

THE DIAGNOSTIC ROLE OF MULTIDETECTOR COMPUTED TOMOGRAPHY VIRTUAL HYSTEROSALPINGOGRAPHY IN DETECTING UTERINE AND TUBAL CAUSE OF FEMALE INFERTILITY

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Abstract

Background: Infertility is a common problem worldwide, primarily attributed to Polycystic Ovarian disease but also influenced by structural issues in the female reproductive system. MDCT Virtual Hysterosalpingography offers a potential solution with its high resolution and advanced reconstruction techniques, allowing precise identification of intrauterine, tubal, and extrauterine pathologies. This study aims to assess the role of MDCT Virtual Hysterosalpingography in diagnosing cause of infertility, comparing its accuracy to conventional X-ray Hysterosalpingography and determining its potential to minimise the need for invasive procedures. **Materials and Methods:** A prospective cross-sectional study was conducted at Stanley Medical College, Chennai, India, over a year, including 35 female patients with infertility complaints. MDCT Virtual Hysterosalpingography was performed using a 128-slice CT scanner, and images were analysed using various reconstruction techniques. **Result:** Results showed that 57% of the enrolled patients had uterine and tubal pathologies. MDCT Virtual Hysterosalpingography demonstrated higher sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy (95%, 100%, 100%, 93.7%, and 97.1%, respectively) than conventional X-ray Hysterosalpingography. **Conclusion:** MDCT Virtual Hysterosalpingography holds potential as a imaging tool for diagnosing female infertility. Its ability to assess uterine and tubal pathologies, visualise pelvic abnormalities, and replace invasive procedures makes it valuable.

INTRODUCTION

Infertility is a disease defined by the failure to achieve pregnancy after 12 months or more of regular unprotected sexual intercourse. Though Polycystic Ovarian disease is the most common cause of female infertility, structural anomalies of the female reproductive system contribute significantly to infertility, and most are treatable. Females undergo multiple investigations (imaging techniques) as a part of their infertility workup, but none is the gold standard. As the incidence of female infertility increases, a single imaging modality that can identify intrauterine, tubal, and extrauterine pathologies and eliminate the need for invasive procedures is essential.^[1,2] With its high resolution, reconstruction techniques, MDCT virtual HSG aid in proper

diagnosis of the structural causes of female infertility.^[3,4]

The study aims to identify the role of MDCT virtual hysterosalpingography in diagnosing the uterine and tubal cause of infertility, to know the accuracy of MDCT virtual hysterosalpingography in comparison with conventional X-ray hysterosalpingography and how it reduces the necessity of invasive procedures like diagnostic hysterosalpingography.

MATERIALS AND METHODS

This prospective cross-sectional study was conducted in the Department of Radiology at Stanley medical college Chennai, Tamilnadu, India, for one year from February 2021 to February 2022, after obtaining ethical Committee Clearance.

Inclusion Criteria

35 Female patients with complaints of infertility were included in this study.

Exclusion Criteria

Patients who have Contrast hypersensitivity, age less than 18 years, active infections like cervicitis and pelvic inflammatory disorder, and those patients who are not willing to give consent to the study.

The study was performed between day 7 to day 10 of the menstrual cycle.

Sample Size Calculation

The study group consisted of 35 patients who were diagnosed with infertility, as the sample size (Based on the reference study done by Abdelrahman et al., Egypt, where Specificity of Multidetector Computed Tomographic Virtual Hysterosalpingography in detecting the tubal cause of infertility among female patients is 93%, sensitivity 100%).^[5]

Study Procedure

After obtaining written and informed consent from the patient, details of the patient and her partner were noted. Detailed patient interviews were done regarding the clinical history and other comorbid conditions. Physical examinations and vitals monitoring were done. A pre-designed proforma was used to collect the clinical details of the participants. All the participants underwent an initial Ultrasonogram. Before the procedure, vascular access was obtained in the antecubital/cephalic vein using an 18–20-gauge catheter to treat unexpected contrast allergic reactions. MDCT virtual hysterosalpingography was performed on a multislice CT with 128 detectors (GE-Optima 660). Images were obtained using Low dose CT protocol and a small field of view to reduce radiation dose. The patient was positioned supine on the CT gantry in a lithotomy position. After the perineum was cleansed with a povidone-iodine solution, the vagina was dilated with a speculum; the cervix was cleansed with a povidone-iodine solution, and then with the Cusco's speculum in place, a scout view of the pelvis was obtained. The localiser was adjusted to localise a small field of view, avoiding unnecessary large fields to avoid excess radiation exposure. Next, without cervical clamping, a specially designed plastic cannula (HSG cannula) was fitted in the external cervical os, and 10–20 ml of diluted (5 ml contrast agent diluted with 15ml saline solution) nonionic, low osmolar contrast media was instilled slowly into the cervical canal to avoid rapid expansion of the uterus which might cause patient discomfort. The average time of Multidetector Computed Tomography Virtual Hysterosalpingography scan after contrast injection was 4 to 5 seconds.

