Original Article

Therapy-related myeloid neoplasms in Korean patients with ovarian or primary peritoneal cancer treated with poly(ADP-ribose) polymerase inhibitors

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Background: Prior prospective studies have demonstrated the efficacy of poly(adenosine diphosphate-ribose) polymerase inhibitors (PARPis) in various cancers with mutations in the breast cancer gene (*BRCA*), such as ovarian and breast cancers. However, PARPi have also been associated with an increased incidence of therapy-related myeloid neoplasms (t-MNs). This study aimed to investigate the incidence of t-MNs following PARPi therapy in patients with ovarian or primary peritoneal cancer in Korea and to identify related risk factors.

Methods: We retrospectively analyzed data of patients with ovarian or primary peritoneal cancer who received PARPi therapy between January 2015 and June 2023.

Results: Among 52 patients treated with PARPi, four were diagnosed with t-MNs. All four patients had *BRCA* mutations, and two of them had breast cancer with no evidence of disease (NED) status following treatment. All patients received radiotherapy and at least one granulocyte-colony stimulating factor (G-CSF) application. The median duration of PARPi therapy was 16.3 (range, 6.2–48.8) months. At the time of analysis, three patients had metastatic ovarian cancer and one maintained the NED status. Next-generation sequencing (NGS) performed in four patients revealed *TP53* mutations and complex karyotypes in all tested patients. Among the four patients, three received only supportive care, and one was actively undergoing t-MN treatment.

Conclusions: The incidence of t-MNs after PARPi therapy in the current study was higher than that of overall t-MNs, which is consistent with the results of previous studies on t-MNs after PARPi therapy. Further international studies are needed to elucidate the mechanism and clinical characteristics of t-MNs associated with PARPi therapy.

Keywords: Breast cancer gene mutations (*BRCA* mutations); ovarian cancer; poly(adenosine diphosphate-ribose) polymerase inhibitors (PARPis); peripheral blood smear (PB smear); therapy-related myeloid neoplasms (t-MNs)

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Introduction

Ovarian cancer is the eighth most common cancer in women worldwide, with a mortality rate of 4.2 per 100,000 (1). According to the Korean cancer statistics for 2020, 2,947 patients were diagnosed with ovarian cancer and 1,369 patients with ovarian cancer died during this year. Although the 5-year survival rate has slightly increased from 60% to 65% from 1993 to 2020, the increase is far from significant (2). This stagnation has been attributed to the lack of a screening program, difficulties in early detection, and the high risk of recurrence following therapy (3). Primary peritoneal cancer has many similarities with epithelial ovarian cancer, including pathological and clinical features and chemotherapeutic agents (4).

Poly(adenosine diphosphate-ribose) polymerase inhibitors (PARPis) are anticancer agents that kill cancer cells by inhibiting the poly(adenosine diphosphate-ribose) polymerase (PARP) enzyme, which is involved in cell cycle regulation and DNA strand repair and is known to be particularly sensitive in patients with breast cancer gene (*BRCA*) mutations (5). Several prospective trials have demonstrated the efficacy of PARPi therapy against breast, ovarian, and prostate cancers in patients with *BRCA* mutations (6-8). Currently, PARPi therapy is widely used as palliative and maintenance therapy in patients with *BRCA*-mutant ovarian cancer (9).

Highlight box

Key findings

- The incidence of therapy-related myeloid neoplasms (t-MNs) post-poly(adenosine diphosphate-ribose) polymerase inhibitors (PARPis) therapy in Korean patients with ovarian or primary peritoneal cancer was higher than the overall incidence of t-MNs.

What is known and what is new?

- PARPi is used as a treatment against breast, ovarian, and prostate cancers in patients with breast cancer gene (*BRCA*) mutations, but several studies have reported an increased risk of t-MNs associated with PARPi treatment.
- Our findings indicate that the incidence of t-MNs following PARPi treatment was higher than the overall incidence observed, consistent with previous research on t-MNs after PARPi treatment.

What is the implication, and what should change now?

