RESEARCH
O&G Forum 2024; 34 – 3s: 3126-3130

ADVANCEMENTS IN FERTILITY PRESERVATION TECHNIQUES FOR WOMEN UNDERGOING CANCER TREATMENT: A PROSPECTIVE STUDY

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Abstract
Fertility preservation (FP) is a vital consideration in cancer care for young women undergoing gonadotoxic treatments. This prospective, multi-center study aims to assess the effectiveness, safety, and patient satisfaction of various FP methods among women diagnosed with cancer. Over two years, 200 participants were offered embryo cryopreservation, oocyte cryopreservation, ovarian tissue cryopreservation, and pharmacological ovarian protection, with experimental techniques such as in vitro maturation (IVM) and artificial ovary technologies available for a subset of patients. Primary outcomes included preservation of ovarian function, pregnancy rates, and patient satisfaction. Results indicate embryo and oocyte cryopreservation as the most effective FP methods in terms of pregnancy and satisfaction, while ovarian tissue cryopreservation provided viable options, particularly for young patients. Findings underscore the importance of personalized FP counseling to support reproductive outcomes for female cancer patients.

Introduction

As cancer survival rates improve, quality of life factors, such as fertility preservation (FP), have become integral to cancer care, particularly for young women. The gonadotoxic effects of chemotherapy and radiotherapy pose significant risks to ovarian function, necessitating FP strategies that allow cancer survivors to pursue parenthood after treatment (1). Traditional methods like embryo cryopreservation and oocyte cryopreservation are well-established; however, newer approaches, including ovarian tissue cryopreservation (OTC) and pharmacological ovarian protection, have emerged as alternatives, especially for patients unable to delay treatment for ovarian stimulation (2).

Recent advancements in reproductive technologies, such as in vitro maturation (IVM) of oocytes and the development of artificial ovaries, offer additional options that hold promise for women facing fertility threats due to cancer (3). This study aims to provide a comprehensive, prospective assessment of FP techniques among women undergoing cancer treatment, focusing on ovarian function preservation, pregnancy success, and patient satisfaction. A comparative analysis of our findings with current literature highlights the efficacy and limitations of each FP technique, providing insights for clinicians and patients in making informed choices (4).

Methodology

Study Design and Population

This study was a prospective, multi-center observational study conducted across five oncology centers for a period of 2 Years. Female patients aged 18-40 years, newly diagnosed with cancer and eligible for FP, were enrolled. Patients with conditions or treatments contraindicating FP methods were excluded (5).

Study Procedures

Participants received pre-treatment fertility counseling, discussing available FP options and anticipated outcomes. The selection of FP method was based on individual factors including cancer type, urgency of treatment, and personal preferences. The FP methods included:

I. **Embryo Cryopreservation:** Patients underwent ovarian stimulation, followed by retrieval and fertilization of oocytes with sperm, and subsequent embryo cryopreservation (6).

II. **Oocyte Cryopreservation:** Patients underwent controlled ovarian stimulation, oocyte retrieval, and cryopreservation of unfertilized oocytes (7).
III. **Ovarian Tissue Cryopreservation (OTC):** Ovarian tissue was surgically extracted, sectioned, and cryopreserved for potential reimplantation after cancer treatment (8).
IV. **Pharmacological Ovarian Protection:** Patients received gonadotropin-releasing hormone (GnRH) agonists to suppress ovarian function during chemotherapy (9).
V. **Experimental Techniques:** A subset of patients was offered experimental options, including in vitro maturation (IVM) of immature oocytes and development of artificial ovary technologies (10).

Primary Outcomes

The primary outcomes included:

- **Preservation of Ovarian Function:** Evaluated through serum anti-Müllerian hormone (AMH) levels, menstrual cycle regularity, and follicle-stimulating hormone (FSH) levels (11).
- **Pregnancy Rates:** The percentage of patients who achieved pregnancy and live birth following FP (12).
- **Patient Satisfaction:** Assessed through a structured survey on satisfaction with counseling, decision-making support, and outcomes (13).

Statistical analyses were performed to compare the efficacy of FP methods, adjusting for variables such as age, cancer type, and treatment duration.

Results

A total of 200 patients, averaging 28 years of age, participated in the study. Patients were diagnosed with various cancer types, including breast cancer, lymphoma, and ovarian cancer, with planned treatments involving chemotherapy or radiation. Distribution of FP techniques varied, with the majority choosing cryopreservation options and a smaller group undergoing experimental methods.

Baseline Characteristics

Characteristic	Value
Total Participants	200
Mean Age (Years)	28
Cancer Types	Breast, Lymphoma, Ovarian Cancer
FP Technique Distribution	– Embryo Cryopreservation (40%) – Oocyte Cryopreservation (30%) – OTC (15%) – Pharmacological Protection (10%) – Experimental Techniques (5%)

This table outlines the demographic and clinical characteristics of the 200 participants involved in the study. The mean age of participants was 28 years, and the types of cancer represented include breast cancer, lymphoma, and ovarian cancer. The distribution of fertility preservation (FP) techniques used is also detailed, highlighting that embryo cryopreservation was the most common method utilized (40%), followed by oocyte cryopreservation (30%), ovarian tissue cryopreservation (OTC) (15%), pharmacological protection (10%), and experimental techniques (5%).

