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Reference values of fetal Doppler at the Instituto Nacional de Perinatología Isidro Espinosa de los Reyes.

John Narváez Chávez,[1] Sandra Acevedo Gallegos,[2] Juan Manuel Gallardo Gaona,[3] Berenice Velázquez Torres[3]

Abstract

OBJECTIVE: To establish the reference values for the pulsatility index using pulsed-wave Doppler in the maternal and fetal assessment of pregnancies followed up between 18 and 39 weeks of gestation.

MATERIALS AND METHODS: Descriptive and cross-sectional study, carried out in patients with a singleton pregnancy, between 18 and 40 weeks, who attended the Department of Maternal Fetal Medicine of the National Institute of Perinatology *Isidro Espinosa de los Reyes*, from September 2017 to May 2018. The Doppler evaluation was performed, with measurement of the pulsatility index of the uterine, umbilical, middle cerebral arteries, and ductus venosus in each week of pregnancy. Reference tables were created for each gestational age, establishing percentiles 3, 5, 10, 90 and 95.

RESULTS: A total of 862 patients were registered. The umbilical artery pulsatility index values were reported to be 17% at early gestational ages and 21% at older gestational ages; umbilical artery values were 3% lower at early gestational ages and 10% lower at term of pregnancy; 20% for the umbilical artery, 15% for the ductus venosus and 10% for the middle cerebral artery. The values of the mean pulsatility index of the uterine arteries were 3% higher at early gestational ages and 28% lower at the end of pregnancy.

CONCLUSIONS: The findings of this study suggest significant differences with the populations of Europe and North America; They even differ from the reference values currently used in the Mexican population, which represents an underestimation of fetal and/or maternal conditions when carrying out evaluations of the feto-placental unit.

KEYWORDS: Pregnancy; Uterine artery; Umbilical artery; Middle cerebral artery; Ductus venosus; Pulsatility index; Doppler; Reference values.

[1]Sixth year Maternal Fetal Medicine Resident.
[2] Head of the Department of Maternal Fetal Medicine.
[3] Physician attached to the Department of Maternal Fetal Medicine.
Instituto Nacional de Perinatología Isidro Espinosa de los Reyes, Mexico City.

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Correspondence
Sandra Acevedo Gallegos
dracevedo_sandra@yahoo.com.mx

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BACKGROUND

Doppler flowmetry is an important development for high-risk fetal treatment,[1-3] especially in cases of intrauterine growth restriction,[4-5] for whom it represents an indirect measurement of placental resistance, performed with umbilical artery Doppler.[6-7] Some alterations with high rates of adverse perinatal outcomes (intrauterine growth restriction, gestational diabetes, and pregnancy hypertensive disorders of the preeclampsia type) have been associated with changes in the hemodynamic pattern of the feto-placental unit. These patterns are obtained from normal reference values of fetuses with a normal pregnancy evolution, when evaluating the resistance and pulsatility indices,[8-9] and thus, they work as predictive, prognosis, and follow-up patterns of fetal well-being in high-risk pregnancies.

The Doppler feto-placental normality value tables were published by Arduini in the decade o the 1990s.[10] Since then, they have been regarded as the reference patterns in most of the literature and medical centers, included the Mexican National Institute of Perinatology (NIP).

The goal of the present study was to establish reference values for the pulsatility index with pulsed-wave Doppler, in the maternal-fetal assessment of pregnancies in follow-up between weeks 18 and 39 of gestation, at the NIP.

MATERIALS AND METHODS

Descriptive, cross-sectional study, carried out with singleton pregnancy patients, between weeks 18 and 40 of gestation. The patients were seen at the Maternal-Fetal Medicine Department of the NIP, between September 2017 and May 2018. The sample was taken from patients who went for a routine ultrasound assessment.

Inclusion criteria: singleton pregnancy, between weeks 18 and 39 of gestation as defined by the day of the last menstruation, calculated based on a reliable first trimester ultrasound; fetal growth of estimated fetal weight between percentiles 10 and 90, according to Hadlock's tables.[11] *Exclusion criteria*: fetuses with identified structural or chromosome anomalies, or suspicion of such anomalies; pregnant women with base diseases which could affect fetal hemodynamics (Doppler): pregestational diabetes without metabolic control, pregnancy hypertensive disorders without control (gestational hypertension, chronic hypertension, or preeclampsia), chronic kidney disease in dialytic therapy, oligohydramnios, alloimmunization, etc.; pregnancies with placental or funicular alterations (placenta previa, placenta with suspicion of accretism, placental tumors, cysts, alteration in the number of vessels, velamentous insertion, or vasa previa); and patients who received fetal lung maturation inducers (betamethasone or dexamethasone) in the seven days prior to the study.

The sociodemographic data was collected, and the weeks of gestation were determined in each patient based on the last date of menstruation, which was corroborated as well with ultrasound in the first trimester.

The ultrasound assessments were made by Maternal-Fetal Medicine specialist doctors attached to the Maternal-Fetal Medicine Department, trained and certified for the measurement of hemodynamic parameters, according to the data sheet registered in the Maternal-Fetal Doppler Clinical Guidelines protocol developed by Figueras.[12] After patients joined the study, the ultrasound assessment was made with a Voluson E8 ultrasound equipment (General Electric Health Care, Mikwaukee, WI, USA), with a 4-8 MHz transducer. During the ultrasound study the following measurements were made: biparietal diameter, head circumference, abdominal circumference, and femoral length to establish the average fetometry and estimated fetal weight. Also, the measurement of the amniotic fluid

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index was made, depending on the weeks of gestation, to determine the absence of alterations as a criterion of non-inclusion. The complete Doppler assessment was also performed, including uterine, umbilical, middle cerebral arteries, and the ductus venosus. The perinatal outcomes were obtained from the electronic records of every patient at the end of pregnancy.

