

Sperm Has an Impact on Embryonic Development and Clinical Outcomes: A Study of Sibling Oocytes.

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Research

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Abstract

Background

Good quality gametes are necessary to produce high-quality embryos in assisted reproductive technology (ART). Both the sperm and oocyte genomes constitute the embryonic genome. Up to now, there is debate about the effect of paternal factors on embryo quality and reproductive outcomes. To investigate whether paternal factors can influence embryonic development and the clinical outcomes.

Methods

The study included 50 patients undergoing split IVF/ICSI procedures: half with sperm from the partner and half with sperm from the donor. In total, 295 sibling oocytes were obtained and fertilized in two groups: partner sperm group (n=145) and donor sperm group (n=150). The main outcomes were the oocyte utilization rate (OUR) and the live birth rate (LBR).

Results

The OUR in the partner sperm group was significantly lower than that in the donor sperm group (18.62% vs. 38.00%, $P < 0.001$). The clinical pregnancy rate (CPR) and the LBR in the group of oocytes fertilized by the partner's sperm was significantly lower than that in the group fertilized by donor sperm (25.00% vs. 57.14%, $P = 0.03$; 16.67% vs. 50.00%, $P = 0.02$, respectively). Furthermore, logistic regression analysis results showed the partner sperm was associated with a significant decrease in the utilized oocyte rate and the live birth rate compared to the donor sperm (OR=0.63; 95% CI [0.42-0.94]; $P = 0.023$ and OR=0.16; 95% CI [0.04-0.69]; $P = 0.014$, respectively).

Conclusions

This study provides strong evidence to support the fact that paternal factors exert influence on embryonic development and clinical outcomes. Further studies are required to confirm and elaborate on our conclusions.

Background

Assisted reproductive technology (ART) has created significant opportunities for the treatment of most cases of infertility; however, only <50% of treatment cycles result in a delivery at term (1). Previous studies have demonstrated that gametes and embryo quality are major determinants of success in ART (2, 3). It is well established that good quality gametes are necessary to produce high-quality embryos in ART, and that both the sperm and oocyte genomes constitute the embryonic genome (4).

Significant interest has developed over recent years with respect to the potential effects of paternal factors on early embryonic development and pregnancy outcomes. Indeed, a number of studies have now demonstrated that abnormalities in sperm DNA can exert significant influence on embryo quality (5-7).

For example, Simon et al. discovered associations between increased levels of sperm DNA damage and poor embryo quality, as well as reduced implantation and pregnancy rates (8). In addition, a recently published review, considering current lines of evidence, reported that abnormal sperm chromatin structure (9-11), sperm DNA fragmentation (12, 13), Y chromosome microdeletions (14), numerical sperm abnormalities (15, 16), and epigenetic changes in the sperm (17), have all been correlated with delayed pronuclear formation, slow rates of embryonic development, and impaired clinical outcomes (18). In contrast, other reports have presented conflicting and inconsistent opinions with regards to this matter. For example, Gill et al. found no associations between the maturity of sperm chromatin and embryonic development or the competence to achieve pregnancy (19). These findings were in accordance with some other independent studies that also failed to identify correlations between the maturity of sperm chromatin and reproductive success (20-25). Moreover, a recent systematic review considered after 859 publications on sperm DNA fragmentation and highlighted the fact that current tests for sperm DNA fragmentation have little or no value with regards to predicting embryo quality and pregnancy outcomes (26). Consequently, there is significant debate in the current literature with regards to the effect of paternal factors on embryo quality and reproductive outcomes.

The aim of this study was thus to use sibling oocytes to investigate the relative effect of sperm from two sources (partner and donor) on OUR, CPR, and LBR. Data derived from these experiments will allow us to determine whether sperm exerts impact on embryonic development and final clinical outcomes.

