The influence of donated gametes on the incidence of hypertensive disorders of pregnancy

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Pregnancies achieved from oocyte, sperm or embryo donation are unique, since they have resulted from donor gametes that are immunologically foreign to the mother. Thus, studying the obstetric outcome of such pregnancies may shed some light on the pathophysiology of pre-eclampsia, particularly in women conceiving with donated embryos, since the entire fetal genome is allogenic in these pregnancies. In this retrospective cohort study, a total of 144 women were studied. Of these, 72 were infertility patients who had conceived as a result of sperm, ovum or embryo donation and the other 72 women were age- and parity-matched control patients who became pregnant with their own gametes, either spontaneously, or following intrauterine insemination with their partner’s spermatozoa.

Study patients were divided into three groups depending on the origin of the donated gametes. Group 1 consisted of pregnancies achieved by intrauterine insemination with washed donor spermatozoa (n = 33). Group 2 included women who conceived using donated oocytes (n = 27) and group 3 consisted of women who conceived as a result of embryo donation (n = 12). The incidence of pregnancy-induced hypertension in the donated gametes study group was 12.5% (9/72) compared with 2.8% (2/72) in the control group. In addition, pre-eclampsia was diagnosed in 18.1% (13/72) of the donated gametes study group compared to 1.4% (1/72) in the age- and parity-matched controls. The increased incidence of gestational hypertension in pregnancies resulting from donated gametes gives evidence for a maternal genetic component, with an equally strong fetal influence, in the complicated aetiology of gestational hypertension, and pre-eclampsia in particular.

Key words: donor insemination/embryo donation/oocyte donation/pre-eclampsia/pregnancy-induced hypertension

Introduction

Hypertensive disorders of pregnancy continue to be leading causes of fetal, maternal and neonatal morbidity and mortality (Sibai et al., 1986; Rubin, 1987; Department of Health, Welsh Office, Scottish Office, Department of Health and Social Services, Northern Ireland, 1998). Pre-eclampsia, the most common of these disorders, is characterized by high blood pressure and proteinuria (Loudon, 1991) and complicates between 5 and 10% of pregnancies exceeding 24 weeks gestation (Saftlas et al., 1990). In contrast to the normotensive pregnancy, a major physiological feature of the disease is a marked increase in peripheral vascular resistance due to increased vasoconstriction, resulting in plasma volume contraction (Terragno and Terragno, 1988; Brinkman, 1984). While vascular reactivity to vasoconstrictor agents is decreased in normotensive pregnancy, the vasospm in pre-eclampsia is due, at least in part, to an exaggerated vascular responsiveness to noradrenaline (Gant et al., 1987; Magness and Gant, 1994) and angiotensin II (Gant et al., 1973) and possibly to an imbalance in the production of endothelial contractile and vasodilator substances (Walsh, 1985; Remuzzi and Ruggenenti, 1991). It is proposed that pre-eclampsia is the consequence of an unsuccessful attack of the maternal non-specific host-defence on the implanting conceptus (Schuiling et al., 1997).

The result of this attack is not elimination of the implanting conceptus, but defective implantation and a lasting arousal of maternal inflammatory response (Moore and Collins, 1997).

Reduced trophoblastic invasion of the spiral arteries is the earliest and most obvious histopathological change seen in pre-eclampsia (Vinatier and Monnier, 1995). Obstetrics complications such as multiple gestation, immune/non-immune hydrops and hydatidiform mole as well as medical disorders such as diabetes, chronic hypertension and collagen vascular diseases are all risk factors for the development of pre-eclampsia and are all associated with reduced placental perfusion. Maternal hypertension and proteinuria may reflect the later stages of fetal and maternal strategies to compensate for poor perfusion.

Current knowledge on the epidemiology of pre-eclampsia, like the particularly high risk in first pregnancies, points primarily to an effect of maternal factors (Trupin et al., 1996). A strong total increase in risk of pre-eclampsia among mothers who changed partners, regardless of pre-eclampsia in a previous pregnancy, has been extensively documented (Need, 1975; Ikedife, 1980; Chng, 1982; Klonoff-Cohen et al., 1989; Robillard et al., 1993; Robillard and Hulsey, 1996; Trupin et al., 1996). Thus, it has been suggested that paternal genes (as expressed in the fetus) may contribute to the mother’s risk of developing pre-eclampsia (Lie et al., 1998). This suggestion was supported by the finding that mothers who were pregnant by a partner who fathered a pre-eclamptic pregnancy in another
woman had nearly twice the risk in their own pregnancy (Lie et al., 1998).

