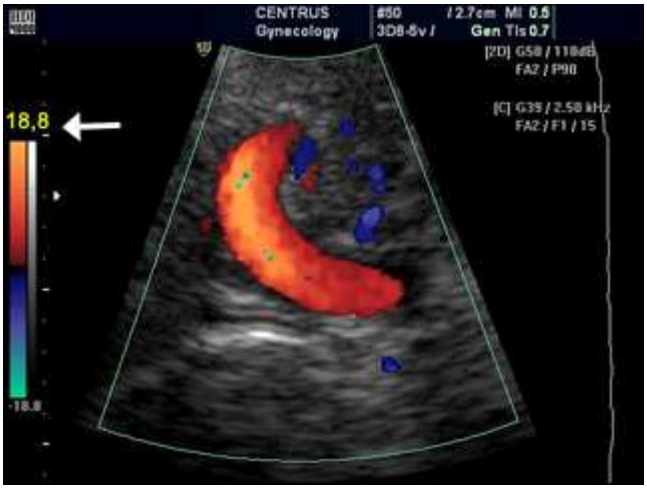


Figure 2-16: Reduce color gain and increase pulse repetition frequency. Shows regions of aliased flow (yellow arrows).

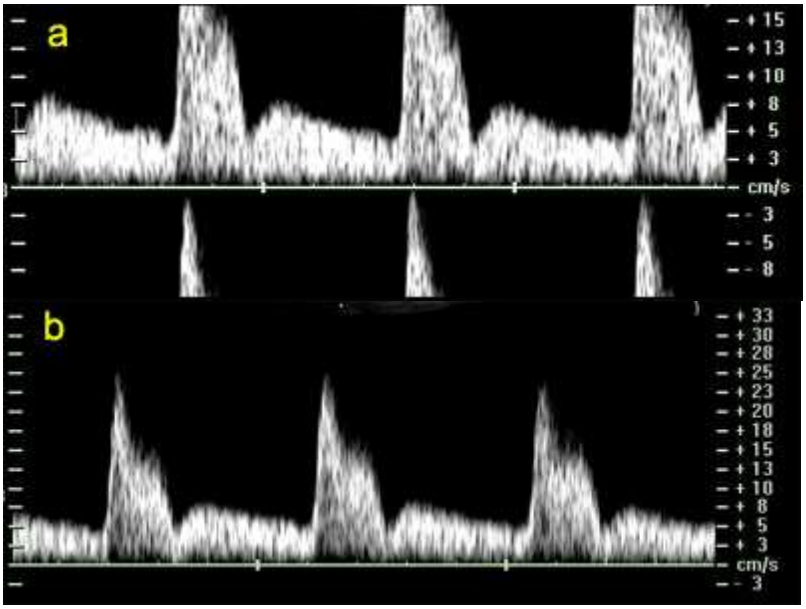


Figure 2-17 (a,b): Example of aliasing and correction of the aliasing. (a) Waveforms with aliasing, with abrupt termination of the peak systolic and display this peaks bellow the baseline Sonogram clear without aliasing. (b) Correction: increased the pulse repetition frequency and adjust baseline (move down)

The pulse repetition frequency is itself constrained by the range of the sample volume. The time interval between sampling pulses must be sufficient for a pulse to make the return journey from the transducer to the reflector and back. If a second pulse is sent before the first is received, the receiver cannot discriminate between the reflected signal from both pulses and ambiguity in the range of the sample volume ensues. As the depth of investigation increases, the journey time of the pulse to and from the reflector is increased, reducing the pulse repetition frequency for unambiguous ranging. The result is that the maximum fd measurable decreases with depth. Low pulse repetition frequencies are employed to examine low velocities (e.g. venous flow). The longer interval between pulses allows the scanner a better chance of identifying slow flow. Aliasing will occur if low pulse repetition frequencies or velocity scales are used and high velocities are encountered (Figure 2-17- a and 2-17-b**).** Conversely, if a high pulse repetition frequency is used to examine high velocities, low velocities may not be identified.(Gill et al. 1985).

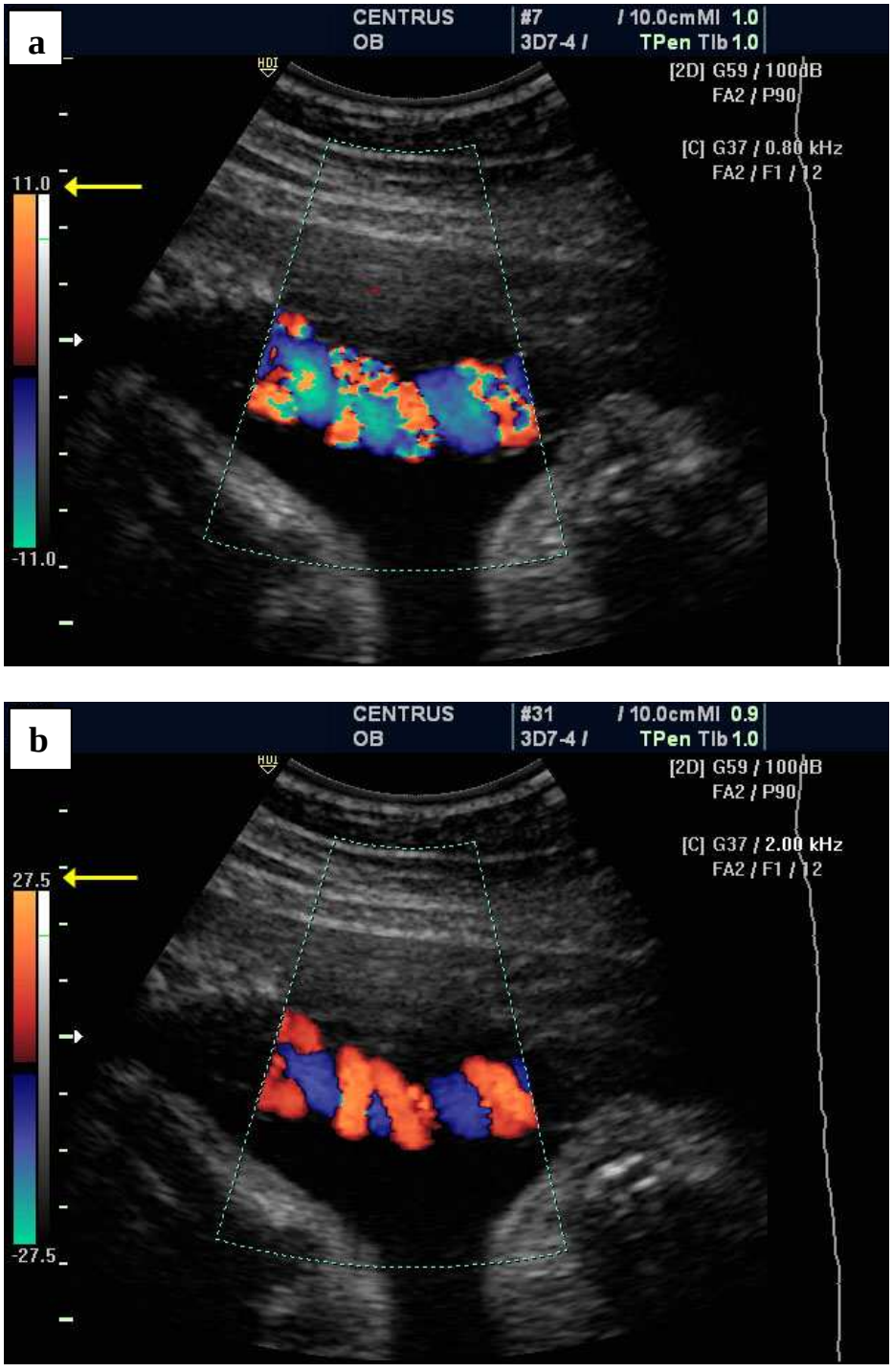


Figure 2-18 (A & B): Color flow imaging: effects of pulse repetition frequency or scale. (above) The pulse repetition frequency or scale is set low (yellow arrow). The color image shows ambiguity within the umbilical artery and vein and there is extraneous noise. (b) The pulse repetition frequency or scale is set appropriately for the flow velocities (bottom). The color image shows the arteries and vein clearly and unambiguously

2-8-11 Color ultrasound flow modes

Since color flow imaging provides a limited amount of information over a large region, and spectral Doppler provides more detailed information about a small region, the two modes are complementary and, in practice, are used as such. Color flow imaging can be used to identify vessels requiring examination, to identify the presence and direction of flow, to highlight gross circulation anomalies, throughout the entire color flow image, and to provide beam/vessel angle correction for velocity measurements. Pulsed wave Doppler is used to provide analysis of the flow at specific sites in the vessel under investigation. When using color flow imaging with pulsed wave Doppler, the color flow/B-mode image is frozen while the pulsed wave Doppler is activated. Recently, some manufacturers have produced concurrent color flow imaging and pulsed wave Doppler, sometimes referred to as *triplex* scanning. When these modes are used simultaneously, the performance of each is decreased. Because transducer elements are employed in three modes (B-mode, color flow and pulsed wave Doppler), the frame rate is decreased, the color flow box is reduced in size and the available pulse repetition frequency is reduced, leading to increased susceptibility to aliasing.
Power Doppler is also referred to as energy Doppler, amplitude Doppler and Doppler angiography. The magnitude of the color flow output is displayed rather than the Doppler frequency signal. Power Doppler does not display flow direction or different velocities. It is often used in conjunction with frame averaging to increase sensitivity to low flows and velocities. It complements the other two modes. Hybrid color flow modes incorporating power and velocity data are also available from some manufacturers. These can also have improved sensitivity to low flow. A brief summary of factors influencing the displays in each mode is given in the following sections. Most of these factors are set up approximately for a particular mode when the application (e.g. fetal scan) is chosen, although the operator will usually alter many of the controls during the scan to optimize the image.(Thompson, 1986 and Gill et al,1985)

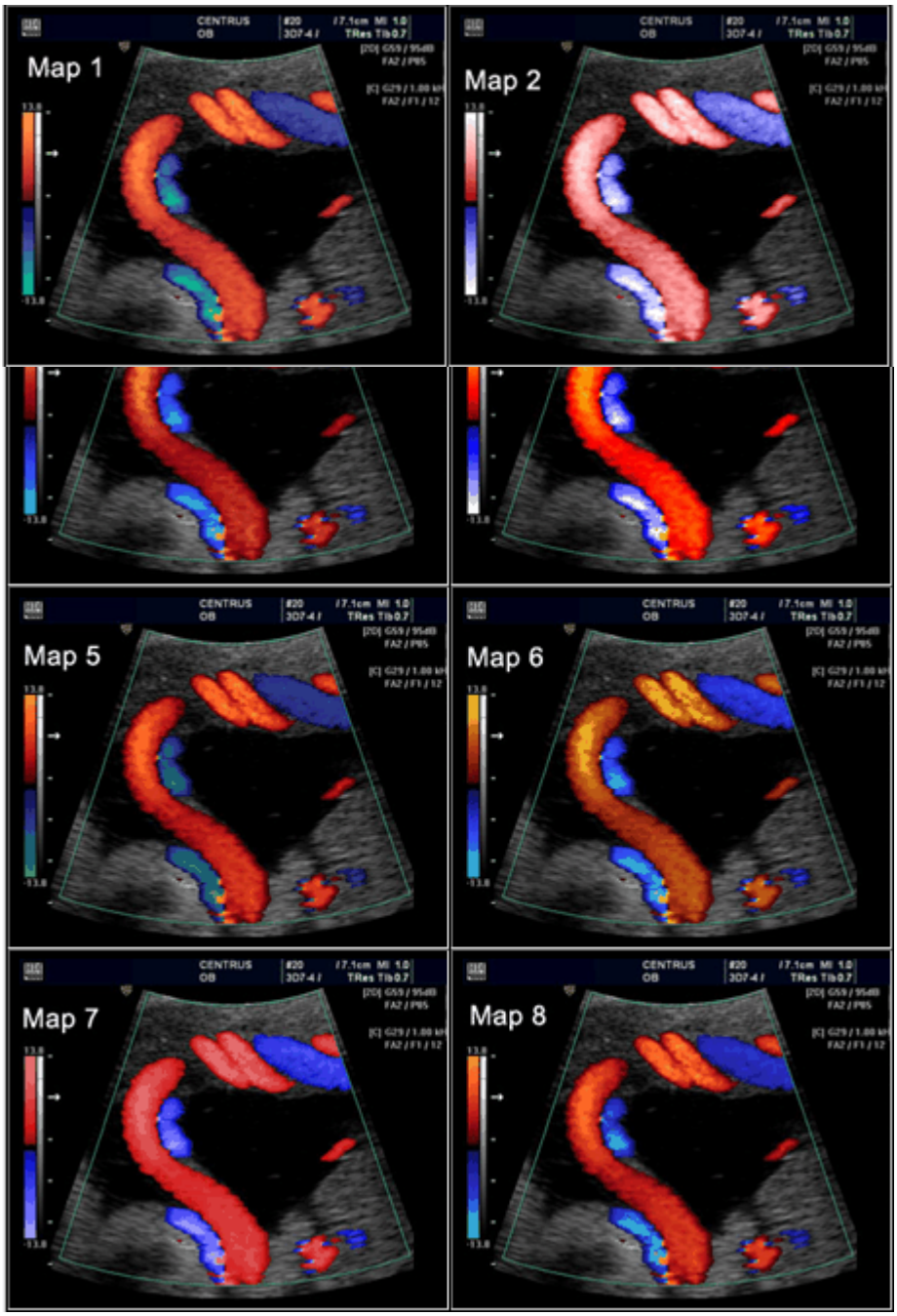


Figure 2-19 Color flow maps (directional)

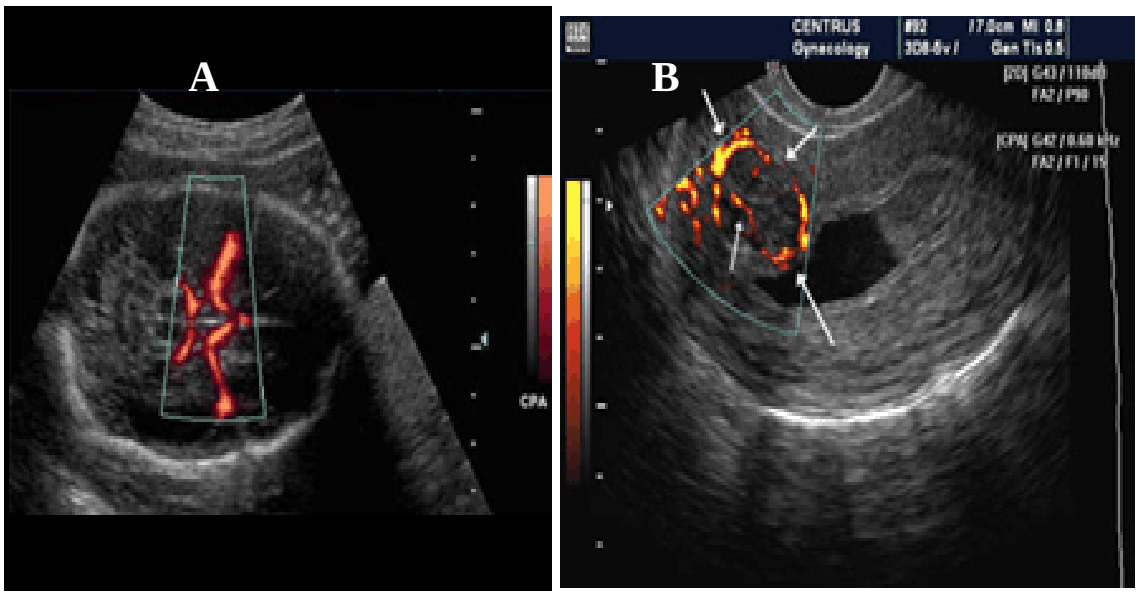


Figure 2-20 (A) Color Power Angio of the Circle of Willis, B Color Power Angio of a submucosus fibroid, note the small vessels inside the tumor

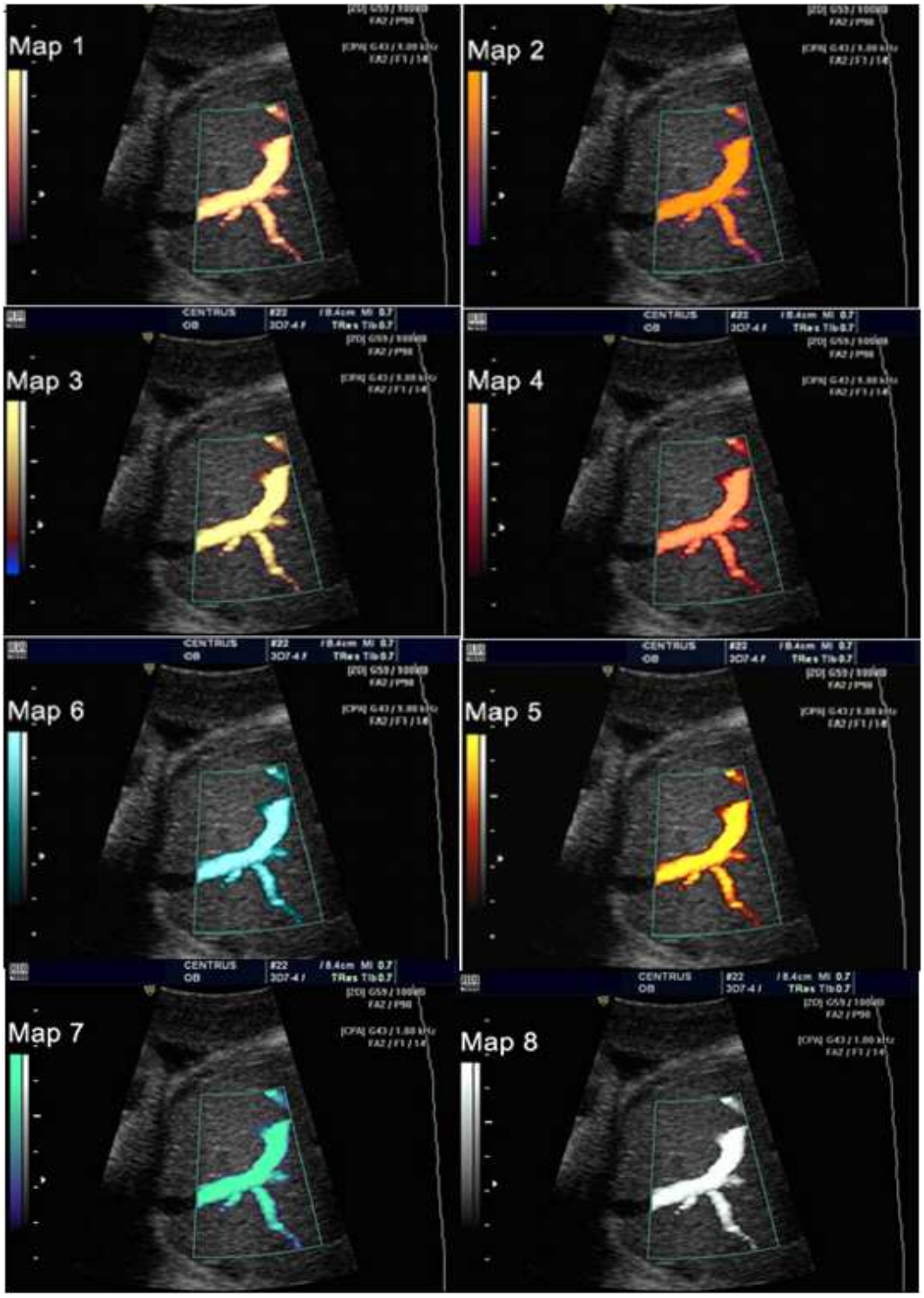


Figure 2-21 Color power energy Doppler (amplitude flow

2-8-12 Color flow imaging

Color flow Doppler ultrasound produces a color-coded map of Doppler shifts superimposed onto a B-mode ultrasound image (**Color Flow Maps**). Although color flow imaging uses pulsed wave ultrasound, its processing differs from that used to provide the Doppler sonogram. Color flow imaging may have to produce several thousand color points of flow information for each frame superimposed on the B-mode image. Color flow imaging uses fewer, shorter pulses along each color scan line of the image to give a mean frequency shift and a variance at each small area of measurement. This frequency shift is displayed as a color pixel. The scanner then repeats this for several lines to build up the color image, which is superimposed onto the B-mode image. The transducer elements are switched rapidly between B-mode and color flow imaging to give an impression of a combined simultaneous image. The pulses used for color flow imaging are typically three to four times longer than those for the B-mode image, with a corresponding loss of axial resolution. Assignment of color to frequency shifts is usually based on direction (for example, red for Doppler shifts towards the ultrasound beam and blue for shifts away from it) and magnitude (different color hues or lighter saturation for higher frequency shifts). The color Doppler image is dependent on general Doppler factors, particularly the need for a good beam/flow angle. Curvilinear and phased array transducers have a radiating pattern of ultrasound beams that can produce complex color flow images, depending on the orientation of the arteries and veins. In practice, the experienced operator alters the scanning approach to obtain good insonation angles so as to achieve unambiguous flow images.(Goldberg, 1997) .

2-8-13 Factors affecting color flow image

Power: transmitted power into tissue

Gain: overall sensitivity to flow signalsFrequency: trades penetration for sensitivity and resolution .Pulse repetition frequency (also called scale): low pulse repetition frequency to look at low velocities, high pulse repetition frequency reduces aliasing Area of investigation: larger area reduces frame rate .Focus: colour flow image optimized at focal zone

2-8-14 other factors

Triplex color: pulse repetition frequency and frame rate reduced by need for B-mode/spectral pulses Persistence: high persistence produces smoother image but reduces temporal resolution Pre-processing: trades resolution against frame rate Filter: high filter cuts out more noise but also more of flow signal Post-processing assigns color map/variance Settings appropriate for specific examinations assigned by set-up/application keys

Figure 2-22 : Setting the color gain to minimize the signals (artifacts) from surrounding tissue, on left color gain = 71, then on right decreasing the color gain to 35.

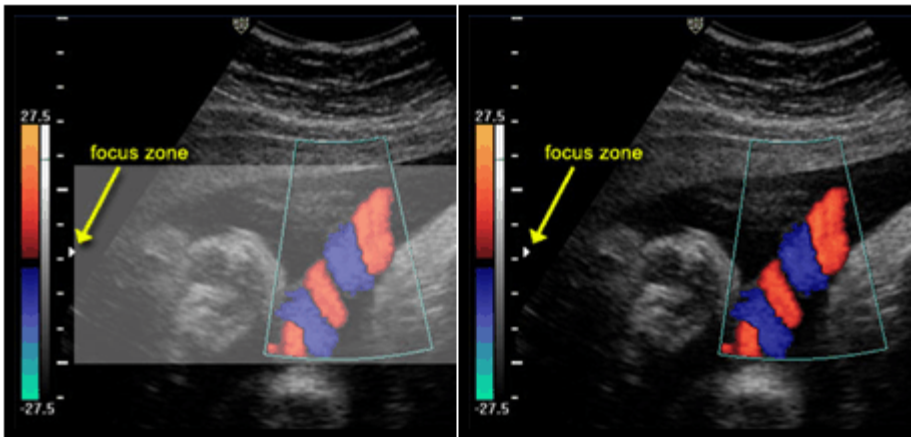


Figure 2-23: Set the focus at the region of interest, and also could use more than one focal zone

In practice, the operator will make many changes to the controls and will try different probe positions to optimize the image.. (Rourkec, et al. 1992)

2-8-15 Color flow imaging: practical guidelines

Select the appropriate applications/set-up key. This optimizes parameters for specific examinations

Set power to within fetal study limits. Adjust color gain. Ensure focus is at the region of interest and adjust gain to optimize color signal

Use probe positioning/beam steering to obtain satisfactory beam/vessel angle

Adjust pulse repetition frequency/scale to suit the flow conditions. Low pulse repetition frequencies are more sensitive to low flows/velocities but may produce aliasing. High pulse repetition frequencies reduce aliasing but are less sensitive to low velocities. Set the color flow region to appropriate size. A smaller color flow ‘box’ may lead to a better frame rate and better color resolution/sensitivity (Powis et al. 1991)

2-8-16 Spectral or pulsed wave Doppler

Pulsed wave Doppler ultrasound is used to provide a sonogram of the artery or vein under investigation (Figure 25). The sonogram provides a measure of the changing velocity throughout the cardiac cycle and the distribution of velocities in the sample volume (or gate) (Figure 24). If an accurate angle correction is made, then absolute velocities can be measured. The best resolution of the sonogram occurs when the B-mode image and color image are frozen, allowing all the time to be employed for spectral Doppler. If concurrent imaging is used (real-time duplex or triplex imaging), the temporal resolution of the sonogram is compromised **(**Rourke, et al. 1992).

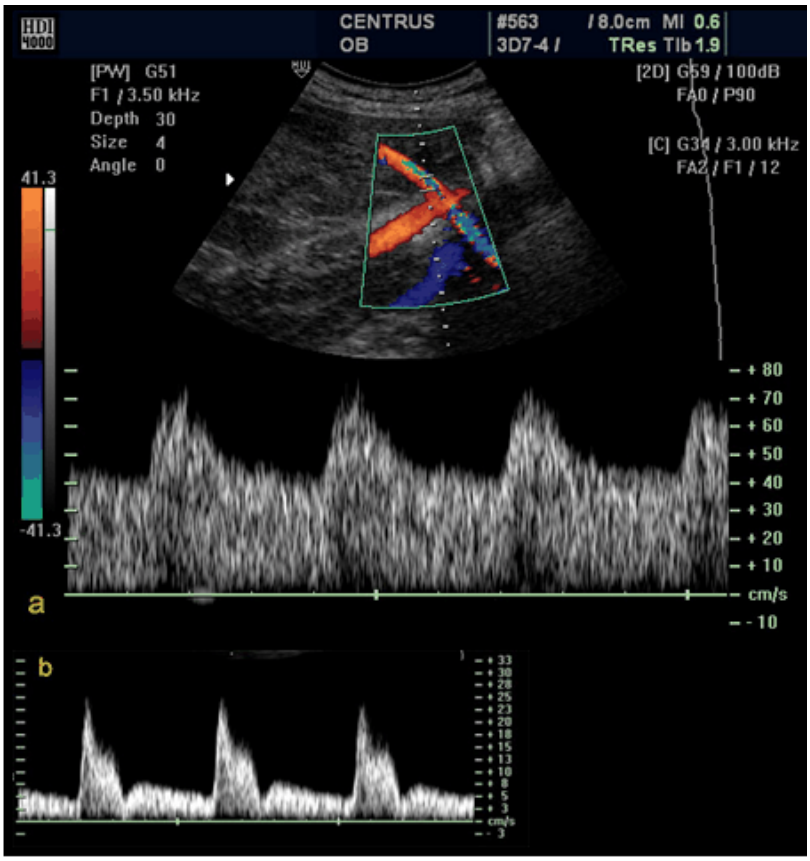


Figure 2-24 (a,b): Doppler spectra of uterine artery flow. (a) The color flow image allows beam/flow angle visualization. The sonogram shows high velocities throughout the cardiac cycle, indicating low distal resistance. (b) The sonogram shows a pulsatile flow waveform with low diastolic velocities. This is indicative of high distal resistance

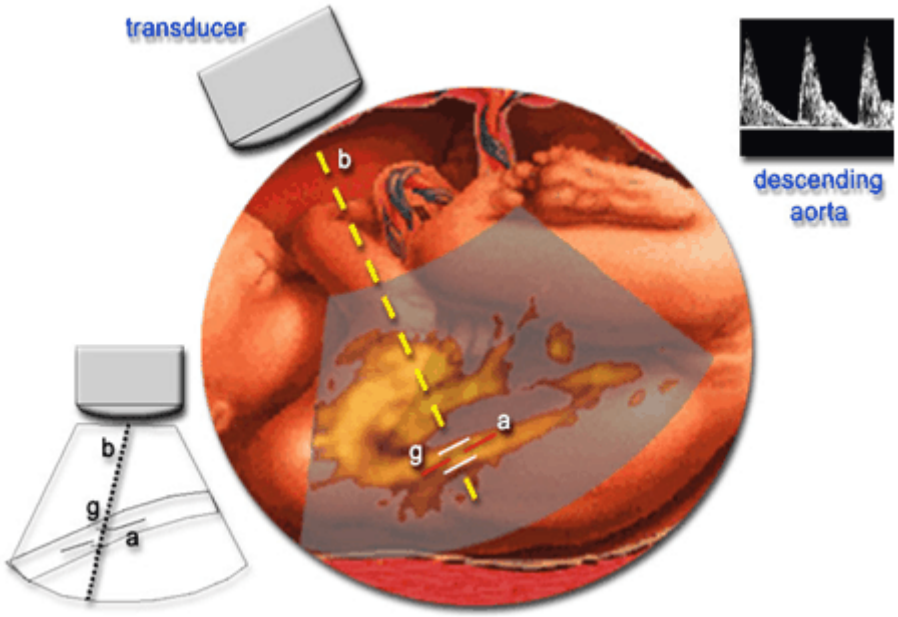


Figure 2-25: Sonogram of the descending aorta with the angle correction the peak velocities could be measured. Where setting up the sample volume shows at lower left, (a) - angle correction, (b) - direction of the Doppler beam and (g) - gate or sample volume,

The controls that affect the appearance of the sonogram are summarized in. The main factors include:

Power and gain: Pulsed wave Doppler uses higher intensity power than B-mode. Attention should be paid to safety indices. Power and gain should be set so that clear signals are obtained.

Velocity scale/pulse repetition frequency: Low pulse repetition frequencies should be used to look at low velocities but aliasing may occur if high velocities are encountered.

2-8-17 Factors affecting the spectral image

*Gate **size:*** If flow measurements are being attempted, the whole vessel should be insonates. A large gate may include signals from adjacent vessels

Power: transmitted power into tissue

Gain: overall sensitivity to flow signals

Pulse repetition frequency (also called scale): low pulse repetition frequency to look at low velocities, high pulse repetition frequency reduces aliasing

Gate size

Beam steering can allow improved beam/flow angle for better accuracy of velocity

calculation

Filter: high filter cuts out more noise but more of flow signal

Post-processing: assigns brightness to output

Live duplex/triplex spectral resolution constrained by need for B-mode/colour pulses

Settings appropriate for specific examinations assigned by set-up/application keys (Thompson, 1986).

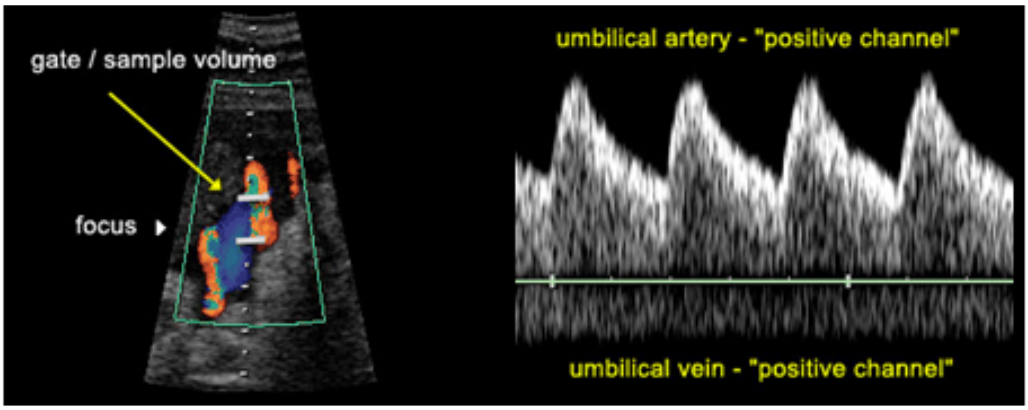


Figure 2-26: Umbilical cord displaying umbilical artery (red) and umbilical vein (blue), the gate or sample volume include both signals (left). Sonogram of the umbilical artery and vein (right).

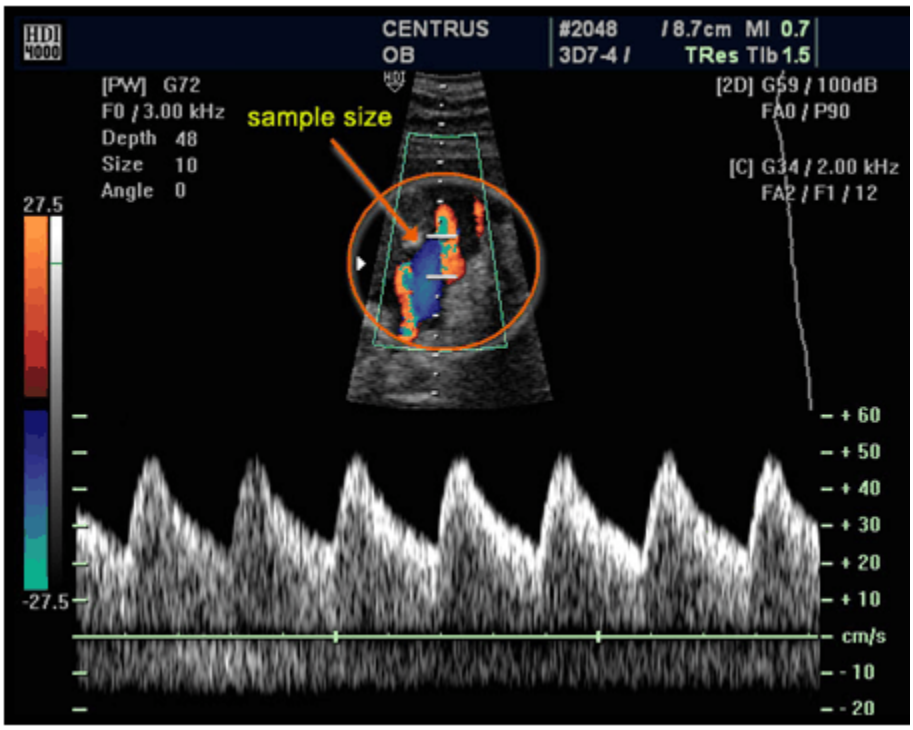


Figure 2-27 Influence of gate size. The spectral Doppler gate insonates an artery and vein and the sonogram shows flow from both of these vessels. The calculation of mean velocity (arrow) is meaningless since velocities from one vessel subtract from those of the other

2-8-18 Other factors

Set power to within fetal study limits

Position the pulsed wave Doppler cursor on the vessel to be investigated

Adjust gain so that the sonogram is clearly visible and free of noise

Use probe positioning/beam steering to obtain a satisfactory beam/vessel angle. Angles close to 90° will give ambiguous/unclear values. The beam/vessel angle should be 60° or less if velocity measurements are to be made

Adjust the pulse repetition frequency/scale and baseline to suit flow conditions. The sonogram should be clear and not aliased

Set the sample volume to correct size. Correct the angle to obtain accurate velocities. Use the B-mode and color flow image of the vessel to make the angle correction.

,

2- 8-19 Blood Flow measurement

2-8-20 Velocity measurement

, once the beam/flow angle is known, velocities can be calculated from the Doppler spectrum as shown in the Doppler equation. However, errors in the measured velocity may still occur. Sources of error can be broadly divided into three categories

Errors can arise in the formation of the Doppler spectrum due to:

Use of multiple elements in array transducers;

Non-uniform insonation of the vessel lumen;

Insonation of more than one vessel;

Use of filters removing low-velocity components.

Errors can arise in the measurement of the ultrasound beam/flow velocity angle.

Use of high angles (q > 60o) may give rise to error because of the comparatively large changes in the cosine of the angle which occur with small changes of angle (Figure 26).

The velocity vector may not be in the direction of the vessel axis.

