Int. J Med. Pharm. Res. (P-ISSN: 2958-3675 | E-ISSN: 2958-3683)
Available on: https://ijmpr.in/

International Journal
of Medical and Pharmaceutical Research

ORGINAL ARTICLE **OPEN ACCESS**

A Retrospective Study of Comparison of Maternal and Fetal Outcomes in IVF Pregnancy versus Spontaneous Conception

Dr. Raksha, H. S[1], Dr. Anita Sharma[2], Dr. Asha Verma[3], Dr. Mamta Meena[4]*, Dr. Bhanuja Choudhary[5], Dr. Pooja Choudhary[1]

[1]3rd Year Postgraduate, Department of Obstetrics and Gynaecology, SMS Medical College, Gangawal Park, Adarsh Nagar, Jaipur, Rajasthan 302007, India
[2]Professor, Department of Obstetrics and Gynaecology, SMS Medical College, Gangawal Park, Adarsh Nagar, Jaipur, Rajasthan 302007, India
[3]Senior Professor, Department of Obstetrics and Gynaecology, SMS Medical College, Gangawal Park, Adarsh Nagar, Jaipur, Rajasthan 302007, India
[4]Assistant Professor, Department of Obstetrics and Gynaecology, SMS Medical College, Gangawal Park, Adarsh Nagar, Jaipur, Rajasthan 302007, India
[5]Senior Resident, Department of Obstetrics and Gynaecology, SMS Medical College, Gangawal Park, Adarsh Nagar, Jaipur, Rajasthan 302007, India

OPEN ACCESS

***Corresponding Author**
Dr. Mamta Meena

Assistant Professor, Department of Obstetrics and Gynaecology, SMS Medical College, Gangawal Park, Adarsh Nagar, Jaipur, Rajasthan 302007, India

Received: 04-07-2024
Accepted: 20-08-2024
Available online: 22-08-2024

A B S T R A C T

Introduction*:** Infertility has become a significant social and medical concern affecting couples worldwide. Over decades, assisted reproductive technique has become a boon for couples to help them with conception. Despite the widespread clinical use and success of In vitro fertilization, its effects on pregnancy, maternal and fetal outcomes are still contentious. With a rise in concerns over increased risk of adverse maternal and fetal/neonatal outcome, this retrospective study was designed with an aim to study and compare the maternal and fetal outcomes in IVF pregnancies versus spontaneous conception. ***Methods: This is a retrospective cohort study. After taking informed and written consent, 100 patients conceived by IVF/ICSI with frozen embryo transfer are taken as cases and 100 patients with spontaneous conception who delivered during this period as controls. Data was analyzed using chi square test and results expressed by p value. p value less than 0.05 was considered as significant. ***Results:*** Mean age among study group was 28.59 ±4.74 years and in control group was 24.81±4.77 years with significant p value of <0.001. Incidence of maternal and fetal complications like multiple pregnancy (21% vs 6%), PIH (20% vs 9%), preterm (25% vs 13%) deliveries and intrauterine growth restriction (16% vs 11%) was significantly higher in study group compared to control group with p value of <0.05. no statistically significant differences were found in the incidence of GDM (7% vs 3%), spontaneous abortions (18% vs 8%), IHCP (5% vs 6%), anemia (9% vs 14%), blood transfusion (7% vs 9%), PROM (8% vs 13%), APH (2% vs 6%), sudden IUFD (1% vs 2%), PPH (4% vs 7%) and surgical site infection (3.7% vs 13%) among two groups. Significant higher low birth weight rate was noted among study group (44.44%) compared to control group (19.56%). No statistical significance was established regarding nicu admissions and cause of neonatal admission among two groups. ***Conclusion***: In our study, we concluded that IVF conceived pregnancies are associated with higher maternal and neonatal complications compared to spontaneously conceived pregnancy. And we emphasized on need for shift of trend towards choosing fresh embryo transfers and natural cycle stimulated cycles instead of frozen embryo transfer whenever possible with single embryo transfer and focusing on attaining a healthy singleton pregnancy.

Keywords: ART- Assisted reproductive techniques, IVF- Invitro fertilization, ICSI- Intracytoplasmic sperm injection, NICU- Neonatal intensive care unit.