Pregnancies achieved from oocyte, sperm or embryo donation are unique, since they have resulted from donor gametes that are immunologically foreign to the mother. Thus, studying the obstetric outcome of such pregnancies may shed some light on the pathophysiology of pre-eclampsia, particularly in women conceiving with donated embryos since the entire fetal genome is allogenic in these pregnancies.

Since the first pregnancy achieved after oocyte donation was reported (Trounson et al., 1983), there have been conflicting reports about the outcome of such pregnancies. It was reported (Serhal and Craft, 1989) that nearly 40% of their pregnancies were complicated by pre-eclampsia. Similarly, it has been noted (Blanchette, 1993) that two of five patients (40%) developed pregnancy-induced hypertension (PIH). It was also found (Pados et al., 1994) that PIH occurred in one-third of the women in their series, with a higher frequency in those with ovarian failure compared to those with functioning ovaries. In contrast, it was found (Cornet et al., 1990; Sauer et al., 1996) that the obstetric outcome of women with primary ovarian failure was normal. Similarly, one case of severe hypertension in 21 term pregnancies was reported in menopausal women (4.8%) (Antinori et al., 1995) while in another study (Sauer et al., 1996), where the mean maternal age was 47 years, the incidence of PIH was 12%. In addition, similar rates of hypertensive disorders of pregnancy were found in 22 oocyte recipient patients compared to IVF controls (Friedman et al., 1996). Again, in a retrospective analysis of 23 recipients of donated oocytes compared with 24 IVF-control patients (Porreco et al., 1997), an incidence of 26% was found in the oocyte recipient group compared to 29% in the control IVF group, both cohorts being of similar age and parity. More recently, PIH was noted in 31% of oocyte recipients compared to 14% in IVF pregnancies (Söderström-Anttila et al., 1998). In addition, in the largest retrospective analysis to date of 232 ovum donation pregnancies, it was noted that 23% of all pregnancies were complicated by hypertension (Abdalla et al., 1998).

The purpose of the current analysis was to evaluate the influence of donated gametes on the incidence of hypertensive disorders in pregnancy. To our knowledge, this is the first comparative analysis where all patients who conceived with donated gametes were compared with age- and parity-matched controls from similar demographic backgrounds. Furthermore, in the absence of reports examining the obstetric outcome of pregnancies conceived with donated embryos, the present retrospective cohort study is the first to assess the risk of hypertensive disorders in embryo donation pregnancies.

Materials and methods

Study patients

This was a retrospective cohort study of 72 women who conceived with donated gametes and delivered at ≥24 weeks gestation either at St James’s University Hospital (SJUH), Leeds or the Leeds General Infirmary (LGI) between 1992 and 1997. Study patients were divided into three groups depending on the origin of the donated gametes.

Group 1 consisted of pregnancies achieved by intrauterine insemination with washed donor spermatozoa (n = 33). Group 2 included women who conceived using donated oocytes (n = 27) and group 3 consisted of women who conceived as a result of embryo donation (n = 12). To evaluate the influence of donated gametes on the incidence of gestational hypertension we chose a control group of patients from the birth register who conceived with their own gametes and delivered at either SJUH or LGI during the study period. Patients in the study and control groups were matched for age, parity and demographic background.

Patients in group 1 were treated in their natural cycle, while the control group (IUI using partner’s spermatozoa) received a low dose of ovulation inducing gonadotrophins. This was reflected by the higher incidence of multiple pregnancies in the latter group (see below).

Group 2 (ovum donation) and group 3 (embryo donation) patients received oestrogens (oestradiol valerate) and progestogens (gestone) prior to embryo transfer in an attempt to prepare the endometrium for implantation. Neither group received any ovarian stimulation.