For the statistical analysis, the IBM SPSS Statistic v. 23.0 software was used. Descriptive statistics were used for demographic variables, with calculation of measures of central tendency (mean, median and mode), and of dispersion (standard deviation) for quantitative variables. The Doppler flowmetry values were used to elaborate intervals or reference ranges for the mean pulsatility index values (PI) of uterine, umbilical, middle cerebral arteries, and the ductus venosus, and for the cerebro-placental relationship. These reference ranges were used to establish percentiles 3, 5, 10, 50, 90, and 95, for every studied value, and reference tables were created to correspond to each Doppler value, according to gestational age.

The study adhered to the Helsinki Declaration principles, and to the norms established in the Regulations of the General Health Law in Mexico, specifically the second title, which addresses ethical aspects of research with human beings, chapter I, article 17, fraction II. According to this norm, the present study is classified as research with higher risk than the minimum (https://www.diputados.gob.mx/LeyesBiblio/regley/Reg_LGS_MIS.pdf). Because of this, the measurements were made with strict adherence to the ALARA (As Low As Reasonable Achievable) principles, where the thermal and mechanical indices remained below 1. This measurement has shown to be of no harm for the mother or the fetus during the second trimester of pregnancy (https://www.cdc.gov/nceh/radiation/alara.html). Given that ultrasound is part of the routine monitoring for all pregnant women who receive prenatal care at the NIP and considering that the information was obtained from the electronic records, no additional informed consent was required.

RESULTS

There were 862 patients with singleton pregnancy. Fetometry and fetal weight were taken during these assessments, as well as hemodynamic parameters. It was not possible to obtain uterine artery measurements in 12 cases, umbilical artery in 14, middle cerebral artery in 29, and ductus venosus in 69, because of technical limitations.

There was an increase in the frequency of visits to the NIP during the weeks 20 to 22, and 27 to 30 of pregnancy. This increase can be attributed to the routine follow-up protocol set for these gestation weeks, which includes structural and fetal growth assessment. **Figure 1**

Sociodemographic characteristics

All the evaluated patients were Mexican, with a mean age of 29 years (range 13 to 48). Regarding the age extremes of the range, 21.6% were in the 35 or over group, while 9.7% were under 18. The civil status of the patients showed a similar distribution between married, common-law, and single, with percentages of 37.1, 32.8, and 30%, respectively. As for the height of the patients, the mean was 157 cm, with a range of 134 to 178 cm. For the body mass index (BMI), 3.1% of the patients were underweight, 42.4% had a normal weight, 28.3% were overweight, and 15.1% were obese. There was no BMI information for 11.1% of the cases. The age of their partners had a mean and median of 31.5 years, with a range of 14 to 61 years. The average height of the partner was 170 cm, with a range of 145 to 190 cm. The BMI was calculated only in 33% of the partners' cases, with 45.5% being overweight, 38% had normal weight, and 16.5% were obese. **Figure 2**

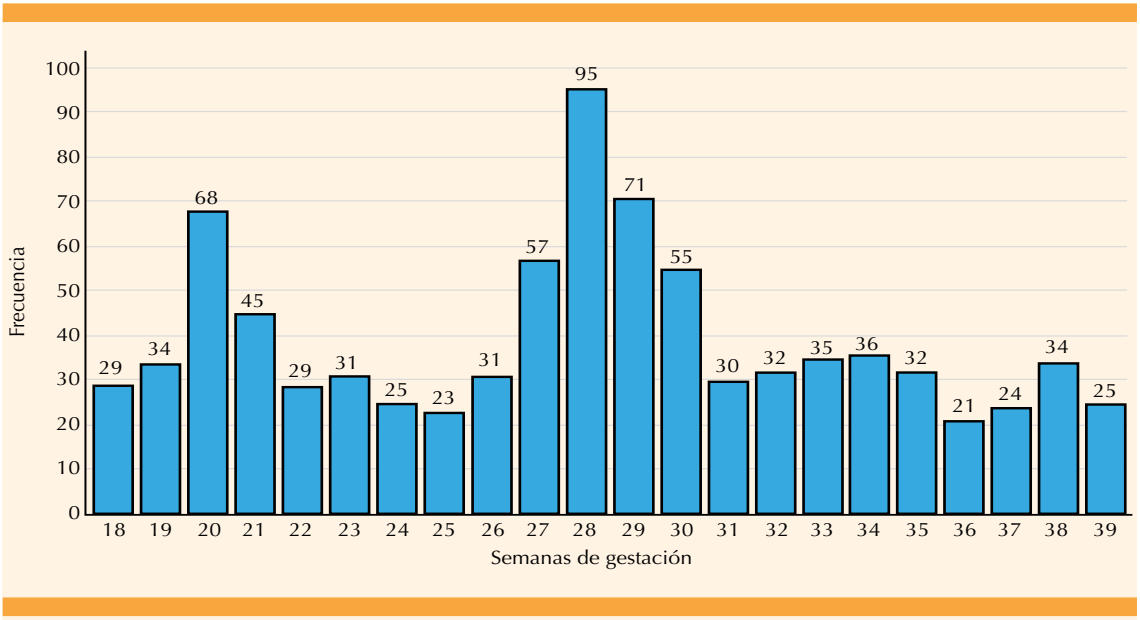


Figure 1. Number of patients treated according to weeks of gestation.

