Measurement of Uterine Cavity Shape of Adult Female on Coronal Section by Three-dimensional Ultrasound

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Abstract

Objective: To describe the measurement of uterine cavity shape on coronal section by three-dimensional ultrasound in Chinese adult female population. Methods: A cross-sectional observational study including 172 adult females with normal uterine cavity was performed and all participants underwent transvaginal two-dimensional and three-dimensional ultrasonography. Seven measurements (uterine cavity width, uterine cavity length, internal os width, lateral indentation depth, lateral indentation angle, cornual angle, uterine cavity area) were determined and evaluated on coronal plane of uterus. Results: The mean age of the participants included was 29.8±5.4 years. 95% reference range of uterine cavity length, uterine cavity width, internal os width, cornual angle, lateral indentation angle and lateral indentation depth were estimated as 26-38 mm, 25-40 mm, 4-11mm, 39-88°, 131-171° and 0.8-6.4 mm, respectively. The mean uterine cavity area was 5.5±1.3 cm^2 and the range of 95% reference value was 3.0-8.0 cm2. Conclusion: Our research showed that a normal uterine cavity in adult women of childbearing age had lateral indentation depth [?]7mm, lateral indentation angle [?]130deg and cornual angle [?]40deg. The width of the uterine cavity measured on the coronal plane less than 22mm and the uterine cavity area less than 3cm2 can be considered smaller than normal.

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Key words: uterine cavity shape; uterine cavity area; three-dimensional Ultrasound; coronal section

Introduction

Transvaginal three-dimensional ultrasound (3D-US) has been used widely in gynecological field ,especially in classification of the uterine malformations(1,2) and diagnosis of uterine adhesion(3,4), which has shown satisfactory concordance with other "gold standard" examinations, such as laparoscopy and hysteroscopy(5,6) and hysterosalpingography(7). The advantage largely arises from its ability to reconstruct the coronal plane of the uterus, which allows for visualization of the outer and inner contour of the uterine walls yielding accurate measurement of the sub-septation length and cavity width(8,9,10). To distinguish between normal uterus cavity and Mullerian duct anomalies or uterine adhesion, a coronal plane would be useful in demonstrating their distinguishing features. Normal uterus was defined as any uterus having either straight or curved fundal and interostial lines but with the internal or external indentation at the fundal midline not exceeding 50% of the uterine wall thickness(11). Internal shape of endometrial cavity, uterine contour, fundal indentation, and septal length can be accurately demonstrated using real-time 3D-US .

Uterine synechiae or adhesions have a significant adverse effect on fertility. The degree of adhesion can be mild, moderate, or severe according on whether adhesions involve one-fourth, one-half, or over three-fourths of the uterine cavity(12). 2D ultrasound may present a diagnostic clue to adhesions within the endometrial cavity through the presence of bands seen within the endometrial echo, particularly with the aid of sonohysterography. However, the true narrowing or "bands" adherent across the cavity is usually well delineated on the coronal plane on 3D imaging and 3D-US can predict adhesions and cavity damage with greater accuracy than hysterosalpingogram(13) and obliteration (undetectable endometrium) in 3D-US showed 100% sensitivity to diagnose uterine adhesion(3). According to our experience, shape and area of uterine cavity in the coronal section of the uterus is very important information to distinguish between normal uterus cavity and uterine adhesion(14), just as it plays an important role in evaluating the endometrial cavity post-septal resection or metroplasty(15). So, We propose that it is very necessary to determine a "normal" and more specific uterine cavity using real-time 3D-US measurements in the coronal view, which could help us to determine the degree of uterine adhesion, to judge whether a certain intrauterine device is suitable or not, to calculate the ratio of normal and abnormal uterine cavity in some gynecological diseases, et al.

The purpose of this study was to evaluate uterine cavity measurements in adult women of childbearing age who have normal uterine cavity confirmed by hysteroscopy and to confirm the range of "normal uterine cavity". It may be a basic research for the clinical application of uterine cavity morphological measurements to judge some gynecological diseases.

