Effect of using an echogenic catheter for ultrasound-guided embryo transfer in an IVF programme: a prospective, randomized, controlled study

Buenaventura Coroleu1,3, Pedro N.Barri1, Olga Carreras1, Itziar Belil1, Rosario Buxaderas1, Anna Veiga1 and Juan Balasch2

1Department of Obstetrics and Gynaecology, Service of Reproductive Medicine, Institut Universitari Dexeus and 2Institut Clinic of Gynaecology, Obstetrics and Neonatology, Faculty of Medicine-University of Barcelona, Hospital Clinic-Institut d’Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), Barcelona, Spain

3To whom correspondence should be addressed at: Institut Universitari Dexeus. Paseo Bonanova 67, 08017 Barcelona, Spain. E-mail: vencor@dexeus.com

BACKGROUND: Recent evidence showed that ultrasound-guided embryo transfer significantly increases successful implantation compared to the clinical touch method. It has been postulated that new echodense catheters which are more readily detectable by ultrasound may refine transfer techniques even more, thus improving IVF outcome.

METHODS: A prospective, randomized, controlled trial comparing IVF outcome for women undergoing embryo transfer under ultrasound guidance by a single healthcare provider with random assignment according to a computer-generated randomization table to either standard soft Wallace catheter (standard catheter group, n = 95) or the new echogenic soft Wallace catheter (echogenic catheter group, n = 98). RESULTS: The use of the echodense catheter facilitated catheter identification under ultrasound, and thus the duration of the embryo transfer procedure since the loaded catheter was handed to the physician and up to embryo discharge was significantly shorter in the echogenic catheter group as compared with the standard catheter group. There were 39 and 53 clinical pregnancies in the standard catheter (41%) and echogenic catheter (54.1%) groups, respectively. This was not statistically significant (P = 0.08) according to the OR (0.6) and CIs (0.33–1.04). However, twin pregnancy rate was significantly increased (P < 0.01) with the use of the new catheter which was the underlying source for obtaining significant increase in implantation rate in this group (37.1%) as compared with the standard catheter group (23.2%). CONCLUSION: This pilot study suggests that the use of the echogenic Wallace catheter simplifies ultrasound-guided embryo transfer but not definite benefit in terms of pregnancy rates was obtained. In contrast, the use of the new catheter was associated with a significant increase in the number of twin pregnancies.

Key words: catheter system/embryo transfer/implantation rates/IVF/ultrasound guidance

Introduction

Over the past two decades, there have been increasing success rates with assisted reproductive technologies (ART). This improvement has been related mainly to improved stimulation protocols and embryology laboratory techniques. The method of embryo transfer, however, has remained very much the same, and when considered with other improvements in the clinic and laboratory, it is clear that this area has evolved poorly (Pasqualini and Quintans, 2002). Thus, studies of IVF describe high success rates (>80%) of ova fertilization in the laboratory compared with a low rate of successful outcome (<20–25%) (Mansour and Aboulghar, 2002; Eytan et al., 2004; Sallam, 2005). These low implantation rates have been variously blamed on compromised endometrial receptivity, compromised implantation capacity of the embryo or a suboptimal embryo transfer technique (Sallam, 2005).

Despite the fact that embryo transfer is the last decisive step on the way to a pregnancy in ART, traditionally embryo transfer has been viewed as an unimportant variable in the success of an ART treatment cycle. Only recent publications have stressed that, despite its apparent simplicity, the technique of embryo transfer is of utmost importance in maximizing the chances of pregnancy (Kovacs, 1999; Salha et al., 2001; Schoolcraft et al., 2001; Mansour and Aboulgahr, 2002; Pasqualini and Quintans, 2002; Sallam, 2005).

There is now a general agreement in the IVF community that a smooth embryo transfer is critical for achieving high success rates, and both choice of technique and choice of embryo replacement catheter may play a crucial role in the uterine embryo replacement (Kovacs, 1999; Salha et al., 2001; Schoolcraft et al., 2001; Mansour and Aboulgahr, 2002 Pasqualini and
Quintans, 2002; Sallam, 2005). Thus, two recent meta-analyses confirmed that ultrasound-guided embryo transfer significantly increases the clinical pregnancy and embryo implantation rates compared to the clinical touch method (Buckett, 2003; Sallam and Sadek, 2003). In addition, an even more recent systematic review and meta-analysis evaluating the firmness of the embryo transfer catheter as a single variable in relation to a successful transfer concluded that using soft embryo transfer catheters results in a significantly higher pregnancy rate as compared with firm catheters (Abou-Setta et al., 2005).