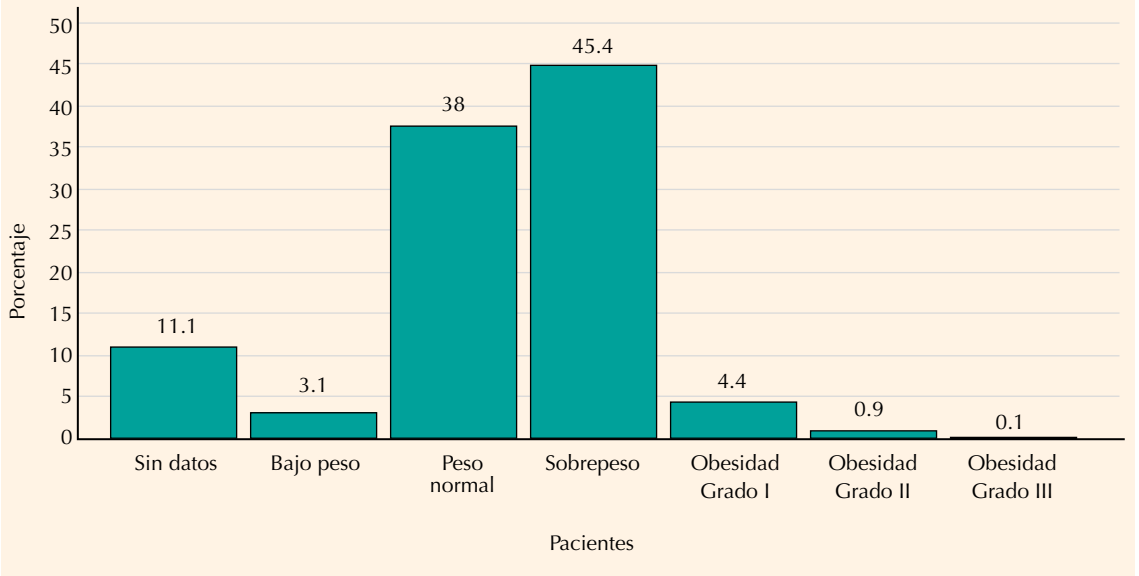


Figure 2. Maternal body mass index.

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Clinical characteristics and background

At the time of the ultrasound assessment, there were 648 patients without associated comorbidities, making 75.2% of the population. The most frequently reported disease was hypothyroidism in 111 cases (12.9%), followed by chronic arterial hypertension in 25 cases (2.9%) with adequate control, epilepsy in 20 cases (2.3%), systemic lupus erythematosus in 16 cases (1.9%) without evidence of activity during the evaluation, pregestational diabetes in 14 cases (1.6%); with 3 corresponding to diabetes type I, and 10 to diabetes type II, all of them with adequate metabolic control and no adverse perinatal outcomes, cardiopathies in 13 cases (1.5%), atrial sept defect in 8 cases, with surgical correction in 4 cases, Ebstein's anomaly in 2 cases, ventricular septal defect in 1 case, corrected tetralogy of Fallot in 1 case, and patent ductus arteriosus in another, all without dysfunction on evaluation of cardiac function with echocardiography, or adverse perinatal outcomes.

For maternal history, there was smoking in 3.8% (N = 33), alcohol consumption in 1.6% (N = 14), and drug addictions in 2.7% (n = 23), from whom 20 corresponded to cannabis consumption, 1 to cocaine consumption, and 2 to both substances. No patient reported consumption during pregnancy. There were no cases of exposure to teratogens. During the interview and search for infectious diseases, no history of active TORCH complex infections was documented. Five patients (0.6%) were informed of HIV infection, and 1 (0.1%) with hepatitis C. The obstetric gynecologic history revealed that 97.3% of the patients had a spontaneous pregnancy, and 2.6% (n = 22) in vitro fertilization, with 1 case (0.1%) of oocyte donation. Forty-two point two percent of the patients were primigravidas, 10.2% were multiparous (with more than 3 births), and 1% had a history of recurrent pregnancy loss. No case reported Rh alloimmunization.

It is noteworthy that 0.8% of the patients had a history of previous pregnancy with large fetus (N = 7), preterm birth in 3% (N = 26), cerclage in 1.7% (N = 15), pregnancy hypertensive disorders in 2% (N = 17), of which there was only 1 case of gestational hypertension, and 16 preeclampsia (only one of them severe). There was intrauterine growth restriction in 15 cases (1.7%), and 11 of the patients had a history of fetal defect, corresponding to 1.3%. The reported defects were 4 cardiopathies, 1 encephalocele, 1 microcephalia, 2 bronchopulmonary sequestrations, 1 trisomy 13, 1 trisomy 21, and 1 case of Treacher Collins syndrome. The pulsatility index values determined for each fetal vessel, by week of gestation are shown in **Figure 3.**

Regarding hemodynamics, percentile tables were constructed for the Doppler pulsatility index values for each vessel. **Tables 1 to 6**

Perinatal outcomes

There were only 471 perinatal outcomes (54.6%), because some pregnancies did not end at the NIP. Two hundred ninety-seven of the former were by C-section (63.1%), whose most frequent surgical indication was a previous C-section or previous uterine scar in 43%, followed by fetopelvic disproportion (fetal or maternal dystocia) in 59 cases (19.8%), 27 cases (9%) of unsatisfactory fetal well-being, detected by abnormal fetal monitoring tracing, 28 cases electively (9.4%), 10 cases (3.4%) for failure of labor progression, and 6 cases (2%) of premature abruption of the normal placenta. One hundred forty-two patients (30%) had a vaginal birth, and 31 patients (6.6%) had an instrumented delivery.