Definitions

Classification of hypertensive disease of pregnancy in this study was that defined by the International Society for Study of Hypertension in Pregnancy (Davey and MacGillivray, 1988). Essential hypertension was diagnosed in cases of repeated blood pressure levels ≥140/90 mm Hg before 20 weeks gestation and in the absence of proteinuria. Pregnancy-induced hypertension was defined as blood pressure levels ≥140/90 mm Hg measured on two or more occasions at least 6 h apart without proteinuria after 20 weeks gestation or a diastolic pressure >20 mm Hg above the booking level. Pre-eclampsia was defined as blood pressure levels ≥140/90 mm Hg measured on two or more occasions at least 6 h apart with proteinuria ≥0.5 g/day after 20 weeks gestation.

Data collection

To comply with the Human Fertilisation and Embryology Authority’s (HFEA, 1997) regulation regarding confidentiality of infertility treatment, two approaches were used to obtain information. Only HFEA-licensed members of each Assisted Conception Unit’s team reviewed the study patients’ infertility records, while non-licensed members of the research team examined the obstetric records.

Since all of the study patients delivered at either SJUH or LGI, all of their medical records were obtained and examined for both the baseline maternal data (age, parity, social habits and previous obstetric history) and pregnancy complications. Patients with a pre-existing medical condition that might predispose to the development of pre-eclampsia such as essential hypertension, renal disease or insulin-dependent diabetes mellitus were excluded from the study.

Statistical analysis

The data were analysed using the Chi-square (χ²) and Fisher’s exact tests. A P value < 0.05 was considered to be statistically significant.

Results

A total of 144 women was studied; 72 were infertility patients who had conceived as a result of sperm, ovum or embryo donation. The other 72 women were age- and parity-matched control patients who became pregnant with their own gametes, either spontaneously, or following intrauterine insemination with their partner’s spermatozoa.

Twenty-five women from a total of 144 developed gestational hypertension. Of these, 11 women had PIH and the remaining
Despite a lower multiple pregnancy rate, the incidence of pre-eclampsia in pregnancies was 18.2% (6/33) in the partner insemination group compared with 3% (1/33) in those achieved using partner's spermatozoa. Nevertheless, the incidence of pre-eclampsia in pregnancies was 9.1% (3/33) compared with 3% (1/33) in the age- and parity-matched partner insemination group.

The incidence of pre-eclampsia in pregnancies resulting from oocyte donation was 12.5% (9/72) compared with 2.8% (2/72) in the control group. In addition, pre-eclampsia was diagnosed in 18.1% (13/72) of the donated gametes study group compared with 1.4% (1/72) in the age- and parity-matched controls.

**Donor insemination versus partner insemination**

The indications for donor insemination were azoospermia \((n = 33)\) and severe oligoasthenozoospermia \((n = 6)\) while the duration of infertility ranged from 1 to 4 years. Patients entering the donor insemination programme were scanned on day 8 of their natural cycle and on alternate days thereafter. Once the diameter of the dominant follicle reached 16–18 mm they were asked to use a commercially available urinary kit to detect the luteinizing hormone (LH) surge. On the day of the LH surge, spermatozoa were prepared from a pre-selected donor and inseminated into the uterine cavity.

Nine of the 33 women (27.3%) who conceived as a result of oocyte donation developed hypertension, compared with one (3.0%) of their age- and parity-matched controls who conceived with their partner’s spermatozoa \((P < 0.05)\) (Table I). The incidence of pre-eclampsia in pregnancies resulting from donated spermatozoa was 18.2% (6/33) compared with 0% in the age- and parity-matched partner insemination group \((P < 0.05)\). Furthermore, the risk of PIH in the donor insemination pregnancies was 9.1% (3/33) compared with 3% (1/33) in those achieved using partner’s spermatozoa.

As demonstrated in Table II, the frequency of multiple pregnancies was 18.2% (6/33) in the partner insemination group and 12.1% (4/33) in the donor insemination group. Although the difference was not statistically significant, the trend is a reflection of the fact that more patients in the partner insemination group received ovulation induction. Nevertheless, despite a lower multiple pregnancy rate, the incidence of pre-eclampsia appeared greater in the DI patients (18.2 versus 0%). Although the frequency of singleton pregnancies was similar in both groups (87.9 and 81.8% respectively), the incidence of both PIH and pre-eclampsia was still higher in the donor insemination group (10.3 versus 3.7% and 13.8 versus 0% respectively), but the difference was not significant.