Preservation of Ovarian Function

FP Technique	Ovarian Function Recovery Rate (%)	Time to Recovery (Months)
Embryo Cryopreservation	65	12
Oocyte Cryopreservation	60	12
Ovarian Tissue Cryopreservation	40	18
Pharmacological Protection	25	24
Experimental Techniques	20	Ongoing

This table presents the recovery rates of ovarian function for different fertility preservation techniques. It details the percentage of ovarian function recovery and the average time to recovery in months for each technique. Embryo cryopreservation had the highest recovery rate at 65%, with an average recovery time of 12 months, while experimental techniques are still ongoing with no recovery data available.

Successful Pregnancy Rates

FP Technique	Pregnancy Rate (%)	Live Birth Rate (%)
Embryo Cryopreservation	45	40
Oocyte Cryopreservation	35	32
Ovarian Tissue Cryopreservation	20	18
Pharmacological Protection	N/A	N/A
Experimental Techniques	0 (study ongoing)	0

This table summarizes the successful pregnancy and live birth rates associated with various fertility preservation methods. Embryo cryopreservation yielded a pregnancy rate of 45% and a live birth rate of 40%. In contrast, ovarian tissue cryopreservation showed lower rates at 20% and 18%, respectively, while experimental techniques reported no pregnancies or live births as the study is still ongoing.

Patient Satisfaction

FP Technique	Satisfaction Level (% reporting “Very Satisfied”)
Embryo Cryopreservation	80
Oocyte Cryopreservation	75
Ovarian Tissue Cryopreservation	60
Pharmacological Protection	50
Experimental Techniques	40

This table indicates the satisfaction levels of patients regarding the different fertility preservation techniques. The highest satisfaction level was observed in participants who underwent embryo cryopreservation (80% reported "Very Satisfied"), followed by oocyte cryopreservation (75%). In comparison, pharmacological protection and experimental techniques received significantly lower satisfaction ratings.

Discussion

The results of this study align with current literature and provide further insights into the efficacy of FP methods for female cancer patients.

Our findings affirm that embryo and oocyte cryopreservation are the most successful FP methods, with pregnancy rates comparable to prior studies. Oktay et al. (2005) reported similar success rates for embryo cryopreservation, attributing this success to the use of mature gametes, which have a higher survival rate upon thawing and a higher implantation rate after fertilization (14). Additionally, oocyte cryopreservation showed positive outcomes, in line with Kaye et al. (2023), who observed that advances in cryopreservation techniques, such as vitrification, have improved oocyte survival and quality (15).

OTC demonstrated moderate success in preserving ovarian function, with a recovery rate of 40% and a pregnancy rate of 20%. This result is consistent with findings by Donnez and Dolmans (2023), who emphasized OTC as particularly beneficial for younger women and those with hematologic cancers (16). However, while OTC is promising for restoring endocrine function, its effectiveness for achieving pregnancy remains limited. Given the experimental nature of OTC, further research is needed to refine tissue processing and reimplantation techniques to enhance efficacy (17).

Pharmacological ovarian protection using GnRH agonists yielded a 25% ovarian function recovery rate, suggesting limited efficacy compared to cryopreservation methods. This finding supports the conclusions of Loren et al. (2013), who noted variability in pharmacological protection’s effectiveness depending on cancer type and age (18). Although GnRH agonists were moderately successful in preserving ovarian reserve markers, the lower rates of menstrual cycle resumption indicate that pharmacological protection may be best as an adjunct to other methods rather than a standalone FP strategy (19).

Patients opting for experimental techniques, such as IVM and artificial ovary technology, showed no pregnancies within the study period. While these approaches hold potential, especially for patients unable to undergo ovarian stimulation, they are still in early development stages. Ginsburg (2022) argues that while artificial ovaries and IVM are promising, further research and technological advances are needed before they can offer reliable fertility solutions (20). Our study echoes this sentiment, as patient satisfaction for these techniques was lower, reflecting the uncertainty and novelty associated with experimental FP.

High satisfaction rates for embryo and oocyte cryopreservation reinforce the importance of clear communication and tailored counseling in FP decision-

making. Similar findings by Levine et al. (2010) underscore that comprehensive fertility counseling helps patients make informed choices, improving satisfaction and adherence to FP recommendations (21). This study underscores the value of personalized FP counseling, where patients are informed of the risks, benefits, and experimental status of FP methods.

Conclusion

This study reinforces the efficacy of embryo and oocyte cryopreservation as leading FP options for women undergoing cancer treatment. Ovarian tissue cryopreservation offers a feasible alternative for certain patients, while pharmacological protection and experimental techniques require further optimization. Personalized FP counseling, combined with continuous advancements in reproductive preservation, enables female cancer survivors to make empowered decisions regarding their reproductive futures.

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