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Current Insights into Ovarian Cancer: Epidemiology, Diagnosis, and Treatment

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ABSTRACT

Ovarian cancer remains one of the deadliest gynecological cancers worldwide. This review summarizes recent findings on its epidemiology, diagnosis, staging, treatment, and future directions. Despite scientific progress, ovarian cancer is still often detected at advanced stages due to vague symptoms and lack of effective early screening. This paper draws from recent studies, guidelines, and databases to outline current trends, molecular mechanisms, and diagnostic methods such as imaging and biomarkers. Surgery combined with platinum-based chemotherapy remains standard care, while genetic profiling and PARP inhibitors mark advances in personalized treatment. Challenges like drug resistance, healthcare disparities, and the lack of early detection persist, urging development of better diagnostic tools and broader access to targeted therapies and immunotherapy. Future research should focus on simple screening tests, deeper understanding of tumor biology, and universal genetic testing availability. Although management has improved, timely detection and individualized treatment are vital. Continued research and better healthcare infrastructure are key to improving survival and quality of life for ovarian cancer patients.

Key words: Ovarian cancer, epidemiology, diagnosis, staging, treatment, personalized medicine, biomarkers, prognosis, PARP inhibitors, immunotherapy, genetic testing.

1. Introduction

Ovarian cancer remains as one of the lethal gynecological cancers globally, often called the "quiet murderer" because of its asymptomatic nature and detection at a late stage. Despite treatment progress, the five-year survival rate is only 30%–50 %, primarily because about two-thirds of cases are diagnosed in advanced stages (step III-IV), where the forecast is poor (Hong & Ding, 2025). In 2020, around 314,000 new cases and more than 207,000 deaths occurred worldwide; the rates of occurrence and death were highest in places with a higher socio-demographic index (SDI), where North America and Europe are located (Reid et al., 2023). Causes include inherited changes like BRCA1/2 changes, hormone reasons, endometriosis, and greater lifetime ovulation. The current clinical challenges center on early detection that includes biomarkers such as CA-125 and transvaginal ultrasound, which lack the sensitivity and specificity necessary for population screening and are thus not recommended routinely (Chakraborty et al., 2023). Emerging diagnostic tools, including new

biomarkers, liquid biopsy, and machine learning-based depiction analyses, show promise, especially for high-risk groups, but require further validation (Liberto et al., 2022). This review synthesizes the current insight into ovarian epidemiology, pathophysiology, diagnosis, and treatment, highlighting essential advances, sustained gaps, and future research directions.

2. Purpose of the Research

The purpose of this research is to synthesize the current evidence on ovarian cancer, which focuses on its epidemiology, diagnosis, and treatment. Given the high mortality rate of ovarian cancer, extensive detection, and delayed phase diagnosis, recent advances and comprehensive analysis of frequent challenges (Hardikar, 2022). The review examines events and survival changes in the global population, such as genetic risk factors, such as BRCA mutations, and reproductive history, and inequalities in disease results by demographic group. In addition, the study examines the development of diagnostic modalities, including serum biomarkers, such as about -125, imaging techniques, such as transvaginal ultrasound, and new tools, such as liquid biopsies and artificial intelligence-driven analyses. The advances in treatment receive equal attention, including surgical approaches, testing of trends in platinum-based chemotherapy, targeted therapy such as PAP inhibitors, immunotherapy, and individual medical strategies reported by tumor genomics. Finally, the review assesses major obstacles, including access disparities, treatment resistance, quality of life, and future research directions, such as vaccine development and overall care models. By integrating the findings in epidemiology, diagnosis, medicine, and systemic challenges, this paper aims to present a fine observation of the current insight, expose areas for clinical and public health improvement, and provide evidence-based guidance for future research and policy efforts in ovarian cancer care.