Errors can arise in the calculation packages provided by the manufacturers for analysis of the Doppler spectrum (for instance, of intensity weighted mean velocity).

While efforts can be made to minimize errors, the operator should be aware of their likely range. It is good practice to try to repeat velocity measurements, if possible using a different beam approach, to gain a feel for the variability of measurements in a particular application. However, even repeated measurements may not reveal systematic errors occurring in a particular machine. The effort applied to produce accurate velocity measurements should be balanced against the importance of absolute velocity measurements for an investigationChanges in velocity and velocity waveform shape are often of more clinical relevance when making a diagnosis. In this and other cases, absolute values of velocity measurement may not be required.

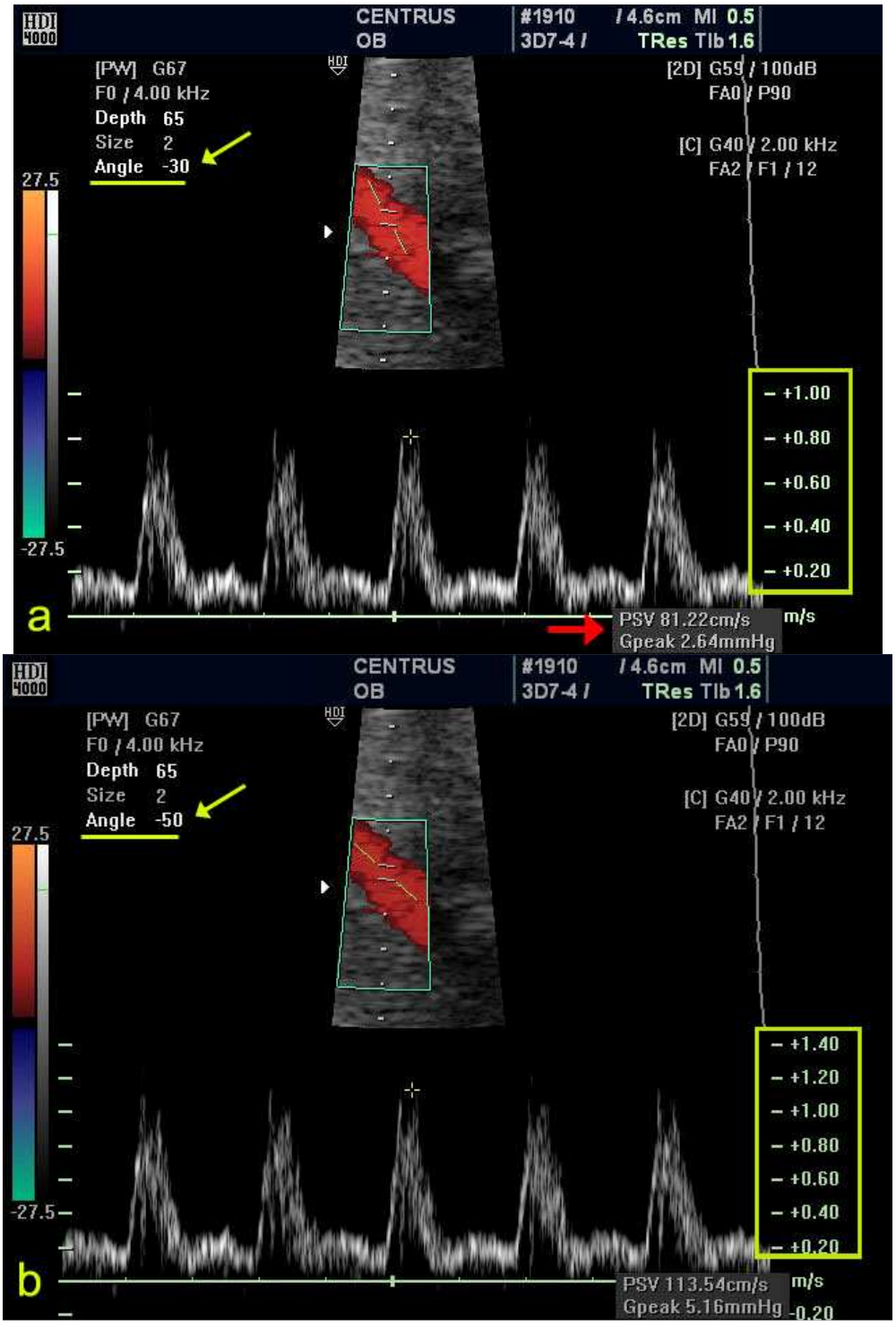


Figure 2-28: Effect of high vessel/beam angles. (a) and (b) A scan of fetal aortic flow is undertaken at a high beam/vessel angle. Beam/flow angles should be kept to 60° or less. A hudge discrepancy is observed when use inappropriate angles > 60°. If absolute velocities are to be measured , beam/flow angles should be kept to 60° or less

Total flow measurement using color or duplex Doppler ultrasound is fraught with difficulties, even under ideal conditions [5]. Errors that may arise include:

Those due to inaccurate measurement of vessel cross-sectional area, for example the cross-sectional area of arteries which pulsate during the cardiac cycle;

2-8-21 Calculation of absolute flow

Those originating in the derivation of velocity These errors become particularly large when flow calculations are made in small vessels; errors in measurement of diameter are magnified when the diameter is used to derive cross-sectional area. As with velocity measurements, it is prudent to be aware of possible errors and to conduct repeatability tests Non-dimensional analysis of the flow waveform shape and spectrum has proved to be a useful technique in the investigation of many vascular beds. It has the advantage that derived indices are independent of the beam/flow angle.

2-8-22 Flow waveform analysis

Changes in flow waveform shape have been used to investigate both proximal disease (e.g. in the adult peripheral arterial circulation) and distal changes (in the fetal circulation and uterine arteries). While the breadth of possible uses shows the technique to be versatile, it also serves as a reminder of the range of factors which cause changes to the local Doppler spectrum. If waveform analysis is to be used to observe changes in one component of the proximal or distal vasculature, consideration must be given to what effects other components may have on the waveform.(Thmpson et al. 1986).

2-8-23 Flow waveform shape: indices of measurement

Many different indices have been used to describe the shape of flow waveforms (Evans et al. 1989) (Techniques range from simple indices of systolic to diastolic flow to feature extraction methods such as principal component analysis. All are designed to describe the waveform in a quantitative way, usually as a guide to some kind of classification. In general, they are a compromise between simplicity and the amount of information obtained.

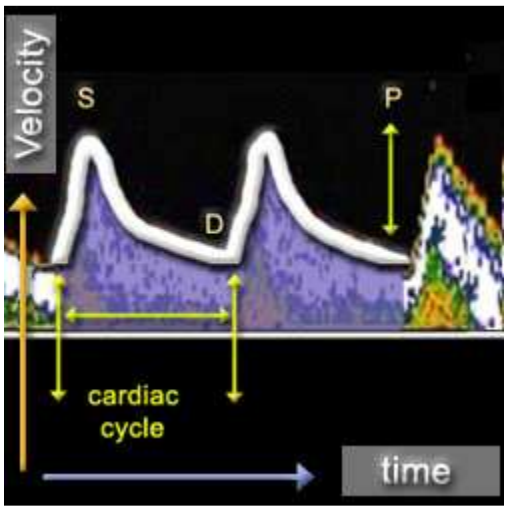


Figure 2-29: Arterial velocity sonogram (waveform).

(Thompson et al. 1986**).** Commonly used indices available on most commercial scanners are:

Resistance index (RI) (also called resistive index or Pourcelot's index);

Systolic/diastolic (S/D) ratio, sometimes called the A/B ratio;

Pulsatility index (PI) (Gosling et al. 1974).

These indices are all based on the maximum Doppler shift waveform and their calculation is described in Figure 12. The PI takes slightly longer to calculate than the RI or S/D ratio because of the need to measure the mean height of the waveform. It does, however, give a broader range of values, for instance in describing a range of waveform shapes when there is no end-diastolic flow.

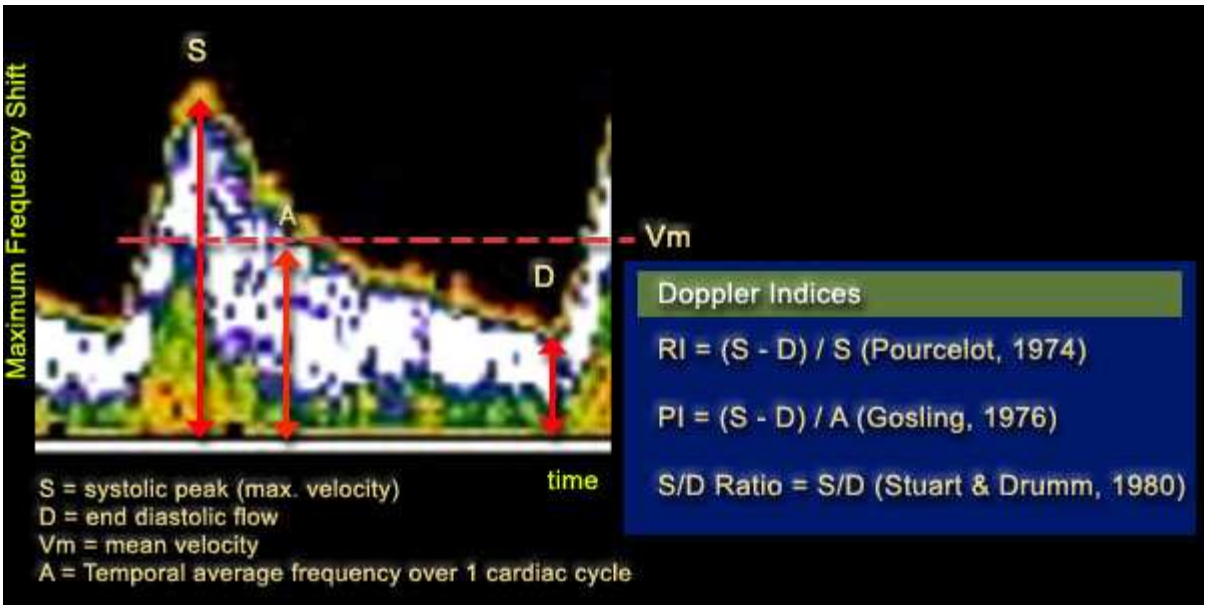


Figure 2-30- Flow velocity indices

In addition to these indices, the flow waveform may be described or categorized by the presence or absence of a particular feature, for example the absence of end-diastolic flow and the presence of a post-systolic notch. Generally, a low pulsatility waveform is indicative of low distal resistance and high pulsatility waveforms occur in high-resistance vascular beds (Figure 28), although the presence of proximal stenosis, vascular steal or arteriovenous fistulas can modify waveform shape. Care should be taken when trying to interpret indices as absolute measurements of either upstream or downstream factors. For example, alterations in heart rate can alter the flow waveform shape and cause significant changes in the value of indices.

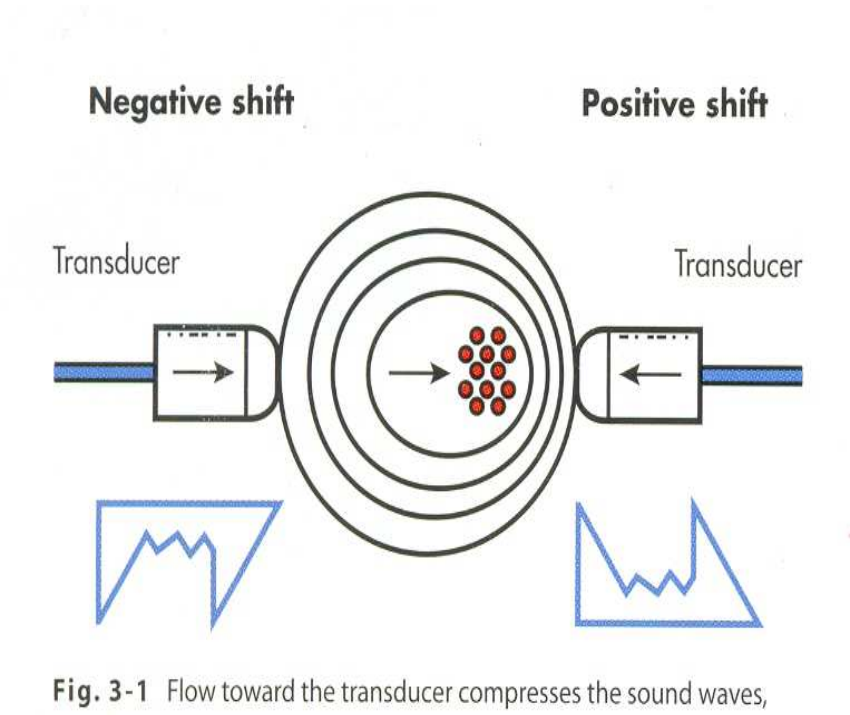


Fig. 3-1 Flow toward the transducer compresses the sound waves,

Figure 2-31 Flow toward the transducer compress the sound waves.

2-8-24 Characteristics of flow in vessels

-Parabolic or laminar flow

Blood cells move faster at the center of the blood vessel, and velocity drops to zero at vessel wall.

-Blunt flow.

In large blood vessels such as the aorta, the flow may take on a more blunt profile.

-Disturbed flow.

A turbulent flow pattern caused by a blockage or narrowing.

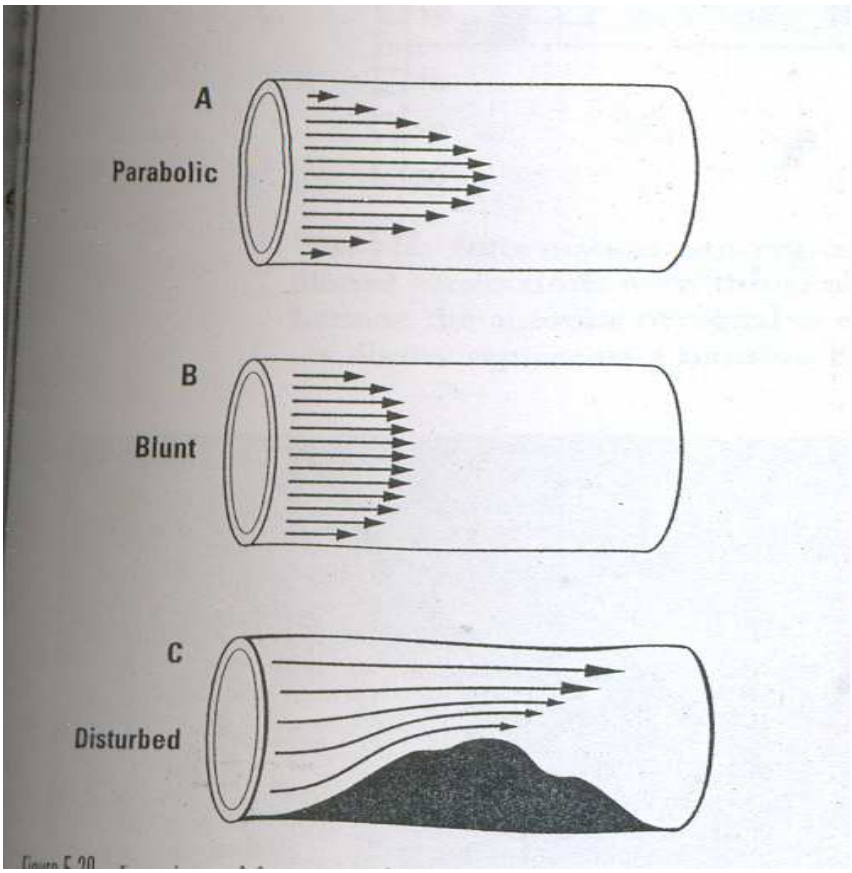


Figure 2-32 Doppler frequency spectrum

2-8-25 Doppler frequency spectrum

It is sometimes called power spectrum.

The Doppler frequencies at each point in time is represented by the brightness of the pixels.

The powerful of the shift and the brightness is proportional to the number of the moving blood cells.

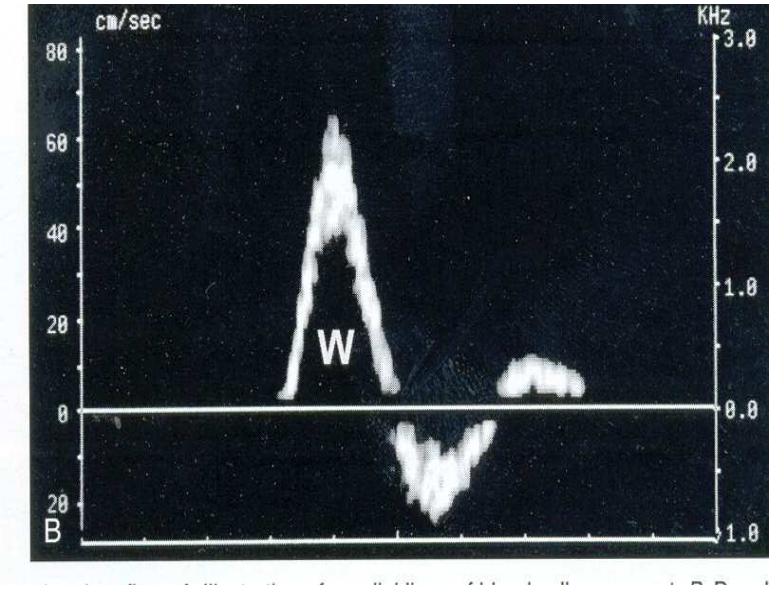


Figure 2-33 uterine sample volume

2-8-26 the sample volume uterine artery

-Specific volume selected from the moving blood stream.

-The Doppler spectrum represents information from the selected volume only.

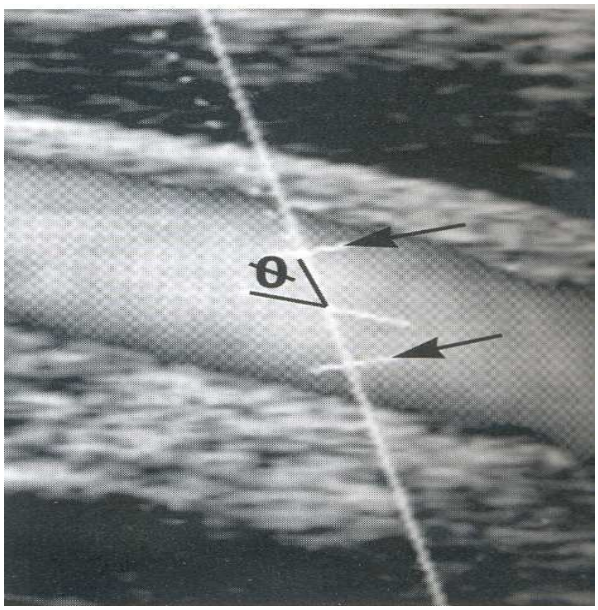


Figure 2-34 Doppler spectral analysis

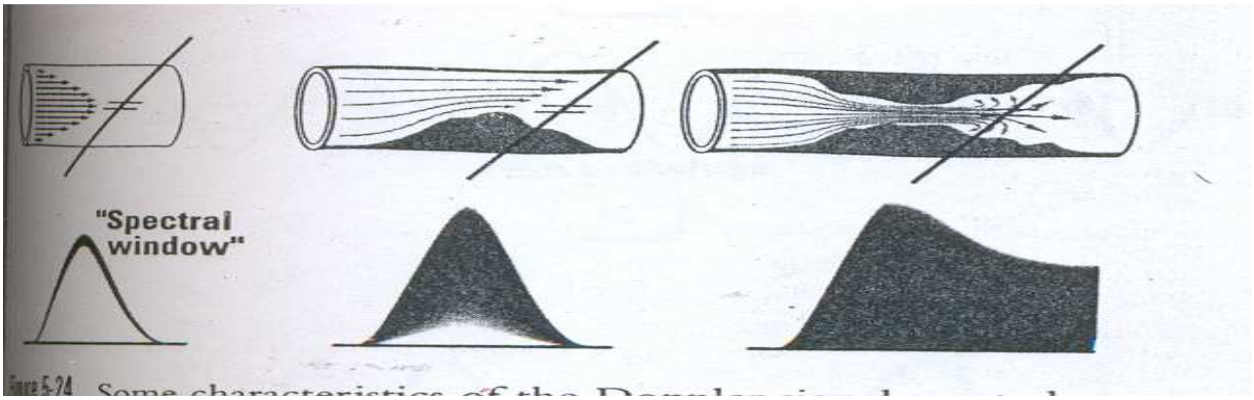


Figure 2-35 spectral analysis flow

2-8-27 Disturbed flow

- Disturbed flow pattern

- Minor flow disturbance which shows *spectral broadening at peak systole and through* diastole.

-moderate flow disturbance causes *fill-in of the spectral window.*

-Severe flow disturbance causes *fill-in of the window, forward and revered flow.*

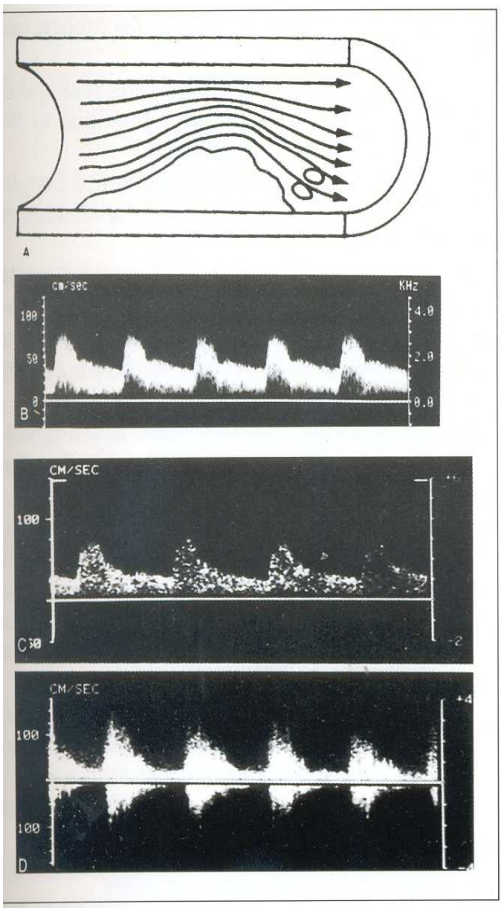


Figure 2-36 Intrastenotic and poststenotic flow changes

2-8-28 intrastenotic and poststenotic flow changes*:*

-Prestenotic wave spectrum in the CCA.

-Intrastenotic spectrum –it shows a marked elevation of the flow velocity.

-Poststenotic spectrum shows filling in the systolic window.

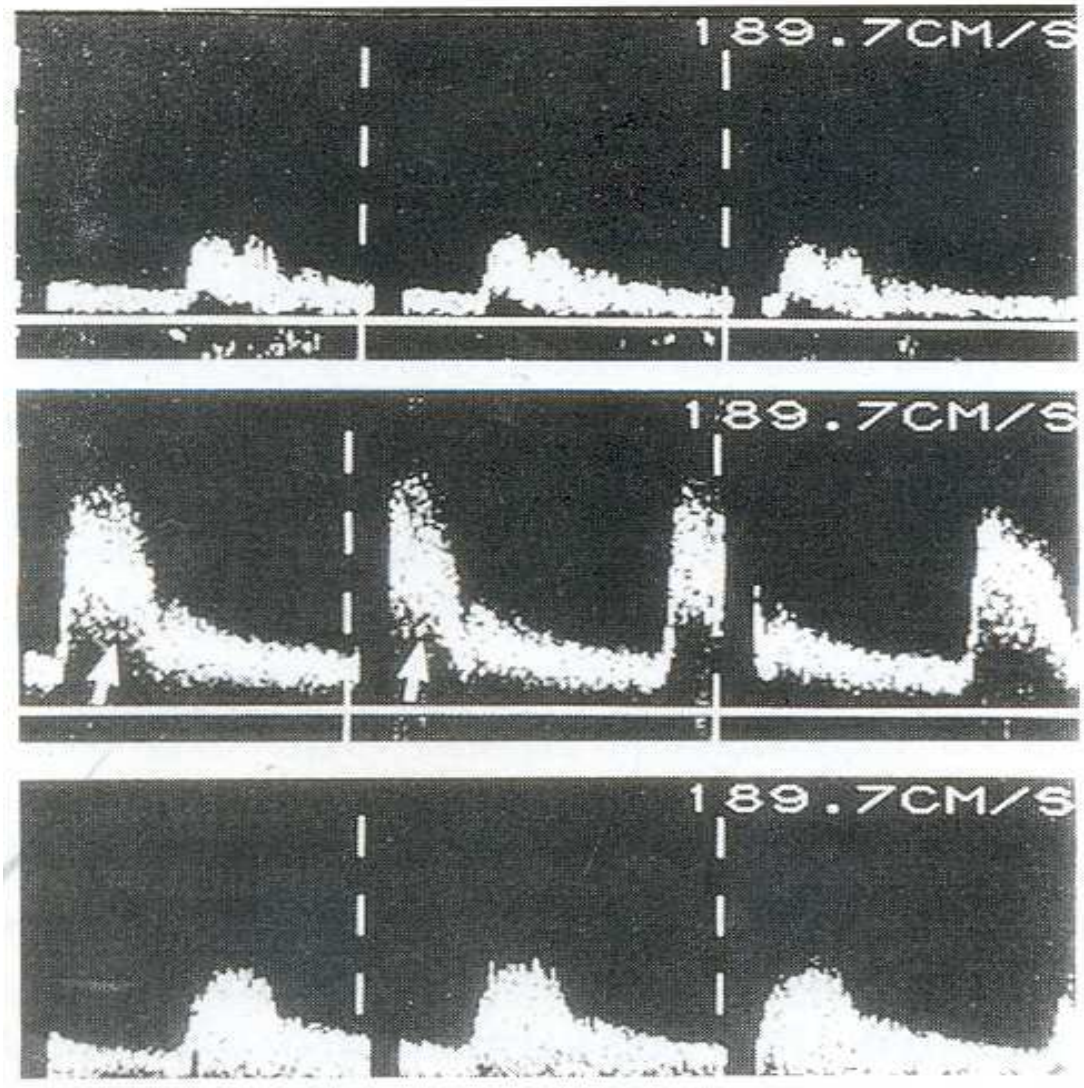


Figure 2-37 Color Flow imaging and the power Doppler imaging

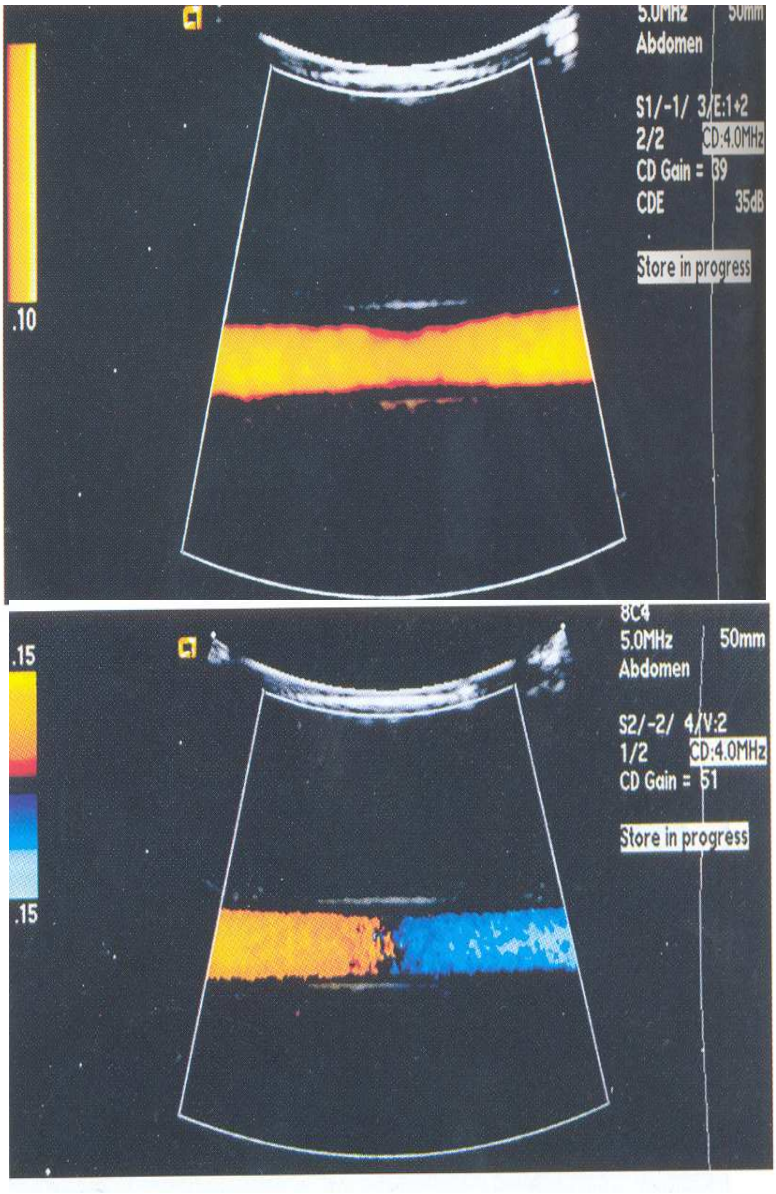


Figure 2-38 Color flow imaging and power Doppler imaging

2-8-29 the effect of the insonation angle

CDI shows turbulence, aliasing and wall thickening.

The same vessel on power Doppler, it shows wall thickening without turbulence and aliasing

2-8-30 Waveform and pulsatility

Low pulsatility (*Monophasic)*-

Broad systolic and forward diastole

Moderate pulsatility (Monophasic)-

sharp and tall systole with forward diastole

-High pulsatility (*triphasic*)

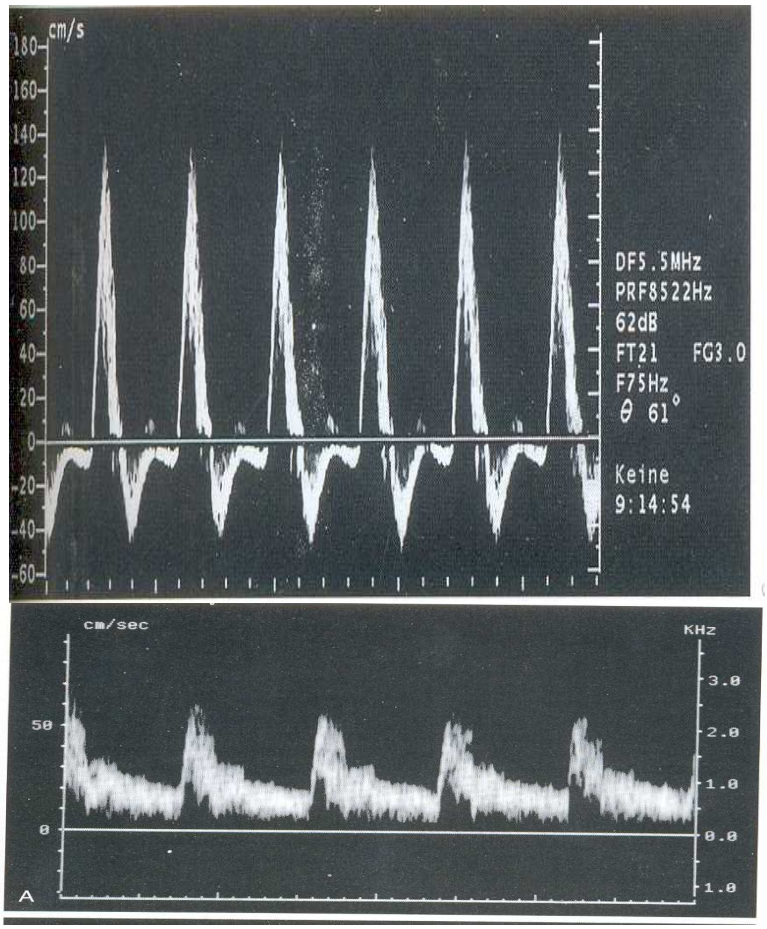


Figure 2-39a tall and sharp systole with reversed diastole

Figure 2-40 vaginal ultrasound probes

2-8-31 Vaginal ultrasound probe (TVP);

Optimal ultrasound imaging of the female pelvic organs is difficult to achieve .this is due to the pelvis being(crowded) with various structures of similar acoustic impedance (which are therefore ,poor reflectors) .The distance from the abdominal probe to these organs is relatively large precluding the use of frequencies higher than. 5MHz.Endo-vaginal sonography has recently emerged as a promising new method for evaluating the pelvis. Advantages of endovaginal sonography include avoidance of subcutaneous fat, optimal placement of the region of interest in the focal zone of the transducer, and the ability to scan when the urinary bladder is empty (Schemer and Lebovic, 1984 and 1985). Indications to use transvaginal sonography include (Demianczuk et al. 2003) .To identify the location and the number of gestational sacs.

To determine whether an early pregnancy has a normal appearance or whether sonographic indicators are present that predict failure.To evaluate maternal symptoms such as pain or bleeding.to evaluate uterine contents before pregnancy termination. To guide diagnostic, therapeutic procedures that requires visual guidance (Chorionic villous sampling and amniocentesis) .To screen for fetal complications and congenital anomalies.

2-9 Doppler ultrasound in investigation of uterine and ovarian blood flow

Uterine blood flow is an important factor contributing to uterine receptivity **(**Goswamy et al. 1988**)** which can be studied by means of TV pulsed and color Doppler ultrasound (Tekay, 1995 and Tekay et al. 1995 The predictive role of Doppler velocimetry has been based on the difference in mean uterine (Sterzik et al. 1989, Stromer et al 1991, Stteer et al. 1992-1995) or ovarian artery pulsatility (pi) or resistance index (Ri) values between the conception and non-conception cycles patients who had become pregnant showed a lower vascular impedance than those who had not .\The seminal article on use of Doppler ultrasound in infertility was that of Goswamy and Steptoe (1988). Those authors were the first to suggest that abnormal uterine artery blood flow might be associated with infertility, and to develop a classification of uterine artery blood flow waveforms. They related specific abnormal waveforms with repeated failure of implantation in in-vitro fertilization (IVF) patients and successfully improved uterine circulation and implantation by use of therapeutic doses of estrogen (Goswamy et al. 1988). Ovarian blood flow to unexplained infertility and to successful implantation following IVF (Sterzik et al. 1989, Steer et al. 1992, Favre et al., 1993; Balkier and Stronell, 1994; Coulam et al., 1994; Serafini et al., 1994; Tekay et al., 1995a; Cacciatore et al., 1996; Zaidi et al., 1996a,c).

