10.5005/jp-journals-10009-1208

LETTER TO EDITOR

Transvaginal Ultrasonography in Female Infertility Evaluation

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ABSTRACT

Ultrasound has become essential in the diagnosis and management of the infertile female. Transvaginal ultrasonography provides a detailed examination of the uterus and ovaries. Evaluation of the infertile female has become increasingly more detailed in recent years because of technologic advancements as vaginal ultrasonography is the first step in assessment of pelvic infertile female.

Keywords: Endometrial thickness, Endometrioma, Hydrosalpinx, Endometrial polyp, Adenomyosis, Leiomyoma.

INTRODUCTION

Infertility is the inability to conceive after one year of intercourse without contraception. The main causes of infertility are: Male factor in 20 to 30% of cases, anovulation in 10 to 30%, tubal factor in 15%, cervical factor in 5%, endometriosis in 5 to 25% and unexplained causes of infertility in 15 to 30%.[1] However, the causes of infertility may be different in different geographic parts.[2]

The most important advances in assisted reproductive technology (ART) have resulted from developments in tools of evaluation of pelvic structure. High resolution transvaginal sonography (TVS) has been extensively accessible since the mid-1980s and has been used as an essential part of gynecologic sonographic examination, including infertility evaluation.[3]

The aim of this paper is how to use vaginal sonography in study of infertile women, including uterus evaluation with more details: Assessment of receptivity of endometrium, endometrial polyp, uterine myoma, adenomyosis, intrauterine adhesion and anatomical abnormalities. Furthermore, the evaluation of ovaries and disorders that affect fertility, such as polycystic ovary, endometrioma, will be explained. In addition, ultrasonographic details of pseudo cyst and hydrosalpinx are described.

This article evaluates women with infertility by 2D ultrasonography—the most accessible diagnostic tool in all infertility centers all over the world, and 3D and Doppler ultrasonography are not included.

UTERUS

Endometrial Evaluation

Two anatomical parameters were recommended to assess uterine endometrium by ultrasound: Endometrial thickness and pattern.

Endometrial Thickness

Definition of endometrial thickness is maximum distance between the echogenic interfaces of myometrium and endometrium in two opposite site measured in the plane through the central longitudinal axis of the uterine body.[4]

Endometrial Thickness and Menstrual Cycle

Endometrial thickness is measured easily by ultrasonography examination and it is different during menstrual cycle. Thickness of endometrium in menstrual, proliferative and secretory phase are 1 to 4 mm, 4 to 8 mm and 8 to 16 mm respectively.[5]

The uterine receptivity is one among several different factors contributing to implantation. The methods to predict uterine receptivity are:

1. Histological evaluation of an endometrial biopsy specimen
2. Serum estradiol and progesterone concentration may reflect endometrial status
3. MRI
4. Use of high-resolution ultrasonography is a noninvasive method of assessment of uterine receptivity.

Endometrial Thickness in ART Cycles

The changes in endometrial thickness is used for monitoring and follow-up of ovarian stimulation in assisted reproduction treatment cycles. The endometrium grows 0.5 mm/day in the proliferative phase and 0.1 mm/day in the luteal phase. If endometrial thickness is more than 7 mm in the preovulatory period, the probability of pregnancy is higher.[6] Robinowitz et al noted that conception cycles have had higher endometrial thickness compared with nonconception cycles.[6] Dickey et al found that chemical pregnancy rate was higher when endometrial thickness was < 9 or > 13 mm.[7] Contrary to the

previous reports, other studies found no association between endometrial thickness and the occurrence of biochemical pregnancy.[8-9] Gissant et al reported that endometrial thickness is not prognostic parameter for pregnancy[10] Despite this disagreement, it seems that low-endometrial thickness reduces endometrial receptivity.

Endometrial Pattern

Endometrial pattern is defined as the type of relative echogenicity of the endometrium and nearby myometrium that observed on a longitudinal uterine ultrasonic section.[4] Several classification of ultrasonographic endometrial patterns used in the evaluation of assisted reproduction treatment cycles. At first four endometrial patterns were suggested (Smith's grading), then this classification was simplified to two or three patterns.[11-13]

Smith's Grading

Grade A: Presence of a halo, endometrial reflectivity increased compared with myometrium. Bright endometrium represents postovulation or the luteal phase.

