WHO CLASSIFICATION OF TUMOURS OF ENDOCRINE ORGANS Updated Version

WHO classification of tumours of endocrine organs is a comprehensive system developed by the World Health Organization to categorize and diagnose tumors originating from endocrine glands. This classification provides a standardized framework that aids pathologists, endocrinologists, and oncologists in understanding the nature, prognosis, and appropriate treatment strategies for these tumors. Given the complexity and diversity of endocrine tumors, the WHO classification has evolved over the years to incorporate advances in molecular pathology, histopathology, and clinical research.

Introduction to Endocrine Tumors and Their Significance

Endocrine tumors are neoplasms arising from endocrine glands such as the thyroid, parathyroid, adrenal glands, pituitary, and neuroendocrine cells scattered throughout various organs. These tumors can be benign or malignant and often produce hormones, leading to diverse clinical syndromes. Accurate classification is vital for prognosis determination, therapeutic decision-making, and research.

Historical Development of WHO Classification of Endocrine Tumors

The WHO classification was first introduced in 2004 and has undergone multiple updates, notably in 2017. These revisions reflect new insights from molecular genetics, immunohistochemistry, and clinical behavior patterns. The current system emphasizes a combined approach that considers morphology, immunophenotype, and molecular features, facilitating precise diagnosis and personalized medicine.

Major Categories in WHO Classification of Endocrine Tumours

The WHO classification divides endocrine tumors primarily based on the organ of origin and tumor behavior. The main categories include:

- Thyroid tumors
- Adrenal tumors
- Parathyroid tumors
- Pituitary tumors
- Neuroendocrine tumors of other organs

Each category comprises benign, uncertain malignant potential, and malignant tumors, with specific subtypes and grading systems.

Thyroid Tumours

Thyroid tumors are among the most common endocrine neoplasms. They are classified into several categories:

Differentiated Thyroid Carcinomas

These tumors retain some features of normal thyroid tissue and are generally associated with a better prognosis.

- **Papillary Thyroid Carcinoma (PTC):** The most common type, characterized by papillary structures and nuclear features such as clearing and grooves.
- **Follicular Thyroid Carcinoma (FTC):** Comprises follicular structures; invasion through the capsule or blood vessels signifies malignancy.
- **Hürthle Cell Carcinoma:** A variant of FTC with oncocytic features.

Medullary Thyroid Carcinoma (MTC)

Arises from parafollicular C cells and secretes calcitonin. It has familial and sporadic forms and is associated with RET mutations.

Anaplastic Thyroid Carcinoma

A highly aggressive undifferentiated carcinoma with poor prognosis.

Other Thyroid Tumors

Includes tumors such as diffuse sclerosing carcinoma and benign adenomas.

Adrenal Tumours

Adrenal tumors originate from the cortex or medulla, with distinct classifications.

Adrenocortical Tumors

These include benign adenomas and malignant carcinomas.

- **Adrenocortical Carcinoma (ACC):** Malignant, often secreting hormones like cortisol, and associated with poor prognosis.
- **Adrenocortical Adenoma:** Usually benign and hormonally active or inactive.

Pheochromocytoma and Paragangliomas

Arise from chromaffin cells in the adrenal medulla or paraganglia.

- **Pheochromocytoma:** Located in adrenal medulla; secretes catecholamines.
- **Paraganglioma:** Extra-adrenal; can be sympathetic or parasympathetic.

Other Adrenal Tumors

Rare tumors include myelolipomas and metastases.

Parathyroid Tumours

The most common parathyroid tumor is the parathyroid adenoma, which causes primary hyperparathyroidism.

Benign Parathyroid Tumors

- Parathyroid adenoma: The majority of cases.

Parathyroid Carcinoma

A rare but aggressive malignant tumor requiring surgical excision.

Pituitary Tumours

Pituitary tumors are classified based on size, hormone secretion, and histology.

Adenomas

Most common, benign tumors classified by the hormone they produce:

- Prolactinomas
- Somatotroph adenomas (growth hormone-secreting)

- Corticotroph adenomas (ACTH-secreting)
- Other hormone-secreting adenomas

Pituitary Carcinomas

Extremely rare malignant tumors with metastatic potential.

Others

Include Rathke cleft cysts and craniopharyngiomas, which are non-neoplastic lesions.

Neuroendocrine Tumours of Other Organs

Neuroendocrine tumors (NETs) are a diverse group originating from neuroendocrine cells in various tissues, including the pancreas, lungs, and gastrointestinal tract.

Pancreatic Neuroendocrine Tumours (PanNETs)

Classified based on differentiation, hormonal activity, and grading.