Velocity waveform analysis Goswamy and Steptoe (1988) developed a highly valuable classification of flow velocity waveforms for use in non-pregnant patients In their classification, the term type C was used for waveforms in which diastolic flow was continuous with systolic flow and present through the cardiac cycle (Figure 41). Type A was used to designate waveforms in which the diastolic component was present in Doppler ultrasound study of uterine and ovarian blood flow (Figure 41.) Waveform type C. Uterine flow velocity waveform showing high systolic flow and diastolic wave extending to the next cardiac cycle. This indicates good uterine perfusion. Reprinted with permission from Goswamy and Steptoe (1988).(Figure 41) Waveform type A. Uterine flow velocity waveform showing high systolic flow and absence of early diastolic flow. This indicates poor uterine perfusion

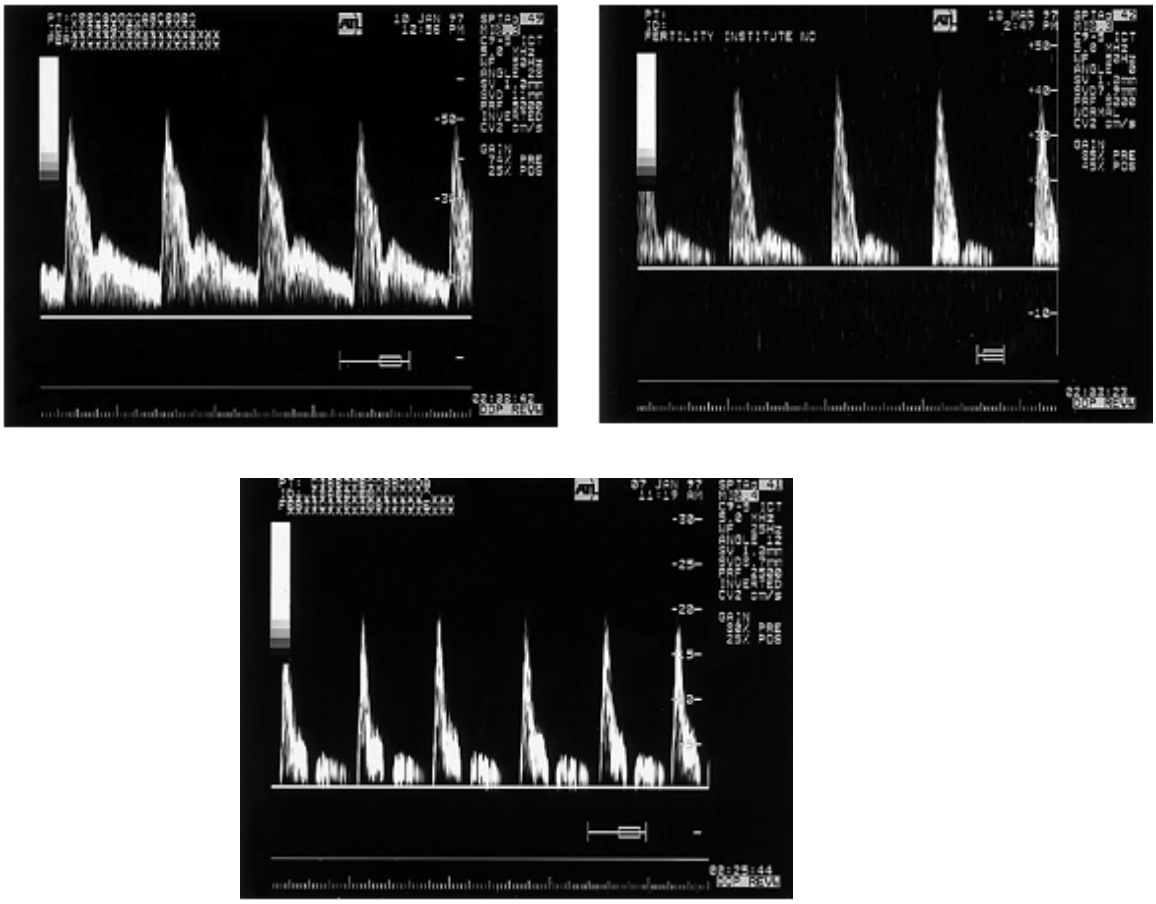


Figure 2-41 .ultrasound flow velocity waveform of uterine artery a-b-c

Type (C) Show high systolic flow and diastolic wave extending to the next cardiac cycle this indicates good uterine perfusionType(B) uterine flow velocity waveform showing diastolic wave continuous with systole but not extending to the next cardiac cycle; this indicates good uterine perfusion Type (A)uterine flow velocity waveform showing high systolic flow and absence of early diastolic flow this indicates poor uterine perfusion reprinted with permission from Goswamy and Steptoe (1988

2-9-1 Resistance index (RI) .

This index, also known as Pourcelot's ratio (Pourcelot, 1974), examines the difference between the peak systolic and end diastolic velocity and is expressed by:

RI = (S – D)/S

where S is the peak systolic velocity and D is the minimum or end diastolic velocity. The RI is suitable for low resistance vascular beds with continuous flow throughout diastole. If the end diastole value (D) goes to zero, the ratio converges to 1.

2-9-2 Pulsatility index (PI)

This index, also known as the mean pulsatility index to distinguish it from the peak to peak pulsatility index, is Expressed by: PI = (S – D)/velocity

where S is the peak systolic velocity, D is the end diastolic velocity and velocity is the time averaged maximum velocity over the cardiac cycle (Gosling et al., 1971).

Velocity is calculated from the average of three or four cardiac cycles. No correction for heart rate is required (Gosling et al. 1991), because it does not go to 1.0 if early or end diastolic flow goes to 0, the PI is often used for vessels where flow is absent during all or part of diastole. In a comment made 20 years after first describing the PI, Gosling stated, 'When blood flow sonograms are studied just proximal to a vascular bed of low impedance, it is likely that small changes in something itself already small will make little difference to the waveform shape, which will mostly be affected by changes in pressure drop across the vascular bed and not the impedance per se (Gosling et al. 1991). The PI is not as accurate as RI because of the variability inherent in measurement of mean velocity with present day software programs**.** Trudinger (1991) states, 'In determining the PI, it is most unlikely that the true mean velocity can be calculated entirely accurately.

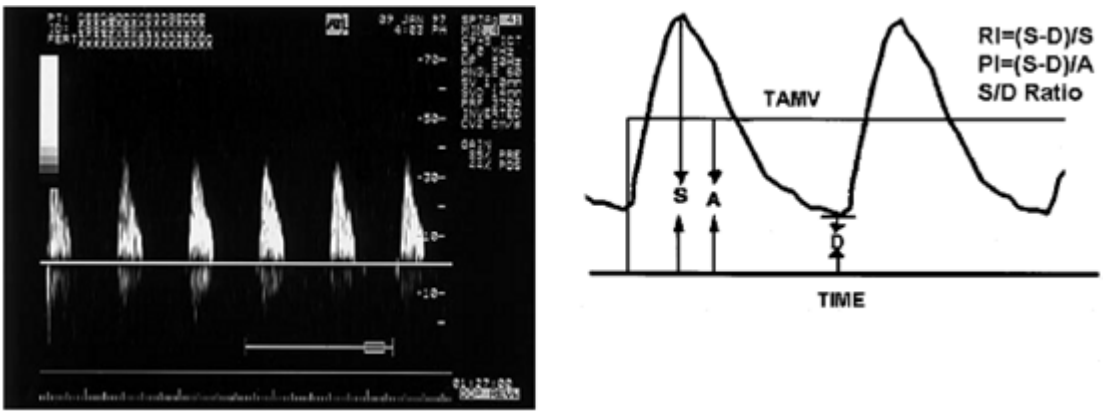


Figure 2-42 Wave form type of uterine artery velocity

Type (0)Uterine flow velocity waveform showing absence of any diastolic flow this indicates very high impedance Reprinted with permission from Goswamy and Steptoe(1988)

2-9-3 Systolic/diastolic ratio (S/D)

The systolic/diastolic ratio is the simplest of all indices and is expressed by S/D, where S is the peak systolic frequency and D is the end diastolic frequency. It is less frequently used, now that the PI and RI can be readily calculated by built-in software programs. Errors in the S/D ratio increase as diastolic velocity becomes small**.** (Spencer et al. (1991), using an in-vitro flow model, found that when flow was reduced in a stepwise fashion, PI and RI increased in linear fashion, whereas the S/D ratio increased exponentially.

2-9-4 Blood flow volume and velocity.

By far the most direct way to describe blood flow is to report blood flow volume or average velocity. Flow volume or average velocity plus a resistance index or waveforms (when diastolic flow is not continuous) are necessary to analyze uterine blood flow satisfactorily. Flow volume and mean velocity describe the actual volume or velocity of blood utilized by an organ, while resistance indices and waveforms indicate the state of smaller vessels downstream from the vessel being analyzed.

2-9-5 Sourcs of error in measurement uterine artery

All blood flow measurements, whether they are of the uterus and ovary or the aorta and carotid artery, are subject to many potential sources of error. Certainly, the most important source in the uterus and ovary is the operator's judgments in selecting the vessel to be examined and the particular part of the vessel on which to focus the Doppler. Selection of the particular waveform or waveforms to analyze, out of the many available, is an equally important operator decision. It must be decided whether to select ones with the highest peak systolic or diastolic velocity, least velocity, or an 'average example'. Doppler blood flow studies of the uterus and umbilical circulation have been published which use each of these choices. Doppler ultrasound operators may cause errors in PI and RI if they mistake brief gaps in diastolic flow as absence in diastolic flow. Analysis of flow volume or resistance indices in a single uterine artery, instead of both arteries, can lead to a false interpretation of uterine blood flow because of the considerable cross circulation in the uterus. Analysis of the relationship between uterine artery flow volume or RI and spiral artery waveforms or RI show that spiral artery blood flow is not affected by a marked decrease of flow in a single uterine artery, but is affected by lesser decreases in flow in both uterine arteries (Dickey et al., 1994). Variability found for vessel diameter ($r = 0.94$) the best correlation between operators was for RI ($r = 0.97$). assessed intra-observer Relationship of flow volume and resistance indices to waveforms The relationship of uterine artery waveforms to a modification of RI and S/D ratio was initially reported by Goswamy and Steptoe (1988). More recently, the relationship of ascending uterine artery and spiral artery waveforms to uterine artery flow volume, PI and RI was investigated by Dickey et

al. (1994 Uterine artery flow volume was significantly lower and PI was significantly higher when waveforms were not continuous.

The effects of Doppler ultrasound on embryonic and fetal development are not known with certainty. Bio effects of Doppler ultrasound are related to the spatial peak time average intensity (ISPTA) and duration of exposure. The American Institute of Ultrasound in Medicine (1993) has recommended that Doppler ultrasound during early pregnancy be limited to500 s (8.3 min) at an ISPTA <94 mW/cm2.

2-9-6 uterine blood flow in the normal cycle

Ultrasound measurements of uterine artery and ovarian artery blood flow were initially described by (Taylor et al. (1985) using Duplex ultrasound with an abdominal transducer.(Goswamy and Steptoe(1988) improved on previous methods by using an offset abdominal Doppler transducer to plot uterine artery waveforms and their own modification of RI and S/D ratios in the mid-proliferative to pre-menstrual phase of the menstrual cycle. They found waveforms were continuous in most multiparous patients throughout the cycle, except for

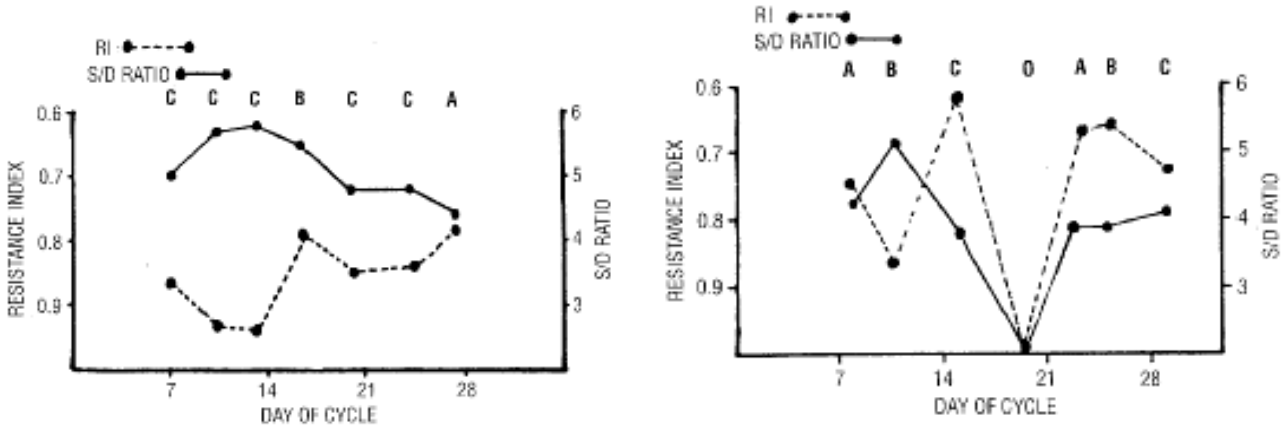


Figure (2-43)Uterine artery wave form (S/D ,RI) in nulliparas during the menstrual cycle (a)

few days immediately after ovulation and during menstruation (Figure 41-a), but were only continuous in multiparous patients immediately before ovulation (Figure41-b). In multiparous, RI fell with the rise in estrogen concentrations during the early follicular phase, then rose along with a post-ovulatory fall in estrogen concentrations. A second decrease in RI occurred along with rising estrogen and progesterone concentrations during the mid-luteal phase of the cycle. In nulliparas, RI was markedly different, especially on days 14 and 21. This difference may have been due to the fact that waveforms were not continuous in nulliparas on most days, or due to Figure 6. Uterine artery waveform type, S/D (systolic/diastolic) ratio and resistance index (RI) in a multiparous subject during the menstrual cycle. Goswamy and Steptoe (1988). Uterine artery waveform type, S/D (systolic/diastolic) ratio and resistance index (RI) in a multiparous subject during the menstrual cycle. Real differences in vascular development and blood flow following completion of a full-term pregnancy. Two Important principles may be derived from this seminal study: (i) normal uterine blood flow values must be obtained from patients with known fertility and ability to carry to term, and (ii) normal values can only be obtained from studies in which flow is continuous throughout the cardiac cycle. Although Goswamy and Steptoe (1988) established the pattern for blood flow in normal cycles and the relationship of blood flow to hormone concentrations, their modified RI and S/D values cannot be easily translated to standard values. Also, results with transvaginal ultrasound could be different from those obtained with abdominal ultrasound. (Dickey 1994) Doppler ultrasound measurement of uterine blood flow holds the promise of being as helpful for investigation of infertility and early pregnancy loss as Doppler analysis of uterine and umbilical blood flow has been in the second and third trimesters of pregnancy. This promise has not yet been fulfilled, in part due to the difficulty of interpreting blood flow measurements performed during the

menstrual cycle and early pregnancy when diastolic blood flow is often not continuous in uterine and spiral arteries. Lack of fulfillment is also due, in part, to the fact that most studies have measured only downstream impedance, which is critical in the second and third trimesters, but may not be as Doppler ultrasound study of uterine and ovarian blood flow important in infertility and early pregnancy, and to the fact that studies have been performed only in the recumbent position.

Despite these limitations, the majority of studies agree that implantation cannot occur when the mean (right and left) uterine artery PI is 3.0–4.0 or diastolic flow is not continuous in at least one artery on the days of HCG administration, oocyte retrieval, or embryo transfer in IVF and donor embryo cycles. Investigation of ovarian blood flow has also proven disappointing, not allowing the predetermination of which follicles will produce oocyte capable of fertilization and implantation, but it may soon help our understanding of luteal insufficiency and the cause of poor oocyte quality in polycystic ovaries. Even more intriguing is the possibility that ovarian blood flow studies may link intrafollicular hypoxia to errors of non disjunction during meiosis. Early pregnancy, in so far as uterine blood flow is concerned, can be divided into two periods, i.e. before and after the onset of maternal intervillous circulation, which begins, according to the most recent authorities, between the 10th and 12th gestational weeks. Notable changes occur during the 10th to 12th weeks in uterine artery RI, PI, mean velocity and flow volume. The 10th week coincides with the end of embryological development, according to classical embryology studies. Uterine blood flow during the earlier period is most like that in the mid to late follicular phase of non-pregnant fertile women, while uterine blood flow in the later period is more like that of the second or third trimester of pregnancy. It is interesting to speculate that deficient uterine blood flow in the earlier period may lead to infertility and abortion, just as

deficient blood flow in the later period can lead to intrauterine growth retardation in the baby and to hypertension in the mothers. Doppler ultrasound measurement of uterine and ovarian blood flow is a relatively new technique. Its role in clinical medicine has still to be established for infertility and early pregnancy. As more investigations are performed, as clinicians become familiar with its use, and as instrumentation is improved, it may yet prove to be an indispensable tool for clinical investigation of disorders of oocyte development, implantation and early pregnancy failure may present with vaginal bleeding or abdominal pain.

Table 2-2 Embryology of Early Pregnancy

Period of development	Weeks	Features
Pre-and preiovlation	1-2	Ovarian follicle matures Ovulation
Conceptus	3-5	Corpus luteum Fertilization Morula Blastocyst
Embryonic	6-10	Trilaminar (1at)embryo C-shaped embryo ↓ Major organs develop Yolk sac detaches
Fetal	11-12	Fetal growth Amniotic& chorionic membranes Approach each other (fusion at 1 Weeks

(Adapted from Sohaey R Woodward P;Zweibel W J First-trimester ultrasound the essential semin Ultrasound CT ME 17;2-14,1996)

Table(3) Ultrasound –based terminology used in the diagnosis of miscarriage.

Diagnosis	Ultrasound appearance	Clinical presentation
Complete miscarriage	Endometrial thickness 15 amino evidence of RPOC	Cessation of vaginal Bleeding and pain
Incomplete miscarriage	Any endometrial thickness Tissue (+/- sac) distorting Midline endometrial echo	+/ _ bleeding & /or Abdominal pain
Delayed miscarriage 9previously an embryonic missed	Gestational sac diameter> 20 mm with no fetal pole or yolk sac (or .20 mm with no change 7 days apart)or fetal pole ,6 mm with no fetal heart activity (or 6mm with no change 7 days apart)	Minimal vaginal bleeding or pain ;loss of pregnancy symptoms

2-10 Role of transvaginal TV) sonography and Doppler in the diagnosis of retained products of conception (RPOC).

Early pregnancy loss is the commonest complication of pregnancy and represent a major clinical workload for the gynecologist .Surgical evaluation of uterus become the treatment of choice for this condition ,since its introduction into clinical practice

in the 1930s (Dunn et al1994). The incidence of RPOC after first trimester termination of the pregnancy (TOP) has been reported as 1-3% and the reduction of this relatively high incidence is a very worthwhile Goal (Crenine et al. 2001). RPOC may cause endometritis, which in turn may associate with intrauterine adhesions and impairment of future fertility (Salvo et al. 2003)

Color Doppler features of the uterus of practical value for the management of RPOC but the absence of blood flow does not exclude the diagnosis of it (Schwarzker et al. 1999) and

(Durfee et al. 2005.

2-11 Evaluation of uterine artery blood flow for RPL(previous studies)

Uterine perfusion appears to regulate uterine receptivity. However, vascular changes in recurrent pregnancy loss (RPL) remain poorly studied One hundred and twenty-one women were enrolled into this study by normal women with sterility caused by male factor (control group: $n = 72$) and women with RPL ($n = 49$). Women with uterine anomaly, impaired glucose tolerance, abnormal thyroid function, or anti-phospholipids antibodies were excluded from the study. In the mid-luteal phase of a non-pregnant cycle, transvaginal pulsed Doppler ultrasonography of the uterine artery was performed. Uterine arterial pulsatility index (PI), endometrial thickness, serum estradiol, progesterone, and nitrite/nitrate concentrations were determined. In the RPL group, the PI in the uterine artery of women with antinuclear antibodies was significantly higher than that of women without antinuclear antibodies ($P < 0.05$). Among women without antinuclear antibodies, the mean (±SD) uterine artery PI in the RPL group (2.44 ± 0.41) was also significantly higher than in the control group (2.19 ± 0.40; $P < 0.01$). The PI was inversely correlated with serum progesterone levels ($r = -0.47$, $P < 0.01$). Elevated uterine arterial impedance is associated with RPL. Pulsed Doppler ultrasonography is useful in identifying women with unexplained RPL who have impaired uterine circulation. The major arterial blood supply to the uterus is derived from the uterine arteries. Therefore, we considered that measurement of uterine artery pulsatility index in the midluteal phase of spontaneous cycles might isolate patients with recurrent pregnancy loss associated with impaired uterine circulation (Habra et al. 2002).

Nakatsuka et al (2003) evaluated uterine perfusion, which regulates uterine receptivity in women with recurrent pregnancy loss**..**He evaluated the blood flow resistance in the uterine arteries of 104 pregnant women at 4 to 5 weeks' gestation by transvaginal pulsed Doppler ultrasonography (control group, n = 52; and recurrent pregnancy loss group, n = 52). Blood tests for antinuclear and antiphospholipid antibodies were also performed**.** The uterine arterial

pulsatility index in the recurrent pregnancy loss group was significantly higher than that in the control group. Women with antinuclear or antiphospholipid antibodies had an elevated pulsatility index in the uterine artery, which is prominent in women with recurrent pregnancy loss. Coagulopathy and vascular dysfunction caused by auto antibodies may impair uterine perfusion. However, the uterine arterial pulsatility index in the recurrent pregnancy loss group was significantly higher than that in the control group even among women without antinuclear antibodies or among women without antiphospholipid antibodies. This observation strongly suggests that the uterine artery pulsatility index may be an independent index for recurrent pregnancy loss. The introduction of pulsed Doppler ultrasonography has provided the means for noninvasive evaluation of uterine impedance and may identify patients with recurrent pregnancy loss associated with impaired uterine perfusion. that ,the uterine arterial pulsatility index in the recurrent pregnancy loss group was significantly Higher than that in the control group women with antinuclear or antipholipid antibodies had an elevated pulsatility index in the uterine artery which is prominent in women with recurrent pregnancy loss, Coagulopathy and vascular dysfunction caused by auto antibodies may impair uterine perfusion .

Vascular changes in the uterine artery of women with recurrent pregnancy loss (RPL) have not been thoroughly studied**.** Frates et al (1996) have reported that the resistance index in the uterine artery at 6 to 13 weeks' gestation does not allow prediction of pregnancy outcome in patients with RPL. He had reported that uterine arterial blood flow resistance of women with unexplained RPL is significantly higher than that of control women in the midluteal phase of a nonpregnant cycle.

Goswamy and Steptoe (1988) compared uterine artery pulsatility index (PI) and flow velocity wave (FVW) patterns between women with no history of abortion and women with recurrent pregnancy loss of unexplained cause. A cross-sectional study was conducted with 43 women with recurrent pregnancy loss and 43 women with no history of abortion and at least 1 child born at term (control group). Transvaginal ultrasonography with uterine artery Doppler evaluation was performed in the second phase of the menstrual cycle to calculate the PI and analyze the FVW pattern. The women with recurrent pregnancy loss had a significantly higher uterine artery PI than those in the control group (2.71±0.54 and 2.30±0.44, respectively), as well as a higher incidence of FVWs of the A and B types. Compared with the control group, a

higher PI and a higher incidence of FVW of the A and B types—and thus higher uterine artery impedance were found among women with recurrent pregnancy loss.

Pellizzari et al. (2002) compared uterine artery blood flow in normal first-trimester pregnancies with those complicated by uterine bleeding. Uterine artery blood flow was investigated by transvaginal color Doppler in 46 pregnant women affected by uterine bleeding and in a control group of 35 women with normal intrauterine pregnancy. Gestational age ranged from the 6th to the 12th week. Three blood flow values were calculated, the pulsatility index, the resistance index and the peak systolic velocity. Results were compared between the two groups. Results of the 46 patients affected by uterine bleeding had an incomplete miscarriage, eight had a blighted ovum, five had a missed miscarriage and 15 continued their pregnancy until term and delivered live born infants. No significant differences were found in any of the three vascular indices between the normal and the pathological groups of patients. Uterine artery pulsatility and resistance indices decreased with gestational age in both normal and abnormal pregnancies but this change was not statistically significant. The peak systolic velocity significantly increased with gestational age in the control group but not in the pathological group. In patients with a retro placental hematoma, uterine vascular resistance appeared higher than in those without a hematoma, while the peak systolic velocity showed no difference between the two groups. Doppler analysis of the uterine artery blood flow is unlikely to have a clinical role in the management of early pregnancies complicated by uterine bleeding. An increase in maternal cardiac output, are necessary for fetal development and growth. A part from providing useful information on the physiology of the uteroplacental circulation, pulsed and color Doppler has become a useful tool for monitoring fetal wellbeing in the second and third trimesters of pregnancy. It is now well established that complications of pregnancy such as preeclampsia, hypertension and intrauterine growth restriction are associated with important vascular alterations of the uterine and placental blood flows which can be easily detected by Doppler analysis. The uteroplacental circulation is the result of the invasion of the trophoblastic tissue of the uterine spiral arteries, which occurs in two different phases. The first vascular invasion occurs from the 5th week of pregnancy and is followed by a second invasion in the 14th week. These changes lead to a progressive decrease in the resistance to flow in uterine vessels and to an increase in blood flow directed to the pregnant uterus. Some investigators have proposed

studying the uteroplacental circulation in early pregnancy to determine if alterations of the early vascular events could influence pregnancy course and outcome This study set out to investigate uterine artery blood flow by transvaginal pulsed and color Doppler to determine if first-trimester pregnancies complicated by uterine bleeding have different blood flow patterns in comparison with normal pregnancies. In such cases, Doppler analysis of the uterine arteries would be of clinical value in the management of early pregnancies complicated by uterine bleeding.

The value of transvaginal B-mode ultrasonography combined with color velocity imaging and pulsed Doppler to detect retained trophoblastic tissue was evaluated prospectively in a series of 40 patients with postpartum (n = 15) or post abortion (n = 25) bleeding. Color velocity imaging was used to identify color-coded blood flow signals within myometrium and/or endometrium. Flow was subjectively quantified as absent, scanty or abundant. Pulsed Doppler was used to assess blood flow impedance by calculating the resistance index. The presence of abundant flow with a lowest resistance index of less than 0.45 was considered as suspicious of residual trophoblastic tissue. Twenty-two (55%) out of the 40 patients underwent dilatation and curettage and chorionic villi were demonstrated in 15 of these. Eighteen (45%) patients were managed conservatively. None of these patients suffered complications or needed readmission for curettage, and all of them were considered as not having retained tissue. On color pulsed Doppler ultrasound examination, 15 patients had suspected retained tissue; all of these underwent curettage and residual trophblasts was found in 14 (93.3%). Out of 25 patients considered as having no residual tissue on color pulsed Doppler ultrasound examination, seven underwent curettage and chorionic villi were found in one patient (false-negative rate 6.7%) All patients managed conservatively had an unsuspicious scan. We concluded that vaginal ultrasonography combined with color velocity imaging and pulsed Doppler could be useful to detect retained trophoblastic tissue and to select patients suitable for conservative management (Alcaer et al. 1998).

Cross-sectional study comprising 117 consecutive first trimester singleton pregnancies was performed using transvaginal sonography (TVS) to evaluate size abnormalities of the secondary yolk sac (YS) vis-à-vis pregnancy outcome. In normal pregnancy outcome (NPO) the YS diameter showed an increase from the 5th to the 11th week, menstrual age, followed by

a decrease and its disappearance after 12 weeks. A YS of abnormal size was statistically significant ($p < 0.001$) versus NPO, with a sensitivity of 68.7%, a specificity of 99%, a positive predictive value of 91.6% and a negative predictive value of 95.2%. These preliminary results indicate that a measurement of the YS very early in gestation may be a useful marker of pregnancy 7-utcome (Stampone et al. 1996).

Prospective study of women recruited by radio and poster appeal and from hospital outpatient clinics. English provincial community. 630 Women from the general population intending to become pregnant. The viability of the pregnancy was assessed by abdominal ultrasonography before completion of the eighth week, and the assessment was repeated if vaginal bleeding occurred. Spontaneous abortion or live births in women with or without a previous history of spontaneous abortion. The overall incidence of clinically recognizable spontaneous abortion before 20 weeks of gestation was 12% (50/407 pregnancies). The risk of spontaneous abortion in each category of patient was classified with respect to the patient's past reproductive performance and found to be influenced greatly by her previous obstetric history. In primigravidas and women with a history of consistently successful pregnancies the incidences of abortion were low (5% (4/87) and 4% (3/73) respectively), whereas women with only unsuccessful histories had a much greater risk of aborting the study pregnancy (24% (24/98)), even when their sole pregnancy had ended in abortion (20% (12/59)). The outcome of the last pregnancy also influenced the outcome of the study pregnancy; only 5% of women (5/95) whose previous pregnancy had been successful aborted, whereas the incidence of loss of pregnancy among women whose last pregnancy had aborted was 19% (40/214). Knowledge of the patient's reproductive history is essential for the clinical assessment of her risk of spontaneous abortion. As the most important predictive factor for spontaneous abortion is a previous abortion, the outcome of a woman's first pregnancy has profound consequences for all subsequent pregnancies (Regan et al 1989)

Dickey et al (1994) studied 97 patients from 5 to 12 weeks' pregnancy who conceived after infertility treatment in an attempt to find a correlation between embryonic growth and uterine circulation blood flow volume and impedance0.3 the volume was calculated from the product of cross-sectional vessel area (by averaging 4 measurements) times the average mean velocity

of 3 waveforms and adjusted for the angle of insonation. The authors found a significant inverse correlation between Gestational age length (GA) and both PI and RI values, but not with the blood volume, of the uterine arteries. They did not find any relationship with either PI or RI values of the spiral arteries. In the same study, The authors showed a significant correlation of CRL and diameter of the gestational sac with serum estradiol, but not with serum progesterone, levels. The correlation of CRL and diameter of the gestational sac was dependent on gestational age. In contrast to that, in a previous Jauniaux et al (2007) reported a positive correlation.Wong et al. (2002) This study was to assess the use of transvaginal sonography to detect retained products of conception after first-trimester spontaneous abortion. All women who arrived at our hospital with spontaneous first-trimester abortions were included in this study and underwent transvaginal sonography. A sonographic diagnosis of "incomplete abortion" was based on a bi- layer endometrial thickness of more than 8 mm. The final diagnosis of complete or incomplete abortion was based on the histopathology findings at dilatation and curettage. The sensitivity and specificity of both clinical and sonographic examinations for detecting products of conception were assessed. A total of 113 women were recruited, and 14 were excluded for various reasons. Among 52 women with a clinically incomplete abortion, only 50% had retained products of conception. The use of transvaginal sonography resulted in a 29% (15/52) reduction of surgical intervention in these women. On the other hand, 30% (14/47) of women with a clinical diagnosis of complete abortion had retained products of conception. The sensitivity and specificity of cervical status for detecting retained products of conception were 65% and 56%, respectively, whereas the overall sensitivity and specificity of transvaginal sonographic examination (bi-layer endometrial thickness 8 mm or less) were 100% and 80%, respectively. Transvaginal sonography is a useful supplement to clinical assessment in women who experience a spontaneous first-trimester abortion. If this modality is used to assess the uterine cavity, the cervical status can be ignored. Use of transvaginal sonography should reduce unnecessary general anesthesia and uterine curettage.

Sieroszewski et al (2001) they found that threatened abortion is one of the major problems in Obstetrics and applies to (1/3) of all pregnancies. The aim of this study was to establish normal ranges for Doppler indices of the flow velocity waveforms in uterine arteries (S/D, RI, PI) and ss-hCG serum concentrations in a control group in the first trimester of pregnancy. The

obtained values were compared with those obtained in pregnancies threatened by abortion (6 - 11 weeks). Investigated groups; 55 controls and 47 with symptoms of threatened abortion, 27 of them aborted. Ultrasound examinations were carried out by means of an endovaginal probe. Serum ss-hCG was determined by immunoenzymatic method. The standards for measured values were established based on means from measurements obtained in the control group in the corresponding week of pregnancy. They observed negative correlation between gestational age and RI and negative tendencies for S/D and PI indices in the control group. Positive correlation ($p < 0.05$) was found between ss-hCG serum concentration and gestational age (up to 9th week) and significant differences in ss-hCG concentrations between both examined groups. There were also statistical differences for S/D, RI and PI indices in both analyzed groups for each week of pregnancy. We conclude that measurement of the quality parameters of the flow velocity waveforms in uterine arteries and calculation of beta-hCG concentration in serum are useful methods in diagnosis of threatened abortion in the first trimester of pregnancy. Our purpose was to determine whether an abnormal uterine perfusion pattern was associated with subsequent pregnancy loss after fetal cardiac activity was documented. Pulsatility indexes of both the right and left uterine arteries were obtained by transvaginal color Doppler ultrasonography in 318 consecutive viable pregnancies between 6 and 12 weeks' gestation. The Δ uterine artery pulsatility index value, expressed as the highest uterine artery pulsatility index value minus the lowest value, was calculated for each pregnancy. Women were subsequently classified as having continuing pregnancies or pregnancy loss before 20 weeks' gestation. To predict subsequent pregnancy loss, Doppler findings were adjusted for maternal age, history of previous abortion, presence of subchorionic hematoma, embryonic bradycardia, and gestational age by means of multivariate logistic regression analysis: Twenty-four pregnancies (8%) were spontaneously aborted before 20 weeks' gestation. Both Δ uterine artery pulsatility index (odds ratio 2.9, 95% confidence interval 1.5-5.8) and history of previous abortion (odds ratio 3.1, 95% confidence interval 1.2-8.2) were significantly associated with pregnancy loss in the multivariate logistic regression analysis. The sensitivity and specificity of the multivariate logistic regression model to predict abortion were 75% and 85%, respectively, significantly higher than the diagnostic performances of qualitative and quantitative variables considered individually. : Discordant uterine artery pulsatility indexes in the first trimester were strongly associated with subsequent pregnancy loss. This suggests that

uterine ischemia may be implicated in certain cases of early pregnancy loss after documentation of fetal cardiac activity during the first trimester. (Am J Obstet Gynecol 1998; 179:1587-93.)

Chapter three
Methodology

This is an experimental study conducted in Sudan in the period from 2006 to 2011 at the clinic of the college of medical radiologic sciences

3-1 Materials

The data were collected by using GE Medical Systems LOGIC TM 5 Expert, made by Yocogama medical systems LTD –JAPAN – model 2302650, serial number 1028924, manufactured April 2005. LOGIQ 5 is a premium multipurpose imaging system designed for abdominal, vascular, obstetrics, gynecology, cardiology, neonatal, urology, transcranial, and small parts applications.

3-2- Ultrasound printers

Ultrasound printer used was digital graphic printer, 100 V, 15 A and 50/ 60 Hz .Made by Sony Corporation-Japan, with serial number of 3-619-GBI-01

3-3- Ultrasound Gel

Ultrasound gel is a type of conductive medium that is used in ultrasound diagnostic techniques and treatment therapies. It is placed on the patient's skin at the beginning of the ultrasound examination or therapy. Ultrasound gel is typically clear and thick, but not uncomfortably sticky. When it is applied to the skin, it doesn't dribble or drip off. It adheres to the skin lightly until it is wiped off at the end of the procedure. The most common complaint about ultrasound gel is that it is cold. For this reason, many medical professionals use special warmers to make their gel a more comfortable temperature before applying it to a patient's ski

3-4-Transvaginal probe multi-frequency probe (10-8-6) MHz

Transvaginal ultrasound is performed very much like a gynecologic exam and involves the insertion of the transducer 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 is usually performed with the patient lying on her back, possibly with her feet in stirrups similar to a gynecologic exam.

3-5-- sample

This prospective study performed in college of Medical Radiological Science ultrasound Department between 2006 -2010 .During this period all women with a history of recurrent abortions were participate in the study .(300)

Patients were classified into three groups.;-

One hundred (100) patients with threatened abortion 100 patients scheduled for an elective termination of the first trimester (abortion) for medical reasons, after the approval of the patient 100 non-pregnant women with a history of recurrent abortion (A group of women in the first trimester of singleton ,low risk normally developing pregnancies who sought took care in antenatal department also asked to participate as controls .(30 0) divided in 2 groups. 200 who were pregnant in first trimester with no complications presenting to the department for routine antenatal care 100 fertile non -pregnant women with no complication

3-5-1 Inclusion criteria;

Age 18-45.

2< previous consecutive abortions

Gestational age calculated from first day of the last menstrual period between 6-13 weeks.

Visible intrauterine GS with a living embryo.

Vaginal bleeding in the preceding 24 hours.

Singleton pregnancy.

The inclusion criteria were the same for control group with the exception of

Of vaginal bleeding,

For each women included in this study, the following were done;

Full history taking and clinical examination

Routine antenatal care investigations include, CBC, urine analysis, blood group RH –

3-5-2 Transvaginal **Doppler scanning**.

