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RESEARCH ARTICLE

Haematological Changes in Patients Undergoing Diverse Anticancer Chemotherapy Regimens

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ΠΕΡΙΛΗΨΗ

Background: The haematological adverse effects linked to anticancer therapy are collectively challenging in clinical settings. Focused research directed to identify the haematological changes associated with each regimen protocol might help in making an appropriate decision for anticancer combination selection based on patient status. **Aim of the study:** We sought to map the haematological status associated with each treatment regimen currently used in clinical settings. **Methods:** A total of 60 patients were enrolled in this observational prospective study; the blood samples were routinely collected for follow-up. Haemoglobin (Hb), white blood cells (WBCs), platelets (PLT), and lymphocytes (LYM) count were analysed by an analyser machine. The treatment regimens were grouped based on the combination chemotherapy used, including platinum therapy (P.T.) regimen, targeted therapy (T.T.) regimen, anthracycline therapy (A.T.) regimen, taxane therapy (Tx.R.) regimen, antimetabolites therapy (Am.T.) regimen, and immunotherapy (I.T.) regimen. **Results:** The most common type of cancer patients who participated in the present study was breast cancer (33%). The lowest WBC count was associated with ovarian cancer ($5.7\pm1.3\times10^3/\mu L$), followed by lung cancer ($6.9\pm2.1\times10^3/\mu L$). The most commonly used treatment regimen was P.T. (30%) followed by T.T. (25%). The lowest WBC count was associated with I.T. ($6\pm1.9\times10^3/\mu L$) and P.T. ($6.1\pm3.2\times10^3/\mu L$). The lowest Hb level was associated with P.T. ($10.9\pm1.3 g/dL$). The lowest PLT count was associated with P.T. ($245\pm121\times10^3/\mu L$) and A.T. ($222\pm89\times10^3/\mu L$). LYM were selectively reduced in Am.T. ($1.3\pm0.5\times10^3/\mu L$) and P.T. ($1.6\pm0.4\times10^3/\mu L$) compared to other regimens. **Conclusion:** The haematological changes were greatly associated with conventional classical therapy of either P.T. or T.T., rather than the newly introduced Am.T. or I.T. Ovarian and lung cancer were mostly associated with haematological disturbances.

1. Introduction

Cancer is one of the leading ailments of morbidity and mortality worldwide, with anticancer agents acting as a gold standard for the management of a variety of malignancies[1]. The advancement in anticancer agents has potentially improved patient status; the haematological toxicity associated with these protocols continues to represent a main challenge[2]. Focused determination of haematological dysfunction linked to each chemotherapy regimen is essential for improving treatment protocols, predicting complications, and practising the appropriate supportive care measures[3].

The hematopoietic system is delicate and hence prone to the cytotoxicity of chemotherapy due to the representative rapid multiplication rate of the progenitor cells of bone marrow[4]. Anticancer-induced bone marrow suppression presented as leucopenia, anaemia, and thrombocytopenia, altogether suppressing immune response, blood oxygenation, and hemostatic mechanisms[5]. These changes not only affect patient quality of life but can also demand treatment postponements, dose reductions, or offending drug discontinuation, potentially declining therapeutic efficacy and patient survival rates[6].

Combination cancer therapy emerged to harness a diverse range of therapeutic remedies, each with specific mechanisms of action and adverse effect profiles[7]. Traditional chemotherapeutic agents, including platinum compounds, anthracyclines, taxanes, and antimetabolites, employ broad effects on rapidly proliferating cells, causing liable but severe haematological cytotoxicity[8]. Even though the blood monitoring in cancer patients is of clinical significance, investigation of the haematological impact of chemotherapy regimens remains limited to single therapy rather than a combination, limiting the generalizability of results to the complex clinical practice where patients receive complex, multi-agent regimens personalised to their specific malignancy and clinical circumstances. The present study sought to investigate the haematological changes across different chemotherapeutic regimens in different cancer patients by evaluating blood parameters across different therapies, cancer types, and patient demographics.

2. Materials and Methods

Study design: In this observational prospective study, a total of 60 patients were enrolled; the patient demographic parameters were collected from medical records, and blood parameters were collected from routine blood analysis for patients' follow-up.

Patients: The study population consisted predominantly of female patients (n=51, 85.0%) with a mean age of 57.8±13.2 years, reflecting the inclusion of gynaecological and breast malignancies. Male patients comprised 15.0% (n=9), with 98.3% participants being married, and 70.0% were housewives.

