Extended Analyses of the German IVF Registry (DIR): Andrological Aspects, Medical-Economical Assumptions Related to the Shift from IVF to ICSI and Stimulation with Gonadotropins

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Extended Analyses of the German IVF Registry (D·I·R): Andrological Aspects, Medical-Economical Assumptions Related to the Shift From IVF to ICSI and Stimulation with Gonadotropins

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Key words: German IVF Registry (D·I·R), azoospermia, lifestyle, reimbursement, intracytoplasmatic sperm injection (ICSI), GnRH analogues, gonadotropin

Practical Aspects

Medical indications rather than economic reasons seem to be responsible for the increase in ICSI treatment. Seven percent of ICSI cycles are performed with testicular or epididymal sperm. In these cases miscarriage and birth rates are not reduced. GnRH antagonist protocols play an increasing part in routine ART cycles.

Indications and Results of ART Cycles for Male Infertility

ICSI cycles have been registered in the D·I·R since 1994 [2]. By 1999, all D·I·R centers in Germany practiced both IVF and ICSI techniques and between 2001 and 2004 one or two centers only documented ICSI cycles. The ESHRE European IVF Monitoring (EIM) recorded the trend in IVF practice with ICSI cycles exceeding the frequency of IVF cycles in 2002 in Europe [3]. In the current analysis of andrological aspects in

Table 1: Retrieval of sperm for ART cycles in the German IVF Registry (D·I·R) 1998–2008.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Cumulative frequency</th>
<th>Percentage</th>
<th>Cumulative percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not specified</td>
<td>7202</td>
<td>7202</td>
<td>2.38</td>
</tr>
<tr>
<td>Antegrade ejaculation</td>
<td>267,572</td>
<td>274,774</td>
<td>88.48</td>
</tr>
<tr>
<td>Retrograde ejaculation</td>
<td>229</td>
<td>275,003</td>
<td>0.08</td>
</tr>
<tr>
<td>Cryopreserved sperm</td>
<td>5,337</td>
<td>280,340</td>
<td>1.76</td>
</tr>
<tr>
<td>Microsurgical epididymal sperm aspiration (MESA)</td>
<td>185</td>
<td>280,525</td>
<td>0.06</td>
</tr>
<tr>
<td>Cryopreserved sperm after MESA</td>
<td>624</td>
<td>281,149</td>
<td>0.21</td>
</tr>
<tr>
<td>Percutaneous epididymal sperm aspiration (PESA)</td>
<td>32</td>
<td>281,181</td>
<td>0.01</td>
</tr>
<tr>
<td>Cryopreserved sperm after PESA</td>
<td>15</td>
<td>281,196</td>
<td>0.00</td>
</tr>
<tr>
<td>Testicular sperm extraction (TESE)</td>
<td>4,260</td>
<td>285,456</td>
<td>1.41</td>
</tr>
<tr>
<td>TESE of cryopreserved testicular tissue</td>
<td>16,143</td>
<td>301,599</td>
<td>5.34</td>
</tr>
<tr>
<td>Electro-ejaculation</td>
<td>41</td>
<td>301,640</td>
<td>0.01</td>
</tr>
<tr>
<td>Artificial spermatocele</td>
<td>11</td>
<td>301,651</td>
<td>0.00</td>
</tr>
<tr>
<td>Donor sperm</td>
<td>762</td>
<td>302,413</td>
<td>0.25</td>
</tr>
</tbody>
</table>

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Sperm Retrieval for ART Cycles

The indication for an ICSI procedure is related to the retrieval of sperm in the mandatory field in the D·I·R database (Tab. 1). Indications for IVF or ICSI treatment can be derived from the origin of sperm for ART (Fig. 1): male factor (poor sperm quality, antegrade ejaculation), obstructive or non-obstructive azoospermia (MESA, PESA, TESE or artificial spermatocoele), retrograde ejaculation (sperm retrieved from urine, electro-stimulation or antegrade ejaculation after medication), male fertility preservation (cryopreserved sperm) or male ART treatment failure (cryopreserved donor sperm). Seven percent of all ART cycles in the German registry were performed with epididymal or testicular sperm due to azoospermia. But no differentiation can be carried out between non-obstructive and obstructive azoospermia and fertilization and pregnancy results cannot be distinguished between cycles with intracytoplasmatic injection of motile and immotile testicular sperm (no mandatory fields). The number of ART cycles with testicular or cryopreserved ejaculated sperm is increasing (Fig. 2). Fluctuations in the numbers of treatment cycles in 2000 and 2004 are due to changes in the reimbursement of ICSI cycles by the public health insurance. 20,403 TESE cycles and 5,337 cycles with cryopreserved sperm were registered between 1998 and 2008 by the D·I·R were analyzed.

