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ROLE OF 3-DIMENSIONAL (3-D) ULTRASOUND (US) IN THE DIAGNOSING THE CAUSES OF INFERTILITY IN WOMEN

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ABSTRACT

Where as2D USG is a novel investigation which not only gives information of the uterine cavity but the ovaries, adnexa and also information about other organs. Most importantly there is no radiation and no intervention/invasion. Modification of a simple 2D USG to sonohysterosalpingography would also give information on tubal patency. Since simple 3D USG has to be combined with sonohysterosalphyngography for patency of tube, we wanted to concentrate more on how the 3rd dimension helps the sinologist and the gyenecologist to obtain and interpret the images in a cost effective safer and robust method, this study was undertaken. 350 Patients attending OBG OPD at medical college and hospital, sent to radiology OPD for us evaluation with history of infertility and recurrent miscarriages. overall 9.5% among uterine anomaly and 4.6%in non-uterine anomaly cases, i.e more than 50%(68%) of the cases with miscarriage among infertile women were in uterine anomaly cases, more so in septate and subseptate uterus. The overall accuracy of 3D US in diagnosing the causes of infertility in females is 100% with sensitivity and specificity 100.

INTRODUCTION

Three-dimensional (3D) pelvic sonography has become a problem-solving technique in evaluation of a variety of gynecologic disorders such as uterine anomalies, endometrial disorders, fibroids, intrauterine device (IUD) localization, adnexal masses, and tubal disorders. It should be used as a standard imaging protocol in the evaluation of most of these disorders. It can add significant clinical information to that obtained by two-dimensional (2D) imaging, and it can also be used selectively for evaluation of adnexal masses. This article provides examples of clinical applications. 3D sonographic imaging of the female organs allows rapid acquisition of ultrasound images with the ability to display volume-rendered images of the uterus, ovaries and adnexa. It has the potential to decrease operator dependency compared with 2D imaging because volume acquisitions should contain all of the anatomic information, which can subsequently be reviewed and manipulated by a different operator in various planes. Any desired plane can be obtained from the volume of data that is acquired, stored, and reformatted. Volumetric imaging has the potential to improve patient management. It requires selective evaluation of the acquired volume and may be limited by accessibility to optimal scan planes for image acquisition. Nowadays 2D USG is an integral part of OB/GYN practice. In particular transvaginal 2D pelvic USG as its color and pulsed Doppler USG have become an important non-invasive tool for the evaluation of pelvic organs in the field of reproductive medicine. There are however, some limitations of 2D USG. Certain views of pelvic organs, such as the coronal plane of the uterus cannot be obtained. Quantitative evaluation of volume using 2D measurements is based on geometric assumptions, and so may be inaccurate, especially for irregularly shaped objects like endometrium [1]. These limitations can be addressed in 3D USG which is a relatively new imaging modality allowing better spatial awareness as well as improved

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volumetric and quantitative vascular assessment. Infertility is defined as inability to conceive a desired pregnancy after one year of unprotected intercourse without conception .The main causes of female infertility are anovulation in 10to 30%,tubal factor in 15%, cervical factor in 5%, endometriosis 5 to 25% and unexplained causes of infertility in 15 to 30% [2]. This study is being done to establish the merits of 3D USG in these aspects and thereby establish its clinical role and accuracy in management of infertility and hence compare it with 2Dusg. 3D-usg has opened a new dimension to diagnosis of pelvic pathologies. These enable imaging the organ structure and spatial relationship simultaneously, facilitating spatial anomalies and 4D in real time.

METHODOLOGY

350 Patients attending OBG OPD at Medical College and Hospital, sent to RADIOLOGY OPD for US evaluation with history of infertility and recurrent miscarriages.

Equipment and specifications:

- GE Volusion 730 pro -Ultrasonography machine with 2D, 3D and 4D acquisition capacity ,
- 2D probe 1-5Mhz
- 3D volume probe-frequency -1-5Mhz with adjustment till 5Mhz
- 3D transvaginal probe- frequency-4-9Mhz
- 3Dbox adjustment, 900 sweep niche and surface rendering mode.

The inclusionary criteria

1. All married females of reproductive age group categorized to have infertility (primary/secondary) sent to the RADIOLOGY department for ultrasonography evaluation from OBG department.

The exclusionary criteria

1.Uncooperative patients
2.Severely ill patients as in toxic state /fulminating diseases

METHODS OF EXAMNINATION

1. History and consent
2. Patient supine with proper exposure of the abdominopelvic region
3. Per abdomen scan – abdomen and pelvis – 2D and 3D US
4. TVS 2D and 3D US
5. As with results followed up with HSG or hysteroscopy
6. Findings noted down and further follow up done

3D US images were obtained after 2D transvaginal and transabdominal imaging of the uterus and adnexa. Once displayed on the screen, the data can be manipulated with the following steps to obtain the coronal plane. The coronal plane is most important for the uterus, but it can be manipulated to gather information in any plane.
If other planes are desired, they can also be obtained in a similar fashion.
1. Place a reference point within the midportion of the endometrium on the sagittal plane.
2. Rotate the image to align the long axis of the endometrium parallel with a horizontal line.
3. Place the reference point within the midportion of the endometrium, again on the transverse plane.
4. Rotate the transverse plane image to align the long axis of the endometrium parallel with a horizontal line.
5. The mid portion of the coronal plane should be properly aligned when displayed.
6. Window and level the image to best display the contrast between the endometrium and myometrium.
7. The fourth quadrant shows the surface- rendered image