The examination of the pelvic vessels has been significantly altered by the transvaginal technique of evaluation of pelvic anatomy and pathology .The course of the uterine artery is particularly suitable for transvaginal assessment with ideal geometry for Doppler signal recording

3-5-3 Uterine and ovarian artery distribution.

The uterine artery is a branch of internal iliac artery and ascends on the lateral border of the uterus .It sends branches to ovary and to the fallopian tube. The ovary is also supplied by the ovarian artery, a branch usually of the r

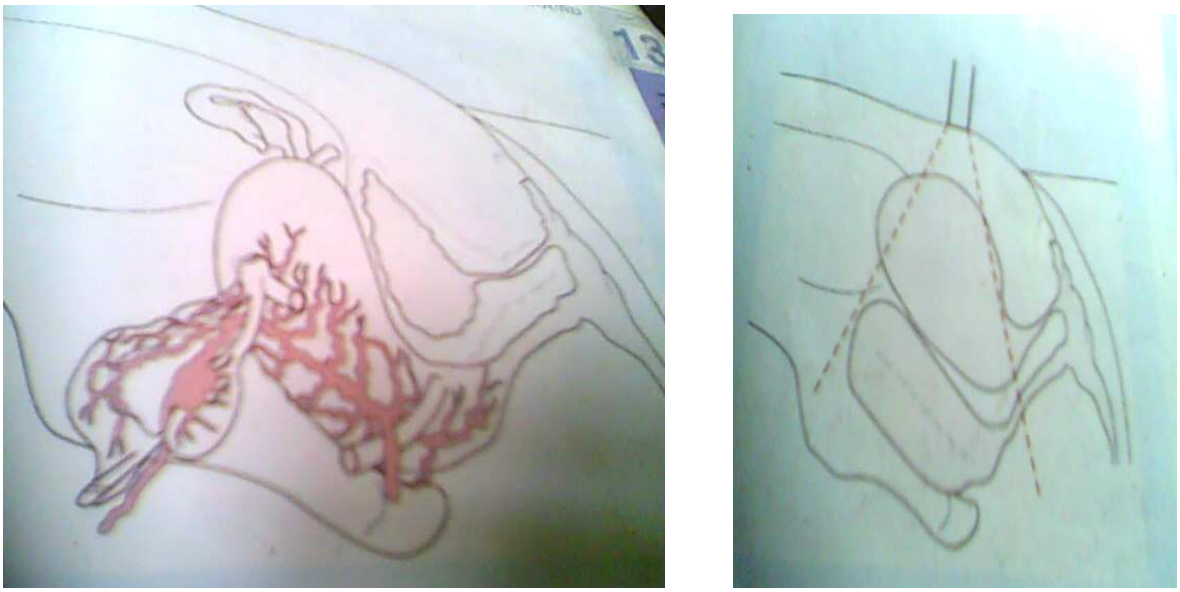


Figure 3-1(A) Sagittal sections through the pelvis demonstrating the optimum geometry Achieved by transvaginal scan With an empty bladder (B) Sagittal planes through abdomen that with a full urinary bladder the geometry for Doppler assessment of flow is suboptimal.

3-5-4 Technique

Transvaginal ultrasound is performed very much like a gynecologic exam and involves the insertion of the transducer 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 is usually performed with the patient lying on her back, possibly with her feet in stirrups similar to a gynecologic exam. The endovaginal probe was inserted gently into the vagina and the uterus and adnexal region were scanned, the intrauterine gestational sac and embryo were identified and, the size of GS was calculated to confirm gestational age. Yolk sac was identified.

The imaging portion of the examination was directed towards the uterus to evaluate any intrauterine contents, Sagittal and transverse images of the uterus were obtained, and dimensions of any uterine contents were measured by using sagittal images. Endometrial thickness was measured, after taking the measures of uterine contents. After embryo viability was confirmed, the color aiming was activated to identify the vessels under study .The uteroplacental circulation was assessed, the uterine arteries localized as they approach the lateral uterine wall at the level of internal os in the transverse plane. Once the vessels identified, pulsed Doppler was activated to obtain the flow velocity waveform from the vessels. The insonation angle was kept at < 30 degrees for assessment of uterine arteries. Then the image was frozen including at least three waveform signals. The three velocity indices: Pulsatility index (Pi) Resistance index (Ri), peak systolic velocity (PSV) were automatically calculated for uterine artery. In each patient, the PSV, RI, Pi from left and right uterine arteries were averaged and used for statistical analysis.

Chapter four
Results

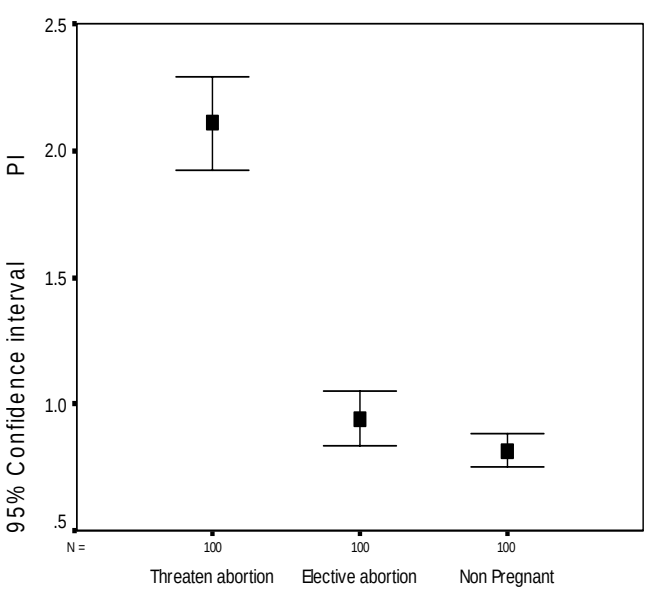
The result of this study presented in tables and graphs, the tables shows the analysis variance, mean distribution and t-test values, while the graphs present errors bar and means, bar plot and scatter plot.

Table 4-1 one way analysis of variance for the recurrence pregnancy loss groups (Threaten abortion, elective evacuation and non Pregnant) using the PI, RI and PSV.

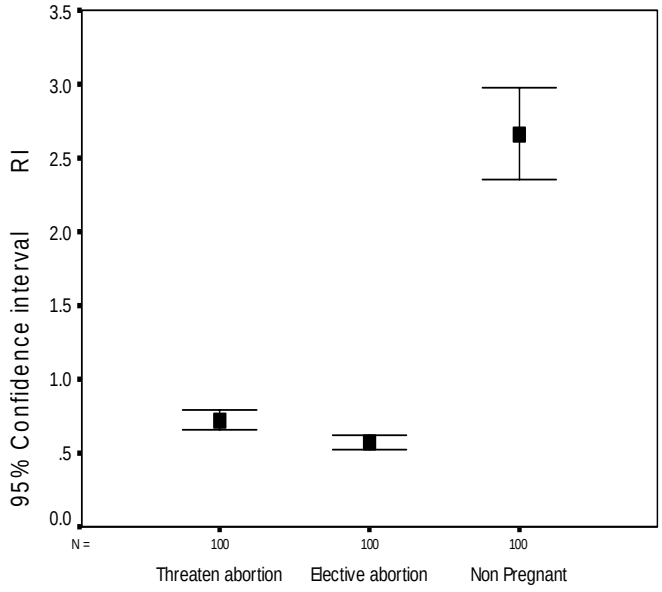
		Sum of Squares	df	Mean Square	F	Sig.
PI	Between Groups	101.5603	2	50.78014	118.9566	.000
	Within Groups	126.7832	297	0.42688		
	Total	228.3435	299			
RI	Between Groups	272.1539	2	136.0769	152.6908	.000
	Within Groups	264.6843	297	0.891193		
	Total	536.8381	299			
PSV	Between Groups	4692.028	2	2346.014	3.57284	0.029
	Within Groups	195017.4	297	656.6243		
	Total	199709.4	299			

Table 4-2 the mean and standard deviation of PI, RI and PSV for the pregnancy groups and control.

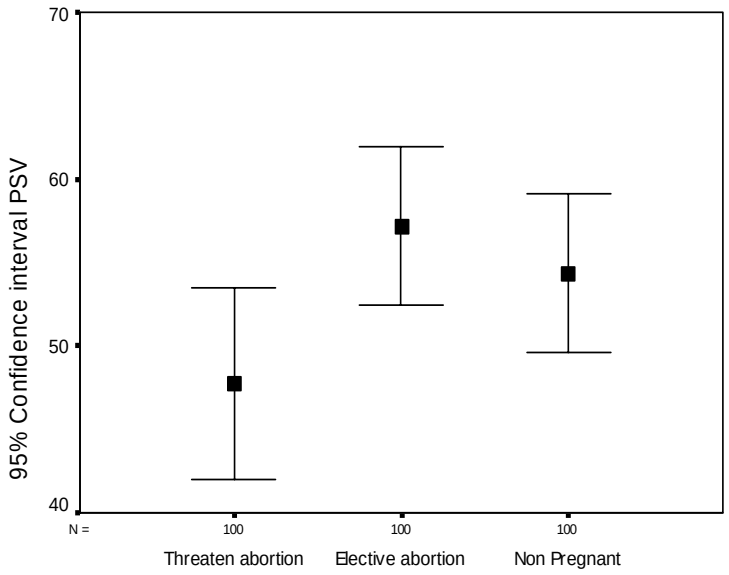
Mean ± SD	**PI**	**RI**	**PSV**
Threaten abortion	2.1±0.9	0.7±0.4	47.7±28.7
Before Elective abortion	1.0±0.5	0.5±0.3	56.1±24.9
After elective abortion	0.9±0.6	0.6±0.3	57.2±23.9
Non pregnant	0.8±0.3	2.7±1.6	54.4±23. 9
Control	1.3±0.8	0.8±0.5	61.3±25.1



(A)



(B)



(C)

Figure 4-1 a box plot shows the mean and standard deviation of the three groups threaten abortion, elective evacuation and non pregnant for (A) PI, (B) RI and (C) PSV.

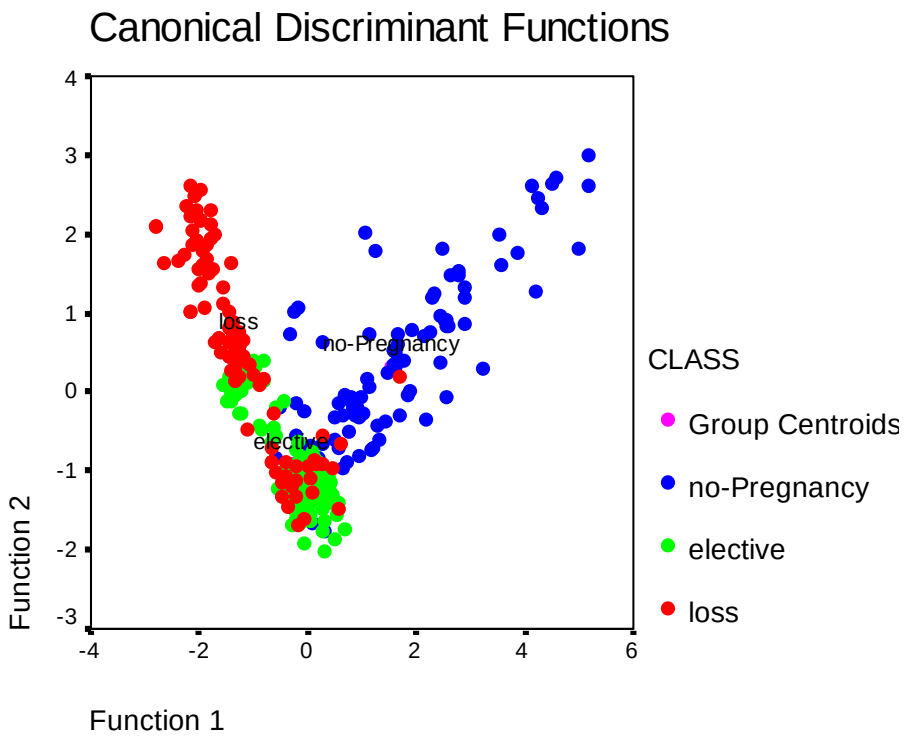
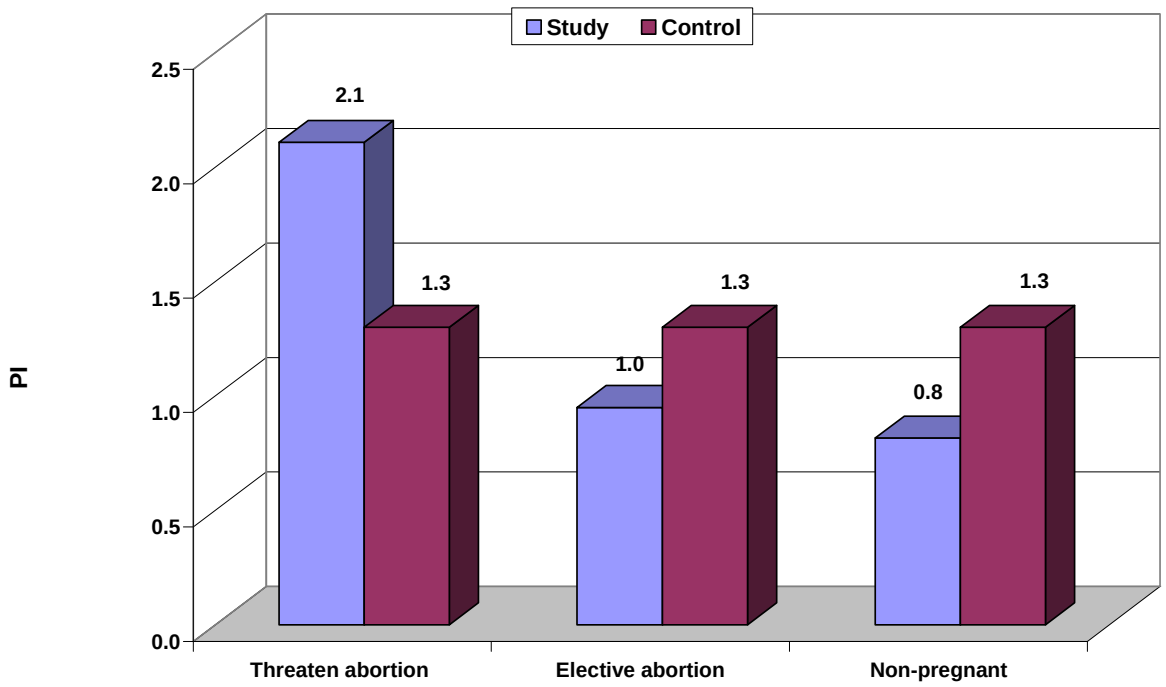


Figure 4-2 scatter plot shows the classification of the pregnancy loss group into three groups using linear discriminant function and the uterine blood flow indices as input.

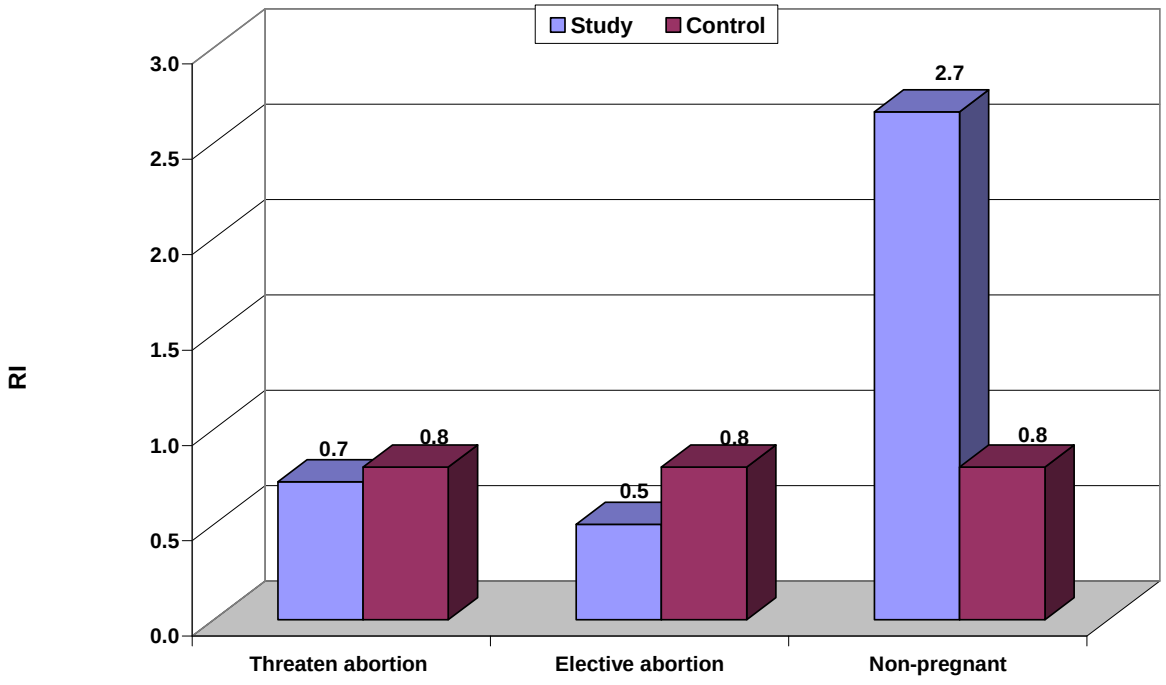
Table 4-3 a classification results by using linear discriminant analysis and the uterine artery blood flow indices as input.

		Predicted Group Membership			Total
CLASS		Threaten abortion	Elective Abortion	Non pregnant	
Original count	Threaten	75	25	0	100
	Elective	22	78	0	100
	Non-Pregnancy	0	20	80	100
%	Threaten	750.	250.	0.0	100.0
	Elective	22.0	78.0	0.0	100.0
	non-Pregnancy	0.0	200.	80.0	100.0

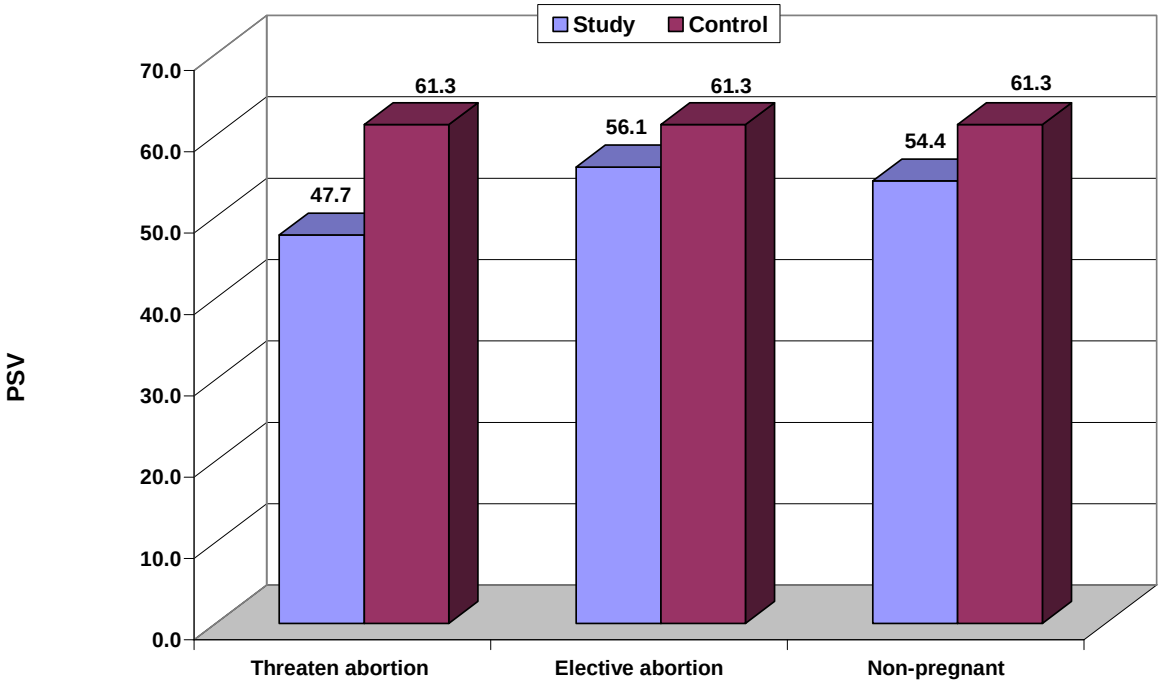
A 77.7% of original grouped cases correctly classified.


Study
Control
PI
2.5
2.0
1.5
1.0
0.5
0.0
2.1
1.3
1.0
1.3
0.8
1.3
Threaten abortion
Elective abortion
Non-pregnant

(A)


Study
Control
RI
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.7
0.8
0.5
0.8
2.7
0.8
Threaten abortion
Elective abortion
Non-pregnant

(B)



(C)

Figure 4-3 a bar graph of the; (A) PI, (B) RI and (C) PSV values for the threaten abortion, elective abortion and non pregnant group versus the control group.

Table 4-4 one sample t-test of PI of the recurrence loss pregnancy groups versus the PI of the control group

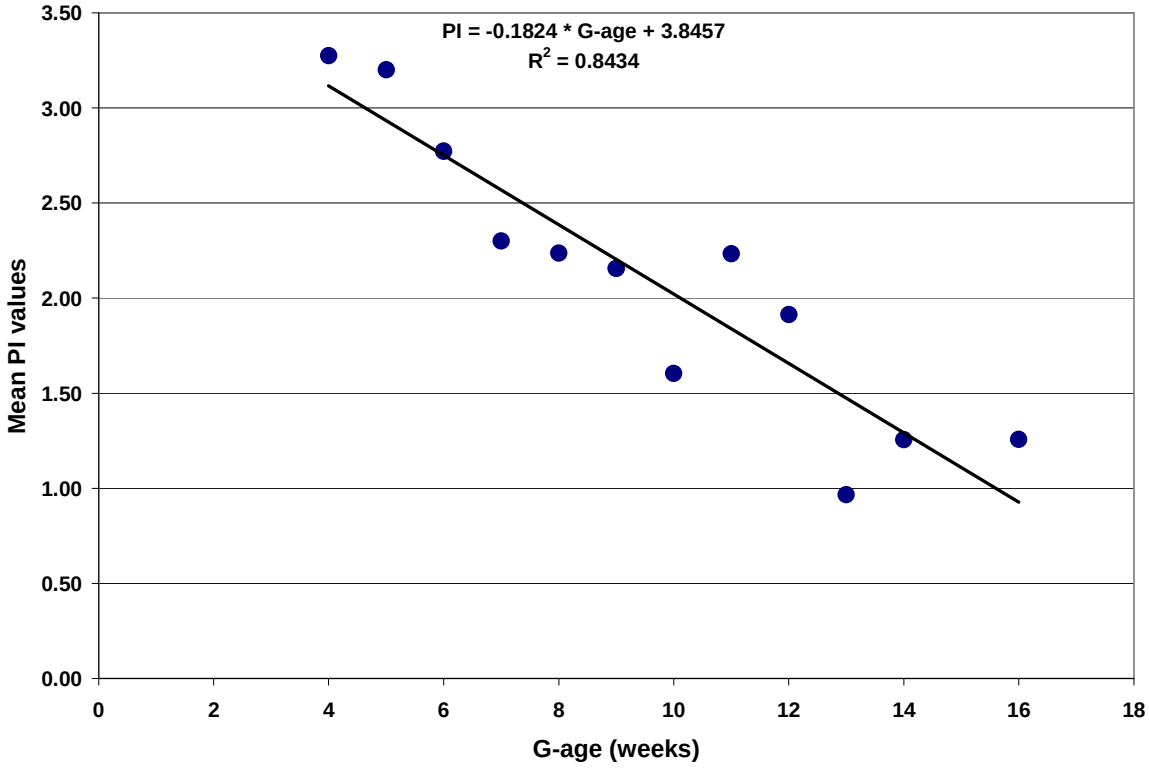
Test Value = 1.3						
PI	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Threaten	8.68	99.00	0.00	0.81	0.62	0.99
elective	-6.60	99.00	0.00	-0.36	-0.47	-0.25
Non-pregnant	-14.19	99.00	0.00	-0.48	-0.55	-0.42

Table 4-5 one sample t-test of RI of the recurrence loss pregnancy groups versus the RI of the control group

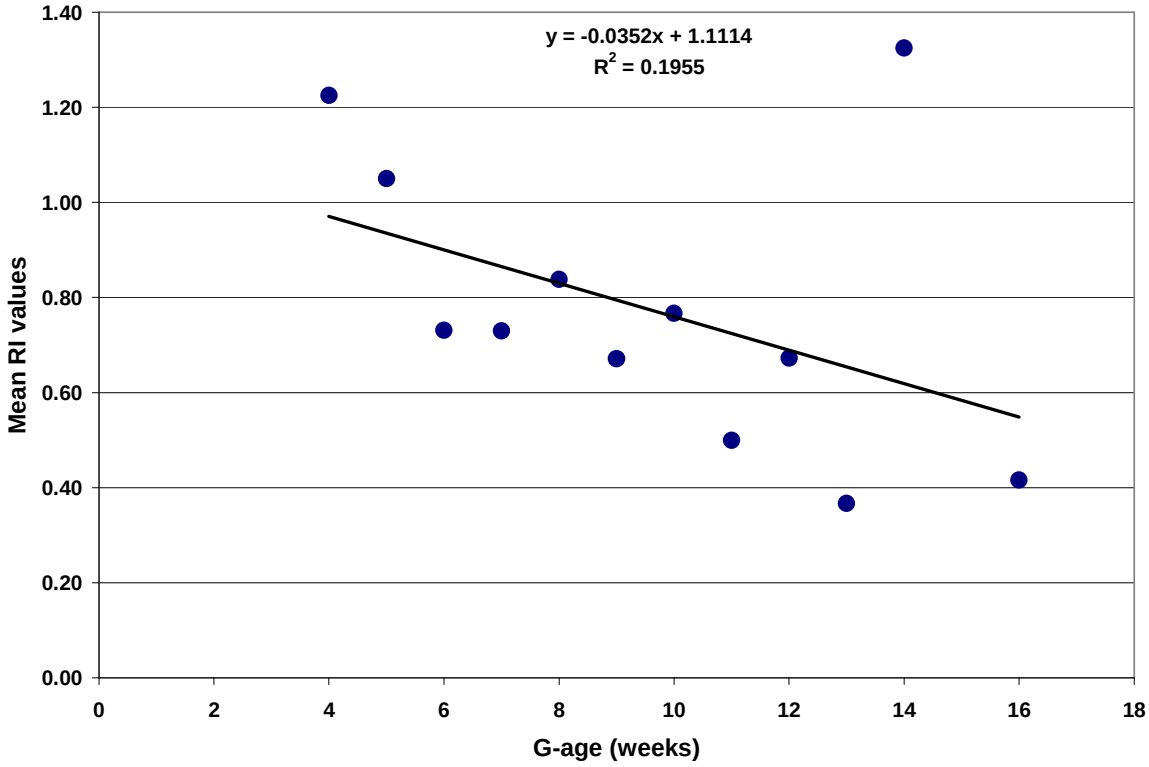
Test Value = 0.8						
RI	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Threaten	-2.16	99.00	0.03	-0.08	-0.15	-0.01
elective	-9.39	99.00	0.00	-0.23	-0.28	-0.18
Non-pregnant	11.81	99.00	0.00	1.86	1.55	2.18

Table 4-6 one sample t-test of PSV of the recurrence loss pregnancy groups versus the PSV of the control group

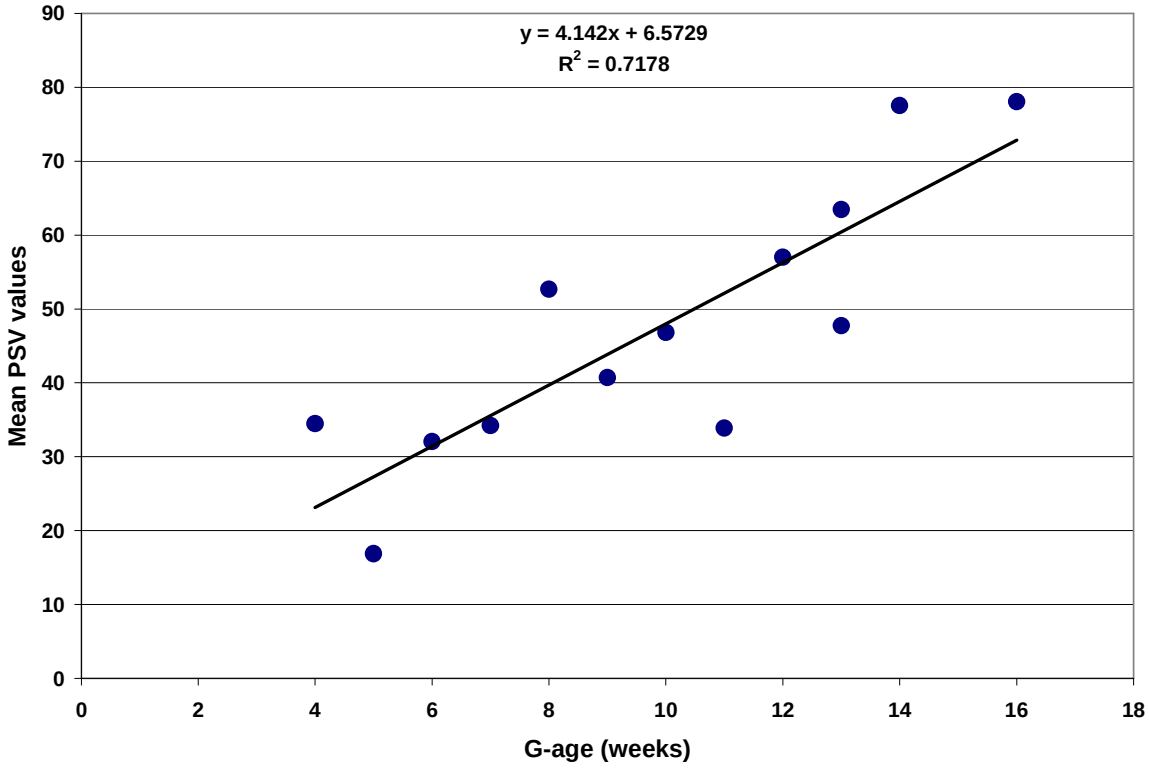
Test Value = 61.3						
PSV	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Threaten	-4.72	99.00	0.00	-13.56	-19.26	-7.87
elective	-1.73	99.00	0.09	-4.13	-8.88	0.61
Non-pregnant	-2.90	99.00	0.00	-6.94	-11.69	-2.19


PI = -0.1824 * G-age + 3.8457
R2 = 0.8434
Mean PI values
G-age (weeks)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
18

(A)


y = -0.0352x + 1.1114
R2 = 0.1955
Mean RI values
G-age (weeks)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
2
4
6
8
10
12
14
16
18

(B)

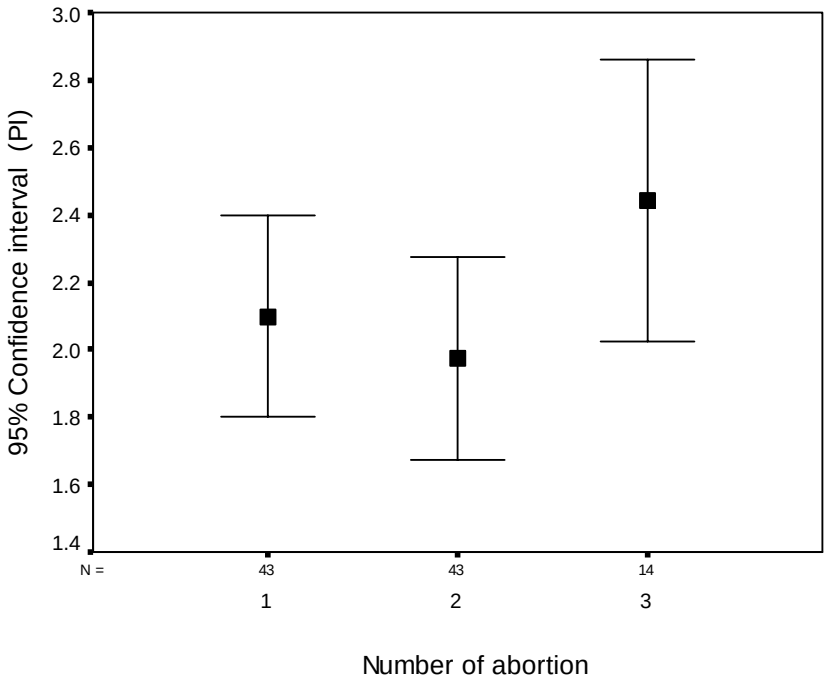


(C)

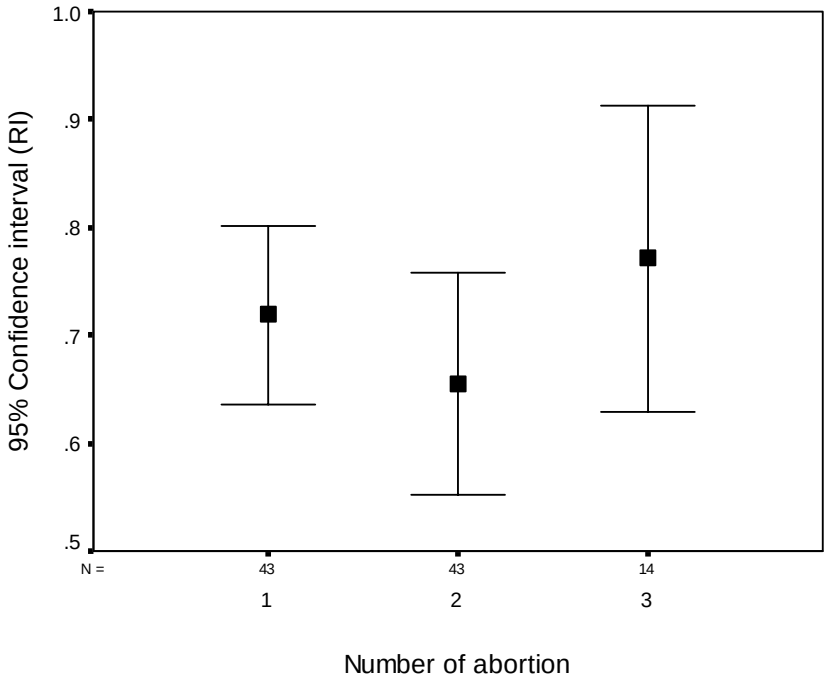
Figure 4-4 scatter plot show the linear relationship between the gestational age and (A) PI, (B) RI and PSV with a trend line depict this relation and the linear equation.

Table 4-7 one way analyses of variance for the different gestational age versus the uterine blood flow indices.