Figure 1: Indications for ART-related diagnosis according to the kind of sperm retrieval 1998–2008 (302,413 ART cycles).

Figure 2: Increase in annual numbers for ART cycles with cryopreserved ejaculated sperm or fresh or frozen testicular sperm (TESE/"cryo"-TESE) 1998–2008 (total 25,740 ART cycles).

Figure 3: Means (± 95 %-confidence interval [CI]) for fertilization rate, pregnancy rate, birth and miscarriage rate and singleton pregnancy rate for ejaculated, cryopreserved or testicular sperm in percent (%), 293,312 ART cycles 1998–2008, lost for follow-up 13.7 %.

Figure 4: Annual pregnancy rates (%) for cryopreserved ejaculated sperm and fresh or frozen testicular sperm (means ± 95 %-CI), p < 0.05 in 2002; 1998–2008 (total 25,740 ART cycles).

Figure 5: Annual development of ART cycles in Germany 1998–2008 (n = 498,784). IVF/ICSI cycles are fresh cycles in which oocytes are divided for both IVF and ICSI treatment.

Figure 6: Percentage of fertilisation failure in IVF (line with filled circle) or ICSI cycles (line with filled quad) plotted against the number of oocytes available for fertilisation (1999–2001).
sperm were performed between 1998 and 2008.

**Success Rates and Sperm Retrieval**

Lower fertilization and pregnancy rates are expected when ART cycles are performed with poor sperm quality or even testicular sperm. The analysis of 293,312 cycles with ejaculated, cryopreserved or testicular sperm confirmed this assumption. Fertilization and pregnancy rates were lowest with testicular sperm \( (p < 0.05) \). But when a pregnancy can be achieved the birth rate seems to be highest and the risk for multiple pregnancies lower than with ejaculated sperm (Fig. 3). Although pregnancy rates are higher for cryopreserved ejaculated sperm in comparison to testicular sperm, the annual analysis of 11 years reveals an improvement in pregnancy rates with almost similar success rates for cryopreserved and testicular sperm (Fig. 4).

**Lifestyle and ART Cycles**

Alcohol, smoking, over- but also underweight are known risk factors for infertility problems in women and men. Especially the prevalence of obesity and infertility is increasing in the developed world.

The body mass index (BMI) can be calculated for women and men in the database of the D-I-R because body weight and height are mandatory fields. However, the analysis of these data revealed that the data entered are incomplete or incorrect. According to the analysis of the BMI data only 2.5 % of the infertile men, 6.3 % of the infertile women and 0.7 % of both partners were overweight with a BMI > 30 \( (\text{expected } 17 \% \text{ for married men and } 14 \% \text{ for married women}) \). Nevertheless, the miscarriage rate for women with obesity was significantly higher in comparison to women with a BMI < 30 and is possibly due to metabolic disorders [2]. Smoking habits are also recorded in the D-I-R database (mandatory field for pre-existing diseases). The data analysis for nicotine abuse gave invaluable results probably also due to incomplete data collection and data entering [2]. All D-I-R centers should be encouraged to improve their data collection at least for main lifestyle parameters like body weight, height and smoking habits. Thus these D-I-R data can become valuable for the future.

