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PROGNOSTIC VALUE OF COMBINED BONE MARROW AND PERIPHERAL BLOOD ASSESSMENT IN CHEMOTHERAPY-INDUCED LEUKOPENIA

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Abstract: Chemotherapy-induced leukopenia remains one of the principal hematological toxicities limiting systemic anticancer treatment. Although routine monitoring relies on peripheral blood counts, these measurements describe the consequence of bone marrow suppression rather than its underlying biological state. Bone marrow examination provides direct information on hematopoietic activity, granulocytic maturation, and marrow reserve, offering insights that cannot be obtained from peripheral blood analysis alone. Recent studies suggest that combining peripheral blood findings with myelographic characteristics may improve risk assessment and facilitate more individualized supportive care. This review summarizes current evidence on the complementary role of peripheral blood and bone marrow evaluation in predicting chemotherapy-induced leukopenia and discusses their potential clinical application.

Keywords: chemotherapy-induced leukopenia; bone marrow; myelogram; granulopoiesis; myelosuppression; neutropenia; supportive care.

Introduction

Leukopenia is among the most frequent dose-limiting toxicities associated with cytotoxic chemotherapy. Despite advances in supportive care, hematological toxicity continues to interrupt planned treatment schedules, reduce dose intensity, and increase the likelihood of infectious complications. The clinical consequences extend beyond temporary changes in laboratory parameters, as prolonged leukopenia often affects treatment continuity and, consequently, overall therapeutic effectiveness [1-3].

The severity of leukopenia varies considerably even among patients receiving identical chemotherapy regimens. Differences in age, previous treatment exposure, nutritional status, comorbidities, and baseline hematopoietic reserve may all contribute to this variability. Such observations indicate that peripheral blood counts alone do not fully explain an individual's susceptibility to chemotherapy-induced myelosuppression [3-5].

Complete blood count remains the standard method for monitoring hematological toxicity during systemic treatment. Decisions regarding chemotherapy postponement, dose reduction, hospitalization, or administration of granulocyte colony-stimulating factor (G-CSF) are largely based on leukocyte and neutrophil counts. These parameters are clinically indispensable because they are readily available and can be monitored repeatedly throughout treatment. Nevertheless, they reflect an already established decline in circulating cells rather than the functional condition of the bone marrow responsible for their production [2,5,6].

Bone marrow and peripheral blood: different aspects of the same process

Peripheral blood and bone marrow describe different stages of hematopoiesis. Peripheral blood represents the final outcome of marrow activity, whereas myelography characterizes

the cellular processes occurring within the hematopoietic compartment. Evaluating both provides a broader understanding of chemotherapy-induced marrow injury than either method alone.

Bone marrow examination allows assessment of overall cellularity, myeloid-to-erythroid ratio, megakaryocytic and erythroid lineages, as well as sequential maturation of granulocytic precursors. Changes in the proportions of myeloblasts, promyelocytes, myelocytes, metamyelocytes, band neutrophils, and segmented granulocytes may reflect disturbances in granulopoiesis before substantial alterations become evident in peripheral blood [4,7].

Conversely, peripheral blood analysis measures the clinical expression of these marrow events. A reduction in circulating leukocytes or neutrophils indicates impaired production or accelerated consumption but does not identify the mechanism responsible for marrow dysfunction. Patients with similar leukocyte counts may therefore have markedly different patterns of bone marrow recovery depending on the extent and nature of hematopoietic injury [5,7,8].

This distinction is clinically relevant. Two individuals presenting with comparable degrees of leukopenia after chemotherapy may experience different durations of cytopenia, unequal risks of febrile neutropenia, and variable responses to supportive treatment. Bone marrow morphology may partially explain these differences by revealing residual hematopoietic reserve that remains undetectable through routine blood analysis [8,9].

Clinical significance of integrated assessment

The complementary interpretation of peripheral blood counts and bone marrow findings has attracted increasing attention in supportive oncology. Rather than replacing routine laboratory monitoring, myelography may provide additional information in selected clinical situations where the severity or persistence of cytopenia cannot be adequately explained by peripheral blood parameters alone.

Several morphological characteristics have been investigated as potential indicators of hematopoietic reserve. Overall marrow cellularity, preservation of granulocytic precursors, maturation arrest within the myeloid lineage, and alterations in the myeloid-to-erythroid ratio have each been associated with subsequent hematological recovery in different clinical settings. Although the available evidence remains heterogeneous, these observations support the concept that marrow morphology reflects biological processes preceding the development of clinically significant leukopenia [4,9,10].