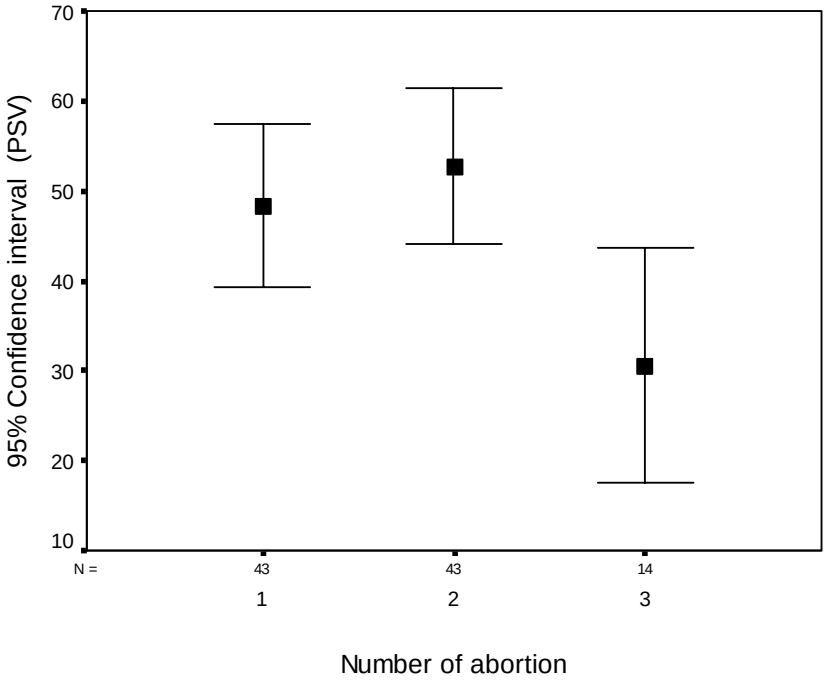
		Sum of Squares	df	Mean Square	F	Sig.
PI	Between Groups	37.75937	11	3.43267	5.82749	0.000
	Within Groups	51.8362	88	0.589048		
	Total	89.59558	99			
RI	Between Groups	4.519413	11	0.410856	8.789198	0.000
	Within Groups	4.113606	88	0.046746		
	Total	8.633019	99			
PSV	Between Groups	29707.68	11	2700.698	4.573762	0.000
	Within Groups	51961.92	88	590.4764		
	Total	81669.6	99			


3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
95% Confidence interval (PI)
N =
43
43
14
1
2
3
Number of abortion

(A)


1.0
.9
.8
.7
.6
.5
95% Confidence interval (RI)
N =
43
43
14
1
2
3
Number of abortion

(B)

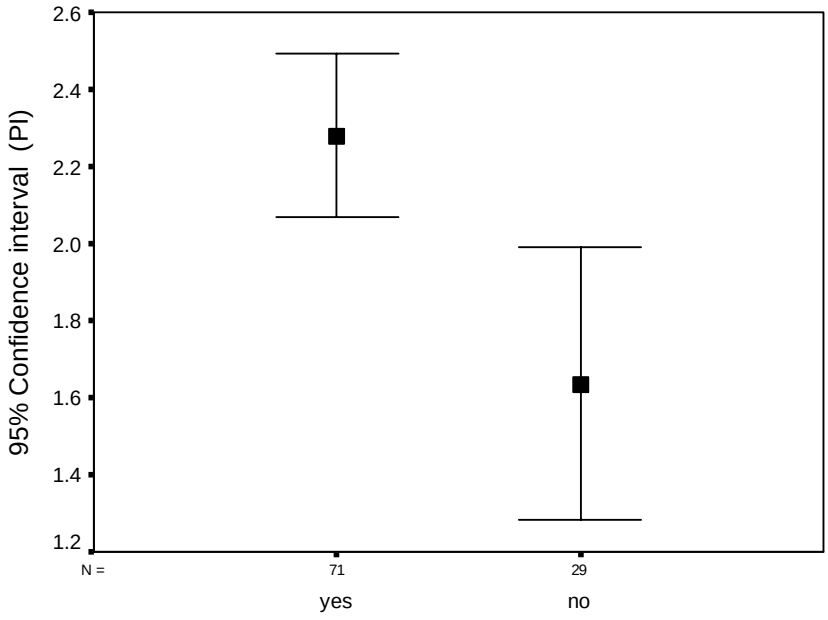


(C)

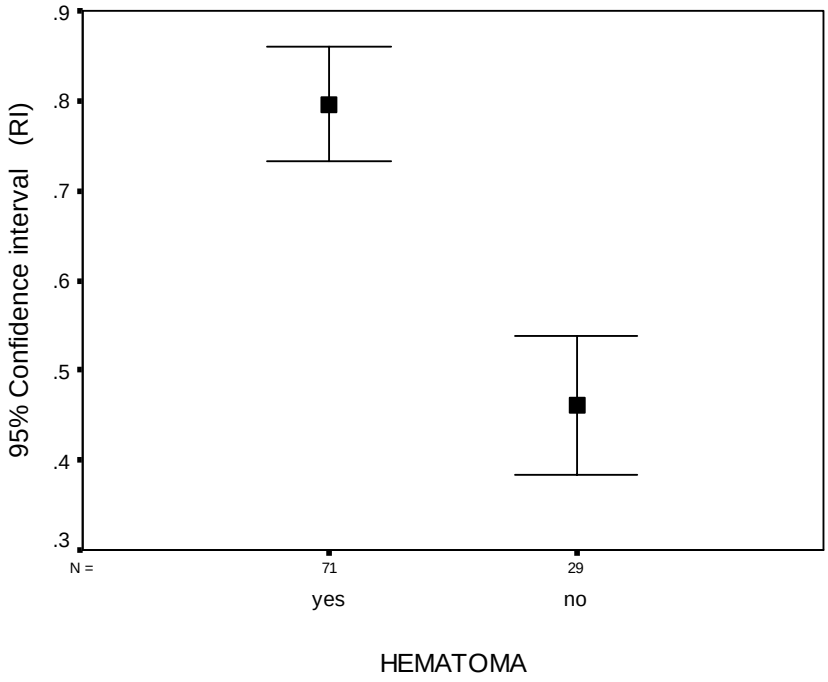
Figure 4-5 error bar plot shows the mean values of, (A) PI, (B) RI and (C) PSV versus the number of abortion.

Table 4-8 one way analyses of variance for the different number of abortion versus the endometrial blood flow indices.

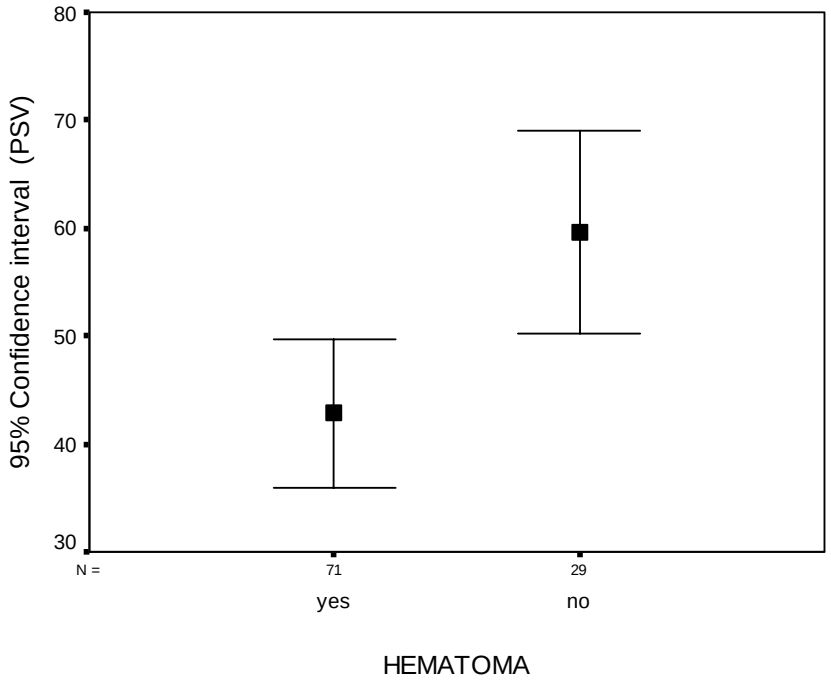
		Sum of Squares	df	Mean Square	F	Sig.
PI	Between Groups	2.331867	2	1.165934	1.29602	0.278
	Within Groups	87.26371	97	0.899626		
	Total	89.59558	99			
RI	Between Groups	0.171824	2	0.085912	0.984906	0.377
	Within Groups	8.461195	97	0.087229		
	Total	8.633019	99			
PSV	Between Groups	5211.732	2	2605.866	3.30599	0.041
	Within Groups	76457.87	97	788.2255		
	Total	81669.6	99			


95% Confidence interval (PI)
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
N =
71
29
yes
no
HEMATOMA

(A)


95% Confidence interval (RI)
.9
.8
.7
.6
.5
.4
.3
N =
71
29
yes
no
HEMATOMA

(B)

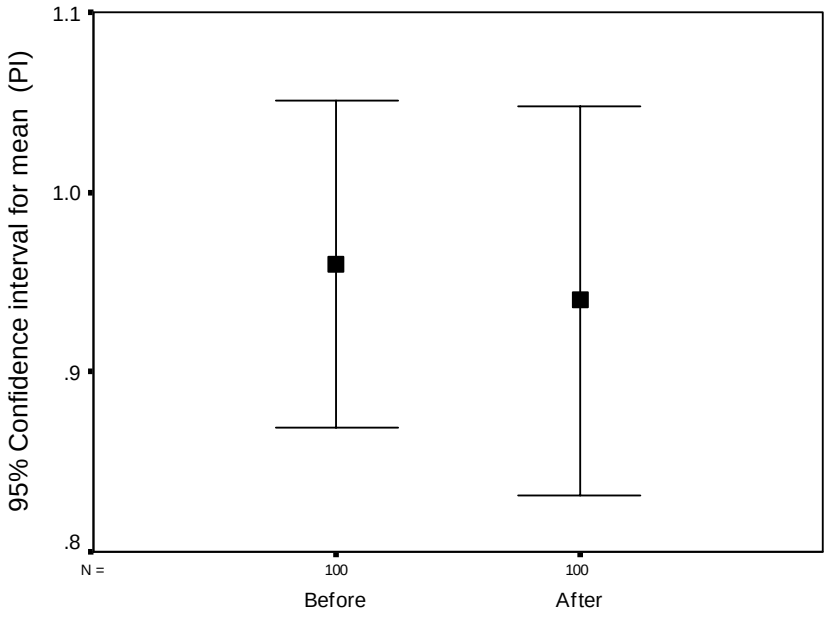


(C)

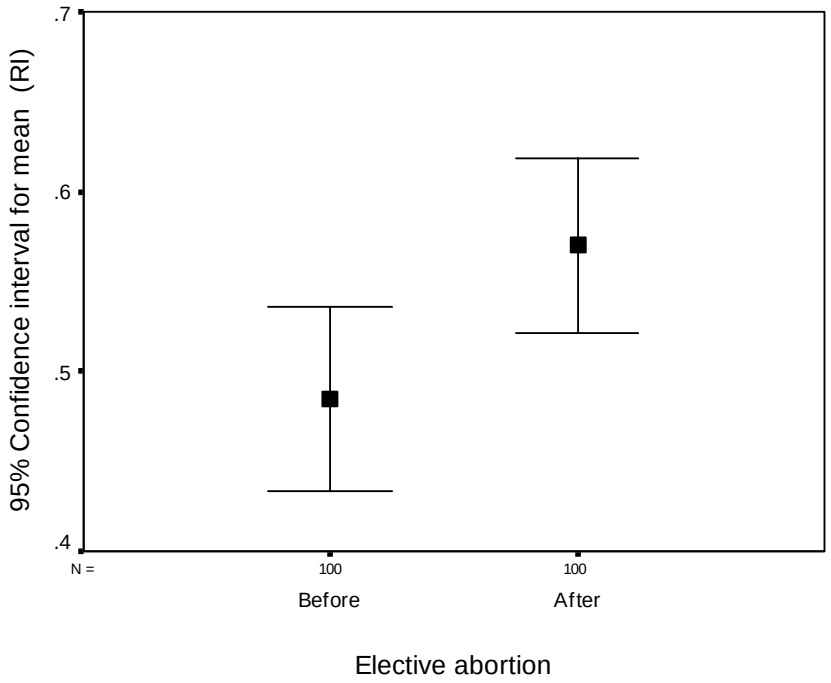
Figure 4-6 error bar plot of the mean values of (A) PI, (B) RI and (C) PSV versus the presence of hematoma.

Table 4-9 one way analyses of variance for the hematoma status versus the endometrial blood flow indices.

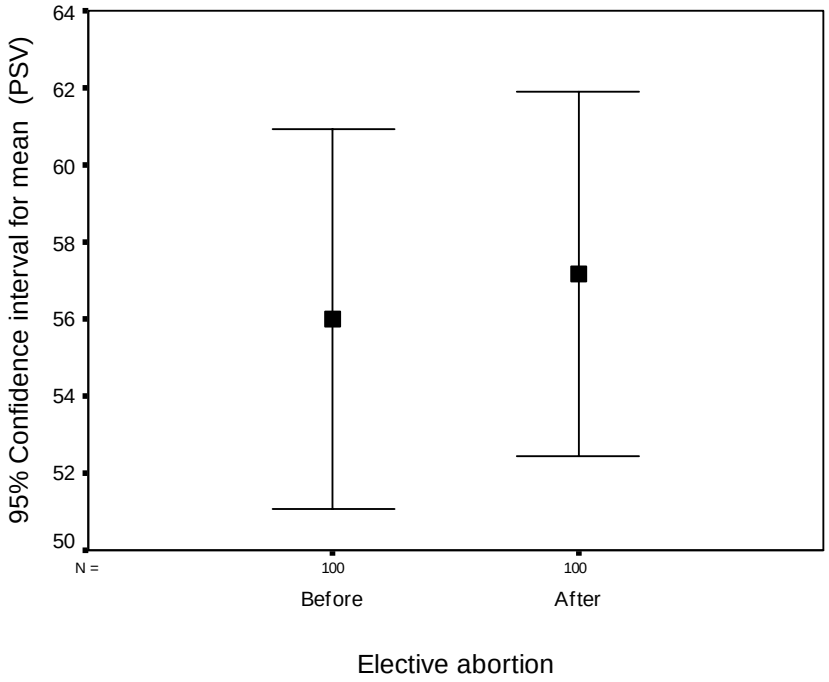
		Sum of Squares	df	Mean Square	F	Sig.
PI	Between Groups	8.51733	1	8.51733	10.295	0.002
	Within Groups	81.0782	98	0.82733		
	Total	89.5956	99			
RI	Between Groups	2.32161	1	2.32161	36.0487	0.000
	Within Groups	6.31141	98	0.0644		
	Total	8.63302	99			
PSV	Between Groups	5802.44	1	5802.44	7.4952	0.007
	Within Groups	75867.2	98	774.155		
	Total	81669.6	99			


95% Confidence interval for mean (PI)
1.1
1.0
.9
.8
N =
100
100
Before
After
Elective abortion

(A)


95% Confidence interval for mean (RI)
.7
.6
.5
.4
N =
100
100
Before
After
Elective abortion

(B)

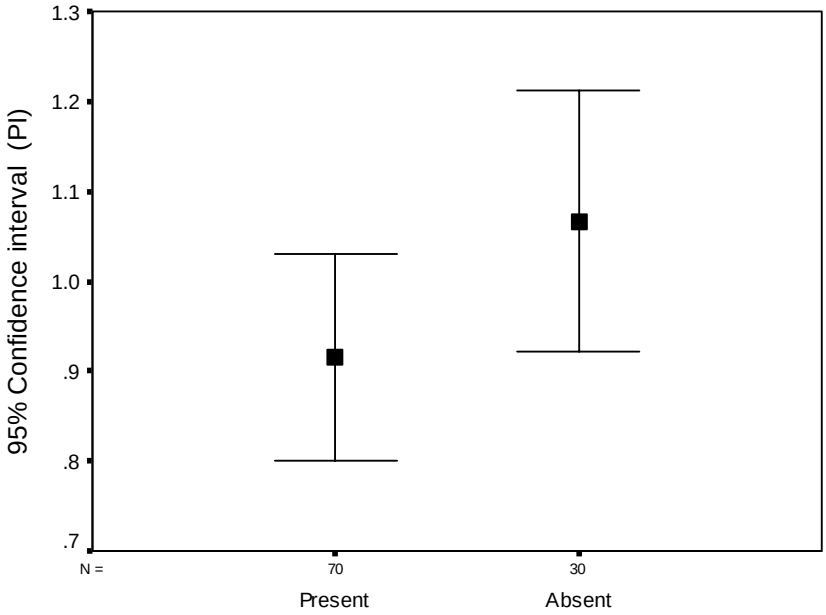


(C)

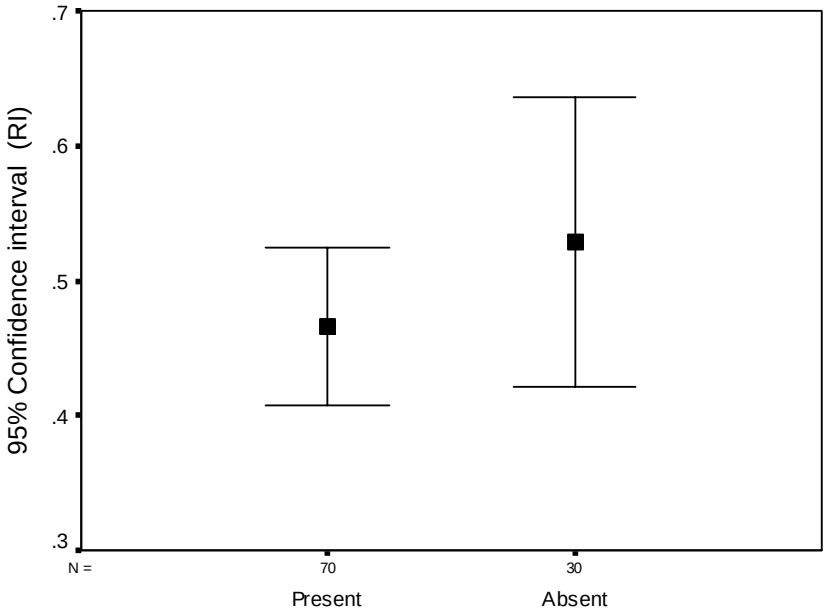
Figure 4-7 an error bar plot shows the mean values of: (A) PI, (B) RI and PSV for elective group before and after abortion.

Table 4-10 one way analyses of variance for the elective abortion; before versus after abortion for the uterine artery blood flow indices

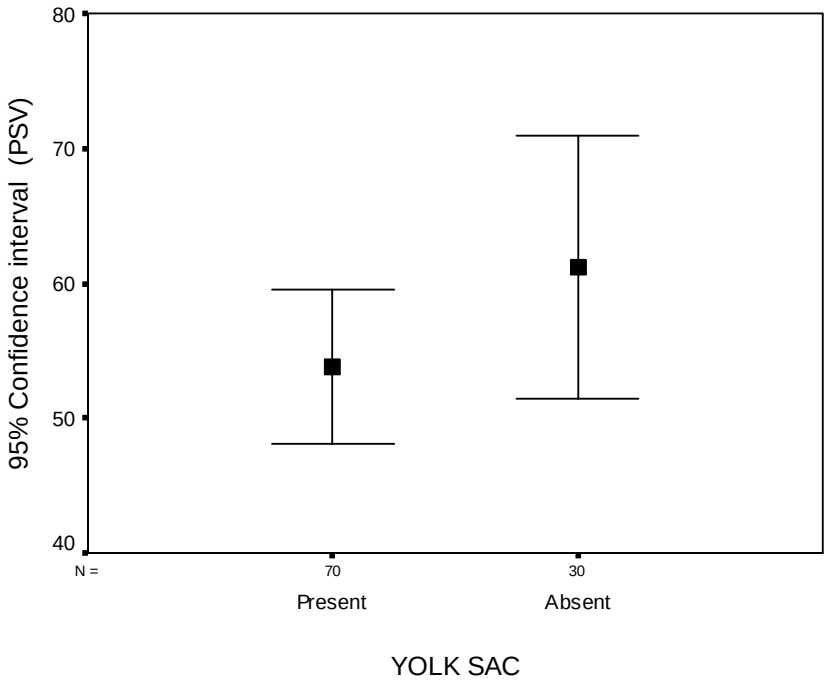
		Sum of Squares	df	Mean Square	F	Sig.
PI	Between Groups	0.02122	1	0.02122	0.08337	0.77
	Within Groups	50.3928	198	0.25451		
	Total	50.414	199			
RI	Between Groups	0.36466	1	0.36466	5.75469	0.02
	Within Groups	12.5467	198	0.06337		
	Total	12.9113	199			
PSV	Between Groups	66.5512	1	66.5512	0.11184	0.74
	Within Groups	117823	198	595.067		
	Total	117890	199			


1.3
1.2
1.1
1.0
.9
.8
.7
95% Confidence interval (PI)
N =
70
30
Present
Absent
YOLK SAC

(A)


.7
.6
.5
.4
.3
95% Confidence interval (RI)
N =
70
30
Present
Absent
YOLK SAC

(B)



(C)

Figure 4-8 error bar plot show the mean value of (A) PI, (B) RI and (C) PSV in case of presence or absence of yolk sac before the elective abortion.

Table 4-11 one way analyses of variance before elective abortion; in case of presence and absence of yolk sac for the uterine artery blood flow indices

		Sum of Squares	df	Mean Square	F	Sig.
PI	Between Groups	0.48579	1	0.48579	2.33682	0.12957
	Within Groups	20.3728	98	0.20789		
	Total	20.8586	99			
RI	Between Groups	0.08449	1	0.08449	1.26857	0.26279
	Within Groups	6.5268	98	0.0666		
	Total	6.61128	99			
PSV	Between Groups	1145.49	1	1145.49	1.86861	0.17476
	Within Groups	60076	98	613.02		
	Total	61221.5	99			

Chapter five

Discussion conclusion and Recommendation

5-1Discussion

The main objective of this study was to evaluate the statues of the uterine artery with recurrent pregnancy loss women by using B-scan and color Doppler. The sample of this study consisted mainly of three groups they include; threatened abortion, elective abortion and non pregnant but all of them they have history of recurrent pregnancy loss. The study showed that the variables PI, RI and PSV were significantly different among the three groups at $p = 0.05$ by using ANOVA with $p < 0.001$ and F equal to 118.9, 152.7 and 3.6 respectively (Table 4-1). This means that the three categories represent different entities even they have a common factor, which is recurrent pregnancy loss but the variability between the groups dictate that they are different sample.

Demonstrated that patients with a pregnancy ending in miscarriage show a different artery blood flow pattern .They reported discordant uterine artery blood velocity waveforms with an abnormally high (Pi)were strongly associated with subsequent pregnancy loss. This result in agreement with Leible et al (1998) .

Impaired artery flow velocity can be identified by a persistent abnormal index a persistent notch, and by a significant difference between the in the two vessels. The upper limit of the S/D ratio is approximately 2,6 and the difference between the vessels should not exceed this ratio. Although Doppler has not proven useful predicting a successful first trimester outcome. Researchers have confirmed a correlation between first trimester uterine artery resistance and subsequent

pregnancy complication, Most authors agree that as early as 11 weeks GA elevated uterine artery resistance can identify patients at risk for both intrauterine growth restriction and pregnancy – induced hypertension (Dugoff et al., 2005).

One explanation for this relationship is inadequate incomplete trophoblastic invasion of the maternal vessels during the first trimester,

Early identification of patients at risk for these complications could allow additional screening and possible intervention (Callen ,2008).

The results as well showed that the mean values of PI, RI and PSV was 2.1±0.9, 0.7±0.4 and 47.7±28.7 for threaten abortion (Table 4-2 and Figure 4-1), and for elective abortion it 1.0±0.5, 0.5±0.3 and 56.1±24.9 (Table 4-2 and Figure 4-1) non pregnant group was 0.8±0.3, 2.7±1.6 and 54.4±23.9 (Table 4-2 and Figure 4-1) respectively. This results showed that the mean value of PI can differentiate between the threaten abortion group and the other groups (Figure 4-1(A)). Similarly RI showed a high level for non pregnant group in respect to other groups which means that; the RI can be used to differentiate between the non pregnant group and the other groups (Figure 4-1(B)).Habra et al (2002) and Frates et al (1996) found that, elevated uterine arterial impedance is associated with RPL. While PSV showed a minor variation among the groups with a higher mean scored by the elective abortion group and the minimum one was recorded by the threaten abortion group. But in respect to PSV values the three groups seem to be overlap when taking into account the deviation (or the spread) of the data from the mean (Figure 4-1(C)). Generally these indexes seem to classify the recurrent pregnancy loss into distinct groups.

The researcher attempt to classify the recurrent pregnancy in to three groups (threaten abortion, elective abortion and non pregnant groups) using Fisher linear discriminant analysis approach to

discriminates between the three groups in respect to their PI RI and PSV only (input). The result of classification (Table 4-3 and Figure 4-2) showed that; the accuracy of classification was 77.7%. The higher classification score was 80% achieved by the non pregnant group, and there were 20% misclassified as elective one. The elective group showed that 78% were correctly classified while 22% were misclassified as. Threaten abortion group showed that 75% were correctly classified and 25% were misclassified as elective abortion. This result prove that there is a common factor between the elective abortion and the threaten abortion group because the misclassified portion were alternate between the two groups while there is no case from these two group were misclassified as non pregnant. This result indicate that each of the group had it is unique properties which distinguish them from each with minor overlap, therefore their relation to the normal (control) should be investigated and hence be apparent.

The control group showed that the mean value for PI, RI and PSV was equal to 1.4±0.87, 1.0±0.60, and 60.8±25.63 respectively (Table 4-2). These values indicate that there is a difference between the mean values of PI, RI, and PSV for the control group and the test groups (threaten abortion, elective abortion and non pregnant groups) as shown in Figure 4-3 (A, B and C) and Table 4-2. This difference was significant by using *t*-test for the entire group versus the control at $p = 0.05$ except for PSV in the elective group .In previously published findings (Nakatsuka et al. 2003). The *t*- values for PI of the threaten abortion, elective abortion and non pregnant groups was 8.68, 6.60 and 14.19 respectively (Table 4-4). As well the *t*-values for RI was 2.16, 9.39 and 11.81 respectively (Table 4-5), similarly in respect to PSV the *t*-values was 4.72, 1.73 and 2.90 where the difference was inconclusive in case of elective abortion at $p = 0.05$ with $p = 0.09$ (Table 4-6). The three group as mentioned earlier got their own differences between the groups and their unique characteristics within the group. This fact represented by a

minor variation of the PI, RI and PSV within the group and the significant differences of these indexes between the groups including the control group. Some investigations have proposed studying the uterine artery blood flow shows, no significant differences were found in any of the three indices between the normal and the pathological groups of patients (Pellizzari et al 2002). These results encourage the researcher to study the effects of other factors which associated which each group individually i.e. the threaten abortion, elective abortion.

In threaten abortion group in respect to gestational age which is range from 4-16 weeks the PI showed a inverse linear proportionality with the gestational age (Figure 4-4(A)), with a coefficient = –0.18/week; this means that for each week the PI will be reduced by 0.18/week with a threshold equal to 3.84. Similarly the RI showed an inverse linear relationship with a coefficient equal to -0.04/week (Figure 4-4(B)) as well it means the RI decrease by 0.04ml for each week with a threshold = 1.11.Also (Dickey et al 1994**)** found a significant inverse correlation between GA and both Pi and Ri But the PSV showed a direct linear relationship with a coefficient equal to 4.1 /week (Figure 4-4(C)), which means that the PSV values will start to increase by 4.1 for each week with a threshold equal to 6.6. Generally the PI, RI and PSV for each gestational age were significantly different at p = 0.05 by using NOVA test with F = 5.82749, 8.789198 and 4.573762 respectively (Table 4-7). This is obviously true because in case of PI and RI they decrease when the Gestational age increase, and in case of PSV it increase as long as the gestational age increase. Also if we grouped the threaten abortion according to the number of abortion the researcher found that the values of PI and RI showed inconclusive result at p = 0.05 using ANOVA with p = 0.27 and 0.37 respectively and F = 1.29602 and 0.984906 respectively, while the PSV values showed a significant difference at p = 0.05 with F = 3.30599 and p = 0.041 (Table 4-8 and Figure 4-5(A, B and C). Where the PSV showed lower values in

case of >4 abortions and higher in >3 abortions and in between for two abortions, therefore the PSV values relatively showed a distinct group with their variation than the PI and RI according to the number of abortions. This result was in agreement with (Regan et al 1989) found. Also in respect to the presence or absence of hematoma there is a significant difference between the indexes (PI, RI and PSV when compare these values in case of the presence or absence of hematoma) at $p = 0.05$ using ANOVA test with $F = 10.295$, 36.0487 and 7.4952 respectively Table 4-9. This difference was genuine because the values of PI and RI were higher when there is a hematoma and lower in case of absence of hematoma, while for PSV they have an inverse fashion i.e. the PSV was low incase of absence of hematoma and higher when it present (Figure 4-6(A, B and C)). Pellizzari et al (2003) found that in patients with a retro placental hematoma, uterine vascular resistance appeared higher than in those without a hematoma,

Elective abortion includes the study of endometrial blood flow (i.e. PI, RI and PSV) before and after the induced abortion as well as the effect of presence or absence of the yolk sac. As shown in Table 4-10 and Figure 4-7 there is no significant difference before and after the elective abortion in respect to PI and RI using ANOVA at $p = 0.05$ with $F = 0.083$ and 0.11 respectively. While RI showed a significant difference before and after elective abortion at $p = 0.05$ with $p = 0.02$ and $F = 5.75$. Figure 4-8 showed that there is a difference in means in PI, RI and PSV in case of presence or absence of yolk sac; the result shows high values in case of absence of yolk sac versus the presence. But generally the presence or absence of yolk sac has no significant effects on the PI, RI and PSV values at $p = 0.05$ using ANOVA with $F = 2.33$, 1.26 and 1.86 respectively (Table 4-11 and Figure 4-8).This result as the same as Wong et al (2002) **.**

5-2 Conclusion

The risk of having spontaneous abortion for the first time is about 15%. This risk at least will be doubled in women experiencing recurrent abortion therefore investigation of recurrent pregnancy loss is mandatory to predict the causes and hence management. The incidence of abortion is influenced by the age of the mother number of pregnancy including a history of previous full-term normal pregnancy, the number of previous spontaneous abortions, a previous stillbirth and a previous infant born with malformations of known genetic defects. Therefore the main objective of this study was to evaluate the uterine artery blood flow in recurrent pregnancy loss groups in order to justify the causes and hence facilitate the management. This study were conducted at the College of Medical Radiological Sciences in the period from 2006 to 21010. The data were collected from 600 patients; 300 were control group and the other 300 were test group they include threaten abortion, elective abortion and non pregnant women each group consisted of 100 patients, all in common they have recurrent pregnancy loss. The ultrasound machine used to collect the data is General electric Logic 5 using a vaginal probe with a frequency = 6-10 MHz. The data was collected by measuring the uterine artery blood flow indices (PI, RI and PSV) as well as the effect of hematoma and the presence of yolk sac on uterine condition, also the indices were measured before and after elective abortion. The result showed that the artery blood flow indices: PI, RI and PSV of the RPL groups were significantly different from the control group at $p = 0.05$ using ANOVA with $p < 0.001$ and F equal to 118.9, 152.7 and 3.6 respectively. The result also in respect to RPL groups showed that the mean values of the PI, RI and PSV were 2.1±0.9, 0.7±0.4 and 47.7±28.7 for threaten abortion, and for elective abortion it is 1.0±0.5,

0.5±0.3 and 56.1±24.9 and for non pregnant group was 0.8±0.3, 2.7±1.6 and 54.4±23.9 respectively. The these indices were different among the different group which facilitate the classification of these groups in respect to their uterine blood flow indices; to achieve this goal the researcher applied Fisher linear discriminant analysis to classify these groups into a separate group. The classification accuracy was 77.7% which indicate that these groups have unique characteristics as well as they are differ from the control group. The presence or absence of yolk sac has no significant effects on the artery blood flow incidence but generally they increase in case of absence. While when there is hematoma these indices were significantly different than the cases where there is no hematoma at $p = 0.05$ using ANOVA.

5-3 Recommendation

-Couples with 2 or more abortions, couples with one abortion, with a still born child or with a malformed child should be investigated. with Doppler ultrasound

-Analysis of uterine artery indices must be combined wither blood tests may help in evaluating the risks of pregnant women

Transvaginal color Doppler technique must be use in evaluating the effects of medications for RPL in early pregnancy.

-Additioal Doppler investigations into physiological and phrmalogical methods to improve uterine blood flow in early pregnancy loss are clearly needed.

-Doppler ultrasound measurement of uterine blood flow is relatively new technique its role in clinical medicine has still to be established for infertility and early pregnancy loss as more investigations are performed as sonologest become familiar with its use, and as instrumentation is improved it may yet prove to be an indispensable tool for ultrasound investigations of disorders of implantation and early pregnancy.

-We think that further study on uterine arterial blood flow will elucidate the effect of therapeutic agents on women with RPL in early pregnancy, and the mechanism of pregnancy loss associated with impaired uterine perfusion**.**

Patients with early pregnancy loss and recurrent early pregnancy loss need education and support from their practitioner. Many controversies exist as to whether any intervention should be performed based on a suspected cause because of lacking scientific proof of therapeutic efficacy in many areas. However, a few recommendations for evaluation and management based on current practices are listed below.

Genetic causes

Perform karyotype of parents with family or personal history of genetic abnormalities.

Perform karyotype of the abortus in recurrent cases.

Provide genetic counseling for families with recurrent loss or familial history of genetic disease.

In patients with a high risk for recurrent, chromosomally abnormal conceptus, discuss the options of adoption, gamete donation, and PGD.

Immunologic causes

Perform APLA testing if indicated.

If APLA levels are elevated, counseling with a hematologist and a specialist in maternal fetal medicine is recommended.

Aspirin and heparin therapy may be given to patients who are diagnosed with APS.

Anatomic causes

Imaging may include HSG, hysteroscopy, ultrasonography, and/or MRI.

Surgical correction may be required.

Infectious causes

Cervical cultures should be obtained during the evaluation of infertility.

Empiric antibiotics should be given before invasive testing, such as HSG.

Environmental causes - Encourage life-style changes and counseling for preventable exposures.

Endocrine factors - Perform thyroid-stimulating hormone (TSH) screening in symptomatic patients.