Ethical considerations: The utilized data extracted from medical records comply with the institutional guidelines for clinical research. Patient confidentiality was maintained during data collection and analysis processes (Approval registration number, Session 14 on 12.05.2025)

Selection criteria: Patients were enrolled in the present study irrespective of their cancer types, stages, or treatment regimens to cover a broad range of oncological practice.

Data collection: the patient demographic data were collected from the medical records, including age, gender, marital status, occupation, and smoking history. Weight (72.1±16.8kg) and height (158.2±8.9cm)

Table 1. The regimen groups used in the participants of the present study.

Regimens group	n(%)	Example of a drug used
Platinum-based	18 (30.0)	carboplatin, cisplatin, and oxaliplatin-containing protocols
Targeted therapy-based	15 (25.0)	HER2-targeted agents (trastuzumab), hormonal therapies (goserelin, tamoxifen), and CDK4/6 inhibitors (palbociclib).
Anthracycline-based	8 (13.3%).	Doxorubicin in combination with cyclophosphamide.
Taxane-based	7 (11.7%)	paclitaxel, docetaxel, and vinorelbine.
Antimetabolite-based	5 (8.3%)	pemetrexed and gemcitabine
Immunotherapy-based	9 (15.0%)	atezolizumab and pembrolizumab

were measured, and calculated body surface area (1.8±0.18m^2). Blood pressure, heart rate, and oxygen saturation were measured. Cancer classification based on anatomical site, into breast cancer (33.3%), lung (13.3%) and uterine cancers (11.7%). A total of 17 different cancer types were represented, including rare malignancies and one case of carcinoma of unknown primary.

Treatment regimens: The regimens used were subclassified based on grouping according to their mechanism of action into six subgroups (Table 1).

Scoring system: Regimen intensity was calculated based on a standardised scoring system reflecting the number of cytotoxic agents and known myelosuppressive potential. Haematological toxicity index was quantified by incorporating the degree of cytopenias across multiple cell lines.

Blood sampling and blood parameters measurement: A total of 2 ml venous blood was collected in an anticoagulant EDTA tube to prevent clotting before the blood tests were performed. Whole blood was used to measure haemoglobin A1c (HbA1c) levels using a kit supplied by Biolabo (France), and CBC was done by a haematology analyser machine (Boule diagnostics, Sweden). This machine was used for White blood cell count (WBC), haemoglobin (Hb), platelet count (PLT), and lymphocyte count (LYM).

Statistical analysis: Non-parametric data were expressed as frequency and percentage, while parametric data were expressed as mean ± standard deviation. A two-sample t-test was used when comparing two parameters; for more than two parameters, ANOVA with Turkey's post hoc test was conducted. Correlation coefficients were applied to determine the correlation between regimen intensity scores and haematological toxicity indices. The p-values less than 0.05 were considered significant.

3. Results

The study enrolled 60 middle-aged patients (age of 57.8±13.2 years), with 51 women (85.0%) compared to 9 men (15.0%). Fifty-nine of the enrolled patients were married (98.3%), with the majority being housewives (42 patients, 70%). Only 4 patients (6.7%) were smokers, and 13 patients (21.7%) were hypertensive (with normal blood pressure, heart rate, and oxygen saturation upon examination). Patients were slightly overweight (BMI=29.5±7.4) with a body surface area of 1.8±0.2m^2 (Table 2). Patients were presented with 3 common cancers: breast cancer 33%, lung cancer 13%, and uterine cancer 12%. Other less common cancers in the present sample were ovarian cancer 7.0% and colon cancer 5.0%, with the remaining types of cancer presented less commonly (Figure 1).

Breast cancer patients demonstrated WBC counts of 7.4±5.1×10^3/μL, Hb levels of 11.5±1.2g/dL, and PLT counts of 283.0±149.0×10^3/μL. Lung cancer patients demonstrated similar Hb levels (11.5±1.1g/dL) but revealed more consistent WBC counts of 6.9±2.1×10^3/μL and lower PLT counts of 241.0±153.0×10^3/μL. Uterine cancer patients demonstrated the highest WBC counts at 7.8±6.1×10^3/μL. Hb levels were slightly lower at 11.3±1.4g/dL, with PLT counts of 244.0±110.0×10^3/μL. Ovarian cancer patients associated with the highest haematological impact, with the lowest WBC counts of 5.7±1.3×10^3/μL and HB levels of 10.7±1.5g/dL. Interestingly, these patients maintained the highest PLT counts at 323.0±152.0×10^3/μL (Table 3).

