REVIEW ARTICLE

Assessment of Uterine Cavity Size and Shape: A Systematic Review Addressing Relevance to Intrauterine Procedures and Events

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Abstract

Uterine cavity measurement began with evaluation of post-mortem and surgical specimens. It has been extended in vivo by use of mechanical instruments and visualization techniques. This is a systematic review of the range of values for the uterine cavity and the practical implications of these measurements, Following a review of multiple data bases & a QUORUM analysis. Only articles with clearly defined quantitative measurements were included. Mechanical cavity measurements with a variety of instruments gave a mean endometrial cavity length (ECL) of 33.73mm (18-22.1) and a mean endometrial cavity width (ECW) of 25.1mm (17.8-32.2) for nulliparae. The values for multiparae were mean ECL 38.6mm(20.61-40.3) and mean ECW 34.9mm (23.4-53).Imaging measurements for the uterine cavity by hysterography and ultrasound were mean ECL 44.3mm (29-64) for multiparae and ECL 37mm for nulliparae. Mean ECW was 28.2mm (21-33) for nulliparae and 32.1mm (26-38) for multiparae. There were wide variations due to parity, ethnicity and gestational states. Accurate measurement of intrauterine parameters is valuable for improving and enhancing many intrauterine procedures including IUD insertion, endometrial ablation, embryo placement in IVF and management of spontaneous and therapeutic abortion. (*Afr J Reprod Health 2012; 16[3]: 129-138).*

Résumé

La mesure de la cavité utérine a commencé avec l'évaluation des échantillons post-mortem et chirurgicaux. Il a été prolongé in vivo par l'utilisation des instruments mécaniques et des techniques de visualisation. Il s'agit d'une revue systématique de l'étendue de valeurs pour la cavité utérine et les implications pratiques de ces mesures, suite d'un examen des bases de données multiples et quelques articles et d'analyse de Quorum. Seuls les articles dont les mesures quantitatives étaient bien définies ont été retenus. Les mesures de la cavité mécanique réalisées à l'aide des divers instruments ont donné une longueur de cavité endométriale moyenne(LCE) de 33.73mm (18 à 22,1) et une largeur de cavité endométriale moyenne de la cavité endométriale (LgCE) de 25.1mm (17,8 à 32,2) pour les nullipares. Les valeurs pour les multipares étaient LCE 38.6mm (20,61 à 40,3) et la moyenne pour LgCE était 34.9mm (23.4 à 53). Les mesures d'imagerie pour la cavité utérine à l'aide de l'hystérographie et l'échographie LCE 44.3mm (29-64) pour les multipares et LCE 37mm pour nullipares. La LgCE moyenne était 28.2mm (21-33) pour les nullipares et 32.1mm (26-38) pour les multipares. Il y avait de grandes variations en raison de la parité, l'appartenance ethnique et les états gestationnels. Une mesure exacte des paramètres intra-utérins est importante pour l'amélioration et le renforcement de nombreuses procédures intra-utérines, y compris l'insertion du DIU, l'ablation de l'endomètre, la mise en place d'embryons dans la FIV et du traitement de l'avortement spontané et thérapeutique (*Afr J Reprod Health 2012; 16[3]: 129-138).*

Keywords: intrauterine, uterine cavity, measurement, endometrial

Introduction

The function of the uterus is to nurture and protect the developing fetus. Most current intrauterine procedures aim to assist or prevent this process. A knowledge of uterine cavity measurements is helpful for predicting and managing various intrauterine events, e.g. infertility and its causes, aspects of gestation and abortion (spontaneous or therapeutic), endometrial malfunction and intrauterine contraception. This review describes how the early academic anatomical uterine cavity evaluations have lead to a need to make measurements which have become indispensable to modern obstetrical and gynecological practice. There are two main methods for determining uterine cavity measurements. The first is by mechanical measurement of post mortem and post surgical uterine specimens and by using probes to make measurements **in vivo**. The second and more recent method is by the use of imaging techniques including the use of X-rays with contrast medium and ultrasound with and without contrast. The use of direct vision e.g. hysteroscopy has concentrated mainly on intrauterine abnormalities rather than size per se. Uterine cavity shape is considered only as it impacts measurements. The range of uterine cavity shape and abnormalities is a subject alone and is not considered independently. **ln vivo** measurements have usually been reported as part of a clinical practice study. There are very few studies restricted to uterine measurements alone.