INTRODUCTION

Infertility has become a significant social and medical concern affecting couples worldwide affecting almost one out of six couples of reproductive age [1]. Estimates shows that the prevalence of infertility in India is 17.9% [2]. With an increase in prevalence of infertility in the past decade that has shown to impose a psychological burden on couples and families, assisted reproductive technique has become an attractive option and boon for couples to help them with conception and ultimately giving birth to a healthy baby.

Despite the widespread clinical use and success of In vitro fertilization, its effects on pregnancy, maternal and fetal outcomes are still contentious. While the outcome and complications of IVF pregnancy is said to be equal as that of spontaneous conception, publications of nationally and internationally collected data says otherwise [3-5]. Literature suggests that women conceived with IVF are at greater risk of developing gestational hypertension, preeclampsia, GDM, intrahepatic cholestasis of pregnancy, placental abruption, and placenta praevia than spontaneously conceived pregnancies [6]. Studies have suggested that IVF conception is associated with higher risk of multiple pregnancies and complications associated with it preterm labor, PPROM, low birth weight, increased nicu admissions [7].

Many studies in past are limited to pregnancy rates and live birth rates in ART, and there is relative lack in research related to pregnancy complications and adverse birth outcomes in IVF-ET pregnancies in India. Even because of the trend shift from fresh to frozen embryo transfer in last decade, there is a lack of robust clinical evidence regarding maternal and neonatal outcomes. With a rise in concerns over increased risk of adverse maternal and fetal/neonatal outcome, this retrospective study was designed with an aim to study and compare the maternal and fetal outcomes in IVF pregnancies versus natural conception.

MATERIAL AND METHODOLOGY

This is a retrospective cohort study conducted at IVF center in a tertiary care hospital under department of obstetrics and gynecology, SMS medical college, Jaipur, Rajasthan, India planned over a period of 2 years (2022 October to 2023 November). In this study 100 patients conceived by IVF/ICSI with frozen embryo transfer as cases and 100 patients with spontaneous conception who delivered during this period as controls were included. After obtaining the informed and written consent, the details of cases and controls were taken from medical record section. The Performa was filled with details including maternal age, duration of marriage, parity, gestational age, number of fetus (singleton or multifetal pregnancy). Obstetrical outcomes like Anemia, pregnancy induced hypertension, gestational diabetes mellitus, intrahepatic cholestasis of pregnancy, premature rupture of membranes, preterm labor, antepartum, and postpartum hemorrhage, and its causes, need for blood transfusion were noted.

Spontaneous/missed abortions, intrauterine fetal demise, mode of delivery, baby weight, baby status, nicu admission and cause of admissions were also noted.

Inclusion Criteria

- Patients conceived by IVF/ICSI with frozen embryo transfer as cases and patients with spontaneous conception who delivered during the period of study as controls.
- All patients giving written and informed consent.
- Women who are not included in any other study.

Exclusion Criteria

- Patients with co-existing medical disorders (cardiac disease, pregestational diabetes, hypertension, diagnosed haematological disorders) were excluded from the study.

Statistical Analysis

Observational and inferential statistical analysis has been carried out in the present study. The data obtained was entered into Microsoft Excel worksheet and then analysed using chi square test and results expressed by p value. p value less than 0.05 was considered as significant.

RESULTS AND DISCUSSION

Table 1: Comparison of age of patients

	Study Group (n=100),(%)	**Control Group (n=100),(%)**	**P value**
Age At Conception			
<30 (non-advanced)	62(62%)	89(89%)	<0.001
>30(advanced)	38 (38%)	11(11%)	
Mean age	28.59 ±4.74	24.81±4.77	<0.001*