Young patients (aged ≤40 years) demonstrated the lowest WBC counts of 6.3±4.0×10^3/μL ($p < 0.05$) and maintained the highest Hb levels at 11.8±1.3g/dL and the lowest PLT counts of 250.0±121.0×10^3/μL ($p < 0.05$). The middle-aged group (41-60 years) demonstrated intermediate WBC counts of 7.0±3.9×10^3/μL and revealed the lowest Hb levels at 11.1±1.4g/dL, with the highest PLT counts were highest in this group at 296.0±144.0×10^3/μL. Old patients (>60 years) demonstrated the highest WBC counts (7.5±4.6×10^3/μL) and

Table 2. Patient demographics and clinical characteristics

Demographic parameters		Values
Age, years		57.8±13.2
Gender, n(%)	**Female**	51.0 (85.0%)
	Male	9.0 (15.0%)
Marital Status, n(%)	**Married**	59.0 (98.3%)
	Widow	1.0 (1.7%)
Occupation, n(%)	**Housewife**	42.0 (70.0%)
	Employee	7.0 (11.7%)
	Retired	8.0 (13.3%)
	Free work	3.0 (5.0%)
Smoking History, n(%)		4.0 (6.7%)
Hypertension, n(%)		13.0 (21.7%)
Body Surface Area, m^2		1.8±0.2
BMI, kg/m2		29.5±7.4
Systolic BP, mmHg		132.2±18.4
Diastolic BP, mmHg		78.1±9.8
SpO_2, %		97.2±1.7
Heart rate, bpm		90.8±16.4
BP=blood pressure, bpm=beat perminute		

a moderate level of Hb levels of 11.5±1.3g/dL, with PLT counts of 272.0±138.0×10^3/μL (Table 3).

Platinum therapy (P.T.) regimens demonstrated the largest treatment group, 18 patients (30%). Targeted therapy (T.T.) regimens were used by 15 patients (25%). Anthracycline therapy (A.T.) regimens were indicated in 8 patients (13.3%), primarily including doxorubicin in combination with cyclophosphamide. Taxane therapy (Tx.T.) regimens were used in 7 patients (11.7%), specifically using paclitaxel, docetaxel, and vinorelbine. Antimetabolite therapy (Am.T.) regimens were used in 9 patients (15%), specifically using pemetrexed and gemcitabine. Immunotherapy (I.T.) regimens were only used for 3 patients (5%), including checkpoint inhibitors atezolizumab and pembrolizumab (Table 4).

The P.T. associated the highest myelosuppressive intensity compared to other treatment groups ($p<0.05$), with WBCs 6.1±3.2×10^3/μL and Hb level of 10.9±1.3g/dL. The PLT count of 245±121×10^3/μL was among the lowest observed, while LYM counts remained at 1.6±0.4×10^3/μL. A.T. presented with the highest WBC count of 9.2±5.1×10^3/μL. Nonetheless, these protocols of therapy were associated with the lowest PLT count of 222.0±89.0×10^3/μL, reflecting selective thrombocytopenia. Hb levels were steady at 11.2±1.5g/dL, with LYM counts of 1.7±0.9×10^3/μL. T.T. showed moderate myelosuppression with WBC counts of 8.5±5.0×10^3/μL and maintained Hb levels of 11.4±1.1g/dL. Interestingly, these patients well-preserved the highest LYM counts (2.2±1.1×10^3/μL). T.T. demonstrated promising haematological profiles (represented by WBC counts of 7.0±3.9×10^3/μL and Hb levels of 11.7±1.2g/dL, with PLT maintained at 312.0±154.0×10^3/μL. The I.T. protocols demonstrated selective effects with low WBC counts of 6.0±1.9×10^3/μL but maintained Hb levels of 11.2±1.1g/dL and the highest PLT counts at 342.0±99.0×10^3/μL. AmR revealed the highest Hb (12.0±1.0 g/dl) and PLT counts (344.0±213.0×10^3/μL). WBCs were moderately affected at 7.5±2.0×10^3/μL, though LYM counts were the lowest at 1.3±0.5×10^3/μL, suggesting selective lymphocytopenia (Table 5).