Materials And Methods

Study Design and Participants Cohort

This retrospective cohort study featured a sibling design was performed at the Center for Reproductive Medicine in Shandong University between January 2010 and October 2019. During the study period, 205 ART cycles were carried out in which half of the acquired oocytes were fertilized with the partner's sperm by intracytoplasmic sperm injection (ICSI) and half were fertilized with sperm from a donor by in vitro fertilization (IVF). The indications of the strategy were as follows: (i) the number of the partner sperm was inadequate to fertilized all of the obtained oocytes; (ii) the quality of embryos was extremely poor (with no embryos to transfer on day 3) in the first few cycles. The exclusion criteria were as follows: the first cycles (n=39)(indication i) the fertilization rate with the partner's sperm following ICSI was < 50% (n=116). Ultimately, our study involved 50 cycles and 295 sibling oocytes. The oocytes were randomly divided into two groups according to the source of sperm: a group fertilized by the partner's sperm (n=145) and a group fertilized by a donor's sperm (n=150). The participant selection process is detailed in Figure 1. The main outcomes were OUR and LBR. This study was conducted in accordance with the guidelines of the International Conference on Harmonization and approved by the Institutional Review Board of Reproductive Medicine at Shandong University (Registration number: 2013 IRB NO. 19). All participants gave written informed consent in this study.

Ovarian stimulation, oocyte insemination, embryo culture and scoring

There were no restrictions with regards to the type of ovarian stimulation protocol applied. Ovarian stimulation and oocyte pick-up were carried out as described previously (27). Cumulus oocyte complexes (COCS) were either inseminated in a 4-well plate with approximately 10,000 motile sperm per oocyte (IVF) or underwent ICSI as appropriate, based on the presence or absence of male infertility. All steps were carried out using sequential culture media from Vitrolife (G-IVF, G1 and G2; Scandinavian IVF Science, Sweden; 10135, 10127 and 10131). On Day 3, two high quality embryos derived from the partner's sperm were routinely selected for embryo transfer (ET). High quality embryos on day 3 were defined as those with ≥ 7 cells and a grade ≥ 3 according to Puissant's criteria (28). Blastocyst culture was then performed for all surplus embryos containing ≥ 4 cells that were \geq grade 2 until day 5 or 6. Blastocyst quality was assessed according to Gardner and Lane's classification (29). Based on this classification, only blastocysts scored $\geq 4BC$ were selected for transfer or cryopreservation.

Frozen-thawed blastocyst transfer

Endometrial thickness was measured by ultrasound and only patients with a thickness ≥ 8 mm were assigned to undergo frozen-thawed blastocyst transfer. Vitrified blastocysts were thawed on the morning of the day of transfer. Assisted hatching was applied for all thawed blastocysts; this involved partial removal of the ZP by laser. Blastocysts were then incubated for 4-5 hours at 37°C in an atmosphere containing 6% CO₂. Only expanded blastocysts were transferred. If none of the blastocysts had expanded, then we would thaw and transfer blastocysts of other grades, or cancel the cycle if no blastocysts remained. Blastocysts derived from donor sperm were thawed to transfer unless no blastocysts derived from the partner's sperm were available. We routinely provided 12 days of luteal support, regardless of whether pregnancy had been achieved or not. Patients with an ongoing pregnancy were provided with progesterone for the first 10 weeks of gestation; the dose was gradually reduced after the fetal heart beat had been detected.

Diagnosis of pregnancy

A clinical pregnancy was defined as the detection of fetal cardiac activity 7 weeks after embryo transfer. A live birth was defined as the delivery of a viable infant after ≥ 28 weeks of gestation. Miscarriage was defined as the loss of a gestational sac after <20-28 weeks of gestation.

Statistically analysis

All statistical analyses were carried out using SPSS version 16.0. Mean and proportional data were analyzed by the Student's t-test, Chi-squared test, or Fisher's exact test, as appropriate. A P value < 0.05 was considered to be statistically significant. In order to locate the relationship of the source of sperm (partner and donor) with the utilized oocyte rate and live birth rate, we performed a logistic regression analysis , controlling for the female age and the fresh cycle number.

Results

Baseline characteristics for all cases are shown in Table 1. Because this was a study involving sibling oocytes, the female baseline characteristics were equivalent when compared between the two groups.

As shown in Table 2, there was no significant difference in the fertilization rate between the two groups, however, the rate of good quality embryos on day 2 in the partner sperm group was significantly lower than that in the donor sperm group (47.50% vs. 67.69%, $P=0.001$). In addition, a higher proportion of embryos derived from the partner's sperm were transferred in fresh cycles compared with the proportion of embryos derived from donor sperm (14.48% vs. 6.00%, $P=0.02$). Furthermore, the proportion of frozen blastocysts that were utilized in the partner sperm group was significantly lower than the proportion of frozen blastocysts utilized in the donor sperm group (4.84% vs. 34.04%, $P<0.001$); the same trend was apparent for the proportion of oocytes utilized (18.62% vs. 38.00%, $P<0.001$).