Methods

A systematic review was performed to evaluate uterine cavity size and its role in various intrauterine procedures.

A Medline/Pubmed, Popline and EMBASE search was conducted using the terms uterine cavity, endometrial cavity, uterine width and uterine fundal width together with the terms IUCD and IUD and nulliparous and multiparous. The internet was searched using Google Scholar. Registries of ongoing trials have been checked and no relevant studies have been found. An omission is the Chinese databases Wangfang data and Weipu data which were not searched due to there being no Chinese translators available. Two experts in the area were contacted. An attempt was made to follow the QUOROM guidelines.[1] However there were only three comparative studies, making this difficult to achieve.

A total of 62 studies were found. Studies which were restricted to uterine volume only and those with fewer than 15 measurements were excluded. Two Chinese studies were excluded because of language problems and minimal English abstracts.

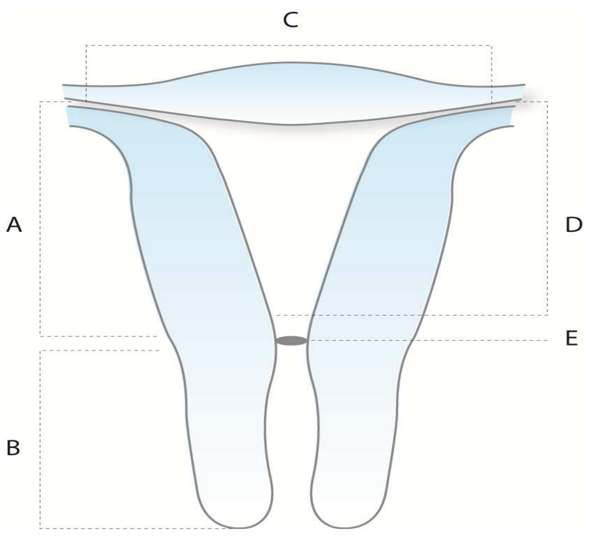
Definitions

The literature is confusing as the term uterine cavity is used to describe the endometrial cavity plus the endocervical canal by some authors, while others use the term to describe the endometrial cavity (area above the internal cervical os) only. This review describes the spaces of the inner uterus in anatomical terms.

Functional Inner Uterine Anatomy

The uterus consists of the body (corpus) and cervix which have different embryological origins and physiological functions. Innervation, vascular supply and lymphatic drainage are distinct. The direction of the muscle fibers in the myometrium is different. The inner surface of the body is lined by endometrium, hence the term endometrial cavity. The inner aspect of the cervical canal is lined by columnar type epithelium which gives way to squamous epithelium at the squamo-columnar junction at or about the external os. The inner cervical canal (cavity) is therefore also the endocervical canal (Fig. 1).

The term endometrial cavity will be used to describe the space above the internal os. Total uterine cavity (or axial) length will be used to describe the space from the external os to the fundal roof of the endometrial cavity.



Legend to Figure

Fig 1. Anatomical map of uterine cavity measurements.
A= Endometrial cavity length. B= Cervical canal length
C= Endometrial cavity fundal width. D= Functional endometrial cavity
E= Level of internal os. A+B= Total uterine (cavity) length
There are no conflicts of interest.

2. Mechanical Measurements of the Uterine Cavity Morbid Anatomy

Two early anatomists, Guyon and Hageman used thinned liquid metal and paraffin wax to make casts of the uterine cavity. Their results were later compared with those made by Dickinson. [2] He observed that there was wide variation in reported total uterine length for both nulliparous and parous women. He concluded that the average nulliparous total uterine cavity length was 6.5cm and the average uterine fundal width was 2.5cm. The multiparous uterus was 7.5cm and 3.5cm for the same measurements. These studies have been repeated more recently using silicone rubber, giving similar values .[3]

Total Uterine Axial Length

Total uterine length measurements are made clinically before gynecological procedures or surgery, using a metal or plastic sound. Reported values vary widely and show a mean of 7.5cm for the multiparous and 6.3cm for the nulliparous uterus. [2] The range in nulliparous women has been reported as being from 5 – 10cm with a mean of 7cm 3 and the multiparous total uterine length 0.5 – 1cm larger 4. The measurement of total uterine length is known to be of questionable accuracy. [5, 6] Due to variable uterine flexion plastic (flexible) sounds are more accurate .[5]