Grade B: Presence of a halo between the myometrium and endometrium and comparable reflectivity between myometrium and endometrium. Endometrial reflectivity is similar with the myometrium. This characterizes late follicular phase.

Grade C: Reduced reflectivity, darker area surrounding the midline echo. This is a pattern of mid-follicular phase.

Grade D: Echogenic black region surrounding the midline echo and a bright central echo is seen, described as the triple-line.[11]

Endometrial Pattern in ART Cycles

The endometrial pattern as assessed by ultrasound may be a predictor of success implantation and embryo transfer following IVF.[14] A triple-line pattern can better demonstrate endometrial receptivity.[11,14,15] However, isoechogenic or intermediate patterns did not rule out the possibility of pregnancy.[7,15,16]

Endometrial Polyp

Endometrial polyps develop as solitary or multiple, soft, sessile and penduculated tumors containing hyperplastic endometrium. Polyps appear to be diffuse or focal thickening of endometrium on transvaginal sonography. Ultrasonographic appearance of endometrial polyp has been shown to endometrial thickening which is usually homogeneous in echo-texture and iso- or slightly hyperechoic relative to the endometrium (Fig. 1). Another sign to the presence of a polyp is the existence of one or more small cystic spaces. The endometrial polyps are easier to visualize by sonohystrography and are better seen during the periovulatory phase.[17]

Although submucous myomas may have adverse effect on fertility, the effect of endometrial polyp is uncertain. However, in a study that conducted on a group of infertile female with documented endometrial polyps (> 2 cm), IVF outcome in

Fig. 1: Endometrial polyp

treated and untreated women were not different.[18] In general prevalence of polyps is approximately 3 to 5% in infertile female.[19] Differentiation between small submucous myomas and endometrial polyps can be distinguished by hysteroscopy.[20]

Uterine Myoma

The incidence of lipomyomas in female older than 30 years age is 20 to 30%. The most common neoplasia of the uterus is myoma.[5] Fibroids may be situated within the myometrial wall (intramural), bulge into the endometrial cavity (submucosal) be placed almost totally within the endometrial cavity (intracavitary) or located on the serosal surface and deformed the surface of the uterus (subserosal) (Fig. 2). Myomas usually found with transvaginal ultrasound that it is the most important tool for screening of fibroids. The uterus seems to be enlarged generally or focal mass with different echogenecities (hypoechoic usually, hyperechoic when calcified and may be isoechoic also) located in uterus. Focal leiomyomas are typically heterogenous but mostly hypoechoic compared to surrounding myometrium.[5]

Submucosal myomas usually cause infertility and abnormal uterine bleeding.[21] Fibroids can cause infertility by blocking the cervical canal or the fallopian tubes mechanically. Myomas

Fig. 2: Intramural myoma

may have pressure effect on endometrial cavity and this decreased receptivity of endometrium for implantation. Also, myoma interferes with the transport of sperms and zygotes. HSG is very useful in recognition of intracavitary extent of a submucosal myoma. Hysteroscopic resection is suitable for removing the myomas that have at least 50% of their volume in the uterine cavity.[5]

The available evidence showed that pregnancy and implantation rates were significantly lower in women with submucousal fibroid,[22] but not in those with subserosal or intramural fibroids with modest size (< 5-7 cm) that do not invade on or clearly deform the endometrial cavity.[23]

Adenomyosis

Adenomyosis of the uterus is a condition in which ectopic endometrium goes into myometrium. It may be localized close to endometrium (adenomyoma), or it may extend through the myometrium and serosa. On sonography, the uterus is usually enlarged with a globular shape. On TVS, the endometrial margin may appear nodular and the myometrium contains ill-defined foci of heterogeneity. Tiny cystic spaces (1-3 mm) may be found within the heterogenous myometrium (Swiss cheese) due to areas of hemorrhage and clots within the muscle (hyperechoic area besides hypoechoic area).[5]