Next, we compared the clinical outcomes between the partner sperm derived embryo transfers and the first donor sperm derived embryo transfers after pregnancy failure transferred with partner sperm derived embryos, in order to investigate the developmental potential of transferred embryos derived from two sources (partner sperm and donor sperm). There were no significant differences in the baseline characteristics in the two groups (Table 3). However, the CPR and LBR in the group of oocytes fertilized by the partner's sperm was significantly lower than that in the group fertilized by donor sperm (25.00% vs. 57.14%, $P=0.03$; 16.67% vs. 50.00%, $P=0.02$, respectively). The CPR of the first donor sperm derived embryo transfers after pregnancy failure with partner sperm derived embryos increased to 57.14% (8/14), while LBR increased to 50.00% (7/14) (Figure 2).

After logistic regression analysis adjusting for female age and the fresh cycle number, we found that partner sperm was associated with a significant decrease in the utilized oocyte rate and the live birth rate compared to donor sperm (OR=0.63; 95% CI [0.42-0.94]; $P=0.023$ and OR=0.16; 95% CI [0.04-0.69]; $P=0.014$, respectively) (Table 4).

Discussion

Principal findings

The data generated by the present study provide strong evidence that sperm quality is associated with embryonic development and final clinical outcomes.

Strengths of the study

The primary strength of our study is that we focused on sibling oocytes, thus eliminating any potential bias relating to female factors. To our knowledge, this is the first study to explore the effect of paternal factors on embryonic development and the clinical outcomes with sibling oocytes. In this study, we observed a significant improvement in clinical outcomes following the first ET with embryos derived from donor sperm in cases where previous ETs, involving embryos derived from the partner's sperm, failed to achieve pregnancy. This split IVF/ICSI strategy might be helpful for patients with no embryos to transfer

in the first few cycles. There are several advantages to this strategy. First, this method provides patients with one or more alternative options for treatment, thus relieving psychological pressure. Second, this method can alleviate economic stress incurred by the patients by increasing the utilization rate of the oocytes acquired. Third, this method may help to define reasons for patients with impaired embryo quality in the first few cycles.

Limitation of the data

However, several limitations need to be considered in interpreting our findings. First, the sample size of the study was relatively small. Second, we did not evaluate sperm DNA fragmentation in semen samples because this is not a routine form of analysis in our center. Finally, the study was limited by the nature of retrospective study.

Interpretation

Our results are in agreement with a number of previous studies showing that abnormalities in sperm morphology and DNA integrity can exert negative effects on embryo quality and development (5-8). Our findings also concur with a recently published review article that provided significant evidence to support the fact that sperm with an abnormal structure of chromatin fragmented DNA, Y chromosome microdeletion, an abnormal number of chromosomes, or an altered genetic imprint, may be correlated to poor fertilization rates, and the impairment of embryogenesis and development (14). However, our results do not support a number of previous publications that found no association between the maturity of sperm chromatin or sperm DNA fragmentation with embryonic development and pregnancy outcomes (30, 31). We believe that these discrepancies are related to inconsistencies in the methods used to determine sperm DNA; it is highly evident that we do not have a gold standard for determining sperm DNA fragmentation at present.

In this study, we observed that the proportion of high quality embryos on day 2 in the group derived from the partner's sperm was significantly lower than that in the group derived from the donor sperm. The results of our experiments fail to support the hypothesis that zygotic genome activation only occurs after the 4-cell stage in humans (32). However, our results are in accordance with the study previously reported by Simon which showed that increased levels of sperm DNA damage can exert negative impact on embryo quality, beginning on day 2 of early embryonic development and continuing after embryo transfer, thus leading to lower implantation rates and pregnancy outcomes (8). In addition, our current data concurred with those generated by Harrouk et al., who previously demonstrated that sperm DNA damage might be translated into chromosome aberration as early as the first metaphase (33). Further studies are now needed to confirm these results.

Apart from paternal factors, a range of female factors are known to be involved in the creation of high quality embryos with the competence to implant, including a number of factors associated with cytoplasmic maturation and nuclear maturation. In the present study, we found an interesting phenomenon in that, for some of the included couples, the proportion of utilized oocytes did not differ

when compared between the group of oocytes fertilized by the partner's sperm and those fertilized by a donor's sperm. Our explanation for this phenomenon is that the delayed embryonic development in these patients might be attributed to the maturity and quality of the oocytes. These results are consistent with the results published previously by Ziegler et al., and others, which reported that a number of female and environmental factors can exert significant influence on embryonic development and implantation (26).