- Owing to the potential association of PARPi treatment with an increased risk of t-MNs, it is essential to consider clinical benefits of this treatment and to implement careful monitoring, including periodic blood work follow-up even after completing PARPi treatment.

Therapy-related myeloid neoplasms (t-MNs), reported to account for approximately 10–20% of newly diagnosed cases of acute myeloid leukemia (AML) and myelodysplastic syndrome (MDS), are assumed to be caused by DNA damage induced by chemotherapy and radiotherapy (10,11). Among chemotherapeutic agents, topoisomerase II inhibitors or alkylating agents are known to be closely related to t-MNs (12). These are the main chemotherapeutic agents used in the treatment of ovarian cancer, and the previous study has reported an incidence of therapy-related MDS and AML in these patients of approximately 0.2% and 0.1%, respectively (13). Furthermore, several studies have reported an association between PARPi use and t-MN occurrence (14-18), including a recent meta-analysis that found that PARPi therapy increases the risk of t-MNs, raising awareness about the use of these agents (18). However, evidence on the incidence of t-MNs following PARPi therapy in the Asian population is scarce.

Therefore, we investigated the incidence of t-MNs in Korean patients following PARPi therapy for ovarian or primary peritoneal cancer. We also analyzed the clinical and molecular characteristics of these patients to identify related risk factors. We present this article in accordance with the STROBE reporting checklist (available at https://tcr.amegroups.com/article/view/10.21037/tcr-24-1131/rc).

Methods

Study design and patients

This retrospective cohort study included patients with ovarian or primary peritoneal cancer who received PARPi therapy at the Korea Cancer Center Hospital between January 2015 and June 2023. The inclusion criteria were as follows: (I) histopathological diagnosis of ovarian or primary peritoneal cancer; (II) completed PARPi therapy; and (III) patients diagnosed with t-MNs after PARPi therapy must meet diagnostic criteria for t-MNs according to the 2016 or 2022 World Health Organization classification (19,20). The exclusion criteria comprise the following: (I) patients with a prior diagnosis of t-MNs before initiating PARPi treatment; and (II) cases with insufficient cytogenetic abnormalities and molecular characterization for diagnosing t-MNs. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional Review Board of the Korea Cancer Center Hospital (IRB No. 2023-07-001) and individual consent for this retrospective analysis was waived.

Data collection

The following data were collected from the patients' electronic medical records: age, sex, history of other cancers, chemotherapeutic agents used, administered radiotherapy, application of granulocyte colony-stimulating factor (G-CSF), tumor response to PARPi therapy, ovarian cancer status at the time of t-MN diagnosis, type of *BRCA* mutation, type of t-MN, time from ovarian cancer diagnosis to t-MN diagnosis, and time from PARPi therapy completion to t-MN occurrence.

Cytogenetic and molecular analysis

This analysis was conducted in patients diagnosed with t-MNs. For conventional chromosome analysis, standard G-banding procedures were performed for bone marrow (BM) cells. Karyotypes were then interpreted following the guidelines outlined in the 2016 International System for Human Cytogenetic Nomenclature (21). For mutation analysis, next-generation sequencing (NGS) was conducted on BM samples to investigate genomic alterations in 49 cancer-associated myeloid neoplasm genes. This process included nucleic-acid isolation, library preparation, sequencing, and data analysis.

Statistical analysis

Descriptive statics were used to summarize categorical data as frequencies with proportions and continuous data as medians with interquartile ranges. Univariable and multivariable Cox proportional hazards regression models were employed to identify prognostic factors with a significant impact on t-MN occurrence. We selected covariables with P values <0.20 in the univariable analysis. In all analyses, two-sided P values of less than 0.05 were deemed to indicate statistical significance. All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

