THE YALE JOURNAL OF BIOLOGY AND MEDICINE 50 (1977), 327–333

Hypertension in Pregnancy: The Use of Ultrasound[1]

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Received February 4, 1977

Great advances in ultrasound instrumentation have enabled the physician to delineate subtle intrauterine changes. Not only can specific measurements of the fetal body be obtained but tissue textures within fetal organs can be appreciated. The perinatologist is constantly searching for ways to learn more about the fetus, and ultrasound has clearly become a major implement in this search. The following discussion will focus on information made available by ultrasound for aid in the modern management of hypertension, one of the most challenging conditions complicating pregnancy.

Approximately 3% to 7% of all patients develop hypertension in pregnancy. In most patients mild elevation of blood pressure is of little consequence and simply warrants close observation, but in other cases hypertensive disease constitutes a potentially lethal situation for the mother and fetus. Since the magnitude of the blood pressure rise does not always correlate with the severity of the fetal condition, it is mandatory to subject all hypertensive patients to an exhaustive ultrasonic evaluation.

A fetal condition often associated with maternal hypertension is intrauterine growth retardation (IUGR). Infants who are growth-retarded are in or below the tenth percentile of mean weight for gestation. These small-for-dates infants have a perinatal mortality rate eight times higher than babies who are appropriate for gestational age. They also have a four times greater chance of becoming asphyxic in labor, and their neonatal course is often complicated by hypoglycemia, polycythemia, and hypocalcemia. Those that survive the neonatal period are subject to higher rates of mental-motor retardation [1]. Therefore, it is imperative that this condition be diagnosed as early in pregnancy as possible. Although investigators have had limited success in identifying the growth-retarded fetus with hormonal parameters [2,3], Stuart Campbell [4] was able to successfully diagnose IUGR with ultrasound. He found that when there was subnormal growth (below the 10th percentile) of the fetal biparietal diameter (BPD), 82% of these infants were growth-retarded at birth. On the other hand, one-fifth of growth-retarded babies did not have a lag in incremental BPD growth. This latter finding is due to the fact that in many cases the fetus has the compensatory ability to spare its brain at the expense of its body when confronted with adverse conditions affecting its supply line. These fetuses have a head-to-body disproportion.

In our work [5] we have attempted to design a method utilizing ultrasound to diagnose IUGR even in those fortunate cases where there is "brain sparing." The method involves the calculation of total intrauterine volume (TIUV) from a 3-dimensional formula for an ellipse. This determination is then compared with the BPD and the patient's dates. We reported on the construction of a nomogram for TIUV in 100 normal patients at different times in gestation (Fig. 1). Ninety-six

[1]Presented at the National Meeting on Diagnostic Ultrasound which was held at the Yale University School of Medicine on July 26, 1976. Kenneth J.W. Taylor, M.D., is guest editor.

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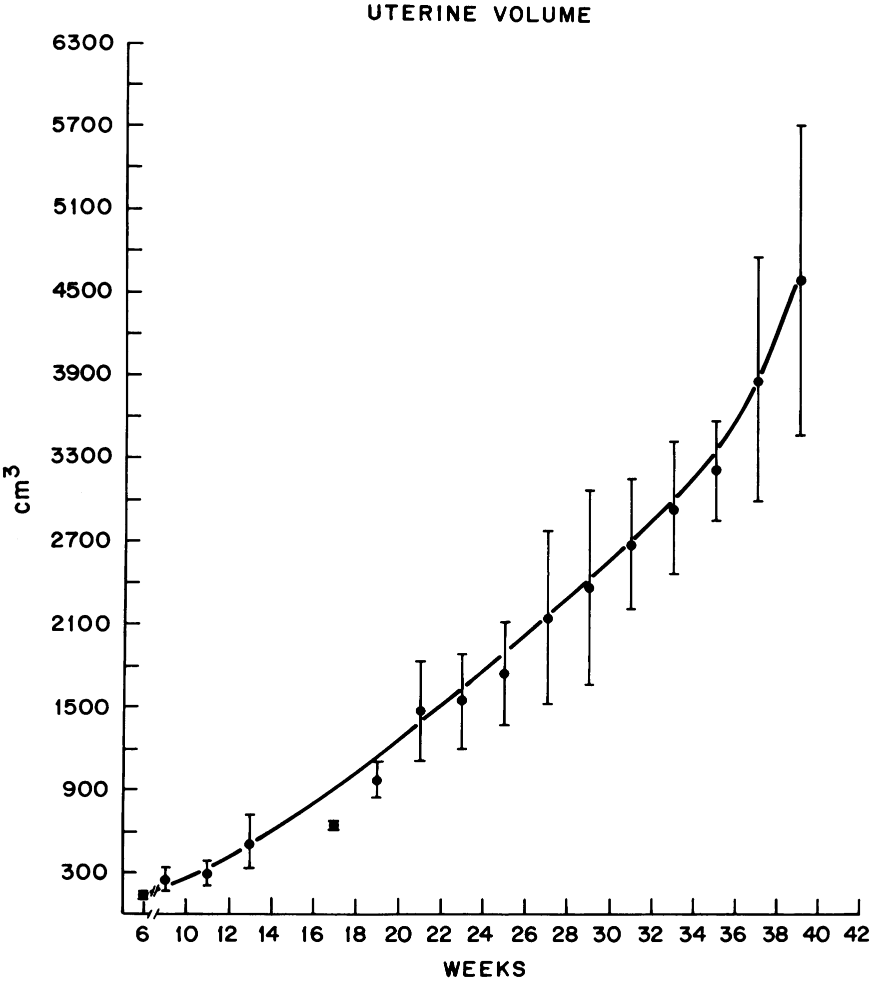