Conclusions

In conclusion, this study provides strong evidence that the sperm can exert impact on embryonic development and ultimate clinical outcomes. Further studies are required to confirm and elaborate on our conclusions.

Abbreviations

ART: assisted reproduction technology; IVF: in vitro fertilization; ICSI: intracytoplasmic sperm injection; FET: frozen embryo transfer; CPR: clinical pregnancy rate; LBR: live birth rate; ET: embryo transfer; OUR: oocyte utilization rate.

Declarations

Ethics approval and consent to participate

Our study was approved by the Institutional Review Board of Reproductive Medicine at Shandong University. All patients admitted at our center had consented to the anonymous use of their medical data for scientific research, and publication, and informed consents were previously signed before their treatments. All participants gave written informed consent in this study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

HBZ and ZY analyzed the data and prepared the manuscript. HBZ drafted the manuscript. ML reviewed the manuscript. KLW designed the study. All authors have read and approved the final manuscript. HBZ and ZY contributed equally to this study.

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References

1. Ajduk A, Zernicka-Goetz M. Quality control of embryo development. *Mol Aspects Med.* 2013;34:903-918. doi: 10.1016/j.mam.2013.03.001.
2. Scott L. Pronuclear scoring as a predictor of embryo development. *Reprod Biomed Online.* 2003;6:201-214. doi: 10.1016/s1472-6483(10)61711-7.
3. Terriou P, Giorgetti C, Hans E, Salzmann J, Charles O, Cignetti L, Avon C, Roulier R. Relationship between even early cleavage and day 2 embryo score and assessment of their predictive value for pregnancy. *Reprod Biomed Online.* 2007;14:294-299. doi: 10.1016/s1472-6483(10)60870-x.
4. Marteil G, Richard-Parpaillon L, Kubiak JZ. Role of oocyte quality in meiotic maturation and embryonic development. *Reprod Biol.* 2009;9:203-224. doi: 10.1016/s1642-431x(12)60027-8.
5. Virro MR, Larson-Cook KL, Evenson DP. Sperm chromatin structure assay (SCSA) parameters are related to fertilization, blastocyst development, and ongoing pregnancy in in vitro fertilization and intracytoplasmic sperm injection cycles. *Fertil Steril.* 2004;81:1289-1295. doi: 10.1016/j.fertnstert.2003.09.063.
6. Benchaib M, Lornage J, Mazoyer C, Lejeune H, Salle B, Guerin JF. Sperm deoxyribonucleic acid fragmentation as a prognostic indicator of assisted reproductive technology outcome. *Fertil Steril.* 2007;87:93-101. doi: 10.1016/j.fertnstert.2006.05.057.
7. Simon L, Brunborg G, Stevenson M, Lutton D, McManus J, Lewis SEM. Clinical significance of sperm DNA damage in assisted reproductive outcome. *Hum Reprod.* 2010;25:1594-1608. doi: 10.1093/humrep/deq103.
8. Simon L, Murphy K, Shamsi MB, Liu L, Emery B, Aston KI, Hotaling J, Carrell DT. Paternal influence of sperm DNA integrity on early embryonic development. *Hum Reprod.* 2014;29(11):2402-2412. doi: 10.1093/humrep/deu228.