Results

Patient characteristics

During the study period, 53 patients received PARPi therapy for either ovarian or primary peritoneal cancer. One patient was excluded from the analysis owing to uncertainty in the diagnosis of t-MNs. The baseline characteristics of the total study population are presented in *Table 1*. The median age was 56 (range, 37–77) years, and the predominant cancer type was ovarian cancer (n=48, 92.3%). Approximately two-thirds of the patients (n=32, 61.5%) had germline *BRCA* mutations and received a median of 5 chemotherapeutic agents (range, 2–9). More than half of the patients (n=30, 57.7%) received at least one dose of G-CSF, and 14 (26.9%) patients received radiotherapy. The types of PARP inhibitors administered were olaparib for 25 patients (48.1%) and niraparib for 27 patients (51.9%). All 4 patients diagnosed with t-MNs were treated with olaparib. The median duration of PARPi therapy was 13.4 (range, 0.2–68.2) months, and the median overall survival (OS) after ovarian cancer diagnosis was 5.2 (range, 1.2–20.9) years.

Among the 52 patients, 4 (7.7%) were diagnosed with t-MNs following PARPi therapy for ovarian cancer. The median age at the time of ovarian cancer diagnosis was 45 (range, 42–53) years. All patients had *BRCA* mutations, and two (cases 1 and 4) had a history of breast cancer. Remarkably, all patients had no evidence of disease (NED) status for breast cancer. All four patients received chemotherapy for ovarian cancer, and the median number of chemotherapeutic agents administered was 7 (range, 5–8), excluding PARPi. Specifically, all patients were treated with carboplatin, an alkylating agent, and paclitaxel, an antitubulin agent. The median duration of PARPi therapy was 16.3 (range, 6.2–48.8) months, with two patients receiving palliative and two patients receiving maintenance treatment. Furthermore, all patients received G-CSF at least once during their chemotherapy period. The clinical details of this population are summarized in *Table 2*.

Prognostic factors

In the univariable analyses, age at ovarian or primary peritoneal cancer [hazard ratio (HR), 0.86; 95% confidence interval (CI): 0.68–1.08; P=0.18], PARPi usage period (HR, 0.96; 95% CI: 0.90–1.02; P=0.18), and OS from ovarian cancer diagnosis (HR, 1.25; 95% CI: 0.96–1.64; P=0.10) were significantly associated with t-MN occurrence. However, in the multivariable analysis, none of these associations remained statistically significant (*Table 3*).

t-MN diagnosis and treatment

Figure 1 presents the timeline of the clinical course in the four patients diagnosed with t-MNs. The median time from initial ovarian cancer diagnosis to t-MN diagnosis was 13.4 (range, 8.2–17.5) years. t-MNs were diagnosed at

Table 1 Patients' baseline characteristics

Variables	t-MNs (–)	t-MNs (+)	Total
Patient number	48	4	52
Age at OC or PPC (years)	57 [37–77]	45 [42–53]	56 [37–77]
Presence of germline *BRCA* 1/2 (+) mutation	28 (58.3)	4 (100.0)	32 (61.5)
Diagnosed other cancer	7 (14.6)	2 (50.0)	9 (17.3)
Cancer type			
OC	44 (91.7)	4 (100.0)	48 (92.3)
PPC	4 (8.3)	0 (0.0)	4 (7.7)
OC or PPC stage	45	4	49
II	1 (2.2)	0 (0.0)	1 (2.0)
III	37 (82.2)	1 (25.0)	38 (77.6)
IV	7 (15.5)	3 (75.0)	10 (20.4)
Median number of chemotherapy agent	4	7	5
Radiotherapy	10 (20.8)	4 (100.0)	14 (26.9)
G-CSF application	26 (54.1)	4 (100.0)	30 (57.7)
Type of PARPi			
Olaparib	21 (43.8)	4 (100.0)	25 (48.1)
Niraparib	27 (56.3)	0 (0.0)	27 (51.9)
Reasons for quitting PARPi			
Progression of cancer	24 (50.0)	4 (100.0)	28 (53.8)
Side effect	2 (4.2)	0 (0.0)	2 (3.8)
Ends after maintenance therapy period	6 (12.5)	0 (0.0)	6 (11.5)
Other cause	6 (12.5)	0 (0.0)	6 (11.5)
Ongoing	10 (20.8)	0 (0.0)	10 (19.2)
PARPi usage period (months)	13.4 [0.2–68.2]	16.3 [6.2–48.8]	14.2 [0.2–68.2]
OS from OC diagnosis (years)	4.8 [1.2–20.9]	13.4 [8.1–17.6]	5.2 [1.2–20.9]