Endometrial Cavity Length and Width

The first recorded attempts to use mechanical means to measure the inner uterus **in vivo** were made in the early and late 1970's using Hasson Wing sound 1,[7] the Batelle uterine caliper [8] the Kurz Cavimeter, [9] the Wang method [10] and Hasson Wing sound II .[11] These measurements were prompted by the desire to be able to choose and design intrauterine devices (IUD) which would conform to the endometrial and /or the functional endometrial cavity. Most mechanical devices act as calipers. The distance between two laterally probing arms is recorded on a meter. Wing sound I and Wing Sound II are different. Wing Sound I measures only the endometrial cavity length (not width) by means of a 12mm wing which is opened and assumed to be able to locate the functional internal os .[7] Wing Sound II has a wing which can record uterine width at both the 12mm and 18mm levels. The shape of the endometrial cavity and fundal width can be determined geometrically .[11] Endometrial cavity length and width measurement has become important prior to endometrial ablation for menstrual disorders. The NovaSure endometrial ablation system has a probe and requires measurement of the endometrial cavity intercornual width and length before use .[12] Mechanical endometrial cavity width and length measurements are summarised in Table 1. The results show wide variations depending upon parity which causes the endometrial cavity to enlarge,[13] while it is also different in different racial and ethnic groups. [8, 7]

2. Imaging Measurements Of The Endometrial Cavity And Total Uterocervical Length

3.1 X-RAYS

X-Rays and more recently ultrasound have proved valuable in detecting normal and abnormal uterine changes. However the resolution required to make accurate measurements is greater than that required to detect gross normal and pathological conditions. The initial attempts to measure the size of the endometrial cavity was once again an attempt to better understand IUD related problems, using the IUD as an internal marker, [18, 19] while in a more recent study, external markers were used .[20] This data is presented in Table 2.

3.2 HYSTEROSCOPY

Numerous publications address the use of hysteroscopy for evaluating the endometrial cavity and endocervical canal by direct vision. lt is not generally used as a measuring technique. One comparative study was found, [21] see Table 2.

2.3 ULTRASOUND

The various types of ultrasound are now indispensable in the practice of obstetrics and gynecology. Measurements of the endometrial and decidual (pregnancy altered) cavity and endocervical canal in the non gravid state and up to 17 weeks of pregnancy and early postpartum are presented in Table 2. Again, as with the other measuring techniques, there is a paucity of

Table 1: Mechanical endometrial cavity measurements (mm)

Measuring device	Cavity length Mean±SD (range)	Cavity fundal width mean±SD (range)	Reference number and comments n=number of subjects
Wing Sound 1	36*F (18-65) 40* (20-61) 31F		7.Total length 72.6 Cervical length 36.6 n=460 13. n=160
Wing sound 11	36*F (20-69)	(26-65)*F	11. n=551 Computation errors acknowledged
	47.1±14.3*	44±13.6*	14. n=15 Hysterography and Hysterectomy comparison
Cavimeter	31.8±4.8F (31.4-32.1) 35.2±5.4* (32.1-40.3)	23.1±3.1F (22.8-32.6) 26.0±2.3* (23.4-27.4)	9. n=795
	38.25*	33.75*	15. n=509
Wang device	37.5*F (10-60)	30.8±3.4*F (10-45)	10. n=200 Internal Os by resistance
Batelle caliper	>35*F (28.7-46.7)	<30*F (17.8-32.2)	8. n=584
Novasure probe		39.8* (25-53)	16. n=107
		35±7* (25-53)	17. n=79
Unspecified	38.4±0.2F 42.5±0.2* (25-60)*F		4. n=570 Direct comparison with ultrasound

*-multiparous F – nulliparous *F – multiparous and nulliparous
SD – Standard deviation

measurement data, since it is used mainly to distinguish normal and abnormal anatomical states. Ultrasound resolution has increased dramatically over the last few decades and can now be used to measure both external and internal uterine parameters. The improving resolution should further improve measurements of total uterine cavity length, endometrial cavity length, endometrial cavity width and endometrial cavity surface area. A recent study to measure uterine cavity width was inspired by attempting to understand IUD problems in terms of dimensional incompatibility, [23] which was the initial impetus for mechanical and x-ray evaluations.

3. Accuracy of Mechanical and Imaging Methods

All measuring techniques have sources of errors. These will not be considered in detail as most investigators attempt to reduce them as far as possible. The various mechanical and imaging methods give results which are similar when allowing for the differences due to parity and ethnicity (Table 1 and 2).

