Measuring the effects of genetic testing: studies on thrombophilia, sickle cell trait, recurrent miscarriage and male subfertility

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Knowledge and perceived risks in couples undergoing genetic testing after recurrent miscarriage or with poor semen quality

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ABSTRACT

In reproductive medicine, couples with recurrent miscarriage (RM) and men with poor semen quality may undergo genetic testing as part of the diagnostic work-up. We explored their knowledge and perception of genetic testing, evaluated psychological well-being and identified associated variables.

A prospective questionnaire study was conducted in seven clinical genetics centres and referring gynaecological departments in couples with RM or poor semen quality. Questionnaires were completed before disclosure of genetic test result. Main outcome measures were knowledge, perceived risk, anxiety and depression.

256 of 439 participants were not aware genetic testing was part of the diagnostic work-up. One-third (36% RM, 33% poor semen quality) indicated they had not received information about the genetic test from their doctor. Perceived risk of receiving an abnormal genetic test result was higher than objective risk. Anxiety was highly correlated with perceived risk. Women with RM were more anxious than women in the poor semen quality group or men (p<0.01). These couples undergoing genetic testing have a suboptimal understanding of the nature of testing, overestimate the risks of receiving an abnormal result, and some show high levels of anxiety. The results of this study can be used to improve patient counseling before genetic testing.

INTRODUCTION

In reproductive medicine, couples with recurrent miscarriage (RM) and men with poor semen quality may undergo genetic testing as part of the diagnostic work-up. In couples with RM one of the partners may carry a balanced structural chromosome abnormality and their offspring is therefore at risk for unbalanced structural chromosome abnormalities leading to severe mental retardation and/or congenital malformations. The prevalence of a parental structural chromosome abnormality is estimated between 3% and 6%. Clinical guidelines recommend parental karyotyping in couples with RM and subsequent invasive prenatal diagnosis when a chromosomal abnormality is found. Genetic testing in couples with RM is generally offered after two or three miscarriages.

Genetic testing in men with poor semen quality is generally performed if the total sperm count is < 1 million spermatozoa per ejaculate. Men undergo karyotyping and are evaluated for deletions on the Y-chromosome before starting with Intra Cytoplasmatic Sperm Injection (ICSI) treatment. A genetic cause is found in 10% to 15% of cases. Men with a chromosomal abnormality have a higher risk of aneuploid offspring after ICSI treatment. In case of Y-deletions, all sons conceived by ICSI will inherit the same deletion with possible consequences for their reproductive chances.

As with any other medical intervention, patients should be properly informed before undergoing genetic testing. It is health care professionals’ duty to involve and support patients in rational decision making, since patients have the legal and ethical right to know what will happen to them. The information provided should at least cover the nature of the procedure and its consequences. Compared to other medical interventions, genetic testing may pose additional challenges to physicians and patients. The principles of genetics and of genetic testing may, in general, be more difficult to convey. The association between risk perception and other psychological variables are key issues in the research on genetic counselling.

We evaluated participants’ understanding of and perceptions about genetic testing. We also assessed to what extent their knowledge, or the lack thereof, and perceived risks influenced the levels of anxiety and depression. We hypothesized that even though couples with RM or with poor semen quality have different underlying mechanisms for their reproductive problems,
both undergo genetic testing and might feel the same uncertainty and psychological distress before disclosure. The main aim of this study is to examine the consequences of genetic testing before disclosure; therefore we studied both groups concurrently. Results of this study give a better insight of the impact of genetic testing and can be used to improve patient counseling before genetic testing.

**METHODS AND MATERIALS**

**Study population and procedure**

Couples with RM in whom parental karyotyping in both partners was performed or couples with poor semen quality in whom karyotyping and DNA-analysis in the male partner was performed were eligible for inclusion. RM was defined as two or more, not necessarily consecutive, miscarriages before 20 weeks of gestation. Poor semen quality was defined as a total sperm count less than 1 million spermatozoa per ejaculate.

Couples were identified between January 2006 and June 2009 in the clinical genetics laboratories of seven academic hospitals in the Netherlands. Only couples still unaware of their genetic test result were included. Exclusion criteria were: pregnancy (gestational age > 12 weeks) at time of disclosure of the genetic test result, an already identified familial genetic abnormality, a serious or life threatening disease or insufficient language proficiency. After being identified, the referring gynaecologist or urologist was contacted by the central researcher and was asked for consent to approach the couple and to determine eligibility.