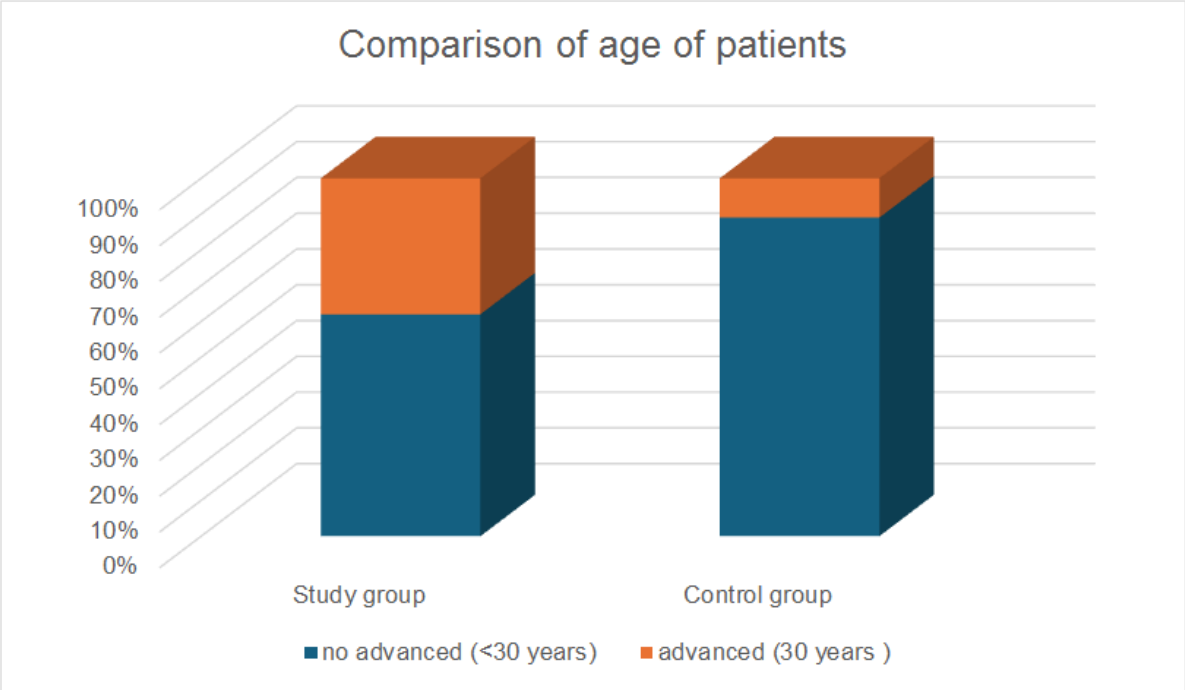

Figure 1: Comparison of age of patients

In the present study, we noticed that the mean age among study group was 28.59 ±4.74 years and in control group was 24.81±4.77 years. 38% of females belonged to advanced age group among study group whereas only 11% participants were over 30 years among the control group. The mean age, as well as the distribution among two subgroups, was significantly different between the two groups, as shown in Table 1 (p<0.001).

Table 2: Pregnancy induced complications in IVF study group and spontaneously conceived controls population.

Obstetrical complications	Study Group (n=100),(%)	Control Group (n=100),(%)	P value
Multiple pregnancy	21 (21%)	6(6%)	<0.001
Spontaneous abortion	18(18%)	8(8%)	0.103
PIH	20(20%)	9(9%)	0.042
GDM	7(7%)	3(3%)	0.194
IHCP	5(5%)	6(6%)	0.756
Anaemia	9(9%)	14(14%)	0.268
BLOOD TRANSFUSION	7(7%)	9(9%)	0.346
PROM	8(8%)	13(13%)	0.631
Preterm delivery	25 (25%)	13(13%)	0.011
APH	2(2%)	6(6%)	0.279
IUGR	16(16%)	11 (11%)	0.002
SUDDEN IUFD	1(1%)	2(2%)	0.249
Vaginal Delivery	1	62	<0.0001(Mode of delivery)
LSCS	81	30	
PPH	4(4%)	7(7%)	0.767
Surgical site infection	3 (3.7%)	4 (13%)	0.197

While the incidence of multifetal pregnancy, pregnancy induced hypertension, preterm delivery and intrauterine growth restriction was significantly higher in the study group (p<0.05), rate of intrahepatic cholestasis of pregnancy, anemia, premature rupture of membranes, antepartum hemorrhage, sudden intrauterine fetal demise was slightly higher in control group. However, the risk did not differ significantly between the two groups (p>0.05). Even though the incidence of gestational diabetes mellitus was higher in study group, it was not statistically significant (p>0.05). Higher incidence of PPH was found among spontaneous conception group (7%) and the rate of surgical site infection was much higher (13%) in control population compared to 3.7% among study population.

