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Umbilical Artery Doppler Waveform Indices in Normal Pregnancies

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ABSTRACT

Objective To establish a normative data of the umbilical artery Doppler waveform indices (S/D ratio, RI and PI) in normal fetus.

Design A cross-sectional descriptive study.

Methods A total of 332 normal singleton pregnant women were recruited into the study from the antenatal care clinic between September 1, 1994 and August 1, 1996. Their gestational ages were from 21 to 40 weeks. The S/D ratio, RI and PI of the umbilical arteries were obtained by the same sonographer. All fetuses were delivered at term with normal outcomes at birth.

Main outcome measures Means with 95% confidence intervals of the 3 Doppler indices for each gestational week.

Results The total of 411 Doppler indices measurements were performed. The values of S/D ratio, RI, PI declined gradually with gestational age. The mean values decreased from 3.560 to 2.511, 0.756 to 0.609 and 1.270 to 0.967, respectively. Doppler indices declined rapidly from 21 to 32 weeks, when compared to that in the last 8 weeks. Notably, the S/D ratio was less than 3 after 30 weeks of gestation.

Conclusion The nomogram of umbilical artery Doppler waveform indices was constructed and showed the decreasing of Doppler indices with gestational age. These normative data could be served as a basis for evaluation the umbilical artery circulation in Thai population.

Key words: Doppler indices, S/D ratio, RI, PI, umbilical artery

Currently, Doppler ultrasound, an evolved noninvasive technique, is widely used to assess blood flow in both fetal and maternal hemodynamic circulatory function. Due to its feasibility and safety, this new innovation has now become an effective instrument for fetal surveillance.

FitzGerald and Drumm first reported the use of Doppler ultrasound to study the fetal circulation in 1977. Since then, the human fetal circulation in various parts has been studied. The umbilical arterial flow, descending aortic flow, cardiac output, cerebral and renal flow were reported in terms of Doppler indices which derived from Doppler waveform analysis. Of the many indices, the S/D ratio, the pulsatility index (PI) and the resistance index (RI) were most commonly used in obstetrical applications.[1,2]

The umbilical artery, the very important vessel of the fetus, was the first vessel to be assessed and has since become the most widely investigated component of the fetal circulation. The unique umbilical artery waveform can easily be detected by real time ultrasound associated with pulse wave Doppler ultrasound (Doppler duplex system). Based on the knowledge that umbilical arterial resistance is increased in the fetus with uteroplacental insufficiency secondary to various causes, the umbilical artery waveforms, reflecting the resistance in fetoplacental circulation, has been used extensively for fetal surveillance, especially in high-risk pregnancy. It is established that an increase in umbilical resistance expressed by Doppler indices is well associated with fetal hypoxia and acidosis, especially in fetus with growth restriction. It is essential that each institution should have its own baseline data to apply to its population in evaluation of fetal dynamic status. However, the relationship between gestational age and Doppler waveform indices in Thai population has not been established. Therefore, we conducted this study to establish a normative data of the 3 umbilical artery Doppler waveform indices (S/D ratio, RI and PI) in normal Thai fetuses from gestation age of 21 to 40 weeks.[3-5]

Materials and Methods

Between September 1, 1994 to August 1, 1996, a total of 332 normal pregnant women attending the antenatal care clinic were recruited into the study with informed consent. All were in gestational age range of 21-40 weeks and met the inclusion criteria consisting of normal singleton pregnancy and known definite gestational age. The pregnancies with preterm delivery, fetal anomalies, and abnormal fetal growth were excluded from the study. Umbilical arterial Doppler flow was obtained by color Doppler duplex ultrasound system, using (transabdominal) curvilinear transducers of 3.5 MHz, Wall Filter 50 Hz, (Aloka-SSD 680 EX; Tokyo, Japan). After fetal biometry for confirmation of gestational age, Doppler indices were measured during fetal apnea by the same examiner at the free loop site where the clearest waveform signal could be visualized. Of 3 measurements, the mean average of S/D ratio, RI and PI were recorded by each gestational week. The data were subsequently analyzed for means and 95 % confidence interval of each waveform index using SPSS computer program.

Result

The total of 411 Doppler indices measurements were performed in 332 pregnancies. The mean maternal age were 25.72 ± 4.61 years, ranged from 16 to 47 years. Most (61.4%) were nullipara. 70.8% had normal deliveries and 8.1% had cesarean sections. No maternal and fetal complication was observed in all of them. Mean fetal weight was 3,024.46 ± 272.13 g.

The S/D ratio, RI and PI with 95 % confidence interval (CI) were presented in table 1. The results showed that the values of all Doppler indices declined gradually by gestational age from 21 to 40 weeks. The mean values of S/D ratio, RI and PI decreased from 3.560 to 2.511, 0.756 to 0.609 and 1.270 to 0.967, respectively.