In MDCT virtual hysterosalpingography, the first step of the analysis is evaluating the original axial CT images. They give knowledge about the pelvic structures and Tubal patency (peritoneal spilling of contrast). Using Multiplanar reformatting (MPR), Maximum intensity projection (MIP), Minimum Intensity projection (MinIP), Volume Rendering (VR), and Virtual hysterosalpingography (VH)

techniques, images are reformatted to analyse the uterine cavity and fallopian tubes.

The following were determined from each patient: Normal/abnormal tubal and uterine anatomy, Normal /abnormal Pelvic structures/ovary, and Presence /absence of peritoneal spillage of contrast.

Statistical Analysis

The collected data were analysed with IBM SPSS Statistics for Windows, Version 23.0. (Armonk, NY: IBM Corp). Frequency analysis, and percentage analysis were used for categorical variables, and the mean & SD were used for continuous variables. To find the efficacy of the MDCT virtual hysterosalpingography and to predict the outcome, the Receiver Operating Characteristics curve (ROC) was used with Sensitivity, Specificity, PPV, NPV & accuracy. The above statistical tool's probability value of .05 is considered significant.

RESULTS

Of the total 35 enrolled patients in the study, 29 were primary infertile, and six were secondary infertile. 60% of patients were between 26 to 30 years. The age distribution is summarised in the [Figure 1]. Comorbidities were present in 2 patients. Uterine and tubal pathologies were present in 20/35(57%). Uterine pathologies were present in 12/35(34%), in which leiomyoma (6/50) has the highest (17%). Uterine adhesion was present in 3 patients, 2 of whom underwent previous Dilatation and Curettage. Mullerian anomalies were detected in 3 patients. Tubal pathologies were present in 8/35(22%). Bilateral tubal blocks were present in 2 patients. Unilateral tubal blocks were present in 3 patients. Tubal irregularity with peritoneal spillage of contrast was present in 1 patient. Hydrosalpinx was present in 2 patients. Of the 12 uterine pathologies, X-ray hysterosalpingogram diagnosed 7 cases, and MDCT virtual Hysterosalpingography diagnosed 11 cases. X-ray hysterosalpingogram showed Tubal pathologies in 10 patients (10/35), and MDCT virtual hysterosalpingogram diagnosed tubal pathologies (8/35). X-ray hysterosalpingography diagnosed bilateral tubal block in 3 patients, and MDCT virtual Hysterosalpingography diagnosed bilateral tubal block only in 2 patients. X-ray hysterosalpingography diagnosed unilateral tubal block in 4 patients, and MDCT virtual Hysterosalpingography diagnosed unilateral tubal block in 2 patients. Compared to MDCT virtual hysterosalpingography, X-ray hysterosalpingogram has significant false positivity in diagnosing tubal block. Other than uterine and tubal pathologies, Complex/Simple ovarian cysts, adnexal cysts, and ileocecal tuberculosis were also detected in MDCT virtual hysterosalpingography [Table 4]. Comparing MDCT virtual hysterosalpingography with xray HSG for uterine and tubal pathology of infertility using the Receiver Operating Characteristic curve (RoC) [Figure 2] showed the area of the curve is 0.900, p-

value= 0.0002 <0.01 with 95% C. I 0.801 to 0.968, which is high statistical significance [Table 2]. The sensitivity was 95%, specificity was 100%, PPV was 100%, NPV 93.7% and diagnostic accuracy was 97.1% [Table 3,4].

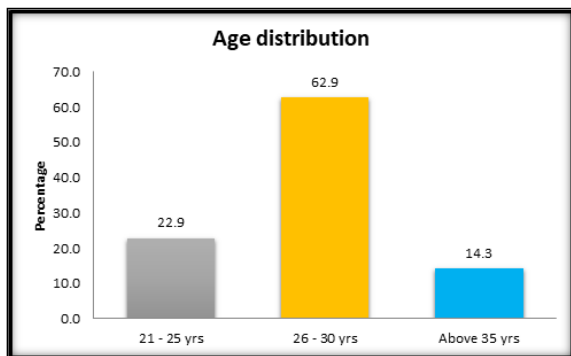


Figure 1: Graphical representation of age distribution in female patients with complaints of infertility.