- Well-differentiated neuroendocrine tumors (NETs)
- Neuroendocrine carcinomas (NECs)

Gastroenteropancreatic Neuroendocrine Tumours (GEP-NETs)

Includes tumors of the stomach, small intestine, colon, and rectum.

Lung Neuroendocrine Tumors

Divided into typical carcinoids, atypical carcinoids, large cell neuroendocrine carcinomas, and small cell lung carcinomas.

Grading and Staging in WHO Classification

The WHO system incorporates grading based on mitotic activity, Ki-67 proliferation index, and histological features to predict tumor behavior. Staging follows the TNM system, considering tumor size, lymph node involvement, and metastasis.

Molecular Pathology and Its Role in Classification

Recent updates emphasize molecular alterations, such as mutations in RET, RAS, TP53, and others, which refine diagnosis and enable targeted therapy. For example:

- RET mutations are prominent in medullary thyroid carcinoma.
- BRAF mutations are common in papillary thyroid carcinoma.
- MDM2 amplification may suggest certain adrenal tumors.

Molecular testing complements histopathology, especially in ambiguous cases.

Clinical Implications of WHO Classification

Accurate classification influences treatment choices, prognosis, and follow-up strategies. For example:

- Benign tumors may require surgical excision with curative intent.
- Malignant tumors often need multimodal therapy, including surgery, radiotherapy, and targeted agents.
- Understanding tumor subtype informs prognosis and genetic counseling, especially in familial syndromes like MEN (Multiple Endocrine Neoplasia).

Conclusion

The WHO classification of tumours of endocrine organs provides a vital framework that integrates morphological, immunohistochemical, and molecular features to deliver precise diagnoses. As research advances, this classification continues to evolve, reflecting our growing understanding of the pathogenesis and behavior of endocrine tumors. Clinicians and pathologists must stay updated with these revisions to optimize patient care, facilitate research, and improve outcomes for individuals affected by these diverse neoplasms.

Keywords: WHO classification, endocrine tumors, thyroid neoplasms, adrenal tumors, parathyroid tumors, pituitary tumors, neuroendocrine tumors, tumor grading, molecular pathology

WHO classification of tumours of endocrine organs is an essential framework that provides a standardized approach to diagnosing, categorizing, and understanding tumors arising from endocrine tissues. These classifications are integral for pathologists, endocrinologists, oncologists, and researchers alike, as they guide clinical management, prognostication, and research directions. Since the World Health Organization?s (WHO) first publication on this topic, the classification system has undergone multiple updates to incorporate advances in molecular biology, histopathology, and clinical outcomes. This review aims to provide a comprehensive overview of the

WHO classification of endocrine tumors, discussing its structure, key categories, updates, strengths, limitations, and clinical implications.

Introduction to WHO Classification of Endocrine Tumours

The WHO classification of tumours of endocrine organs is a globally recognized system that categorizes tumors based on histological features, immunohistochemical profiles, molecular genetics, and clinical behavior. It serves as an authoritative reference for tumor diagnosis and classification, promoting consistency and comparability across different institutions and studies. The latest edition, published in 2022, reflects significant advances in understanding the molecular underpinnings of endocrine tumors, which have led to refinements in classification criteria.

The classification encompasses tumors originating from various endocrine organs, including the thyroid, parathyroid, adrenal glands, pituitary, neuroendocrine neoplasms of the pancreas, and other neuroendocrine tumors (NETs). It distinguishes benign from malignant lesions, identifies variants with distinct behavior, and integrates molecular insights for a more precise categorization.

Structure of the WHO Classification System

The WHO classification is organized by organ system, with each chapter dedicated to a specific endocrine organ. Within each chapter, tumors are classified into categories based on their histogenesis, differentiation, and aggressiveness. The key elements include:

- Benign tumors: e.g., adenomas
- Borderline or uncertain malignant potential: e.g., certain tumors with atypical features
- Malignant tumors: e.g., carcinomas, neuroendocrine carcinomas

The classification also incorporates:

- Grading: based on proliferative activity
- Staging: for clinical prognosis
- Molecular features: genetic mutations associated with tumor types

This systematic approach enhances diagnostic accuracy and informs prognosis and management strategies.

Thyroid Tumours

The thyroid gland harbors a variety of neoplasms, with papillary thyroid carcinoma (PTC) being the

most common.

