Features of the neutrophil granulocyte system in patients with common scalp defects

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Abstract

Objective. To identify the dynamics of changes in the structure of the neutrophil granulocyte system in patients with extensive scalp defects before and after their surgical closure.

Materials and methods. A computer morphometric analysis of the quantitative and qualitative characteristics of neutrophilic granulocytes of patients with common scalp defects who were treated at the Department of Microvascular Plastic and Reconstructive Surgery of the Shalimov National Scientific Centre of Surgery and Transplantation from 2017 to 2023. The main group included 15 patients with widespread defects of the soft tissues of the scalp in the I–II stage of the wound process (10) and arteriovenous angiodysplasias in the III stage according to Schobinger (5). The control group consisted of 15 volunteers without pathology. The structure features (optical cytoplasmic density in units, which indicates the presence of bactericidal potential, and cell area in μm², which indicates the level of activation) of peripheral blood neutrophil granulocytes before and after surgical closure of the defect were studied.

Results. Before the surgical intervention, a pronounced polymorphism was detected, which meant a functional failure of the neutrophil granulocyte system. After surgery and healing of the defect, excessive polymorphism of the neutrophil granulocyte system was not detected in patients.

Conclusions. The assessment of the degree of cellular polymorphism of neutrophil granulocytes determines the diagnostic efficiency of the study and makes it possible to identify and predict the development of local inflammation and infectious complications in patients with scalp defects.

Key words: neutrophilic granulocytes; scalp defect; cellular polymorphism.

The neutrophil granulocyte (NG) system is one of the most sensitive indicators of the state of the homeostasis system [1, 2]. Normally, NGs are in an inactive state or have moderate signs of activation. In pathological conditions, they are constantly exposed to various endogenous and exogenous irritating factors, stimulating these cells, depleting their bactericidal potential and leading to functional failure. Stimulated NGs, in turn, become powerful effectors that trigger a cascade of reactions that cause the development of inflammation [3, 4].

In surgical practice, similar processes are observed in inflammatory and purulent–septic processes, when endogenous agents (microorganisms and their products) constantly activate the NG in the body of patients [5, 6]. Today, this is extremely important, as the incidence of purulent inflammatory diseases of soft tissues and infectious wound complications is growing catastrophically fast, especially in combat. Entering the bloodstream from a wound site, toxic histolytic products disrupt liver and kidney function, and threaten to cause various complications, often life-threatening.

This is especially true for scalp defects, as the specific characteristics of soft tissue make primary closure of common tissue defects in this area virtually impossible. Unsuccessful reconstruction attempts or the surgeon’s conscious choice of secondary tension healing often result in the defect remaining in place for a long time, acting as an irritant that causes hyperactivation and depletion of the bactericidal potential of the NG, which leads to an imbalance in the body's nonspecific defence and, as a result, the development of infectious and inflammatory complications.

The aim of the study is to identify the dynamics of changes in the structure of the blood coagulation system in patients with common scalp defects before and after their surgical closure.

Materials and methods

The study was based on the results of the study of the structure of peripheral blood NGs (optical density of the cytoplasm in units, which indicates the presence of bactericidal potential, and cell area in μm², which indicates the level of activation) in 15 patients (main group) with widespread defects of the soft tissues of the scalp in the I–II stage of the wound process (10) and arteriovenous angiodysplasias in the III stage according to Schobinger (5). The control group consisted of 15 volunteers without pathology.

Blood samples stained by the Romanowsky–Gimza method were examined under standard lighting and magnification conditions on an Olympus computer analyser using DP–SOFT software (Japan and Paradise, Ukraine). The obtained quantitative results were processed statistically.

Results

The morphometric analysis revealed a significant variability in the values of NG parameters both in normal and pathological conditions.
In the control group, the cell area ranged from 82 to 134 μm², with an average of (107 ± 3.31) μm² (CV 19.7%), and the cytoplasmic optical density from 14 to 38 units, with an average of (27 ± 0.5) units (CV 14.1%).

In patients, cell area values ranged from 86 to 160 μm², with an average of (124 ± 5.01) μm² (CV 28.5%), and cytoplasmic optical density from 25 to 50 units, with an average of (36.3 ± 1.0) units (CV 21.3%).

The quantitative and qualitative characteristics of blood NGs were analysed, and 4 types of cells were identified in each observation, which differed in their size (area) and qualitative characteristics of the cytoplasm: small dark inactive NGs; medium moderate (normal) weakly activated; moderately enlarged enlightened moderately activated; large light polymorphic cells with degenerative changes, toxicogenic granularity and depleted bactericidal potential (Fig. 1).

The ratio of different cell types reflected the presence of signs of activation by the degree of polymorphism in the studied blood NG system.

