REVIEW OF LITERATURE
1. AMNIOTIC FLUID VOLUME

Amniotic fluid is increased rapidly to an average volume of 50 ml at 12 weeks gestation and 400 ml at mid pregnancy. It reaches a maximum of about 1000 ml at 36 weeks to 38 weeks of gestation. Then the volume decreases as term approaches and if the pregnancy is prolonged, amniotic fluid may become relatively scanty. There are rather marked individual differences in amniotic fluid volume however as reported by Fuchs (1962).

Gadd (1966) reported majority of values for normal pregnancy lay between 500 ml to 1,100 ml from 30th to 37th week and then fell to between zero and 600 at 43rd week.

The mean change in amniotic fluid volume was calculated on weekly basis. Robert, A brace and Edward, J Wolf (1989) reported mean amniotic fluid volume is increasing 45% per week at 8 weeks, 25% per week at 15 weeks, 10% per weeks at 24 weeks and 0% at 33 weeks. At 40 weeks, volume is decreasing an average of 8% per week.
Graph: Nomogram shows Amniotic fluid volumes with gestational age on a linear scale (Robert A. Brace, Edward J. Wolf, 1989).
Graph: Weekly changes in mean amniotic fluid volume as calculated from polynomial regression equation. (Robert A. Brace, Edward J. Wolf, 1989).
2. AMNIOTIC FLUID DYNAMICS

A number of hypotheses were suggested in past years to explain amniotic fluid formation and regulation.

i) **Secretion of water or Amniotic Fluid by Amniotic epithelium or chorionic Laeve (Seeds AE, 1980).**

Amniotic fluid in early pregnancy is a product primarily of the amniotic membrane covering the placenta and cord. As pregnancy advances the surface of the amnion expands and the volume of fluid increases.

There is no evidence for the active transport of water across these tissue layers. Water crosses these membranes only in response to a chemical potential gradient, osmotic or hydrostatic. If a net movement of water should take place across the amnion and chorion laeve in the third trimester, it would occur by a passive transport or by osmosis from the amniotic sac to the maternal compartment, mediated by the chemical potential gradient between hypotonic amniotic fluid and isotonic maternal fluid.

ii) **Transfer of water between Amniotic fluid and Foetal vessels in the Umbilical cord**

Again water can only cross the exchange surface between the large vessels and the amniotic cavity in response to chemical potential gradients.
Although the isotonic foetal plasma can be expected to reabsorb some water from the hypotonic amniotic fluid, in fact the very small ratio of the vessel wall surface area to the flow provided by large vessels makes this a totally ineffective exchange site compared to the favourable large ratio of surface area to vessel flow found in capillary bed. It, thus, seems impossible for any sizeable exchange of water or solute to occur between foetus and amniotic fluid by this pathway.

iii) Basic Biological Mechanism Involved in Water Transfer

Water mixes across body membranes in response to hydrostatic or osmotic gradient bulk flow. In presence of such gradient water moves across multicellular porous tissues layers such as amnion and chorion by a non diffusional process known as bulk flow. The rate of water transfer is accelerated when movement occurs in bulk or solvent form in response to chemical potential gradient. The passive movement of water molecules becomes augmented when the membrane contains pores or channels.

Leaky or Partially Semipermeable Membrane

Amniotic and chorionic tissues are highly permeable to water. Many small compounds readily diffuse across corion and amnion but still exert some
small osmotic force. In this case, placental tissue does not discriminate perfectly between solute and solvent but is partially permeable or leaky to smaller solute molecules. These solute may diffuse across the placenta in large amounts, however, since they do not cross as rapidly as water, they still exert some small osmotic force.

iv) Exchange of Amniotic Fluid solute and water with Adjacent Compartments

There is a strong evidence for significant exchange of water and solute amniotic fluid and foetal compartments throughout pregnancy.

