Effect of Fetal Gender on Ductus Venosus Pulsatility Index and Diameter at Gestational Age 17-37 Weeks

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Objective: *Recent findings have suggested that ductus venosus blood flow in the first trimester may be influenced by fetal gender. The aim of the present study was to investigate further the influence of fetal gender on ductus venosus (DV) pulsatility index (PI) and diameter at gestational age 17-37 weeks.*
Material and Method: *This was a cross-sectional study. Three measurements were made for each the DV PI and diameter in each fetus during fetal quiescence. Statistical Package for the Social Sciences 14.0 software was used to create nomograms for the DV PI and diameter against gestational age in each gender group. The DV PI and diameter were compared between fetal genders using independent Student's t-test.*
Results: *There was no statistically significant difference in the DV PI and diameter between fetal sexes.*
Conclusion: *Fetal gender does not influence the DV PI and diameter at gestational age 17-37 weeks.*

Keywords: *Blood flow velocity, Crown-Rump length, Ductus arteriosus, Fetus, Pregnancy trimester - second, Pregnancy trimester - third, Pulsatile flow, Sex*

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The ductus venosus (DV) is one of the three physiological shunts in the fetus. It is a small funnel shaped vessel found posterior to the fetal liver connecting the intra abdominal umbilical vein (IAUV) and the inferior vena cava (IVC). It directs a large part of the well- oxygenated blood from the placenta to the foramen ovale to the left side of the heart. The DV has been extensively investigated in animal models[1-5]. Recently, due to improved color Doppler techniques, the venous vessels have been analyzed across gestation in the human fetus[1-15]. Normal and abnormal flow patterns of the DV are becoming standardized in the human fetus.

The DV regulates the amount of oxygenated blood directed toward the heart from the IAUV away from the liver. The DV appear at a right angle to the curve of the IAUV. The double-layer wall of the DV contains elastic, collagen and argyrophilic fibers[16]. The specific anatomical finding of the ductal isthmus is an accumulation of smooth muscle cells in a local focus as an "intimal pillow" can protrude into the vascular lumen[16]. This region also contains vesa vasorum and nervi vasorum. This pillowed isthmus performs the role of the resistor to flow similar to the valve. The thickness of the DV is consistently greater near the inlet than near the outlet. It is significantly greater than the wall thickness of either the portal sinus of IAUV or left hepatic vein[16].

Recent findings have no consensuses whether ductus venosus blood flow is influenced by fetal gender in the first trimester[17,18].

It is important to evaluate ductus venosus blood flow and diameter using correct nomograms, because abnormal values may be associated with fetuses at risk for hypoxia and acidemia because of anemia, congenital heart disease, congestive heart failure and intrauterine growth restriction. If gender-related differences exist, the correction of risk should be performed according to gender. The objective of the present study was to investigate further the influence of fetal gender on ductus venosus pulsatility index (DV PI) and diameter at gestational age 17-37 weeks.

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Material and Method

This was a cross-sectional observation study. Ethical approval was obtained from the Ethic Committee of Faculty of Medicine, Thammasat University, Thailand. From July 10, 2006 to August 31, 2007, four hundred and sixty low-risk pregnant women with a gestational age of 17 to 37 weeks were recruited in the present study. All of these women underwent trans-abdominal ultrasound examination at Maternal-Fetal Medicine Unit, Thammasat University Hospital. Exclusion criteria was fetus had abnormal growth or anomaly on that scan.

Fetal ultrasound studies were performed on all fetuses with a coaxial pulsed Doppler color flow imaging system (Aloka ProSound SSD - α5sv Tokyo, Japan) employing 3.5-7.5 MHz transducer. Two-dimensional structural identification and gender of the fetus was accomplished. Doppler interrogation included a free loop of the umbilical artery (UA) and umbilical vein (UV), middle cerebral artery (MCA), IAUV, ductus arteriosus (DA) and DV were undertaken.

The DV can be visualized in its full length in a mid- sagittal section of the fetal trunk. In an oblique transverse section through the upper abdomen, it can be found where color Doppler indicates high velocities compared to the IAUV. In Doppler velocimetry, the most consistent measurements could be obtained by placing the sample volume at the initial half portion of the length of the DV. The flow velocity waveform of the DV demonstrates a continuous forward flow throughout the cardiac cycle. The DV is identified by color aliasing of the vessel arising from the IAUV; the color scale then increased and the color gain reduced until the echogenic surfaces of the DV could be observed with near transparent color flow then the narrowest DV diameter was measured (Fig. 1). All ultrasound studies were performed by the first author. Three measurements were made in each fetus during fetal quiescence.