**Considerations on the Increase of IVF to ICSI**

Reimbursement policies can have significant impact on the accessibility and use of ART treatments, and lack of medical reimbursement will act as a barrier to the use of ART. The analysis of the D-I-R data demonstrate that no reimbursement for ICSI cycles by the public health insurance in the year 2000 re-
Stimulation with Gonadotropins

Since the commercial launch of GnRH antagonists in 1999 (cetrorelix) and 2000 (ganiрrelix) stimulation protocols with GnRH antagonists have become routine in ART cycles.Meanwhile > 90 % of IVF and ICSI protocols in Germany are performed with GnRH agonists (54.8 %) and GnRH antagonists (31.5 %) (Tab. 2). This is in accordance with the current trend in ART practice worldwide [6]. Especially in PCOS patients with a higher risk for ovarian hyperstimulation syndrome (OHSS), but also in common ART patients, GnRH antagonists are favoured by more and more clinicians on an individualized patient-centered approach including flexible administration of GnRH antagonists or even the use of a GnRH agonists to trigger final oocyte maturation and ovulation [7, 8]. Pregnancy rates improved for antagonist protocols particularly because less poor responder but more normal or high responder patients with normal ovarian function are treated with this protocol.

Approximately 90 % of the IVF and ICSI cycles in Germany are performed with recombinant FSH (rFSH), highly purified menotropin (HP-hMG), rFSH plus HP-hMG, recombinant LH (rLH), not specified (n.s.), short GnRH protocol (microdose flare-up protocol), cycles to embryo transfer (ET), pregnancy rate per embryo transfer (PR).

Table 2: Percentage of cycles with embryo transfer (ET) and pregnancy rate (PR) in relation to different stimulation protocols and gonadotropin preparations, German IVF Registry (D·I·R) 2008.

<table>
<thead>
<tr>
<th>Gonadotropin preparation/ Stimulation protocol</th>
<th>uFSH</th>
<th>rFSH</th>
<th>hMG</th>
<th>rFSH plus LH</th>
<th>rFSH plus hMG</th>
<th>Others</th>
<th>n.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GnRH agonist, short (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>168</td>
<td>3,749</td>
</tr>
<tr>
<td>ET (%)</td>
<td>94.6</td>
<td>93.0</td>
<td>92.2</td>
<td>91.2</td>
<td>90.2</td>
<td>96.4</td>
<td>66.7</td>
<td>92.1</td>
</tr>
<tr>
<td>PR (%)</td>
<td>26.4</td>
<td>23.9</td>
<td>23.7</td>
<td>27.5</td>
<td>15.8</td>
<td>15.4</td>
<td>50.0</td>
<td>22.9</td>
</tr>
<tr>
<td><strong>GnRH agonist, long (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>258</td>
<td>21,695</td>
</tr>
<tr>
<td>ET (%)</td>
<td>90.3</td>
<td>92.4</td>
<td>93.6</td>
<td>90.4</td>
<td>88.8</td>
<td>89.7</td>
<td>80.0</td>
<td>92.7</td>
</tr>
<tr>
<td>PR (%)</td>
<td>30.5</td>
<td>32.3</td>
<td>29.3</td>
<td>33.1</td>
<td>32.2</td>
<td>25.8</td>
<td>25.0</td>
<td>31.7</td>
</tr>
<tr>
<td><strong>No GnRH analogues (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>1,686</td>
</tr>
<tr>
<td>ET (%)</td>
<td>75.0</td>
<td>93.5</td>
<td>89.8</td>
<td>91.3</td>
<td>89.5</td>
<td>83.1</td>
<td>76.6</td>
<td>89.4</td>
</tr>
<tr>
<td>PR (%)</td>
<td>33.3</td>
<td>32.9</td>
<td>28.4</td>
<td>22.2</td>
<td>30.2</td>
<td>19.1</td>
<td>9.7</td>
<td>279</td>
</tr>
<tr>
<td><strong>Antagonist (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>93</td>
<td>12,475</td>
</tr>
<tr>
<td>ET (%)</td>
<td>93.6</td>
<td>92.7</td>
<td>89.6</td>
<td>90.3</td>
<td>88.4</td>
<td>100.0</td>
<td>90.9</td>
<td></td>
</tr>
<tr>
<td>PR (%)</td>
<td>9.2</td>
<td>29.6</td>
<td>24.2</td>
<td>25.6</td>
<td>23.5</td>
<td>8.3</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td><strong>Total (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>523</td>
<td>39,605</td>
</tr>
<tr>
<td>%</td>
<td>1.3</td>
<td>53.7</td>
<td>20.2</td>
<td>6.7</td>
<td>13.7</td>
<td>4.4</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: urinary FSH (uFSH), recombinant FSH (rFSH), highly purified menotropin (HP-hMG), rFSH plus hMG, recombinant LH (rLH), not specified (n.s.), short GnRH protocol (microdose flare-up protocol), cycles to embryo transfer (ET), pregnancy rate per embryo transfer (PR).