4.1 CROSS COMPARATIVE STUDIES

There were three studies in which more than one measuring technique was used in the same subjects. ln the first study endometrial cavity length and width and surface area were measured with Wing Sound II, hysterography and directly post hysterectomy and reasonable agreement was found. [14] In the second the endometrial cavity was measured using a mechanical device and ultrasound, [4] and in the third hysteroscopy was compared with transabdominal and transvaginal ultrasound in measuring total uterine length. [21]

Table 2: Endometrial cavity and total uterine cavity length measurements obtained by imaging (mm)

Type	TUL Mean ± SD (Range)	ECL Mean ± SD (Range)	ECFW Mean ± SD (Range)	ECSA (mm²) Mean±SD (Range)	Reference number and comments n = number of subjects
Hysterography		34* Ŧ (16-67)	33* Ŧ (16-59)		18. n=100 IUD as reference marker
		50* (29-64)	66%<27* (20-31)	(420-920)	19. n=45 Planimeter technique
	90.5±16.2*	44.7±8.3*	34.0±13.3*	1111±613*	14. n=15 Direct comparison with Wing Sound II
			28.8* Ŧ SEM0.94 29.2 Ŧ 30.0*		20. n=40 *=17 Ŧ= 23
Hysteroscopy	71±17				21. n=50
Ultrasound	72±12				21. n=50 Transvaginal, comparison with above
	72±15				21. n=50 Transabdominal, comparison with above
		37±0.3 Ŧ 38.4±0.3* (22-65) * Ŧ			4. n=570 Comparison with mechanical measurement
	71±7.8				22. n=64 Transvaginal comparison with colpohydroscopy and mechanical sounding
			27.2±6.95 Ŧ 31.13±6.49*		23. n=210
			28±6	362±195	24. n=50(all subjects) 6-8 weeks gestation
			29.3±8.5	514±208	24. 9-11 weeks gestation
			37.9±18.1	941±734	24. 12-14 weeks gestation
			31.5±12.5	830±455	24. 15-17 weeks gestation
	161±17*	127±69*	87±10*		25. n=40 Occasional echogenic material 48 hours post - partum

* - multiparous Ŧ – nulliparous *Ŧ – multiparous and nulliparous

TUL – total uterine cavity length ECL – Endometrial cavity length ECFW –Endometrial cavity fundal width

ECSA-Endometrial cavity surface area SD-Standard Deviation SEM- Standard Error of the Mean

These very different methods all gave reasonably similar results which is reassuring. The uterus is a dynamic organ and as such the uterine cavity size and shape is subject to change due to many factors including menstrual cycle changes. [26, 27]

5. ENDOMETRIAL CAVITY SHAPE

The normal endometrial cavity has a variable conical shape. [2, 3,7,11].These variations may affect the values of the readings obtained, more especially in the case of the mechanical devices. Kurz et al adjusted the Cavimeter to account for possible changes produced by the arcuate or subseptate uterus .[28] Hasson concluded that although the endometrial cavity was conical it in fact behaved functionally as an isosceles trapezoid. [11] Wing Sound II permits estimations of endometrial fundal width by geometrical extrapolation. Any sources of initial measuring errors are therefore greatly compounded by minor shape variations in the lower part of the endometrial cavity. Imaging techniques therefore have a fundamental advantage over mechanical methods in determining alteration in the endometrial cavity shape and its effects on measurements.

6. Intrauterine Measurement Before or After Intr Auterine Procedures

6. I MECHANICAL MEASUREMENT

6. II TOTAL UTERINE AXIAL LENGTH

a) Intrauterine Device Insertion

The measurement of total uterine length is still advocated prior to IUD insertion. It is performed to be able to ascertain where to set the stop on the IUD inserter to prevent IUD insertion problems e.g. perforation. There is no evidence that it does this. In fact the metal sound itself may be a factor in IUD related problems. [29] Very long or very short total uterine axial length may be unsuitable for IUDs, [6] but identification of total uterine axial length alone is not robust enough to enable intelligent IUD selection because it gives no indication of the width of the IUD which is required.

