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MORPHOLOGICAL ERRORS IN THE EVALUATION OF SMALL BIOPSIES AND THEIR PREVENTION

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Abstract. *Small biopsies are of great importance in pathological diagnostics, as they allow for the early detection of many diseases and the determination of treatment strategies.*

However, morphological errors that occur during the evaluation of these samples can lead to incorrect diagnosis and a negative impact on the patient's health. The article analyzes the main morphological errors that occur during the study of small biopsies, their causes and clinical consequences. It also highlights the importance of improving the biopsy technique, proper sample preparation, and the use of modern diagnostic methods (immunohistochemistry, molecular diagnostics) to prevent errors. The study also shows the possibilities of reducing diagnostic errors by improving the professional skills of pathologists and strengthening quality control.

Keywords: *Small biopsy, morphological errors, diagnostic errors, pathological diagnosis, biopsy technique, sample preparation, immunohistochemical analysis, molecular diagnostics, diagnostic accuracy.*

МОРФОЛОГИЧЕСКИЕ ОШИБКИ ПРИ ОЦЕНКЕ МАЛЫХ БИОПСИЙ И ИХ ПРОФИЛАКТИКА

Аннотация. *Небольшие биопсии важны в патологической диагностике, поскольку они позволяют на ранней стадии выявлять многие заболевания и определять стратегию лечения. Однако морфологические ошибки, возникающие при оценке этих образцов, могут привести к неправильной диагностике и отрицательно сказаться на здоровье пациента.*

В статье анализируются основные морфологические ошибки, встречающиеся при исследовании малых биоптатов, их причины и клинические последствия. Также подчеркивается важность совершенствования методик биопсии, правильной подготовки образцов и использования современных методов диагностики (иммуногистохимия, молекулярная диагностика) для предотвращения ошибок. В исследовании также подчеркивается потенциал снижения диагностических ошибок за счет повышения профессиональных навыков патологоанатомов и усиления контроля качества.

Ключевые слова: *Микробиопсия, морфологические ошибки, диагностические ошибки, патологическая диагностика, методика биопсии, подготовка образцов, иммуногистохимический анализ, молекулярная диагностика, диагностическая точность.*

Introduction

In recent years, diagnostic methods based on small biopsy specimens have been widely used in clinical practice. Fine needle aspiration biopsy, tru-cut biopsy, endoscopic and stereotaxic biopsies are important in the early detection of various diseases, especially neoplastic processes.

These methods are characterized by low invasiveness, rapidity and relatively low risk.

However, the small size of biopsy specimens and the limited morphological features create a number of difficulties in the diagnostic process. Decreased accuracy in pathomorphological assessment, incorrect or ambiguous diagnosis, mainly occur as a result of errors in the biopsy technique, sample processing or microscopic analysis stages. According to data, the error rate of pathological diagnoses based on small biopsies is around 5-15%, which significantly affects clinical decisions and patient prognosis.

The causes of morphological errors are multifaceted: they include incorrect sample collection, shortcomings in fixation and processing technologies, tissue artifacts, poor-quality preparation of histological preparations, misinterpretation of immunohistochemical markers, or subjective assessment errors by the pathologist. Insufficient or incorrect interpretation of clinical data also increases the likelihood of diagnostic errors. In order to increase diagnostic accuracy in modern pathology, it is necessary to strengthen quality control at each stage of small biopsy specimens, implement standard diagnostic protocols, and use advanced technologies, including immunohistochemistry, molecular diagnostics, and digital pathology. This article provides an in-depth analysis of the main errors encountered in the morphological evaluation of small biopsies, their causes, impact on the diagnostic process, and strategies for their prevention.

Literature review and method

This study analyzed 200 small biopsy specimens submitted to the pathology laboratory for histological examination between 2022 and 2024. The tissues included skin, respiratory tract, digestive tract, liver, and kidney biopsies with suspected tumors. Each specimen was fixed using a classical fixation method (in 10% formalin solution) and embedded in paraffin blocks. Sections stained with standard hematoxylin-eosin were prepared for microscopic evaluation. The following parameters were studied in the evaluation of biopsies: the presence of artifacts in the specimen, incorrect orientation of the specimen, quality of fixation, quality of sectioning, and the degree of clarity of the histological structure. Each biopsy was reviewed by at least two experienced pathologists, and when errors were identified, they were grouped according to their causes: preanalytical (biopsy collection and preparation errors), analytical (morphological errors in assessment), and postanalytical (reporting errors).

Biopsy protocols, specimen fixation and processing procedures, and the use of immunohistochemical and molecular analysis techniques were also reviewed to develop strategies to prevent morphological errors. Simple percentage distributions and error frequencies were calculated for statistical analysis. Correlation analyses were performed to determine their dependence on biopsy type, site, and sample preparation method. A total of 450 biopsy specimens (tru-cut biopsy, fine needle aspiration biopsy, and endoscopic biopsies) were selected for morphological evaluation. The tissue types of the samples were: lung, liver, kidney, gastrointestinal tract, skin and lymph node biopsies.

The study was carried out in the following stages:

- In the preanalytical stage, the biopsy method, sample fixation and delivery conditions to the laboratory were evaluated.
- In the analytical stage, the processes of histological section preparation, staining (hematoxylin-eosin, immunohistochemistry) and microscopic evaluation were studied.
- In the postanalytical stage, the diagnosis, report preparation and correlation with clinical data were analyzed.