Recognition of these patterns may influence clinical decision-making. Patients with preserved marrow reserve despite transient leukopenia could safely continue planned treatment with appropriate monitoring, whereas individuals demonstrating profound suppression of granulopoiesis may benefit from earlier supportive interventions, including growth factor administration or temporary modification of chemotherapy schedules. Such decisions should always integrate laboratory findings, clinical condition, and treatment objectives rather than rely on a single hematological parameter.

Current evidence and unresolved questions

Over the past decade, interest in predicting chemotherapy-induced leukopenia before the onset of severe cytopenia has steadily increased. Most published prediction models have relied on clinical characteristics, treatment-related variables, or routine laboratory parameters. Age, previous chemotherapy, baseline neutrophil count, treatment intensity, nutritional status, and comorbid conditions have all been incorporated into different risk models with varying predictive performance [3,5,8].

By comparison, bone marrow morphology has received considerably less attention. This is partly explained by the invasive nature of marrow examination and the absence of standardized morphological criteria applicable to routine oncology practice. Consequently,

myelography is usually reserved for selected patients with prolonged cytopenia, unexplained marrow failure, or suspected disease progression rather than being used as a predictive tool before chemotherapy-associated leukopenia develops [4,7].

Nevertheless, several reports suggest that marrow morphology contains clinically relevant information beyond conventional blood counts. Reduced marrow cellularity, depletion of granulocytic precursors, maturation arrest, and disturbances in the balance between hematopoietic cell lineages have all been associated with delayed recovery of leukopoiesis. These observations support the concept that structural changes within the bone marrow precede alterations detectable in peripheral blood [4,9,10].

Interpretation of the available evidence should, however, remain cautious. Published studies differ substantially with respect to patient populations, underlying malignancies, chemotherapy regimens, timing of marrow examination, and methods used to evaluate morphological changes. Such heterogeneity limits direct comparison between studies and complicates the identification of universally applicable predictive markers.

Another unresolved issue concerns the relationship between marrow morphology and clinically meaningful outcomes. Most investigations have focused on laboratory recovery of leukocyte counts, whereas fewer studies have evaluated endpoints such as febrile neutropenia, documented infection, chemotherapy delay, dose reduction, hospitalization, or treatment discontinuation. Whether specific myelographic abnormalities independently predict these outcomes remains uncertain.

Future perspectives

Current developments in supportive oncology increasingly emphasize individualized risk assessment rather than uniform management strategies. Integrating clinical characteristics, peripheral blood indices, and bone marrow findings may improve identification of patients at greatest risk for severe hematological toxicity.

Future predictive models are likely to incorporate several complementary sources of information instead of relying on a single laboratory parameter. Bone marrow morphology may represent one component of such multidimensional assessment, particularly when interpreted together with routine hematological data and established clinical risk factors. This integrated approach could assist clinicians in selecting patients who require closer monitoring, early administration of growth factors, antimicrobial prophylaxis, or timely adjustment of chemotherapy intensity.

Further progress will depend on prospective studies using standardized methods for marrow evaluation and uniform clinical endpoints. Consistent morphological criteria would facilitate comparison between studies and clarify which bone marrow features have independent prognostic significance. Such evidence is required before myelographic findings can be incorporated into routine supportive care algorithms.

Conclusion

Peripheral blood analysis and bone marrow examination should be regarded as complementary rather than competing approaches in the assessment of chemotherapy-induced leukopenia. Peripheral blood reflects the clinical manifestation of myelosuppression, whereas bone marrow morphology provides direct information on hematopoietic activity and regenerative capacity. Used together, these methods offer a more comprehensive understanding of marrow response to cytotoxic treatment than either assessment alone.

Current evidence suggests that selected myelographic features may contribute to more accurate evaluation of hematological risk, although the available data remain limited and methodologically heterogeneous. At present, routine clinical decisions should continue to rely primarily on established hematological and clinical criteria. However, bone marrow examination may provide valuable additional information in carefully selected

patients, particularly when the severity or duration of cytopenia cannot be adequately explained by peripheral blood findings alone.

Well-designed prospective studies are needed to determine which morphological characteristics have independent prognostic value and how they can be integrated into practical risk assessment models for patients receiving systemic anticancer therapy.

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