Abstract

Objective: To demonstrate that a PGD program can be successfully established after the 2011 verdict of the German Bundestag concerning PGD.

Material and Method: Eight years previously, the couple had had a daughter who suffered from clinically manifest hemophilia A due to an unbalanced X-inactivation, as well as microdeletion syndrome resulting in severe physical and mental disability. The couple wished to have a second child but refused the idea of a "trial pregnancy.

Given the indications for both, it was necessary to carry out polar body diagnosis (PBD) to rule out hemophilia A and, during the same cycle, a subsequent PGD on the blastocysts to rule out genetic aberrations. The PBD and PGD (trophectoderm biopsy, TEB) were performed after high-dosage ovarian stimulation and ICSI fertilization of the oocytes. A blastocyst was successfully transferred on day 6.

Results: The patient conceived immediately. The pregnancy developed normally and the patient gave birth to a girl in the 40th week of pregnancy. Post-natal examinations showed that the baby is free from hemophilia A and is developing normally both physically and mentally.

Conclusion: Establishment of a PGD program is now possible after legalization of PGD in Germany. It is possible to apply two investigative techniques in a single treatment cycle if multifactorial diagnosis is required.

Zusammenfassung


Schlussfolgerung: Die Etablierung eines PID-Programms ist nach Legalisierung der PID erfolgreich möglich. Es ist machbar, in einem Behandlungszyklus Doppeluntersuchungen durchzuführen, wenn mehrere Indikationen vorliegen.
**Introduction**

In Germany, key areas of reproductive medicine are governed by the Embryo Protection Act (Embryonenutzschutzgesetz; ESchG). Previous commentaries had raised the assumption that the Act prohibits preimplantation genetic diagnosis (PGD) of embryos. After a voluntary disclosure, the German Federal Supreme Court of Justice (Bundesgerichtshof) [1] ruled that the ESchG does not actually prohibit PGD in principle, especially not when trophoderm biopsy (TEB) is used in which pluripotent, not totipotent cells are analysed. One year later, the German parliament (Bundestag) [5] passed a draft of the Preimplantation Diagnosis Act (Präimplantationsgesetz; PräimpG) according to which PGD is still prohibited in principle, but defining exceptions: for example, PGD may be performed in cases where genetic predisposition poses a high risk for offspring having severe disorders, or to avoid a severe damage of an embryo that is likely to result in miscarriage or stillbirth. The law came into effect in December 2011 [2].

**Case Report**

**Initial clinical and legal situation**

A couple at risk of a monogenic disease and a chromosomal aberration first consulted us in 2010. Their daughter was born in 2004, she suffered from haemophilia A due to a mutation in the coagulation factor VIII (gene F8) and a non-random X-inactivation. Additionally, she showed clinical features of a 1 p36 microdeletion syndrome as a result of an unbalanced translocation which evidently occurred as a germ cell mosaicism in one parent (karyotype: 46.XX,der[1][t1;12][p36.32;p13.33]).

After extensive counselling in genetics and reproductive medicine, it became clear that the female consulter (age 32) and her 38-year-old husband wished to have a second child but refused PGD, in principle, because it was too invasive. After a voluntary disclosure, the German Federal Supreme Court of Justice (Bundesgerichtshof) [1] ruled that the ESchG does not actually prohibit PGD in principle, especially not when trophoderm biopsy (TEB) is used in which pluripotent, not totipotent cells are analysed. One year later, the German parliament (Bundestag) [5] passed a draft of the Preimplantation Diagnosis Act (Präimplantationsgesetz; PräimpG) according to which PGD is still prohibited in principle, but defining exceptions: for example, PGD may be performed in cases where genetic predisposition poses a high risk for offspring having severe disorders, or to avoid a severe damage of an embryo that is likely to result in miscarriage or stillbirth. The law came into effect in December 2011 [2].

**Procedure**

After down regulation in the midluteal phase of the previous cycle (Decapeptyl®), daily 0.1 mg s.c., hormonal stimulation was carried out from the third day of the cycle with 200 IU recombinant human FSH (Puregon®); ovulation was induced with 10 000 HCG. Transvaginal ultrasound guided oocyte retrieval was carried out 35 hours later and yielded 17 oocytes, on 11 of which ICSI was performed according standard procedures. Biopsy of the 1st polar body (PB1) was accomplished by immobilizing the oocyte using a holding pipette to position the polar body at the 3–o’clock position. The zona then was opened using multiple laser beams (approx. 8 ms) to enable the polar body to be extracted using a biopsy pipette (diameter of opening approx. 15–20 µm). The polar body was placed into a drop of fresh culture medium and then transferred to a marked and labelled slide under the stereo microscope using a specially manufactured glass capillary. The 2nd polar bodies were removed accordingly from the 9 fertilized oocytes which showed pronuclei the next morning.