Intrauterine Adhesions

Endometrium destruction causes the formation of scar tissue or adhesions within the uterine cavity. This damage may happen as an effect of vigorous curettage of the uterus or infection (TB). Intrauterine adhesions can be prove by HSG and sonohysterography. Depending on their composition (mucosal, fibromascular, connective tissue), adhesion may or may not have a surface of endometrium.[24]

Congenital Anomalies

The incidence of congenital mullerian duct anomalies is in 0.4% (0.1-3%) of the general population and in 4% of infertile females.[25,26] Uterine anomalies have been classified by the American Society of Reproductive Medicine.[27]

The diagnosis of unicornuate uterus is not easy by sonography, because it can be confused as a small uterus. Ultrasound view of the bicornuate uterus seems to be that broad or separated cavities. When transvaginal sonography is performed during the secretary phase, diagnosis of two separated cavity is easier (Fig. 3). Sonographically in a septate uterus, the cavity of uterus has been separated with thin wall (Fig. 4).[5]

The septate uterus is the most common and must related to reproductive failure and obstetrics complications.[28] In addition to sonography, MRI, hysterosalpingography (HSG) and hysteroscopy are helpful for assessment of uterine malformations.[29]

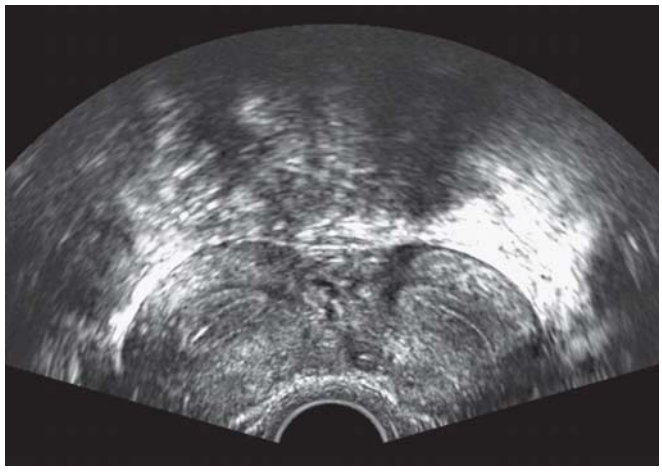


Fig. 3: Bicornuate uterus

Fig. 4: Septate uterus

Ovarian Evaluation

Ovarian size is related to age, menstrual status, pregnancy, body habitués and phase of menstrual cycle. Normal ovarian volume in reproductive age is 5 to 15 ml, however, the volume as high as 22 ml have been shown in normal ovaries.[30]

Follicles with size of 1 to 2 mm can be observed with TVS. Dominant follicles can be documented by day 8 to 12 of menstrual cycle. For 4 to 5 days before ovulation, the dominant follicle grows at a rate of 2 to 3 mm/day to reach a maximum mean diameter of approximately 20 mm.[4]

Functional Ovarian Cysts

Ovarian cysts are frequent in all age groups, but especially in women of menstrual age. Typical benign cyst has thin wall, no septation and no solid elements.[31]

Aflatoonian and colleagues performed a research on women in reproductive age with ovarian mass. They found that if morphology of ovarian mass was benign by ultrasound, chance of it being malignant was near to zero.[32]

Polycystic Ovaries

The Rotterdam criteria for definition of polycystic ovary syndrome are anovulation or oligo-ovulation, clinical or