A nomogram was constructed from the results by using an average of three measurements for each normal fetus. All normal fetuses included for the present study had normal anatomy and normal growth assessed by these scan. All normal fetuses also had normal Doppler flow of the UA, UV, MCA, IAUV and DA. Statistical Package for the Social Sciences 14.0 (SPSS) software was used to create nomograms for DV PI and diameter against gestation in each gender group. The DV PI and diameter were compared between fetal genders using independent Student's t-test. A p-value of less than 0.05 was considered statistically significant.

DV, ductus venosus; IAUV, intra-abdominal umbilical vein

Fig. 1 The ductus venosus was identified in transverse section through the upper abdomen

Results

There were 228 male fetuses and 214 female fetuses aged 17 to 37 weeks included in the present study. The mean maternal age was 29 years in both groups. The maternal demographic data between both groups were similar (Table 1). The number of cases in each gestational age is shown in Table 2.

The DV PI and diameter were compared between fetal genders using independent Student's t-test (Table 3).

A nomogram was constructed from the results, using an average of three measurements from each fetus in each gender group. The curve-fitted percentile charts of the DV PI and diameter for male and female fetal groups were created (Fig. 2, 3). The DV PI decreased with advancing gestation (DV PI = 0.58 - (0.01 x GA), $r^2 = 0.01$, R = 0.110 ($p > 0.05$) for male fetuses and DV PI = 0.64 - (0.01 x GA), $r^2 = 0.02$, R = 0.148 ($p > 0.05$) for female fetuses). The mean diameter of the DV was linear across gestation (DV diameter = 0.36 + (0.04 x GA), $r^2 = 0.55$, R = 0.749 ($p < 0.05$) for male fetuses and DV diameter = 0.32 + (0.05 x GA), $r^2 = 0.49$, R = 0.703 ($p < 0.05$) for female fetuses). There was no statistically_significant difference in the DV PI and diameter between fetal sex (p = 0.993 and 0.574, respectively).

Discussion

The authors have established the normal ranges for DV PI and diameter throughout gestation in the normal fetuses for each group of fetal gender.

Table 1. Maternal demographics (442 cases)

Data	Male fetuses (n = 228)			Female fetuses (n = 214)			p-value
	Number of cases	Mean ± SD	Percent	Number of cases	Mean ± SD	Percent	
Age (years)		29.5 ± 5.3			29.3 ± 5.3		0.601
Gravida							
1	116		50.9	112		52.3	
2	73		32.0	70		32.7	
≥ 3	39		17.1	32		15.0	
Parity							
0	140		61.4	132		61.7	
1	67		29.4	70		32.7	
≥ 2	21		9.2	12		5.6	
Gestational age (weeks)		24.9 ± 4.3			25.0 ± 4.2		0.764
2nd trimester	179		78.5	170		79.4	
3rd trimester	49		21.5	44		20.6	

SD, standard deviation

Table 2. The number of cases in each gestational age

GA (weeks)	Male fetuses	Female fetuses
17	1	0
18	2	2
19	3	2
20	9	10
21	23	17
22	41	42
23	43	34
24	19	19
25	12	13
26	16	12
27	3	9
28	7	10
29	14	6
30	3	6
31	5	8
32	5	5
33	7	10
34	4	5
35	5	1
36	6	2
37	0	1
Total	228	214

GA, gestational age

Table 3. The comparison of DV PI and diameter between fetal genders

	Male fetuses Mean ± SD	Female fetuses Mean ± SD	p-value
DV PI	0.45 ± 0.20	0.46 ± 0.20	0.993
DV diameter (mm)	1.47 ± 0.26	1.49 ± 0.27	0.574