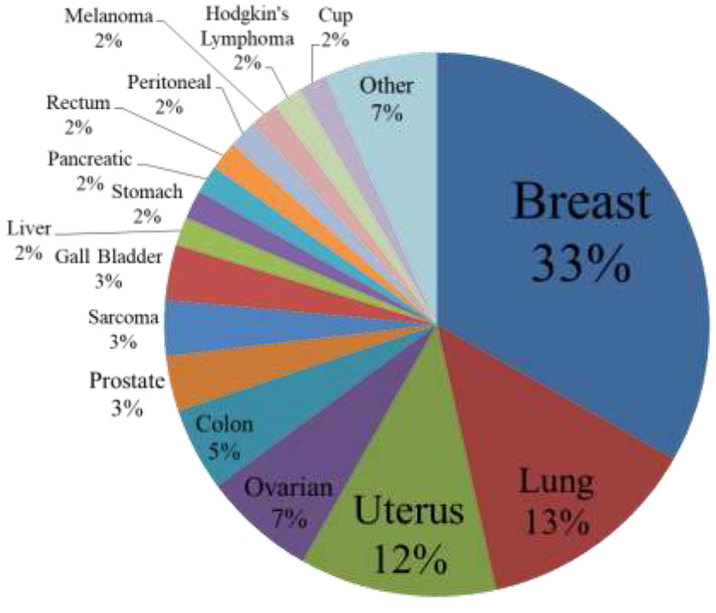

Figure 1. *Cancer types and distribution. CUP = carcinoma of unknown primary.*

A.T. was associated with the greatest correlation (r=0.7, p<0.05) between intensity score (3.8±1.2) and haematological toxicity (1.9±0.7). Also, positive correlations (r=0.7, p<0.05) existed in T.T. with regimen intensity score (3.5±0.9) and haematological toxicity index (2.0±0.6). In P.T., moderate-to-strong correlation (r=0.6, p<0.05) existed between intensity score (3.2±1.1) and haematological toxicity index (2.1±0.8). Similarly, T.T. have shown moderate correlation (r=0.6, p<0.05) with the lowest intensity score (1.8±0.6) and minimal haematological toxicity (1.2±0.5). Am.T. demonstrated a weaker correlation (r=0.5) with intermediate intensity (2.8±0.8) and toxicity scores (1.5±0.4). I.T. demonstrated the weakest correlation (r=0.5, not statistically significant) with low intensity (2±0.5) and minimal toxicity scores (1±0.3) (Table 6).

The combination of carboplatin and paclitaxel revealed the most common myelosuppressive effects. Conversely, trastuzumab monotherapy showed the lowest haematological toxicity. Paradoxically, the combination of doxorubicin and cyclophosphamide demonstrated significantly (p<0.05) high WBCs (12.7±4.9**×10^3/μL**) with nearly normal Hb. Moderate myelosuppression associated with combined carboplatin and bevacizumab (Table 7).

4. Discussion

The haematological profile in breast cancer patients demonstrated by the variability in WBC counts, normal Hb levels, and moderate PLT counts. These findings related to medication individualisation based on patients' condition and hence more targeted and less myelosuppressive combinations[9], while lung cancer patients demonstrated normal Hb levels, and moderate PLT counts. The predominance of P.T. in lung cancer treatment, often combined with taxanes or antimetabolites such as pemetrexed, is known to cause significant thrombocytopenia[5,8]. Additionally, the potential impact of thoracic malignancy on bone marrow function through local invasion, paraneoplastic syndromes, or radiation-induced marrow suppression may contribute to the observed haematological alterations[10].

In uterine cancer patients, WBC count is elevated;

Table 3. Haematological parameters subclassified by cancer type and age groups.

Cancer and age		Hematological parameters		
		WBC(×10^3/μL)	Hb (g/dL)	PLT (×10^3/μL)
Cancer Types	**Breast,** n=20	7.4±5.1b	11.5±1.2b	283.0±149.0a
	Lung, n=8	6.9±2.1b	11.5±1.1b	241.0±153.0a
	Uterus, n=7	7.8±6.1b	11.3±1.4b	244.0±110.0a
	Ovarian, n=4	5.7±1.3a	10.7±1.5a	323.0±152.0b
Age Groups	**≤40 years**, n=9	6.3±4.0a	11.8±1.3a	250.0±121.0a
	41-60 years, n=26	7.0±3.9b	11.1±1.4a	296.0±144.0b
	>60 years, n=25	7.5±4.6b	11.5±1.3a	272.0±138.0b
Data expressed as mean±SD, WBC=white blood cells, Hb=hemoglobin, PLT=platelet. One-way ANOVA was used, followed by Turkey's post hoc test, and a p-value less than 0.05 was considered significant. Similar letters indicate non-significant differences, while different letters indicate significant differences.				

