



INFORMATION PLATFORM "CENTER FOR INNOVATIVE THINKING"
UKRAINIAN INSTITUTE OF SCIENTIFIC STRATEGIES
EUROPEAN UNION RESEARCH DEPARTMENT
SCIENTIFIC AND PUBLISHING CENTER "PROGRESS"

PARIS SCIENCE AND EDUCATION FORUM

PROCEEDINGS OF THE INTERNATIONAL SCIENTIFIC
AND PRACTICAL CONFERENCE



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The collection of scientific articles is a scientific and practical publication that includes research papers by students, postgraduate students, Candidates and Doctors of Sciences, researchers, and practitioners from Ukraine, Europe, neighboring countries, and beyond. The articles reflect studies of processes and changes in the structure of modern science. This collection is intended for students, postgraduate and doctoral candidates, educators, researchers, practitioners, and all those interested in current trends in the development of modern science.

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THYROID CANCER: ASPECTS OF MORPHOLOGICAL DIAGNOSTICS AND NANOTECHNOLOGIES

Abstract. Thyroid cancer (TC) shows a steady upward trend in incidence worldwide and in Ukraine, which makes it important to improve approaches to its diagnosis and treatment. The aim of this study was to analyze current literature on the morphological features of TC and the potential use of molecular biomarkers and nanotechnologies in its diagnosis. The main histological types of tumors, their prognostic significance, and problematic aspects of morphological verification, particularly in follicular neoplasms, are highlighted. The role of molecular markers (RET, BRAF, RAS) in differential diagnosis, prognosis, and the selection of personalized therapy is demonstrated. The prospects for the use of nanoparticles, nanosensors, drug delivery nanosystems, and nanoimaging technologies for early detection and improved biopsy accuracy are discussed. The use of innovative

molecular and nanotechnological approaches expands the possibilities for early diagnosis and improves treatment outcomes for patients with TC.

Keywords: thyroid cancer, incidence, morphological diagnosis, biomarkers, nanotechnology

Over the past decades, thyroid cancer (TC) has shown a consistent increase in incidence worldwide, making it one of the most dynamic forms of oncological pathology. Current concepts of carcinogenesis indicate that a significant proportion of malignant neoplasms are associated with the influence of anthropogenic factors, including chemical compounds, physical and biological agents, pharmacological substances, occupational hazards, and complex exogenous exposures. These factors play a crucial role in the development of the majority of clinicopathological forms of TC [1].

Within the histological spectrum of TC, differentiated carcinomas predominate—papillary (60–80%) and follicular (15–30%)—which are characterized by a relatively favorable course and high survival rates. Medullary carcinoma, arising from parafollicular C-cells, accounts for 7–10% of cases and exhibits intermediate prognostic features. Undifferentiated (anaplastic) tumors of uncertain histogenesis (2–5%) demonstrate aggressive clinical behavior and are associated with unfavorable prognosis [2].

According to global epidemiological data (GLOBOCAN 2022), in 2020, 586,000 new cases of thyroid cancer (TC) were registered worldwide, ranking it ninth in the overall structure of oncological incidence. The crude incidence rate was 7.5, while the age-standardized rate was 6.6 per 100,000 population. In Central and Eastern European countries, incidence rates exceed the global average, partially attributed to the effects of radionuclide contamination. However, high incidence levels are also observed in several Western and Southern European countries that were not significantly affected by radiation exposure, indicating a complex, multifactorial etiology and the need for a broader analysis of disease determinants [3].

In Ukraine, a pronounced upward trend in TC incidence is also evident, particularly among women. Between 1989 and 2012, incidence more than doubled, with an average annual increase of 5–6%. Territorial distribution shows considerable variability: the highest rates are recorded in major urbanized regions, while the western regions of the country demonstrate relatively lower incidence [1, 3-5].

Thyroid cancer remains a priority area in contemporary endocrinology, endocrine surgery, oncology, and pathological anatomy. A key factor in improving long-term prognosis is early detection of thyroid carcinomas, which allows for organ-preserving treatment at initial tumor stages, minimizes postoperative complications, and achieves sustained clinical outcomes. Consequently, new diagnostic algorithms and therapeutic strategies are actively being developed to enhance treatment efficacy and improve patients' quality of life [4, 6, 7].

The aim of this study is to analyze current literature concerning the morphological features of thyroid cancer (TC) and the potential applications of nanotechnologies in its diagnosis. Most pathological changes characteristic of TC can be verified using standard histological preparations stained with hematoxylin and eosin. At the same time, a significant proportion of tumors exhibit ambiguous and subjective morphological features, complicating the prediction of outcomes, particularly in the case of follicular nodular lesions.