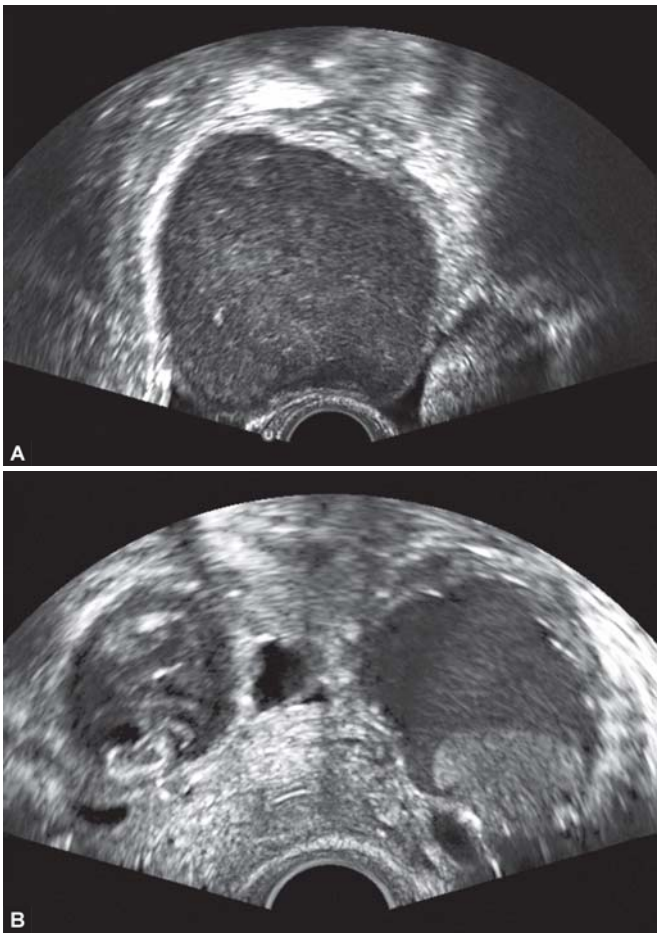
biochemical signs of hyperandrogenism or polycystic ovaries, that two of three features are necessary for diagnosis of PCOS.[33]

In PCOS, the ovaries are large (> 10 cc) with 10 or more peripheral follicles with size of 2 to 9 mm in diameter. The stroma in these ovaries is increased (> 25% of the cross-sectional area) and echogenic.[34]

Endometrioma

The incidence of ovarian endometrioma is 13 to 38% in women with endometriosis.[35] The endometriosis is diagnosed by visual inspection of the pelvis by laparoscopy or laparotomy. The accuracy of transabdominal ultrasonography is low for diagnosis of endometriosis.[36] In a study, diagnosis of endometriomas by transvaginal ultrasound has 90% or higher sensitivity and almost 100% specificity.[37] In Aflatoonian's study, the accuracy of transvaginal ultrasound for diagnosis of endometriomas was 97.5%.[32] Guerriero et al found that for diagnosis of endometrioma CT scan had a lower accuracy than transvaginal ultrasonography.[38]

The typical appearance of an endometrioma or "chocolate cyst" is a thick-walled cyst filled with homogenously low-level echoes (ground-glass appearance), they are unilateral or bilateral (Fig. 5A). Sometimes the irregular internal wall of the cyst is covered with a sludge-like material, however, there are wall nodularities in 20% of endometriomas. The endometriomas are often adherent to the uterus or pelvic sidewall (Fig. 5B).[39]



Figs 5A and B: Endometrioma

In addition aspiration of endometrioma and washing with normal saline and then injection of alcohol ethanol 98% and retrieval after 10 minutes as sclerotherapy was effective in recurrent endometrioma.[40-42] This shows high accuracy of transvaginal ultrasonography for diagnosis of endometrioma that we studied before,[32] and these results permit us to perform such procedure by transvaginal ultrasonography.

Ultrasound Characteristics of Hydrosalpinx

The normal fallopian tube length is 10 cm and is rarely seen on transvaginal sonography. When a fluid-filled sausage-shaped cystic structure with existence of partial septa is seen on ultrasound, the hydrosalpinx should be suggested.[43] Hydrosalpinx is more tubular with anechoic pattern and partial septa compared to ovarian cyst.[31]

Peritoneal Pseudo Cyst

Peritoneal pseudo cysts are fluid collections between adhesions happening following an inflammatory process in the peritoneal cavity or after an operation.[44] The cyst fluid may be anechoic or echoic, and the cyst may have both septa and papillary projections.[45]

Ultrasound in ART

Some of the most significant advances in ART have resulted from developments in ultrasonography. Ultrasound makes easy oocyte retrieval techniques enabling the procedure to be performed under sedation and has totally replaced laparoscopic oocyte retieval under general anesthesia. It is also the method of preference for monitoring follicular growth.