Table 4. Classification of chemotherapy regimen groups

Regimen Group	Description	Used agents	n (%)
Platinum therapy (P.T.)	Carboplatin/Cisplatin-containing regimens	Carboplatin, Cisplatin, Oxaliplatin	18 (30.0%)
Targeted therapy (T.T.)	HER2-targeted and hormonal agents	Trastuzumab, Goserelin, Tamoxifen, Palbociclib	15 (25.0%)
Anthracycline therapy (A.T.)	Doxorubicin-containing regimens	Doxorubicin, Cyclophosphamide	8 (13.3%)
Taxane therapy (Tx.T.)	Paclitaxel/Docetaxel combinations	Paclitaxel, Docetaxel, Vinorelbine	7 (11.7%)
Antimetabolite therapy (Am.T.)	Folate/Purine antagonists	Pemetrexed, Gemcitabine	9 (15.0%)
Immunotherapy (I.T.)	Checkpoint inhibitors	Atezolizumab, Pembrolizumab	3 (5.0%)

this heterogeneity may reflect the diverse histological subtypes of uterine malignancies, ranging from endometrioid adenocarcinomas to more aggressive serous and clear cell variants, each requiring different therapeutic approaches[11,12]. The chemotherapeutic approach for treatment of uterine cancer listed carboplatin and paclitaxel combinations[13], which usually produce expected marrow suppression trends, suggesting that the observed variability may be influenced by patient-specific factors such as baseline bone marrow status, medication profile, or underlying history of comorbidities[14,15].

Lowest WBC counts reported in ovarian cancer patients are perhaps linked to the intensive cytotoxic combinations employed in ovarian cancer therapy, including the standard carboplatin and paclitaxel combination, which is associated with marked myelosuppression[16]. The paradoxical protection of PLT counts in this patient population suggests differential exposure of hematopoietic lineages to treatment impacts, potentially reflecting the complex interaction between tumour burden, ascites-related hemodilution, and the mechanisms of platinum-induced cytotoxicity on megakaryopoiesis versus other hematopoietic precur-

Table 5. Haematological parameters by chemotherapy regimen groups

Regimen Group	WBC (×10³/μL)	Hb (g/dL)	PLT (×10³/μL)	LYM (×10³/μL)
P.T.	6.1±3.2a	10.9±1.3a	245.0±121.0a	1.6±0.4b
T.T.	7.0±3.9b	11.7±1.2b	312.0±154.0b	1.9±0.7c
A.T.	9.2±5.1b	11.2±1.5b	222.0±89.0a	1.7±0.9c
Tx.T.	8.5±5.0b	11.4±1.1b	294.0±169.0b	2.2±1.1c
Am.T.	7.5±2.0b	12.0±1b	344.0±213.0b	1.3±0.5a
I.T.	6.0±1.9a	11.2±1.1b	342.0±99.0b	1.8±0.3c

Data expressed as mean±SD, WBC=white blood cells, Hb=hemoglobin, PLT=platelet. One-way ANOVA was used, followed by Tukey's post hoc test, and a p-value less than 0.05 was considered significant. Similar letters indicate non-significant differences, while different letters indicate non-significant differences.
P.T.=Platinum therapy, T.T.=Targeted therapy, A.T.=Anthracycline therapy, Tx.T.=Taxane therapy, I.T.=Immunotherapy, and Am.T.=Antimetabolites therapy.

sors[3,17].

Younger patients (≤40 years) demonstrated leukopenia with normal Hb and low PLT levels. The middle-aged (41-60 years) adults demonstrated the lowest Hb levels with the highest PLT counts and intermediate WBC counts. Elderly patients (>60 years) demonstrated elevated WBC counts, normal HB and PLT levels. These age-linked patterns of response to chemotherapy greatly impact the indication decision for clinical practice, reflecting that chronological age, patient status, comorbidities, and patient vital organ status, perhaps more accurately guide chemotherapy schedule and dose[18,19].