Materials and methods

Study subjects

This cross-sectional observational study was performed at Sun Yat-sen Memorial Hospital of Sun Yat-sen University. From January 2018 to March 2020, 172 consecutive premenopausal women from the gynecology clinic center who were referred for pelvic ultrasonography were included. The inclusion criteria were as follows: 1) childbearing age; 2) with regular menstrual cycle; 3) pelvic and ultrasonic examination revealed normal sized uterine body; 4) had a normal uterine cavity on two- and three-dimensional transvaginal ultrasonography; 5) no history of uterine cavity surgery before the ultrasonography; 6) the subsequent hysteroscopy confirmed normal uterine cavity (without fibroids, endometrial polyps, uterine synechiae and intrauterine device). The exclusion criteria included the following items: 1) thickened endometrium ([?]15mm); 2) simple or atypical endometrial hyperplasia, or endometrial malignancies; 3) having used contraceptives or any other kind of hormones in the 3 months before participating in the study; 4) had a history of pregnancy in the 6 months preceding the ultrasound scan.

Ultrasonography measurement

After emptying the bladder, all participants underwent transvaginal ultrasonography in the dorsal lithotomy position avoiding menstrual period. Ultrasonographic examination was performed using an ultrasonography machine (Voluson^{TM} E6 BT15, GE Healthcare Austria) and a volumetric intravaginal probe (RIC 5-9-D, frequency 5–9 MHz, 3D measurement angle 75°, PD: 0.6). Among all the subjects, the standard setting of each parameter was kept consistent. First, 2D ultrasonography was used to observe the morphology and position of the uterine body, endometrial thickness, and whether there is any abnormity in the uterine cavity. Then, the 3D energy mode was switched on, and all 3D data-sets acquisitions were performed in a standardized manner (sagittal view of the central part of the uterus; manually drawing a straight or curved line through the middle of the endometrium; maximum sweep angle of 180°; the approximate angle between the uterine axis and the ultrasound beam, 90°; ultrasound probe held steadily by the investigator, holding breath and refrain from moving by the study women during 3D volumes acquisition). Upon acquisition the 3D volume, a satisfactory coronal plane of uterus was obtained by adjusting the slice through the multiplanar views. Uteri with internal fundal indentation depth[?]5mm (namely arcuate/septate uteri) were excluded. Eligible 3D datasets of each uterus were recorded and stored in hard disk of ultrasonography machine for further manipulation and analysis offline. The techniques of post processing functions for image optimization include surface rendering and volume contrast imaging(VCI). Rendering is applicable to visualizing the external serosal contour of the uterus and identifying the internal os in the coronal plane with the function of Fixed ROI(fixed region of interest) in 2D sagittal view. OmniView combined with VCI improves the image contrast between endometrial cavity and myometrium and can also allow the identification of the internal os in the coronal plane.

All measurements were taken after obtaining a satisfactory coronal view with visible bilateral horns of uterus and the internal os. A standardized set of seven measurements and their methodology was established. Detailed criteria and definitions of each morphological parameter is presented in Figure 1. The width of the uterine cavity was measured between the two cornual ostia of endometrial cavity. The length of the uterine cavity was the distance from the fundus to the anatomical internal os. The width of the internal os was the width of inferior segment of the uterine cavity running through the anatomical internal os. The surface area of uterine cavity was determined by manually outlining the entire surface of the endometrial cavity, including all the external limits and the anatomical internal os. The cornual angle was calculated by connecting the three points: the point of cornual ostia and two points on the fundus and lateral edge respectively 5mm distant from this point. The lateral indentation angle was measured using the three points including the apex of lateral indentation and two points on the lateral edge of uterine cavity 5mm distant from this point. The lateral indentation depth was defined as the distance between the line connecting the anatomical internal os and the point of cornual ostia and the parallel one across the apex of lateral indentation. The measurement method of this study was partially based on the work of Ludwin et al (16).