Data are presented as number, median [range], or n (%), unless otherwise stated. t-MNs, therapy-related myeloid neoplasms; OC, ovarian cancer; PPC, primary peritoneal cancer; *BRCA*, breast cancer gene; G-CSF, granulocyte colony stimulating factor; PARPi, poly(ADP-ribose) polymerase inhibitor; OS, overall survival.

a median of 57.0 (range, 24.6–59.9) months after PARPi therapy initiation and 28.3 (range, 11.1–43.2) months after PARPi therapy completion. At the time of t-MN diagnosis, three patients (cases 1–3) had metastatic ovarian cancer and one patient (case 4) maintained the NED status for ovarian cancer. Due to their ovarian cancer status, previous treatment history, and poor Eastern Cooperative Oncology Group performance status (ECOG PS), the former three patients received only supportive care, while the latter patient began induction treatment for AML. The median OS after t-MN diagnosis was 2.2 (range, 0.06–3.7) months.

Cytogenetic and molecular analysis

Peripheral blood (PB) and BM findings at the time of t-MN diagnosis are summarized in *Table 4*. Among four patients, one patient (case 1) was diagnosed with MDS and three (cases 2, 3, and 4) were diagnosed with AML. At the time of

Table 2 Clinical details of patients included in the study

No.	Age at diagnosis of OC (years)	Sex	Other cancer history	Chemo therapy	Chemotherapy agent	Radiotherapy	G-CSF application	*BRCA* (1/2) mutation	Best response of a PARPi	Duration of PARPi medication (months)	Time between PARPi initiation and diagnosis of t-MNs (months)	Time between PARPi termination and diagnosis of t-MNs (months)	Time between OC and diagnosis of t-MNs (years)	OC status at t-MNs	Survival status
1	42	F	Breast cancer (NED)	Yes	Paclitaxel; carboplatin; topotecan; cisplatin; docetaxel; ifosfamide; gemcitabine; cyclophosphamide	Yes	Yes	*BRCA* 1	PR	16.7	59.9	43.2	15.1	Stage IV	No
2	47	F	–	Yes	Paclitaxel; carboplatin; bevacizumab; topotecan; pegylated liposomal doxorubicin	Yes	Yes	*BRCA* 1	NED maintenance	48.8	59.9	11.1	17.5	Stage IV	No
3	43	F	–	Yes	Paclitaxel; carboplatin; pegylated liposomal doxorubicin; topotecan; navelbine; cisplatin pembrolizumab	Yes	Yes	*BRCA* 1	PR	6.2	24.6	18.4	11.7	Stage IV	No
4	53	F	Breast cancer (NED)	Yes	Paclitaxel; carboplatin; bevacizumab; pegylated liposomal doxorubicin; docetaxel; topotecan; pembrolizumab	Yes	Yes	*BRCA* 1	NED maintenance	15.9	54.1	38.2	8.2	NED	Yes

OC, ovarian cancer; G-CSF, granulocyte colony-stimulating factor; BRCA, breast cancer gene; PARPi, poly(ADP-ribose) polymerase inhibitor; t-MNs, therapy-related myeloid neoplasms; F, female; NED, no evidence of disease; PR, partial response.

Table 3 Cox-proportional hazard model of factors associated with t-MNs

Variables	Univariate analysis			Multivariate analysis		
	HR	95% CI	P value	HR	95% CI	P value
Age at OC or PPC	0.86	0.68–1.08	0.18	0.87	0.64–1.18	0.37
Presence of other cancer	0.71	0.06–8.21	0.79			
Number of chemotherapy agent	1.55	0.79–3.05	0.21			
PARPi usage period	0.96	0.90–1.02	0.18	0.96	0.89–1.03	0.24
OS from OC diagnosis	1.25	0.96–1.64	0.10	1.35	0.85–2.16	0.21

t-MNs, therapy-related myeloid neoplasms; HR, hazard ratio; CI, confidence interval; OC, ovarian cancer; PPC, primary peritoneal cancer; PARPi, poly(ADP-ribose) polymerase inhibitor; OS, overall survival.