FIG. 1. Uterine volume. *Source:* Gohari P, Berkowitz RL, Hobbins JC: Prediction of intrauterine growth retardation by determination of total intrauterine volume. Am J Obstet Gynecol 127: 3, 250–260, 1977.

antepartum patients were then studied whose fetuses were at risk for IUGR, 28 of whom went on to deliver babies with this condition. When TIUV (Fig. 2) fell more than 1.5 standard deviations below the mean for gestation as indicated by simultaneously obtained BPD (abnormal zone), the babies (21) were all growth-retarded. If the TIUV was within one standard deviation of the mean for gestation (normal zone), the babies (53) were all appropriate for gestational age. When the TIUV was between 1.0 and 1.5 standard deviations below the mean for gestation (gray zone), seven babies were growth-retarded and 15 were normal at birth. The seven babies, however, were all symmetrically growth-retarded (Table I), and had the patients' dates been secure and used instead of the BPD for determining gestational age, these TIUV's would also have fallen into the abnormal zone. The total intrauterine volume nomogram is currently being used in an ongoing investigation of pregnancies at risk for IUGR in order to see if it continues to be as useful as the initial results would suggest.

The degree of "brain sparing" in a growth-retarded fetus can be appreciated by determining the head-to-body ratio [6]. The head circumference is displayed at the level of the lateral ventricles (Fig. 3) and measured with a map reader. The abdominal circumference is measured in a similar fashion at the level of the umbilical vein, which

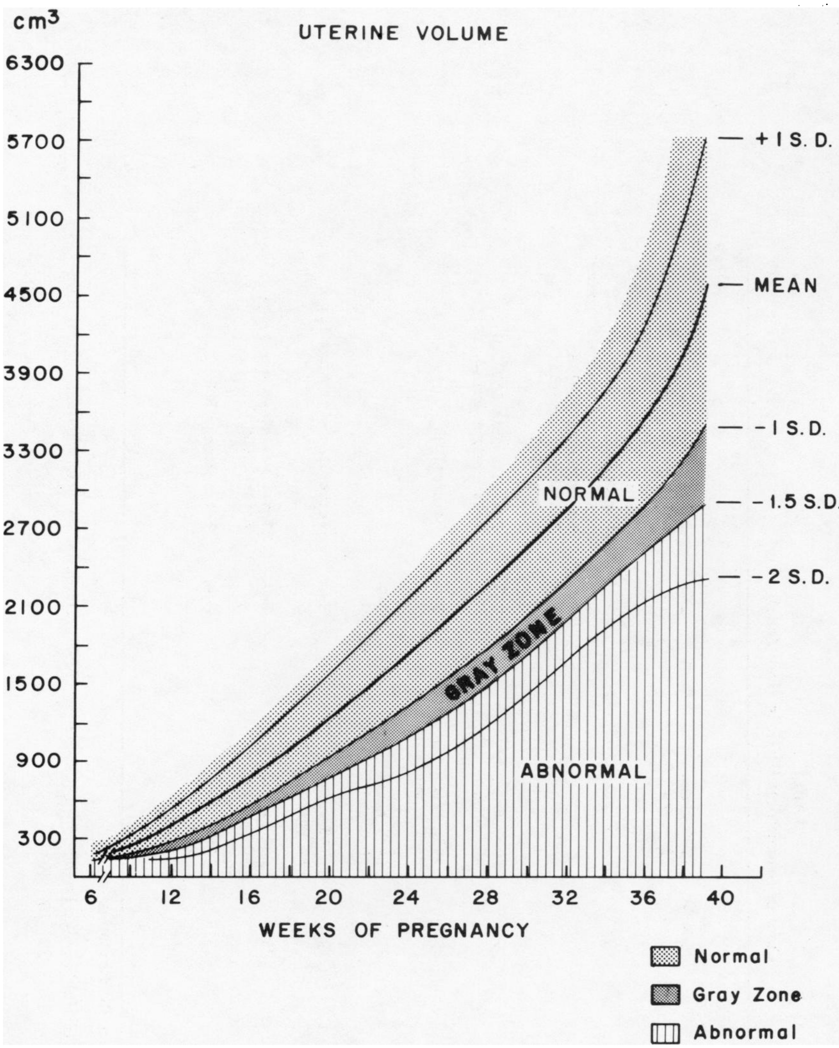

FIG. 2. Uterine volume zones. *Source:* Gohari P, Berkowitz RL, Hobbins JC: Prediction of intrauterine growth retardation by determination of total intrauterine volume. Am J Obstet Gynecol 127: 3, 250–260, 1977.