9. Carrell DT, Hammoud SS. The human sperm epigenome and its potential role in embryonic development. *MHR: Basic science of reproductive medicine*. 2009;16:37-47. doi: 10.1093/molehr/gap090.
10. Nanassy L, Liu L, Griffin J, T Carrell D. The clinical utility of the protamine 1/protamine 2 ratio in sperm. *Protein Pept Lett*. 2011;18:772-777. doi: 10.2174/092986611795713934.
11. Nasr-Esfahani MH, Salehi MO, Razavi S, Mardani M, Bahramian H, Steger K. Effect of protamine-2 deficiency on ICSI outcome. *Reprod BioMed Online*. 2004;9:652-658. doi: 10.1016/s1472-6483(10)61776-2.
12. Oleszczuk K, Augustinsson L, Bayat N, Giwercman A, Bungum M. Prevalence of high DNA fragmentation index in male partners of unexplained infertile couples. *Andrology*. 2013;1:357-360. doi: 10.1111/j.2047-2927.2012.00041.x.
13. Zini A, Libman J. Sperm DNA damage: importance in the era of assisted reproduction. *Curr Opin Urol*. 2006;16:428-434. doi: 10.1097/01.mou.0000250283.75484.dd.
14. Colaco S, Modi D. Genetics of the human Y chromosome and its association with male infertility. *Reprod Biol Endo*. 2018;16:14. doi: 10.1186/s12958-018-0330-5.
15. Fragouli E, Alfarawati S, Spath K, Wells D. Morphological and cytogenetic assessment of cleavage and blastocyst stage embryos. *Mol Hum Reprod*. 2013;20:117-126. doi: 10.1093/molehr/gat073.
16. Kirkpatrick G, Ferguson KA, Gao H, Tang S, Chow V, Yuen BH. A comparison of sperm aneuploidy rates between infertile men with normal and abnormal karyotypes. *Hum Reprod*. 2008;23:1679-1683. doi: 10.1093/humrep/den126.
17. Laurentino S, Borgmann J, Gromoll J. On the origin of sperm epigenetic heterogeneity. *Reproduction*. 2016;151:R71-78. doi: 10.1530/REP-15-0436.
18. Colaco S, Sakkas D. Paternal factors contributing to embryo quality. *J Assist Reprod Genet*. 2018;35(11):1953-1968. doi: 10.1007/s10815-018-1304-4.
19. Gill K, Rosiak A, Gaczarzewicz D, Jakubik J, Kurzawa R, Kazienko A, Rymaszewska A, Laszczynska M, Grochans E, Piasecka M. The effect of human sperm chromatin maturity on ICSI outcomes. *Hum Cell*. 2018;31(3):220-231. doi: 10.1007/s13577-018-0203-4.
20. Rubino P, Viganò P, Luddi A, Piomboni P. The ICSI procedure from past to future: a systematic review of the more controversial aspects. *Hum Reprod Update*. 2016;22:194-227. doi: 10.1093/humupd/dmv050.
21. Bach PV, Schlegel PN. Sperm DNA damage and its role in IVF and ICSI. *Basic Clin Androl*. 2016;26:15. doi: 10.1186/s12610-016-0043-6.
22. Bronet F, Martínez E, Gaytán M, et al. Sperm DNA fragmentation index does not correlate with the sperm or embryo aneuploidy rate in recurrent miscarriage or implantation failure patients. *Hum Reprod*. 2012;27:1922-1929. doi: 10.1093/humrep/des148.
23. Coughlan C, Clarke H, Cutting R. Sperm DNA fragmentation, recurrent implantation failure and recurrent miscarriage. *Asian J Androl*. 2015;17:681-685. doi: 10.4103/1008-682X.144946.

24. Tavalae M, Razavi S, Nasr-Esfahani MH. Influence of sperm chromatin anomalies on assisted reproductive technology outcome. *Fertil Steril*. 2009;91:1119-1126. doi: 10.1016/j.fertnstert.2008.01.063.
25. Zhang Z, Zhu L, Jiang H, Chen H, Chen Y, Dai Y. Sperm DNA fragmentation index and pregnancy outcome after IVF or ICSI: a meta-analysis. *J Assist Reprod Genet*. 2015;32:17-26. doi: 10.1007/s10815-014-0374-1.
26. Cissen M, Wely MV, Scholten I, Mansell S, Bruin JP, Mol BW, Braat D, Repping S, Hamer G. Measuring Sperm DNA Fragmentation and Clinical Outcomes of Medically Assisted Reproduction: A Systematic Review and Meta-Analysis. *PLoS One*. 2016;11(11):e0165125. doi: 10.1371/journal.pone.0165125.
27. Wu KL, Zhao HB, Liu H, Li M, Ma S, Li C, et al. Day 3 ET, single blastocyst transfer (SBT) or frozen-thawed embryo transfer (FET): which is preferable for high responder patients in IVF/ICSI cycles? *J Assist Reprod Genet*. 2014;31:275-278. doi: 10.1007/s10815-013-0156-1.
28. Puissant F, Van RM, Barlow P. Embryo scoring as a prognostic tool in IVF treatment. *Hum Reprod*. 1987;2:705-708. doi: 10.1093/oxfordjournals.humrep.a136618.
29. Gardner DK, Lane M. Culture and selection of viable blastocysts: a feasible proposition for human IVF? *Hum Reprod Update*. 1997;3:367-382. doi: 10.1093/humupd/3.4.367.
30. Anifandis G, Bounartzi T, Messini CI, Dafopoulos K, Markandona R, Sotiriou S, Messinis IE. Sperm DNA fragmentation measured by Halosperm does not impact on embryo quality and ongoing pregnancy rates in IVF/ICSI treatments. SDF measured by does impact embryo and pregnancy in/treatments. *Andrologia*. 2014;47:295-302. doi: 10.1111/and.12259.
31. Chi HJ, Chung DY, Choi SY, Kim JH, Kim GY, Lee JS, Roh SI. Integrity of human sperm DNA assessed by the neutral comet assay and its relationship to semen parameters and clinical outcomes for the IVF-ET program. *Clinical and Experimental Reproductive Medicine*. 2011;38, 10-17. doi: 10.5653/cerm.2011.38.1.10.
32. Edwards RG, Hollands P. New advances in human embryology: implications of the preimplantation diagnosis of genetic disease. *Hum. Reprod*. 1988;3:549-556. doi: 10.1093/oxfordjournals.humrep.a136742.
33. Harrouk W, Codrington A, Vinson R, Robaire B, Hales BF. Paternal exposure to cyclophosphamide induces DNA damage and alters the expression of DNA repair genes in the rat preimplantation embryo. *Mutat Res*. 2000;461:229-241. doi: 10.1016/s0921-8777(00)00053-7.