All patients were undergoing 3D ultrasonography measurement by two deputy directors of ultrasound doctors, who were blinded to each other's measurements and there was no statistically significant difference in the measurements between both ultrasonography specialists. The coefficient of variation was <4.6% for uterine cavity area and <3.6% for uterine cavity width.

Statistical analysis

All statistical descriptions and analyses were conducted using SPSS Statistics 17.0 (IBM, Chicago, IL, USA). The one-sample Kolmogorov-Smirnov test was first applied to check normal distribution. Continuous measurements are presented as mean+- standard deviation (SD), median (minimum-maximum) and 95% medical reference range. Mean+-1.96SD and P2.5-P97.5 were defined as 95% reference range for the normally distributed data (lateral indentation angle, cornual angle, lateral indentation depth and uterine cavity surface area) and non-normally distributed data (endometrial thickness, uterine cavity length, uterine cavity width and internal os width), respectively. Regression analyses were used to screen the factors that influence the area of uterine cavity. Variables with univariate P[?]0.1 were included in the multiple linear regression model for simple linear regression analysis. Statistical significance was set at $P < 0.05$.

Results

The last participant was enrolled in March 2020 and data collection was completed in April 2020. There were 172 women eligible for the study. The mean age was 29.8 years with SD 5.4 years and range 18–49 years. The median endometrial thickness was 8mm with range 4-15 mm (uteri with endometrial thickness greater than15mm were excluded). The rest seven measurements were carried out on a 3D coronal image of the uterus, and among them three symmetrical measurements (cornual angle, lateral indentation angle and lateral indentation depth) from left and right side were used for calculation the average value of these measurements. Table 1 shows the mean, SD, median, range and 95% reference range of the 3D measurements. Based on normal distribution, two-sided 95% reference range of uterine cavity surface area, cornual angle, lateral indentation depth and angle of normal adult women in our clinic center were estimated as 3.0-8.0 cm2, 39-88deg, 0.8-6.4 mm and 131-171deg, respectively. Due to the non-normal distribution, 95% reference range of uterine cavity length, uterine cavity width and internal os width were estimated as 26-38 mm, 25-40 mm and 4-11 mm, respectively, which were calculated by 2.5th and 97.5th percentile.

Focusing on the uterine cavity surface area , we found that 25.6% of uterine cavities were less than 4.5 cm2; 10.5% less than 4 cm2; and 2.3% less than 3.5 cm2, respectively. Only 7 participants or 4% had surface areas greater than 8 cm2. The interquartile range shows that 50% of surface areas in the group were between 4.5 cm2 and 6.2 cm2, respectively. 80% of subjects had a surface area between 4.0 cm2 and 7.2 cm2, respectively. In our group 95% of surface areas were between 3.5 cm2 and 8.2 cm2, respectively.

Univariate linear regression analyses revealed that the uterine cavity surface area was affected by age, endometrial thickness, cornual angle, uterine cavity width, uterine cavity depth, internal os width, lateral indentation depth and lateral indentation angle (all $P < 0.05$). We included all above variables in the multiple linear regression model using stepwise method. Table 2 showed the main statistics of the final model. The results indicated that uterine cavity width, uterine cavity length, lateral indentation depth, internal os width, endometrial thickness and cornual angle were significant independent influence factors of uterine cavity surface area. The variable of uterine cavity width had the biggest effect on uterine cavity surface area according to the standardized coefficient. The coefficient of determination R2= 90% suggested that final model fitted the data well.

Discussion

Evaluating the shape and size of the uterine cavity is helpful for us to understand and make a correct judgement in our clinical work. For instance, it has been reported that small uterine cavity size was beneficial in LNG-IUS users, as they reported less bleeding and pain compared with women with larger measurements (17) and transverse dimensions of uterine cavity far less than the length the transverse arm of IUD resulted in distortion, displacement, and expulsion of the IUD (18). So, it is especially important and necessary to have a detailed understanding of the shape of the uterus cavity of the patients. The present study was original in that we presented data of uterine cavity measurements of adult women on a 3D coronal view of uterine cavity.