Independent Student's t-test ; $p \leq 0.05$, statistical significant

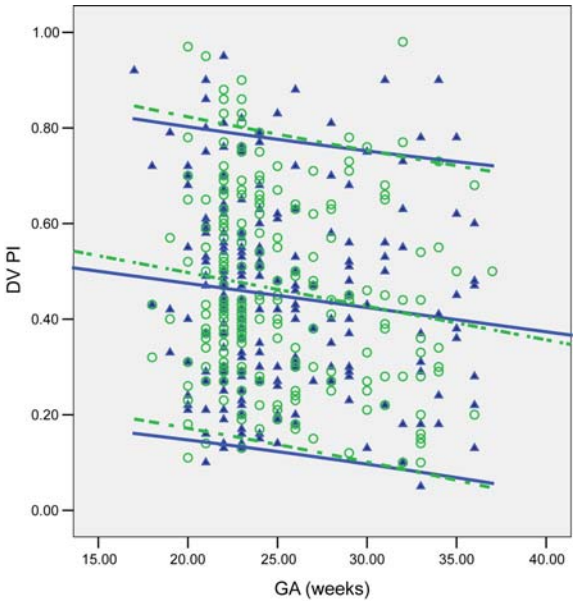
The present data supports a previous study of this institution[19].

Prefumo et al[17] found the gender-related difference of the DV blood flow in the first trimester. They reported the DV PI, peak velocity during ventricular systole, and time-averaged maximum velocity were lower in male fetuses. They also suggested the gender-related difference might be due to difference in DV diameter. Contrary to the previous study[17], the authors revealed no statistically significant difference in the DV PI and diameter between fetal sexes at gestational age 17-37 weeks ($p = 0.993$ and 0.574, respectively).

The strong point of the present study is that the number of sample size was greater than the previous study[17]. Therefore, the authors conclude that the same nomogram of the DV PI and diameter for both fetal genders should be used for a reference to investigate in fetuses at risk for hypoxia and academia.

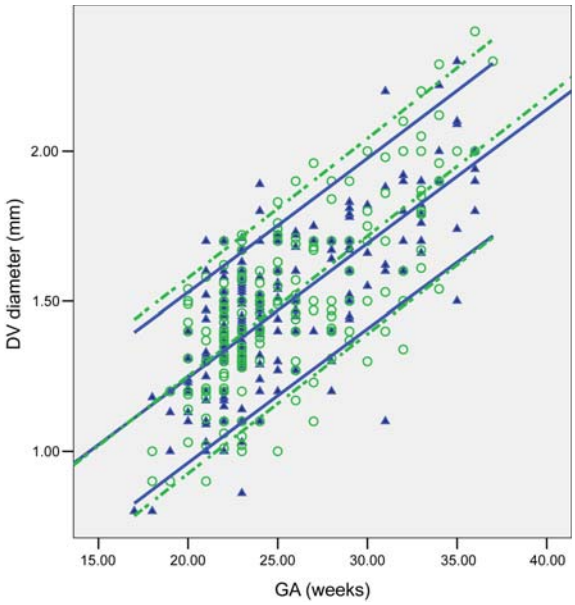
References

1. Kiserud T, Eik-Nes SH, Blaas HG, Hellevik LR. Ultrasonographic velocimetry of the fetal ductus venosus. Lancet 1991; 338: 1412-4.
2. Kiserud T, Eik-Nes SH, Blaas HG, Hellevik LR. Foramen ovale: an ultrasonographic study of its



DV, ductus venosus; PI, pulsatility index; GA, gestational age; ▲, male; O, female

Fig. 2 Individual values for the pulsatility index of the ductus venosus during gestation with mean, 5th and 95th percentiles from the regression analysis in male and female fetuses



DV, ductus venosus; GA, gestational age; ▲, male; O, female

Fig. 3 Individual values for the diameter of the ductus venosus during gestation with mean, 5th and 95th percentiles from the regression analysis in male and female fetuses