Both partners of eligible couples were sent an identical questionnaire including a letter explaining the purpose of the study and asking for written informed consent. Every couple was assigned with a unique study number, identifying both partners as a couple. Following the standardized study protocol, 3 to 5 days after receiving the questionnaire the couples were contacted by telephone to provide additional information about the study. Both partners of the couple were asked to complete the questionnaire separately. A stamped return envelope was included.

Most couples had a blood draw for the genetic test 6 to 8 weeks before being contacted and a scheduled appointment for disclosure of the genetic test result 1 to 3 weeks after receiving the questionnaire. All invited couples were unaware of the results of genetic testing at the moment of returning the questionnaire.

Before study initiation, the Institutional Review Board (IRB) of the Academic Medical Center in Amsterdam had indicated that IRB approval was not needed for this study, according to the legal requirements in the Netherlands.

**Pre-test counseling**

In the Netherlands, pretest counseling in couples with RM or poor semen quality is provided by the gynecologist or urologist who requests the test. That health care professional is supposed to inform the couples and to mention advantages and disadvantages. In case a genetic abnormality is found, the physician ordering the test is supposed to discuss this result with the patients and to refer them to a clinical geneticist for further counseling and information.

**Study instrument**

A pilot study was conducted among 10 couples (20 participants) to evaluate clarity, ease of reading and feasibility of the questionnaire. The final questionnaire consisted of multiple choice and open ended questions and included two validated standardized psychological measurements (STAI, BDI-II):

- **Socio-demographics and obstetric history**
  Participants were asked about their religion, education, occupation and obstetric history.

- **Knowledge and awareness**
  Knowledge of what is in particular tested with a genetic test, awareness of the genetic test that was performed and the information received during counseling was asked by multiple choice questions. Participants were asked to tick only one answer.

- **Perceived risks**
  Participants were asked how they perceived their risk of receiving an abnormal genetic test result, their risk of another miscarriage, a stillborn child, a child with major congenital abnormalities, their chance of conceiving at least one child and their chance of conceiving their desired number of children. Participants marked their perceived risk on visual analog
scales ranging from 0% to 100%. Participants were asked to indicate their perceived risk for each possible risk-scenario in contrast with the risk for the general population (lower, comparable or higher).

Anxiety
Anxiety was measured using the validated Dutch version of the Spielberger State-Trait Anxiety Inventory (STAI). The STAI consists of two subscales, the 20-item State anxiety scale and the 20-item Trait anxiety scale. The STAI differentiates between the temporary condition of “state anxiety” and the more general and long-standing quality of “trait anxiety.” Responses are rated on a four point scale (1 to 4). Sum scores on this measure range from 20 to 80, with higher scores representing higher levels of anxiety. Scores on the STAI were compared to a Dutch reference population.

Depression
Depression was measured using the validated Dutch version of the 21-item second edition of the Beck Depression inventory (BDI-II). Respondents are asked to rate how they felt in the last two weeks. Responses are rated on a four point scale (0 to 3). Sum scores on this measure range from 0 to 63, with higher scores reflecting more depressive symptoms. A score of 0–9 indicates minimal depression, 10–18 indicates mild depression, 19–29 indicates moderate depression and 30–63 indicates severe depression. Scores on the BDI-II were compared to a Dutch reference population.

Statistical Analysis
We used the Statistical Package for the Social Sciences (SPSS 15.0) to analyze the data. Descriptive statistics were generated to describe the total sample of participants and the subsamples of participants with RM and poor semen quality in terms of socio-demographics and obstetric history. Differences were tested with t-tests statistics and ANOVA for parametric data, and Mann-Whitney, Kruskall-Wallis and Chi² tests statistics for non-parametric data. Correlations were tested with Spearman's Rho or Pearson's r where appropriate. We used a general linear model to identify factors related to the Trait and State anxiety scores and to identify factors associated with the perceived risks. A logistic model was used to evaluate factors associated with the BDI-II. Various factors were included: education (categorical), religion (categorical), time trying to conceive (categorical), age (continuous), number of previous miscarriages (continuous), number of previous pregnancies (continuous). Two-tailed \( p \) values < 0.05 were considered to indicate statistical significance.

RESULTS

During the study period (2006-2009) 482 potentially eligible couples were identified in the seven participating clinical genetics laboratories (figure I), 198 couples with RM and 284 couples with a man with poor semen quality. Of all those couples, 41 couples were excluded, because of a language barrier (n=10), current pregnancy (n=5), a previous disclosed genetic test result (n=10), serious illness (n=4), no consent from the referring physician (n=6), a familial genetic abnormality (n=1) or other reasons (n=5). Consequently the questionnaire was sent to 441 couples (882 potential participants). Of these subjects, 439 (222 men and 217 women) returned the questionnaire (response rate 49%), 172 had a history of RM (39%) and 267 a history of poor semen quality (61%). Almost all participants were part of an included couple; only 2 women in the RM group and 7 men in the poor semen quality group participated without their partner.

