PROGRESOS DE
Obstetricia y Ginecología
Revista Oficial de la Sociedad Española de Ginecología y Obstetricia

Prog Obstet Ginecol 2020;63(1):17-22

Trabajo Original

Referential intervals of the pulsatility index of fetal umbilical artery in Peruvian population

Intervalos referenciales del índice de pulsatilidad de la arteria umbilical fetal en población peruana

Antonio Limay-Ríos[1,2], Marcos Espínola-Sánchez[1], Erasmo Huertas-Tacchino[1,2], Walter Castillo Urquiaga[1], Walter Ventura Laveriano[1], Jaime Ingar Pinedo[1], Ricardo Sugara Rosado[1], Cecilia Ibáñez Rodríguez[1], Oswaldo Gonzales Carrillo[1], Pedro Arango Ochante[1], Mario Zárate Girao[1], Cristian Allcahuaman Arones[2], Flavio Espinoza Trujillo[2], Ammi Coyure López[2]

[1] *Instituto Nacional Materno Perinatal. Perú.* [2] *Universidad Nacional Mayor de San Marcos. Perú*

Abstract

Objective: To describe the reference values of the umbilical artery Doppler pulsatility index in healthy fetuses of pregnant women aged 14 - 40 weeks attended at the National Maternal Perinatal Institute during the period 2011-2016.

Material and methods: A Retrospective observational study. We evaluated all healthy fetuses of 2,633 pregnant women at low risk, in the fetal-obstetrics department of National Maternal Perinatal Institute, from 14 to 40 weeks, who were measured the pulsatility index between 2011 and 2016. Participants: Healthy fetuses in order to determine referential intervals of pulsatility index.

Results: The percentile shows a progressive decrease from 14 to 40 weeks. The pulsatility index in percentile 50 started with 1.7 in week 14 and decreased to 0.81 in week 40. The pulsatility index percentile 95 started with 2.35 in week 14, decreased to 1.68 in week 20, 1.29 in week 30, to 1.18 in week 36 and to 1.13 in week 40. The pulsatility index 1.13 in percentile 95 is normal for everyone weeks. The pulsatility index 2.35 is abnormal for every one week.

Conclusions: The pulsatility index curve of the uterine artery presents similar descriptions in previous studies of other populations; however, knowledge of the eigenvalues in the Peruvian population can be useful as an indicator to discriminate fetus in good conditions in our population.

Key words:

Reference intervals of the pulsatility index. Normal curve of the pulsatility index. Umbilical artery. Peru.

Resumen

Objetivo: describir los valores de referencia del índice de pulsatilidad Doppler de la arteria umbilical en fetos sanos de mujeres peruanas embarazadas de 14 a 40 semanas de edad gestacional.

Material y métodos: estudio observacional retrospectivo. Se evaluaron todos los fetos sanos de 2.633 mujeres peruanas embarazadas con bajo riesgo que presentaron una edad gestacional entre 14 a 40 semanas, atendidas en el departamento de medicina fetal del Instituto Nacional Perinatal Materno.

Resultados: el percentil muestra una disminución progresiva de 14 a 40 semanas. El índice de pulsatilidad en el percentil 50 comenzó con 1,7 en la semana 14 y disminuyó a 0,81 en la semana 40. El percentil índice de pulsatilidad 95 comenzó con 2,35 en la semana 14, disminuyó a 1,68 en la semana 20, a 1,29 en la semana 30, 1,18 en la semana 36 y a 1,13 en la semana 40. El índice de pulsatilidad 1,13 en el percentil 95 es normal para todas las semanas. El índice de pulsatilidad 2,35 es anormal por cada semana.

Conclusiones: la curva del índice de pulsatilidad de la arteria uterina presenta similares descripciones en estudios previos de otras poblaciones; sin embargo, el conocimiento de los valores propios en población peruana puede ser de utilidad como indicador para discriminar un feto en buenas condiciones en una población como la nuestra.

Palabras clave:

Intervalos de referencia del índice de pulsatilidad. Curva normal del índice de pulsatilidad. Arteria umbilical. Perú.