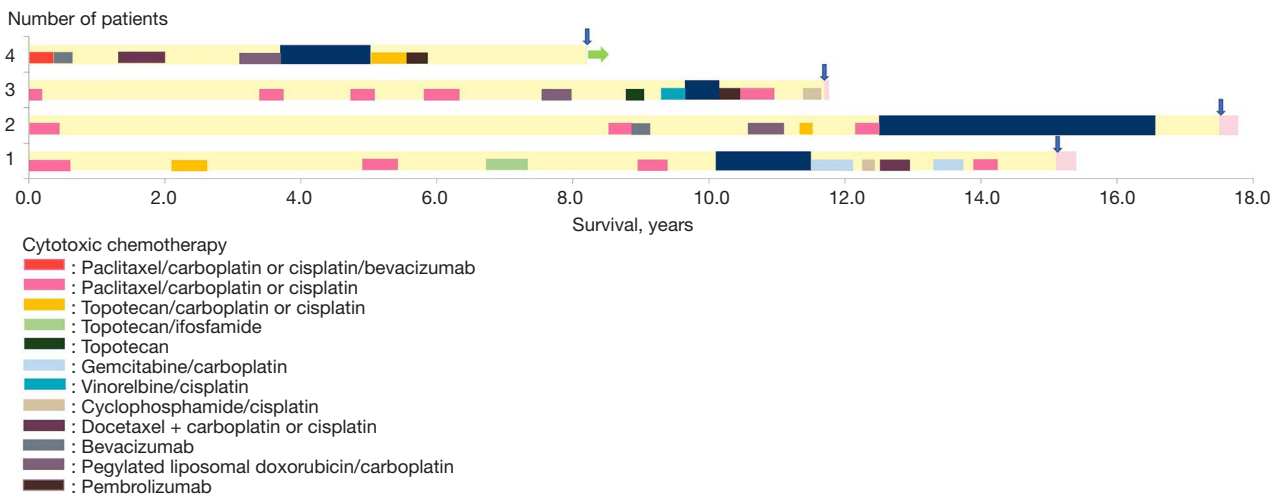

Figure 1 Timeline of the clinical history of four patients with ovarian cancer diagnosed with t-MNs following PARPi treatment. The yellow graph represents the time between ovarian cancer diagnosis and t-MN diagnosis. The navy graph represents the duration of PARPi therapy. The blue arrow indicates the time of t-MN diagnosis. The pink graph indicates the survival period after t-MN diagnosis. The light green arrows indicate living patients. t-MNs, therapy-related myeloid neoplasms; PARPi, poly(ADP-ribose) polymerase inhibitor.

t-MN diagnosis, PB revealed bicytopenia or pancytopenia in all cases. Three patients showed blasts in their PB; specifically, case 3 had 18% blasts and case 4 had 25% blasts. One patient (case 1) diagnosed with MDS showed ring sideroblasts in >15% of BM erythroid precursors. Chromosome studies conducted on BM samples revealed complex karyotypes carrying aberrations of chromosome 5, 7, and/or 17 in four cases. Fluorescence *in-situ* hybridization of BM samples from case 1, diagnosed with MDS, revealed positive findings for 5q and 7q deletions. NGS conducted for 49 myeloid neoplasms-associated genes revealed *TP53* mutations in all four patients. Cases 1 and 4 had a multi-hit *TP53* mutation, and other genes such as *PTPN11* and *PPMD1*, classified as tier 1 variants, showed abnormal results.