The mean age of the RM group was 35.4 years versus 35.1 years in the poor semen quality group (p=0.57) (table I). Most participants had the Dutch nationality, had finished secondary education and reported no religious affiliation. Information on obstetric history is presented per couple. The poor semen quality group had been trying to conceive significantly longer than the RM group (p=0.02) (table I). On average, the RM group would have liked to have 2.3 children, slightly higher than the mean of 2.1 children in the poor semen quality group (p=0.01). The RM group reported a median of three pregnancies and two miscarriages, whereas the poor semen quality group obviously recorded none.
Figure I Flowchart summarizing inclusion and response. * See text for details.
More than half of participants stated that, before their consultation, they were not aware genetic testing was part of the diagnostic work-up of RM or poor semen quality (101 in the RM group (59%) and 155 in the poor semen quality group (58%)) (table II). One third of participants stated that they did not receive any information about the genetic test from their referring doctor during the consultation (36% RM, 33% poor semen quality). Only 40% (44% poor semen quality) of the participants with RM understood the meaning of the genetic test, 38% stated they had no idea (42% poor semen quality). In the RM group 68% of participants felt it was not possible to ask questions about the genetic test during the consultation, and 12% could not remember the genetic test being discussed at all. In the group of men with poor semen quality the percentages were 60% and 21% respectively (table II). In contrast, around 60% of the participants did not feel they needed any more information during their visit (58% RM, 64% poor semen quality). There were no significant statistical differences between participants with RM or poor semen quality in knowledge or awareness. Preferences for information were examined by gender. More women indicated that they preferred additional information, but this was not statistically significant (p=0.07), nor were other preferences.

The mean perceived risk of the probability of an abnormal genetic test result was 15% in both groups (figure II and III). The participants with RM estimated their risk of subsequent miscarriage around 50%. The RM group estimated their chances of conceiving at least one child (75%) much higher than the poor semen quality group (50%) (p<0.01). The individual perceived risks for all risk scenarios were highly correlated (p<0.01). The range of $r$ was 0.136 – 0.694.

Most participants felt that their risk indicated on the different scenarios was equal to that of the general population (data not shown). There were two exceptions. The risk of another miscarriage was perceived as higher by the RM group. The chances of conceiving at least one child and conceiving the desired number of children were perceived as lower in the poor semen quality group compared to a general population.

### Table II Knowledge and information about the genetic test related to the fertility work-up

<table>
<thead>
<tr>
<th></th>
<th>Recurrent miscarriage n=172 (%)</th>
<th>Poor semen quality n=267 (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aware of standard genetic testing</td>
<td>No 101 (59%)</td>
<td>Yes 155 (58%)</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>Yes 70 (41%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information received about genetic testing</td>
<td>No 110 (36%)</td>
<td>Yes 177 (33%)</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Yes 87 (64%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is tested (only 1 answer possible)</td>
<td>Antibodies 8 (5%)</td>
<td>Yes 8 (3%)</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Clotting factors 11 (6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Changes in DNA or chromosomes 68 (40%)</td>
<td>117 (45%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Something else 17 (10%)</td>
<td>26 (10%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Don’t know 66 (39%)</td>
<td>111 (42%)</td>
<td></td>
</tr>
<tr>
<td>Possible to ask questions</td>
<td>No 117 (69%)</td>
<td>Yes 160 (61%)</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Don’t remember the genetic test discussed 21 (12%)</td>
<td>57 (21%)</td>
<td></td>
</tr>
<tr>
<td>Wanted to ask questions</td>
<td>No 81 (54%)</td>
<td>Yes n=151* 114 (55%)</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>70 (46%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More information needed</td>
<td>No 88 (58%)</td>
<td>Yes 131 (64%)</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>63 (42%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offered the choice to have genetic test</td>
<td>No 53 (35%)</td>
<td>Yes 63 (31%)</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>60 (40%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Don’t know 38 (25%)</td>
<td>70 (34%)</td>
<td></td>
</tr>
<tr>
<td>Chosen for genetic testing?</td>
<td>No 21 (14%)</td>
<td>Yes 101 (67%)</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Don’t know 29 (19%)</td>
<td>42 (20%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Questions only answered by people who could remember the genetic test was being discussed during the consult.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There was a high level of agreement between partners of a couple in knowledge, awareness and risk perceptions. Spearman’s Rho varied in the recurrent miscarriage group between 0.274 (p=0.01) and 0.588 (p<0.001), and between 0.360 and 0.599 (p<0.001) in the poor semen quality group.
Scores on the BDI and the STAI trait were highly correlated ($r = 0.714, p<0.001$). This was also true for scores on the BDI and the STAI state ($r = 0.733, p<0.001$).

