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Histopathology: an Ancient Technique for a New Insight in the Ecotoxicology

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Opinon

The biotic integrity of an ecological system is often reflected in the health of the organisms that inhabit it. In aquatic ecosystems, fish and amphibians, particularly those species at the top of the food chain, are representative bioindicators of the system's overall health. In general, aquatic organisms in their natural environments are typically exposed to numerous stressors, includaing adverse or fluctuating temperatures, poor water quality and sediment loads, low dissolved oxygen concentrations, limited food availability, and other episodic variables. In addition, anthropogenic stressors such as contaminant loads (e.g., agrochemical compounds) can add to the insults already experienced by these organisms in many aquatic systems. In this context, the histopathology is a singular tool in ecotoxicological studies.

Although histopathology is ultimately a descriptive science, the recognition and quantification of microscopic findings play a pivotal role in studies aimed at environmental quality based on a broad range of organism bioindicators. In an original study, Bernet, et al. [1] proposed a new interpretation of tissue changes based on their reversible or non-reversible effects (w1, w2, and w3) and their distribution (a1…a4) in the tissue. Furthermore, this methodology allows for the reliable comparison of controlled groups in experimental cause-and-effect studies, monitoring ecosystems using bioindicator fish, and the analysis of environmental events over time. Indeed, in the present day, many studies utilize this histopathological approach, which provides insights into how organisms can respond to environmental stressors. Unfortunately, similar methods have not been proposed for other groups of aquatic organisms besides the fish.

The utilization of histopathology as a biomarker constitutes a component of a comprehensive analytical framework designed to discern exposure processes and their associated effects, with due consideration given to the diverse levels of biological organization. However, while technology advances rapidly to identify new biomolecules, peptides, genetic mechanisms, and cytotoxic and degenerative oxidative responses from almost instantaneous tests, histopathology remains a classic tool for studying and interpreting organic responses. For example, the best tissue stain remains hematoxylin and eosin (H&E), which has been used worldwide as a gold standard for analyzing tissue morphology for almost 150 years [2]. Integrated with novel microscopic techniques and image digitalization, the classic histopathological reading in H&E has become renewed. It allows us to explore new aspects of the relationship between aquatic organisms and the native environment [3].

In aquatic organisms, a set of cellular and tissue alterations (histopathological lesions) demonstrate patterns associated with acute or chronic exposure processes according to the degree of environmental contamination. As a result, the lesions can be considered excellent biomarkers or endpoints of effect, mainly due to their reversible and distribution character. Specific patterns of certain histopathological endpoints play a pivotal role in environmental diagnosis and prognosis of morbidity and mortality against the different stressors. From the perspective of the target organism's health, biomarkers of effect illustrate the spectrum of pathological manifestations, encompassing the disruption of homeostatic and functional mechanisms, as well as the emergence of alterations in behavioral, anatomical, morphological, histopathological, functional, and biochemical characteristics in diverse bioindicators exposed to an array of contaminants. In cases of chronic toxic exposure, lesions may undergo evolutionary (irreversible) or regressive (reversible) processes. These dynamics cannot always be interpreted from an individual perspective but must be quantified based on the experimental group. This approach provides a more accurate way to establish the risk of environmental contamination.

In conclusion, quantitative data based on lesions' relative weights and distribution provide a more biologically realistic and practical approach to histopathological analysis than traditional descriptive criteria. The combination of histopathological indices enables the establishment of novel statistical methodologies for correlating lesions with many environmental stressors. According to their reversibility pattern, the frequency of changes permitted the sensible grouping of histopathological lesions following their biological significance.

References

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