Discussion

In our study, four of 52 patients who received PARPi therapy developed t-MNs, accounting for an incidence of 7.7%. These findings are consistent with the results of previous studies, wherein the reported incidence of t-MNs in ovarian cancer was 0.3% and that following PARPi therapy was 1.54–3.81% (5,6,14,15,22) (Table S1). This difference in the incidence of t-MNs between patients receiving PARPi and those treated with other agents suggests an association

Table 4 PB and BM findings at the time of t-MNs diagnosis

Parameters	Number			
	1	2	3	4
PB				
WBC count (μL)	3,560	7,100	18,320	6,020
Hb (g/L)	10.8	8.4	10.7	9.5
Platelets ($\times 10^9$/L)	78	35	78	98
Blasts (%)	1	0	18	25
BM				
BM blast (%)	9	18	20	20
Ring sideroblasts (%)	>15	0	0	0
Chromosome study	45,XX,add(3)(p13),del(4)(q23),der(5)del(5)(q15q33)t(5;17)(q35;q21),-7,add(13)(q12),add(14)(q24),der(17)t(5;17),add(19)(p13.3)[cp15]/46,XX[5]	45,XX,der(5;17)(p10;q10),add(7)(q11.2)[cp4]/46,XX[8]	46,XX,del(5)(q22q35),-7,+8,der(18;21)(q10;q10),+21[20]	42~44,XX,t(1;2)(p13;p23),-3,-5,add(7)(q32),-10,-12,-16,-17,+2~5mar[cp18]/46,XX[2]
FISH	5q deletion: positive (26.5%) Monosomy 7: positive (25.0%)	Negative finding	Not done	Not done
NGS	Tier 1 variant detected (*TP53* p.Val173Glu, VAF 14%; *TP53* p.Arg156Gly, VAF 15%; *PTPN11* p.Phe71Leu, VAF 3%)	Tier 1 variant detected (*PPM1D* p.Pro518Leufs*4, VAF 5%; *PPM1D* p.Arg552*, VAF 7%; *TP53* p.Ala161Asp, VAF 3%). Tier 3 variant detected (*GATA2* p.Ala411Val, VAF 51%; *NOTCH1* p.Arg2263Gln, VAF 48%)	Tier 1 variant detected (*RUNX1* c.496_508+2dup, VAF 37%; *TP53* p.Gln144*, VAF 81%). Tier 3 variant detected (*NRAS* p.Gly12Thr, VAF 10%; *PTPN11* p.Gly503Glu, VAF 36%)	Tier1 variants detected (*TP53* p.Arg213Ter, VAF 45.2%; *DNMT3A* p.Tyr623Ter, VAF 23.6%)
Pathologic diagnosis	MDS with increased blasts-1	AML with mutated *TP53* post-cytotoxic therapy	AML with mutated *TP53* post-cytotoxic therapy	AML with mutated *TP53* post-cytotoxic therapy

PB, peripheral blood; BM, bone marrow; t-MNs, therapy-related myeloid neoplasms; WBC, white blood cell; Hb, hemoglobin; FISH, fluorescence in situ hybridization; NGS, next-generation sequencing; VAF, variant allele frequency; MDS, myelodysplastic syndrome; AML, acute myeloid leukemia.

between PARPi therapy and t-MN occurrence. Indeed, a large-scale meta-analysis of 28 recently published randomized controlled trials reported an increased risk of t-MNs associated with PARPi use (18). However, our multivariable analysis did not identify any prognostic factors for the occurrence of t-MNs.

The median duration of PARPi therapy in our study was 16.3 (range, 6.2–48.8) months, and *BRCA* mutations were identified in all four patients. In a previous prospective clinical trial in patients with *BRCA*-mutant ovarian cancer, the incidence of t-MNs was 1.15–3.08% (22,23). In real-world retrospective study, the incidence of t-MNs was reported to be 3.5%, with a median PARPi-therapy duration of 9 months (14). The incidence of t-MNs in our study was significantly higher than those described above. This may be attributable to several factors, including racial differences, previous use of other chemotherapy agents, duration of PARPi therapy, G-CSF application, and *BRCA*

mutation status. Notably, PARPi demonstrated significant effectiveness in the presence of *BRCA* mutations, with proven survival benefits in patients with *BRCA*-mutant breast and ovarian cancers (7,22).