Recibido: 16/02/2020
Aceptado: 18/02/2020

Limay-Ríos A, Espínola-Sánchez M, Huertas-Tacchino E, Castillo Urquiaga W, Ventura Laveriano W, Ingar Pinedo J, et al. Referential intervals of the pulsatility index of fetal umbilical artery in Peruvian population. Prog Obstet Ginecol 2020;63(1):17-22. DOI: 10.20960/j.pog.00HHH. DOI: 10.20960/j.pog.00256

Correspondencia:
Dr. Marcos Augusto Espinola Sánchez
Instituto Nacional Materno Perinatal
Jirón Miro Quesada 941
Cercado de Lima 15001, Perú
e-mail: marcosespinola.es@gmail.com

INTRODUCTION

The umbilical artery borns from the anterior division of the internal iliac or hypogastric artery, it is directed downward and forward, it is reflected in lateral walls of the bladder, goes up its walls and it is directed straight to the belly button, raising the peritoneum, which forms a fold called lesser omentum; in its path it sends a division which is the anterior bladder artery; in the post-natal development this artery remains permeable; the umbilical artery, once it reaches the umbilical ring, joins with its pair and the umbilical vein forming the umbilical cord. The anastomosis of the umbilical arteries located approximately 3 cm of the placenta acts as an equalizer system of the pressure between the umbilical arteries that can be shown with the ultrasound (1). Many years later the study of Doppler flowmetry has been considered an important advance in the management of high-risk fetuses, especially in cases of intrauterine growth restriction, where the umbilical artery Doppler is an indirect measure of impedance or placental resistance (2-5); the umbilical artery flowmetry initially was measured with Doppler in the studies of Mac Callum (6) and Fitzgerald in 1977 (7); after time, were developed the indexes of systole/diastole (S/D), resistance and pulsatility, whose first tables were published more than 25 years ago by Trudinger (5). Later, Arduini (8) published nomograms with a large number of cases that are considered as standard in most texts and centers. The countries of South America have few publications and tables to reevaluate the pulsatility index (PI), except for Chile and Brazil (9-11). PI has become an effective method in the indirect evaluation of placental uterine circulation, whose abnormal results are strongly related to adverse events during the maternal perinatal process (3). The clinical use of PI requires of reference ranges according to our population (12). In conclusion, this study is interested in establishing reference ranges about PI during the pregnancy into 14 to 40 weeks, which would serve as an indicator with respect to a fetus in good condition in our population.

MATERIAL AND METHODS

We performed a retrospective observational study. We evaluated all healthy fetuses of 2,633 pregnant women at low risk, in the fetal-obstetrics department of the National Maternal Perinatal Institute, from 14 to 40 weeks who were measured the PI between 2013 and 2018.

Inclusion criteria: Healthy fetuses, patients with a single pregnancy, pregnant women from 14 to 40 weeks confirmed by date of last menstrual period and first ultrasound of the first trimester, pregnant women who were measured the PI between 14 and 40 weeks and had a healthy newborn.

Exclusion criteria: Fetuses with intrauterine growth restriction or fetal macrosomia, clinical history with incomplete data, pregnant women with high risk.

A General Electric Voluson E8 with 2-6 MHz volumetric probes was used for all measurements; the PI was calculated as described by Gosling in 1971 (PI = [systolic velocity - diastolic velocity]/mean velocity) (13).

The data was obtained by the document review technique according to our inclusion and exclusion criteria. The collection form includes data such as clinical history, maternal age, gestational age of the fetus when performing the Doppler. Three researchers independently corroborated the photos of the umbilical Doppler, the correct technique, the insonation of the umbilical Doppler and we have also evaluated that the patients have been healthy and the babies were born healthy with an adequate weight, without morbidity neither fetal malformations.

Our study was approved by the Ethics and Research Committee, the Fetal Medicine Department and the Obstetrics Service.