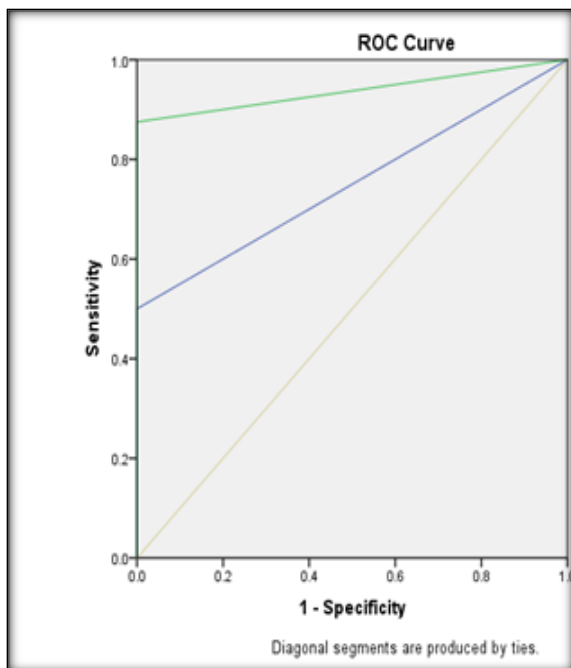


Figure 2: Receiver Operating Characteristic curve, the blue line indicates X-ray HSG and the green line indicates MDCT V-HSG.

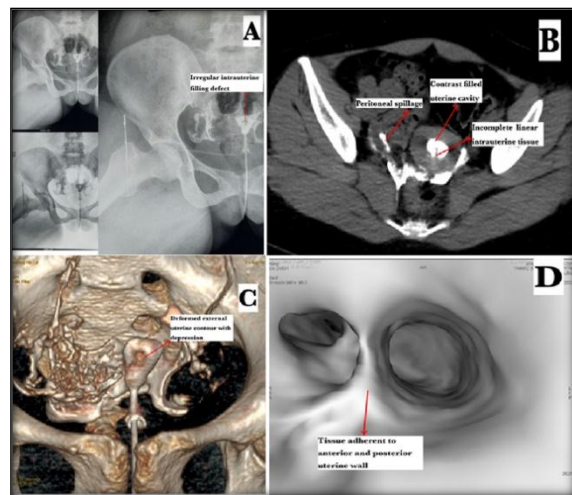
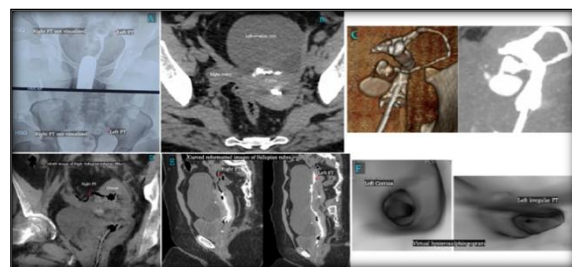


Figure 3: 29 years female with H/O four recurrent first-trimester abortions and underwent dilatation and curettage for 1st abortion four years back. A) X-ray HSG image shows irregular intrauterine filling defect with normal uterine contour. B) axial CT image confirms the presence of thin tissue within the uterine cavity. C)VR image shows external uterine contour depression at the same level as a normal volume uterus. D)VE image shows intervening tissue partially separating the uterine cavity -synechiae.



[Figure 4]: 35-year-old female nulligravida, A) X-ray HSG image shows right fallopian tube cornual block and left irregular fallopian tube with left fimbrial block and hydrosalpinx, No evidence of peritoneal spillage of contrast bilaterally. B) MDCT HSG CT axial image in soft tissue window shows no peritoneal spillage of contrast bilaterally, normal uterine contour, normal right ovary and large left ovarian cyst. C) 3D volume rendered (VR on the right side) and MIP (Maximum Intensity Projection on the left side) images show the left irregular fallopian tube, block at the fimbrial level and fimbrial hydrosalpinx, Right tube cornual block. D) MinIP (Minimal Intensity projection) image shows an air-filled right fallopian tube block at the fimbria (not at the level of cornua). E) Curved reformatted image shows the entire length of bilateral fallopian tubes in a single image. F) Virtual HSG image shows obstruction at the level of cornua (right) and irregular left tube at the level of ampulla (left).

Table 1: Pathologies other than uterine and tubal detected in MDCT virtual hysterosalpingography Pathologies other than the uterine and tubal cause of infertility were diagnosed.