duced the number of ICSI cycles performed. The 50 % co-payment portion by patients and limitations for the reimbursement e.g., to 3 cycles and to the age of 25–39 for women and 25–49 for men since 2004 dramatically decreased the use of all ART cycles by 50 % (Fig. 5).

Despite the discussion on the decrease in male fertility over the last 2 decades 2 hypotheses were tested: is ICSI preferred to avoid fertilisation failure or is ICSI performed frequently to increase the income of physicians working in reproductive medicine?

Between 1998 and 2004 successful fertilisation and pregnancy rates in IVF and ICSI cycles, IVF cycles with fertilisation failure, the relationship between the number of fertilizable oocytes and IVF or ICSI treatment and cycles in patients with advanced maternal age were analysed to answer the first question. Although pregnancy rates were similar for IVF and ICSI cycles, the rate for successful fertilisation dropped in 2000 for IVF by approximately 7 % (84.8 %). Fertilisation failure in IVF or ICSI cycles depended on the number of oocytes available for fertilisation with an increase in fertilisation failure in IVF cycles with higher numbers of oocytes and vice versa for ICSI cycles (Fig. 6).

Against the anticipation that patients with low numbers of oocytes frequently favour ICSI treatment to optimize their chance for fertilisation, low numbers of oocytes are related to a more frequent performance of IVF than ICSI (Fig. 7). Even in women with advanced maternal age, which is associated with a low number of oocytes, there is a tendency towards the IVF procedure (Fig. 8). This is possibly due to a higher incidence of female infertility factors in the affected couples and the additional cost factor for the ICSI procedure especially for women beyond the age of 39 with no reimbursement for ART by the public health insurance.

Fertility doctors sometimes are criticised for claiming high costs for infertility treatment. Despite this unjustified critique, employed physicians in clinics in comparison to private fertility centers are less dependent on earning money with IVF and ICSI treatment. Only a few clinics including university hospitals still offer infertility treatment in Germany [5]. However, the percentage of ICSI cycles in clinics is constantly higher compared with private fertility centers (Fig. 9). Thus medical indications rather than economic reasons seem to be responsible for the increase in ICSI treatment. The higher number of oocytes in ICSI compared to IVF cycles emphasize the unrestrained female fertility potential and suggests a severe male fertility disorder (Fig. 10).

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be derived from this fact, because the stimulation of a patient should be individualized which includes the prediction of ovarian response and reduction of the risk for OHSS. Moreover, in a randomized controlled study with oocyte donors no difference was detected between the stimulation with rFSH, hMG or a combination of rFSH and hMG regarding ovarian response and IVF outcome [9]. Interestingly, non-medical factors can influence the choice of gonadotropins for stimulation. Figure 12 demonstrates very clearly the impact of costs for the increase in cycles stimulated with hMG and the decrease in cycles stimulated with rFSH in 2000 for ICSI and 2004 for IVF and ICSI. In those years hMG, not highly purified, was still commercially and considerably cheaper than rFSH. Between 1997 and 2000 ICSI cycles were not reimbursed by the public health insurance and in 2004 the 50 % co-payment for treatment and medication was established by the public health insurance. Thus patients decided to prefer hMG preparations for ART stimulation. Meanwhile the prices for rFSH and HP-hMG have become similar and non-purified hMG preparations have disappeared from the national and neighbourhood pharmaceutical market.

The analysis of the cycle cancellation rate and pregnancy rate relating to maternal age and rFSH or hMG preparations gives a clear advantage for rFSH in women beyond 34 but not for younger women. Since 2003 the percentage of stimulated cycles leading to oocyte retrieval and the pregnancy rate per transfer have been significantly higher when the stimulation was performed with rFSH (Fig. 13, 14).

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