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Mini Review

Doppler Ultrasonography in Infertility and Assisted Reproduction

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Abstract

The female reproductive system vascularization seems to play an important role in oocyte developmental competence and endometrial receptivity. The first studies to investigate genital vascularity using Doppler technique employed pulsed Doppler. The introduction of the power Doppler appeared particularly suited for the study of micro vascular events, especially in organs like the ovary and uterus. Furthermore, 3D power Doppler ultrasonography can provide information on the quality and quantity of moving blood cells per volume to demonstrate the underlying vascularity of the target organ.

Keywords: Doppler ultrasonography; Infertility; Assisted reproduction

Introduction

In infertility and assisted conception, the female reproductive system vascularization seems to play an important role in oocyte developmental competence and endometrial receptivity. The first studies to investigate genital vascularity using Doppler technique employed pulsed Doppler. The technical limitations of traditional Doppler are especially evident in the study of micro vascularity in that the technique has very poor specificity to low flow rates and the need to correct the angle.

The introduction of the power Doppler in 1994 got round these limitations and appeared particularly suited for the study of micro vascular events, especially in organs like the ovary and uterus. Furthermore, 3D power Doppler ultrasonography can provide information on the quality and quantity of moving blood cells per volume to demonstrate the underlying vascularity of the target organ [1].

The main indices of blood flow and vascularity using 3D power Doppler are [2]: Vascularization Index (VI) = percentage of power Doppler data in volume examined; Flow Index (FI) = signal intensity of power Doppler information; and Vascular Flow Index (VFI) = combination of both indices (VI and FI).

Ovarian factor (Follicular Vascularization)

Polycystic ovary syndrome (Pcos): Three-dimensional transvaginal power Doppler ultrasound demonstrated increased VI, FI and VFI in the ovarian stromal Doppler signals in PCOS assessed on day 2 or 3 of the menstrual cycle. This result might imply the excessive response often observed during gonadotrophin administration in women with PCOS. In addition, treatment using laparoscopic ovarian drilling in young adult women with PCOS significantly decreased VI and VFI in a short-term follow-up [3]. Power Doppler may be a possible future parameter in the ultrasonographic diagnosis of PCOS.

Endometriosis: Blood flow in the ovarian stroma was assessed using 3D power Doppler in women undergoing In-Vitro Fertilization (IVF) after surgery for ovarian endometriotic cyst. Significantly reduced ovarian blood flow indices (VI, FI and VFI) were recorded in the group of patients with endometriosis versus controls without any apparent difference in overall ovarian size [4].

Ovulation induction: Three-dimensional power Doppler ultrasonographic indices are used to quantify ovarian stromal blood flow and vascularization in hyper-responders and poor responders to controlled ovarian stimulation in IVF. The VFI, FI, and VI were significantly higher in the hyper-responders [5], and significantly lower in the poor responders [6] compared with the women with a normal response.

Power Doppler may be considered as a possible ultrasonographic marker for assessment of ovarian reserve, and also for prediction Of Ovarian Hyperstimulation Syndrome (OHSS).

Oocyte quality

As regards Intrauterine Insemination (IUI), perifollicular vascularity was an important factor with clinical consequences for predicting cycle outcome. The pregnancy rate was significantly higher, the number of multiple pregnancies was double, and the miscarriage rate was lower in the group with highly vascularized follicles than in patients with follicles of mixed vascularity. Poor perifollicular blood flow was considered as a condition which, after careful counseling, could prompt cancellation of the IUI cycle [7].

With regard to IVF treatment, the morphological parameters commonly used to assess embryo quality are thought to be of poor predictive value. Perifollicular vascularization is closely associated with fertilization potential of oocytes and embryo cleavage, which is the most predictive factor for pregnancy. The oocytes coming from poorly vascularized follicles were also characterized by a higher proportion of embryos with chromosomal and cytoplasmic anomalies [8,9].

The patients receiving embryos coming from highly vascularized follicles presented statistically higher pregnancy rates than those whose embryos originated from poorly vascularized oocytes. Therefore, the use of follicular blood flow indices was proposed as parameter for selecting embryos with the best chance of implantation and pregnancy [10,11].

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Tubal factor (Tubal patency)

Comparing hysteron salpingo contrast sonography (HyCoSy) with 3D power Doppler imaging in evaluating the tubes, the former detects the ecogenicity of the contrast agent inside the tubes, while the latter visualizes its flow.

The 3D power Doppler technique appears to have advantages versus the conventional HyCoSy method not only in terms of visualizing the overspill of the contrast agent from the tube fimbria but also in terms of duration and consumption of contrast agent [12].

Endometrial factor (Endometrial vascularization)

The endometrium is considered the key determinant in successful implantation. Endometrial receptivity is regulated by many factors including endometrial perfusion [13]. Doppler investigation of uterine artery blood flow may be very important in predicting the pregnant state in IVF cycles; uterine artery PI and RI were found to be significantly lower in conception than in non-conception cycles [14,15].

Other studies, however, reported that Doppler sonography of the uterine arteries was not a reliable predictor of subsequent IVF outcome [16,17]. Doppler ultrasound assessment of uterine arteries blood flow does not appear to reflect the actual blood flow to the endometrium.

Endometrial and subendometrial blood flows can be more objectively and reliably measured with 3D power Doppler [18]. Several studies have reported that the detection of endometrial and subendometrial blood flow by 3D power Doppler may be useful in prediction of endometrial receptivity and the pregnancy rate of IVF cycles [19,20], which could be helpful data in a single Embryo Transfer (ET) policy [19].

The use of subendometrial VFI (at cut-off >0.24) proved to be a better predictive parameter for pregnancy than the study of endometrial volume, subendometrial VI and FI. The established VFI cut-off value would allow identification not only of those women with a high chance of implantation, but also of those cycles where endometrium receptivity is poor, suggesting postponement of ET [20].

Other studies, however, reported that measurement of endometrial and subendometrial blood flows by 3D power Doppler [21,22] is not reliable for prediction of subsequent IVF outcome. These controversial data necessitate further studies.

In addition, the values of endometrial and subendometrial vascularity in women who conceived, leading to live birth, were significantly higher than those of women who suffered miscarriage following IVF treatment [23].

Unexplained infertility

Peri-implantation endometrial perfusion has been shown to be impaired in women with unexplained infertility irrespective of the endometrial measurements and hormonal levels; the uterine artery PI and RI were significantly increased and the endometrial and subendometrial VI, FI, and VFI were significantly decreased in women with unexplained infertility [24].

This finding suggests that abnormal endometrial perfusion may have a possible role in the pathogenesis of infertility. Doppler study of uterine hemodynamics should therefore be considered in infertility workup, and women with suboptimal uterine perfusion may be offered therapy aimed at improving uterine blood flow.

Conclusion

Current development of 3D power Doppler ultrasound has been proved to be beneficial in the evaluation of infertility. Power Doppler indices of perifollicular vascularization may have a possible important application in IVF in selecting oocyte-embryos with superior implantation potential. The degree of endometrial perfusion shown by power Doppler ultrasonography can indicate the more favorable endometrium for successful IVF. Further research should be conducted to explore more potential uses of 3D power Doppler ultrasonography in the investigation of infertility and reproductive endocrinology.

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