Amniotic fluid become moderately hypotonic near term and is thought to be the product of numerous exchanges with the foetus. The human foetus is estimated to produce 600-800 ml per day of very hypotonic urine at term. Foetal urine is hypotonic in comparison to maternal and foetal plasma but it contains more urea, creatinine and uric acid than does plasma. The net effect is that the osmolality of fluid decreases with increasing age of gestation. The foetus swallow between 200-450 ml of amniotic fluid per day by which about only half of the urine and urine products are removed, whenever foetal swallowing is greatly impaired, a great excess of amniotic fluid develops (hydroamnios) conversely when urination in
uterone cannot take place, as in the instances of renal agenesis or atresia of urethra. This volume of amniotic fluid surrounding the foetus is limited (oligohydroamnios).

Since foetal plasma is significantly hypertonic to amniotic fluid a sizeable net transfer of fluid from amniotic to the foetal compartments would result whenever a foetal capillary bed is in proximity of this fluid.

Recent studies by Duenhoelter and Pritchard have indicated a sizeable steady rate in and out amniotic fluid through the foetus lungs in response to active respiratory movement in the 3rd trimester. This process would presumably introduce hypotonic amniotic fluid to a large alveolar capillary bed surface area and a daily net reabsorption of fluid could be expected to take place.

The large foetal skin capillary bed may serve as a site for amniotic water and solute exchange in early pregnancy, but after keratinization of this layer at about 24-28 weeks gestational age, this tissue become very impermeable. Keratinized skin may remain partially permeable to small highly lipid soluble compounds such as carbon dioxide and oxygen.

An additional site for possible exchange of water and solute between amniotic fluid and foetus would
be across the foetal surface of the discord placental
that is across the amnion and chorionic plate from
the placental capillary bed. Abramovich and Page (1970)
have shown that water, sodium, chloride, urea and
creatinine readily cross this exchange surface.

Prolactin has been reported in preliminary
studies to reduce the permeability of human amnion.
These findings together with a significant reduction
in normally very high amniotic fluid prolactin values
associated with hydroamnios have resulted in specula-
tions that prolactin may be active in regulation of
human amniotic fluid volume and composition.

The evidences presented suggested that foetal
swallowing and voiding play a small part in the control
of amniotic fluid volume. There is also a dynamic
interchange of water and electrolyte between the fetopla-
cental unit and mother which undoubtedly plays a
role in the control of amniotic fluid volume (Abramovich,
1970).

VARIOUS METHODS OF AMNIOTIC FLUID VOLUME
determination

1. Abdominal Palpation
   (Clinical signs of oligohydroamnios)
   - Size of uterus less than period of gestation.
   - Poor fluid foetal interface.
- Marked crowding of foetal small parts.

- Easily palpable foetal parts (Philipson et al, 1983).

2. **Direct Measurement**

The method used for estimation of volume of liquor in late pregnancy have varied from crude direct method (Fehling, 1879) to weighing the patients before and after delivery and deducting the weight of foetus and placenta from the difference (Gassner, 1862; Lehn, 1916) or collecting liquor at caesarian section in measuring cylinder (Guttmann and May, 1930) and adding arbitrary 300 ml for the amount lost during collection (Cox and Chalmer, 1953).

In early pregnancy a direct method was used on fresh specimen obtained at abdominal hysterectomy or complete abortion. Amniotic fluid volume was determined from gestational sac (Harrison and Malpas, 1953; Monie, 1953; Wagner and Fuchs, 1962).

In the last trimester, knowledge of volume has been based on clinical bed side impression (Macafee, 1950), sometimes confirmed by measurement of the liquor escaping from the uterus on artificial rupture of the membranes (Scott and Wilson, 1957).

3. **Dye Dilution Technique**

In 1933 Dieckmann and Davis of Chicago
introduced a new method of estimating the volume without disturbing the pregnancy as dye dilution technique. Different dyes were used in different studies as Congo-red (Dieckmann and Davis, 1933; Dennis and Cheyne, 1964), Inulin (Lambiotte and Rosa, 1949), Evans blue (Nelson et al, 1954), Deutrium oxide, radio active iodinated serum albumin (RISA), (Nelson et al, 1954). Coomassie blue (Elliott and Inman, 1961; David and Peter, 1966) and Paraamnio hippurate (PAH) (Queenan et al, 1972).