Tables

Table 1. The demographics of patients included in this study

	Donor sperm IVF/partner sperm ICSI cycles (n=50)
Mean number of cycle	2.90 ± 0.93
Female age (years)(±SD)	30.74 ± 4.96
BMI (kg/m ²)	22.64 ± 3.39
Type of infertility	
Primary (%)	78.00% (39/50)
Secondary (%)	22.00% (11/50)
Patient's ovarian reserve	
Basal serum FSH (IU/l)	6.78 ± 2.08
Basal serum LH (IU/l)	5.46 ± 3.22
AMH (ng/ml)	5.09 ± 2.73
Stimulation protocol	
Long protocol (%)	56.00% (28/50)
Short protocol (%)	12.00% (6/50)
Other protocols (%)	32.00% (16/50)
E2 on hCG trigger day (pg/ml)	4702.00 ± 2645.04
Duration of stimulation (days)	10.00 ± 2.26
Total dose of Gn administrated (IU)	2268.84 ± 1154.36
Number of OCCC retrieved (mean ± SD)	12.62 ± 4.54
partner age (years)(±SD)	31.44 ± 5.21
BMI (kg/m ²)	24.72 ± 3.03
partner sperm analysis parameters	
Volume	2.41±1.39
Concentration (×10 ⁶ /ml)	17.92 ± 18.22
Rapid forward motility(%)	12.48% ± 14.87%
Donor sperm analysis parameters	
Volume	2.00 ± 0.00
Concentration (×10 ⁶ /ml)	47.68 ± 7.26
Rapid forward motility(%)	38.64% ± 6.15%

BMI☐body mass index; FSH☐follicle-stimulating hormone; LH☐luteinizing hormone; AMH☐anti mullerian hormone.

Table 2. IVF/ICSI embryonic outcomes of embryos derived from partner sperm versus embryos derived from donor sperm

^a χ^2 test or Fisher's exact test.

	Partner sperm	Donor sperm	<i>P</i>
Number of MII oocytes	145	150	-
Fertilized oocytes (%)	82.76%(120/145)	86.67%(130/150)	0.35 ^a
Good quality embryos on day 2 (%)	47.50%(57/120)	67.69%(88/130)	0.001 ^a
Good quality embryos on day 3 (%)	36.67%(44/120)	47.69%(62/130)	0.08 ^a
Transferred embryos in fresh cycles (%)	14.48%(21/145)	6.00%(9/150)	0.02 ^a
Frozen blastocysts (%)	4.84%(6/124)	34.04%(48/141)	<0.001 ^a
Utilized oocytes (%)	18.62%(27/145)	38.00%(57/150)	<0.001 ^a

Table 3. Clinical outcomes of partner sperm derived embryos versus first donor sperm derived embryos after pregnancy failure

	Partner sperm	Donor sperm	<i>P</i>
Total number of cycles	36	14	-
Mean number of cycle	2.84 ± 0.87	2.93 ± 0.92	0.90 ^b
Female age (years)(±SD)	30.65 ± 5.00	30.86 ± 5.88	0.74 ^b
Clinical pregnancy rate	25.00%(9/36)	57.14%(8/14)	0.03 ^a
Live birth rate	16.67%(6/36)	50.00%(7/14)	0.02 ^a
Miscarriage rate	33.33%(3/9)	12.50%(1/8)	0.31 ^a

^a χ^2 test or Fisher's exact test.