b) Endometrial Ablation

Prior to performing endometrial ablation by thermal balloon (Therm a Choice (Gynecare, Somerville, NJ, USA)), circulated hot fluid (Hydro Therm Ablator (Boston Scientific, San diego, CA, USA)), cryotherapy (Her Option (American Medical Systems, Minnetonka, MN, USA)), radiofrequency electrosurgery (NovaSure (Cytyc, Marlborough, MA, USA)) or microwave energy (MEA) it is necessary to measure total uterine axial length. It must be 100mm or less for all except MEA (140mm) to avoid damage to the endocervical canal. [12]

c) In – Vitro Fertilisation (IVF)

Uterine sounding is used to facilitate embryo transfer to the appropriate position in the endometrial cavity. [22,30] Egbase et al found the highest implantation and pregnancy rate if total uterine length was 70 - 90mm. They placed embryos 5mm from the fundus. Mechanical measurement of total uterine length for embryo placement has been largely superseded by ultrasound measurement.

6.12 ENDOMETRIAL CAVITY LENGTH AND FUNDAL WIDTH

a) Intrauterine Device Insertion

The Lippes Loop IUD and the T device were designed on the basis of the early cast studies of the inner uterus. [31] These values are probably too large compared to the functional uterine cavity.[31] Problems with these early devices was thought to be due to a mismatch between the size of the devices and the functional endometrial cavity. The first validation of this was by hysterography.[18,19,32] Hasson designed Wing Sound I to be able to measure the functional uterine cavity length, [7] and later showed that IUDs which were placed 1.25 – 1.75cm above the lower endometrial cavity gave the best results. [33] The Kurz Cavimeter measured both length and width of the endometrial cavity to improve the fit of the device to provide improved results [34]. Wang [10] also found improved results with custom fitting of IUDs using his measuring device. These results have been challenged by other investigators who concluded that matching the IUD to the uterine cavity does not give improved results [4, 35]. There are probably factors other than dimensional disproportion which give rise to IUD related problems because IUDs without frames e.g. the Gyne-Fix (Contrel, Ghent, Belgium) may give certain problems [36]. Mechanical measurement to determine the size of the endometrial cavity is no longer carried out & the only mechanical measurement of the inner uterus is determination of total uterine axial length.

b) Endometrial Ablation

Prior to endometrial ablation with the NovaSure electrosurgical technique

it is necessary to measure both endometrial cavity length and width (intercornual). This is to avoid causing electrothermal injury beyond the endometrial cavity. The endometrial cavity length must be between 4 to 6.5cm. The fundal intercornual width is also measured and these two values entered into the radiofrequency controller. [12]

7.1 IMAGING MEASUREMENT

7.11 TOTAL UTERINE AXIAL LENGTH

a) In Vitro Fertilisation

Assessment of total uterine axial length is required before deposition of embryos in the endometrial cavity. The precise position of deposition of embryos is still controversial. Ultrasound total uterine length measurement is now preferred over mechanical because it is less invasive and it is not possible to 'tent' the fundus leading to inaccurate measurement. [22,27]

7.12 ENDOMETRIAL CAVITY LENGTH, WIDTH AND SHAPE

b) Intrauterine Devices

Hysterography suggested that in some circumstances IUDs may be unsuitable because of non conformity with the endometrial cavity. [18,19,32,35] Its use as an imaging technique for evaluating IUDs has subsequently been overtaken by ultrasound. Ultrasound was originally used to verify that IUDs were in fact intrauterine and not translocated into the pelvis and abdomen, or downwardly displaced into the endocervical canal. Downward displacement from the fundus of more than 10mm was associated with problems with the device.[37] Current ultrasound methods can demonstrate detailed mismatch between IUDs and the endometrial cavity in the same way hysterography did previously, [23] and is capable of making endometrial cavity measurements before IUD insertion, [4, 23] rendering mechanical uterine cavity measurement obsolete.

c) In Vitro Fertilisation

Measurement of the total uterine cavity length and endometrial cavity shape is routinely performed prior to deposition of fertilized ova. The aim is to locate the intrauterine site most conducive for successfully developing the fertilized ova into successful pregnancies. The most optimal site for ova deposition is still a subject of intense study.