Morphological errors were classified based on the following criteria:

1. Preanalytical errors (small biopsy volume, fixation errors, tissue artifacts).
2. Analytical errors (incorrect staining, poor section quality, misinterpretation of morphological features).
3. Postanalytical errors (incorrect final diagnosis, incorrect assessment of clinical data).

Statistical analysis in the study was performed using SPSS 26.0 software. Percentages and the χ^2 (chi-square) test were used for categorical data. $P < 0.05$ was considered statistically significant.

The overall morphological error rate in the 200 small biopsy specimens analyzed was 28%. 60% of the errors were detected in the preanalytical stage, i.e. during biopsy collection and sample preparation, 30% occurred in the analytical stage, i.e. during microscopic evaluation, and the remaining 10% were detected in the postanalytical stage, i.e. during diagnostic reporting. The most common preanalytical errors were insufficient biopsy specimen collection (20%), poor fixation quality (15%), and incorrect specimen orientation (10%). Analytical errors were mainly related to misinterpretation of histological structure and errors in differential diagnosis. The results of the study showed that the number of diagnostic errors increases significantly when the biopsy technique is not strictly followed. At the same time, high diagnostic accuracy and reduced morphological errors were observed in biopsies using immunohistochemical and molecular diagnostic methods.

In the discussion section, it is worth noting that the specific characteristics of small biopsies - small tissue volume, easy susceptibility to artifacts and limited amount of material from a diagnostic point of view - require a high level of care and experience from the pathologist. Also, the use of proper fixation and professional histological preparation methods, starting from the biopsy extraction stage, can significantly reduce the level of errors. This study shows that effective communication between pathologists and clinicians, regular training sessions and the introduction of a quality control system in laboratories are necessary to prevent morphological errors in the evaluation of small biopsies.

Discussion

The evaluation of small biopsies presents unique challenges in the field of pathology, where morphological errors can significantly affect diagnostic accuracy and, consequently, patient outcomes. Small biopsies, often taken through minimally invasive techniques such as needle biopsies, are subject to a range of limitations that make their interpretation particularly challenging. In our study, we observed that despite advances in histopathological techniques, morphological errors in the evaluation of small biopsies remain a prevalent issue.

These errors can occur due to various factors, including sample size, tissue fragmentation, technical issues during processing, and the subjective nature of pathologist interpretation.

One of the most common errors identified in the evaluation of small biopsies is the misinterpretation of tissue architecture. Small samples often fail to provide a full representation of the lesion or disease process, leading to incomplete or incorrect diagnoses. For example, in cases of malignancy, small biopsies may not capture the heterogeneity of the tumor, resulting in an underestimation of the aggressiveness or spread of cancer. This is particularly problematic in cancers with poorly differentiated areas or those with subtle morphological changes that are not easily detected in small sections of tissue. The diagnostic accuracy can also be affected by the presence of inflammatory cells or necrosis, which may obscure underlying pathological features.

Another significant challenge is the issue of sampling errors. Small biopsies may not include key areas of interest, such as the invasive front of a tumor or areas with distinct histopathological characteristics. This can lead to a false negative result or an incomplete diagnosis, especially when biopsies are taken from sites that are not representative of the overall pathology. Inadequate sampling can also result in a lack of adequate tissue for comprehensive molecular or genetic analysis, further complicating the diagnostic process.

To prevent these morphological errors, it is essential to improve both the techniques used to obtain biopsies and the processes involved in their evaluation. First and foremost, clinicians should ensure that biopsies are taken from representative areas of the lesion, and where possible, larger samples should be obtained to increase the likelihood of capturing the full scope of the pathological process. The use of imaging guidance, such as ultrasound or CT scans, can aid in obtaining more accurate samples from the most relevant regions of the lesion.

Furthermore, pathologists should be aware of the limitations associated with small biopsy specimens and adopt a more cautious approach when interpreting these samples. Cross-referencing clinical information, radiological findings, and, when possible, additional tissue samples can help to reduce the risk of diagnostic errors. Pathologists must also be trained to identify the potential pitfalls of small biopsies, including recognizing the subtle differences between benign and malignant conditions in small tissue sections. Advances in technology, such as the development of more sophisticated imaging techniques and molecular diagnostic tools, can also play a key role in improving the accuracy of small biopsy evaluations. The incorporation of digital pathology, artificial intelligence, and automated image analysis may help to identify morphological features that are difficult to detect with the human eye, thus reducing the potential for error.

In addition to technical improvements, collaboration and communication between clinicians and pathologists are critical in preventing errors in the evaluation of small biopsies. A multidisciplinary approach, where pathologists work closely with radiologists and surgeons, can ensure that biopsy samples are collected appropriately, and the interpretation of these samples is aligned with the overall clinical picture.

Conclusion

Morphological errors in the evaluation of small biopsies directly affect the accuracy of diagnosis and are an important factor determining the outcome of patient treatment.

The results of this study showed that errors can occur at all stages, from biopsy collection to laboratory processing and microscopic evaluation. In particular, errors at the preanalytical stage have a serious impact on the quality of morphological evaluation. To prevent morphological errors, it is necessary to improve the biopsy technique, prepare samples on a standardized basis, use immunohistochemical and molecular methods more widely, and improve the skills of pathologists.

It is also necessary to establish effective cooperation between clinical and laboratory staff and implement a regular quality control system. By correctly evaluating small biopsies and minimizing errors, it will be possible to increase diagnostic reliability, early detection of diseases, and develop an individual approach to patients.

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