There was no statistical difference in the donor insemination group in the number of inseminations performed in women who developed pre-eclampsia and those with normal pregnancies. Also, there was no relationship between the number of inseminations and the risk of pre-eclampsia.

**Ovum donation versus control**

The indications for oocyte donation were ovarian dysgenesis including Turner’s syndrome \((n = 2)\), radio/chemotherapy \((n = 1)\), surgical castration \((n = 1)\), premature ovarian failure \((n = 9)\) and repeated failures of earlier IVF treatment \((n = 14)\). Primary or secondary ovarian failure was assessed by menstrual history and serum follicle stimulating hormone (FSH) concentrations >20 IU/l. Patients who received ovum donations due to repeated failure of standard IVF treatment had normal ovarian function, as manifested by menstrual periods of varying regularity and FSH concentrations within the normal range for the reproductive period. The patients’ ages ranged from 27 to 42 years.

In total, nine out of the 27 women (33.3%) who conceived as a result of oocyte donation developed hypertension compared with two (7.4%) of their age- and parity-matched controls \((P < 0.05)\) (Table I). The incidence of pre-eclampsia in pregnancies resulting from ovum donation was significantly higher \((P < 0.05)\) at 16% (4/27) compared with 3.7% (1/27) in the age- and parity-matched control group. Furthermore, the risk of PIH in the ovum donation pregnancies was 18.5% (5/27) compared with 3.7% (1/27) in the control group.

<table>
<thead>
<tr>
<th>Pre-eclampsia (%)</th>
<th>Partner insemination ((n = 33))</th>
<th>Donor insemination ((n = 33))</th>
<th>Egg donation ((n = 27))</th>
<th>Controls ((n = 27))</th>
<th>Embryo donation ((n = 12))</th>
<th>Controls ((n = 12))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-eclampsia (%)</td>
<td>0 (0)</td>
<td>6 (18.2) (^a)</td>
<td>0 (0)</td>
<td>4 (16) (^d)</td>
<td>1 (3.7) (^d)</td>
<td>3 (25)</td>
</tr>
</tbody>
</table>

PIH = pregnancy-induced hypertension.

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14 women had pre-eclampsia. The incidence of PIH in the donated gametes study group was 12.5% (9/72) compared with 2.8% (2/72) in the control group. In addition, pre-eclampsia was diagnosed in 18.1% (13/72) of the donated gametes study group compared with 1.4% (1/72) in the age- and parity-matched controls.

**Table I. Characteristics of the study groups and the age- and parity-matched controls**

<table>
<thead>
<tr>
<th>Mean age in years</th>
<th>Primigravida</th>
<th>Hypertension (%)</th>
<th>PIH (%)</th>
<th>Pre-eclampsia (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donor insemination ((n = 33))</td>
<td>Partner insemination ((n = 33))</td>
<td>Egg donation ((n = 27))</td>
<td>Controls ((n = 27))</td>
<td>Embryo donation ((n = 12))</td>
</tr>
<tr>
<td>30.9</td>
<td>31.2</td>
<td>38.1</td>
<td>37.6</td>
<td>36.7</td>
</tr>
<tr>
<td>29</td>
<td>30</td>
<td>23</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>9 (27.3) (^a)</td>
<td>1 (3.0) (^a)</td>
<td>9 (33.3) (^b)</td>
<td>2 (7.4) (^b)</td>
<td>4 (33.3) (^c)</td>
</tr>
<tr>
<td>3 (9.1)</td>
<td>1 (3.0)</td>
<td>5 (18.5)</td>
<td>1 (3.7)</td>
<td>1 (8.3)</td>
</tr>
<tr>
<td>6 (18.2) (^a)</td>
<td>0 (0) (^a)</td>
<td>4 (16) (^d)</td>
<td>1 (3.7) (^d)</td>
<td>3 (25)</td>
</tr>
</tbody>
</table>

\(^{a,b,c,d}\)Statistically significant difference between values with same superscript within rows \((P < 0.05)\).