Using the soft Wallace embryo transfer catheter system, we performed a randomized, controlled trial showing that implantation and pregnancy rates were improved with ultrasound-guided embryo transfer compared with clinical touch (Coroleu et al., 2000). A recent development is the availability of the soft Wallace echogenic catheter (SureView Wallace Embryo Replacement Catheter; Smiths Medical, Hythe, Kent, UK), which utilizes new technology specifically designed to visually enhance the catheter’s appearance under ultrasound.

Therefore, this pilot study was designed to prospectively investigate the effect of using an echogenic catheter for ultrasound-guided embryo transfer in an IVF programme. The rationale for this study was that an echogenic embryo transfer catheter should be easier to see and make the transfer easier and quicker than the nonechogenic catheter. To this end, embryo transfer under transabdominal ultrasound guidance was performed by a single healthcare provider with random assignment to either standard or echogenic soft Wallace catheters.

Materials and methods

Patients and ovarian stimulation

Between September 2004 and January 2005, 188 patients from the IVF-embryo transfer programme of the Institut Universitari Dexeus’ Reproductive Medicine Service underwent ultrasound-guided fresh embryo transfers. They were aged between 25 and 43 years, and the main patient indications for IVF/ICSI included male factor, tubal infertility, unexplained infertility and endometriosis. Eligible patients who agreed to participate were randomized in two treatment groups: 92 patients underwent ultrasound-guided embryo transfer with the standard soft Wallace catheter (Smiths Medical) (standard catheter group) and 96 patients with the new soft SureView™ Wallace catheter (echogenic catheter group). A flow chart of inclusion, randomization and dropout of patients treated in the study is shown in Figure 1.

The SureView™ Wallace catheter combines all of the characteristics of the classic soft Wallace catheter, with the unique opportunity to view the entire length of the catheter under ultrasound. The echogenicity is brought about by small air bubbles contained within the polyurethane of the catheter lumen itself and used along the whole length of the catheter (Figure 2). Patients were randomized on the day of embryo transfer, prior to the procedure being carried out, according to a computer-generated randomization table. Sealed envelopes for the randomization list were used. The study was approved by the Ethics and Clinical Trials Committee of the Institut Universitari Dexeus, and all women involved gave informed consent to participate in the study.

As previously reported (Coroleu et al., 2000), in our IVF programme, ovarian stimulation is routinely accomplished using gonadotrophin treatment with FSH under pituitary suppression with GnRH agonist. Leuprolide acetate (Procrin; Abbott Laboratories S.A., Madrid, Spain) suppression is started in the midluteal phase of the previous cycle at a subcutaneous daily dose of 1 mg. This dose is reduced to 0.5 mg/day once ovarian arrest has been achieved and then is continued until the administration of HCG. Gonadotrophin stimulation of the ovaries was started when serum estradiol concentrations declined to <50 pg/ml, and a vaginal ultrasonographic scan showed an absence of follicles >10 mm in diameter. On days 1–5 of ovarian stimulation, 225 IU per day of recombinant FSH (Gonal-F; Serono S.A., Madrid, Spain) was administered s.c. From day 6 onwards, FSH was administered on an individual basis according to the ovarian response as assessed by follicular development and serum estradiol levels.