Monitoring Follicular Development in ART

The ultrasound technique provides information of follicular number and size. Under best situation, a follicle in the ovary can be seen from a diameter of 2 to 3 mm. Follicles usually grow by 2 to 3 mm daily.[4]

In an ART cycle, the frequency of ultrasound examination is depend on the type of ovarian stimulation regimen and patient's response. Wittmaack et al, in a retrospective study, found a relatively constant oocyte retrieval in follicles measuring between 12.5 mm and 24 mm in diameter. This study also showed that with increasing follicular size fertilization and cleavage rates increased.[46]

Ultrasound-guided Embryo Transfer

Usually, transcervical embryo transfer is undertaken as a blind procedure. In a study, embryo transfer under ultrasound control improved IVF outcome.[44] This can be done under transabdominal or transvaginal ultrasound guidance. In a meta-analysis study, these were seen conflicting results about increasing pregnancy rate and embryo transfer with ultrasound guided.[48]

CONCLUSION

Currently, it seems that evaluation of infertility is impossible without ultrasound assessment. This tool helps all physicians to examine the pelvic organs (ovaries, uterus, fallopian tube, peritoneal cavity) and is used to prediction of ovulation, endometrial receptivity and many disorders that may affect infertility. In recent years, 2D and 3D sonography and Doppler transvaginal ultrasonography have been completed evaluation of infertile women.