Thrombophilia disorders - Aspirin and heparin therapy may be given for proven diagnoses

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Appendix A

Table A-1 Data collected from a threaten abortion group

Case #	Age	Gestational age	Number of abortion	Hematoma	Loss	PI	RI	PSV
1	36	4	1	1	1	3.2	1.3	10.2
2	26	6	1	1	1	3.1	0.9	15.1
3	33	7	1	1	1	2.9	0.8	20.8
4	29	9	3	1	1	2.1	0.7	30.2
5	22	9	1	1	1	2.1	0.7	30.1
6	40	10	2	1	1	2	0.5	25.6
7	37	10	2	2	2	2	0.4	25.9
8	34	10	2	1	1	2	0.5	25.4
9	31	4	2	1	1	3.1	1.2	101.3
10	41	8	3	1	1	2.2	0.6	20.9
11	35	6	3	1	1	3.1	0.9	15.1
12	32	7	1	1	1	2.9	0.8	22.2
13	19	5	1	1	1	3.3	1	12.5
14	22	5	1	1	1	3.2	1.1	13.3
15	30	8	2	1	1	2.1	0.6	20.7
16	26	6	2	1	1	3	0.9	16.1
17	19	7	3	1	1	2.8	0.8	23.1
18	24	11	1	1	1	2	0.6	28.5
19	36	11	3	1	1	2.1	0.5	29.1
20	33	5	3	1	1	3.3	1.1	24
21	28	8	1	1	1	2.3	0.7	24.5
22	27	13	1	2	2	1.2	0.4	50.3
23	33	14	2	2	2	1.1	0.3	81.9
24	28	16	2	2	2	1.5	0.2	95.1
25	37	8	2	1	1	1.9	0.7	22.5
26	41	7	2	1	1	2	0.7	70.2
27	39	4	1	1	1	3.4	1.2	16.2
28	29	6	1	1	1	2.9	0.9	14.2
29	21	5	1	1	1	3	1	22.1
30	19	7	1	1	1	2.8	0.6	28.5
31	39	9	3	1	1	1.9	0.7	33.9
32	24	8	3	1	1	1.7	0.8	24.2
33	40	12	2	2	2	1	0.5	48.3
34	23	9	1	1	1	1.8	0.7	25.2
35	28	16	1	2	2	0.7	0.2	100
36	41	5	3	2	2	3.4	1	15.2
37	33	8	2	1	1	2.2	0.8	29.8
38	28	7	3	1	1	2.5	0.8	26.2
39	42	6	2	1	1	3.2	0.9	13.2
40	34	11	1	2	2	2.2	0.4	30.9

41	37	10	1	2	2	2.3	0.5	30.1
42	25	10	1	2	2	2.3	0.5	28.2
43	18	13	3	2	2	1	0.3	70.9
44	29	8	2	1	1	2.2	0.7	26.1
45	18	14	2	1	1	0.8	0.2	80.9
46	22	9	2	1	1	2.1	0.7	35.1
47	32	7	2	1	1	2.4	0.8	26.2
48	29	4	3	1	1	3.4	1.2	10.3
49	32	6	3	1	1	2.8	0.9	14.2
50	27	11	1	1	1	2.1	0.5	40.7
51	31	9	1	1	1	2	0.7	35.2
52	37	7	1	1	1	2.3	0.8	22.6
53	38	12	2	2	2	0.8	0.4	50.1
54	18	13	2	2	2	0.7	0.4	69.2
55	21	6	2	1	1	3.1	0.8	15.1
56	19	7	2	1	1	0.9	0.6	25.2
57	23	11	2	2	2	1.9	0.4	41.2
58	28	5	2	1	1	3	1.1	14.3
59	30	12	2	2	2	0.9	0.3	50.5
60	27	16	2	2	2	0.5	0.2	100.3
61	19	8	1	1	1	3.2	1.1	90
62	22	10	1	1	1	0.8	0.9	56.32
63	39	14	1	1	1	0.9	0.4	81.34
64	41	8	2	2	2	2.1	0.8	80
65	27	12	2	1	1	3.5	1.2	43.61
66	25	11	1	1	1	3.1	0.6	32.89
67	32	16	2	1	1	1.4	0.7	73.9
68	37	14	1	2	2	1.9	0.4	29.96
69	38	8	1	1	1	0.6	1.1	95.13
70	23	10	1	1	1	0.8	0.8	75.34
71	31	12	1	1	1	1.7	0.7	100
72	19	16	2	2	2	1.1	0.3	34.76
73	28	14	2	2	2	0.8	0.5	70.34
74	37	8	2	1	1	3.1	0.9	60.22
75	25	10	2	1	1	2.7	1.2	42.11
76	25	14	3	1	1	1.9	0.5	90.45
77	19	12	1	2	2	2.6	0.9	50.32
78	40	10	2	1	1	0.7	1	43.67
79	21	8	1	1	1	0.9	1.2	98.4
80	19	10	2	2	2	2.2	0.6	45.6
81	39	14	2	1	1	0.7	2.7	100
82	24	7	1	1	1	0.3	0.9	73.9
83	40	9	1	1	1	3.1	0.5	95.3
84	23	8	2	1	1	3.4	1.3	42.7
85	28	10	2	1	1	0.7	1.4	85.3
86	40	6	2	1	1	3.2	0.28	46.9
87	37	12	1	2	2	2.9	0.71	56.3
88	34	14	1	2	2	2.7	0.28	93.6

89	31	6	1	1	1	0.6	0.65	37.4
90	41	8	2	1	1	3	1.2	92.7
91	35	16	1	2	2	2.1	0.6	72.7
92	32	7	2	1	1	3.5	0.43	37.8
93	19	10	1	1	2	0.76	0.9	78.3
94	22	6	2	1	1	2.8	0.63	99
95	30	16	1	2	2	0.71	0.7	67.4
96	26	8	1	1	1	2.6	0.51	23.8
97	19	14	1	2	2	0.5	0.34	69.2
98	24	6	2	1	1	2.7	0.28	66.3
99	36	16	1	2	2	3.5	0.43	80.50
100	33	8	2	2	2	2.3	0.4	91.2

Table A-2 data collected from non pregnant women

Case #	PI	RI	PSV
1	0.97	3.72	29.91
2	0.73	5.9	35.7
3	0.87	2.19	32.46
4	0.94	4.27	45.68
5	0.52	6.69	65.79
6	0.86	2.02	35.61
7	0.78	1.81	25.2
8	0.79	1.87	58.75
9	0.99	2.98	55.45
10	0.74	1.85	74.78
11	0.7	1.32	38.75
12	0.79	0.48	43.3
13	0.72	3.74	46.33
14	0.98	1.81	38.82
15	0.81	1.88	91.05
16	0.79	2.72	79.32
17	0.93	1.87	24.77
18	0.91	1.85	17.08
19	0.74	1.92	37.92
20	0.71	0.95	68.71
21	1.9	1.72	50.21
22	0.75	0.85	37.92
23	0.72	1.61	74.78
24	0.78	3.31	25.2
25	0.77	0.99	50.22
26	0.21	3.2	95.21
27	0.91	4.25	65.52
28	0.93	1.5	80.28
29	0.53	1.23	25.83
30	0.72	6.9	38.21
31	0.84	1.83	17.32
32	0.73	3.72	55.41
33	0.82	5.9	74.71
34	0.52	2.18	38.67
35	0.78	4.25	92.05
36	0.81	6.2	24.77
37	1.9	1.81	17.08
38	0.93	2.91	37.92
39	0.54	1.34	50.21
40	0.77	1.87	74.61
41	1.1	0.41	25.2
42	0.67	3.74	57.33
43	0.43	1.82	87.1
44	0.76	1.84	96
45	0.82	2.71	87

46	0.54	0.94	18
47	1.2	1.12	37.6
48	0.85	0.85	21.2
49	0.91	3.2	35.5
50	0.49	1.56	95
51	0.82	2.55	45.30
52	0.91	2.80	70.20
53	0.84	1.13	22.2
54	1.1	0.84	36.7
55	0.53	2.72	86
56	0.81	1.89	97.2
57	0.77	1.34	18.8
58	0.4	0.42	56.12
59	0.68	3.72	74.41
60	1.2	4.22	92.41
61	0.54	2.03	35.93
62	0.76	3.45	65.81
63	0.94	5.91	59.39
64	0.82	6.32	75.37
65	1.9	3.27	39.78
66	0.72	0.78	17.66
67	0.93	0.89	51.36
68	0.52	2.66	26.17
69	0.88	5.1	49.41
70	0.98	3.76	67.32
71	0.22	2.76	70.52
72	0.12	3.91	82.91
73	0.45	1.95	26.98
74	0.9	2.81	24.28
75	0.49	3.34	90.28
76	0.67	4.9	67.27
77	0.19	6.1	80.31
78	1.2	2.6	55.34
79	0.92	0.96	61.37
80	0.55	0.86	38.31
81	0.79	3.71	93.63
82	0.22	5.2	43.71
83	0.92	2.8	37.41
84	1.8	1.48	57.41
85	1.4	0.83	78.63
86	0.78	2.87	30.15
87	0.87	1.62	72.42
88	0.45	1.76	69.21
89	0.99	1.65	85.51
90	0.1.7	1.9	75.91
91	0.25	0.54	28.31
92	0.94	2.23	78.03
93	0.44	2.41	43.82

94	0.56	3.98	83.27
95	0.98	4.12	68.31
96	0.72	4.18	29.81
97	0.62	5.23	47.82
98	1.3	1.08	71.5
99	1.7	3.26	28.54
100	0.76	1.84	96

Table A-3 data collected from elective abortion women

Case #	PI		RI		PSV		yolk sac
	Before	After	Before	After	Before	After	
1	1.27	0.43	0.3	0.4	15.1	32.46	1
2	0.33	1.97	0.2	0.2	21.8	54.68	2
3	1.9	0.33	0.32	0.6	30.9	35.61	1
4	0.92	0.54	0.3	0.96	95.7	58.75	2
5	1.52	1.85	0.26	0.69	14.65	55.23	2
6	1.63	0.54	0.42	0.85	70.5	74.9	2
7	1.25	0.53	0.5	0.71	34.8	44.31	1
8	1.71	0.71	0.61	0.78	56.3	91.05	1
9	1.4	0.4	0.4	0.81	43.4	24.75	1
10	0.72	0.61	0.2	0.54	34.9	68.23	1
11	0.62	0.59	0.22	0.27	14.89	37.92	1
12	0.54	0.91	0.61	0.62	28.21	26.2	2
13	1.1	0.12	0.19	0.83	22.8	86.52	2
14	1.23	1.42	0.08	0.77	56.2	80	1
15	0.81	0.59	0.32	0.64	93.8	98.05	1
16	0.23	0.75	0.21	0.4	46.2	17.78	1
17	0.25	1.82	0.46	0.95	23.9	79.54	1
18	0.28	0.49	0.31	0.29	67.5	38.54	1
19	0.93	0.65	0.29	0.89	32.8	18.98	1
20	1.62	1.86	0.6	0.24	91.6	18.41	2
21	1.01	0.86	0.34	0.62	44.80	52.10	1
22	1.02	0.65	0.33	0.82	44.90	55.10	1
23	0.34	0.68	0.23	0.26	91.5	18.4	1
24	0.43	0.83	0.88	0.88	32.7	28.99	1
25	0.19	0.57	0.3	0.3	67.8	83.55	1
26	0.92	0.52	0.94	0.93	23.9	79.43	1
27	0.87	0.86	0.5	0.95	46.4	17.78	1
28	0.28	1.89	0.63	0.81	93.2	98.05	1
29	1.51	1.9	0.76	0.72	56.9	80	1
30	1.01	0.42	0.82	0.65	22.7	85.51	1
31	1.52	1.92	0.38	0.53	28.12	27.23	1
32	1.24	1.4	0.62	0.4	14.89	37.91	1
33	1.05	0.87	0.26	0.64	35.9	68.43	2
34	1.64	0.73	0.27	0.77	55.8	25.91	2
35	1.43	0.59	0.54	0.82	34.6	68.43	2
36	1.61	1.85	0.82	0.63	70.5	24.7	2
37	1.22	0.66	0.78	0.28	14.5	91.06	1
38	1.45	1.81	0.87	0.55	95.3	44.32	1
39	1.32	0.56	0.61	0.8	31.9	47.89	2
40	1.7	1.86	0.5	0.78	22.8	55.67	1
41	1.17	0.49	0.27	0.71	15.9	58.71	1
42	1.69	0.93	0.5	0.42	44.8	35.63	1
43	0.65	0.49	0.34	0.27	26.4	55.67	1

44	0.56	1.84	0.25	0.32	89.4	32.67	1
45	0.55	1.82	0.3	0.34	90.1	27.28	2
46	1.2	1.67	0.31	0.21	65.7	66.65	2
47	1.03	1.23	0.21	0.43	32.5	87.9	1
48	0.91	0.75	0.31	0.6	65.5	54.3	1
49	0.87	0.57	0.15	0.3	87.5	87.8	1
50	0.23	0.87	0.32	0.31	61.7	57.5	1
51	0.29	1.7	0.54	0.79	61.6	59.3	1
52	0.43	1.64	0.54	0.25	92.4	45.9	1
53	0.29	0.58	0.62	0.33	88.1	66.4	1
54	0.53	0.95	0.67	0.39	51.4	74.9	1
55	0.65	0.48	0.12	0.45	85.3	91.3	1
56	0.75	1.43	0.19	0.41	74.3	45.8	1
57	1.63	1.04	0.21	0.81	66.2	62.9	2
58	1.23	0.6	0.65	0.63	33.1	44.5	2
59	1.05	1.24	0.55	0.55	60.2	69.4	2
60	1.22	0.55	0.78	0.49	81.4	58.3	2
61	0.93	0.81	0.51	0.91	77.9	71.5	2
62	0.39	0.72	0.41	0.83	90.2	65.9	1
63	0.19	0.58	0.32	0.99	67.8	27.4	1
64	1.4	0.62	0.34	0.51	43.6	38.4	1
65	1.2	0.12	0.9	0.62	78.3	31.9	2
66	0.91	0.92	0.17	0.75	65.6	69.4	1
67	0.87	0.89	1.1	0.19	71.43	69.3	1
68	1.7	1.24	0.9	0.44	66.3	28.9	1
69	1.3	1.82	0.91	0.29	67.23	90.4	1
70	0.68	0.93	0.38	0.45	90	43.6	2
71	0.59	0.34	0.51	0.94	23.6	88.2	1
72	0.43	0.47	0.12	0.8	77.12	65.7	1
73	0.55	0.28	0.55	0.81	66.3	77.4	1
74	0.54	1.8	0.98	0.41	21.5	99.2	1
75	0.87	0.83	0.58	0.62	88.3	30.33	1
76	0.35	0.71	0.44	0.34	29.6	27.9	1
77	1.23	0.54	0.39	0.34	54.2	31.7	1
78	1.9	1.3	0.78	0.59	66.3	66.2	1
79	0.68	1.8	0.43	0.19	91.5	71.2	2
80	0.72	0.76	0.34	0.24	44.2	63.9	1
81	1.45	0.66	0.71	0.41	54.7	55.1	1
82	1.32	0.29	0.66	0.9	34.8	26.3	2
83	0.93	0.27	0.61	0.51	54.1	22.8	1
84	0.54	0.54	0.51	0.23	90.4	75.9	1
85	1.56	0.49	0.24	0.66	34.2	82.2	1
86	0.69	1.87	1.4	0.31	90.6	77.2	2
87	0.59	1.83	0.19	0.14	63.5	90.4	1
88	0.65	0.75	0.4	0.94	73.9	85.4	2
89	1.2	0.59	0.54	0.62	71.4	91.5	1

90	0.79	1.41	0.38	0.92	34.4	84.6	1
91	1.65	1	0.9	0.75	49.5	27.9	1
92	1.09	0.13	0.34	0.37	61.7	34.1	1
93	1.63	0.72	0.19	0.56	91.5	89.4	1
94	0.68	0.54	0.21	0.91	23.9	74.3	2
95	0.63	1.84	0.98	0.77	61.9	26.2	2
96	1.31	0.54	0.58	0.12	86.4	77.1	2
97	0.71	0.33	0.52	0.16	68.4	90.2	2
98	0.93	1.97	1.02	0.34	87.3	25.8	2
99	0.28	0.44	0.67	0.91	44.6	54.8	1
100	1.01	0.86	0.34	0.62	44.80	52.10	1

Table A-4 data collected from a control group

Case #	PI	RI	PSV
1	2.8	0.59	65.9
2	3	1	60.4
3	2.5	0.7	70.2
4	2.1	0.8	80.3
5	0.8	0.3	110.5
6	0.5	0.2	120.1
7	3.2	1.2	20.5
8	2	0.8	82.3
9	0.7	0.4	100.3
10	0.6	0.6	100
11	0.6	0.6	90.9
12	2	0.8	80.7
13	2.1	0.8	80.8
14	2	0.8	80.1
15	2.5	0.7	72.1
16	2.4	0.7	73.4
17	2.4	0.7	74
18	3.1	1.1	61.2
19	3.1	1	62.5
20	3	1.1	60.9
21	3.2	1.2	21.2
22	3.2	1.2	22.5
23	3.1	1.2	20.3
24	2.4	0.8	68.9
25	2.4	0.8	67.6
26	2.4	0.8	68.1
27	2.4	0.8	69.2
28	2.5	0.8	68.4
29	0.6	0.6	99.9
30	0.6	0.6	100.2
31	0.6	0.6	100.1
32	2.8	0.8	64.8
33	2.7	0.9	64.3
34	2.8	0.9	64.5
35	2.1	2.8	65.5
36	0.8	2.4	67.8
37	0.5	2.3	67.3
38	1.3	3	22.1
39	0.9	3.1	100
40	1.5	0.6	83.14
41	2.0	1.2	71.3
42	2.30	2.10	83.00
43	2.9	1	76.9
44	3.5	0.8	90.2
45	2.7	2.5	45.8

46	3.2	3	53.77
47	2.6	2.3	77.6
48	0.9	2.9	54.6
49	1.5	0.8	87.3
50	2.4	0.6	100
51	2.6	0.9	65.87
52	0.8	1.9	79.4
53	3.6	1.5	80.1
54	2.1	1.2	56.3
55	3.8	0.9	75.7
56	3.1	0.8	80.5
57	0.9	2.5	23.21
58	0.7	3.55	98.6
59	3.8	3.1	90
60	2.8	0.59	65.9
61	3	1	60.4
62	2.5	0.7	70.2
63	2.1	0.8	80.3
64	0.8	0.3	110.5
65	0.5	0.2	120.1
66	3.2	1.2	20.5
67	2	0.8	82.3
68	0.7	0.4	100.3
69	0.6	0.6	100
70	0.6	0.6	90.9
71	2	0.8	80.7
72	2.1	0.8	80.8
73	2	0.8	80.1
74	2.5	0.7	72.1
75	2.4	0.7	73.4
76	2.4	0.7	74
77	3.1	1.1	61.2
78	3.1	1	62.5
79	3	1.1	60.9
80	3.2	1.2	21.2
81	3.2	1.2	22.5
82	3.1	1.2	20.3
83	2.4	0.8	68.9
84	2.4	0.8	67.6
85	2.4	0.8	68.1
86	2.4	0.8	69.2
87	2.5	0.8	68.4
88	0.6	0.6	99.9
89	0.6	0.6	100.2
90	0.6	0.6	100.1
91	2.8	0.8	64.8
92	2.7	0.9	64.3
93	2.8	0.9	64.5

94	2.1	2.8	65.5
95	0.8	2.4	67.8
96	0.5	2.3	67.3
97	1.3	3	22.1
98	0.9	3.1	100
99	1.5	0.6	83.14
100	3.2	1.2	21.2
101	0.78	0.02	60
102	1.2	0.6	46.48
103	0.9	0.74	35.61
104	0.73	0.62	55.45
105	0.81	0.9	74.78
106	0.77	0.57	38.75
107	1.1	0.6	91.06
108	0.91	0.56	79.3
109	1.3	0.7	24.73
110	0.81	0.45	58.75
111	0.67	0.71	17.8
112	0.79	0.71	37.92
113	1.1	0.63	68.79
114	1.3	0.39	50.29
115	0.97	0.43	37.92
116	0.74	0.61	74.77
117	1.15	0.8	25.78
118	0.73	0.49	25.21
119	0.9	0.72	29.91
120	1.28	0.73	35.73
121	1.1	0.49	46.6
122	0.86	0.9	35.66
123	1.31	0.6	58.71
124	0.65	0.5	38.92
125	0.72	0.56	43.44
126	0.72	0.49	90.43
127	1.2	0.72	74.68
128	0.69	0.65	55.8
129	0.77	0.72	32.25
130	1.32	0.6	68.89
131	0.94	0.82	50.48
132	0.73	0.72	70.22
133	1.2	0.44	37.77
134	0.78	0.67	41.54
135	0.68	0.73	92.74
136	1.21	0.67	67.81
137	0.73	0.69	66.9
138	0.78	0.56	33.67
139	0.66	0.7	32.24
140	1.32	0.68	55.21
141	0.87	0.51	57.41

142	1.2	0.97	75.43
143	1.3	0.65	78.24
144	0.92	0.78	90.4
145	0.74	0.71	92.29
146	1.25	0.41	45.72
147	0.98	0.29	47.76
148	1.29	0.82	42.13
149	1.11	0.59	37.98
150	0.78	0.89	35.66
151	0.65	0.54	58.15
152	0.83	0.63	56.41
153	1.28	0.71	59.33
154	0.94	0.61	36.31
155	1.21	0.8	37.19
156	0.78	0.5	45.25
157	0.83	0.92	49.23
158	0.75	0.56	29.81
159	0.92	0.72	25.6
160	1.19	0.34	27.23
161	1.04	0.51	73.37
162	0.79	0.59	71.8
163	0.67	0.39	67.13
164	0.71	0.68	32.92
165	0.85	0.67	37.51
166	0.54	0.43	50.34
167	1.21	0.5	53.81
168	0.81	0.87	68.36
169	1.03	0.49	69.32
170	0.54	0.82	38.73
171	1.07	0.77	36.44
172	1.21	0.98	17.9
173	0.73	0.65	58.23
174	0.81	0.63	57.13
175	1.2	0.65	24.8
176	0.9	0.9	25.8
177	1.05	0.74	33.9
178	0.85	0.72	38.19
179	0.66	0.68	79.29
180	1.12	0.54	77.28
181	1.03	1.1	94.14
182	0.76	0.71	91;4
183	0.82	0.92	37.18
184	0.86	0.7	74.36
185	1.13	0.67	55.9
186	1.31	0.58	54.24
187	1.18	0.72	36.14
188	0.79	0.73	83.25
189	1.16	0.85	47.72

190	1.3	0.88	48.32
191	0.73	0.73	69.13
192	0.62	0.55	48.65
193	0.59	0.56	87.24
194	1.17	0.34	19.94
195	1.3	0.87	92.16
196	1.1	0.68	57.53
197	0.62	0.79	55.4
198	0.82	0.71	39.84
199	0.64	0.46	96.16
200	0.73	0.72	70.22
201	1.11	0.44	87.9
202	0.61	0.61	24.8
203	1.09	0.52	19.6
204	0.51	0.63	34.3
205	0.67	0.41	29.3
206	0.71	0.53	65.9
207	0.82	0.6	65.1
208	0.83	0.48	18.5
209	0.98	0.4	34.1
210	0.6	0.66	43.9
211	0.78	0.42	43.8
212	0.61	0.63	85.2
213	1.24	0.55	100.7
214	0.71	0.5	98.5
215	1.28	0.64	92.7
216	0.73	0.44	77.3
217	1.45	0.6	62.8
218	1.22	0.4	40 .6
219	0.66	0.61	34.4
220	0.81	0.59	27.2
221	1.36	0.53	55.05
222	1.20	0.60	60.20
223	1.08	0.44	30.21
224	0.74	0.43	55.11
225	1.23	0.65	34.93
226	0.71	0.52	50.23
227	0.82	0.41	86.3
228	0.93	0.66	20.4
229	0.62	0.42	65.7
230	0.81	0.65	18.7
231	0.9	0.61	34.4
232	0.65	0.53	54.9
233	0.81	0.44	85.6
234	0.66	0.64	100.1
235	0.71	0.45	89.5
236	0.93	0.48	92.13
237	0.69	0.63	40.65

238	0.64	0.47	28.6
239	0.86	0.44	35.19
240	0.75	0.63	87.4
241	1.07	0.66	19.5
242	1.07	0.47	66.5
243	0.87	0.49	98.16
244	0.65	0.67	78.3
245	0.59	0.58	41.8
246	0.79	0.66	25.6
247	0.62	0.47	28.3
248	0.95	0.61	93.8
249	1.08	0.66	77.4
250	0.7	0.44	19.7
251	0.76	0.47	87.23
252	0.63	0.49	84.2
253	0.81	0.46	29.5
254	1.04	0.51	98.65
255	0.84	0.48	54.9
256	0.61	0.58	90.4
257	0.73	0.66	19.6
258	0.83	0.44	99.1
259	0.91	0.67	67.5
260	1.04	0.48	23.9
261	0.89	0.61	97 21
262	0.61	0.46	90.65
263	1.05	0.45	32.49
264	0.84	0.44	80.3
265	0.94	0.67	78.21
266	0.61	0.66	78.45
267	1.1	0.61	34.55
268	1.02	0.62	100.3
269	0.62	0.46	65.15
270	0.9	0.44	20.76
271	0.79	0.66	87.41
272	0.61	0.48	56.04
273	1.02	0.44	88.6
274	1.03	0.49	67.3
275	0.85	0.68	29.6
276	0.91	0.66	37.9
277	1.02	0.63	28.7
278	1.08	0.44	18.7
279	0.81	0.62	81.9
280	0.76	0.49	53.66
281	1.11	0.44	34.21
282	0.76	0.49	81.76
283	0.82	0.47	18.28
284	1.04	0.66	99.31
285	0.72	0.44	27.43

286	0.64	0.65	56.61
287	0.62	0.61	90.8
288	0.74	0.65	26.1
289	0.65	0.65	64.88
290	1.01	0.44	62.67
291	0.76	0.48	86.3
292	0.61	0.66	94.7
293	0.61	0.45	67.8
294	0.85	0.49	57.53
295	1.09	0.46	86.24
296	1.01	0.66	26.84
297	0.62	0.44	87.23
298	0.71	0.47	55.29
299	0.79	0.66	97.13
300	1.30	0.73	85.05

Information about GE Medical System Loogic TM 5

Applications

- Abdominal to see most of abdominal organs gall bladder ,liver , kidneys,ect___
- Obstetrical to detect pregnancy in all trimesters ,detect pregnancies and fetal abnormalities
- Gynecological to see uterus and ovaries shape, congenital anomalies and blood flow.
- Cardiac ventricles atriums vales .
- Musculoskeletal to see muscles defects
- Vascular to detect blood flow using Doppler shift
- Urological to scan urinary system kidneys ureters and urinary bladder
- Small Parts and Superficial to see thyroid gland ,breast and testecles.
- Pediatric and Neonatal to see neonates anamoliese.g hydrocephalic spina pefida
- Tran cranial to see CSF,hydrocephalus

3-3 Scanning Methods

- Electronic Sector
- Electronic Convex
- Electronic Linear

3-4 **Transducer Types**

- Sector Phased Array
- Convex Array

- Micro convex Array
- Linear Array

3-5 Operating **Modes**

- B-Mode
- M-Mode
- Anatomical M-Mode
- Color Flow Mode (CFM)
- Power Doppler Imaging (PDI) with
- Directional Map
- PW Doppler with High PRF
- M-Color Flow Mode
- Steerable CW Doppler (TBD)
- Dedicated CW Doppler (TBD)

3-6 **Standard Features**

- State-of-the-art User Interface with High Resolution 6.4 inch Color LCD Touch Panel,
- 40 GB Hard Disk with over 25 GB of image storage
- Without compression:

o Raw DICOM: >4,000 images,

o DICOM: > 19,000 images

o Secondary capture: >30,000 images,

- With JPG compression:,

- Raw DICOM: >4,800 images
- DICOM: >220,000 images
- Secondary capture: >330,000, images

- 970 Frames (60 sec) CINE Memory (192MB)
- Real-time Triplex Mode at any Depth and PRF
- Automatic Optimization
  - Auto Tissue Optimization: ATO
  - Auto Spectrum Optimization: ASO
- ACE
- Tissue Harmonics
- Virtual Convex
- Patient Information Database
- Image Archive on Hard Drive and CD
- Vascular Calcs
- Cardiac Calcs
- OB Calcs
- Fetal Trending
- Multi Gestational Calcs
- Hip Dysplasia Calcs
- Gynecological Calcs
- Urological Calcs
- Renal Calcs

- Real-time Auto Doppler Calculations
- TruAccess, Raw Data Processing

3-7 **Options**

- Additional probe port
- DICOM 3.0 Connectivity
- InSite . Capability
- Physio Input Panel for ECG, PCG, Aux
- ECG Cable
- CW Doppler
- Anatomical M-Mode
- LOGIQView
- Easy 3D (Baby Face)
- Advanced 3D, with 3D Landscape
- Image archive on MOD
- 3-Pedal Foot Switch, with
- Programmable Functionality

TruDigital Architecture represents a fundamentally different way of acquiring and viewing ultrasound images. The software-intensive platform creates a flexible imaging environment that is also easy to upgrade. LOGIQ 5 features the same TruScan Architecture used in GE's leadership products – the LOGIQ 9 and LOGIQ 7.

3-8Live scanning techniques to stored images.

With TruDigital raw data digital processing, you can now apply live scan techniques to image data long after your patient leaves your office. With an onscreen image clipboard and flexible display, formatting your workflow and DICOM information management is simple and fast. TruAccess stores your data in its original fidelity to help prevent the loss of data or a reduction in image quality. For example, if you forget to take an M-mode with the patient in the office. No problem. Just recall a cine loop image of the heart and perform an M-mode at a later time. This is just one of the many ways TruDigital can benefit you in your daily tasks.

TruDigital also provides image flexibility – allowing stored image optimization and measurement such as:

- Overall B-mode gain – dynamic range and gray scale maps
- Overall Doppler gain – baseline shift, sweep speed and inverted spectral wave form
- Tru3D – 3D processing and reconstruction from a stored cine loop

3-9 Digital Anatomic M-Mode:

Conventional Analog and "Quasi" Digital ultrasounds require users to create, optimize, freeze, measure, label, and print cardiology M-Mode sweeps in real time. This works in human medicine, where patients are, well, human. With animals, this is of course nearly impossible. Animals move. Time "on patient" is limited. Animals have an infinite number of anatomic size and conformation combinations. It is unlikely that most fixed-plane views in animals will anatomically align for an accurate M-Mode. The solution: Anatomic M-Mode, a revolutionary new technology from GE Medical Systems. Capture an entire Apex

to Base cardiology data set using Raw Digital Clips in under five minutes. Create, align, and measure M-Modes in multiple planes, adjusting for anatomical variations in organ alignment. Be accurate, be efficient, be TruDigital. Only with Anatomic M-Mode from GE Medical Systems and Sound Technologies.

3-10 Features:

LOGIQ 5 was designed by ultrasound users for ultrasound users. As a result, it features dramatic ergonomic improvements that help combat repetitive stress injuries. This improved work environment increases job satisfaction – which ultimately enhances the patient

- Exclusive Raw Data Digital acquisition and storage
- Color Doppler, Spectral Doppler, B, M, Triplex, 3-D
- 150+ Frames per Second True Digital imaging
- All digital video clip and still image capture (4,000)
- On-board patient, image and reporting archive
- CD-ROM disk burner included, plus PCMCIA and USB
- Raw Data manipulation on image recall for Post Exam:
- Anatomic M-mode creation and adjustment
- Gain, magnification, and colorization control
- Playback speed, sweep speed, angle, baseline, and more…
- 3-D Digital processing and manipulation
- Clip and still measure-annotate-enhance-store new
- DICOM 3.0 capable, plus VetPACS all Digital interfacing…

Appendix B

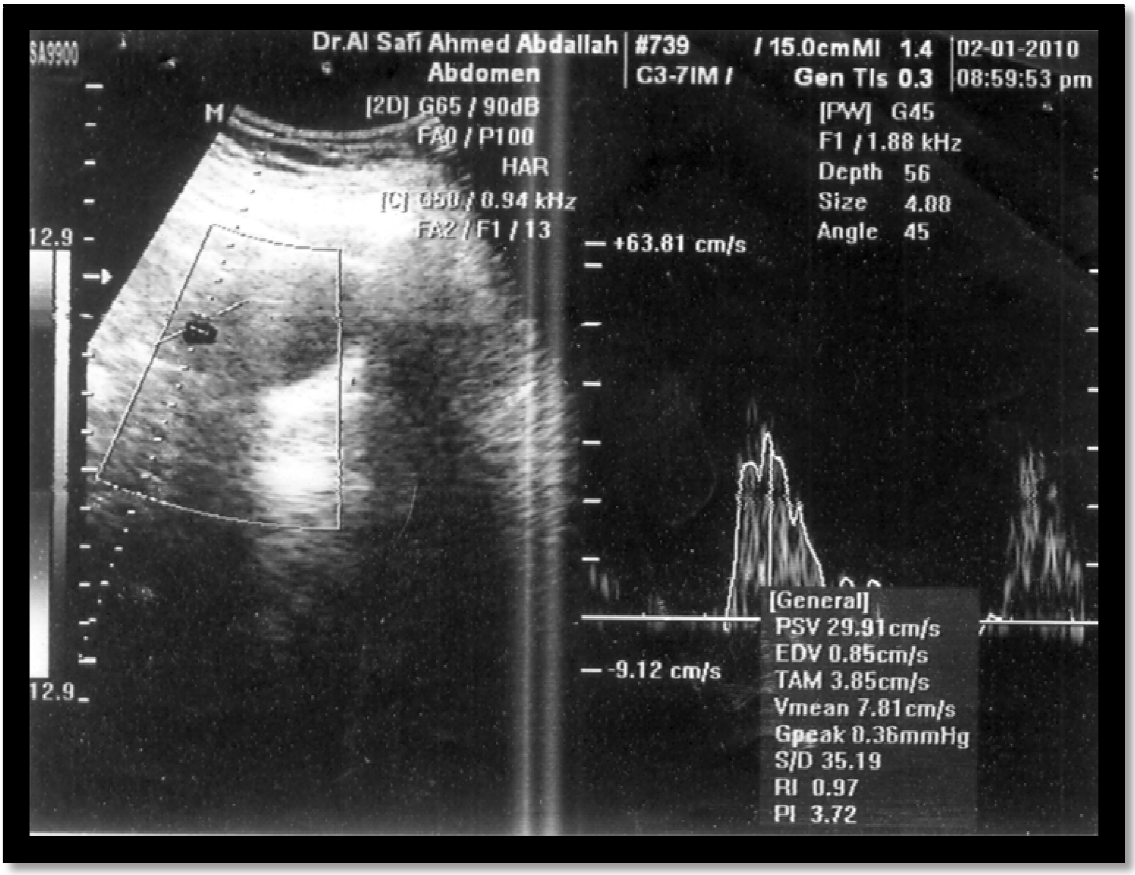


Image (1)25 years old lady complete abortion with a history of (RPL)

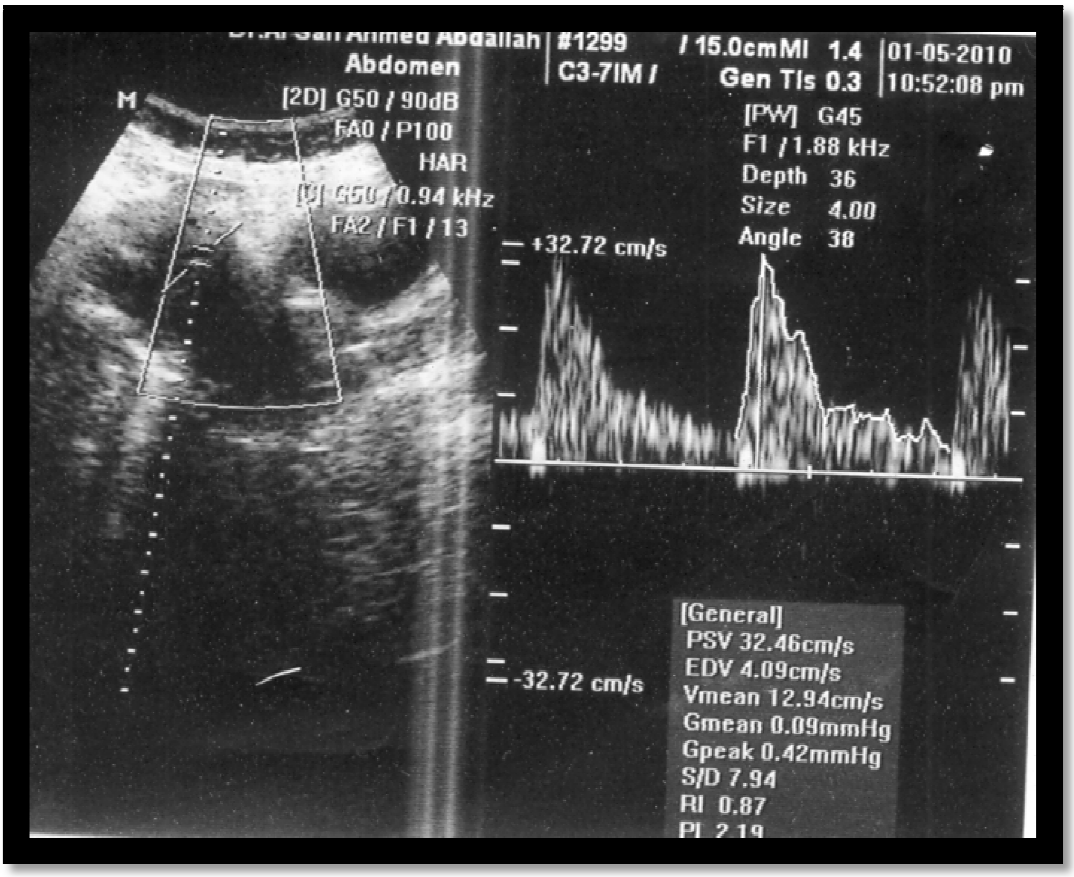


Image (2) 32 years old women with a history of (RPL) color Doppler scan shows complete abortion.