In those patients having a previous poor response and/or basal (cycle days 2–4) FSH serum concentrations >10.5 IU/l which, according to our experience, is associated with poor responsive cycles (Barri et al., 2000), we used a flare-up protocol. Leuprolide acetate (0.5 mg
becco’s PBS solution; Irvine Scientific, Santa Anna, CA, USA), and was cleaned with a phosphate-buffered saline (PBS) solution (Dulbecco’s). Mammalian embryos having ≤ 50% fragmentation were scored 4, ≥ 50% and 2 and 0, respectively, on both day 2 and day 3, respectively. In contrast, embryos having <4 blastomeres on day 2, or <6 blastomeres on day 3, after IVF, were scored 0. In contrast, embryos having <4 blastomeres on day 2, or <6 blastomeres on day 3, after IVF, were scored 0. In contrast, embryos having <4 blastomeres on day 2, or <6 blastomeres on day 3, after IVF, were scored 0. In contrast, embryos having <4 blastomeres on day 2, or <6 blastomeres on day 3, after IVF, were scored 0. In contrast, embryos having <4 blastomeres on day 2, or <6 blastomeres on day 3, after IVF, were scored 0. In contrast, embryos having <4 blastomeres on day 2, or <6 blastomeres on day 3, after IVF, were scored 0.

Two days after oocyte recovery, usually two (range one to three) embryos per patient were replaced depending upon the age of the patient, the indication for IVF, the number of previous IVF attempts and the number and quality of embryos available for replacement. Embryo quality was established according to the number and form of blastomeres and the percentage of cytoplasmic fragmentation as previously suggested (Plachot and Mandelbaum, 1990). As previously reported (Coroleu et al., 2002a,b), for statistical comparison purposes and to quantify objectively the embryo quality, those three variables were coded according to fixed criteria and then assigned an arbitrary score of 0, 2 or 4. Embryos having ≤ 4 blastomeres on day 2, or ≤ 6 blastomeres on day 3, after IVF, were scored 0. In contrast, ≥4- and ≥6-cell embryos on days 2 and 3, respectively, were scored 2. Irrespective of the day after IVF, symmetrical cells were scored 4, whereas asymmetrical ones scored 0. Embryos having ≤15%, ≥15 to <50% and ≥50% fragmentation were scored 4, 2 and 0, respectively, on both day 2 and day 3. Accordingly, an optimal quality embryo would score 10. For the final analysis of results, the embryo score per patient was considered as the mean value of the scores given to each of transferred embryos.

No mock or trial embryo transfer was performed, and the preparation for embryo transfer was the same for the two study groups (Coroleu et al., 2000, 2002a,b). Patients were placed in the lithotomy position, and the cervix was exposed using a bivalve speculum. The exocervix was cleaned with a phosphate-buffered saline (PBS) solution (Dulbecco’s PBS solution; Irvine Scientific, Santa Anna, CA, USA), and the endocervical mucus was removed by means of a sterile Teflon catheter (Malleable Stylet Wallace, SIMCARE, Lancung, West Sussex, UK) connected to a syringe. Prior to embryo transfer, the endometrial thickness, the distance from the external cervical os to the fundal endometrial surface and the point of the tip of the catheter should reach for proper embryo replacement (approximately 15 mm from the fundal surface of the endometrium according to previous studies by us (Coroleu et al., 2002a) was measured by means of transabdominal and transvesical (with full bladder) ultrasonography. To facilitate this measurement, the speculum was withdrawn, if necessary, so that the external cervical os could be seen. Transfer was performed by the same provider (B.C.) in all patients included in the present study.

The same transfer technique was scrupulously maintained with all patients. The Wallace embryo replacement catheters, either the standard or the SureView™, connected to an insulin syringe were used for embryo transfer. Both catheters possess a stiffer outer sheath that stabilizes the softer inner cannula which carries the embryos and actually enters the endometrial cavity for embryo transfer. The catheter was first loaded with transfer medium [50% synthetic serum substitute (Irvine Scientific) and IVF-50 medium (Scandinavian IVF Science, Göthenburg, Sweden)], taking care to avoid air bubbles. The embryos were loaded in the catheter. Under ultrasound transabdominal guidance, the soft inner catheter was introduced into the cervix and passed through the internal cervical os without using the outer sheath whenever possible. If resistance was met, the inner sheath was withdrawn and the outer sheath of the catheter was then passed through the endocervix and placed to or just through the internal os, not advanced into the uterine cavity. Grasping the cervix with a tenaculum was performed to facilitate this manoeuvre only in difficult cases. The inner catheter was now threaded through the outer sheath and advanced under real-time ultrasound guidance to the preselected position. At this point, the distance between the catheter tip and the fundal endometrial surface was again measured using ultrasonography and was considered valid if it was found to be within 15 ± 2 mm from the uterine fundus. Otherwise, the inner catheter tip was very gently advanced or withdrawn and thus appropriately relocated, keeping its movement to an absolute minimum. This final distance between the catheter tip and the fundus was considered for analysis of the results. Ultrasound visualization of the catheter to obtain the preselected position for embryo transfer was assessed as excellent/good when the catheter could be easily tracked during the first pass with any or minimal transducer movement in the transverse plane. Fair/poor visualization during the procedure was recorded if marked transducer or catheter movements were necessary for appropriate catheter placement or suboptimal identification of the catheter was obtained.