The most extensive myelosuppression was associated with P.T., an impact which is consistent with the known mechanism of platinum compounds, which form DNA cross-links that preferentially affect rapidly dividing cells, including hematopoietic progenitors[20–22]. The observed lymphocytopenia is congruent with previous studies demonstrating platinum-induced immunosuppression, which may contribute to increased infection risk and potentially compromise immune protection responses[23,24]. A.T. selectively reduced PLT count, perhaps reflecting the differential sensitivity of megakaryocytes to anthracycline-induced oxidative stress and DNA damage, as these agents are known to generate ROS and extrapolate with DNA[25,26]. Nonetheless, the preservation of WBC count and Hb concentration, perhaps reflecting that these hematopoietic lineages may be potentially preserved, which could be explained in the context of the longer lifespan of RBCs and WBCs compared to PLT, hiding acute effects on these precursors[4,26]. T.T. is associated with well-preserved LYM counts, given that the mechanism of taxanes, which stabilise microtubules and disrupt mitotic spindle function, primarily affects cells in the M phase of the cell cycle[27]. The differential maintenance of LYM populations is perhaps explained by varying cell cycle kinetics among hematopoietic lineages.

The T.T. have the most favourable haematological profile reflecting the selective targeting of specific molecular pathways in malignant cells while sparing normal hematopoietic functions [1,2,28]. I.T. selectively reduced WBC and reserved PLT and Hb, which align with their mechanism of action and reflect the complex immunomodulatory effects of these agents rather than direct cytotoxic mechanisms[29,30]. The reported LYM count may reflect dynamic redistribution patterns rather than absolute LYM depletion, as immune checkpoint inhibitors can cause profound changes in LYM trafficking and activation states[31–33]. The haematological profile associated with AmR was demonstrated by maintaining the highest Hb levels and PLT counts. LYM was selectively reduced, which is congruent with the reported preferential effects of antimetabolites on lymphoid cells, which have high nucleotide turnover rates and are particularly susceptible to folate antagonism and DNA synthesis inhibition[6,34].

Table 6. Correlation between regimen intensity and haematological toxicity indices

Regimen Group	Regimen Intensity Score[a]	Hematological Toxicity Index[b]	Correlation (r)
P.T.	3.2±1.1	2.1±0.8	0.6*
T.T.	1.8±0.6	1.2±0.5	0.6*
A.T.	3.8±1.2	1.9±0.7	0.7*
Tx.T.	3.5±0.9	2.0±0.6	0.7*
Am.T.	2.8±0.8	1.5±0.4	0.5
I.T.	2.0±0.5	1.0±0.3	0.5

[a]Based on the number of cytotoxic agents and known myelosuppressive potential
[b]Composite score based on the degree of cytopenias
*p < 0.05
P.T.=Platinum therapy, T.T.=Targeted therapy, A.T.=Anthracycline therapy, Tx.T.=Taxane therapy, I.T.=Immunotherapy, and Am.T.=Antimetabolites therapy.

Table 7. Most common drug combinations by haematological impact

Drug combination	WBC (×10³/μL)	Hb (g/dL)	Toxicity profile
Carboplatin+Paclitaxel (n=8)	5.4±1.9d	11.0±1.3	High myelosuppression
Trastuzumab monotherapy (n=7)	7.9±4.1b	11.7±1.2	Minimal hematologic toxicity
Doxorubicin+Cyclophosphamide (n=4)	12.7±4.9a	11.7±1.5	Variable WBC response
Carboplatin+Bevacizumab (n=6)	6.2±2.0c	10.7±1.2	Moderate myelosuppression

Data expressed as mean±SD, WBC=white blood cells, Hb=hemoglobin. One-way ANOVA was used, followed by Turkey's post hoc test, and a p-value less than 0.05 was considered significant. Similar letters indicate non-significant differences, while different letters indicate non-significant differences.

The limitation of the present study includes a small sample size and a unicentre study, which hinders the generalizability of the data. Patients were presented with different cancers and were using more than one medication, making the prediction of changes in blood indices difficult in terms of being related to disease pathology or medication profile. Dosing variation could also be an additional confounding parameter. Haematological suppression due to ageing could also affect the blood indices as a part of the normal ageing process. These multiple confounding factors make the decision on haematological changes with cancer therapy underestimated, suggesting the development of individualised medical approaches that reflect tumour nature, biomolecule markers, and patient status regarding age, baseline blood indices, and past medical history to optimise therapeutic outcomes while minimising adverse effects.

5. Conclusion

The haematological changes were greatly associated with conventional classical therapy of either P.T. or T.T., rather than the newly introduced Am.T. or I.T. Ovarian and lung cancer were mostly associated with haematological disturbances. The study recommends monitoring myelosuppression associated with P.T. and raising cautions of dose modifications. The selective

thrombocytopenia in the A.T. regimen necessitates PLT monitoring.

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