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The Anterior Pelvic Index (API) in the Classification of the Female Pelvis and Prediction of Fetopelvic Disproportion

El Índice Pelviano Anterior (API) en la Clasificación de la Pelvis Femenina y Predicción de la Desproporción Fetopélvica

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SUMMARY: Measurements of the upper strait of the pelvis can be calculated using the Anterior Pelvic Index. The objective of the study was to determine the external validity and cut-off point of the API, to classify narrow pelvises from normal ones. We selected 214 women from 15 to 55 years old, 171 had vaginal delivery and 43 by caesarean section by feto-pelvic disproportion (FPD) of maternal origin, in whom the API was calculated, of which its mean difference was established with an alpha error of <0.05. Maximum values of sensitivity and specificity, ROC curve and Youden index were determined. The student's t gave a p-value =0.000 of the mean difference between the women who had vaginal delivery and those who had cesarean section by FPD of maternal origin; the value of the area under the ROC curve was 0.758 (CI 95% 0.695 – 0.814) with a p-value=0.0001. Maximum sensitivity was 74.42 % (CI 95%: 58.8 % to 86.5 %) and maximum specificity was 73.10 % (CI 95%: 65.8 % to 79.6 %), produced a Youden index of 0.475 (CI 95% 0.283 – 0.590) which is associated with the 15.44 (CI 95% 14.19 – 15.83) of the API scale. The API is a good tool for predicting women with suspected narrow pelvis and allows its classification into three types of pelvises: an API value of more than 15.83 would indicate pelvis suitable for vaginal delivery; an API value between 14.19 and 15.83 would be suspected of pelvic narrowness; an API value less than 14.19 would confirm a narrow pelvis.

KEY WORDS: Pelvimetry; Anterior pelvic index; Fetopelvic disproportion.

INTRODUCTION

The pelvis is the bone structure that is forming the base of the trunk, which supports its weight and transmits it to the lower limbs. It has the shape of a truncated cone with a broad anterosuperior base and lower vertex. It has an external or exopelvian surface and an internal or endopelvian surface. The internal or endopelvian surface is divided in two by the upper strait: Above this we find the greater or false pelvis, the same one comprising the two internal iliac fossas and the ailerons of the sacrum, covered by the psoasiliac muscles; below the upper strait we find the minor or true pelvis, which constitutes the so-called pelvic excavation, the place that the fetus crosses during the birth process (Ruiz Liard *et al.*, 2005; Moore *et al.*, 2013; Guerrero & Ocampo, 2015).

The pelvic inlet is irregularly circular, similar to an oval or a french card heart, it is a complete bony ring formed backwards by the promontory followed on both sides by the anterior edge of the wings of the sacrum, the sacroiliac joint, the arcuate line, the iliopubic ramus, the pectineal crest and the upper edge of the pubic symphysis. To determine its functionality, obstetricians have established various points of measurement of the same, resulting in a series of anatomical and obstetric diameters that are related to fetal

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cephalic diameters mainly, and in this way prepare for an eventual dystocia of childbirth by fetopelvic disproportion (FPD) (Aller & Pagés, 1999; Guerrero & Ocampo, 2015).

Initially indirect measurements of the pelvic inlet through the instrumental external pelvimetry were used, and then with the use of pelvic radiography the indirect measurement was left aside. However, the use of X-rays in pregnancy presented fetal genetic alterations that limited its usefulness (Benson & Doubilet, 2014). With the advent of ultrasound and nuclear magnetic resonance imaging, it has been possible to measure the pelvic dimensions very accurately and thus predict the risks of dystocic childbirth (Awonuga *et al*., 2007; Sigmann *et al*., 2014).

The measurement of internal pelvic diameters, especially those of the pelvic inlet, have included a wide range of research projects and studies have been published regarding these measurements, using nuclear magnetic resonance, computed tomography and even ultrasound (Franz *et al*., 2017), however it is not always feasible to have the appropriate technology to measure pelvic diameters or it is simply not accessible to the target population.

Few studies establish an indirect measurement of pelvic inlet diameters using external pelvimetry (Lenhard *et al*., 2010; Daghighi *et al*., 2013), which has been used again, mainly the external conjugated, intercrestal, interspinous, intertrochanteric, intertuberosous, transverse and diagonal of the sacral rhomboid diameters, alone or combined with maternal height (Liselele *et al*., 2000); and studies have also been developed with indices such as the fetopelvic (Korhonen *et al*., 2015), the anterior pelvic (Guerrero *et al*., 2016) and others.