Figure 1-3 shows Doppler indices values; X axis represents gestational week and Y axis represents values of the Doppler indices. In general, the values decreased rapidly in the first 21 to 32 weeks and slowly declined in the last 8 weeks. Notably, the S/D ratio was less than 3 after 30 weeks of gestation. Based on the curve, the high accuracy of the measured value was indicated by the narrowing of 95% CI of each index. The narrowest range of 95 % CI was observed during GA of 22 to 26 weeks in RI, 34 to 36 weeks and 22 to 23 weeks in S/D ratio and PI, respectively. The widest range of 95% CI in S/D ratio, RI and PI were at 21, 26 and 32 weeks of gestation, respectively.

Discussion

To detect fetal distress earlier before any permanent damage occurs is the main principle of antenatal care. In addition to traditional NST and CST, Doppler indices have been described several times as a noninvasive predictor of adverse perinatal outcomes

in complicated pregnancies. Subsequently, the feasibility of using and interpretation has led to its extensive obstetric application.

Many clinical studies reported in both pro- and con- manners about Doppler indices efficacy. Initially, Trudinger and co-workers[6] reported that the diagnostic efficacy of umbilical arterial S/D ratio in high risk pregnancy appeared to be more sensitive, but less specific than NST in predicting fetal growth restriction and fetal distress.

Before this new technology is accepted as a standard fetal surveillance, the baseline data of Doppler indices must be collected. To reduce the influence of racial factors, the normative data should be derived from their own population. We believe that the data presented here can represent our normal population and be used as baseline data in evaluation of fetal condition due to adequate sample size, known exact gestational age confirmed by early ultrasound, well-selected patients with stricted criteria of normal pregnancy such as normal newborns with appropriate weight.

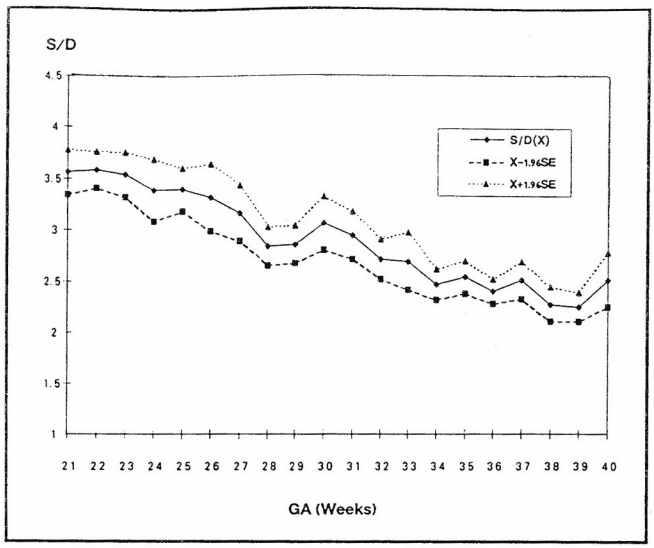

Fig. 1. Shows S/D ratio with 95% Confidence Interval.

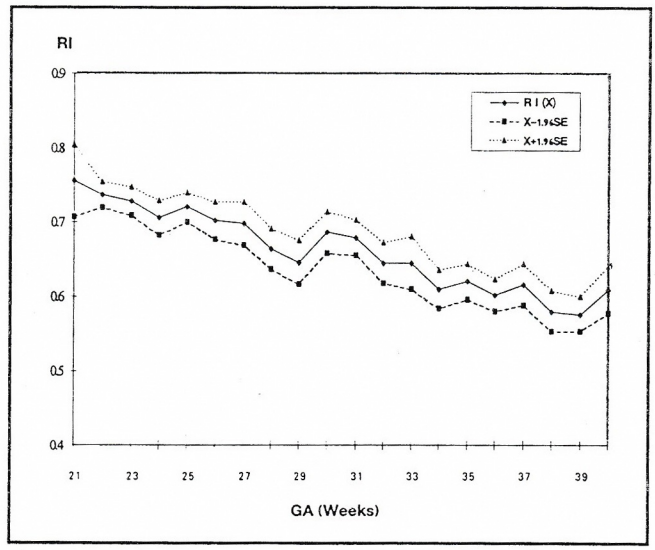

Fig. 2. Shows RI with 95% Confidence Interval.