RESULTS

In our study the maximum (80%) of the study population the age group lies between 20-25yrs and mean age of 26years. 94% of the study population lies between 2-4yrs group of infertility years. 81.2% of primary infertility and 18.8% secondary infertility. The uterine anomalies among the study population (infertile patients) was 10.8% as diagnosed by 3DUS, HSG and with the help of hysteroscopy (previous studies). About only fifteen cases underwent hysteroscopy of these infertile females 13.8%had history of recurrent missed abortion .overall 9.5% among uterine anomaly and 4.6% in non-uterine anomaly cases, i.e more than 50% (68%) of the cases with miscarriage among infertile women were in uterine anomaly cases, more so in septate and subseptate uterus.

The overall accuracy of 3D US in diagnosing the causes of infertility in females is 100% with sensitivity and specificity 100% (among 300 cases, i.e when PCOS and Tubal block cases not considered as we compared our study with HSG the gold standard) since its understood that tubal blocks cannot be diagnosed on US and the PCOS cannot be diagnosed on HSG. And 2D US is 55% accurate, has sensitivity of 57% and specificity of 49%, However when all the cases (368) are considered the accuracy decreases to 89% & for 3D US and 92.8% for HSG and 148.9 in 2D US. The p values of 2d is greater than 0.5% and less than 0.1%for 3D US and HSG with high positive likelihood ratio for 3D and HSG. Hence all the above data confirms that the 3D US is highly sensitive, specific and accurate in diagnosing the causes of infertility among females and hence can in coming years replace HSG or other expensive investigations. Among the 368 cases there were 40 cases of uterine anomalies (~10%) this slight increase in the percentage could be due to selection of patients from referring gynecologist ,the increasing awareness among patients and increased accuracy of investigations to diagnose these cases. Among these cases Arcuate uterus (10) was the most common anomaly and almost invariably missed on 2D US then Bicornuate uterus

(9), unicornuate (7), subseptate (6), complete septate (4) and hypoplastic uterus (3). Overall Septate uterus (subseptate + complete sptate) when considered is equal to the number of arcuate uteruses in our study population. Our study shows almost same results as previous studies but with minimal higher prevalence.

Table 1. below table show the diagnostic accuracy of 2D USG, 3D USG and HSG with study population size 300 (i.e. without PCOS+NUUS+NUBS). And it is found that only 55.33% of the overall accuracy found in diagnostic accuracy in 2D USG and about 100% overall accuracy found both in 3D USG and HSG

	2D USG	3D USG	HSG
True Positive	28	49	49
True Negative	128	0	0
False Positive	123	251	251
False Negative	21	0	0
Overall Accuracy	50.33%	100%	100%
P-Value	P>0.05	P<0.001	P<0.001

Table 2. below table show the sensitivity, specificity, positive likelihood ratio and negative likelihood ratio of 2D USG, 3D USG and HSG of the study population size 300 (i.e. without PCOS+NUUS+NUBS). And it is found that in 2D USG sensitivity=57%, specificity=49%, positive likelihood ratio=1.15 and negative likelihood ratio=0.87. In 3d USG, sensitivity=100% and specificity=100%, positive likelihood ratio=1.20 and negative likelihood ratio=0.56. And in HSG, sensitivity=100%, specificity=100%, positive likelihood ratio=1.26 and negative likelihood ratio=0.16

	2D USG	3D USG	HSG
Sensitivity	0.57	1.00	1.00
Specificity	0.49	1.00	1.00
Positive Likelihood Ratio	1.15	<0.01	<0.01
Negative Likelihood Ratio	0.87	<0.01	<0.01

Table 3. below table show the diagnostic accuracy of 2D USG, 3D USG and HSG with study population size 368 (i.e. with PCOS+NUUS+NUBS). And it is found that only 48.9% of the overall accuracy found in diagnostic accuracy in 2D USG, about 89.6% overall accuracy found in 3D USG and about 92.8% of overall accuracy found in HSG

	2D USG	3D USG	HSG
True Positive	56	77	89
True Negative	128	0	0
False Positive	123	251	251
False Negative	59	40	28
Overall Accuracy	48.9%	89.6%	92.8%
P-Value	P>0.05	P<0.001	P<0.001

Table 4. below table show the sensitivity, specificity, positive likelihood ratio and negative likelihood ratio of 2D USG, 3D USG and HSG of the study population size 368 (i.e. with PCOS+NUUS+NUBS). And it is found that in 2D USG sensitivity=48%, specificity=49%, positive likelihood ratio=0.94 and negative likelihood ratio=1.16. In 3d USG, sensitivity=65% and specificity=100%, positive likelihood ratio<0.01 and negative likelihood ratio=0.35. And in HSG, sensitivity=76%, specificity=100%, positive likelihood ratio<0.01 and negative likelihood ratio=0.24