The objective of pelvimetry is to know in advance the measurements of the pelvic inlet to avoid fetomaternal morbidity and mortality caused by FPD (Alijahan *et al*., 2014), considering that a large part of dystocic deliveries is treated for emergency and ends in caesarean section. The prevalence of caesarean sections due to FPD ranges between 2 % and 5 % as follows: in the Isidro Ayora Obstetric-Gynecological Hospital in Quito in 2017 it was 2.23 % (Hospital Gineco Obstétrico Isidro Ayora, 2017). In a study conducted by Carrasco Palomeque *et al*. (2009), at the Vicente Corral Moscoso hospital in Cuenca and the Homero Castanier Crespo hospital in Azogues, the prevalence of caesarean sections due to FPD was 3.91 % and 4.68 % respectively (Carrasco Palomeque *et al*., 2009); Dávila, (2014) reported that at the Carlos Andrade Marín Hospital in Quito, the prevalence of caesarean sections due to FPD was 5.25 % (Dávila Valdiviezo & Sisa, 2014); Espinosa & Leime (2017) reported that at the Delfina Torres de Concha Hospital in Esmeraldas, the prevalence of caesarean sections due to FPD was 1.38 %. FPD is the second leading cause of caesarean section in Ecuador and other countries in the region and the world (Espinosa & Leime, 2017).

In the research carried out by Guerrero *et al*. (2016), applying the principle of the harmonious and symmetrical development of the human body, it was possible to identify an index taking as parameters the height and the interspinous distance (anterior bispinous diameter), called "Anterior Pelvic Index" which was correlated with the ecosonographic obstetric conjugated diameter, and these two measures were subjected to a simple linear regression procedure, finding an obstetric conjugate diameter prediction equation. However, this was still to be applied in women who are parturient or who have had children by normal delivery or caesarean section, to determine the cut-off point values that discriminate a normal pelvis for a vaginal delivery versus a narrow pelvis for this type of delivery. Therefore, the objective of the present study was to determine the external validity and cut-off point of the Anterior Pelvic Index (API) that allows the classification between narrow and normal pelvises for childbirth.

MATERIAL AND METHOD

An instrumental validation study of a cross-sectional type was conducted, with a systematic random selection among women in the postpartum period or who have had children by means of normal delivery or by caesarean section in the Isidro Ayora and Luz Elena Arismendi from Nueva Aurora Obstetric-Gynecological Hospitals, as well as in the Pablo Arturo Suarez Hospital, all of them in the city of Quito, during the second half of the year 2018.

The consent of the health authorities of the hospitals where this study was carried out was obtained, as well as the informed consent of the participating women or their representatives for minors.

A total of 214 women aged 15 to 55 years were selected, 171 women had their delivery vaginally and 43 women did so by caesarean section due to FPD of maternal origin because of a pelvis inlet not suitable for a normal delivery duly verified. Women with caesarean section for other reasons of FPD such as macrosomic, macrocephalic or hydrocephalic products were ruled out.

The API was calculated by dividing the interspinous distance (measured with calibrated Martin-type pelvimeters) for the height of women (according to the Frankfort technique with calibrated height rods marked "Detecto") and

multiplying by 100. The measures were taken by a professional in each hospital, duly trained in the corresponding techniques.

The data were consigned in the registration form and transferred to an Excel 2013 sheet and processed in the statistical programs SPSS® version 24 and MedCalc® version 13.3.3. Absolute and relative frequencies of age groups and type of delivery were obtained, as well as measures of central tendency, position and dispersion of age, height, interspinous distance and anterior pelvic index (API). The difference in means of the API between the groups of women who had vaginal delivery and cesarean section was established, with an alpha error of <0.05. We proceeded to the external evaluation of the diagnostic performance of the API to discriminate vaginal delivery from cesarean section by FPD of maternal origin, by determining the maximum values of sensitivity and specificity, the ROC curve and the Youden index.

RESULTS

Of the 214 women undergoing the study, 68 % (CI 95%: 61.49 to 74.02) were less than 30 years (Table I); 80 % (CI 95%: 74.94 to 85.28) had birth vaginally, and 20 % (CI 95%: 14.72 to 25.46) by caesarean due fetus pelvic disproportion of maternal source (narrow bone pelvis).

Table I. Frequency distribution of age groups in a sample of women between the ages of 15 and 55 from the city of Quito, subjected to the bony pelvis classification study according to the Anterior Pelvic Index.

Age groups/years	n	%	IC 95 %
< 20	46	21.5	15.99 – 27.00
21 - 30	99	46.3	39.58 – 52.94
31 - 40	50	23.4	17.70 – 29.03
41 - 50	13	6.1	2.87 – 9.28
> 51	6	2.8	0.59 – 5.02

Measures of central tendency and dispersion of the variables age, height, interspinous diameter (ID) and anterior pelvic index (API), are presented in Table II.