Statistical analysis

The reference curves were constructed based on the normal exponential distribution method of Royston and Wright, with logarithmic transformation of the response variable (umbilical artery PI of the Doppler examination). We then applied a third-degree polynomial function, with gestational age as the explanatory variable. The normality of the distribution was assessed using the Shapiro-Wilk test. Thus, we obtained the 5th, 50th and 95th percentiles, with a confidence level of 95%, and their respective graphs. The analysis was performed using MedCalc version 17.8.6.

RESULTS

A total of 2,633 patients were evaluated between 14 and 40 weeks, the average number of patients evaluated per week is 97, week 14 was the one with the lowest number of patients evaluated with 18 and week 37 was the one with the highest number of patients evaluated with 212. We obtained the percentile 5, 50 and 95 of PI according to the gestational age from 14 to 40 weeks, and the number of patients for each gestational age. Besides, there is a progressive decrease in the PI as the gestational age advances, whose high rate of pulsatility at the beginning of pregnancy decreases as the gestational age advances; consequently, final stages has low PI (Table I). We observed a gradual decrease of the PI, also a deceleration in this index whose maximum deceleration is on 40 weeks (Figure 1).

Tabla I.
Percentiles of the pulsatility index of fetal umbilical artery according to gestational age

Gestational age	n	Percentile 5	Percentile 50	Percentile 95
14	18	1.22	1.70	2.35
15	50	1.13	1.57	2.18
16	66	1.06	1.47	2.04
17	59	1.00	1.39	1.93
18	59	0.95	1.32	1.83
19	88	0.91	1.26	1.75
20	153	0.87	1.21	1.68
21	90	0.84	1.16	1.62
22	126	0.81	1.13	1.56
23	126	0.79	1.09	1.51
24	139	0.76	1.06	1.47
25	78	0.74	1.03	1.43
26	60	0.73	1.01	1.40
27	42	0.71	0.99	1.37
28	56	0.70	0.96	1.34
29	30	0.68	0.95	1.31
30	57	0.67	0.93	1.29
31	80	0.66	0.91	1.27
32	105	0.65	0.9	1.25
33	138	0.64	0.89	1.23
34	137	0.63	0.87	1.21
35	169	0.62	0.86	1.20
36	183	0.61	0.85	1.18
37	212	0.61	0.84	1.17
38	169	0.60	0.83	1.15
39	93	0.59	0.82	1.14
40	50	0.59	0.81	1.13

We describe the behavior of the curves of the PI in percentile 95 in the four most prominent authors, including ours results (Figure 2).

We observed that when the values fall in the grey area the PI is absolutely abnormal regardless of gestational age, when these values fall in the blue area, the PI is absolutely normal independent of the gestational age, while when the values fall in the yellow area the normality of the PI will vary according to gestational age (Figure 3).

DISCUSSION

The Lubchenko curve, which was obtained in 1963, in Denver, Colorado, is used in most hospitals (14). In some hospitals this curve proposed is used by CLAP and, in very few, the Peruvian curve proposed by Hernández of the Institute of Neonatology and Maternal and Child Protection in 1972 (15). In our Institute we use the Hernández curve and the Lubchenko curve; however, in a recent publication several growth restrictions were found when they were between 10 and 25 percentiles (16). The weight curve of Peruvian newborns is different from foreign tables since the average weight was significantly higher than those reported by Lubchenco between 37 and 42 weeks of gestational age (17).

In our study we analyzed four curves that we compared with our results. The Arduini curve, published in the year 1990, with a total of 1,556 patients (8), is described as a thin continuous line that stands well above the other curves, possibly due to the limitations of the statistical packages of the time or by the equipment used that was an Ansaldo Esacord 81 of which we do not have many references; the PI started in obstetrics in the year of 1977 with Fitzgerald and Drum in their study of non-invasive measurement of fetal circulation using ultrasound, but the ultrasound scanners did not have a good resolution, the vessels are not very well distinguished; in the Arduini study no photos of the ultrasound shots are appreciated, there are no photos of the umbilical artery Doppler, as if it had Fitzgerald in which it used the NE 4102, the NE 4102 is the equipment of ultrasound (7). However, the Arduini curve has in its 95th percentile a very high fence, due to the fact that hides pathologies as the Doppler of the pathological umbilical artery and restriction of fetal growth without diagnosis, leading dangerously to fetal deaths. Arduini used the Stat View II statistical package that was later called SAS, were the beginnings of the statistical programs, did not consolidate and was surpassed by SPSS and Stata; however, it was the first statistical package that began to perform a more statistical analysis advanced (13,18). In 1983, the color Doppler ultrasound was just started to be used to see blood vessels; Doppler ultrasound was starting during this entire stage until the mid-1990s, ultrasound filters were very high and generated lower diastoles and therefore higher IP (19,20).