REFERENCES

1. Speroff L. Female infertility. Clinical gynecologic endocrinology and infertility (7th ed). Philadelphia Wolters Kluwer 2005; 1014-67.
2. Aflatoonian A SS. Epidemiological and etiological aspects of infertility in Yzad, Iran. Abstract of the 21st Annual Meeting of the ESHRE Compenhagen, Denmark 2005;181.
3. Freimanis MG, Jones AF. Transvaginal ultrasonography. Radiol Clin North Am Sep 1992;30(5):955-76.
4. Narendra Malhotra JM. Transvaginal sonography in infertility. In: Rao KA (Ed). The Infertility Manual (3rd ed). New Dehli: Jitendar P Vij 2009;28-54.
5. Poder L. Ultrasound evaluation of the uterus. In: Callen PW (Ed). Ultrasonography in obstetrics and gynecology philadwiphia: Saunders, an imprint of Elsevier Inc 2008;919-41.
6. Rabinowitz R, Laufer N, Lewin A, Navot D, Bar I, Margalioth EJ, et al. The value of ultrasonographic endometrial measurement in the prediction of pregnancy following in vitro fertilization. Fertil Steril Jun 1986;45(6):824-28.
7. Dickey RP, Olar TT, Curole DN, Taylor SN, Rye PH. Endometrial pattern and thickness associated with pregnancy outcome after assisted reproduction technologies. Hum Reprod Mar 1992;7(3):418-21.
8. Krampl E, Feichtinger W. Endometrial thickness and echo patterns. Hum Reprod Aug 1993;8(8):1339.
9. Bassil S. Changes in endometrial thickness, width, length and pattern in predicting pregnancy outcome during ovarian stimulation in in vitro fertilization. Ultrasound Obstet Gynecol Sep 2001;18(3):258-63.
10. Glissant A, de Mouzon J, Frydman R. Ultrasound study of the endometrium during in vitro fertilization cycles. Fertil Steril Dec 1985;44(6):786-90.
11. Smith B, Porter R, Ahuja K, Craft I. Ultrasonic assessment of endometrial changes in stimulated cycles in an in vitro fertilization and embryo transfer program. J In Vitro Fert Embryo Transf Dec 1984;1(4):233-88.
12. Gonen Y, Casper RF. Prediction of implantation by the sonographic appearance of the endometrium during controlled ovarian stimulation for in vitro fertilization (IVF). J In Vitro Fert Embryo Transf Jun 1990;7(3):146-52.
13. Sher G, Herbert C, Maassarani G, Jacobs MH. Assessment of the late proliferative phase endometrium by ultrasonography in patients undergoing in vitro fertilization and embryo transfer (IVF/ET). Hum Reprod Feb 1991;6(2):232-37.
14. Welker BG, Gembruch U, Diedrich K, al-Hasani S, Krebs D. Transvaginal sonography of the endometrium during ovum pickup in stimulated cycles for in vitro fertilization. J Ultrasound Med Oct 1989;8(10):549-53.
15. Fleischer AC, Herbert CM, Hill GA, Kepple DM, Worrell JA. Transvaginal sonography of the endometrium during induced cycles. J Ultrasound Med Feb 1991;10(2):93-95.
16. Serafini P, Batzofin J, Nelson J, Olive D. Sonographic uterine predictors of pregnancy in women undergoing ovulation induction for assisted reproductive treatments. Fertil Steril Oct 1994;62(4):815-22.
17. Roger A, Pierson M. Ultrasonographic imaging in infertility. In: Callen PW (Ed). Ultrasonography in obstetrics and gynecology philadwiphia: Saunders, an imprint of Elsevier Inc 2008;986-1019.
18. Mastrominas M, Pistofidis GA, Dimitropoulos K. Fertility outcome after outpatient hysteroscopic removal of endometrial polyps and submucous fibroids. J Am Assoc Gynecol Laparosc Aug 1996;3(4, Supplement):S29.
19. Soares SR, Barbosa dos Reis MM, Camargos AF. Diagnostic accuracy of sonohysterography, transvaginal sonography, and hysterosalpingography in patients with uterine cavity diseases. Fertil Steril Feb 2000;73(2):406-11.
20. Preutthipan S, Linasmita V. A prospective comparative study between hysterosalpingography and hysteroscopy in the detection of intrauterine pathology in patients with infertility. J Obstet Gynaecol Res Feb 2003;29(1):33-37.
21. Gronlund L, Hertz J, Helm P, Colov NP. Transvaginal sonohysterography and hysteroscopy in the evaluation of female infertility, habitual abortion or metrorrhagia: A comparative study. Acta Obstet Gynecol Scand May 1999;78(5):415-18.
22. Eldar-Geva T, Meagher S, Healy DL, MacLachlan V, Breheny S, Wood C. Effect of intramural, subserosal, and submucosal uterine fibroids on the outcome of assisted reproductive technology treatment. Fertil Steril Oct 1998;70(4):687-91.
23. Check JH, Choe JK, Lee G, Dietterich C. The effect on IVF outcome of small intramural fibroids not compressing the uterine cavity as determined by a prospective matched control study. Hum Reprod May 2002;17(5):1244-48.
24. Anna S Lev-toaff DL. Female pelvis. In: Johan P, McGahan BBG (Eds). Diagnostic Utrasound: Informa healthcare 2008; 987-1016.
25. Byrne J, Nussbaum-Blask A, Taylor WS, Rubin A, Hill M, O'Donnell R, et al. Prevalence of mullerian duct anomalies detected at ultrasound. Am J Med Genet Sep 4, 2000;94(1): 9-12.
26. Acien P. Incidence of müllerian defects in fertile and infertile women. Hum Reprod Jul 1997;12(7):1372-76.
27. The American Fertility Society classifications of adnexal adhesions, distal tubal occlusion, tubal occlusion secondary to tubal ligation, tubal pregnancies, mullerian anomalies and intrauterine adhesions. Fertil Steril Jun 1988;49(6):944-55.
28. Homer HA, Li TC, Cooke ID. The septate uterus: A review of management and reproductive outcome. Fertil Steril Jan 2000;73(1):1-14.
29. Bermejo C, Martinez Ten P, Cantarero R, Diaz D, Perez Pedregosa J, Barron E, et al. Three-dimensional ultrasound in the diagnosis of müllerian duct anomalies and concordance with magnetic resonance imaging. Ultrasound Obstet Gynecol May 2010;35(5):593-601.
30. Cohen HL, Tice HM, Mandel FS. Ovarian volumes measured by US: Bigger than we think. Radiology Oct 1990;177(1): 189-92.
31. Valentin L. Ultrasound evaluation of the Adnex. In: Callen PW (Ed). Ultrasonography in obstetrics and gynecology philadwiphia: Saunders, an imprint of Elsevier Inc 2008; 968-85.
32. Abass Aflatoonian RA, Zahra Khashavi. Comparison between transvaginal sonography and cytological results for detection of ovarian cysts. Research and Clinical Center for Infertility, Shahid Sadoghi University of Medical Sciences of Yazd, Iran 2003.