In all transfers, only 30 µl of transfer medium, containing the embryos was gently expelled into the uterine cavity under sonographic control, which allowed the visualization of the transfer-associated air bubble (bubble of air between the embryos) into the uterine cavity. The catheter was gently removed immediately after transfer and then checked under a stereomicroscope to ensure that all embryos had been transferred. At the end of the procedure, patients remained resting in bed for 30 min. The ease of each transfer procedure was assessed according to the following criteria: very easy, when the catheter passed smoothly through the cervix; easy, when the rigid outer Teflon sheath was required; and difficult, when the use of a tenaculum was necessary in addition to the above.

For the specific purpose of this study, the embryologist recorded both the duration of embryo loading (i.e., the time elapsed since the embryos were removed from the incubator for loading until the loaded catheter was passed to the physician) and the duration of the embryo transfer procedure (defined as the time elapsed since the loaded catheter was handed to the physician till embryos were gently discharged into the uterus).

Pregnancy was diagnosed by increasing serum concentrations of β-HCG after embryo transfer, and the subsequent demonstration of at least one intrauterine gestational sac by ultrasonography at 6 weeks gestation or an ectopic pregnancy. Implantation rates were defined as the number of sacs seen on the 4-week postretrieval ultrasound per number of embryos transferred.

**Hormone analyses and ultrasonography**

Serum estradiol, FSH and β-HCG were determined by electrochemiluminescence immunoassay (ECLIA) on the Elecsys 2010 analyser (Roche Diagnostics, Basel, Switzerland). The inter- and intra-assay coefficients of variation were 6.2 and 5.7% for estradiol, 5.3 and 1.8% for FSH and 5.1 and 4.5% for β-HCG, respectively. Ultrasonic scans for ovarian follicular measurements were performed using a Toshiba Power vision 6000 unit (Toshiba, Tokyo, Japan) equipped with a...
5–7 MHz endovaginal probe (PVM-651VT). Transabdominal and transvesical (with full bladder) ultrasonography was carried out using a TOSBEE [SSA-240 A] convex 3.75 MHz (Toshiba).

Statistical analysis

Data are presented as mean ± SD and were analysed by Statistical Package for Social Sciences (SPSS, Chicago, IL, USA). We used the chi-square test and Fisher’s exact test to compare qualitative variables and Student’s t-test to compare quantitative variables. The significance level was set at $P < 0.05$. For pregnancy rate comparison between groups, the results are given in terms of odds ratio (OR) and 95% CIs, with OR > 1.0 corresponding to positive associations and OR < 1.0 corresponding to negative associations. CIs which did not include the value of 1.0 correspond to $P$-values < 0.05 and, hence, were considered statistically significant. Data were analysed according to intention-to-treat (ITT) population.

Results

The results are summarized in Tables I–IV. As summarized in Table I, the main demographic and baseline characteristics of the patients in the standard catheter and echogenic catheter groups were similar, including age, body mass index, causes and duration of infertility, FSH serum concentration and antral follicle count in the early follicular phase, number of assisted conceptions and number of patients undergoing ICSI. This supports the validity of the randomization process.

Table II summarizes the data regarding ovarian response, ovum retrieval and IVF outcome in the two groups studied. The type of stimulation protocol, the duration of ovarian stimulation, the total amount of gonadotrophins administered, the number of follicles punctured, serum concentration of estradiol on the day of HCG injection, the number of oocytes retrieved, the number of embryos suitable for replacement and cryopreservation, the endometrial thickness on the day of embryo transfer, the number of embryos replaced, the proportion of patients with single embryo transfer and the quality of embryos replaced were similar for the two groups of ART patients. Remarkably, the numbers of embryos per replacement as well as the mean embryo score per replacement were almost identical in the two groups.