John T. Queenan et al (1972) have done amniotic fluid volume estimation using para amino hippurate. Transabdominal aminocentesis was performed with a 20 gauze stellated needle PAH in a measured dose of 200-400 mg was injected. The patient was ambulated to encourage amniotic fluid mixing. After 20-30 minutes, second aminocentesis was performed and amniotic fluid sample withdrawn. This fluid was centrifuged for 10 minutes at 3000 revolutions per minute and the concentration of PAH was determined by diazoreaction method. Queenan et al (1972) found a method to provide reproducible results with less than 8 percent error.

4. **Amniography**

Water soluble radio opaque dye like urograffin or hypaque injected into the amniotic sac. X-ray scan reveal roughly the amount of amniotic fluid.
5. Ultrasound Determination of Amniotic Fluid Volume

In 1942 Dussik was the first person who made an attempt at visualising structures using a technique based on the principles of echo-sounding.

Estimation of total intrauterine volume (TIUV) was developed by Gohari et al (1977). This technique was used to assess the amniotic fluid volume and to predict intrauterine growth retardation. Total intrauterine volume was determined by taking sagittal and transverse echograms of pregnant uterus. Gohari et al (1977) found direct relationship between placental size and IUGR and that the condition is almost always associated with oligohydroamnios.

Volume = 0.5233 x longitudinal diameter

X transverse diameter X Ant Post diameter.

By this method 75% cases of IUGR were detected by single examination. Chinn and Associates (1981) showed that the positive predictive value of total intrauterine volume was poor. Grossman and associates (1982) questioned the reproducibility on the measurement basis that appropriate landmarks were difficult to identify and varied relative to bladder filling.

However, with the development of real time ultrasound, newer techniques were sought. Initially the qualitative amniotic fluid volume assessment was
used to predict intrauterine growth retardation and oligohydroamnios.

A. **MAXIMUM VERTICAL POCKET METHOD**

Manning et al (1980) observed amniotic fluid volume by linear array ultrasound method in patients referred with a diagnosis of intrauterine growth retardation. In their study largest pocket of amniotic fluid was measured in its vertical diameter or broadest diameter and qualitative AFV was coded normal if any pocket exceeded 1 cm in broadest diameter. With a q AFV less than 1 cm incidence of IUGR was 89.9%. Manning, Platt and Sipon (1980) included this criteria of less than 1 cm in biophysical profile along with other biophysical variables like foetal breathing movements, foetal tone, non stress test and foetal movements.

Hoddick et al (1984) suggested by their study that if this rigid criteria had been applied for detection of IUGR, it is highly under diagnosed. Determination of IUGR was falsely negative in 96% of cases. In prolonged pregnancy less than one cm rule was significantly associated with perinatal morbidity (Leveno et al, 1984). Phelan et al (1985) and Eden et al did find that q AFV technique could reliably predict oligohydroamnios, but definition was too restrictive.
Chamberlain et al (1984) described the maximum depth of amniotic fluid pocket as

\[ L \leq 1 \text{ cm} \] decreased amniotic fluid volume

\[ 1 < L < 2 \text{ cm} \] marginal

\[ L \geq 2 \text{ cm} \] normal group.

Patient with largest pocket of amniotic fluid of \( L \geq 2 \text{ cm} \) should be investigated intensively to ascertain early delivery might be indicated.

Patricia Crowley et al (1984) diagnosed reduced amniotic fluid volume when no single vertical pool of amniotic fluid measured more than 3 cm. Pockets of amniotic fluid were usually found around foetal limbs or nuchal area. Patient with reduced amniotic fluid had a statistically significant increase in meconium stained amniotic fluid and growth retardation with increased incidence of caesarian section.