Table 3: Comparison of neonatal outcomes

	Study Group (n=81),(%)	Control Group (n=92),(%)	P value
NICU admission	22 (27.16%)	19 (20.65%)	0.177
Foetal distress/ RDS	12 (14.81%)	10(10.86%)	
Neonatal jaundice	6 (7.40%)	6 (6.5%)	
Birth Weight			
<2.5 kg	36 (44.44%)	18 (19.56%)	0.01
>2.5 kg	54 (66.66%)	64 (69.56%)	

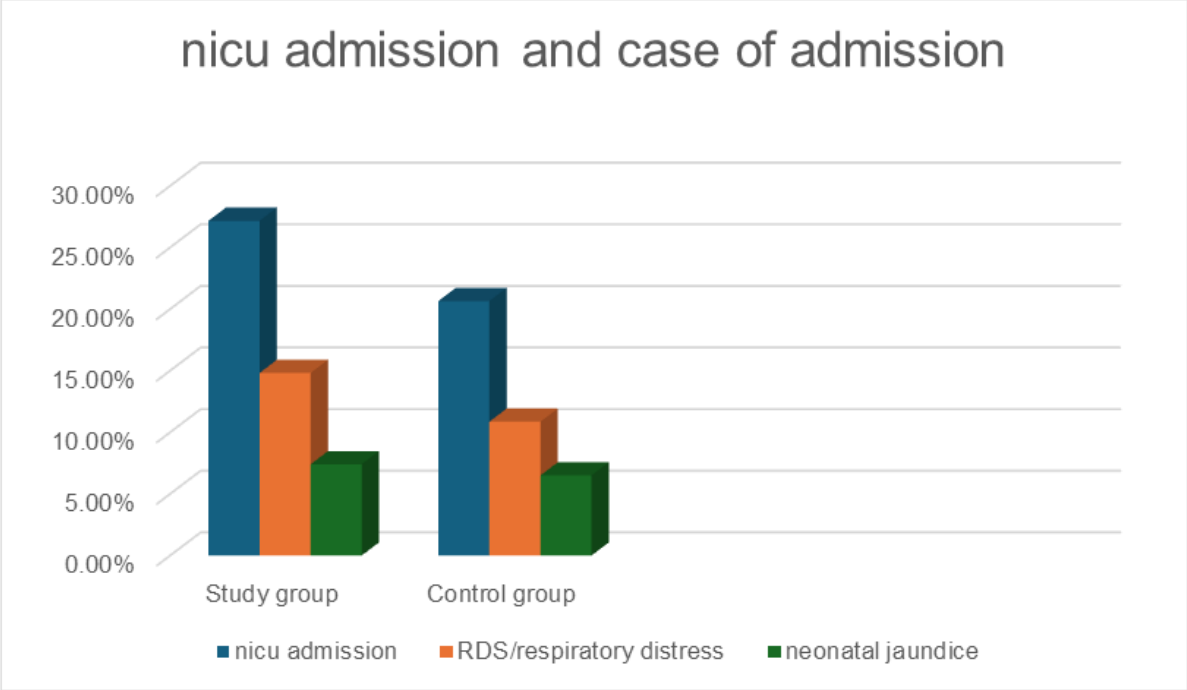

Figure 2: Comparison of neonatal outcomes

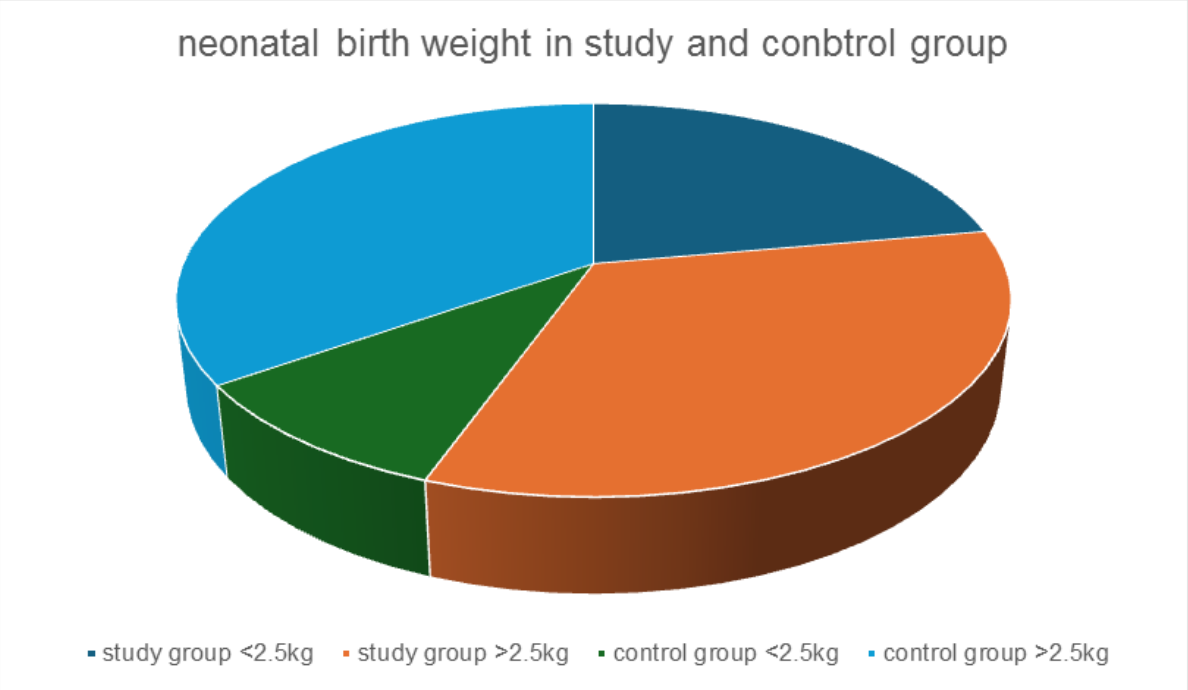

Figure 3: Comparison of neonatal outcomes

Neonatal outcomes were measured between the two groups in terms of birth weight and NICU admission rate. Lower birth rate, that is <2.5kg was higher among the study group (44.44%) whereas it was 19.56% among control population. Incidence of low birth weight was significantly higher among the study group. And NICU admission was 27.16% among study group and 20.65% with control group and with 14.81% and 7.40% incidence of foetal distress/RDS and neonatal jaundice respectively in study group which was almost similar to control group. However no statistical significance was established in comparing neonatal outcomes among the two groups.

DISCUSSION

With the advent of the 21st century and significant advances in culture media and IVF procedures, ART has proven to be a boon for infertile couples. Reported success rates can be as high as 40-45%, variable according to patient profile, but it does come with adverse effects. In this retrospective cohort study we attempted to analyse the overlooked aspects of ART adverse antenatal and neonatal outcomes in frozen transfer IVF/ICSI cycles of conceived pregnancies from a single tertiary care centre in Rajasthan, India.