There were complications at the end of pregnancy in 14 cases (2.97%), mainly postpartum hemorrhage in 10 cases, requiring obstetric hysterectomy in one patient, due to hypotonia resistant to medical treatment; there were 2 cases with bladder injury, with a history of

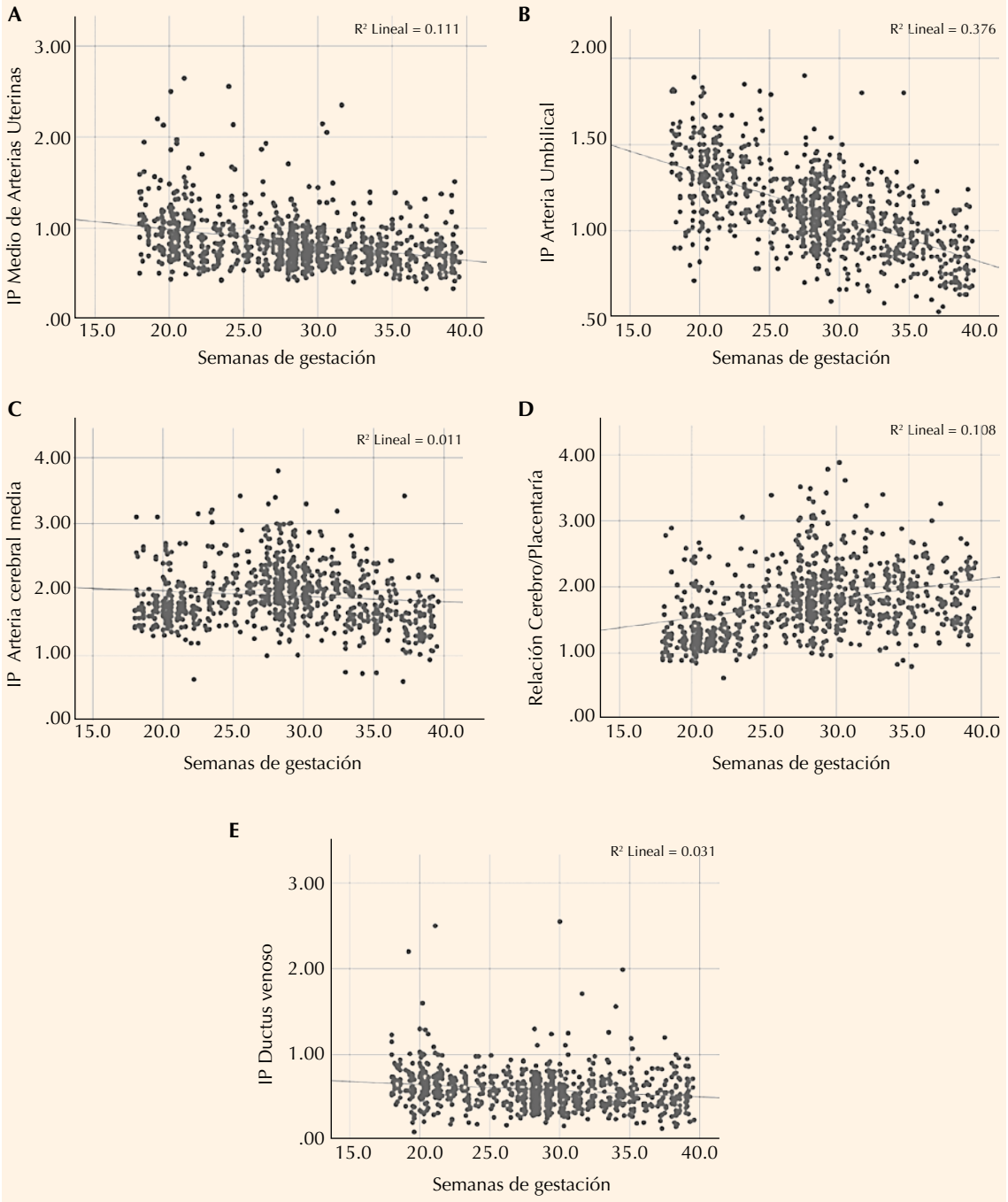


Figure 3. Uterine arteries mean pulsatility index **(A)**; umbilical artery pulsatility index. **(B)**; middle cerebral artery pulsatility index **(C)**; C/P relation pulsatility index **(D)**; ductus venosus pulsatility index **(E)**.