In a study done by Robert M. Patterson (1987) to evaluate the reproducibility of amniotic fluid measurement, maximum vertical pocket was compared to an average of three diameters of the largest pocket of amniotic fluid. In this study the vertical and two perpendicular horizontal diameters of the largest pocket of amniotic fluid that was free of umbilical cord and extremities was measured and averaged.
B. **AMNIOTIC FLUID INDEX**

Phelan (1987) described the amniotic fluid assessment with the four quadrant technique, which provide a more representative image of the intrauterine content. The uterine cavity was divided into four quadrants. With the use of linear array, real time B scanning, the vertical diameter of the largest pocket in each quadrant was measured. The sum of these four quadrants was used to provide a single number for the amniotic fluid volume are termed the amniotic fluid index. This approach is simple, requires little time and gives a semiquantitative estimate of amniotic fluid volume. Based on their observations, the normal amniotic fluid index in term gestation is 12.9±4.6 cm.

Amniotic fluid index rises progressively from 11th to 26th weeks. Thereafter until term AFI remains approximately 16.2±5.3 cm. After 38 weeks the AFI appeared to decline gradually. Thus serial measurement of amniotic fluid index may be effective means of assessing foetal status throughout pregnancy (Phelan, Smith, Rutherford et al, 1987).

Thomas R. Moore and Cayle (1990) provided normative data for amniotic fluid index through out the pregnancy. Amniotic fluid index curve showed that AFI decreases by approximately 12% per week in post date period.
Amniotic fluid index was evaluated in relation to foetal heart rate, and perinatal morbidity and an inverse relationship was found between the amniotic fluid index and NST, FHR decelerations, meconium staining, caesarian section for foetal distress and low Apgar scores. Adverse perinatal outcome was significantly more frequently with diminished compared with normal amniotic fluid volume, even if the NST was reactive (Phelan, 1987).

Rutherford et al (1987) have suggested a 5 cm rule as the lower limit for the acceptability for the amniotic fluid index in term gestation, because there is significant morbidity in pregnancies with AFI less than 5 cm. Moore (1990) took this 'Alarm point' as 5th percentile value of amniotic fluid index for the detection of oligohydramnios. Grubb and Paul (1992) reported that women with amniotic fluid index less than 2 cm had 64% operative interference, compared to 21% who had index of 2 cm or more.

Phelan (1991) reported that AFI less than 5 cm during intrapartum period is also related with increased perinatal morbidity even if the membranes had been ruptured in early labour.
OLIGOHYDROAMNIOS

The volume of amniotic fluid may fall far below the normal limits and occasionally be reduced to only few ml of viscid fluid. This is a clinical hallmark of impending severe perinatal compromise. The risk of cord compression and foetal distress in them is increased as the consequence of scanty volume of fluid.

Oligohydroamnios is practically always evident when there is either obstruction of the foetal urinary tract or renal agenesis. A chronic leak from a defect in membranes may reduce the volume of amniotic fluid appreciably. Oligohydroamnios is found in common association with intrauterine growth retardation and post dates.

When amniotic fluid is scanty, pulmonary hypoplasia is very common. Normal infants may suffer the consequences of severely diminished amniotic fluid, since severe deformities including amputation, musculoskeletal deformities like club foot, torticollis are frequently observed. Skin of the foetus typically appears dry, leathery and wrinkled.

This leads to prolonged labour due to uterine inertia and mal presentation. Thus both foetal and maternal distress are common during labour. It is advisable to terminate pregnancy within 48 hours in cases of severe oligohydroamnios unless extreme prematurity.
INTRAUTERINE GROWTH RETARDATION

IUGR is defined as birth weight more than 2 SD below the mean birth weight for that gestational age (Usher et al, 1969). Birth weight criteria as less than 2.51 kg does not necessarily imply IUGR as it does not take gestational age in account.