Benign Thyroid Tumours

- Follicular adenoma: encapsulated, benign tumor of follicular cells.
- Features:
- Well-circumscribed, non-invasive
- No capsular or vascular invasion

Thyroid Carcinomas

- Papillary thyroid carcinoma (PTC):
- Most common thyroid malignancy
- Characterized by papillary structures, nuclear features like grooves and inclusions
- Molecular hallmark: BRAF mutations, RET/PTC rearrangements
- Follicular thyroid carcinoma:
- Invades capsule or blood vessels
- Molecular features: RAS mutations, PAX8-PPAR? rearrangements
- Medullary thyroid carcinoma (MTC):
- Arises from parafollicular C cells
- Associated with RET mutations, MEN syndromes
- Anaplastic thyroid carcinoma:
- Highly aggressive, undifferentiated tumor
- Poor prognosis

Features & Pros/Cons:

| Feature | Pros | Cons |

|---|---|---|

| Molecular profiling | Guides targeted therapies | Not always available in resource-limited settings |

| Histological classification | Standardized diagnosis | Overlap in some subtypes complicates diagnosis |

Parathyroid Tumours

Most parathyroid tumors are benign adenomas responsible for primary hyperparathyroidism.

Benign Parathyroid Tumours

- Parathyroid adenoma:
- Encapsulated, monoclonal proliferation
- Features: Chief cell proliferation, sometimes with oxyphil cells
- Features & Considerations:
- Usually solitary
- Can be distinguished from hyperplasia by histology

Malignant Parathyroid Tumours

- Very rare
- Parathyroid carcinoma:
- Invasive growth, potential metastasis
- Features: Trabecular growth, capsular invasion, mitoses

Features & Pros/Cons:

| Feature | Pros | Cons |

|---|---|---|

| Histology | Helps differentiate benign from malignant | Limited by overlapping features and rarity of carcinomas |

Adrenal Gland Tumours

Adrenal tumors include benign adenomas, malignant carcinomas, and neuroendocrine tumors.

Adrenal Cortical Tumours

- Adenomas: benign, non-functional or functional
- Carcinomas: aggressive, associated with hormonal syndromes
- WHO criteria: Weiss score assesses malignancy potential

Pheochromocytomas and Paragangliomas

- Neuroendocrine tumors arising from chromaffin cells
- Features:
- Pheochromocytomas are adrenal
- Paragangliomas are extra-adrenal
- Genetic mutations: SDHx, RET, VHL, NF1

Features & Pros/Cons:

| Feature | Pros | Cons |

|---|---|---|

| Molecular genetics | Allows targeted therapy and risk stratification | Requires advanced testing infrastructure |

Pituitary Tumours

Most are benign adenomas, with a few aggressive or malignant variants.

Types of Pituitary Tumours

- Lactotroph adenomas: prolactin-secreting
- Somatotroph adenomas: growth hormone-secreting
- Corticotroph adenomas: ACTH-secreting, causing Cushing's disease
- Non-functioning adenomas: do not secrete hormones

Features & Pros/Cons:

| Feature | Pros | Cons |

|---|---|---|

| Immunohistochemistry | Helps identify tumor subtype | Hormone levels often guide diagnosis more directly |

Neuroendocrine Tumours of the Pancreas and Other Sites

This includes pancreatic neuroendocrine tumors (PNETs) and other neuroendocrine neoplasms.

Classification of PNETs

- Well-differentiated tumors:
- Functioning (insulinoma, gastrinoma, etc.)
- Non-functioning
- Graded based on proliferative index (Ki-67) and mitotic rate
- Poorly differentiated neuroendocrine carcinomas:
- High-grade, aggressive tumors
- Features: high mitotic rate, necrosis

Features & Pros/Cons:

| Feature | Pros | Cons |

|---|---|---|

| WHO grading | Provides prognostic information | Requires precise proliferation assessment |

Advantages of the WHO Classification

- Standardization: Ensures consistent terminology across institutions.
- Integration of Molecular Data: Reflects current understanding of tumor genetics.
- Prognostication: Helps predict clinical behavior based on histology and molecular features.
- Guides Treatment: Facilitates tailored therapeutic approaches, including targeted therapies.
- Research Facilitation: Provides a framework for clinical and translational research.

Limitations and Challenges

- Complexity: The detailed molecular classifications can be resource-intensive.
- Variability in Access: Not all centers have access to advanced molecular diagnostics.
- Evolving Nature: Rapid advances mean classifications need frequent updates.
- Overlap in Features: Some tumors display overlapping histological and molecular features, complicating diagnosis.
- Prognostic Uncertainty: Some tumors with similar histology behave differently clinically.

Clinical Implications of WHO Classification

The WHO classification influences various aspects of patient care:

- Diagnosis: Accurate tumor typing determines prognosis and management.

- Treatment Planning: Molecular insights enable targeted therapy and personalized medicine.
- Follow-Up: Grading and staging inform surveillance strategies.
- Research and Trials: Uniform classification allows for better patient stratification in clinical trials.