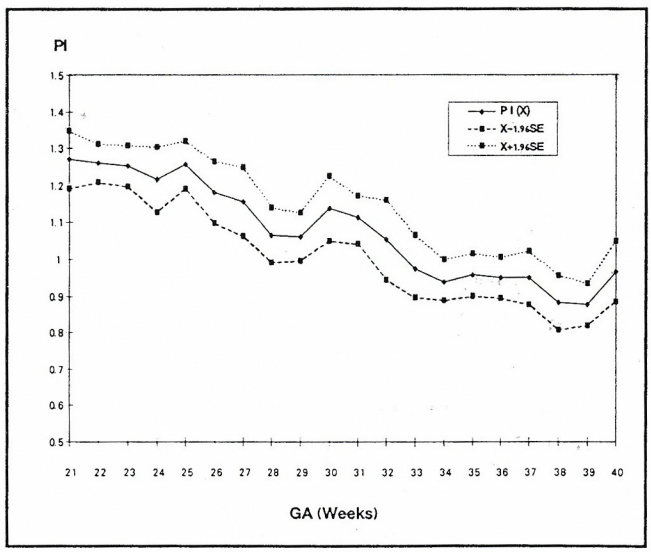

Fig. 3. Shows PI with 95% Confidence Interval.

Table 1. Doppler Indices and 95 % Confidence Interval of Umbilical Artery in Normal Pregnancy

Week	NO	S/D		RI		PI	
		mean	95%CI	mean	95%CI	mean	95%CI
21	24	3.56	3.338,3.781	0.756	0.707,0.805	1.27	1.191,1.348
22	15	3.587	3.406,3.767	0.737	0.719,0.754	1.261	1.210,1.311
23	18	3.541	3.321,3.760	0.728	0.708,0.747	1.253	1.198,1.307
24	27	3.386	3.080,3.691	0.706	0.682,0.729	1.217	1.128,1.305
25	25	3.391	3.179,3.602	0.72	0.700,0.739	1.256	1.191,1.320
26	21	3.31	2.984,3.635	0.702	0.676,0.727	1.182	1.099,1.264
27	17	3.158	2.889,3.426	0.698	0.668,0.727	1.156	1.063,1.248
28	21	2.837	2.650,3.023	0.664	0.636,0.691	1.066	0.991,1.140
29	18	2.853	2.670,3.035	0.646	0.616,0.675	1.061	0.996,1.125
30	18	3.059	2.800,3.317	0.686	0.658,0.713	1.138	1.049,1.226
31	22	2.941	2.709,3.172	0.679	0.655,0.725	1.113	1.042,1.183
32	20	2.71	2.515,2.904	0.645	0.617,0.672	1.053	0.945,1.160
33	22	2.69	2.413,2.966	0.645	0.609,0.680	0.974	0.881,1.066
34	21	2.464	2.317,2.611	0.61	0.584,0.635	0.939	0.878,0.999
35	18	2.535	2.376,2.693	0.62	0.596,0.643	0.958	0.901,1.014
36	25	2.397	2.277,2.516	0.602	0.580,0.623	0.951	0.896,1.005
37	18	2.505	2.326,2.683	0.616	0.588,0.643	0.95	0.877,1.022
38	19	2.272	2.105,2.438	0.58	0.552,0.607	0.883	0.808,0.957
39	21	2.248	2.108,2.387	0.576	0.552,0.599	0.877	0.820,0.933
40	17	2.511	2.246,2.775	0.609	0.577,0.640	0.967	0.884,1.049

Similar to many previous studies, our findings indicate that S/D ratio, PI and RI decrease gradually as gestation advances, as a result of progressive increase in end-diastolic velocity with gestational age resulting in a decrease in the pulsatility. This trend is consistent with a gradual decline in the fetoplacental flow resistance reflected by Doppler indices.[7-12] Like the study reported by Barr and associates,[13] we found that after 30 weeks of gestation S/D ratio was less than 3. High S/D ratio (> 3) was significantly related to an increased incidence of SGA infants, fetal distress in labor, presence of meconium at delivery, cesarean sections and 5-minute Apgar scores less than 7.[13] Clearly, the end-diastolic component of the Doppler waveform was very important in fetal prognostication. Absent or reversed end-diastolic flow velocity is associated with a remarkably adverse perinatal outcomes, fetal death and chromosome abnormality.[14]

Several factors like gestational age, fetal heart rate, fetal breathing and the site of measurement in the cord have been reported to effect to Doppler indices. Fetal heart rate may contribute to15-18% of the variation. Intrathoracic pressures and blood flow change occur during fetal breathing, therefore, Doppler indices measurement should be performed during fetal apnea. The inter- and intraobserver variations of measurement are about 10-14% and 5-9% respectively. In addition, the closer to the placental site, the greater value.[15-18]

To reduce the variation in measurements in this study, we had all patients evaluated by the same sonographer in short duration each, during the period of regular fetal heart rate and fetal apnea, and at free loop site which the clearest signals could be obtained

and finally each value of Doppler indices was averaged from 3 measurements.

In conclusion, we have established the normative data of umbilical artery Doppler indices in the hope that it could be served as a baseline data in evaluation of fetal conditions in conjunction with other conventional fetal testing. Obviously, further work is needed to determine the efficacy of Doppler for improving the perinatal outcome in a cost-effective manner.

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