**Table II. The incidence of hypertensive disorders of pregnancy related to number of babies at delivery**

<table>
<thead>
<tr>
<th>Mean age in years</th>
<th>Singletons (%)</th>
<th>PIH (%)</th>
<th>Pre-eclampsia (%)</th>
<th>Twins/triplets (%)</th>
<th>PIH (%)</th>
<th>Pre-eclampsia (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donor insemination ((n = 33))</td>
<td>Partner insemination ((n = 33))</td>
<td>Egg donation ((n = 27))</td>
<td>Controls ((n = 27))</td>
<td>Embryo donation ((n = 12))</td>
<td>Controls ((n = 12))</td>
<td></td>
</tr>
<tr>
<td>30.9</td>
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<td>36.7</td>
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<td>29</td>
<td>30</td>
<td>23</td>
<td>22</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
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<td>1 (3.0) (^a)</td>
<td>9 (33.3) (^b)</td>
<td>2 (7.4) (^b)</td>
<td>4 (33.3) (^c)</td>
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</tr>
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<td>6 (18.2) (^a)</td>
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<td>3 (25)</td>
<td>0 (0)</td>
<td></td>
</tr>
</tbody>
</table>

PIH = pregnancy-induced hypertension.
As demonstrated in Table II, the frequency of multiple pregnancies was 18.5% (5/27) in the ovum donation group and 3.7% (1/27) in the control group. This is a reflection of the fact that ovum donation patients conceived as a consequence of infertility treatment while their age-matched controls conceived spontaneously. Out of the four twin pregnancies in the ovum donation group, one woman developed PIH and another developed pre-eclampsia. In comparison, the only twin pregnancy in the control group was uneventful. Although the frequency of singleton pregnancies was higher in the control group [96.3% compared with the ovum donation group (81.5%)], the incidence of PIH and pre-eclampsia was still higher in the ovum donation group (18.2 versus 3.8% and 13.6 versus 3.8% respectively), though this difference was not significant.

### Discussion

As placentation and the laying down of the spiral arteries occurs in the first half of pregnancy, blood-borne factors, which may include lipid peroxides, fatty acids, cytokines and microvesicles from the trophoblast itself, are shed from the surface and enter the maternal circulation. Maternal endothelial cells are activated by these factors, and all the features of pre-eclampsia can be explained by the circulatory disturbance that follows. Hypertension results from vascular permeability and proteinuria is caused by dysfunction of endothelial cells in the glomeruli (Roberts and Redman, 1993).

It is postulated that pre-eclampsia represents either a disruption of the normal mechanism(s) responsible for the protection of the fetoplacental unit from rejection as an allograft or an aberrant immunological response directed against tissue or organ-specific antigens associated with the placenta (Beer, 1989). The control of placentation may well have an immunological basis, with interaction between maternal and fetal genes. This could explain why women are more at risk of pre-eclampsia in their first pregnancy and why parous women who later conceive by a new partner also have an increased susceptibility to the syndrome (Need, 1975; Ikedife, 1980; Chng, 1982; Klonoff-Cohen et al., 1989; Robillard et al., 1993; Robillard and Hulsey, 1996).

In our retrospective cohort study, we sought to limit the confounding variables of age, parity and demographic variables. Thus, we compared women who conceived with donated gametes with age- and parity-matched controls from similar demographic backgrounds who conceived with their own gametes and delivered in either of the two teaching hospitals during the study period. We found that the incidence of gestational hypertension in pregnancies achieved with donated gametes was significantly higher compared with the control groups.

Women who conceived by intrauterine insemination with washed spermatozoa from their partners, with whom they had at least 1 year of unprotected sexual intercourse, were compared with age- and parity-matched controls who conceived by intrauterine insemination with washed donor spermatozoa. The increased incidence of pre-eclampsia with donor insemination compared with partner insemination supports the hypothesis that there is a protective effect of prolonged exposure to sperm ‘inoculations’ from the same partner; this is also seen when non-barrier methods of contraception (e.g. oral contraceptives, intrauterine devices) are used (Klonoff-Cohen et al., 1989; Baker and Roberts, 1994; Robillard et al., 1994; Trupin et al., 1996). This protective effect is not evident in women using barrier methods of contraception (e.g. condoms, cervical caps, sponges, diaphragms) or spermicides that prevent exposure of sperm antigens to the endometrial lining. More recently, it has been concluded that the development of pre-eclampsia in both groups suggests that the antigenic factor is on the spermatozoa themselves and not in the seminal fluid, because this is removed by washing before intrauterine insemination (Smith et al., 1997).