With emerging globalization and gender equality, a trend of delayed conception until the late 20's and early 30's of life is becoming pervasive [8]. Also evident in this study, the average age of IVF-conceived females is around 29 years and more, so >50% are above 30 years of age. This was mainly because our patients were referred and reported to our tertiary care IVF centre after years of futile treatments in peripheral primary centres. The average age of spontaneously conceived females being 24 years emphasizes that increasing age predisposes to a heightened need for ART. Advanced maternal age further predisposes to increased risk of prematurity, preeclampsia, abruption, placenta previa, and adverse perinatal outcomes [9].

The trend of multiple embryo transfers in the greed of increasing the success rate of IVF cycle and the request of the desiring parents who desire pregnancy at any cost leads to implantation of more than one embryo resulting in a twin or multiple pregnancy. In our study, 21% of cases of IVF conceived pregnancy had multifetal gestation as opposed to 6% in the control group. In a study by Modi *et al*., and Bergh *et al*., the risk of multifetal gestation in the study and control group was 40.7% vs 5.5% and 26.95% vs 1% respectively. In a retrospective multicentre cohort study by Tan *et al*., 18.7% of women conceived via IVF had multiple pregnancies versus only 1.53% of spontaneous conception ($p<0.001$) [10-12]. As multiple pregnancy is considered to be a high risk pregnancy, we promote the use of single embryo transfer and achieving singleton pregnancies to reduce maternal and neonatal morbidity.

The risk of preterm delivery was found to be 22% in IVF conceived pregnancy group in a study by Modi *et al*., 25% in a study by Tan *et al*., which was similar as compared to our study where it was 25% [11, 12]. The most probable reason behind this is higher percentage of multiple pregnancies and pre-eclampsia in our study which could be the reasons for both spontaneous as well as iatrogenic premature deliveries.