At the time of t-MN diagnosis, 4 patients in our study showed either bicytopenia or pancytopenia, with 3 patients also showing blasts on the PB smear. These findings align with those of a previous retrospective study, which also found that all patients had bicytopenia or pancytopenia at diagnosis and that two-thirds of them had blasts on the PB smear (16). Furthermore, a previous trial revealed that cytopenia is commonly observed with the use of PARPi (23). However, t-MNs should be considered if cytopenia occurs 7–24 months after PARPi therapy or if it persists for more than 4 weeks after PARPi therapy discontinuation (17). In our study, all patients had been taking PARPi for a minimum of 6 months, and each of them experienced cytopenia lasting for over a month, necessitating the need to rule out t-MNs. Given these characteristic patterns, it is advisable to conduct a thorough work-up to actively exclude t-MNs in cases of cytopenia persisting for more than 1 month more than 6 months after PARPi therapy. Furthermore, if dysplatic changes of blood cells are detected on PB smears, it is recommended to consult a hematologist.

In our study, molecular analysis was conducted in four patients, all of whom exhibited chromosomal abnormalities. All patients had complex karyotype and mutations involving *TP53*. Typically, *TP53* mutations are frequently observed in t-MNs, serving as a distinguishing feature from primary MNs (24). While approximately 30–40% of PARPi-unrelated t-MNs have been reported to contain *TP53* mutations (24,25), our study revealed a higher prevalence of *TP53* mutations. This result is consistent with a prior study that reported a *TP53* mutation rate of 71.1% in 69 t-MN patients following PARPi therapy (14). Considering that PARPi play a role in inhibiting DNA strand repair, it is reasonable to hypothesize that the high prevalence of *TP53* mutations may be linked to the inactivation of this repair mechanism. Furthermore, several studies have reported an association between preexisting clonal hematopoiesis of indeterminate potential (CHIP) variants and the development of t-MNs following PARPi treatment (26-28). These studies suggest that PARPi therapy imposes selective pressure, leading to the enhanced expansion of specific clones, particularly those with *TP53* mutations (27). Therefore, performing NGS to identify CHIP variants before starting PARPi treatment could provide a clearer understanding of the associated risks.

Our study has several limitations. In our study, the incidence of t-MNs after PARPi therapy was 7.7%, which is higher than the incidence of 1.54–3.81% reported in previous studies (5,6,14,15,22). Several factors could account for the higher incidence of t-MNs, such as prior treatment history, BRCA status, and prior CHIP variants. However, we were unable to identify any statistically significant factors. Additionally, the occurrence of t-MNs is notably influenced by prior treatment history. Therefore, including the cumulative doses of cytotoxic chemotherapy and radiotherapy in the analysis would have been valuable. However, owing to missing data for some patients, this analysis could not be performed. Despite these limitations, to the best of our knowledge, this is the first study to report the incidence of t-MNs following PARPi therapy in Korea. However, further research is necessary to understand the mechanism behind t-MNs occurrence after PARPi use.

Conclusions

In conclusion, PARPi are thought to be associated with a higher likelihood of t-MN occurrence compared to that with other chemotherapeutic agents. Furthermore, the occurrence of t-MNs affects patient survival. Therefore, it is necessary to consider the clinical benefits of this treatment and to conduct careful monitoring through periodic blood work follow-up even after PARPi therapy completion. Routine t-MN screening is recommended in cases of long-term PARPi therapy and cytopenia persisting for more than 1 month. Future large-scale international studies should analyze the clinical characteristics and prognosis of t-MNs and PARPi.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tcr.amegroups.com/article/view/10.21037/tcr-24-1131/rc

Data Sharing Statement: Available at https://tcr.amegroups.

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional Review Board of the Korea Cancer Center Hospital (IRB No. 2023-07-001) and individual consent for this retrospective analysis was waived.

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