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Table 1. Mean values of the pulsatility index of fetal vessels by gestational age

Semanas de gestación	n	IP medio arterias uterinas P95	IP arteria umbilical P95	IP ACM P5	Relación C/P P5	IP dectus venoso P95
18	29	1.78	0.82	1.40	0.89	1.19
19	34	2.14	1.83	1.37	0.91	1.3
20	68	1.89	1.73	1.39	0.95	1.28
21	45	1.63	1.65	1.31	1.03	1.39
22	29	1.56	1.56	0.91	0.83	0.79
23	31	1.28	1.71	1.39	0.94	0.82
24	25	2.43	1.77	1.46	0.96	0.98
25	22	1.35	1.71	1.37	1.12	0.98
26	26	1.89	1.36	1.36	1.20	0.89
27	57	1.17	1.50	1.42	1.26	0.87
28	95	1.21	1.41	1.52	1.16	0.80
29	71	1.05	1.39	1.33	1.07	0.89
30	55	1.60	1.42	1.46	1.21	1.15
31	30	1.88	1.57	1.32	1.13	1.21
32	32	1.20	1.35	1.48	1.35	0.96
33	35	1.30	1.31	1.03	1.07	1
34	36	1	1.41	1.08	0.88	1.66
35	32	1.22	1.31	1.13	1	1.12
36	21	1.27	1.23	1.24	1.34	0.83
37	24	1.27	1.19	0.70	1.16	1.11
38	34	1.14	1.12	1.15	1.30	0.97
39	25	1.46	1.21	0.97	1.17	0.93

previous C-section; one case of neonatal facial paralysis, secondary to birth instrumentation, and another pulmonary thromboembolism in a patient with severe preeclampsia diagnosis at 29 weeks.

The obstetric alterations diagnosed during pregnancy were hypertensive disorders (3%), included 4 cases of gestational hypertension, and 10 of preeclampsia, from whom 9 had severe characteristics. Eighteen cases (3.8%) had gestational diabetes, and 25 (5.3%) were intolerant to carbohydrates; both types of cases were adequately controlled metabolically and did not have adverse perinatal outcomes.

The gestational age at the time of birth was over 37 weeks in 87.7% (n = 413), and 12.3% were considered preterm (under 37 weeks). Regarding the sex of the newborns, there were 245 (52%) male births, and 226 (48%) female births. The weight at birth was analyzed according to gestation weeks, and it was found adequate in 93.8% (n = 442), low weight in 4.9% (n = 23), and large for gestational age in 1.3% (n = 6).

There were 3 cases of perinatal death, which corresponded to extremely premature births, and 1 unexplained death at 29 weeks of gestation. Also, there were 10 (2.1%) cases of perinatal asphyxia, and 5 cases (1%) had low Apgar scores.

Table 2. Uterine artery mean pulsatility index values by gestation week

IP medio de uterinas						
	Percentil					
Semanas de gestación	3	5	10	50	90	95
18	0.50	0.57	0.69	104	159	1.78
19	0.51	0.58	0.67	0.95	ISS	2.14
20	0.53	0.63	0.66	0.92	1.39	1.89
21	0.52	0.57	0.6	1.02	1.48	1.63
22	0.5	0.52	0.55	0.74	1.2	1.56
23	0.43	0.44	0.56	0.83	1.13	1.28
24	0.54	0.55	0.59	0.93	1.85	2.43
25	0.54	0.55	0.63	0.83	1.27	1.35
26	0.48	0.49	0.51	0.78	1.48	1.89
27	0.55	0.57	0.6	0.79	1.09	1.17
28	0.46	0.52	0.56	0.77	1.04	1.21
29	0.50	0.51	0.52	0.74	1.01	1.05
30	0.55	0.56	0.59	0.77	1.16	1.60
31	0.52	0.53	0.56	0.69	1.29	1.88
32	0.41	0.48	0.55	0.75	1.04	1.20
33	0.50	0.51	0.54	0.74	1.05	1.30
34	0.50	0.53	0.60	0.73	0.91	1
35	0.44	0.45	0.49	0.68	1.08	1.22
36	0.42	0.43	0.46	0.69	1.19	1.27
37	0.34	0.37	0.46	0.70	1.07	1.27
38	0.46	0.47	0.49	0.72	0.91	1.14
39	0.34	0.36	0.45	0.66	1.25	1.46

Four of the newborns (0.9%) were sent to the Pathology Department due to perinatal death, 431 (91.5%) were roomed-in, and 37 (7.5%) required neonatal intensive care. The causes for these last cases were perinatal asphyxia in 10 babies, premature birth in 11, respiratory distress syndrome of the newborn in 8, 3 cases of babies born to mothers with type I diabetes, with metabolic monitoring, chorioamnionitis in 2 cases, and 1 facial ecchymosis secondary to instrumented birth.

DISCUSSION

The present study has a considerable sample size of assessed patients at different gestation weeks. When analyzing the sociodemographic characteristics, we observed a behavior similar to that of Mexican pregnant women, according to the reports generated by the National Institute of Statistics and Geography (INEGI) of 2015.[13] We found that the population had a normal distribution regarding age, with a peak of pregnancies

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Table 3. Umbilical artery pulsatility index values by gestation week