The mean score on the State anxiety scale was 36.6 (SD 12.2) in the RM group and 34.6 (SD 10.1) in the poor semen quality group ($p=0.08$) (table I). We observed a statistically significant difference between the RM and the poor semen quality group on the Trait anxiety score ($p<0.01$), with participants with RM having higher scores. Scores on the Trait anxiety scale and State anxiety scale are presented for both men and women. Between men in the RM group and in the poor semen quality group, there were no statistical significant differences in scores on either the State anxiety and Trait anxiety subscales. Only in women the State anxiety score was significantly higher in the RM group than in women in the poor semen quality group (40.0 vs. 36.3, $p=0.04$). This was the same for scores on the Trait anxiety scale (40.0 vs. 34.4, $p<0.01$).

To put the results of the State anxiety and Trait anxiety subscales in perspective we used a reference population of 121 Dutch couples visiting a fertility clinic for preconception counseling.22 The scores on the State anxiety and Trait anxiety scales for men in both RM and poor semen quality in our study were not different from those in the reference population. The scores of women with a partner with poor semen quality also did not differ significantly. The scores of women with RM were significantly higher on both the State anxiety and the Trait anxiety subscale. The means were 40.0 versus 35.5 in the State ($p<0.01$) and 40.0 versus 35.6 on the Trait ($p<0.01$) scale. Using linear regression the scores on the State anxiety and the Trait anxiety were found to be highly correlated with the perceived risks: the higher the perceived risk, the higher the score on the State anxiety and Trait anxiety subscales. This was especially robust for the perceived risk of an abnormal genetic test result ($p<0.01$) in both groups, and for the majority of the clinical outcomes (risk of another miscarriage, risk of a stillborn child and risk of a child with birth defects). The range of $r$ was 0.177 - 0.298 in the RM group and 0.234 – 0.317 in the poor semen quality group.

The median score on the BDI-II was 5.0 for the RM group and 3.0 for the poor semen quality group. These scores were comparable to the scores of a Dutch reference population, consisting.

Figure II: Perceived and actual risks for different scenario’s in couples with recurrent miscarriage. Literature20,21

Thin line: Perceived risk (Median and Inter Quartile Range)
Thick line: Mean actual risk

Figure III: Perceived and actual risks for different scenario’s in couples with male partner with poor semen quality. Literature8,20,21

Thin line: Perceived risk (Median and Inter Quartile Range)
Thick line: Mean actual risk
of 505 people, and were classified in the lowest category of the BDI-II ‘none to minimal depression’. In a logistic regression model no relations were found between any of the potential determinants and the BDI-II score.

**DISCUSSION**

In this study of couples undergoing genetic testing after RM or in case of poor semen quality, we found that most couples had a suboptimal knowledge of the genetic test and overestimated their risks of receiving an abnormal genetic test result before disclosure of the test result. Women with a history of RM had higher levels of anxiety compared to a reference population and compared to women with a partner with poor semen quality. In good clinical practice it is essential that patients are well informed about the tests and procedures they are exposed to. The pre-testing information needs to be structured and concise to enable shared decision making.

As far as we know this is the first study to explore the perceived risks and knowledge about genetic testing in couples with RM or with poor semen quality before disclosure of the genetic test result. Although couples with RM or with poor semen quality have different underlying mechanisms for their reproductive problems, both undergo a genetic test and face the same uncertainty before disclosure.

This study was conducted in seven of the eight academic hospitals in the Netherlands, which means we invited a representative sample of patients undergoing genetic testing at outpatient clinics of gynecology because of reproductive problems. So far few studies have included men as participants, as most studied addressed only attitudes and emotional responses of women undergoing fertility treatments.