Characteristics of embryo transfer are presented in Table III. No significant differences were found when technical details of embryo transfer procedure including the mean catheter tip–uterine fundus distance, the ease of transfer, the occurrence of blood-stained catheter and the number of patients with repeated transfer because of embryo(s) left at tip of catheter were compared, although the last three parameters were somewhat in favour of the echogenic catheter group. However, the ease of visualization of the catheter was significantly better in the echogenic catheter group. Also, while the duration of embryo loading was similar in both study groups, the duration of the embryo transfer procedure was significantly shorter in the echogenic catheter group as compared with the standard catheter group.

Table I. Main demographic and baseline characteristics of patients in the two groups studied

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard catheter (n = 95)</th>
<th>Echogenic catheter (n = 98)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>35.5 ± 3.5</td>
<td>35.9 ± 2.8</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>22.6 ± 3.1</td>
<td>22.5 ± 2.5</td>
</tr>
<tr>
<td>Cause of infertility [n (%)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>37 (38.9)</td>
<td>33 (33.7)</td>
</tr>
<tr>
<td>Tubal</td>
<td>26 (27.4)</td>
<td>27 (27.5)</td>
</tr>
<tr>
<td>Unexplained</td>
<td>17 (17.9)</td>
<td>25 (25.5)</td>
</tr>
<tr>
<td>Endometriosis</td>
<td>15 (15.8)</td>
<td>13 (13.3)</td>
</tr>
<tr>
<td>Duration of infertility (years)</td>
<td>3.6 ± 1.5</td>
<td>3.7 ± 2.1</td>
</tr>
<tr>
<td>Days 2–4 FSH (IU/L)</td>
<td>7.3 ± 2.8</td>
<td>7.7 ± 2.2</td>
</tr>
<tr>
<td>Count of antral follicles (days 2–4)</td>
<td>8.6 ± 4.6</td>
<td>8.5 ± 3.6</td>
</tr>
<tr>
<td>Number of IVF attempts</td>
<td>1.6 ± 0.8</td>
<td>1.7 ± 0.8</td>
</tr>
<tr>
<td>Number with ICSI (n, %)</td>
<td>51 (53.7)</td>
<td>64 (65.3)</td>
</tr>
</tbody>
</table>

Values are means ± SD.

Table III. Embryo transfer characteristics in the two groups studied

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard catheter (n = 95)</th>
<th>Echogenic catheter (n = 98)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter tip–fundsus distance (mm)</td>
<td>15.8 ± 1.2</td>
<td>16.1 ± 1.1</td>
</tr>
<tr>
<td>Visualization of catheter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent/good</td>
<td>54 (56.8) a</td>
<td>85 (86.7) a</td>
</tr>
<tr>
<td>Fair/poor</td>
<td>41 (43.2) b</td>
<td>13 (13.3) b</td>
</tr>
<tr>
<td>Ease of transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very easy</td>
<td>57 (60)</td>
<td>71 (72.4)</td>
</tr>
<tr>
<td>Easy</td>
<td>27 (28.4)</td>
<td>20 (20.4)</td>
</tr>
<tr>
<td>Difficult</td>
<td>11 (11.6)</td>
<td>7 (7.2)</td>
</tr>
<tr>
<td>Blood-stained catheter</td>
<td>6 (6.3)</td>
<td>2 (2.1)</td>
</tr>
<tr>
<td>Repeated transfer</td>
<td>3 (3.2)</td>
<td>2 (2.0)</td>
</tr>
<tr>
<td>Duration of embryo loading (s)</td>
<td>68.1 ± 15.6</td>
<td>67.1 ± 18.9</td>
</tr>
<tr>
<td>Duration of embryo transfer (s)</td>
<td>60.2 ± 31.6 a</td>
<td>42.6 ± 26.1 b</td>
</tr>
</tbody>
</table>

Values are n (%) or means ± SD.