IP arterias umbilicales						
Percentil						
Semanas de gestación	3	5	10	50	90	95
18	0.9	0.91	1.05	1.44	1.81	0.82
19	0.71	0.77	0.94	1.28	1.69	1.83
20	0.90	0.97	1.04	1.32	1.57	1.73
21	0.79	0.98	1.07	1.34	1.59	1.65
22	0.97	0.98	1.03	1.28	1.44	1.56
23	1.05	1.06	1.10	1.30	1.54	1.71
24	0.78	0.79	0.83	1.21	1.67	1.77
25	0.78	0.79	0.86	1.12	1.39	1.71
26	0.84	0.86	0.92	1.17	1.30	1.36
27	0.81	0.87	0.92	1.1	1.31	1.50
28	0.80	0.83	0.88	1.10	1.34	1.41
29	0.75	0.80	0.89	1.09	1.36	1.39
30	0.66	0.71	0.82	1.10	1.33	1.42
31	0.69	0.73	0.80	0.99	1.29	1.57
32	0.65	0.67	0.84	1.04	1.29	1.35
33	0.59	0.71	0.79	1	1.28	1.31
	0.69	0.70	0.82	0.93	1.23	1.41
35	0.62	0.69	0.75	0.93	1.23	1.31
36	0.60	0.61	0.72	0.93	1.19	1.23
37	0.53	0.54	0.62	0.82	1.04	1.19
38	0.63	0.65	0.68	0.85	1.11	1.12
39	0.63	0.64	0.65	0.80	1.14	1.21

between 20 and 29 years, similar to what's reported by the INEGI. We found a difference with the INEGI report regarding civil status, with 11% of single patients, in contrast to 30% in their report. We found 47% women in common law relationships, as opposed to 32.8% reported by the INEGI. The percentage of married women was similar in both studies.

The fertility rate reported by the INEGI is 2.3 births per women, while we obtained a slightly lower rate in the present study (2.1%). The percentage of pregnant women under 19 years is 12.9%, while for the present study it was 9.7%.[13]

When evaluating somatometry, we found that the average height of the patients was 157 cm, with a BMI of 25.7 kg/m2, while the INEGI reports 158 cm and a BMI of 27.5 kg/m2. Regarding partners, the average height was 170 cm, with a BMI of 26.4 kg/m2, while the INEGI reports an average height of 164 cm and a BMI of 27.8 kg/m2.[13]

As for the clinical characteristics of the patients, 12.9% had diagnosis of hypothyroidism, which

Table 4. Middle cerebral artery pulsatility index values by gestation week

IP arteria cerebral media						
	Percentil					
Semas de gestación	3	5	10	50	90	95
18	1.38	1.40	1.43	1.69	2.60	2.89
19	1.30	1.37	1.42	1.74	2.28	2.68
20	1.36	1.39	1.45	1.74	2.41	2.58
21	1.26	1.31	1.40	1.71	2.07	2.52
22	0.63	0.91	1.19	1.7	2.01	2.58
23	1.39	1.39	1.46	1.96	2.94	3.18
24	1.45	1.46	1.57	1.80	2.60	2.67
25	1.36	1.37	1.46	2	2.82	3.36
26	1.26	1.36	1.52	1.96	2.56	2.95
27	1.3	1.42	1.77	2.10	2.78	2.92
28	1.38	1.52	1.61	2.05	2.71	2.98
29	1.22	1.33	1.52	2.08	2.79	2.88
30	1.39	1.46	1.59	2	2.38	2.65
31	1.23	1.32	1.42	1.88	2.47	2.84
32	1.34	1.48	1.60	2.09	2.46	2.81
33	0. 77	1.03	1.29	1.71	2.52	2.69
34	0. 77	1.08	1.25	1.77	2.39	2.45
35	0.74	1.13	1.36	1.64	2.39	2.4
36	1.23	1.24	1.42	1.83	2.38	2.44
37	0.61	0.70	1.05	1.49	2.03	3.17
38	1.02	1.15	1.22	1.46	1.93	2.21
39	0.94	0.97	1.07	1.59	2	2.18

is similar to what Shields et al. reported, with 12.4% of pregnancy hypothyroidism.[14] Chronic arterial hypertension was found in 2.9% of the patients, while Noriega et al. reported it in 1 to 5% pregnancies.[15] Cardiopathies were found in 1.5% of the cases, and the Mexican Health Department reports them in between 2 to 4%.[16] In the present study, epilepsy was found in a higher percentage (2.3%), in comparison with what Bistre et al. reported, with 0.4 to 1.2% of Mexican pregnant women.[17] The same situation happened with pregestational diabetes, reported here in 1.6% of the patients, while Mexican pregnancy statistics report a prevalence of 0.3% of the population.[18] The discrepancy between these data can be explained because of the characteristics of the NIP, being a tertiary care hospital, working as a reference center for pregnant women with diabetes and epilepsy diagnoses. Thus, it is likely that there is a larger number of patients with these characteristics, in comparison with other centers.

Regarding maternal habits, we found smoking in 3.8% of the patients, like what's reported by the National Public Health Institute (3.1%) for smoking in women in reproductive age. However, we

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Table 5. Cerebro-placental pulsatility index values by gestation week

Relacion cerebro/placentaria						
Percentil						
Semanas de gestación	3	5	10	50	90	95
18	0.88	0.89	0.92	1.23	2.28	2.83
19	0.89	0.91	0.98	1.24	1.98	2.46
20	0.88	0.95	1.02	1.31	2.19	2.43
21	0.99	1.03	1.07	1.23	1.98	2.33
22	0.62	0.83	1.04	1.30	1.83	2.08
23	0.9	0.94	1.05	1.59	2.14	2.77
24	0.95	0.96	1.02	1.62	2.32	2.46
25	1.1	1.12	1.29	1.52	2.46	3.29
26	1.16	1.20	1.28	1.73	2.37	2.90
27	1.16	1.26	1.39	1.90	2.69	3.01
28	1.11	1.16	1.37	1.88	2.83	3.07
29	0.99	1.07	1.32	1.99	2.55	3.03
30	1.15	1.21	1.35	1.81	2.52	2.94
31	1.12	1.13	1.48	1.85	2.48	2.93
32	1.3	1.35	1.44	2.04	2.79	2.99
33	1.05	1.07	1.37	1.79	2.54	2.97
34	0.83	0.88	1.25	1.99	2.40	2.53
35	0.8	1	1.32	1.85	2.38	2.67
36	1.33	1.34	1.37	2.16	2.63	2.98
37	1.15	1.16	1.21	1.74	2.43	3.09
38	1.26	1.30	1.40	1.75	2.23	2.38
39	1.13	1.17	1.26	1.94	2.40	2.58