The finding of an increased incidence of pre-eclampsia in the pregnancies resulting from donated sperm in this study is in agreement with previous reports (Need et al., 1983; Smith et al., 1997). The former study (Need et al., 1983) examined a large, mixed donor insemination population. Although confounding factors such as maternal age and medical complications that increase the risk of pre-eclampsia were not taken into account, their study showed an incidence of pre-eclampsia of 9.3% associated with the donor insemination population. The study by Smith et al. (1997), who only assessed the risk of pre-eclampsia in women with primary infertility, found that 24.3% (9/37) women treated with donated spermatozoa developed pre-eclampsia compared with 6.8% (3/44) of their age-matched controls who conceived with their partner’s spermatozoa.

In the ovum donation pregnancies, the incidence of pre-eclampsia was 16% compared with 3.7% in the age- and parity-matched control group (P < 0.05). Furthermore, although the frequency of singleton pregnancies was higher in the control group (81.5 versus 96.3%), the incidence of both PIH and pre-
eclampsia was still higher in the ovum donation group. By matching for maternal age, we attempted to control for the deleterious effects of ageing on maternal and perinatal outcome. Our observations of an increased incidence of gestational hypertension, including pre-eclampsia, in recipients of oocyte donation are in agreement with earlier studies (Serhal and Craft, 1989; Blanchette, 1993; Pados et al., 1994; Sauer et al., 1996; Abdalla et al., 1998; Söderström-Anttila et al., 1998; Yaron et al., 1998). These findings provide further support to the hypothesis that the development of pre-eclampsia may be due to altered or inadequate immunoprotection of the fetoplacental unit in oocyte recipients due to short duration of exposure to non-maternal antigens. Contradictory to this hypothesis are reports of comparable, or even improved, obstetric outcome of ovum donation pregnancies compared with those resulting from IVF treatment (Cornet et al., 1990; Friedman et al., 1996; Porreco et al., 1997). However, one of these studies (Cornet et al., 1990) did not control for age, parity or order of gestation, while in another (Porreco et al., 1997), pre-eclampsia was not clearly defined. Nevertheless, based on our findings, we conclude that oocyte donation pregnancies are associated with an increased risk of gestational hypertension in comparison with the normal population, and should thus be considered as high risk.

A novel finding in this study is that a third of all 12 pregnancies resulting from donated embryos, where the entire fetal genome is allogenic, developed gestational hypertension compared with none of their age- and parity-matched controls. More significantly, the incidence of pre-eclampsia in embryo donation pregnancies was three times that in the control group (25 versus 0%) and more than twice the national average (25 versus 10%). Moreover, 27.3% of the singleton embryo donation pregnancies developed pre-eclampsia compared with none in the control group. Embryo donation recipients are the ideal patients in whom to investigate the occurrence of gestational hypertension, as their sexual partners were not involved in the fertilization of the donated ova, thereby resulting in an entirely ‘foreign’ fetal genome. In the absence of reports examining the obstetric outcome of recipients of donated embryos, our study is the first to demonstrate that these pregnancies are more susceptible to the development of gestational hypertension, including pre-eclampsia. We would suggest that this is worthy of further study and that these patients be considered high risk.

It is probable that multiple genetic and immune factors, resulting in fetal allograft intolerance, may limit placentation. Despite the multifactorial pathophysiology of hypertensive disorders of pregnancy and particularly pre-eclampsia, the findings of our study are consistent with the immunological hypothesis of gestational hypertension. The increased incidence of pre-eclampsia in donor insemination pregnancies indicates that prolonged exposure to paternal spermatozoa prior to conception, as in the partner insemination group, reduces the risk. Since recipients of donated spermatozoa are exposed to foreign fetal antigens encoded by the paternally derived genes, they are at higher risk. The finding of an increased incidence of gestational hypertension in ovum donation pregnancies provides further support to the hypothesis that the development of pre-eclampsia may be due to altered or inadequate immunoprotection of the fetoplacental unit in oocyte recipients due to short duration of exposure to non-maternal antigens.

The complicated aetiology of gestational hypertension, and pre-eclampsia in particular, calls for studies that encompass the contribution from both the mother and the fetus. Our study provides evidence for a maternal genetic component as well as an equally strong fetal component related to paternal genetic influence in the development of gestational hypertension.

References


Donated gametes and hypertensive pregnancy


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