Values in rows with common superscripts were significantly different: a,b: ($P < 0.001$) and c: ($P < 0.0001$).
Clinical pregnancy rates per embryo transfer showed a 12.8% absolute difference (55.2 versus 42.4%) in favour of the echogenic catheter group, though this was not statistically significant ($P = 0.08$) according to the OR (0.6) and CIs (0.33–1.04). Implantation rate was significantly higher ($P < 0.01$) in the echogenic catheter group (37.1%) than in the standard catheter group (23.2%), but this did not translate into significant higher pregnancy rates. Thus, this fact implied that the number of twin pregnancies was significantly increased in the group where the new catheter was used (Table IV). The outcome of pregnancy was not different in the two groups studied (Table IV).

### Discussion

Embryo transfer has emerged as a significant aspect influencing the success of IVF. Considerable attention is paid to atraumatic passage of the catheter through the uterine cavity and precise location of the catheter tip and site of transfer of the embryos. Easy and atraumatic transfers of embryos placed in the middle of the uterine cavity are considered essential for successful implantation (Levi Setti et al., 2003; Sallam, 2005). A diversity of techniques, monitoring and catheters has been evaluated to enhance and refine this process (Kovacs, 1999; Salha et al., 2001; Schoolcraft et al., 2001; Mansour and Aboulghar, 2002; Pasqualini and Quintans, 2002; Sallam, 2005). In this respect, transabdominal ultrasound-guided embryo transfer is designed to follow the movement of the catheter into the uterus, with the aim of enhancing transfer efficiency. It may help to refine the transfer technique by tracking the position of the cannula and transfer the catheter in relation to the endometrial surface and uterine fundus, thus avoiding endometrial damage (Pasqualini and Quintans, 2002). Using ultrasound guidance, the position and movement of a transfer-associated air bubble, and the impact of subendometrial myometrial contraction leading to endometrial movement, may also be observed. The method also permits the media drop containing the embryos to be inspected and to ensure that it is retained (Pasqualini and Quintans, 2002).

Accordingly with the above postulates, two recent meta-analyses provided robust evidence in favour that ultrasound-guided embryo transfer using transabdominal ultrasound is significantly more effective than embryo transfer by clinical touch alone (Buckett, 2003; Sallam and Sadek, 2003). Catheters could be made more readily detectable by ultrasound to refine transfer techniques even more. Some catheters already in the market have this feature, due to an echodense tip (Cook Echo-Tip catheter (Cook Ob/Gyn, Spencer, IN, USA), a modification of the soft-tip Wallace catheter in that the catheter has an echogenic stainless steel band at the tip of the inner sheath) (Letterie et al., 1999) or echogenicity extending along the whole length of the catheter (SureView Wallace embryo replacement catheter). It was hypothesized that these echogenic catheters could be immediately imaged by transabdominal ultrasonography, and with small movements of the transducer in the transverse plane, the echodense catheter would be easily tracked during passage through the entire uterine cavity into the fundal region during the first pass. This would minimize the to-and-fro motion necessary to identify the catheter tip which, in turn, would minimize disruption of the endometrium with improvement in implantation rates (Letterie et al., 1999).

The above notwithstanding, a prospective, randomized study concluded that the use of the Cook Echo-Tip catheter simplifies ultrasound-guided embryo transfer and the need to move the catheter for identification, but no differences in success rates were observed when compared with the standard Wallace catheter (Karande et al., 2002). In the current investigation, pregnancy rates were similar in the two study groups, but the upper limit of the 95% CI (1.04) and the $P$-value (0.08) obtained when the OR was used for comparison purposes between groups suggest that a trend in favour of the new echogenic catheter may exist. However, twin pregnancy rate was significantly increased ($P < 0.01$) with the use of the new catheter which was the underlying source for a significant increase in implantation rate in this group (37.1%) as compared with the standard catheter group (23.2%). In this respect, it is to note that twins and higher multiple births tend to be disadvantageous from the start, and reducing the multiple gestation pregnancy rate is considered to be a high priority for ART programmes (The ESHRE Capri Workshop Group, 2000). Therefore, the current study is still early work, and further data are needed to determine the real magnitude of any benefit with echogenic catheters, and if possible which patients would benefit the most.