Pathologies other than the uterine and tubal cause of infertility were diagnosed.	Frequency	Percent
Adnexal Cyst	5	14.0
Ovarian complex cyst	3	8.0
Ovarian simple cyst.	4	11.0
PCOS with enlarged ovaries.	4	11.0
Bilateral Inguinal Lymphadenopathy	2	5.7
Distal ureteric calculus	2	5.7
Free fluid in the pelvis	2	5.7

Cystitis	1	2.8
Ileocecal TB	1	2.8
Diverticulosis	1	2.8
Spondylolysis of lumbar vertebra	1	2.8

Table 2: showing p-value and confidence interval of the area under the curve

Area Under the Curve				
Area	Std. Error	p-value	95% C.I	
			LB	UB
.900	.070	0.0002**	.801	.968

** Highly Statistical Significant at p < 0.01 level

Table 3: The above table compares X-ray HSG for uterine and tubal pathologies of infertility with Hysteroscopy for uterine and tubal pathologies of infertility with sensitivity and specificity values.

		Diagnostic hysteroscopy		Total	Sensitivity	83.0
		Present	Absent		Specificity	88.0
Xray HSG	Present	15	2	17	PPV	88.2
	Absent	3	15	18	NPV	83.3
Total		18	17	35	Accuracy	85.7

Table 4: The above table compares MDCT V-HSG for uterine and tubal pathologies of infertility with Hysteroscopy for uterine and tubal pathologies of infertility with sensitivity and specificity values.

		Diagnostic hysteroscopy		Total	Sensitivity	95.0
		Present	Absent		Specificity	100.0
MDCT V-HSG	Present	19	0	19	PPV	100.0
	Absent	1	15	16	NPV	93.7
Total		20	15	35	Accuracy	97.1

DISCUSSION

As the incidence of female infertility increases, finding an investigation that will replace/eliminate the need for multiple investigations is necessary. For assessing the female reproductive system in the infertility workup, ultrasound (Hysterosonography), HSG and hysteroscopy are widely accepted procedures. Carrascosa et al,^[1,2] reported that the MDCT VHSG was proposed as a alternative diagnostic procedure for evaluating the female genital tract. Carrascosa et al,^[1] first used 16-row MDCT, which gave a good result comparable with conventional X-ray HSG for detecting uterine pathology. Then he tried 64-row MDCT VHSG, which reported good results comparable to conventional X-ray HSG for uterine and fallopian tube pathology.^[2,3] In our study, we used a 128-slice GE OPTIMA 660 machine with better resolution and less radiation dose (less scanning time) compared to 64-row and 16-row CT.

According to Carrascosa et al. MDCT VHSG has a better diagnostic evaluation for intrauterine filling defects such as intrauterine synechiae and polyp, with better evaluation of the submucous myoma regarding its size, site and precise depth,^[1] in addition to its ability to evaluate and define uterine contour adding to accurately diagnosing uterine malformation. One of our patients presented with a history of four recurrent abortions and history of dilatation and curettage. X-ray HSG visualised a small filling defect, interpreted as a small intrauterine clot, but we had a strong suspicion of the incomplete septate uterus/uterine synechiae. We proceeded with MDCT virtual hysterosalpingography, which confirmed presence of uterine synechiae's, and the patient

underwent hysteroscopic synechiae lysis [Fig 3]. The ability of MDCT VHSG to define contour, outer wall, myometrium of the uterus, uterine cavity and better diagnostic value of virtual endoscopy provided by MDCT VHSG helped in arriving at a diagnosis .^[6,7]

Hasan DI et al. compared findings of MDCT-VHSG with hysteroscopy or laparoscopy; using 128-slice multidetector CT and found that MDCT-VHSG is more accurate in the diagnosis of uterine and ovarian infertility causes, while less accurate in the diagnosis of tubal causes.^[8-12] The sensitivity for detecting uterine and fallopian tube pathology by MDCT-VHSG was 100% and 100%, respectively, while the specificity was 100% and 85.71%, respectively. MDCT-VHSG had reported 100% and 92.85% PPV in detecting uterine and fallopian tube pathology, respectively, while the NPV was 100% and 100%, respectively. In our study, MDCT VHSG showed a Sensitivity 95%, Specificity 100%, PPV 100%, NPV 93.7% diagnostic accuracy 97.1% [Table 4].