In the statistical Student's t test, Levene test of equal variances gives a p-value = 0.126, whit a t-value = 5.488 with 212 degrees of freedom, produces a p-value = 0.000, which demonstrates the existence of a statistically significant mean difference of anterior pelvic index between women who delivered vaginally and those who underwent cesarean due to FPD of maternal source. Measures of central tendency, dispersion and normality test can be seen in Table III.

Table III. Descriptive statistics and normality test of the API between vaginal delivery and cesarean delivery due to FPD of maternal origin, in a sample of women aged 15 to 55 years from the city of Quito.

Statistical		Vaginal delivery (n=171)	Cesarean delivery for DFP (n=43)
Mean		16.4	14.9
IC 95 % mean	Upper limit	16.1	14.4
	Lower limit	16.7	15.3
Standard error of the mean		0.1	0.2
Variance		2.9	2.0
SD		1.7	1.4
Kolmogorov-Smirnov (p-value)		0.1	0.1

The external evaluation of the diagnostic performance of the Anterior Pelvic Index discriminating vaginal birth by cesarean delivery due to DFP of maternal source, the ROC curve shows a under the curve area value of 0.758 (CI 95%: 0.695 to 0.814) with a p-value = 0.0001. Maximum sensitivity coordinates (74.42 % CI. 95 %: 58.8 % to 86.5 %) and highest specificity (73.10 % CI. 95 %: 65.8 % to 79.6 %), yield a Youden index 0.475 (CI95 % from 0.283 to 0.590) which it is associated to the value 15.44 (CI 95% 14.19 to 15.83) of the scale of the Anterior Pelvic Index (Fig. 1).

Table II. Descriptive statistics of the variables age, height, interspinous distance and API, in a sample of women aged 15 to 55 years from the city of Quito. (n = 214)

Statistical		Age (years)	Height (cm)	Interspinous Distance (cm)	Anterior Pelvic Index (API)
Mean		27.8	152.7	24.6	16.1
CI 95 % mean	Upper limit	26.6	151.8	24.2	15.9
	Lower limit	28.9	153.6	24.9	16.3
Standard error of the mean		0.6	0.5	0.2	0.1
Variance		72.8	46.3	7.9	3.1
SD		8.5	6.8	2.8	1.8
Coefficient of variation (%)		30.7	4.5	11.4	10.4

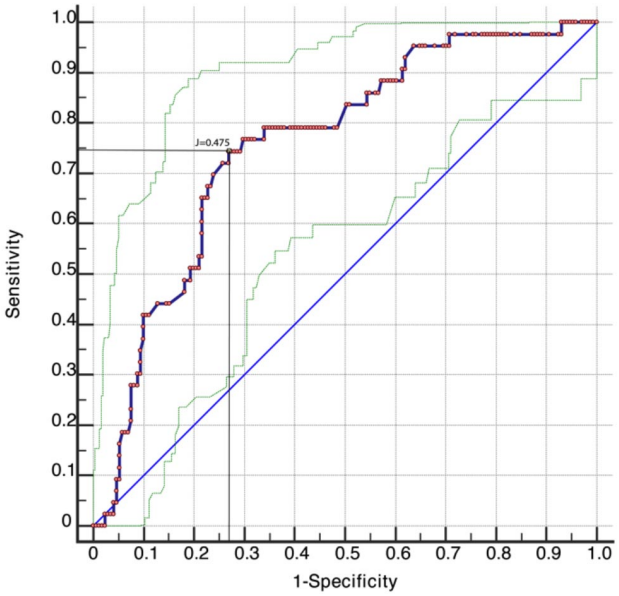

Fig. 1. ROC curve and value of the Youden Index of the IPA to discriminate vaginal delivery from cesarean delivery by PFD of maternal origin, in a sample of women aged 15 to 55 years from the city of Quito.

DISCUSSION

Imaging tests, mainly pelvic anthropometry by Magnetic Resonance has allowed to obtain more precise values of the dimensions of the birth canal and the various morphometric studies indicate this, considering that this procedure has no risk to the mother and fetus (Lenhard *et al*., 2010; Franz *et al*., 2017). Morphometric studies have also been carried out with Computed Tomography, in this sense Sigmann *et al*. (2014) using four methods measured several obstetric diameters and the Magnin index, obtaining high correlation coefficients and therefore an adequate method of pelvimetry. However, the use of this technology presents some important problems: the radiation that it produces and that would affect the fetus in case the woman is pregnant; the expertise of the professional who makes the images and who subsequently interprets them; the cost of using the equipment and technological accessibility, among others (Sigmann *et al*., 2014).