The exact mechanism whereby ultrasound-guided embryo transfer improves clinical pregnancy rates and embryo implantation is unclear, although confirming the position of the tip of the embryo transfer catheter actually within the uterine cavity obviously is a major benefit (Woolcott and Stanger, 1997; Buckett, 2003). A number of studies have suggested other mechanisms whereby the IVF outcome is improved with ultrasound-guided embryo transfer, by increasing the frequency of easy transfers (Matorras et al., 2002), by avoiding bloody and/or repeated transfers (Sallam et al., 2002; Alvero et al., 2003) or by properly replacing the embryos in the midcavity (Coroleu et al., 2002a). In the current study, those physical aspects of embryo transfer as well as the depth of embryo replacement into the uterine cavity were similar in both study groups (Table III). No mock or trial embryo transfer was performed in

### Table IV. Implantation and pregnancy rates and outcome of gestation in the two groups studied

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard catheter ($n = 95$)</th>
<th>Echogenic catheter ($n = 98$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical pregnancies / ET</td>
<td>39 (41.0) b</td>
<td>53 (54.1) b</td>
</tr>
<tr>
<td>Single</td>
<td>36 (92.3)c</td>
<td>36 (67.9)c</td>
</tr>
<tr>
<td>Twins</td>
<td>3 (7.7)c</td>
<td>17 (32.1)c</td>
</tr>
<tr>
<td>Implantation rate</td>
<td>23.0g</td>
<td>37.0g</td>
</tr>
<tr>
<td>Spontaneous miscarriage</td>
<td>7 (17.9) d</td>
<td>4 (7.5) d</td>
</tr>
<tr>
<td>Ectopic pregnancy</td>
<td>1 (1.9)</td>
<td>1 (1.9)</td>
</tr>
</tbody>
</table>

Values are $n$ (%).

*Values in rows with common superscripts were significantly different ($P < 0.01$).

*Values in rows with common superscripts were significantly different ($P < 0.05$).
the current investigation, but a recent study (Henne and Milki, 2004) reported the lack of consistency in the uterine position between mock and real embryo transfer and stressed the value of using transabdominal ultrasound guidance in order to more accurately assess the uterine position and to avoid misdirecting the embryo transfer catheter.

Remarkably, however, a recent study showed that the time interval from loading the embryo transfer catheter to depositing the embryos in the uterine cavity is a prognostic factor of the implantation and pregnancy rates independent of transfer difficulty (Matorras et al., 2004). It was postulated that a longer ‘interval loading-discharging embryos’ would favour the influence of some environmental factors potentially having detrimental effects on oocytes and embryos such as exposure to light, temperature, inappropriate O2 and CO2 concentrations and other environmental conditions which would decrease implantation rates (Matorras et al., 2004). These authors stressed, however, that a relatively prolonged endocervical manipulation could also play a role (Matorras et al., 2004). In fact, limiting the time of embryo manipulation during the transfer technique may increase pregnancy rates after ART (Tomás et al., 2002; Neithardt et al., 2005). This is supported by the current study where the duration of the embryo transfer procedure from the moment when the loaded catheter was handed to the physician and up to embryo discharge was significantly shorter in the echogenic catheter group (having a higher implantation rate) than in the standard catheter group. The shorter duration of the embryo transfer procedure among patients in the echogenic catheter group would be explained by the use of the echodense catheter which facilitated catheter identification under ultrasound. This is to be noted considering that, as in our previous studies (Coroleu et al., 2002a,b), all embryo transfers were performed by a single experienced physician who consistently used the same technique, thus avoiding any impact of the ‘physician factor’ on implantation rates (Karande et al., 1999; Hearns-Stokes et al., 2000).

In conclusion, our results suggest that the use of the echogenic SureView catheter simplifies ultrasound-guided embryo transfer as compared with the widely used standard soft Wallace catheter. This notwithstanding, although this study provided sound data for later interpretation, it was intended to be a pilot study and was therefore limited by a lack of power. With a sample size of 95 and 98 patients for the standard catheter and the echogenic catheter groups, respectively, and an α of 0.05, our study had a power of 44% to detect a 13.1% absolute difference (41.0 versus 54.1%) in clinical pregnancy rate per randomized patient. Three hundred and six subjects in each catheter group would be needed to conclude that a true difference between groups existed if the reported pregnancy rates were true. Therefore, further studies are needed to confirm our results.

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