Carascosa P et al. evaluated pathologies in the uterine cavity detected by MDCT-VHSG in infertile females compared to diagnostic hysteroscopy. They concluded that virtual hysterosalpingography by MDCT had detected variable abnormalities in the uterine cavity, such as endometrial polyps, submucosal myoma, synechiae and cesarean scar defect. His study mentioned that diagnostic hysteroscopy and MDCT-HSG detected all the pathologies similarly.^[9]

Carascosa et al. concluded that one of the advantages of MDCT-HSG is its ability to visualise the external uterine contour, which can help differentiate between septate and bicornuate.^[2] Septate uterus has a flat or

convex fundal contour, whereas bicornuate uterus has fundal depression.

Heuser et al. conducted a study on MDCT virtual HSG using a 32-slice MDCT machine in Brazil, and they used it to acquire CT images at the time of contrast injection, like conventional X-ray HSG.^[13] In our study though we acquire an image soon after contrast administration, a modern plastic catheter with a 2-way adapter prevents the spillage of contrast externally, so we can distend the uterus as much as possible, thereby identifying the pathologies. Heuser et al. also proposed the usage and advantage of balloon catheters in virtual hysterosalpingography. Our study used balloon catheters instead of metal cannula to reduce patient discomfort and vasovagal attack.

According to Carascosa, et al., the most common complication is the intravasation of contrast into the venous plexus^[11] (not encountered in our study). Mild pain during contrast injection is the most common complication in my study (50% of patients), but it is self-limiting, and patients were devoid of pain within 10 to 20 mins. There was no clinically significant vasovagal response in our patients.

MDCT diagnosed intramural, submucosal, and subserosal leiomyomas, but X-ray hysterosalpingography diagnosed only submucosal leiomyoma. The Tubal block identified by X-ray Hysterosalpingography was predominantly in the cornual (proximal tube) location. Some Cornual blocks visualised in X-ray Hysterosalpingography were not found in MDCT virtual hysterosalpingography. A patient diagnosed with a cornual block by X-ray hysterosalpingography finally turned into a fimbrial block, diagnosed by MDCT virtual hysterosalpingography [Figure 4] and confirmed by diagnostic hysterolaparoscopy. Since the management and prognosis for the cornual and fimbrial blocks vary, identifying the anatomical location of the block is essential.

In our study, in addition to uterine and tubal pathologies other pathologies such as adnexal cysts (n=5), simple ovarian cyst (n=4), complex ovarian cyst (n=3), enlarged ovaries (n=4), free fluid in pelvis (n=2), inguinal lymphadenopathy (n=2), distal ureteric calculus (n=2), cystitis (n=1), ileocecal TB (n=1), diverticulosis (n=1) were also identified. The current study has some limitations. Although MDCT virtual HSG gives adequate information regarding the cause of female infertility, the radiation dose is a concern. The radiation dose received by the patients was not calculated in this study. However, previous studies in the literature have reported dosage values varying from 7.25 to 8.26 MSV. As these values are acceptable, no separate radiation dose calculation was made.

Our studied compared X-ray HSG and MDCT virtual HSG with the hysterolaparoscopy (gold standard technique). None of the above-mentioned studies compared both modalities' diagnostic accuracy with hysterolaparoscopy.

Limitation(s)

Small sample size, Radiation exposure, Higher cost, Low availability, risk of contrast allergy, does not allow selective tubular cannulation in case of proximal obstruction, risk of pelvic infection.

CONCLUSION

The MDCT VHSG, with its 3D reconstruction and 3D virtual navigation techniques, allows comprehensive evaluation of the female reproductive system. It can be a better imaging tool for diagnosing the structural cause of female infertility. Multidetector CT is simple and well-tolerated and can be used with ultra-low-dose radiation. However, the resulting exposure of the patient to ionising radiation is a relative disadvantage to be judged according to the risk-benefit. The ability of the MDCT VHSG to image the uterine wall allows quick and easy detection of abnormal contour, and focal masses. Leiomyomas (Submucosal and intramural), and postoperative synechiae can be recognised with a high degree of accuracy compared to X-ray HSG. Multidetector CT Virtual HSG is considered to have the best method of image reconstruction to assess the patency of the fallopian tubes. It not only represents the tubal lumen and the wall of the fallopian tube, but it also allows virtual navigation endoscopy within the fallopian when dilated. MDCT VHSG can readily visualise tubal occlusion and stenosis. Because the whole pelvis is scanned during MDCT VHSG, uterus and tubal anatomy can be evaluated simultaneously. Incidental findings may include solid and cystic adnexal lesions, intestinal abnormalities, pelvic mass, and bone abnormalities that MDCT VHSG can detect. With ultra-low radiation doses, MDCT can better replace invasive hysterolaparoscopy. In the future, it can be a single imaging modality of choice for evaluating female infertility.

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