found 1.6% of the patients who drank alcoholic beverages before pregnancy, in comparison with 22.2% reported by the National Public Health Institute. This marked difference can be interpreted as an error in the report of pregnant women regarding their habits, yielding a subsequent underestimation. A history of drug addiction was reported in 2.7% of our cases, while the National Survey of Addictions reported a 1.3% of any illegal drug consumption, and 0.9% for marihuana. This difference in the reports is justified because the NIP is a health center which receives high-risk pregnant women with this kind of history.[19]

The present analysis established a proportion of pregnant women with hepatitis C (0.1%) and HIV (0.6%), similar to what the WHO reports, with 1% for hepatitis C in Latin America, and 0.1% for HIV in Mexico.[20-21]

The maternal and perinatal outcomes of the analyzed group show a similar behavior of the NIP patients and the literature reports for the Mexican population. C-sections were a 63% of the births in our study, while for the Mexican population, the rate is of 46.1%. This is one of the highest C-section rates in the world,

Table 6. Ductus venosus pulsatility index values by gestation week

IP ductus venoso						
Percentil						
Semanas de gestación	3	5	10	50	90	95
18	0.42	0.43	0.5	0.71	1	1.19
19	0.1	0.18	0.28	0.59	0.86	1.3
20	0.3	0.34	0.4	0-67	1	1.22
21	0.3	0.34	0.46	0.66	1	1.39
22	0.19	0.22	0.25	0.57	0.75	0.79
23	0.21	0.25	0.36	0.57	0.77	0.82
24	0.19	0.25	0.40	0.66	0.90	0.98
25	0.27	0.28	0.37	0.58	0.75	0.98
26	0.18	0.23	0.35	0.65	0.81	0.89
27	0.27	0.29	0.34	0.54	0.81	0.87
28	0.30	0.31	0.34	0.53	0.76	0.80
29	0.26	0.30	0.35	0.54	0.81	0.89
30	0.23	0.28	0.32	0.57	0.85	1.15
31	0.31	0.32	0.33	0.48	0.73	1.21
32	0.25	.029	0.34	0.52	0.88	0.96
33	0.26	0.29	0.34	0.63	0.82	1
34	0.25	0.28	0.35	0.51	0.79	1.66
35	0.2	0.24	0.30	0.52	0.94	1.12
36	0.21	0.22	0.35	0.47	0.78	0.83
37	0.14	0.16	0.26	0.46	0.83	1.11
38	0.16	0.18	0.25	0.50	0.88	0.97
39	0.22	0.23	0.28	0.53	0.87	0.93

clearly above the WHO recommendation of 10 to 15%.[22] Regarding pregnancy alterations, there was a 3% of hypertensive disorders in our study, while for the general Mexican population the diagnosis is made in 2 to 10% of pregnancies. This percentage is similar to that of of global reports, where hypertensive disorders are associated with complications in 5% of pregnancies.[23] The diagnosis of gestational diabetes was established in 5.3% of the cases, and the Mexican prevalence is reported between 8.7 and 17.7%.[24]

Regarding gestational age at birth, 12.3% of the cases were considered premature, which is higher than what is reported for the Mexican population, at 7%, according to the CENETEC Guidelines 2017 for the prevention of pre-term births. Given that pre-term births are a multifactor alteration, and the main risk factor is a history of pre-term birth, this difference can be explained because 3% of the assessed population had a history of pre-term birth, and 1.7% had cervical insufficiency; both are direct risk factors that could contribute, significantly, to

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the elevated number of pre-term births.[25] For the weight at birth, there were similar observations for low weight for gestational age (4.9%; n=23), compared with the report by the National Mexican Public Health Institute (8.7%).[26] The perinatal death rate was of 8.5 deaths for every 1000 births. The global perinatal death rate is of 18.6 for every 1000 births, while in Mexico the rate is 8 for every 1000 births.[27] Perinatal asphyxia had a percentage of 2.1%, which is similar to what is reported in the literature (1 to 1.5%), going even as high as 9%, depending on the health center where the study is carried out.[28-29]

When comparing pulsatility indices values with those of previous reports, Arduini et al. informed of lower umbilical artery pulsatility indices, with a 17% in early gestational stages, and 21% in later gestational stages. This finding is similar to what Bustos found.[30] When comparing the results of the present study with those of Bustos, the umbilical artery pulsatility index values are 3% lower in early gestational stages, and 10% lower at pregnancy term. The reference tables of the Barcelona Clinic show 20% higher values for the umbilical artery, 15% for the ductus venosus, and lower in 10% for the middle cerebral artery.[12]

Comparing our results with those of Gomez,[31] based on a healthy population, with normality curves of the umbilical artery pulsatility index; considering that our results show a minimum difference of 0.5% at 35 weeks, with an increase at pregnancy term; where there is a higher difference of the pulsatility index, even of 15% in relation to those obtained in the present analysis . Compared to studies carried out in Mexico, when contrasting our results with Medina's[32] report of uterine and umbilical arteries pulsatility indices values, lower values (9%) can be identified for the present study, in early gestational stages, and at pregnancy term, they are lower down to a 12%.