Conclusion

The WHO classification of tumours of endocrine organs represents a cornerstone in endocrine pathology, integrating histopathological features with molecular genetics to refine tumor diagnosis, prognostication, and treatment. While it offers numerous advantages, ongoing updates and integration of novel molecular techniques are necessary to overcome current limitations. As our understanding of tumor biology deepens, future iterations will likely become even more precise, facilitating personalized approaches that improve patient outcomes. Ultimately, the WHO classification remains a dynamic and vital tool in the management of endocrine neoplasms, reflecting the evolving landscape of tumor biology and clinical practice.

QuestionAnswer What is the WHO classification of tumors of endocrine organs based on? The WHO classification of tumors of endocrine organs is based on histopathological features, including cell type, differentiation, molecular characteristics, and tumor behavior, to provide a standardized framework for diagnosis and prognosis. How are neuroendocrine tumors of the pancreas categorized in the WHO classification? In the WHO classification, pancreatic neuroendocrine tumors are categorized into well-differentiated neuroendocrine tumors (NETs) grades 1 and 2, poorly differentiated neuroendocrine carcinomas (NECs), and mixed neuroendocrine-non-neuroendocrine neoplasms (MiNENs), based on differentiation and proliferative activity. What are the key features used to differentiate benign from malignant endocrine tumors in WHO classification? Key features include tumor size, invasion into surrounding tissues, mitotic rate, Ki-67 proliferation index, presence of metastasis, and cellular atypia, which help determine whether an endocrine tumor is benign or malignant. How does the WHO classify medullary thyroid carcinoma? The WHO classifies medullary thyroid carcinoma as a malignant tumor arising from parafollicular C cells, characterized by amyloid stroma and calcitonin production, and distinguishes it from other thyroid neoplasms based on histology and immunohistochemistry. What is the significance of molecular markers in the WHO classification of endocrine tumors? Molecular markers such as MEN1, DAXX, ATRX, and RET mutations are increasingly incorporated into the WHO classification to improve diagnostic accuracy, predict behavior, and guide targeted therapies for endocrine tumors.

Related keywords: endocrine tumors, WHO tumor classification, endocrine neoplasms, endocrine gland tumors, neuroendocrine tumors, endocrine pathology, tumor grading, tumor staging, endocrine tumor types, tumor histology

labelled internal organs of a dissected rabit

Labelled internal organs of a dissected rabbit

Dissecting a rabbit provides valuable insights into mammalian anatomy, offering a detailed view of the internal organs and their spatial relationships. Understanding the labelled internal organs of a dissected rabbit is essential for students, veterinarians, zoologists, and biology enthusiasts who aim to comprehend the complex systems that sustain life in mammals. This article explores the major internal organs, their functions, and their anatomical positions within the rabbit's body, providing a comprehensive overview that is both educational and accessible.

Overview of Rabbit Anatomy

The rabbit?s internal anatomy consists of several vital systems working harmoniously to sustain life. These include the digestive system, respiratory system, circulatory system, reproductive system, nervous system, and excretory system. During dissection, these organs are carefully exposed, identified, and labelled to facilitate understanding of their structure and function.

Major Internal Organs of a Dissected Rabbit

The primary internal organs in a dissected rabbit can be categorized into various systems:

- Digestive organs
- Respiratory organs
- Circulatory organs
- Reproductive organs
- Excretory organs
- Nervous system components

Below is a detailed description of each system's organs with their labels.

1. Digestive System

The digestive system in a rabbit is responsible for processing food, absorbing nutrients, and eliminating waste. The key organs include:

- **Stomach** ? Located in the upper left abdominal cavity, it is a sac-like organ where initial digestion occurs.
- **Small Intestine** ? A long, coiled tube where most nutrient absorption happens. It consists of three parts: duodenum, jejunum, and ileum.
- **Large Intestine (Cecum and Colon)** ? Responsible for water absorption and feces formation.

The cecum is prominent in rabbits, aiding in fermentation of fibrous materials.

- **Liver** ? Situated just below the diaphragm on the right side, the liver produces bile and processes nutrients.
- **Pancreas** ? Located near the stomach, it produces digestive enzymes and insulin.
- **Rectum and Anus** ? End of the digestive tract, responsible for expelling feces.

2. Respiratory System

The respiratory system supplies oxygen to the blood and removes carbon dioxide. Key organs include:

- **Lungs** ? Paired organs situated on either side of the thoracic cavity, responsible for gas exchange.
- **Trachea** ? The windpipe, a tubular structure that conducts air from the larynx to the lungs.
- **Larynx** ? Located at the top of the trachea, involved in voice production.