In order to identify (an) unaffected oocyte(s) without the mutated F8 allele, we established a single cell protocol for an indirect polar body diagnosis approach, based on a multiplex PCR with fluorescently labelled primers for five microsatellite markers (DXS1073, KIR3, F8C-IVS22, KIIIR, DXS1107) located close to the mutation in the F8 gene. The mutation analysis of the polar body DNA was achieved performing the first amplification steps on an AmpliGrid slide (Beckmann Coulter). Polar body diagnosis for haemophilia A resulted in the detection of two unaffected oocytes.

By day 5, two blastocysts had developed timely. Trophoblast cells were removed after the zona pellucida had been opened using a laser. A biopsy pipette was used to separate 2–6 cells from the trophectoderm extruded from the hernia; the biopsy material was placed into a drop of fresh medium and transferred under the stereo microscope into an Eppendorf tube containing 2 µl 1× PBS and transferred to a marked and labelled slide under the stereo microscope using a specially manufactured glass capillary. The specimens were frozen at −20 °C until collection and Array CGH analysis. Array CGH was then performed according to the 24sure protocol (BlueGnome) using the 24sure+ chip format. Sample TE1 from blastocyst 1 revealed an aneuploid karyotype (trisomies of chromosomes 5 and 11), whereas sample TE2 from blastocyst 2 showed a euploid (or balanced) karyotype.

The couple requested the transfer of the unaffected blastocyst 2 on day 6 and refused the transfer or cryopreservation of the other blastocyst. The luteal phase was supported by the administration of progesterone (3 × 200 mg Utrogest® intravaginal). During the luteal phase, progesterone was continued, while injections of Clexane® were discontinued, while injections of Clexane® were discontinued, while injections of Clexane continued until the 12th week of pregnancy, which developed normally. Invasive prenatal diagnosis by amniocentesis in 15th week of gestation revealed normal results for F8 gene and the karyotype (female). In June 2012, the patient gave birth to a healthy girl (5.6.2012; 4280 g; 55 cm).

**Discussion**

Polar body diagnosis (PBD) for genetic testing was first described in the 90s [17,19], our programme was established in 2003 according to the first ESHRE guidelines [6,16] Preimplantation genetic diagnosis (PGD) was first described by Handyside et al. in 1989 [9]. First reports applying PGD on blastocysts were pub-
lished from 2002 on [4, 14]. Our PGS programme with tropho
derm biopsy (TEB) was introduced in 2010 [15], after the deci-
sion of the German Federal Supreme Court and according to the
ESHRE guidelines [11, 12].
The majority of PGD is done on day 3 embryos, however, the per-
centage of cycles with TEB is increasing [7, 10]. There are only a
few papers on performance of PBD and PGD in one treatment
cycle [13, 18], usually applying on day 3 embryos. The present
case, to best of our knowledge, is the first of a sequential PGD
with blastocysts, in particular in Germany: a targeted molecular
genetic analysis of polar bodies and an array CGH analysis after
TEB.

This approach is demanding as biopsies of polar bodies and
trophectoderm have to be conducted at different times. For X-
linked diseases, polar bodies can be employed to perform the
mutation analysis for the monogenic disease. However, for exam-
ple, in case of paternally inherited diseases, only a genetic testing
of a trophoectoderm sample is conductive. Then, a sequential pre-
implantation genetic diagnosis may be difficult to achieve due to
the different diagnostic procedures for the mutation analysis and
the molecular karyotyping (array CGH). To overcome this issue,
from a single nucleotide polymorphism (SNP)-based chip format
(karyomapping) has been developed by Alan Handside at Blue-
Gnome, the manufacturer of the 24sure format for molecular
karyotyping in PGD. This approach makes it possible to test for
gene mutations and copy number variations simultaneously.

It is noteworthy to mention that the legal regulation in Germany
concerning PGD is unique; both the Preimplantation Diagnosis
Act and the associated regulations clearly set forth that PGD re-
mains prohibited for totipotent embryonic blastomeres [8],
which eliminates the use of day 3 blastomeres for genetic diagno-
sis. The position is different with respect to pluripotent troph-
blast cells, which can be biopsied from the trophoectoderm on
day 5 after fertilisation. For this reason, in Germany, PGD can only
be performed on late preimplantation embryos.

Conflicts can already be predicted for couples who call on PGD for
monogenic diseases without an indication for molecular karyo-
typing. In these cases, only the targeted mutation analysis can be
performed; trisomies and monosomies thus, escape detection.

The focus of the Preimplantation Diagnosis Act undoubtedly lies
from the diagnosis of monogenic disorders; however, it is impor-
tant to understand that the impetus must come entirely from
the couple (or the woman) involved, and may not be given by
the doctor in question. In fact, the Embryo Protection Act gener-
ally focuses on the woman in question. In fact, the Embryo Protec-
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Preimplantation genetic diagnosis for monogenic disorders is an
extremely complex process and is currently performed by only
very few institutions in Germany. This number should not neces-
sarily be expected to increase significantly, especially given that
the prevalence of the corresponding disorders is not rising. It
may therefore be assumed that in the future preimplantation ge-
netic diagnosis of monogenic diseases will continue to be limited
to a few cooperation centers for human genetics and assisted re-
productive medicine.

Conflict of Interest

All authors declare that there is no conflict of interest.

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