relation to the inferior vena cava, ductus venosus and hepatic veins. Ultrasound Obstet Gynecol 1992; 2: 389-96.
3. DeVore GR, Horenstein J. Ductus venosus index: a method for evaluating right ventricular preload in the second-trimester fetus. Ultrasound Obstet Gynecol 1993; 3: 338-42.
4. Hecher K, Campbell S, Snijders R, Nicolaides K. Reference ranges for fetal venous and atrioventricular blood flow parameters. Ultrasound Obstet Gynecol 1994; 4: 381-90.
5. Hecher K, Campbell S, Doyle P, Harrington K, Nicolaides K. Assessment of fetal compromise by Doppler ultrasound investigation of the fetal circulation. Arterial, intracardiac, and venous blood flow velocity studies. Circulation 1995; 91: 129-38.
6. Kiserud T. In a different vein: the ductus venosus could yield much valuable information. Ultrasound Obstet Gynecol 1997; 9: 369-72.
7. Bellotti M, Pennati G, Pardi G, Fumero R. Dilatation of the ductus venosus in human fetuses: ultrasonographic evidence and mathematical modeling. Am J Physiol 1998; 275 (5 Pt 2): H1759-67.
8. Kiserud T. Hemodynamics of the ductus venosus. Eur J Obstet Gynecol Reprod Biol 1999; 84: 139-47.
9. Kiserud T, Rasmussen S, Skulstad S. Blood flow and the degree of shunting through the ductus venosus in the human fetus. Am J Obstet Gynecol 2000; 182 (1 Pt 1): 147-53.
10. Bahlmann F, Wellek S, Reinhardt I, Merz E, Steiner E, Welter C. Reference values of ductus venosus flow velocities and calculated waveform indices. Prenat Diagn 2000; 20: 623-34.
11. Kiserud T. The ductus venosus. Semin Perinatol 2001; 25: 11-20.
12. Axt-Fliedner R, Diler S, Georg T, Friedrich M, Diedrich K. Reference values of ductus venosus blood flow velocities and waveform indices from 10 to 20 weeks of gestation. Arch Gynecol Obstet 2004; 269: 199-204.
13. Axt-Fliedner R, Wiegank U, Fetsch C, Friedrich M, Krapp M, Georg T, et al. Reference values of fetal ductus venosus, inferior vena cava and hepatic vein blood flow velocities and waveform indices during the second and third trimester of pregnancy. Arch Gynecol Obstet 2004; 270: 46-55.

14. Borrell A. The ductus venosus in early pregnancy and congenital anomalies. Prenat Diagn 2004; 24: 688-92.
15. Kiserud T. Physiology of the fetal circulation. Semin Fetal Neonatal Med 2005; 10: 493-503.
16. Ailamazyan EK, Kirillova OV, Polyanin AA, Kogan IY. Functional morphology of ductus venosus in human fetus. Neuro Endocrinol Lett 2003; 24: 28-32.
17. Prefumo F, Venturini PL, De Biasio P. Effect of fetal gender on first-trimester ductus venosus blood flow. Ultrasound Obstet Gynecol 2003; 22: 268-70.
18. Chanthasenanont A, Pongrojpaw D, Somprasit C. Fetal ductus venosus pulsatility index and diameter during 20-30 weeks gestation. J Med Assoc Thai 2008; 91: 794-8.

ผลของเพศทารกต่อการไหลเวียนเลือดและขนาดของหลอดเลือด *ductus venosus* ในช่วงอายุครรภ์ไตรมาสที่สองและสาม

อธิตา จันทเสนานนท์, เด่นศักดิ์ พงศ์โรจน์เผ่า, จรินทร์ทิพย์ สมประสิทธิ์

วัตถุประสงค์: *มีการศึกษาพบว่าเพศของทารกอาจมีผลต่อการไหลเวียนเลือดของหลอดเลือด ductus venosus การศึกษาครั้งนี้ต้องการศึกษาว่าเพศของทารกมีผลต่อการไหลเวียนเลือดและขนาดของหลอดเลือด ductus venosus ในช่วงไตรมาสที่สองและสามของการตั้งครรภ์หรือไม่*

วัสดุและวิธีการ: *ทำการวัด pulsatility index และ เส้นผ่านศูนย์กลางของหลอดเลือด ductus venosus ของทารกในครรภ์ที่ปกติโดยวัด 3 ครั้งในทารกแต่ละคน แล้วนำค่าที่ได้มาคำนวณหาค่าปกติที่อายุครรภ์ต่าง ๆ แยกตามเพศทารก โดยใช้ SPSS13.0 ค่าวัด pulsatility index และ เส้นผ่านศูนย์กลางของหลอดเลือด ductus venosus ระหว่างทั้งสองเพศทารกจะถูกเปรียบเทียบกันด้วย Student's t-test*

ผลการศึกษา: *ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติของ ค่า pulsatility index และ เส้นผ่านศูนย์กลางของหลอดเลือด ductus venosus ระหว่างเพศทารก*

สรุป: *เพศของทารกไม่มีผลต่อการไหลเวียนเลือดและขนาดของหลอดเลือด ductus venosus ในช่วงไตรมาสที่สองและสามของการตั้งครรภ์*