is a consistently obtainable landmark (Fig. 4). The abdominal circumference (AC) is normally smaller than that of the head until 32 to 36 weeks when the ratio approaches unity. After this time, the body circumference becomes larger than the head. In many cases of IUGR the head circumference remains larger than that of the body. The abdominal circumference of a growth-retarded baby is significantly smaller than that of a normal fetus at the same time in gestation.

The ability to reliably estimate fetal weight has always eluded the obstetrician. Many investigators have attempted to predict fetal weight by clinical parameters [7], and measurements of BPD [8]. These methods have not been of sufficient accuracy to be clinically useful. Ultrasonic measurements of the thorax or abdomen are somewhat more reliable. Combinations of many fetal measurements [9] provide a geometrically pleasing but somewhat impractical model to measure.

We have recently utilized a computer-assisted analysis of data from 85 patients to determine the best formula to derive fetal weight from three *independent* variables (BPD, TIUV, and AC) [10]. We found that the best of three *dependent* variables

TABLE 1
7 Cases of Symmetrical IUGR in Gray Zone*

1.	B.B.	BPD 6.7 (28 weeks)	1684	1720 grams 39 weeks	1-0	Bilateral dysplastic Multicystic kidney Hypoplastic ureters and urinary bladder Microcephaly Head cir.=28 cm. Brain=200 grams Ambiguous genitalia Dysmorphic extremities Fetus died
2.	D.S.	BPD 7.9 (33.5 weeks)	2473	2000 grams 38 weeks	7-8	Pre-eclampsia 150/110 Total weight gain - 10 lbs.
3.	A.B.	BPD 7.8 (33 weeks)	2500	1430 grams 38-1/2 weeks	3-6	Severe IUGR
4.	P.B.	BPD 7.8 (33 weeks)	2367	2485 grams 38 weeks	9-9	
5.	E.N.	BPD 7.2 (30 weeks)	1952	1740 grams 40 weeks	3-2	Fetus died - trisomy 18
6.	J.M.	BPD 8.4 (35.5 weeks)	2590	2000 grams 40 weeks	7-8	Total weight gain - 5 lbs. Severe IUGR
7.	K.M.	BPD 6 (25.5 weeks)	1313	936 grams 32 weeks	3-4	Fetus died - RDS

*Delivered less than two weeks after BPD examination

SOURCE: Gohari P, Berkowitz RL, Hobbins JC: Prediction of intrauterine growth retardation by determination of total intrauterine volume. Am J Obstet Gynecol 127: 3, 250–260, 1977.

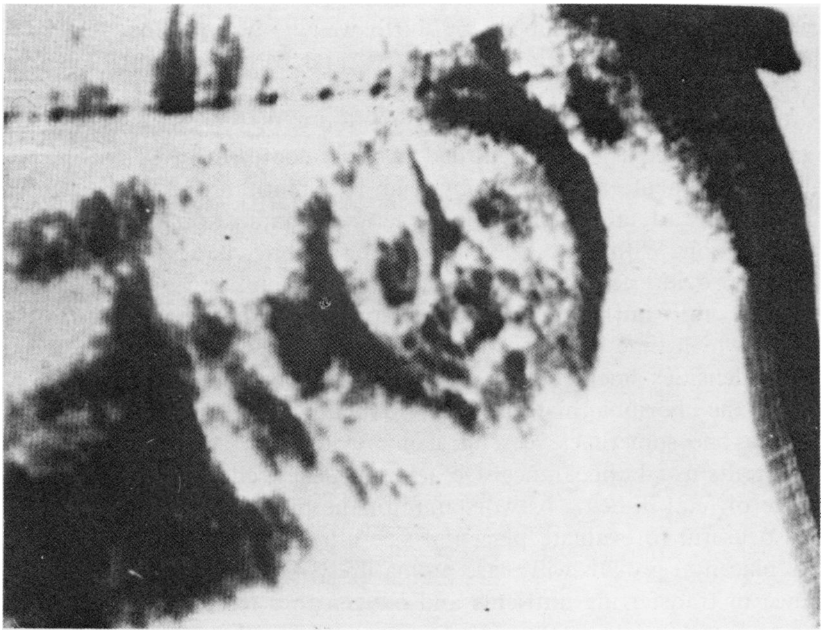

FIG. 3. Head circumference at the level of the lateral ventricle. *Source:* Berkowitz RL, Hobbins JC: Ultrasonography in the antepartum patient. In Perinatal Medicineeds. Schwartz R, Bolognese RJ. Baltimore: The Williams & Wilkins Co., 1977.