The length and internal os width of uterine cavity do not seem to be important Clinically, but the importance of the cavity width has been studied a lot, especially in the field of application of intrauterine device (18, 19, 20). In our study the measurements of uterine cavity width (fundal transverse diameter) obtained using 3D-US ranged from 24 mm to 44 mm. This result was consistent with Jia-guang Wang's results (19), who measured 8217 transverse diameter of the uterine cavity of the normal fertile women in Liao-Ning district of China and reported that normal transverse diameter of the uterine cavity was 23-39mm. In another research it was reported that the more usual transfundal endometrial cavity width was 22–34 mm depending on parity (20). According to these researches, we propose that if the width of the uterine cavity measured on the coronal plane is less than 22mm it can be judged to be narrow.

One can now use three measurements with cut-offs (lateral indentation depth [?] 7 mm, lateral indentation angle [?] 130deg and T-angle [?] 40deg), which have good accuracy and moderate reliability to confirm the diagnosis when there is any suspicious of T-shape uterus by subjective assessment of the uterine cavity on the coronal plane (16). Our research showed the consistent results with this consensus. In our study an adult female with normal uterus had lateral indentation depth [?] 7mm (the maximum was 7mm), lateral indentation angle [?]130deg (the minimum was 130deg and the mean was 151deg) and cornual angle [?]40deg (the minimum was 40deg and the mean was 63 deg). Our research shows that these three indexes and the thresholds we currently apply can well distinguish between normal uterus and T-shape uterus.

So far, we have not found any report on the uterine cavity area on the coronal section by 3D ultrasound in adult women(only one publication reported the uterine cavity area[21] but used different calculating method without comparability). We found the uterine cavity surface area on the coronal section ranged from 3.4 to 10.5cm^2, the mean was 5.5cm^2, which was a relatively large range of floats. We speculate that this is due to many factors, such as the width, length, and angles of the uterus cavity, can affect the area of uterine cavity. Further multivariate analysis confirmed this point. We think that measuring the area of uterine cavity is helpful to diagnose uterine adhesion. For uterine adhesion, the commonly used diagnostic methods are hysterosalpingography and hysteroscopy, but they are invasive procedures that cause pain and have certain complications (22). With the development of ultrasonography resolution, transvaginal three-dimensional ultrasonography (3D TVS) has been more frequently used in the diagnosis of IUA (4). 3D ultrasound can provide a more accurate depiction of adhesions and extent of cavity damage than hysterosalpingography in patients with suspected Asherman's syndrome(23). In another article we have published, we found that using uterine cavity area 4.23cm^2 on the coronal section as the diagnostic threshold to distinguish uterine adhesion, it could reach 86% sensitivity and 74% specificity, and for every 1 cm^2 reduction in the area of the uterine cavity, the risk of uterine adhesion increased by 18.9%(14). In the present data, about 10% adult females had uterine cavity areas less than 4cm^2 and about 2% less than 3.5cm^2. The mean uterine cavity area was 5.5cm^2 and 95% reference interval was 3-8cm^2. Maybe uterine cavity area less than 3cm^2 can be considered "small uterine cavity". We believe Data from present study may be useful in screening cases of uterine adhesion and other disorders that may need further evaluation.

In conclusion, our research showed that a normal uterine cavity in adult women of childbearing age had lateral indentation depth [?]7mm, lateral indentation angle [?]130deg and cornual angle [?]40deg. The width of the uterine cavity measured on the coronal plane less than 22mm and the uterine cavity area less than 3cm^2 can be considered smaller than normal.

Our study is limited by the lack of data concerning gravity and parity of the subjects in the study. So, we cannot analyze the relationship between uterine cavity measurements and the number of pregnancies and parturient. It was reported that nulligravid and nulliparous women have smaller uterine dimensions than parous women(24,25). But considering that our purpose of this study is to provide data for clinical work, the results of this study are still of practical significance.