The results of our study suggest that participants did not have proper knowledge about the nature of the genetic test. They also felt they could not discuss this issue with their physician. The exact reason for this cannot be inferred from this study. It might be that physicians do not inform their patients adequately. It is also possible that patients fail to understand the information given to them or do not remember it correctly. It is known that knowledge and understanding of genetics is low among the general public since this is often complex

More than half of participants answered that they did not need any more information at the pre-test counseling. Combining this outcome with the finding that only a minority knew about the purpose of the genetic test it seems that patients awareness of genetic counseling is low. In our study all participants overestimated their perceived risks for the different risk-scenarios presented; their risk of receiving an abnormal genetic test result, their risk of another miscarriage, a stillborn child, a child with major congenital abnormalities, their chance of conceiving at least one child and the chance of conceiving the desired number of children. This overestimation was regardless of educational status, gender or age. Most studies in hereditary cancer, such as breast and ovarian cancer, also show an overestimation of patients of perceived risks of getting cancer. Whether this is a representation of a truly perceived risk, or more of a coping strategy is unclear. Other studies have shown that individuals, both patients and physicians, experience difficulty in understanding probability and relative risk data. A higher perceived risk may lead to more anxiety in patients. More realistic perceptions of the possible risk could therefore lead to less anxiety in patients. On the other hand, it might also be that higher anxiety levels lead to higher perceived risks. Higher perceived risks have also been linked to a lack of knowledge about the disease. Research has shown that the process by which individuals construct their risks is complex, and influenced by many factors, such as environmental factors, occupation, stress and worry, in addition to their own experiences or family history factors.

Besides this, subfertility in itself has an enormous impact on psychological wellbeing of couples. The unfulfilled desire to have children and the possible threat of permanent infertility have been shown to lead to increased levels of depression and anxiety in women. In our study, women with a history of RM were more anxious before disclosure of the genetic test result than women with a partner with poor semen quality, they recorded higher scores on both state and trait anxiety. Recurrent pregnancy loss has been described as a traumatic event, leading to symptoms of anxiety and depression and feelings of guilt. Maybe women with RM blame themselves for the miscarriages which can lead to increased anxiety, while women with a partner with poor semen quality do not. Women with RM may need extra attention and counseling during their consultations. Why women with RM also have higher scores on trait anxiety is unknown. This might be the result of a selection bias where women with a higher trait anxiety were more willing to participate. In contrast we did not observe higher levels of anxiety in men with poor semen quality compared to men with RM. Only a few studies have
focused on the emotional wellbeing of infertile men. It has been suggested that men speak less of personal issues and, in case of poor semen quality, will keep emotional distress to themselves and that men are psychologically affected as much as women but are less open about it.\textsuperscript{35,36}

Several limitations of our study should be considered. Firstly, the response rate in our study was about fifty percent. Only one telephone call to include eligible participants could be made, since in the study design there was little time before disclosure of the genetic test result. We have no data on the non-responders and for most of them we have no reason for not participating. It is therefore possible that a form of selection bias occurred where participants who felt more attracted to the subject of the study were more willing to participate. Nevertheless, comparing the patient characteristics in our study to those of a large earlier study in couples with recurrent miscarriage, it seems that at least the participants in our study are a good representation of the (Dutch) clinic based population.\textsuperscript{2} Secondly, we only have self-reported data of participants. We had no access to the medical records of participants and therefore it is unknown what information was given during the consultations by their clinicians. There is no real standardization in informing and counseling couples who undergo genetic testing. Last but not least, although couples were asked to complete the questionnaire independently, nevertheless, it cannot be ruled out that some respondents’ answers may have been influenced by their partners’.

It is important to understand why patients have a suboptimal knowledge of genetic testing and why they overestimate their genetic risk. Future research should therefore include observing the consultation process and the topics discussed and the patients’ knowledge afterwards. The knowledge about genetics and genetic testing among gynecologists should also be explored. Furthermore it would be interesting to study if patients who have realistic expectations about the genetic test and their risks experience less anxiety before disclosure of the test result and if realistic perceived risks reflect whether patients truly understand their risk.

Results of this study could be used to improve patient counseling before genetic testing, leading to well-informed patients. Potentially, this could be established if gynecologists take more time to discuss the pros and cons of genetic testing and explain clearly the objective risks the couples have in the different outcome scenarios, such as the risk of an abnormal genetic test result or the risk of another miscarriage. The information given in these consultations should be standardized and gynaecologists probably need more training in providing genetic counselling. Since gynaecologists have limited time per patient and are have to inform couples about other diagnostic tests (such as a hysterosalpingogram and blood tests for various antibodies) at the same moment, it might be an alternative to work with specialized counsellors providing the genetic pre-test counselling. To improve counseling in general it is important to realise that patients might not understand all the information given to them and do not always feel free to ask questions. In conclusion, improved knowledge about genetic testing in couples with recurrent miscarriage and poor semen quality is needed before a genetic test is performed. This could lead to more realistic expectations of patients about the consequences of the genetic test and to less anxiety before disclosure of the genetic test result.
REFERENCES