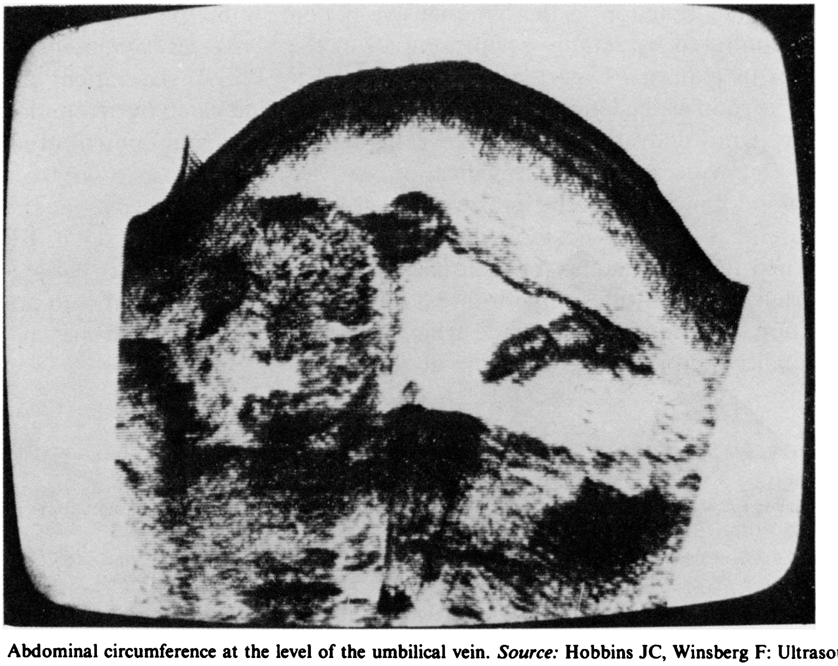

FIG. 4. Abdominal circumference at the level of the umbilical vein. *Source:* Hobbins JC, Winsberg F: Ultrasound in Obstetrics and Gynecology. Baltimore: The Williams & Wilkins Co., 1977.

(birth weight, birth weight cubed, $\log_{10}$birth weight) was the $\log_{10}$birth weight. A "best fit" multifactorial equation utilizing AC and BPD was constructed in which fetal weight could be predicted to within 106 g/kg (± 1 S.D.). The predicted fetal weight obtained by this method can be compared with expected infant weight from existing charts. Since a growth-retarded baby is identified by weight in relation to age, this measurement enables the physician to quantitate the fetal deficit.

The placenta is a fetal organ and its structural organization may indirectly reflect the fetal condition. With grey scale one can study subtle changes in placental texture which often provide helpful clues concerning the fetal status. For example, the placenta is generally fairly homogeneous in appearance until the 37th to 38th week of gestation at which time it takes on a more heterogeneous appearance. Near term, comma-like densities emerge which increase in number as the pregnancy progresses. In addition, the chorionic plate becomes lobulated. In pregnancies complicated by hypertension one sometimes sees ultrasonic evidence of placental maturity many weeks before its usual appearance. Occasionally, these changes are observable prior to evidence of fetal ill-being or worsening of the maternal condition.

It is also useful to evaluate placental size ultrasonically. In severe hypertensive disorders placental growth will cease prematurely. Since the placenta is of primary importance in transferring nutrients and oxygen to a fetus whose growth requirements are greatest in late gestation, it is not surprising that fetal deprivation occurs when the placenta ceases to grow or function properly.

Utilizing a profile composed of TIUV, AC, BPD, head circumference, along with placental volume and texture studies, it has been possible for us to identify intrauterine deprivation, to assess the severity of the condition, and to obtain useful clues about placental function in the hypertensive patient. Subsequent fetal growth can then be monitored by serially performing all of the above measurements.

In cases of maternal hypertension complicated by IUGR, the patient should be delivered as soon as the fetus is pulmonically mature as indicated by an amniotic fluid L/S ratio. Until delivery, however, the fetus will benefit from control of maternal hypertension with appropriate medication. A very effective method to enhance uterine blood flow and thereby improve fetal growth is to place the patient at bed rest in the lateral recumbent position. We have seen beneficial responses in BPD and TIUV when this therapeutic regimen has been utilized.

Hypertension constitutes a major threat to fetal survival, but armed with ultrasonic information, decisions can be made which will save many lives and may provide a better quality of life for the offspring at risk.

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