Tiras et al used ultrasound guidance to transfer embryos. [38] They measured the distance between the fundal endometrial surface and the ova deposition catheter tip. They found the optimal site for embryo deposition to be 10 – 20mm below the fundus. While Coroleu and colleagues in a similar study found the optimal site to be 5 -20mm below the fundus, [39] and Pope et al found the optimal distance to be 5 -10mm below the fundus. [40] Using 3D ultrasound Gergely et al calculate the maximal implantation potential [MIP] point. [41] Employing the fact that the uterine cavity resembles an inverted triangle and the fallopian tubes open into the cavity at the base, they constructed two imaginary lines originating from each tube. MIP is the intersection of these lines. This is a point usually 5 -10mm below the fundus.

Identifying normal and abnormal endometrial cavity shape has significant bearing on ultrasound guided ovum deposition in IVF. In the normal shaped endometrial cavity pregnancy rates were similar if the ova were deposited in the upper, middle or lower portions of the uterine cavity. If the cavity had an abnormal shape then deposition of ova in the middle region of the cavity gave the best outcomes. [42]

c) Spontaneous and Therapeutic Abortion

The use of ultrasound to examine the uterine cavity for remnants of products of conception after both spontaneous and therapeutic abortion has been used for decades. The presence of echogenic material is very often apparent and may or may not be significant. [43] Endometrial cavity measurements may be able to help decide whether surgical intervention is required or not. ln one study the endometrial cavity was measured before and after evacuation for pregnancy failure. [24] The investigators measured both endometrial cavity width and surface area. By defining the dimensions of an empty cavity at different gestational ages (see Table 2) they postulated that it may be possible to avoid many operative procedures by sonographic measurement on presentation. From their study they determined that if they used the mean plus two standard deviations of width and surface area as the upper limit of cavity size (width 5cm, surface area 60cm^2) then only 44% of the subjects in their study would have needed curettage. After medical abortion a median distance of 16mm (95% confidence interval 15.1 – 16.6) between the myometrial interfaces in asymptomatic patients does not appear to require surgical intervention. [43]

8.1 THE UTERINE CAVITY IN PREGNANCY

During pregnancy the endometrial cavity is for all intents and purposes obliterated by the amniotic sac which grows after implantation in the decidual lining.

The cervical canal is the area of the total uterine cavity which is not compressed. Measurement of external cervical length [44] and endocervical cavity length [45] via transvaginal ultrasound can predict spontaneous preterm birth in twin pregnancies. A short cervical canal length at 16 -19 weeks followed by rapid canal shortening in the second trimester are specific features in preterm labor in twin pregnancies. Sequential measurement of cervical canal length from the mid second trimester may be used to predict preterm labor and delivery in twin pregnancies. [45]

8.2 UTERINE DIMENSIONS IN THE PUERPERIUM

Knowledge of uterine dimensions including total uterine length and endometrial (decidual) cavity length and width measurements in the puerperium may be helpful in managing puerperal problems. Echogenic material in the uterine cavity is not related to the amount and duration of bleeding. [25] Abnormal cavity measurements may be a harbinger of puerperal problems. This is analogous to the situation after spontaneous or induced abortion. [43]

Discussion and Conclusions

Historically the measurements of the inner uterus were made by anatomists. Although of no direct clinical application at the time, they were aware that knowledge of female (and male) reproductive anatomy could give insight into sexual and reproductive function and diseases of the reproductive organs. [2] As the ability to perform and manage intrauterine events has improved it has become necessary to critically measure the inner uterus. Originally caliper type instruments were used to make clinical measurements. This has given way to less invasive and more accurate imaging techniques, especially ultrasound.

The relationship of endometrial cavity length and IUD performance is an unsettled question. The mean endometrial cavity length is invariably larger than the standard IUD length (3.5 cm) in multiparae and somewhat shorter in nulliparae. This appears to be a factor for the poorer performance of the IUD in this group but there are doubtless other factors. The Gynefix-200 IUD will invariably conform to the endometrial cavity of nulliparae but still gives problems in this group.[36] While Hasson et al found a relationship between IUD use and endometrial cavity length [33], Bahamondes and co-workers do not[4]. The answer to this problem will probably come from China which has a strong interest in this area.

More precise knowledge of the anatomy of the inner uterus will undoubtedly lead to improved results with intrauterine procedures e.g. endometrial ablation, management of abortion, IVF and IUD insertion. They should also continue to become more accurate and less invasive. The term uterine cavity has been used generically for the inner uterus. The term should be abandoned for metrology research because it is imprecise and often used in a confusing manner.

It is suggested that uterine measurements should be described in strictly anatomical terms for the sake of conformity.