According to the results of the analysis of the dynamics of changes in the structure of the blood NG system in terms of cell area and cytoplasmic density, moderate values were considered to be normal, and significant variability reflected different levels of cell activation and degradation.

A characteristic feature of the NG structure in the cytograms of the control group was moderate polymorphism in cell size and cytoplasmic density. Cells of medium (normal) size (70%) and moderately enlarged cells (20%) predominated, 0–1% were large polymorphic cells, and 10% were small inactive forms (Fig. 2).

In the cytograms of patients with scalp tissue defects before surgery, the variability of NG in terms of cell size and...
cytoplasmic density was significant and differed significantly from the corresponding indicator in the control group.

Activated NGs were dominated not only by moderately enlarged (44 – 46%), but also by large polymorphic cells with degenerative and dystrophic cytoplasmic changes (41 – 42%), often with toxicogenic granularity, medium (normal) cells in size were 10 – 12%, and small (inactive) forms were 0 – 2% (Fig. 3).

The expressed polymorphism meant functional failure of the NG system, severe metabolic intoxication with a high probability of chronic active inflammation.

In the enlarged and large forms of activated NGs, cytoplasmic vacuoles were observed, which looked like unevenly distributed transparent areas not connected to the cell membrane. Vacuolation was more common in the cytoplasm and sometimes in the nucleus. Its presence indicated deep dystrophic and degenerative changes in the cell and the severity of the pathological process.

After surgical intervention and healing of the defect, excessive polymorphism of the NG system was not detected in patients. Cells with medium (normal) size (47%) and moderately enlarged size (33%) predominated. The proportion of large polymorphic cells with signs of activation decreased to 13%, small inactive forms accounted for 7% (Fig. 4).

Discussion
The problem of diagnosing and predicting the occurrence of infectious complications in patients with defects remains relevant, despite practical experience and scientific achievements in this area [7, 8].

The absence of clear criteria for assessing the course of the wound process in the defect, the emergence of various high-tech diagnostic techniques cause differences in the assessment of the effectiveness of treatment and the risk of complications [9].

Today, the treatment of defects and chronic wounds is often ineffective without a comprehensive assessment of the structural and functional state of the immune system [10].

In modern practice, the function of the immune system can be quite accurately assessed by its nonspecific cellular component, namely the functional state of the NG [11, 12].

One of the most informative and effective methods for studying the activity of the NGs is morphometric analysis, which involves determining their perimeter, area, compactness, etc. [13, 14]. Of course, the main disadvantage is that the technique requires a specific automated system for image processing [15, 16]. However, today, with the widespread computerisation of the medical field, obtaining a digitised image of the cell projection and calculating their morphometric parameters is becoming more accessible [17, 18].

The morphometric analysis of the NG performed in our study revealed a number of parameters that were characteristic of patients with scalp defects before surgical treatment and changes in these parameters after defect healing. The obtained results of blood tests of patients before surgical closure of scalp defects (pronounced cell polymorphism) indicated a functional failure of the NG system, impaired bactericidal function of cells with a high probability of chronic active inflammation and development of infectious complications. The literature describes similar features in patients with trophic limb ulcers on the background of varicose veins, as well as in patients with purulent inflammatory diseases of the trunk and extremities (abscesses, phlegmon, paraproctitis, chronic ulcers, etc.) on the background of diabetes mellitus, which corresponded to the third degree of morphological and functional failure of the HP [5, 6].

After surgical intervention and healing of the defect in patients, the obtained values of cell area and optical density of the cytoplasm corresponded to those in the control group. According to the literature, such indicators correspond to the first degree of morphological and functional insufficiency of the NG and are considered normal, physiological cell degradation [6].

The normalisation of patients' cytograms after surgery demonstrates the importance of timely closure of scalp defects, as the effectiveness of treatment affects not only the course of the wound process but also the body's susceptibility to the development of infectious and inflammatory diseases of other organs and systems.

Conclusions
1. Comparison of the state of the NG system of patients before and after surgery revealed severe disorders, depression of function, signs of metabolic intoxication and its damage of varying severity.
2. After closure and complete healing of the defect, the structural and functional state of the NG system in terms of cell polymorphism had significantly fewer deviations from the norm, NGs did not have cytoplasmic vacuolation and toxicogenic granularity.
3. Evaluation of the degree of cellular polymorphism of NG confirms the diagnostic efficiency and value of the study and makes it possible to identify and predict the development of local inflammatory process and infectious complications.

Ethical statement. All procedures involving the study participants complied with the ethical standards of the Institutional Research Committee of the National Scientific Centre of Surgery and Transplantation named after A.A. Shalimov, as well as the 1964 Declaration of Helsinki as amended or comparable ethical standards.

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