For this reason, for developing countries where technology is not yet accessible to the entire population, it is necessary to look for alternatives that, without losing the quality of care, can provide solutions to health problems still unresolved, and emergency caesarean section by FPD is one of them; hence, this research is fully justified, where with very simple measurement tools such as the height rod and the pelvimeter or anthropometer we can contribute to the reduction of maternal and infant morbidity and mortality due to dystocia of childbirth.

The harmonious development of the different organs and systems of the human body has made it possible for researchers to correlate different structures and anatomical points in such a way that the dimensions of some determine others, in most cases. Rozenholc *et al*., (2007) used maternal height and diagonal transverse diameter of the sacral rhomboid (of Michaleis) in a study conducted in Cameroon with 807 parturient women, determining that these measures have high values of sensitivity, specificity, positive predictive value, and probability index, and therefore, can predict pelvic dystocia in nulliparous women before childbirth, in more than half of the cases, (Rozenholc *et al*., 2007).

The anatomical principle of harmonic development guided Guerrero *et al*. (2016), to obtain the Anterior Pelvic Index. This result, with the value of the ecosonographic obstetric conjugate diameter, was used to construct a mathematical model, applying the statistical technique of simple linear regression to obtain a predicted value of the obstetric conjugate diameter, by calculating coefficients of the linear regression line.

The difference in the API mean between vaginal delivery and cesarean delivery (FPD) shows us that this measuring instrument is reliable because it correctly classifies women with a pelvis for vaginal delivery and those with a narrow pelvis who should have a cesarean section.

The age range of 15 to 55 years and height from 135 cm to 172 cm indicates that the sample of women broadly covers groups of women of reproductive age, on the one hand, and height on the other, as both variables, among others, are used to evaluate and determine obstetric risk (Alijahan & Kordi, 2014).

The main finding of our study was that the API is a good tool for predicting women with suspected narrow pelvis, because the value of the Area Under the Curve in the analysis of diagnostic performance using ROC provides a value of 0.758 (CI 95% 0.695 – 0.814) and it is statistically significant, in addition, for its high sensitivity, allows their identification in 74.42 % (CI 95%: 58.8- 86.5 %) of the cases.

The value of the Youden index is associated with the value of the API scale, allowing to establish a classification of three types of pelvises: an API value of more than 15.83 would indicate pelvis suitable for a vaginal delivery; an API value between 14.19 and 15.83 would be suspected of pelvic narrowness; an API value less than 14.19 would confirm a narrow pelvis.

CONCLUSIONS

In developing countries such as ours where access to imaging technologies such as MRI and low-intensity CT are not yet in massive use due to their high cost; anthropometric techniques where methods and tools of measurement are used as the one proposed here, can be the solution for the forecast of pelvic narrowness and therefore foresee the type of childbirth to which women would be subjected.

Ethical aspects. This study was submitted for review and approval by the Human Research Ethics Committee of the Central University of Ecuador SEISH-UCE, as well as the National Health Authority. The confidentiality and anonymity of the participating women was kept.

Limitations. One of the major limitations we found was the low prevalence of FPD of maternal origin in the Health Units where the study was conducted.

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RESUMEN: Las medidas del estrecho superior de la pelvis pueden calcularse mediante el Índice Pelviano Anterior. El objetivo del estudio fue determinar la validez externa y el punto de corte del API, para clasificar pelvis estrechas de las normales. Seleccionamos 214 mujeres de 15 a 55 años, 171 tuvieron parto vaginal y 43 mediante cesárea por DFP de origen materno, en quienes se calculó el API, del cual se estableció su diferencia de medias con un error alfa de <0,05. Se determinaron valores máximos de sensibilidad y especificidad, curva ROC e índice de Youden. La t de Student dio un p-valor=0,000 de la diferencia de medias entre las mujeres de tuvieron parto vaginal y las que fueron sometidas a cesárea por DFP de origen materno; el valor del área bajo la curva ROC fue 0,758 (IC 95% 0,695 – 0,814) con un p-valor=0,0001. La máxima sensibilidad (74,42 %. IC 95%: 58,8 % a 86,5 %) y máxima especificidad (73,10 %. IC 95%: 65,8 % a 79,6 %), produjeron un índice de Youden de 0,475 (IC 95% 0,283 – 0,590) el cual está asociado al valor 15,44 (IC 95% 14,19 – 15,83) de la escala del API. El API es una buena herramienta de predicción de mujeres con sospecha de pelvis estrecha y permite su clasificación en tres tipos de pelvis: un valor de API de mas de 15,83 indicaría pelvis aptas para un parto vaginal; un valor de API entre 14,19 y 15,83 se sospecharía de estrechez pélvica; un valor de API menor a 14,19 confirmaría una pelvis estrecha.

PALABRAS CLAVE: Pelvimetría; Indice pelviano anterior; Desproporción fetopélvica.

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