The term endometrial cavity should be the term used for the area above the internal os, and endocervical cavity the term for the area from the internal os to the external os. The area from the fundus to the external cervical os should be termed the uterocervical cavity.

References

1. Mohor D, Cook DJ, Eastwood S, et al. Improving the quality of reports of meta-analyses of randomized controlled trials: the QUOROM statement. Lancet 1999;354: 1896-1900
2. Dickson RL. Human Sex anatomy. Robert E. Krieger Publishing Co., 1971: 20-3.
3. Lewis RB, Zuspan IP. A method for determining contour volume of the uterine cavity. Contraception 1970; 2: 249-57.
4. Canteiro R, Bahamondes MV, Fernandes ADS, et al. Length of the endometrial cavity as measured by uterine sounding and ultrasonography in women of different parities. Contraception 2010; 81: 515-9.
5. Goldstuck ND. The Mark-7 sound- an accurate determinant of uterine axial length. Contraception 1979; 20:359-65.
6. Gibor Y, Deysack L, Nissen CH. Uterine length: a prognostic indicator for the successful use of the Copper 7 intrauterine device. J Reprod Med 1973; 11: 205-8.
7. Hasson HM. Differential uterine measurement recorded in vivo Obstet Gynecol 1974; 43: 40-12.
8. Reynoso L, Zamora G, Gonzalez-Didi M, Lozano M, Aznar R Uterine metrology in Mexican women. In Hasson H, Hafez ES, van Os WA eds Biomedical aspects of IUDs. Hingham, Mass. MTP Press, 1985: 119-24.
9. Kurz KH. Cavimeter uterine measurements and IUD clinical correlation. In Zatuchni GI, Goldsmith A, Sciarra JJ, eds. Intrauterine contraception: Advances and future prospects. Philadelphia, Harper and Row, 1984: 126-41.
10. Wang JG. Development of a new method of insertion of IUDS. Contraception 1982; 25: 405-20.
11. Hasson HM. Clinical Studies of the Wing sound II metrology device. In Zatuchni GI, Goldsmith A, Sciarra JJ, eds.Intrauterine contraception: Advances and future prospects. Philadelphia, PA. Harper and Row, 1984:126-41.
12. Sharp HT. Assessment of new technology in the management of idiopathic menorrhagia and uterine leiomyomata. Obstet Gynecol 2006; 108:990-1003.
13. Theron F, Wessels PH. Uterine measurement in the fitting of intrauterine devices. S Afr Med J 1984; 65: 1054-6.
14. Ismail AAA, ANSWER SM, Keshk SM, et al. Uterine geometry by Wing sound and hysterography versus direct measurements. Adv Contracept 1987; 3: 237-43.
15. de Castro A. Assessment of uterine shape and size using Kurz's Cavimeter. Adv Contracept 1988; 4: 115-23.
16. Gullinat A. NovaSure impedance controlled system for endometrial ablation: three years follow up on 107 patients. Am J Obstet Gynecol 2004; 191: 1585-9.
17. Fulop T, Rakozi I, Barna I. NovaSure impedance controlled endometrial ablation: Long term follow up results. J Min Invasive Gynecol 2007: 14; 85-90.
18. Burnhill MS, Birnberg CH. The size and shape of the uterine cavity determined by hysterography with an intrauterine contraceptive marker. Int J Fertil 1966; 11: 187-93.
19. Tejuja S, Malkani PK. Clinical significance of correlation between size of the uterine cavity and IUCD: a planimeter hysterogram technique. Am J Obstet Gynecol 1969; 105: 620-7.
20. Bromer JG, Sanguenetti M, Tal P, Patrizio P. Assessment of the uterine cavity and the intraostial distance using hysteosalpingography. Fertil Steril 2007; 88 (Suppl 1): S202.
21. Castellotti DS, Cambioghi AS. Comparing measurements of endometrial cavity length by performed at hysteroscopy with transvaginal and pelvic ultrasound before in-vitro fertilization. Fertil Steril 2007; 88 (Suppl 1): S145.
22. Sher G, Fisch JD. Measuring uterine depth with colpohydroscopy. Reprod Med 2003; 48: 325-9.
23. Benacerraf BR, Shipp TD, Lyons JG, Bromley B. Width of the normal uterine cavity in premenopausal women and effect of parity. Obstet Gynecol 2010; 116: 305-10.
24. Haines CJ, Shaund KL, Leung DYL. Transvaginal sonography of the uterine cavity following curettage for early pregnancy failure. Ultrasound Obstet Gynecol 1991; 1: 417-9.
25. Sokol ER, Casele H, Haney EI. Ultrasound Examination of the postpartum uterus: what is normal? J of Mat-Fetal Neonat Med 2010;15:95-9.
26. Bourne TH, Hagstrom HG, Granberg S, et al. Ultrasound studies of vascular and morphological changes in the human uterus after a positive self-test for the urinary luteinizing hormone surge. Human Reproduction 1996; 11: 369-75.
27. Madani T, Ashrati M, Abandi AB, et al. Appropriate timing of uterine cavity length measurement positively affects assisted reproduction cycle cutcome. Reprod Biomed online 2009; 19: 734-6.
28. Kurz KH, Tadese E, Haspels AA. In vivo measurement of uterine cavities in 795 women of fertile age. Contraception 1984; 29: 495-510.
29. Goldstuck ND. Insertion forces with intrauterine devices: implications for uterine perforation. Eur J Obstet Gynecol Reprod Biol 1987: 25: 315-23.
30. Egbase PE, Al-Sharhan M, Grudzinskas JG. Influence of position and length of uterus on implantation and clinical pregnancy rates in IVF and embryo transfer treatment cycles. Human Reproduction 2000; 15: 1943-6.