The next curve published in 2005 that is in continuous points is that of Ganesh Acharya (21), this curve is universally known and is one of the most used, this curve describes from 19 weeks, however, does not have among the 11 and 18 weeks, we suggest that this is the curve which should be a reference in the fetal evaluation because it was a longitudinal prospective study, although its population is a little 130 pregnant women affected by 513 evaluations, it is a study done fundamentally In Norwegian pregnant women, Acharya stands out for its

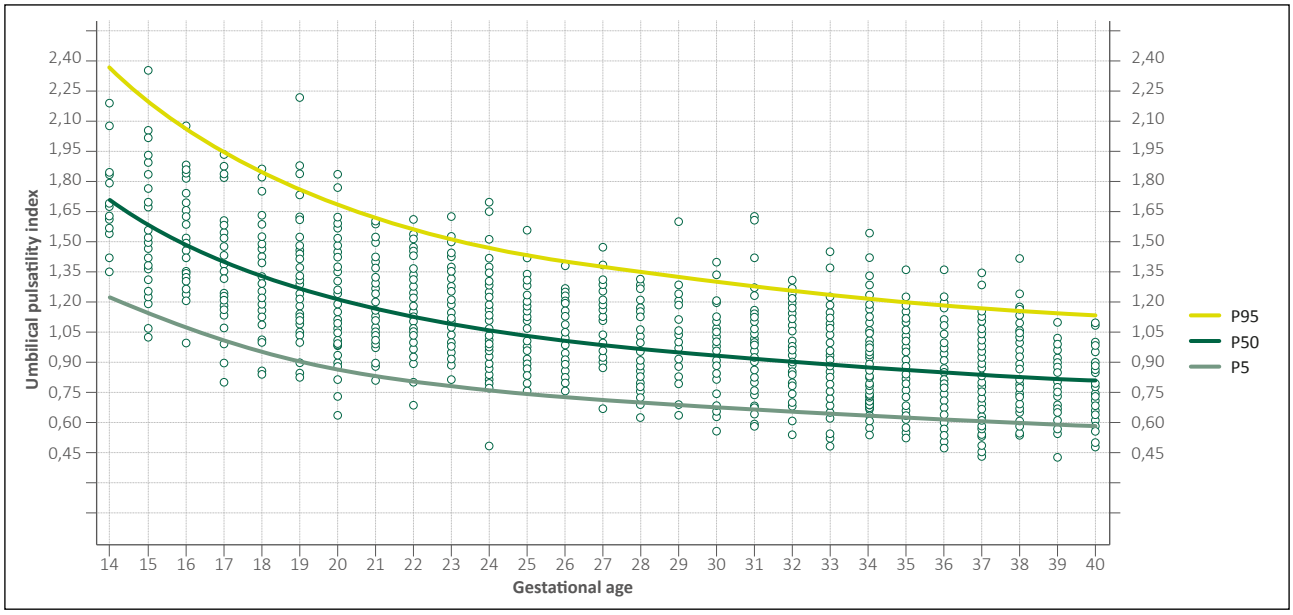

Figure 1. Reference curves of the pulsatility index of fetal umbilical artery according to gestational age.