According to histological classification, TC is divided into well-differentiated and undifferentiated (anaplastic) carcinomas originating from follicular epithelium, while medullary carcinoma, arising from parafollicular C-cells, occupies an intermediate prognostic position. Differentiated forms—papillary and follicular adenocarcinomas—generally display a slow course and favorable prognosis. Among all nodular lesions of the thyroid gland, differentiated TC accounts for approximately 5%, with papillary carcinoma representing about 80% of cases. Thyroid nodules are frequently detected in population screenings (20–50% of cases), imposing a substantial burden on endocrine healthcare services [6, 7].

Histological criteria based on mitotic count, presence of necrosis, and Ki67 index are applied to identify high-grade malignancies, as well as follicular-cell and

medullary carcinomas. High-grade malignancy is defined by ≥ 5 mitoses per 2 mm² or the presence of necrotic areas [7, 8].

Molecular biomarkers play a key role in the diagnosis, prognosis, and monitoring of TC by detecting specific genetic or molecular alterations in thyroid cells. The most significant markers include mutations in RET, BRAF, and RAS genes, which assist in treatment planning, predicting disease progression, and guiding surgical interventions. The use of molecular techniques such as polymerase chain reaction, genome sequencing, and mass spectrometry supports therapy personalization and enhances the accuracy of clinical decision-making [9, 10].

Nanotechnologies hold significant potential in the diagnosis and treatment of malignant tumors, including thyroid cancer (TC), as they can enhance diagnostic accuracy, facilitate early detection, and improve disease monitoring. The main research directions include:

- Nanoparticles for tumor imaging (nanoimaging). Magneto-responsive nanoparticles can accumulate in tumor tissues due to passive effects associated with microcirculation characteristics. Once accumulated, they can be utilized for magnetic resonance imaging, enhancing contrast and allowing more precise determination of tumor size and localization. Some nanoparticles also emit light, which can be used for fluorescent imaging during surgical resection or for monitoring tumor progression. Currently, these technologies are in clinical research stages but show promising prospects for broader implementation in the near future [11].

- Nanorobots. Microscopic machines introduced into the body that interact with cells can be applied for targeted drug delivery or removal of pathological tissues, offering potential for both therapeutic intervention and more precise diagnosis of TC [12].

- Nanosensors. Sensors based on nanomaterials can detect specific tumor biomarkers, circulating tumor cells, and extracellular vesicles, enabling early detection of TC and improving treatment monitoring. One example is the targeted Affi body-Au-Tripod nanosensor, which allows photoacoustic imaging of EGFR-

positive cells with minimal cytotoxicity and high chemical and physical stability [11, 13].

- Nanotechnologies in biopsy. The use of nanorobots, nanosensors, and micro- and nanoneedles allows tissue samples to be obtained with high precision and minimal trauma. Nanocoatings on instruments enhance durability and maneuverability. Additionally, nanotechnologies can be employed to label cells within samples, increasing the accuracy of histological verification [14].

- Nanosystems for drug delivery. Organic (liposomes, polymer-based nanoparticles, dendrimers) and inorganic (gold, carbon, mesoporous silica, magnetic, and quantum dots) nanoparticles and their hybrids provide targeted delivery of antitumor agents to TC cells. This approach reduces side effects, increases therapeutic efficacy, and allows integration of screening, diagnosis, and treatment into a unified system [15].

Thus, nanotechnologies significantly expand the capabilities for early diagnosis, biopsy accuracy, and personalized treatment of thyroid cancer (TC). Although most of these methods are still at the research stage, their integration into clinical practice promises substantial improvements in treatment outcomes and patients' quality of life.

Early diagnosis and determination of the histological type of TC remain crucial for predicting disease progression and selecting the optimal therapeutic strategy. The use of molecular biomarkers in combination with contemporary techniques, such as polymerase chain reaction, genome sequencing, and mass spectrometry, enables precise verification of tumor cells, assessment of their aggressiveness, and formulation of personalized treatment approaches [11, 16].

The application of nanotechnologies in TC diagnostics opens new avenues for early detection and disease monitoring. Nanoparticles, nanosensors, nanorobots, and nanoscale drug delivery systems not only enhance the accuracy of examinations and biopsies but also enable effective targeted therapy with minimal side effects. The implementation of such technologies in clinical practice has the potential to significantly improve patient survival and post-treatment quality of life.

Although many of these approaches are still under clinical investigation, current evidence indicates their promise for integration into modern diagnostic and therapeutic protocols for TC. Continued development of nanotechnologies and molecular methods is expected to create highly effective strategies for screening, early detection, and personalized therapy, offering patients a more favorable prognosis and improved long-term clinical outcomes.

In conclusion, the contemporary approach to TC combines traditional morphological methods, molecular diagnostics, and innovative nanotechnologies, enhancing the precision of early tumor verification, optimizing treatment, and improving patient quality of life. Ongoing research in this field remains critically important for developing effective clinical protocols and integrating innovative technologies into routine medical practice.

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