31. Wildermeersch D, Janssens D, Andrade A. The Femilis LNG-IUS: Contraceptive performance- an interim analysis. Eur J Cont Reprod Health Care 2009; 14: 103-110.
32. Adel SK, Ghonheim MA, Sobrero AJ. Hysterography study of long term effects of intrauterine contraceptive devices. Fertil Steril 1971; 22: 651-2.
33. Hasson HM, Berger GS, Edelman DA. Factors affecting intrauterine contraceptive device performance. Am J Obstet Gynecol 1976; 126: 973-81.
34. Kurz KH. Avoidance of the dimensional incompatibility as the main reason for side effects in intrauterine contraception. Contracept Deliv Syst 1981; 2: 21-9.
35. Toppazada M, Ismail AA, Bakry MA. Uterine geometry and IUD induced pain. Adv Contracept 1986;2: 169-175.
36. O'Brien P, Marfleet CC. Frameless versus classical intrauterine device for contraception. Cochrane Database Syst Reviews 2005; 1: Art no. CDOO3282.
37. Tadesse E, Van Brandenburg WJA, Exalto N. Intrauterine devices: results of a separate clinical and ultrasound follow-up study. Eur J Obstet Gynecol Reprod Biol 1985; 19: 289-95.
38. Tiras B, Polot M, Korucuogla U, Zeyneloglu B, Yarali H. Impact of embryo replacement on in vitro fertilization and embryo transfer outcomes. Fertil Steril 2010; 94: 1341-5.
39. Corolen B, Barri PN, Carreras O, et al. The influence of the depth of embryo replacement into the uterine cavity on implantation rates after IVF: a controlled, ultrasound –guided study. Human Reproduction 2002; 17: 341-6.
40. Pole CS, Cook EKD, Arny M, Novak A, Grow DR. Influence of embryo transfer depth on in vitro fertilization and embryo transfer outcomes. Fertil Steril 2004; 81: 51-8.
41. Gergely RZ, De Ugarte CM, Danzer H, et al. Three dimensional four dimensional ultrasound-guided embryo transfer using the maximal implantation potential point. Fertil Steril 2005; 84: 500-3.
42. Sun Y, Fang L, Su Y, Guo Y. Uterine cavity shape and the best site for embryo transfer. Int J. Gynecol Obstet 2009; 105: 140-4.
43. van Bogaert LJ, Misra A. Sonography of uterine cavity contents after medical abortion. Int J Obstet Gynecol 2009; 104: 150-1.
44. Conde-Agudelo A, Romero R, Hassan S, Yeo L. Transvaginal sonographic cervical length for the production of spontaneous preterm birth in twin pregnancies: a systematic review and meta-analysis. Am J Obstet Gynecol 2010; 203: 128e 1-12.
45. Yoshizato T, Inoue Y, Fukami T, Sanui A, Miyamato S, Kawarabayashi T. Longitudinal changes in canal length at 16-35 weeks in normal twin pregnancies with preterm labor and delivery. J Obstet Gynecol Res 2010; 36: 733-8.