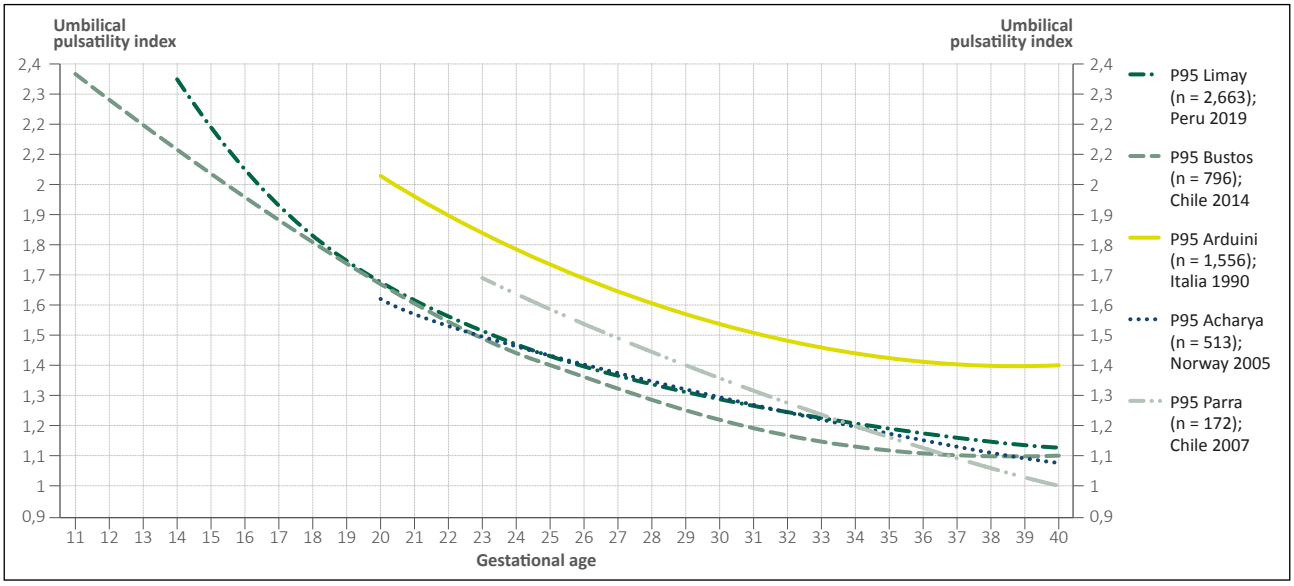

Figure 2. Comparison of referential curves of the umbilical artery Doppler pulsatility index in percentile 95 according to several authors.

methodological grueling, its study done using an Acuson Sequoia 512 from Siemens.

The next curve that behaves in the form of a "line-point-point-line" published by Parra in 2007, using a Siemens Acuson, is a straight line that starts at 23 and reaches 41 weeks (9), being four last weeks well below the 95th percentile with respect to the other curves. It is not precisely a curve that is described but a line, does not mention how many pregnant women who underwent the Doppler were used per week, and the straight Doppler line of the umbilical artery described is due to the use of linear regression.

In 2014, the curve of Bustos, described in the form of a broken line, in his cross-sectional study in 887 unique fetuses, a Medison Sonoace 8000 and a Philips HD9 were used (10). This curve starts from 11 weeks and has a slow descent and then has a deceleration from 35 weeks to 40 weeks. This curve closely resembles ours. Our curve, which has the shape of a "dotted line," has a much more vertiginous descent and continues to descend, although slower, until 40 weeks.