IVF pregnancies owing to the baseline differences in the process of placental development during the formation of chorion invitro lead to all varieties of abnormalities associated with abnormal placental vasculature. These include pregnancy induced hypertension, foetal growth restriction, placenta previa, accreta, percreta and abruption. In our study, PIH was found in 20% IVF conceived women as compared to 9% in the control group. In a study by Modi *et al.,* an increased risk of PIH was found in IVF conceived pregnancies; 22% versus 5% in spontaneous conception, and in a study by Maman *et al*., the risk of PIH was 14%, and 4% in study and control group respectively [11, 13]. This result may stem from several independent risk factors associated with PIH, including age >30 years, primigravida, nulliparity, previous history of abortion, twin pregnancy, or pre-existing hypertension/diabetes mellitus. Incidence of APH was higher in control group (6%) and only 2% in study population. But it was not found to be statistically significant. In contrast to our study many studies have reported an increased risk of APH in IVF conceived pregnancies. a metanalysis by Pandey *et al*., [14] analysing 20,807 IVF conceptions reported an increased risk of APH in IVF pregnancies. ART involves frequent manipulation of gametes, thereby potentially disrupting the epigenetic reprogramming of the embryo, thus affecting both embryonic and extraembryonic tissue. Consequently, edema and micro calcifications also occur in the placenta. Transmission electron microscopic examination of the ART placenta has demonstrated degenerative changes in terminal villi, decreased apical microvilli, and increased multiple vacuoles. These changes result in placenta-mediated complications, reportedly: antepartum haemorrhage (APH), abruptio placenta, and placenta previa. Several previous studies have shown that IUGR, SGA, and preterm birth are more common in the IVF population. A recent meta-analysis by Rebecca A Jackson *et al*., fifteen studies comprising 12,283 IVF and 1.9 million spontaneously conceived singletons, stated that IVF singleton pregnancies were associated with an elevated risk of SGA (odds ratio 1.6; 95%CI 1.3, 2.0) [15]. Tan *et al*., in his study have reported that 13% of IVF singleton babies were classified as IUGR [16] similar to our study with 16% incidence of IUGR.

Multiple studies have propounded an increased risk of gestational diabetes in ART pregnancies [17]. Various risk factors interplay in the pathogenesis of GDM, which comprises positive family history, high parity, advanced

maternal age, multiple pregnancy, and hypothyroidism. However in our study we could not establish a statistical significance in spite of having higher incidence of GDM among study group (7%) compared to control population (3%).

In our study, we noticed that the incidence of anaemia and blood transfusion was higher among control group (9% and 7%) compared to study population (7%, 9%) respectively. This may be attributed to the fact that the IVF patients were followed regularly throughout their antenatal period in contrast to control population which included unbooked and referred cases to our tertiary care centre. Even the incidence of post-partum haemorrhage was higher among control group compare to study group. Again it was not statistically significant.

IVF babies are usually deemed "precious" and therefore there is a high maternal request for a safer delivery option mainly a caesarean section. In our centre, LSCS was the chosen mode of delivery for all IVF conceived patients (elective or indicated). This being a major limitation of our study, we couldn't comment on the mode of delivery and its importance between study and control population.

Neonates obtained through IVF were more frequently admitted in NICU, compared with those obtained spontaneously. Given the increased incidence of multifetal pregnancy and prematurity in the IVF group, the neonates included in our study had general prematurity complications. Thus, they were more likely to be hospitalized in NICU for respiratory complications such as respiratory distress syndrome (RDS), for which they needed oxygen therapy and non-invasive respiratory support. The increased incidence of iatrogenic/elective preterm deliveries among IVF group, we observed that neonates obtained by IVF have a higher risk of LBW and SGA, compared to those obtained spontaneously. This may be associated with the increased rate of multiple pregnancies in the IVF population, but Schieve *et al*., demonstrated that the risk was also observed for singleton ART pregnancies [18]. However, the associated maternal complications such as pregnancy-induced hypertension and placental abnormalities could have influenced birth weight.