Disclosure of interest

All authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Contribution to authorship

1.Ya-xiao Chen, contributions to the conception of the work, Drafting the work critically for important intellectual content

2. Na Di, acquisition and interpretation of data for the work.

3. Shu-ying Feng, acquisition of data for the work.

4. Hong Ding , analysis of data for the work.

5. Tingting Xiang, acquisition and interpretation of data for the work.

6. Tingting Ma, design of the work, statistical analysis of data, revising the work and final approval of the version to be published and be accountable for all aspects of the work .

Details of Ethics Approval

This study was approved by the Ethics Committees of Sun Yat-Sen Memorial Hospital of Sun Yat-Sen University on 14, Oct 2020, with approval number: SYSEC-KY-KS-2020-150.

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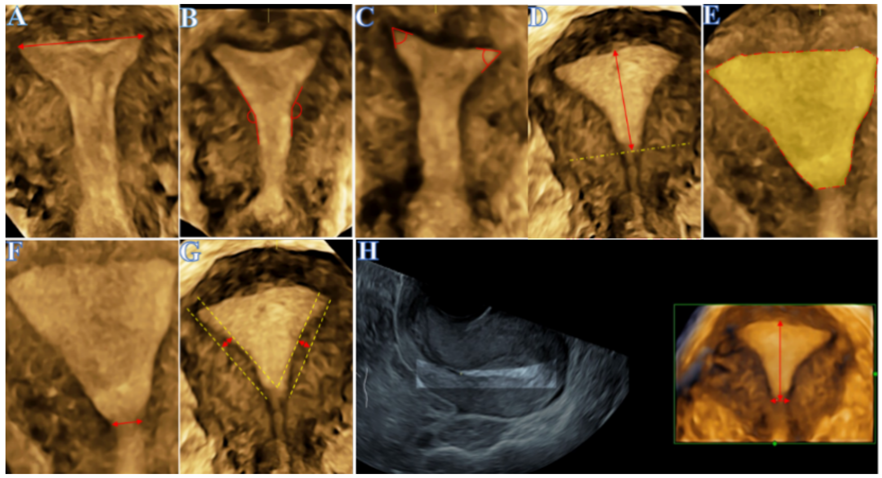
Figure 1: Parameters of 3D measurement: (A) Uterine cavity width; (B) Lateral indentation angles right and left; (C) Cornual angles right and left; (D) Uterine cavity length; (E) Uterine cavity area; (F) Internal os width; (G) Lateral indentation depths right and left; (H) Identification of anatomical internal os in coronal plane utilizing the function of Fixed ROI in 2D sagittal view.

Table 1 Statistical descriptions of the quantitative variables from study participants (n=172)

Variable	Mean±SD	Median (min-max)	95% reference range
Age (years)	29.8±5.4	30(18-49)	-
Endometrial thickness (mm)	8.7±2.7	8(4-15)	-
Uterine cavity width (mm)	31.6±4.0	31(24-44)	25-40
Uterine cavity length (mm)	31.9±3.1	32(23-42)	26-38
Internal os width (mm)	7.3±1.6	7(4-11)	4-11
Lateral indentation depth (mm)	3.6±1.4	3.5(0-7)	0.8-6.4
Lateral indentation angle (degree)	150.9±10.1	152(130-180)	131-171
Cornual angle (degree)	63.1±12.5	62(40-104)	39-88
Uterine cavity area (cm^2)	5.5±1.3	5.2(3.4-10.5)	3.0-8.0

Lateral indentation angle = (right lateral indentation angle + left) /2 , Lateral indentation depth = (right lateral indentation depth + left) /2, Cornual angle= (right cornual angle + left) /2

Table 2 Multiple linear regression analysis of variables influencing Uterine cavity area	**Table 2 Multiple lin**
Variable	Unstandardized coeffic
Constant	-6.172
Uterine cavity width	0.177
Uterine cavity length	0.148
Lateral indentation depth	-0.259
Internal os width	0.135
Endometrial thickness	0.066
Cornual angle	0.011
F=247.1, P=0.000, R^2=0.900	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