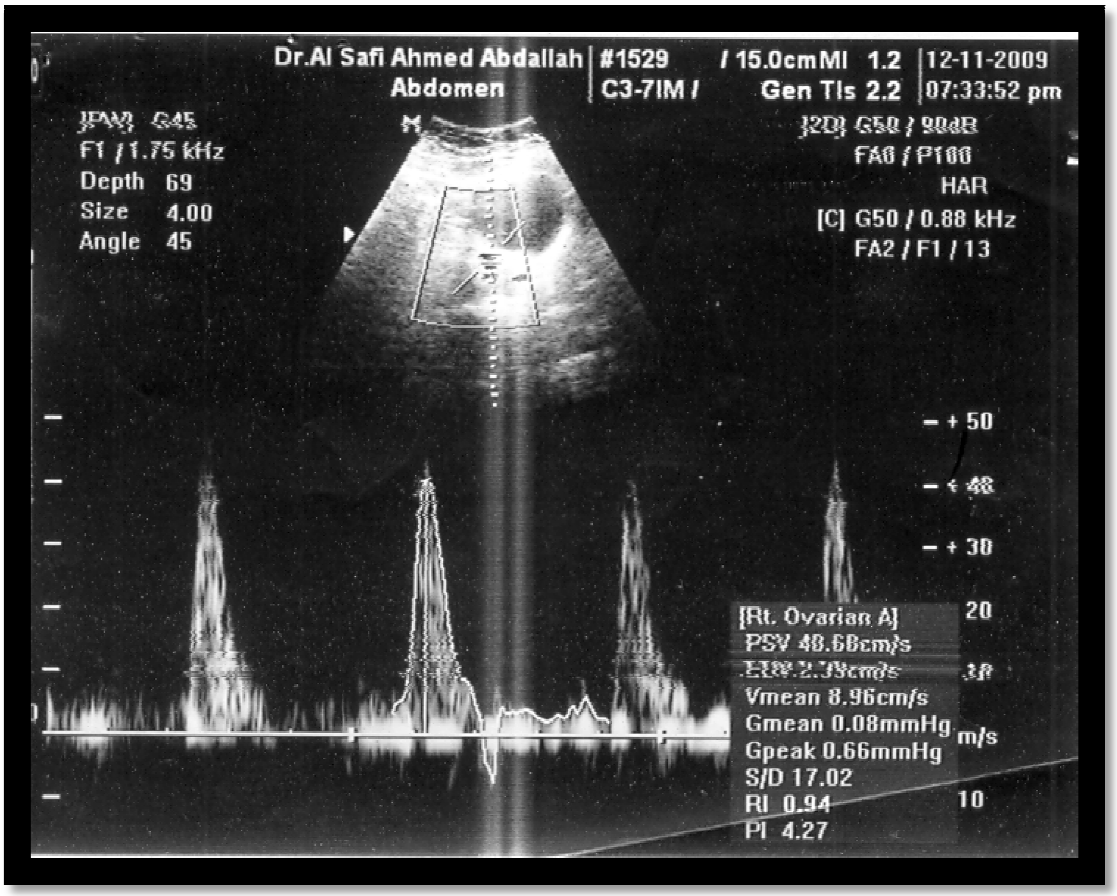


Image (3) Sagittal abdominal color Doppler scan for uterine artery shows complete abortion this patient Has a history of recurrent abortion.

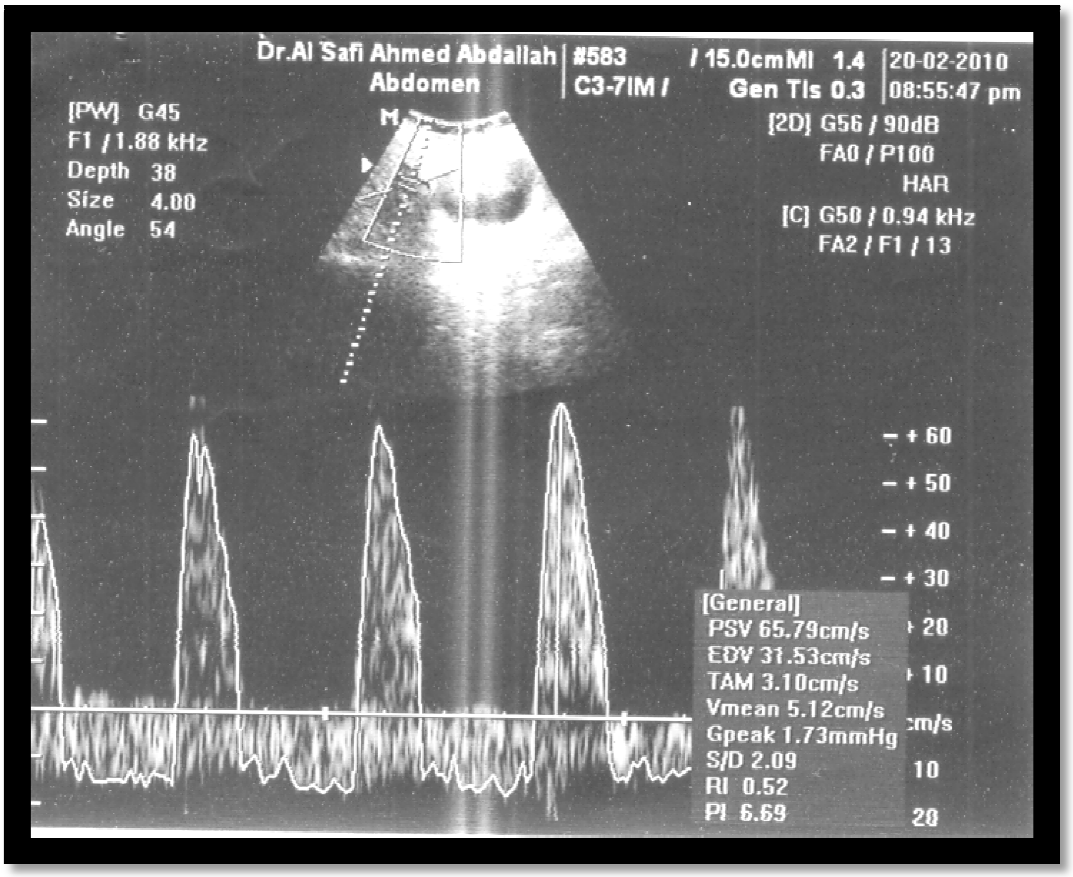


Image (4)Color Doppler scan for a 41 patient with a history o(f RPL) the Sagittal abdominal scan shows a complete abortion

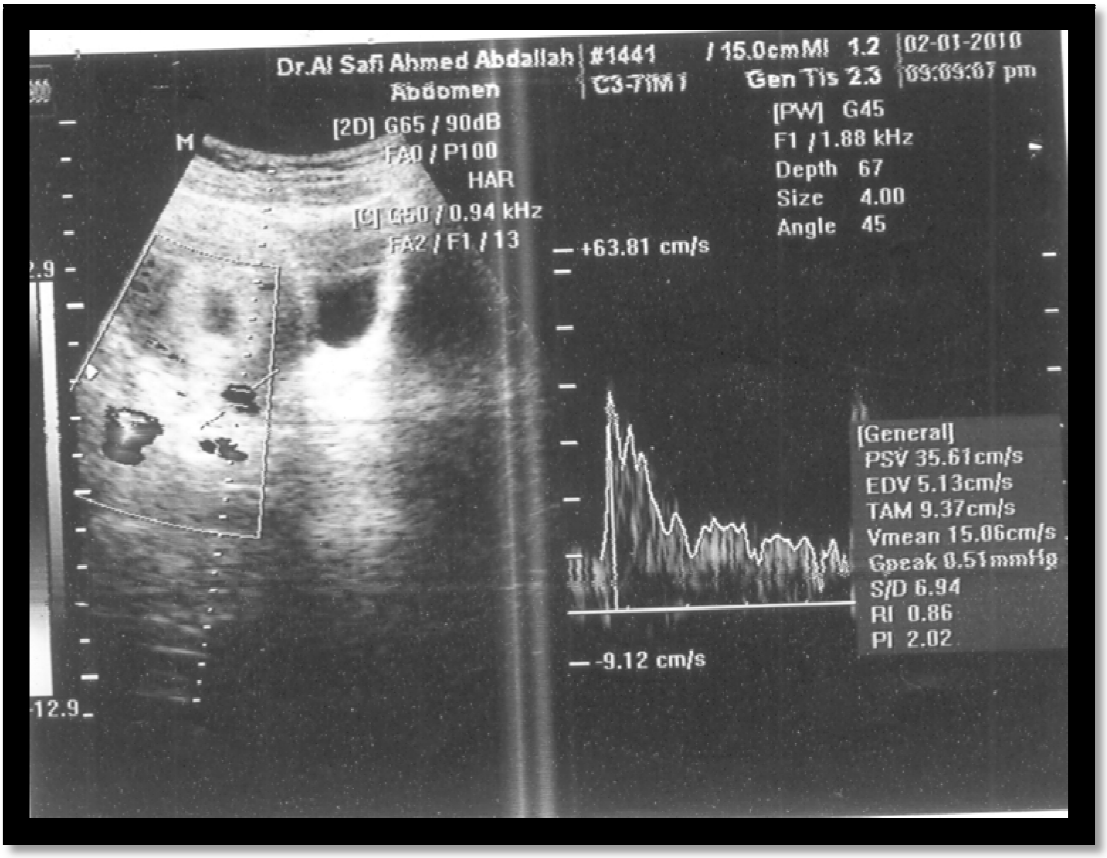


Image (5) A39 pregnant patient with a history of (RPL) the abdominal color Doppler scan shows threatened abortion.

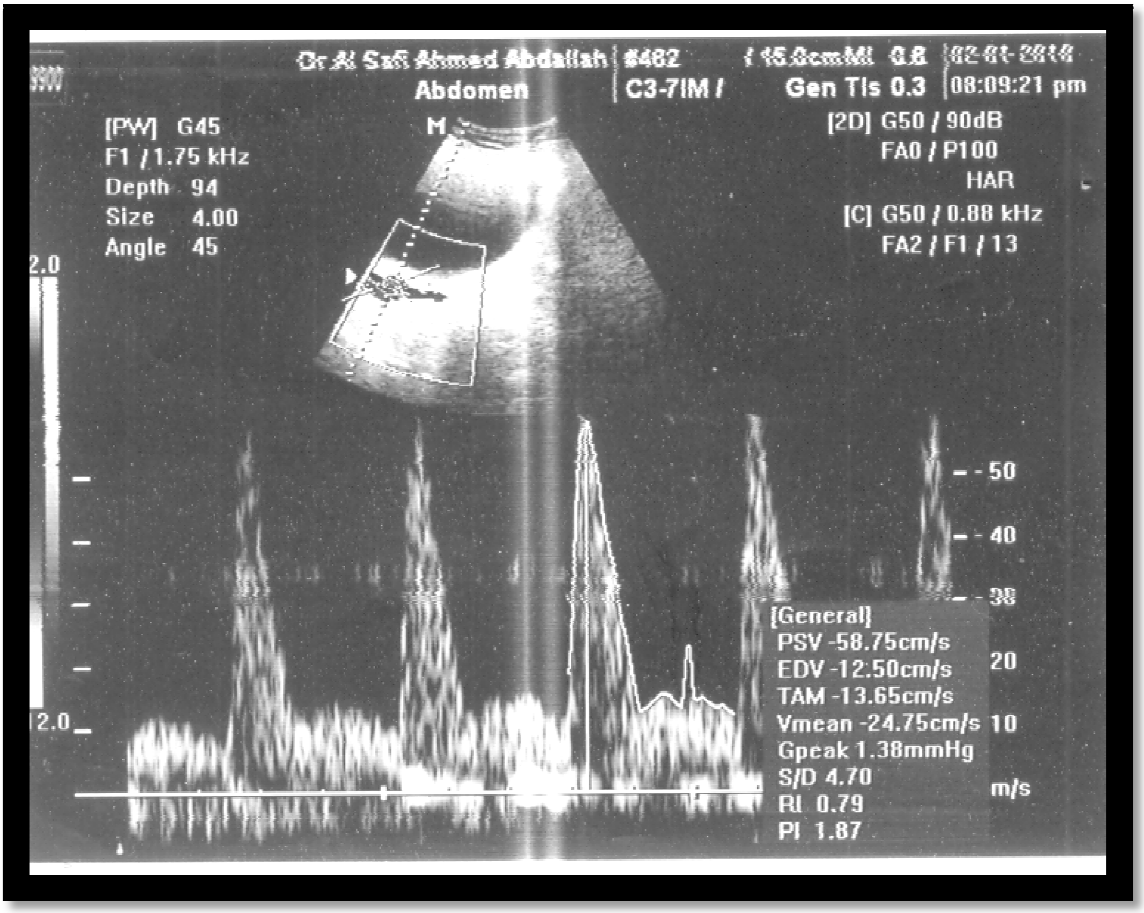


Image (6) Color Doppler scan for a 24 years old lady (RPL) .The Sagittal abdominal scan shows complete abortion.

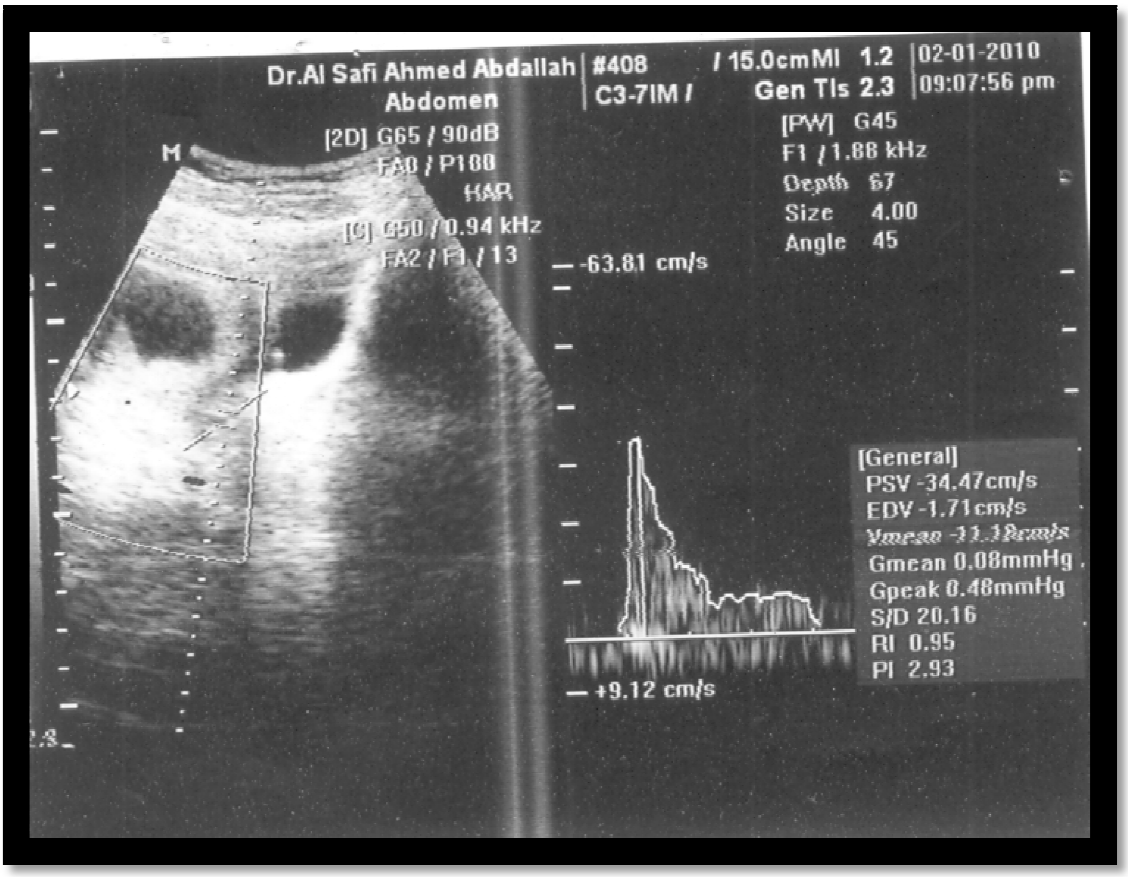


Image (7) Sagittal abdominal scan of the uterus for 21 years old patient with a history of (RPL)

Showing incomplete abortion .

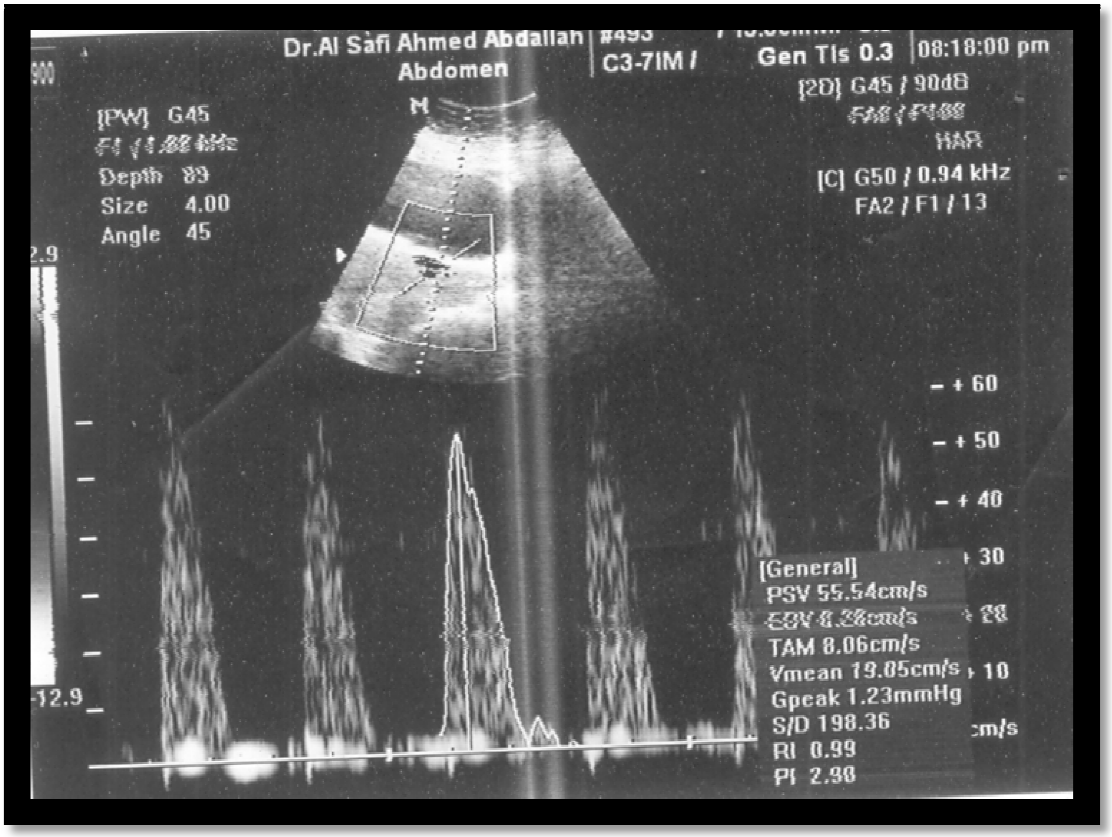


Image (8) Trans- abdominal color Doppler scan for a 35 old women has a history of (RPL)

Showing complete abortion.

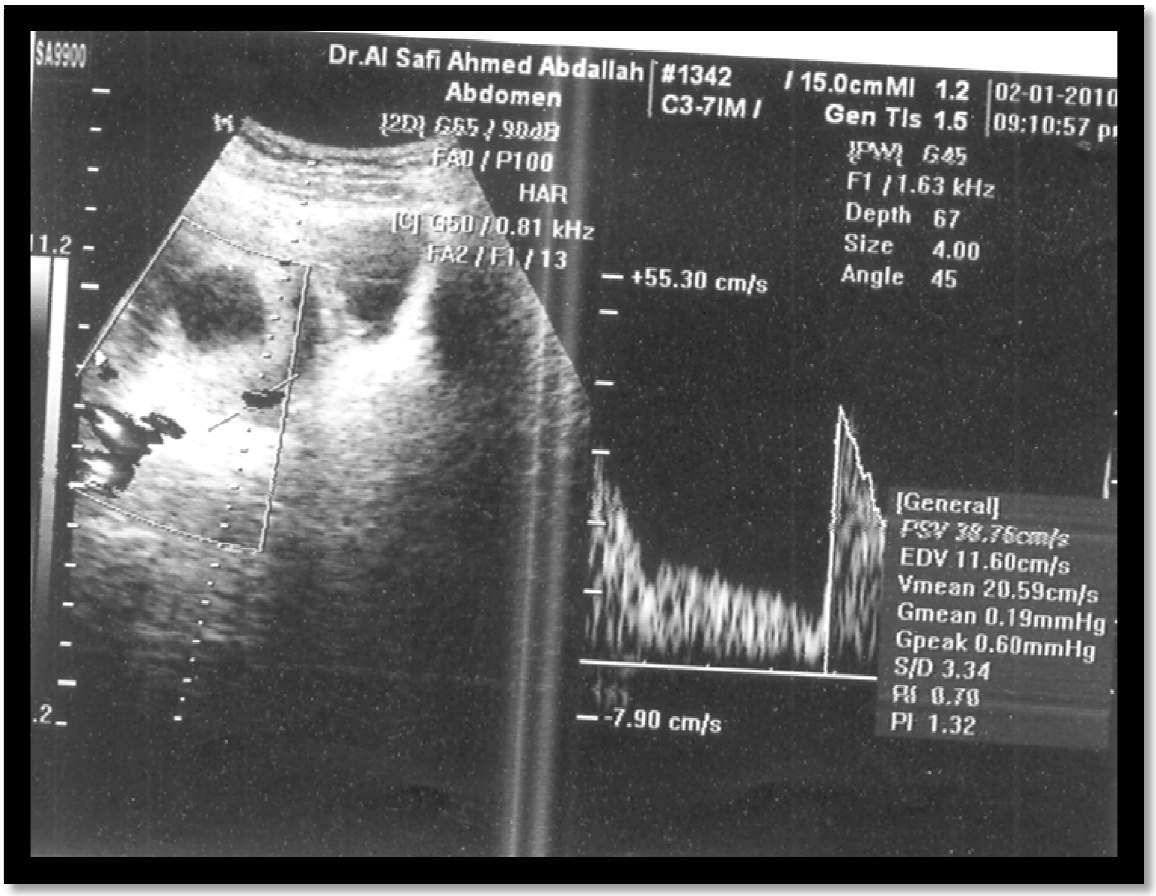


Image (9) 30 old patient has a history of (RPL) the abdominal Sagittal color Doppler scan

Showing a Blighted ovum pregnancy.

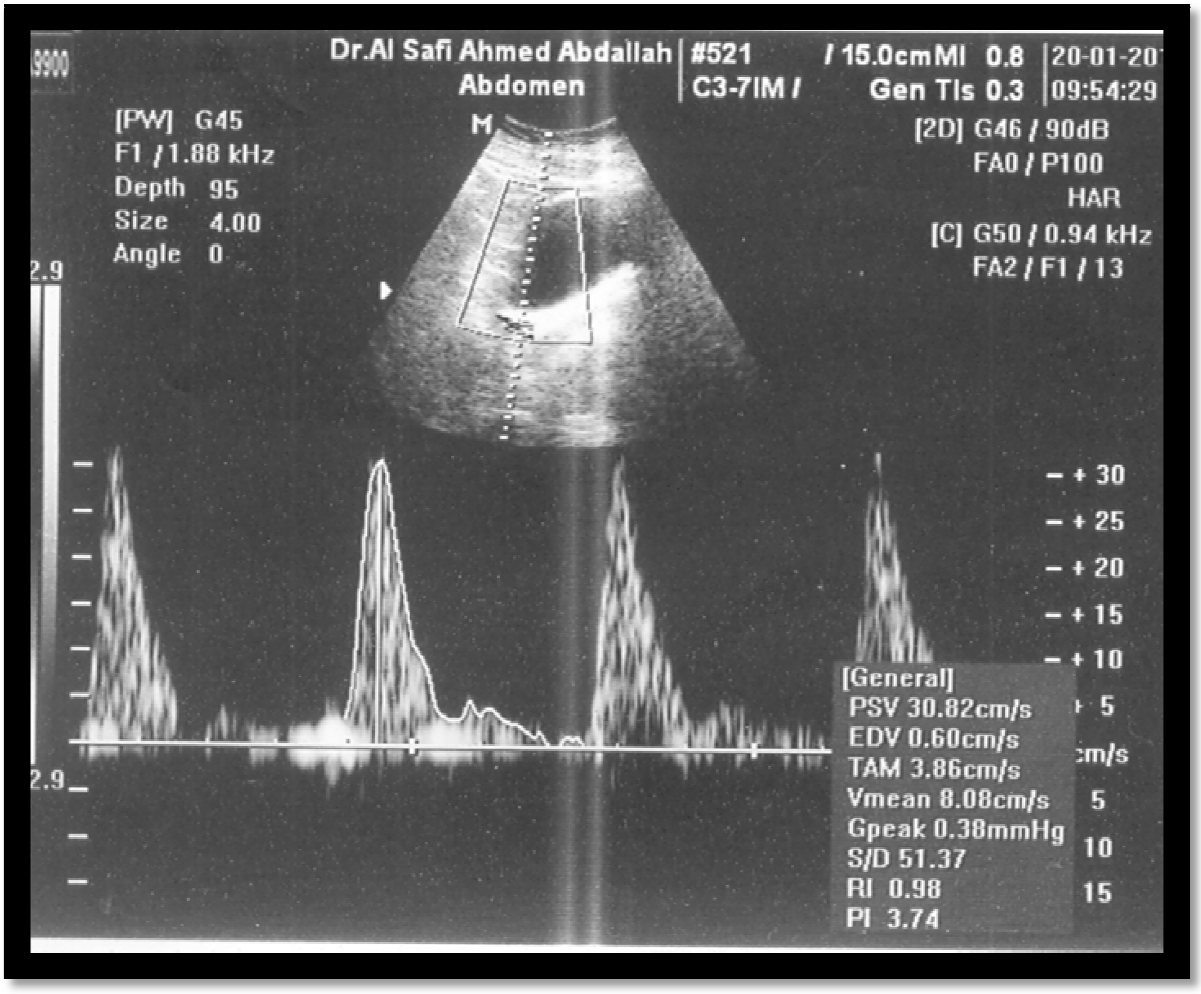


Image (10) Color Doppler scan for 39 old patients with a history of (RPL) showing complete abortion.

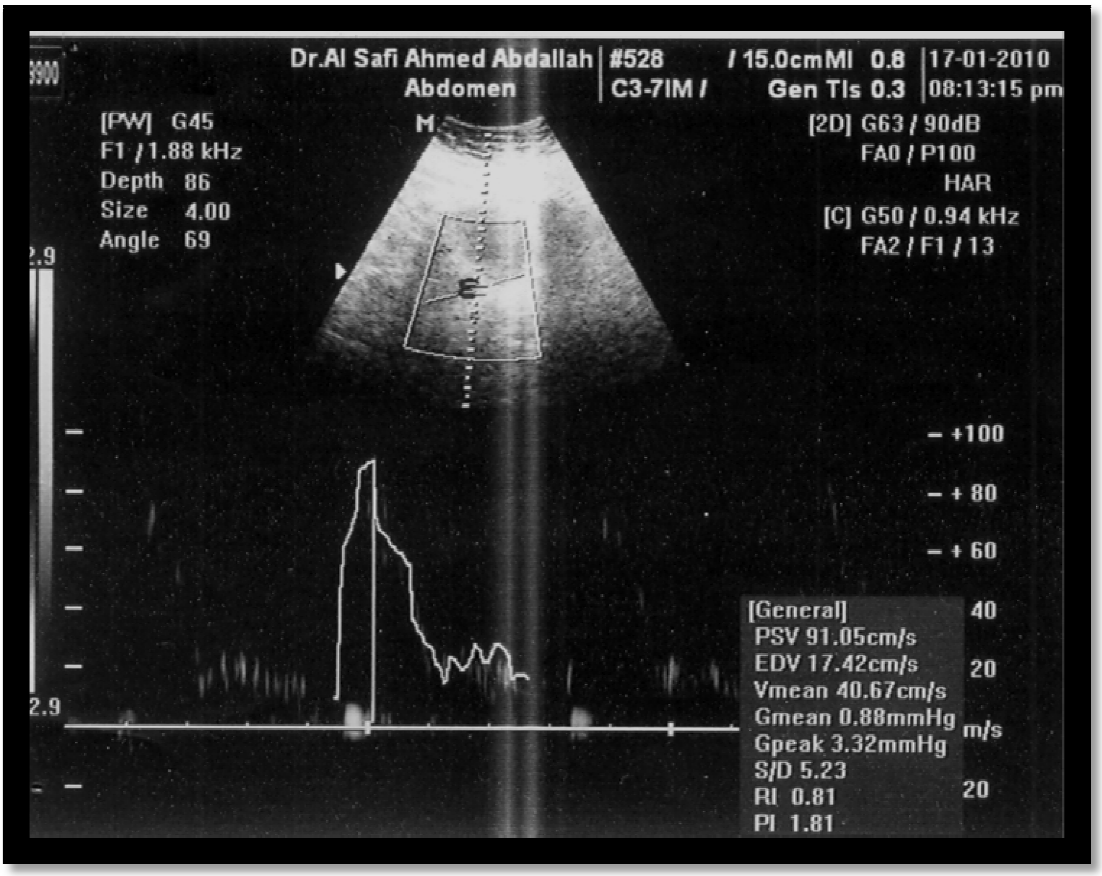


Image (11) sagittal color Doppler abdomen scan for 35 old patients showing complete

Abortion the patient has a history of (RPL)

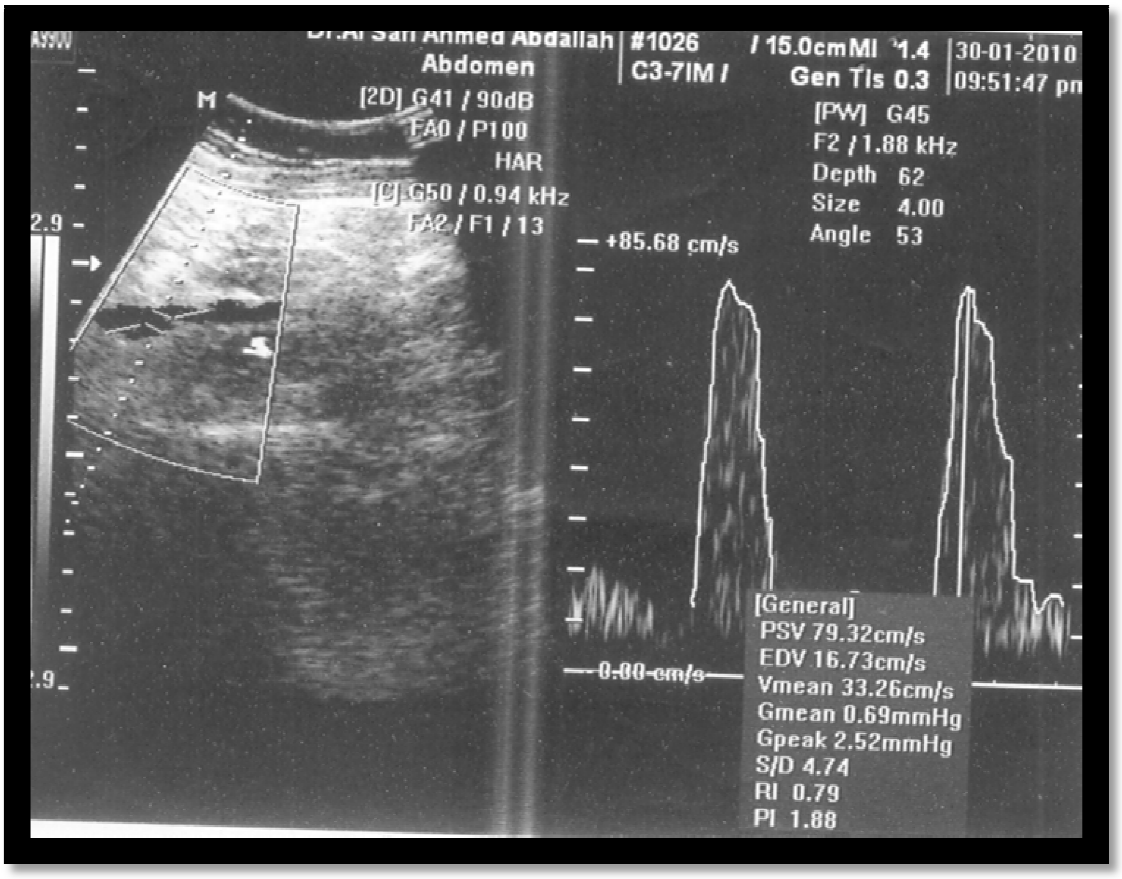


Image (12) Color Doppler abdominal scan Showing complete abortion for a 41 patient with history of (RPL) .

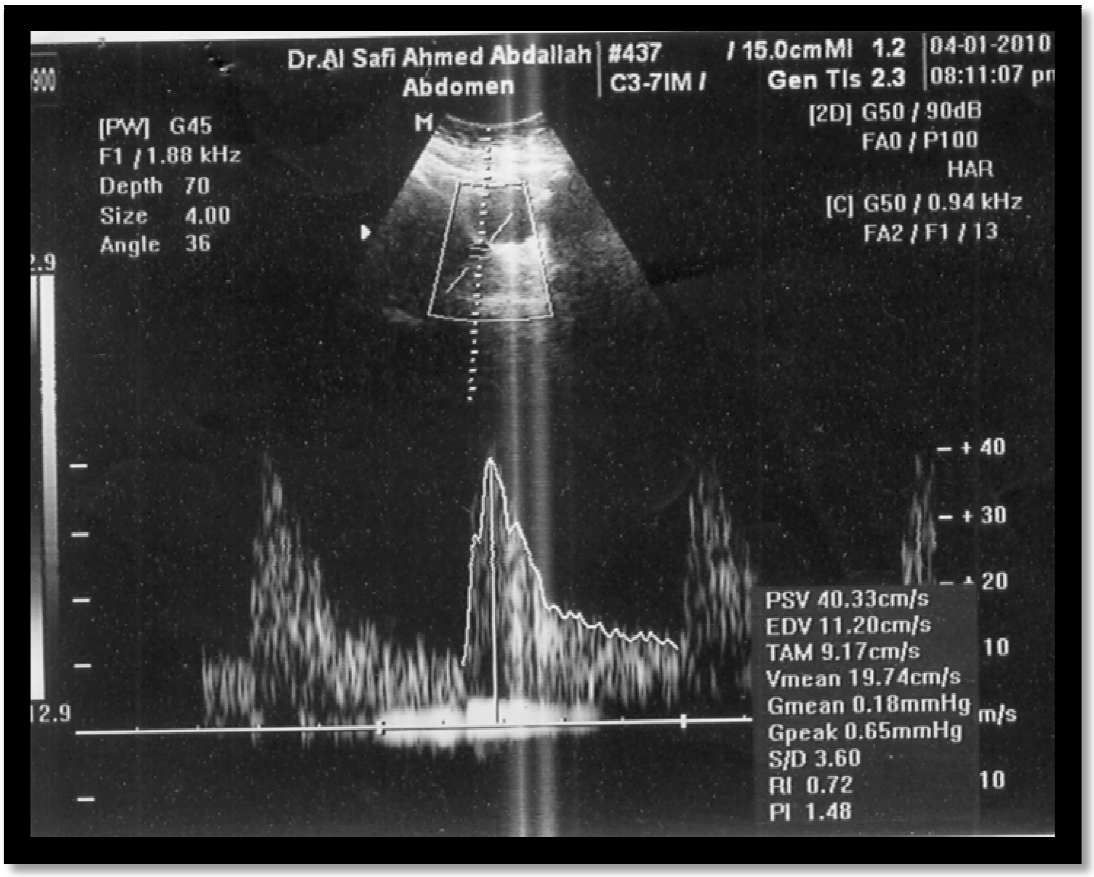


Image (13) 21 patient has a history of (RPL) color Doppler abdominal scan showing complete abortion.