In conclusion, women who become pregnant through in vitro fertilization have a higher risk of complications in pregnancy. Multiple pregnancies can be considered a risk factor, but literature data show that singleton pregnancies obtained through IVF also present complications. Mounting evidence suggests that certain perinatal outcomes in frozen embryo transfer (FET) cycles are affected by the manner of endometrial preparation, likely due to the presence or absence of a corpus luteum (CL). FETs are not only associated with more hypertensive disorders of pregnancy (HDP) but also with lower rates of low birth weight, small for gestational age, preterm delivery, placenta previa, placental abruption, and perinatal mortality [19]. Conrad *et al*., [20] have demonstrated that the CL has a critical role in maternal cardiovascular adaptation to pregnancy. The usual maternal cardiovascular adaptations of early pregnancy were attenuated or absent in the first trimester in women who conceived without a CL. Increased rates of HDP and reduced aortic compliance were noted in cycles without a CL [21]. Additional factors that could not be controlled in the present study (ovarian stimulation protocol, culture medium used, type of embryo transferred, population of sub fertile women) may influence this risk. Given the results of the present study, we recommend the implementation of frozen single embryo transfer protocols to reduce the complications associated with multiple pregnancies.

CONCLUSION

With the rising incidence of infertility, assisted reproductive techniques are gaining popularity with a steep rise in ART cycles and frozen embryo transfer cycles. Although ART has been a boon for many distressed couples, the procedure is not without complications. Through this study, we made an attempt to create awareness among reproductive specialists and to optimise the patients before recruitment in IVF and sensitization of IVF specialists towards choosing fresh embryo transfers and natural cycle stimulated cycles instead of frozen embryo transfer whenever possible because few ill-fated ART births are associated with poorer maternal and neonatal outcomes. Also Fresh-embryo transfer is less costly from both a health-care and a patient perspective reducing the financial burden on patients. According to evidence, ART increases the likelihood of pregnancy-related maternal complications comprising PIH, multifetal pregnancy, GDM, APH, preterm deliveries and increased rate of caesarean delivery. Thus, all patients undergoing ART procedures should receive pre-conceptional counselling regarding the associated obstetric risks and neonatal outcomes and consider ART-pregnancy as a high-risk pregnancy. And are advised to maintain a close vigil during the antepartum and immediate postpartum period to balance the risk of complications and successful conception.

List of Abbreviations

ART- Assisted reproductive techniques, IVF- Invitro fertilization, ICSI- Intracytoplasmic sperm injection, NICU- Neonatal intensive care unit, PIH- pregnancy induced hypertension, GDM- gestational diabetes mellitus, IUGR- intrauterine growth restriction, IHCP- intrahepatic cholestasis of pregnancy, PPH- postpartum hemorrhage, APH- antepartum hemorrhage, RDS- respiratory distress syndrome.