33. Azziz R. Diagnosis of polycystic ovarian syndrome: The Rotterdam criteria are premature. J Clin Endocrinol Metab March 1, 2006;91(3):781-85.
34. Adams J, Polson DW, Franks S. Prevalence of polycystic ovaries in women with anovulation and idiopathic hirsutism. Br Med J (Clin Res Ed). Aug 9, 1986;293(6543):355-59.
35. Moore J, Copley S, Morris J, Lindsell D, Golding S, Kennedy S. A systematic review of the accuracy of ultrasound in the diagnosis of endometriosis. Ultrasound Obstet Gynecol Dec 2002;20(6):630-34.
36. Buy JN, Ghossain MA, Sciot C, Bazot M, Guinet C, Prevot S, et al. Epithelial tumors of the ovary: CT findings and correlation with US. Radiology Mar 1991;178(3):811-18.
37. Mais V, Guerriero S, Ajossa S, Angiolucci M, Paoletti AM, Melis GB. The efficiency of transvaginal ultrasonography in the diagnosis of endometrioma. Fertil Steril Nov 1993;60(5):776-80.
38. Guerriero S, Mallarini G, Ajossa S, Risalvato A, Satta R, Mais V, et al. Transvaginal ultrasound and computed tomography combined with clinical parameters and CA-125 determinations in the differential diagnosis of persistent ovarian cysts in premenopausal women. Ultrasound Obstet Gynecol May 1997;9(5):339-43.
39. Patel MD, Feldstein VA, Chen DC, Lipson SD, Filly RA. Endometriomas: Diagnostic performance of US. Radiology. Mar 1999;210(3):739-45.
40. Ikuta A, Tanaka Y, Mizokami T, Tsutsumi A, Sato M, Tanaka M, et al. Management of transvaginal ultrasound-guided absolute ethanol sclerotherapy for ovarian endometriotic cysts. Journal of Medical Ultrasonics 2006;33(2):99-103.
41. Koike T, Minakami H, Motoyama M, Ogawa S, Fujiwara H, Sato I. Reproductive performance after ultrasound-guided transvaginal ethanol sclerotherapy for ovarian endometriotic cysts. European journal of obstetrics, gynecology, and reproductive biology 2002;105(1):39-43.
42. Hsieh CL, Shiau CS, Lo LM, Hsieh Ts-Ta, Chang MY. Effectiveness of ultrasound-guided aspiration and sclerotherapy with 95% ethanol for treatment of recurrent ovarian endometriomas. Fertility and Sterility 2009;91(6):2709-13.
43. Okaro E, Valentin L. The role of ultrasound in the management of women with acute and chronic pelvic pain. Best Pract Res Clin Obstet Gynaecol Feb 2004;18(1):105-23.
44. Jain KA. Imaging of peritoneal inclusion cysts. AJR Am J Roentgenol Jun 2000;174(6):1559-63.
45. Hoffer FA, Kozakewich H, Colodny A, Goldstein DP. Peritoneal inclusion cysts: Ovarian fluid in peritoneal adhesions. Radiology Oct 1988;169(1):189-91.
46. Wittmaack FM, Kreger DO, Blasco L, Tureck RW, Mastroianni L Jr, Lessey BA. Effect of follicular size on oocyte retrieval, fertilization, cleavage, and embryo quality in in vitro fertilization cycles: A 6-year data collection. Fertil Steril Dec 1994;62(6):1205-10.
47. Kojima K, Nomiyama M, Kumamoto T, Matsumoto Y, Iwasaka T. Transvaginal ultrasound-guided embryo transfer improves pregnancy and implantation rates after IVF. Hum Reprod Dec 2001;16(12):2578-82.
48. Buckett WM. A meta-analysis of ultrasound-guided versus clinical touch embryo transfer. Fertil Steril Oct 2003;80(4):1037-41.