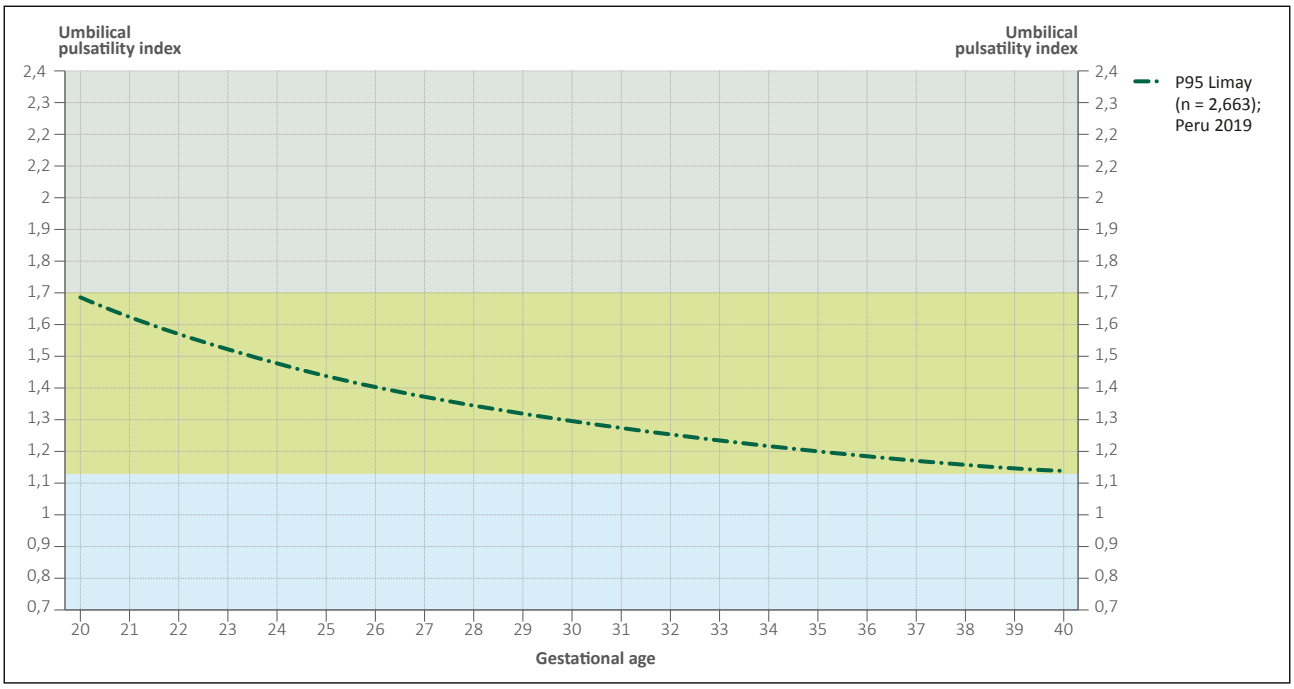

Figure 3. Comparison of referential curves of the umbilical artery Doppler pulsatility index in percentile 95 according to several authors.

While it is true it is a retrospective study, we have confirmed the neatness of these umbilical Doppler results that have been taken by experts in the Fetal Medicine Service. We have corroborated the photos of the umbilical Doppler, the correct technique, the insonation of the umbilical Doppler and we have also evaluated that the patients have been healthy and the babies born healthy with an adequate weight without morbidity nether fetal malformations. The performance of our referential curves closely resembles the load curve and the Bustos curve but it is necessary for each population to have its own tables.

The advantage of our curve is that it has been done in a specialized institute that attend an average of 20,000 deliveries per year and the patients come from all parts of Peru. We cannot universalize a curve or a table for everyone because the ethnic groups are diverse and therefore there are certain variations that require each population to have its own curves.

CONCLUSIONS

This study results shows the referential curves of fetal umbilical artery in Peru, which are the first ones. The reference values obtained for umbilical artery PI can be used for follow-up of umbilical artery ultrasound, thus helping us to personalize our approach based on gestational age between 11 and 40 weeks. This is the national average and therefore a reference in Peru to the calculation of the umbilical Doppler, when this value is above the 95th percentile that we are presenting, it would be an umbilical Doppler increased in its resistance and therefore it would be a valuable weapon to detect babies with intrauterine growth retardation, be able to solve the problem in a timely manner and thus reduce the perinatal morbidity and mortality.