Conflict of Interest: The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

REFERENCES

1. World Health Organization: Infertility prevalence estimates, 1990–2021[Internet]. Geneva: World Health Organization; cited 2023 Nov 13.
2. Purkayastha, N., & Sharma, H. (2021). Prevalence and potential determinants of primary infertility in India: Evidence from Indian demographic health survey. *Clinical Epidemiology and Global Health*, *9*, 162-170.
3. Saunders, D. M., &Lancaster, P. A. L. (1993). A critical review of outcome of in vitro fertilisation based on the Australian IVF register. In: Eng-Soon-Teoh, S., Ratnam, S. S., MacNaughton Sir, M. eds. Parthenon, Carnforth, The Current status of Gynaecology in Obstetric Series, 1, 159-169.
4. Lancaster, P. A. L. (1992). International comparisons of assisted reproduction. In: Assisted Reproduction Reviews. Williams and Wilkins. USA, 2(4), 212-221.
5. Assisted Conception Australia and New Zealand 1991. Australian Institute of Health and Welfare National Perinatal Statistics Unit Fertility Society of Australia. Sydney ISSN 1038-7234, 1993.
6. Chasen, S. T., Luo, G., Perni, S. C., &Kalish, R. B. (2006). Are in vitro fertilization pregnancies with early spontaneous reduction high risk?. *American journal of obstetrics and gynecology*, *195*(3), 814-817. DOI: 10.1016/j.ajog.2006.06.022
7. De Geyter, C., Calhaz-Jorge, C., Kupka, M. S., Wyns, C., Mocanu, E., Motrenko, T., ...&Goossens, V. (2018). ART in Europe, 2014: results generated from European registries by ESHRE: The European IVF-monitoring Consortium (EIM) for the European Society of Human Reproduction and Embryology (ESHRE). *Human reproduction*, *33*(9), 1586-1601.
8. Mills, M., Rindfuss, R. R., McDonald, P., TeVelde, E., & ESHRE Reproduction and Society Task Force. (2011). Why do people postpone parenthood? Reasons and social policy incentives. *Human reproduction update*, *17*(6), 848-860. doi: 10.1093/humupd/dmr026.
9. Blomberg, M., Tyrberg, R. B., &Kjølhede, P. (2014). Impact of maternal age on obstetric and neonatal outcome with emphasis on primiparous adolescents and older women: a Swedish Medical Birth Register Study. *BMJ open*, *4*(11), e005840. doi: 10.1136/bmjopen-2014-005840.
10. Bergh, T., Ericson, A., Hillensjö, T., Nygren, K. G., &Wennerholm, U. B. (1999). Deliveries and children born after in-vitro fertilisation in Sweden 1982–95: a retrospective cohort study. *The Lancet*, *354*(9190), 1579-1585.
11. Modi, D., Jindal, M., &Pednecar, G. (2019). Co-relation of IVF pregnancy to maternal health and pregnancy outcome at a tertiary health care center, Goa medical college. *J Public Health Med*, *7*(2), 7-13.
12. Tan, J., Qi, Y. N., Zhang, J., Wang, W., Zhang, G. T., Zou, K., ...& Sun, X. (2019). The mediation effect of multiple gestations on the association between in vitro fertilisation and severe maternal morbidities: a retrospective cohort study. *BMJ open*, *9*(7), e022670.
13. Kashyap, S., &Claman, P. (2000). Polycystic ovary disease and the risk of pregnancy-induced hypertension. *The Journal of reproductive medicine*, *45*(12), 991-994.
14. Pandey, S., Shetty, A., Hamilton, M., Bhattacharya, S., &Maheshwari, A. (2012). Obstetric and perinatal outcomes in singleton pregnancies resulting from IVF/ICSI: a systematic review and meta-analysis. *Human reproduction update*, *18*(5), 485-503. doi: 10.1093/humupd/dms018.
15. Jackson, R. A., Gibson, K. A., Wu, Y. W., &Croughan, M. S. (2004). Perinatal outcomes in singletons following in vitro fertilization: a meta-analysis. *Obstetrics &Gynecology*, *103*(3), 551-563.
16. Tan, S. L., Doyle, P., Campbell, S., Beral, V., Rizk, B., Brinsden, P., ...& Edwards, R. G. (1992). Obstetric outcome of in vitro fertilization pregnancies compared with normally conceived pregnancies. *American journal of obstetrics and gynecology*, *167*(3), 778-784.
17. Zhu, L., Zhang, Y., Liu, Y., Zhang, R., Wu, Y., Huang, Y., ...& Zhang, D. (2016). Maternal and live-birth outcomes of pregnancies following assisted reproductive technology: a retrospective cohort study. *Scientific reports*, *6*(1), 35141.doi: 10.1038/srep35141.
18. Schieve, L. A., Meikle, S. F., Ferre, C., Peterson, H. B., Jeng, G., & Wilcox, L. S. (2002). Low and very low birth weight in infants conceived with use of assisted reproductive technology. *New England Journal of Medicine*, *346*(10), 731-737.doi: 10.1056/NEJMoa010806.
19. Sha, T., Yin, X., Cheng, W., & Massey, I. Y. (2018). Pregnancy-related complications and perinatal outcomes resulting from transfer of cryopreserved versus fresh embryos in vitro fertilization: a meta-analysis. *Fertility and sterility*, *109*(2), 330-342.
20. Conrad, K. P., Petersen, J. W., Chi, Y. Y., Zhai, X., Li, M., Chiu, K. H., ... & Segal, M. S. (2019). Maternal cardiovascular dysregulation during early pregnancy after in vitro fertilization cycles in the absence of a corpus luteum. *Hypertension*, *74*(3), 705-715.
21. vonVersen-Höynck, F., Schaub, A. M., Chi, Y. Y., Chiu, K. H., Liu, J., Lingis, M., ... & Baker, V. L. (2019). Increased preeclampsia risk and reduced aortic compliance with in vitro fertilization cycles in the absence of a corpus luteum. *Hypertension*, *73*(3), 640-649.