Regarding the uterine arteries mean pulsatility index, there are higher values here in a 3% in early gestational stages, and at pregnancy term they are 28% lower, in contrast with Medina's report. Thus, it can be inferred that the results obtained in the present study are similar to those reported in the Latino population; however, when comparing them with Europe and North America, they have showed higher pulsatility indices values. **Figure 4**

The strength of this study was the large number of patients that share clinical and sociodemographic characteristics, similar to those reported in statistics for the general Mexican population. Thus, the applicability of the analysis suggests that it is possible to transpolate these results to the pregnant women of all the country and use the pulsatility index tables as a reference for fetal hemodynamic assessments. According to this analysis, the tables that we have been using until now have a pronounced percentual difference in comparison with the findings of the present study for the Mexican population, this with the intention of reaching a more accurate fetal assessment, and with lower probability of error in clinical decision making.

One of the main weaknesses of the study is the small number of patients at certain gestational stages, especially those over 36 weeks. This situation does not let us establish with certainty that the value obtained for that gestational age really reflects the normal hemodynamic fetal behavior. Another point to consider is that our team defined fetuses with a normal pattern of growth as those between percentiles 10 to 90, according to Hadlock's tables.[11] This is because we don't have fetal growth tables for the Mexican population, which can lead to a bias in the initial classification of the fetuses for our study.

It is important to highlight that this study was carried out to establish Doppler reference values for the pulsatility index, which is the most useful clinical value. Thus, more studies are needed to validate the risk cutoff points for adverse

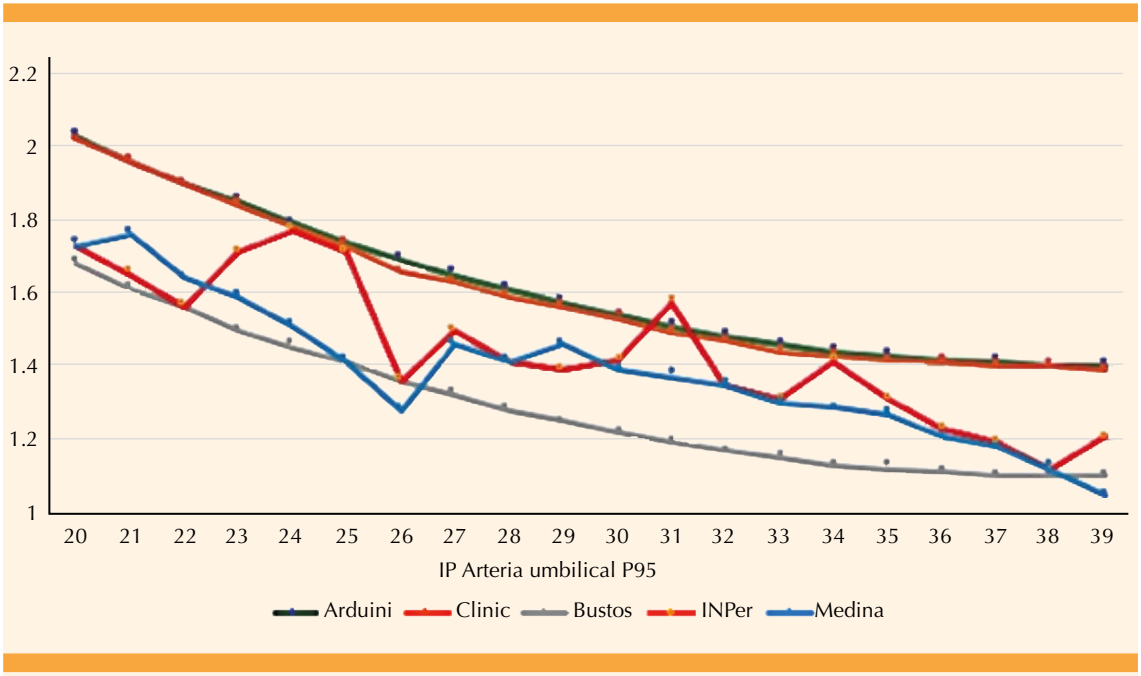


Figure 4. Comparative curves of percentile 95 of the umbilical artery pulsatility indices with other countries' values.

perinatal outcomes, according to the obtained Doppler values.

CONCLUSIONS

The results of the present study differ from the ones currently used as reference for the monitoring and treatment of our population. This is something that must be reviewed because we could be underestimating fetal or maternal conditions at the time of the assessment of the fetoplacental unit. This study is a base and a reference guide of pulsatility indices for the different gestational weeks under study, with the population of pregnant women seen at the National Institute of Perinatology; thus, this must be taken into account when using them and trying to transpolate the results to other populations. The goal of this study was to determine the reference values of the pulsatility index of fetoplacental circulation; however, it is not possible to ascertain that the cutoff points commonly used to define normality are correct. That is why it is necessary to validate the results with further studies through the validation of perinatal outcomes. A door is left open to the development of multiple studies, with the aim of obtaining more accurate results in fetal hemodynamic assessments.

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