	2D USG	3D USG	HSG
Sensitivity	0.48	0.65	0.76
Specificity	0.49	1.00	1.00
Positive Likelihood Ratio	0.94	<0.01	<0.01
Negative Likelihood Ratio	1.06	0.35	0.24
Uterine anomaly	2D	3D	HSG /HSG+hyst.or the final impression
Hypoplasia	3	3	3
Unicornuate	0+2 (RH as F)	7	7
Arcuate	0	10	10
Bicornuate	7+2(suspicion)	9	9
Subseptate	5+2(suspicion)	7	7
Septate	1(suspicion)	4	4
Total	22	40	40

Hence it's obvious that 3D US is 100%accurate and sensitive in diagnosing uterine anomalies, but HSG many a times needs confirmation from hysteroscopy or MRI. However in our study only in a single case it was doubtful in HSG as to whether it is a Bicornuate uterus or subseptate but it was confirmed on Hysteroscopy hence HSG too has 100 %accuracy as stated in earlier tables, whereas 2D is only 48-55%accurate.

DISCUSSION

Beyond doubt till date it was HSG was and is the gold standard for diagnosing causes of infertility in women. But from the study we have seen 3D can even replace this invasive and radiological, relatively expensive procedure especially in cases of uterine anomalies .Also other techniques with treatment aspect along with are hysteroscopy and laparoscopy, both need skill and are very expensive [3,4].

In our study we came across 40 cases of uterine anomalies in 368 cases of women with complains of infertility with uterine anomalies accounting for 10.8% as the cause of infertility compared to other studies (~7-9%), the slight appraisal in the percentage of uterine anomalies causing infertility in our study may be because of selection of patients, also previously many arcuate uteruses, septate (complete /subseptate) uteruses could have been missed which could be the cause of lesser percentage in their study and awareness and approach of patients for the treatment.

Arcuate uterus is the mildest form of anomaly and most commonly missed anomaly as the difference between this anomaly and a normal uterus are subtle such that it is considered a normal variant instead ,but the consequence of an arcuate are different. Out of 10 cases of arcuate uteruses 4 had preterm deliveries and 2 early trimester abortions but 7 of them did have successful pregnancies previously .This anomaly may be missed on HSG if not interpreted properly and many a times due to rotation or retroversion or anteflexion the anomaly is missed on HSG, but the 3D definitely will show this anomaly as it gives the image in all the 3 dimensions, rotating the image and viewing the whole of the uterus provides the apt diagnosis irrespective of the flexions or versions of the uterus. ON 3D US and HSG imaging arcuate uterus demonstrate a single endometrial canal, with a smooth, broad indentation of the myometrium (<1 cm) at the uterine fundus.

3D has 100% sensitivity in diagnosing Unicornuate uterus cases, usually these appear as a small banana shaped structures, with or without rudimentary horns .in our study out of 7 cases 4 had a rudimentary horn and five had miscarriages in the early trimester. All these patients had undergone 2D US several times before presenting to our OPD and none of these were diagnosed on 2DUS even in our study 2D did not suspect /diagnose this anomaly. 3 of these patients had undergone HSG elsewhere and were diagnosed to have unicornuate uterus, rest of the four patients underwent HSG in our hospital and the diagnosis was confirmed. 3D US with no doubt easily showed a banana shaped unicornuate uterus with or without rudimentary horn which cannot be seen on HSG. Also we noted that much cases of this anomaly have small sized uterus though two of our patients had successful pregnancy it is still a cause of infertility among uterine anomalies in substantial cases [5].

In our study we came across 10 Bicornuate uterus cases where in 4 had miscarriages, in a particular patient who had early trimester abortion previously and now when came for routine obstetric checkup was diagnosed to have a well-defined gestational sac in the right horn but this time again it got aborted in 11th week of pregnancy. However comparatively the percentage of miscarriage compared to septate is less. The diagnosis of Bicornuate uterus and its confirmation would need laparoscopy or MRI, but it has been long established the features of Bicornuate uterus being intercornual distance >4cms (widly placed cornua) and indentation >10mm. This condition may be diagnosed at 2D and HSG but at times it becomes difficult to differentiate it from a subseptate uterus which needs a coronal image of the outer contour of the uterus, i.e the indentation over outer surface of the fundus due to non-fusion, which is provided with ease in 3D US imaging .even in our cases these cases were diagnosed on 3D without any discrepancy and hence they were not subjected to MRI or laparocopy for further evaluation as this condition is not treatable it would be of no use in undergoing such procedure [6].

Theoretically it is easy to say we can obtain coronal image, but due to some degree of rotation a septate uterus may be mistaken as bicornuate, archiving the image with proper adjustments / processing gives the proper diagnosis.

CONCLUSION

3D US is in almost all the cases of uterine anomalies was able to diagnose , but the 2D US always remains the primary choice of investigation to begin with, along with history it would be a good practice for a sonologist to do 3D routinely or at least as a problem solving tool.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

STATEMENT OF HUMAN AND ANIMAL RIGHTS

All procedures performed in human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

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