^b *t* test.

Table 4. Logistic regression analysis results of the source of sperm (partner versus donor) affecting the utilized oocyte rate and live birth rate.

	OR	95% CI	<i>P</i>
Utilized oocyte rate	0.63	0.42-0.94	0.023 ^a
Live birth rate	0.16	0.04-0.69	0.014 ^a

^a *P* value after logistic regression analysis controlling for the female age and the fresh cycle number.

Figures

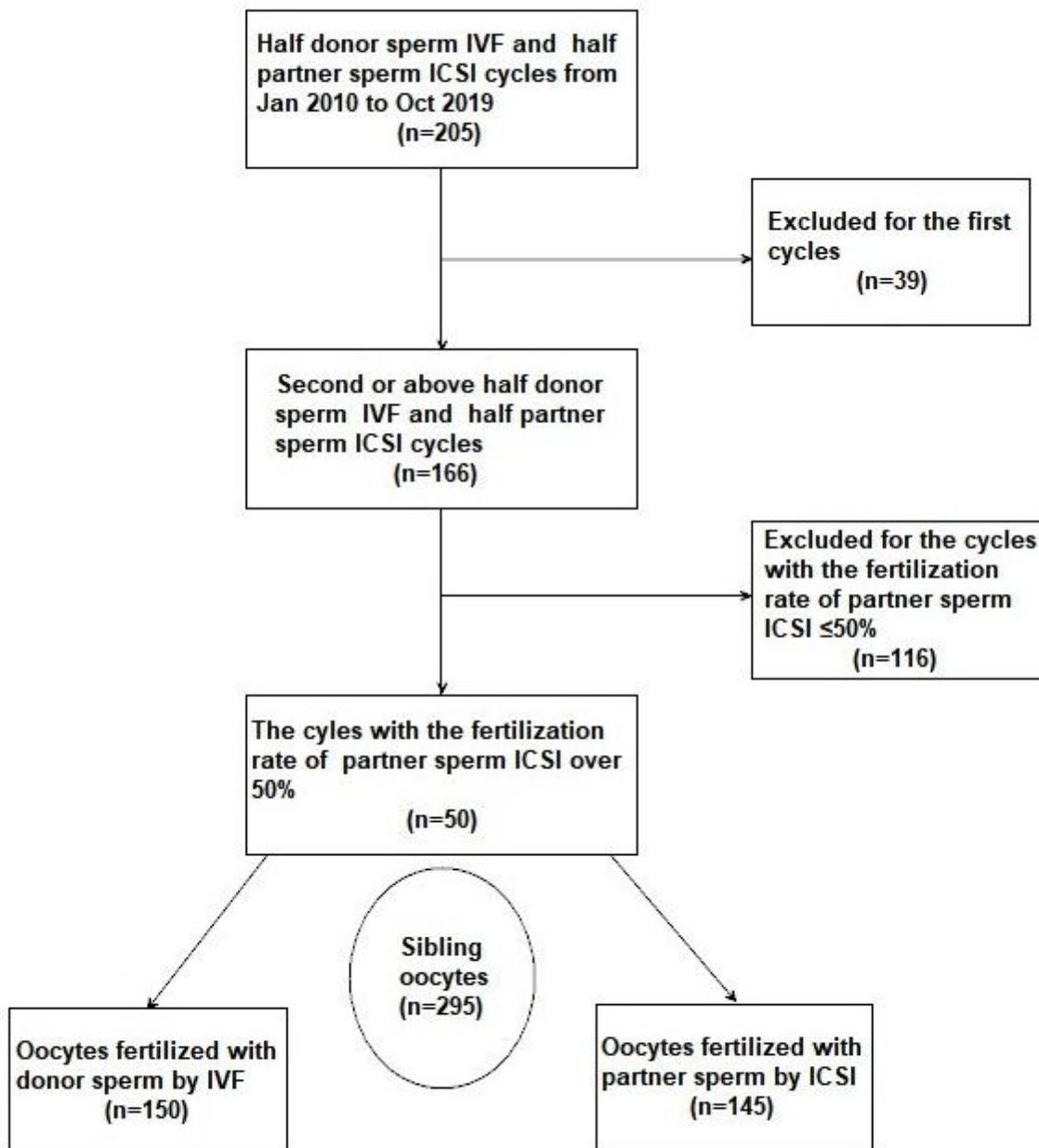


Figure 1

Flowchart of patients through the trial

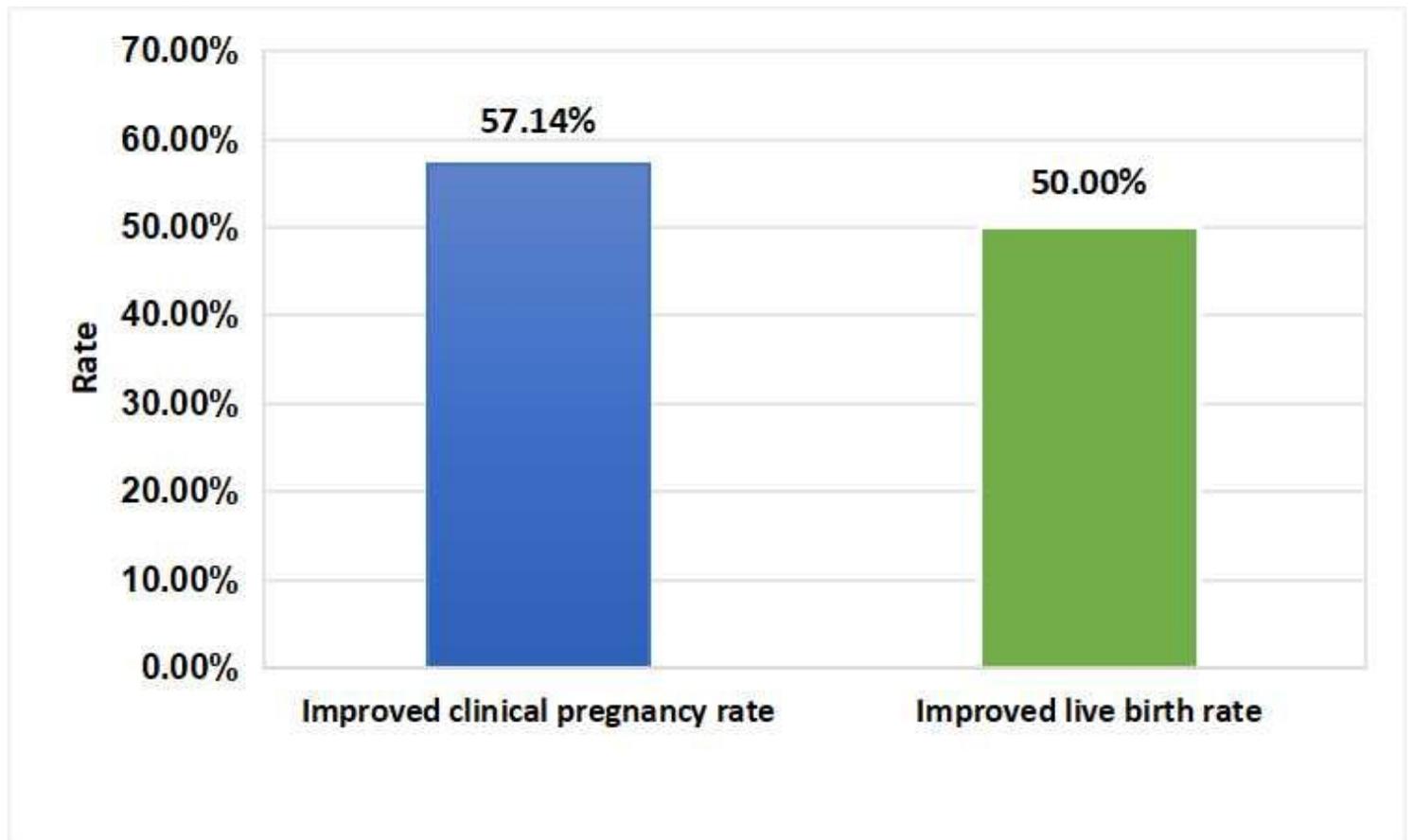


Figure 2

The improved clinical outcomes following first donor sperm derived embryos transfers after pregnancy failure