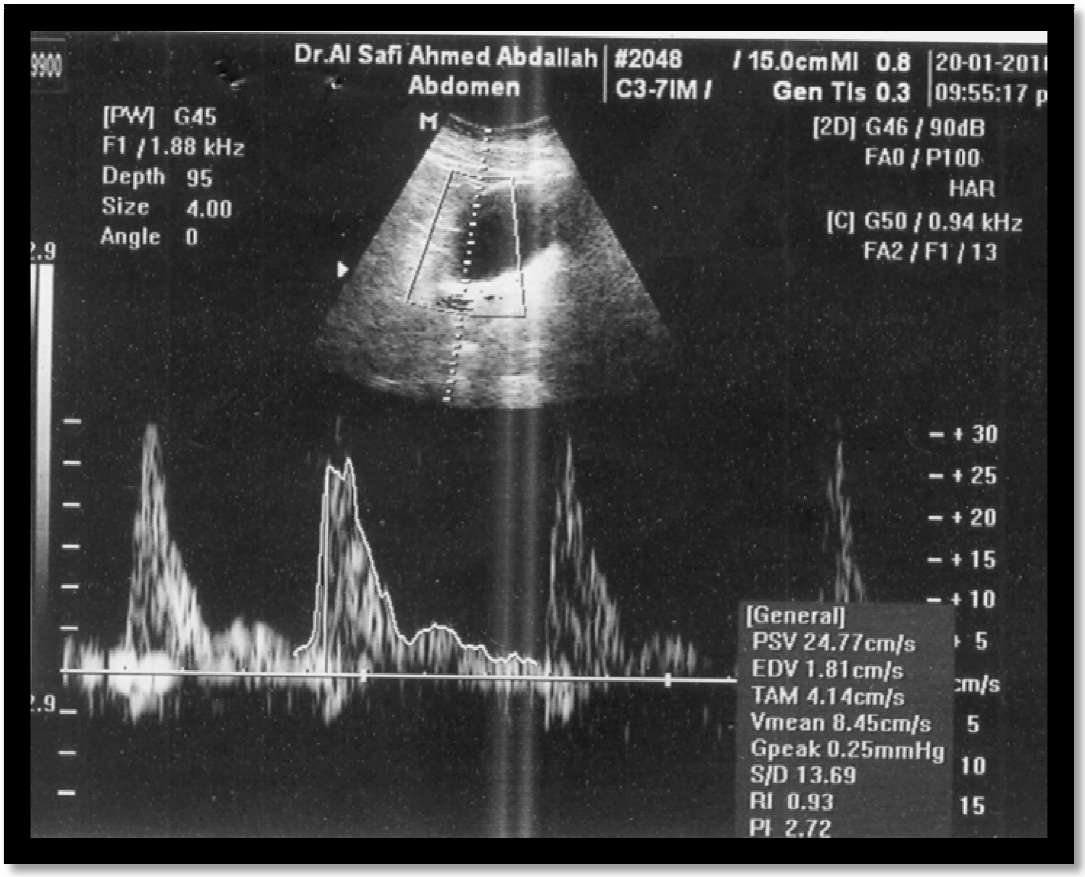


Image (14) color Doppler scans 35 old patient (RPL) showing incomplete abortions.

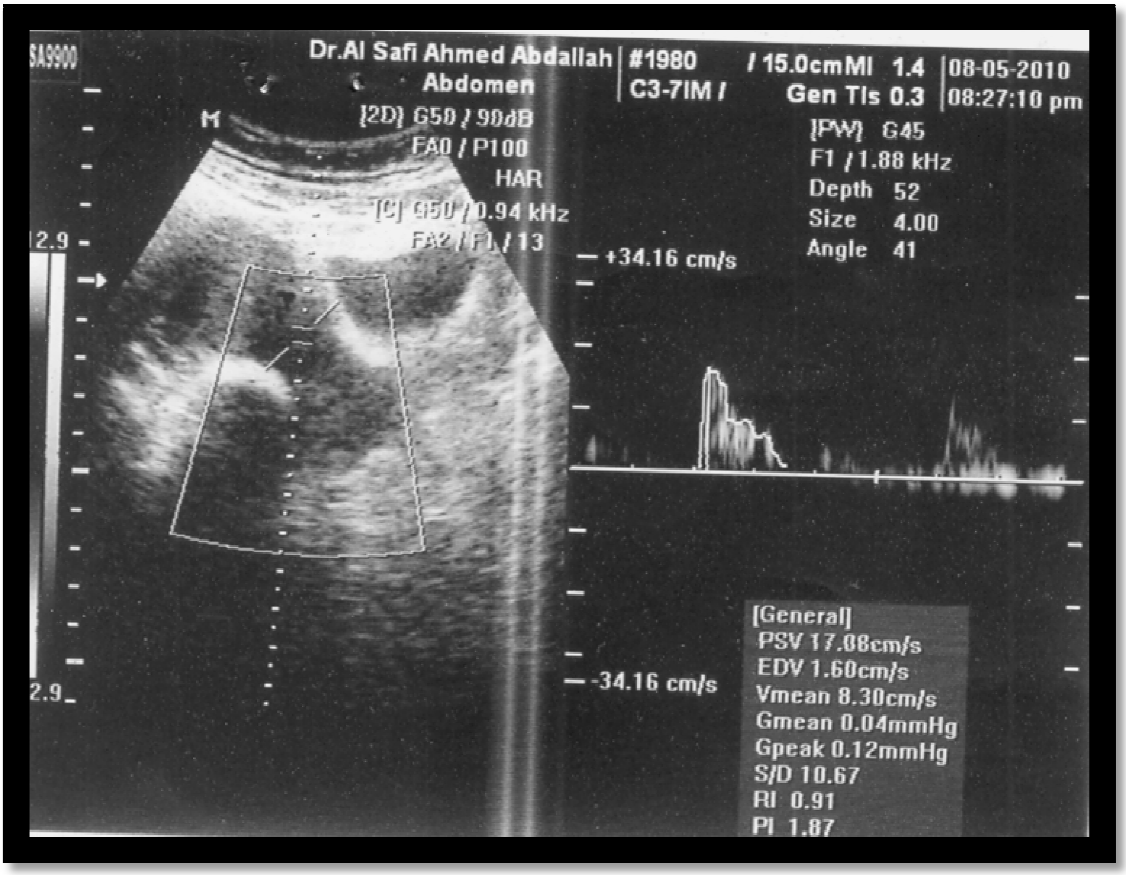


Image (15) abdominal color Doppler scan showing incomplete abortion for 22 old lady complains from (RPL)

(A)

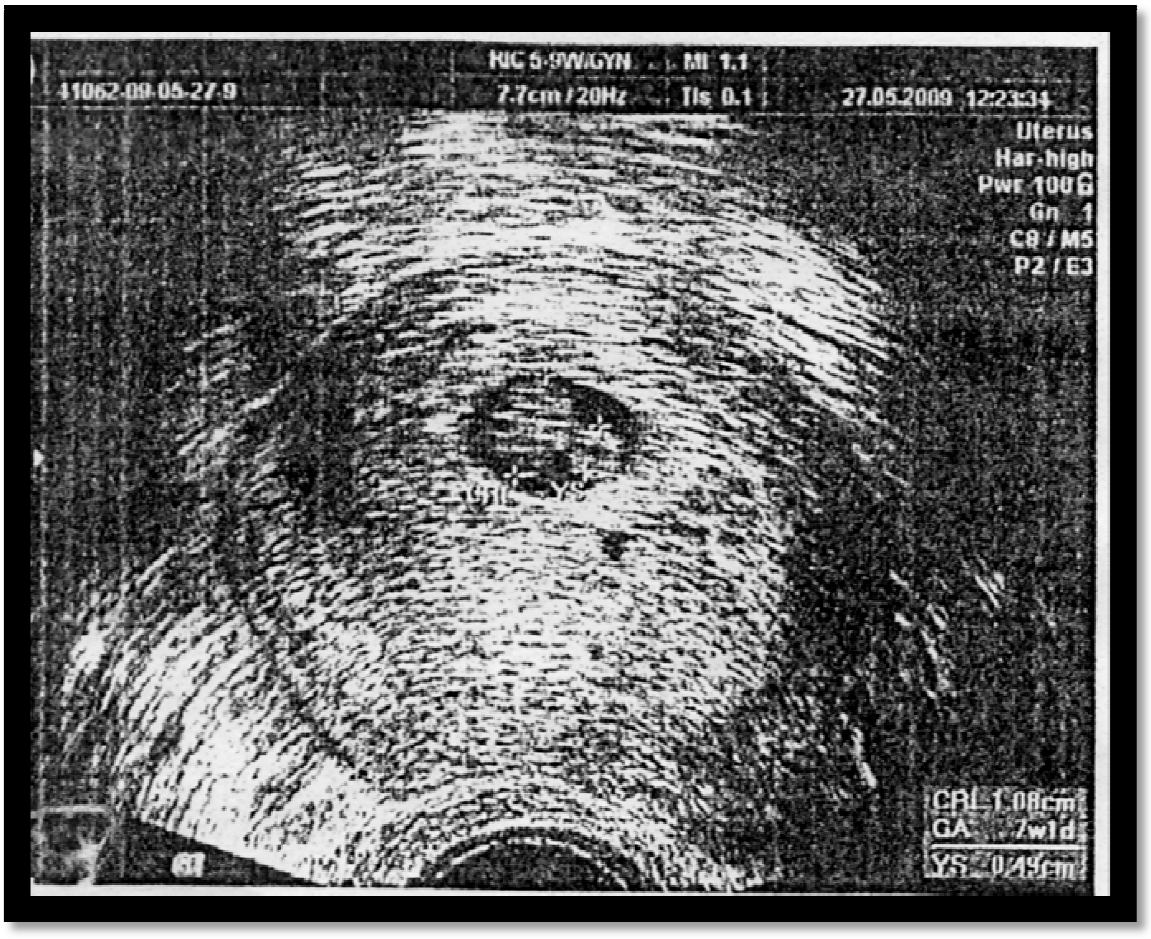


Image (16 a) A28 years old patient who is pregnant ±7 weeks , and coming for routine antenatal care .Ultrasound demonstrated healthy viable intrauterine pregnancy .

(B)

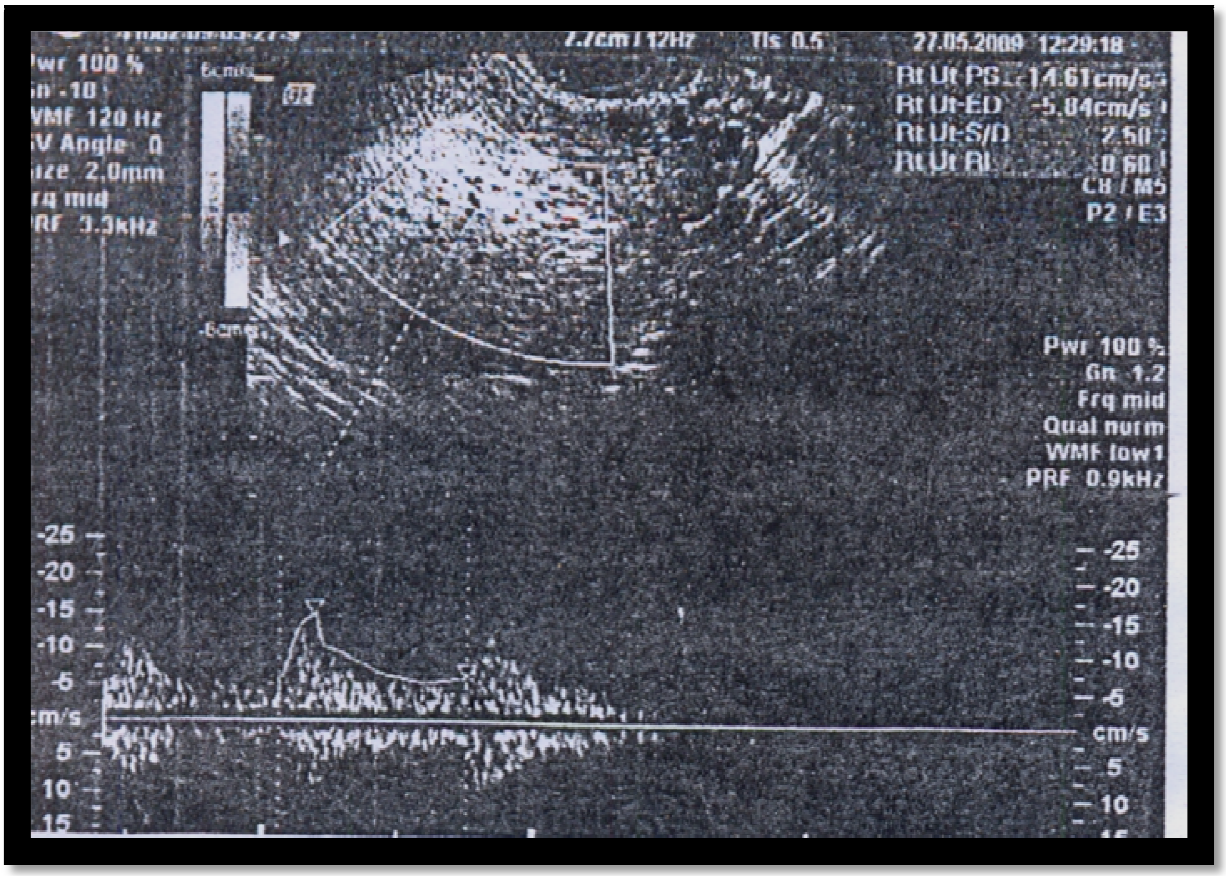
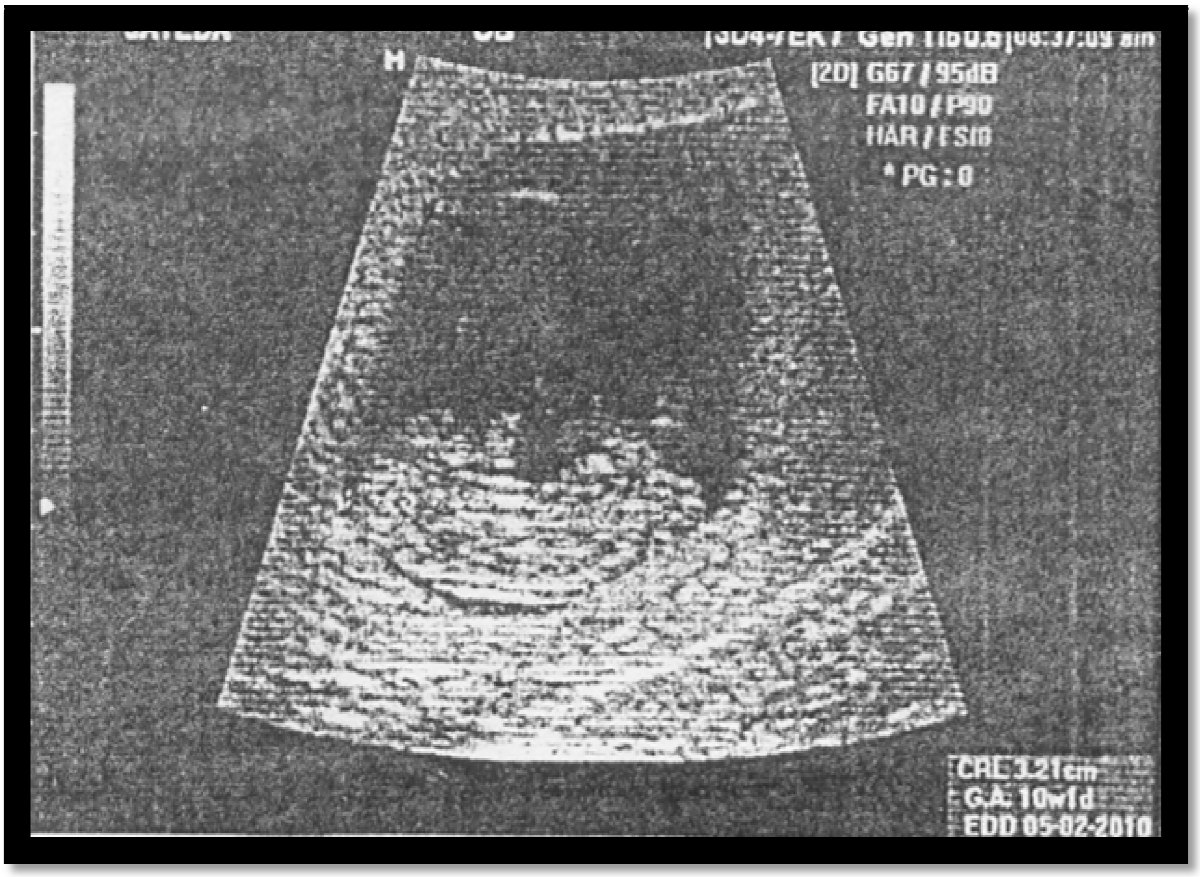
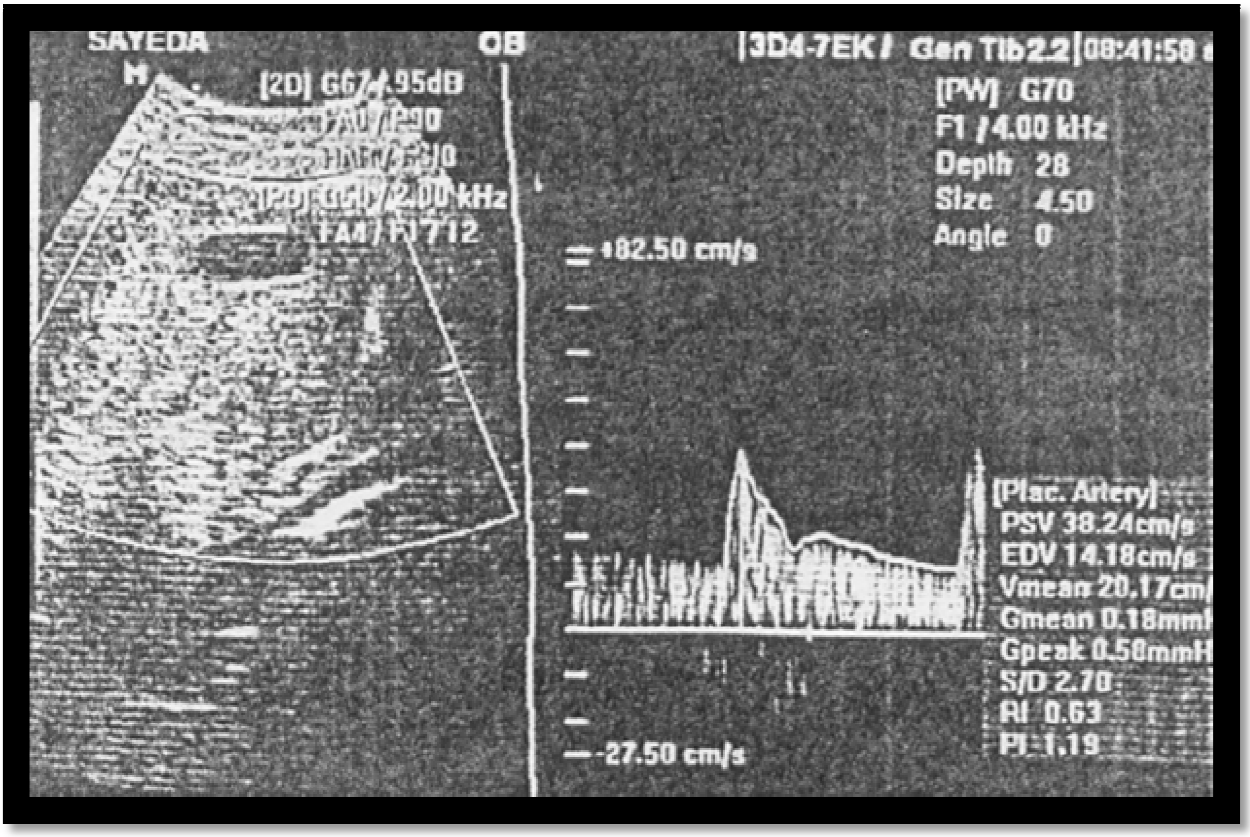


Image (16 b) Doppler evaluation of first trimester pregnancy above patient



(A)

Image (17 a) 10 weeks pregnancy, fetal pole with evident pulsations.



(B)

Image (17b) same patient above showing normal flow in first trimester .pregnancy.

(A)

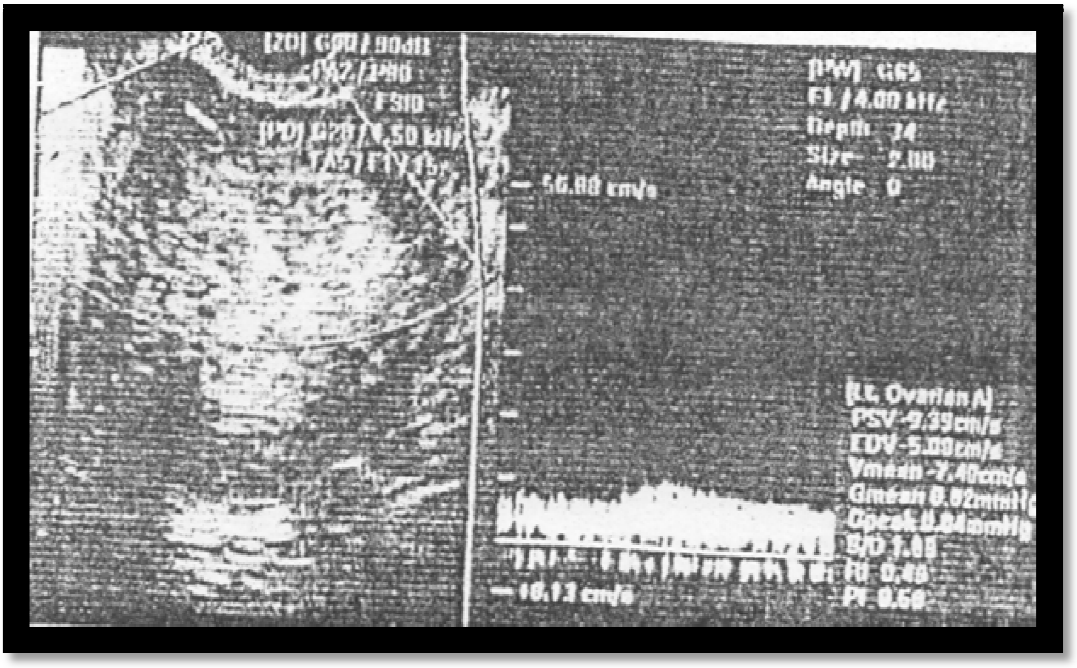


Image (18 a) Post-evacuation Doppler evaluation of the same patient (A) endometrial blood flow

(b) Myometrium blood flow

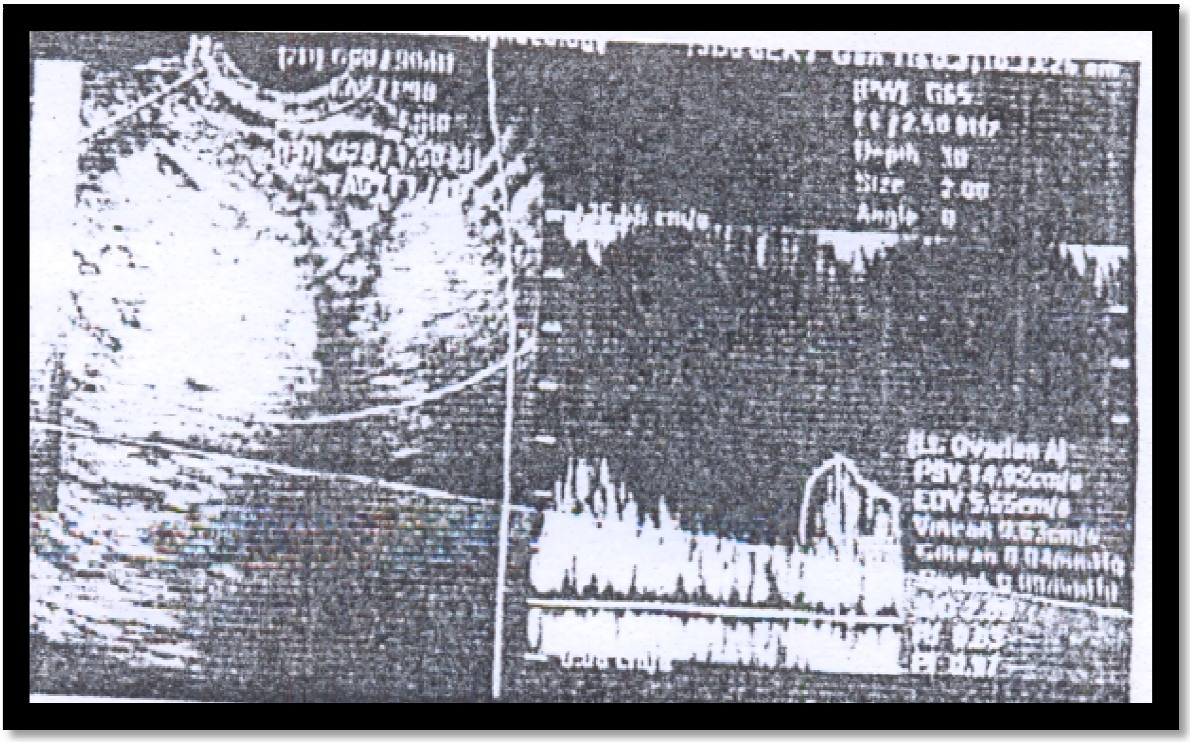


Image (18 B)

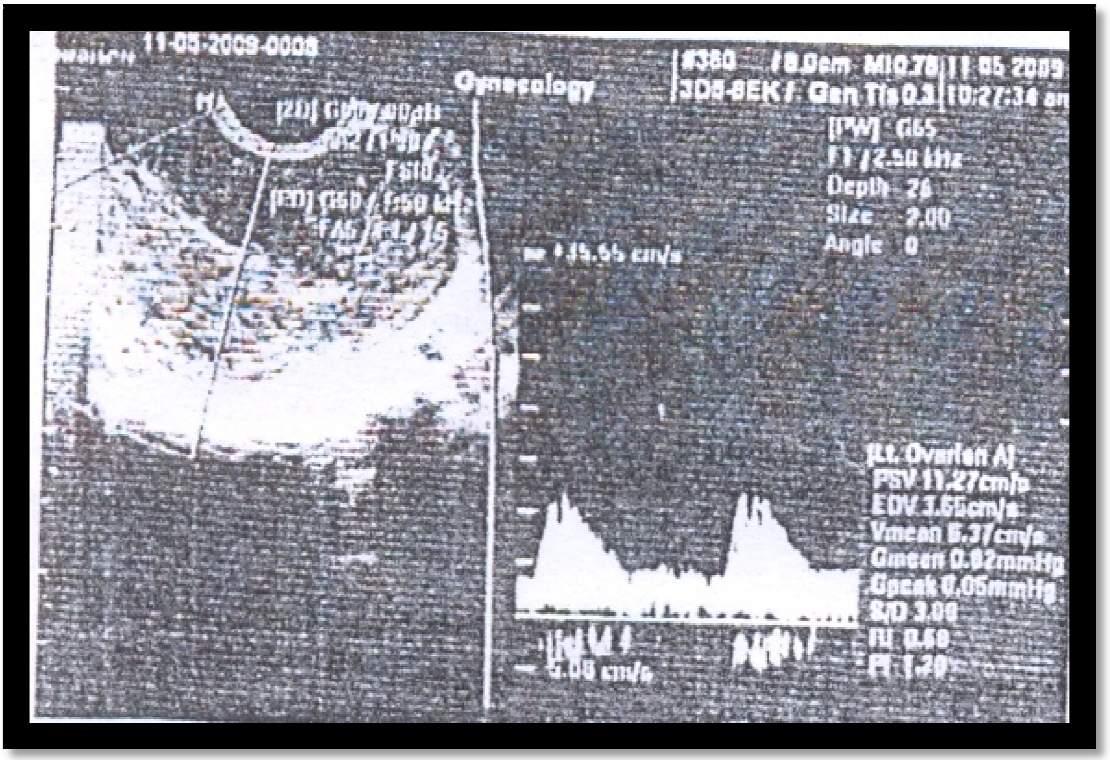


Image (19) Post- evacuation endometrial thickness 11mm (A) .With demons ratable blood flow (B)

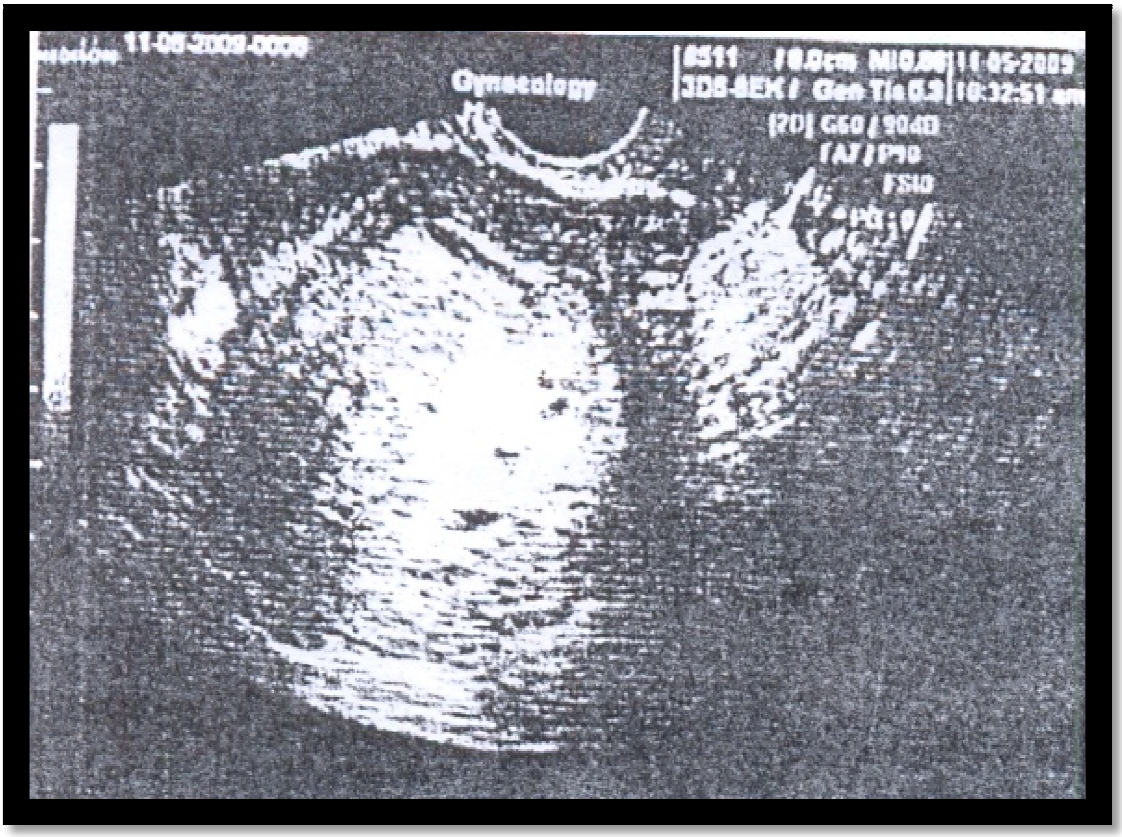


Image (20) A 31 years old patient who was pregnant ± 9 weeks, presenting by severe vaginal bleeding. Ultrasound showed endometrial thickness of 35 mm suggestive of RPOC as a result of incomplete spontaneous abortion.

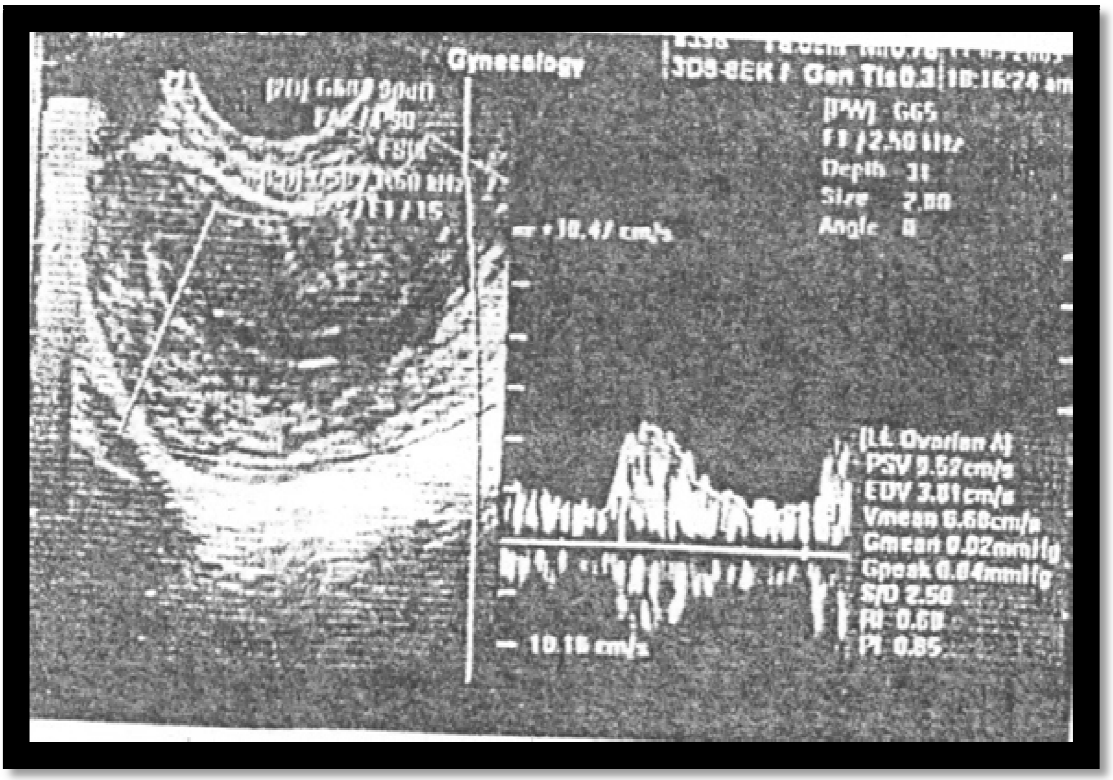


Image (21) A 23 old patient who was pregnant ±10 week's ultrasound confirmed the diagnosis of missed abortion, and was scheduled for elective termination of pregnancy.