REFERENCES

1. Fort JA. Anatomía descriptiva y disección que contiene un resúmen de embriología, estructura microscópica de los órganos y de los tejidos. Vol. II. 2.ª ed. Manuel Rodríguez, editor. Madrid; 1872. 732 p.
2. Reuwer PJ, Bruinse HW, Stoutenbeek P, Haspels AA. Doppler assessment of the fetoplacental circulation in normal and growth-retarded fetuses. Eur J Obstet Gynecol Reprod Biol 1984;18(4):199-205.
3. Erskine RL, Ritchie JW. Umbilical artery blood flow characteristics in normal and growth-retarded fetuses. Br J Obstet Gynaecol 1985;92(6):605-10.
4. Giles WB, Trudinger BJ, Baird PJ. Fetal umbilical artery flow velocity waveforms and placental resistance: Pathological correlation. Br J Obstet Gynaecol 1985;92(1):31-8.
5. Trudinger BJ, Giles WB, Cook CM. Flow velocity waveforms in the maternal uteroplacental and fetal umbilical placental circulations. Am J Obstet Gynecol 1985;152(2):155-63.
6. McCallum WD, Williams CS, Napel S, Daigle RE. Fetal blood velocity waveforms. Am J Obstet Gynecol 1978;132(4):425-9.
7. Fitzgerald DE, Drumm JE. Non-invasive measurement of human fetal circulation using ultrasound: A new method. Br Med J 1977;2(6100):1450-1.
8. Arduini D, Rizzo G. Normal values of pulsatility index from fetal vessels: A cross-sectional study on 1556 healthy fetuses. J Perinat Med 1990;18(3):165-72.
9. Parra-Cordero M, Lees C, Missfelder-Lobos H, Seed P, Harris C. Fetal arterial and venous Doppler pulsatility index and time averaged velocity ranges. Prenat Diagn 2007;27(13):1251-7.

10. Bustos JC, González V. Curvas normales de índices de pulsatilidad y tiempo medio de desaceleración de arteria umbilical fetal en población chilena. Rev Chil Obstet Ginecol 2014;79(4):255-61.
11. Tavares NMC, Ferreira SG, Bennini JR, Marussi EF, Barini R, Peralta CFA. Longitudinal reference intervals of maternal-fetal Doppler parameters. Rev Bras Ginecol Obstet 2013;35(1):33-8.
12. Krampl ER, Espinoza-Dorado J, Lees CC, Moscoso G, Bland JM, Campbell S. Maternal uterine artery Doppler studies at high altitude and sea level. Ultrasound Obstet Gynecol 2001;18(6):578-82.
13. Gosling RG, Dunbar G, King DH, Newman DL, Side CD, Woodcock JP, et al. The quantitative analysis of occlusive peripheral arterial disease by a non-intrusive ultrasonic technique. Angiology 1971;22(1):52-5.
14. Lubchenco LO, Hansman C, Dressler M, Boyd E. Intrauterine growth as estimated from liveborn birth-weight data at 24 to 42 weeks of gestation. Pediatrics 1963;32(5):793-800.
15. Hernández J, Acosta M, Maldonado C, Sacieta L, Meza A. Curva de crecimiento intrauterino. Pediatría UNMSM 1976;1(1):7-18.
16. Castillo-Urquiaga W, Ventura-Laveriano W, Limay-Ríos OA, Zárate-Girao M, Sugajara-Rosario R, Ingar-Pinedo J, et al. Tabla de referencia para la evaluación Doppler de la arteria umbilical. Rev Peru Investig Materno Perinat 2018;7(1):68-75.
17. Rendón MT, Apaza DH. Crecimiento fetal en el recién nacido peruano. Rev Peru Ginecol Obstet 2008;54(1):33-7.
18. Grimes DA, Schulz KF. Bias and causal associations in observational research. Lancet 2002;359(9302):248-52.
19. Xiaoming L, Torp H. Effects of the wall filter on the estimation of high blood velocity. En: 1997 IEEE Ultrasonics Symposium Proceedings an International Symposium (Cat No97CH36118) vol.2. Toronto: Institute of Electrical and Electronics Engineers; 1997; p. 1263-7.
20. Mikkonen RH, Kreula JM, Virkkunen PJ. Reproducibility of Doppler ultrasound measurements. Acta Radiol 1996;37(4):545-50.
21. Acharya G, Wilsgaard T, Berntsen GK, Maltau JM, Kiserud T. Reference ranges for serial measurements of umbilical artery Doppler indices in the second half of pregnancy. Am J Obstet Gynecol 2005;192(3):937-44.