3. Circulatory System

This system circulates blood, nutrients, and gases throughout the body. Major components include:

- **Heart** ? Located centrally within the thoracic cavity, slightly to the left, it pumps blood through the arteries and veins.
- **Aorta** ? The main artery emerging from the heart, distributing oxygenated blood to the body.
- **Vena Cava** ? Large veins (superior and inferior) that return deoxygenated blood to the heart.
- **Blood Vessels** ? Including arteries, veins, and capillaries, which are distributed throughout the body.

4. Reproductive System

Reproductive organs vary between male and female rabbits.

In females:

- **Ovaries** ? Small, oval structures located near the kidneys.
- **Oviducts** ? Tubes connecting the ovaries to the uterus.
- **Uterus** ? Located centrally in the pelvis, where developing embryos reside.
- **Vagina** ? The passage leading to the outside of the body.

In males:

- **Testes** ? Located within the scrotal sacs outside the body or near the inguinal region.
- **Vas Deferens** ? Tubes transporting sperm from testes to the urethra.
- **Penis** ? External organ involved in copulation.

5. Excretory System

The excretory system removes waste products from the body:

- **Kidneys** ? Bean-shaped organs located near the dorsal body wall, responsible for filtering blood.
- **Ureters** ? Tubes that carry urine from kidneys to the bladder.
- **Bladder** ? Stores urine before excretion.
- **Urethra** ? Duct through which urine exits the body.

6. Nervous System Components

The nervous system controls bodily functions:

- **Brain** ? Encased within the skull, controlling sensory processing, motor functions, and coordination.
- **Spinal Cord** ? Extends from the brain down the vertebral column, transmitting nerve signals.
- **Nerves** ? Peripheral nerves branch out to innervate various organs and tissues.

Detailed Identification and Labeling Tips

To effectively identify and label these organs during dissection:

- Use anatomical diagrams as references before beginning.
- Carefully remove connective tissues

Labelled Internal Organs of a Dissected Rabbit: An In-Depth Exploration

Dissecting a rabbit provides an invaluable window into mammalian anatomy, offering insights into the complex arrangement and function of internal organs. The rabbit, as a mammal, shares many anatomical features with humans, making it an excellent model for educational and research

purposes. In this comprehensive review, we will systematically examine the labelled internal organs of a dissected rabbit, detailing their locations, structures, functions, and interrelationships within the thoracic and abdominal cavities.

Overview of Rabbit Anatomy

Before delving into individual organs, it is essential to understand the general layout of the rabbit?s internal anatomy. The rabbit's body is divided into two primary cavities:

- Thoracic cavity: Houses the lungs and heart.
- Abdominal cavity: Contains digestive, excretory, reproductive, and other vital organs.

The diaphragm separates these cavities, acting as a muscular partition that facilitates respiration.

Labelled Internal Organs of a Dissected Rabbit

The main internal organs typically labelled during a rabbit dissection include:

- Thoracic organs: Heart, lungs, trachea, esophagus, thymus gland.
- Abdominal organs: Liver, stomach, small intestine, large intestine, kidneys, urinary bladder, reproductive organs (ovaries, uterus or testes), spleen.

Each of these organs plays a critical role in the rabbit's physiology,

QuestionAnswer What are the main internal organs labeled in a dissected rabbit? The main internal organs labeled in a dissected rabbit typically include the heart, lungs, liver, stomach, intestines, kidneys, and spleen. Why is it important to identify the rabbit's liver during dissection? Identifying the liver is important because it plays a crucial role in metabolism, detoxification, and digestion, and helps students understand the digestive and circulatory systems. Which organ in a dissected rabbit is responsible for oxygen exchange? The lungs are responsible for oxygen exchange in a dissected rabbit, facilitating respiration. How can you distinguish the rabbit's stomach from other digestive organs? The stomach is usually a J-shaped organ located near the liver and intestines, often darker in color with a muscular wall, making it distinguishable from other digestive organs. What is the significance of labeling the rabbit?s kidneys during dissection? Labeling the kidneys helps students understand the excretory system and the process of waste removal in mammals. Where are the rabbit's intestines located and what is their function? The intestines are located in the abdominal cavity, surrounding other organs, and are responsible for nutrient absorption and waste elimination. What is the purpose of identifying the spleen in the dissected rabbit? The spleen is identified to understand its role in blood filtration and immune response within

the circulatory system.

Related keywords: rabbit anatomy, dissected rabbit organs, internal anatomy, veterinary dissection, biological illustration, anatomical labels, animal anatomy study, laboratory dissection, biological education, veterinary science

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