Among all IUGR fetuses 2/3rd comes from high risk group and 1/3rd from patients with no high risk factor. Hence all fetuses should be analysed for IUGR in all obstetrical sonograms regardless of reason of study. Detection of IUGR by clinical means alone is difficult and subjected to a wide range of errors. Diako (1979) reported that maternal weight gain less than 2 pounds per week was noted in 64% of IUGR but also noted in 36% of normal pregnancies. Fudal growth less than 2 cm/week was present in 64% of IUGR cases but also present in 25% cases of normal growth pregnancies.

Estriol estimation in maternal serum and urine is also of limited value low estriol/creatinine ratio was found to be better indices for the diagnosis of IUGR (Diako, 1979).

By ultrasound foetal growth is assessed by serial estimation of biparietal diameter, head circumference, Abdominal circumference, femur length, approximate weight estimation. IUGR can better be detected by combined measurements and body proportions like head
circumference/abdominal circumference; femur length and abdominal circumference ratio and total intrauterine volume (Hadlock et al, 1983).

A reduction of amniotic fluid is a common finding in pregnancies affected by IUGR. Manning (1981) and Seeds (1984) suggested using an estimate of amniotic fluid volume as a screening for IUGR. They observed that largest pocket of amniotic fluid less than 1 cm gave high probability (89.9%) of the foetus being growth retarded. Philipson et al (1983) reported that chance for IUGR increases 4 fold in oligohydroamnios.

Several large studies have established that IUGR babies have a 3-10 fold increase in perinatal mortality. IUGR babies are subjected to numerous problems during the immediate post partum period such as intrapartum asphyxia, neonatal hypoglycemia, acidosis, hypocalcemia, polycythemia. For these measures, it is imperative that the diagnosis should be made earlier and timely decision for termination of pregnancy should be taken.

POST DATED PREGNANCY

Any pregnancy running over the expected date of delivery is termed as post dated pregnancy. Post maturity criteria were given by Finn and Boe (1950) as:

i) Pregnancy of more than 290 days.

ii) Baby weight more than 4.0 kg.

iii) Height of fetus more than 54 cm.
Any 2 criteria should be present to diagnose the case as postmature.

The effect of deprivation on the fetus vary with the duration and have been divided into 3 phases (Peter G, 1964).

i) Acute perinatal distress with a duration of a few hours before birth is usually related to the effect of labour and delivery in previously compromised fetus.

ii) Subacute fetal distress lasts days and results in wasting and often meconium staining most of the deprivations in prolonged pregnancy belong to this category.

iii) Chronic fetal distress extends over weeks of intrauterine life and results in IUGR.

As pregnancy extends postterm, incidence of placental insufficiency, fetal dysmaturity and fetal perinatal mortality and morbidity increased rapidly as a consequence of reduced respiratory and nutritive placental function and despite a compensatory fetoplacental respiratory reserve capacity. Fetal distress is observed in about 1/3rd of post term pregnancies (Helmuth Vorherr, 1975).

Ultrasound is a very effective mean for the diagnosis of postmaturity and for antepartum fetal
surveillance. Leveno et al (1984) reported increased incidence of fetal distress and caesarian sections with oligoamnios as this typically leads to umbilical cord compression. Crowley (1984) also reported increased incidence of caesarian section in prolonged pregnancy with reduced amniotic fluid volume. There was a significant increase in the incidence of grade II and III meconium. Caesarian rate was 43% in oligoamnios group in comparison to 16% of normal group in study of Phelan (1985). Oligohydroamnios was very common (81.8%) among postmature pregnancies and it was associated with grade II and III placenta (Fernando, 1985). Presence of immature placenta is rare after 42 weeks and placental grading can not be used to predict postmaturity.


Timing of delivery of the post term gestation balances the risk of loss of a viable fetus with risk of uncertain dating and failure of induction. He reported mean amniotic index as 9.1 in post term pregnancy. Grubb et al (1992) reported 64% caesarian section rate in cases with AFI \( \leq 2 \) cm and only 21% caesarian rate with 72 cm AFI.