3. Research Materials and Methods

This review used a systematic approach to collect, evaluate, and synthesize the literature on ovarian cancer. The primary goal was to identify the current insight into treating epidemiology, diagnosis, and ovarian cancer while including emerging challenges in the region. The research design for this letter was qualitative and descriptive, dependent on secondary data from colleagues, review journalists, clinical studies, and institutional reports. The data sources were selected from reputable scientific databases, including PubMed, ScienceDirect, Google Scholar, and Scopus. Search terms included "ovarian cancer," epidemiology, "ovarian cancer diagnosis," "ovarian cancer treatment," "personal medicine," "Biomarker," "CA -125,"

"BRCA mutation," "BRCA mutation," PARP inhibitor, "existence rate," and "preliminary identification." Boolean operators (and, or, not) were implemented to refine the discoveries and reconstruct the most relevant and recent literature. The articles were selected if they met the following inclusion criteria: Published between January 2021 and May 2025, written in English, colleagues were reviewed, and primarily focused on ovarian cancer. The study entirely focused on other gynecological cancers in 2021 and was excluded until they were considered fundamental or referred to by more current articles.

Initially, a total of 65 sources were collected. After reviewing the abstracts and full texts, 20 articles were considered appropriate and included in the final analysis. These included a mixture of systematic reviews, meta-analyses, original research articles, and clinical practice guidelines. Data extracted from each source included the purpose of the study, methods, sample size, major conclusions, and relevance for the current understanding of ovarian cancer. The material covered a broad spectrum of topics. Epidemiological data focused on events, mortality rates, age distribution, genetic and environmental risk factors, and regional inequalities. Diagnostic-related studies discussed traditional and emerging biomarkers, imaging tools, histopathological techniques, and innovations such as artificial intelligence and liquid biopsy. In the context of treatment, the literature reviewed the efficacy and limitations of restorative surgery, chemotherapy regimens, especially platinum-based treatment, and targeted remedies, including PARP inhibitors and angiogenic obstructions. In addition, recent immunotherapy and accurate therapy developments were reviewed, focusing on their clinical applications and test results.

The methods used in evaluating collected literature adhere to PRISMA (preferred reporting items for systematic reviews and meta-analysis) guidelines where applicable. Each article was assessed for its methodological quality, validity of findings, sample representation, and overall relevance to the subject. The themes and trends were held under key titles for easy synthesis: epidemiology, diagnosis, treatment, emerging technologies, challenges, and future directions.

In maintaining the integrity of data interpretation, prejudice was minimized by selecting a study from various geographical regions and institutional backgrounds. Currently reviewed articles with strong study designs, such as randomized controlled tests and extensive contrast studies, were preferred. All the information extracted from the literature was carefully cross-checked in many sources to ensure continuity and reliability. Moral views were seen in the review process. Since no original human or animal subjects were included, there was no need for formal approval from an institutional review board (IRB) or Bioethics Committee.

However, all data were publicly accessible, ethically prepared from research conducted, and cited appropriately to maintain educational integrity.

4. Literature Review

I. Epidemiology

Ovarian cancer is a major global health burden, ranking as the eighth most common cancer in women, with an estimated 313,959 new cases and deaths recorded 2020 in 2020 (Huang et al., 2022). While its overall age-standardized event rate (ASIR) fell from 7.22 per 100,000 to 0.38% in 2021 with an estimated annual decrease of 6.71, the total number of cases during this period was almost doubled, which reflects the dynamics of the changing population in areas (Li et al., 2025). Incidence and mortality demonstrate marked geographical and socio-economic disparities. High Human Development Index (HDI) regions such as North America, Europe, and Australia carry an inconsistent burden, with ASIRS 8.0 per 100,000 (Huang et al., 2022). In contrast, low SDIs and HDI regions, especially in Africa and parts of Asia, show growing trends in both event and mortality, experiencing in Africa an annual growth of more than 1% in age-standard mortality rates (Ahmed et al., 2024).

Age remains an important risk factor, with incidence climbing in postmenopausal women, and concentrations are at their peak after the age of 60 (Ali et al., 2023). Breeding and hormonal factors such as nulliparity, endometriosis, and hormone replacement therapy also increase the risk of the occurrence of oral contraceptives and tubal ligation (Ali et al., 2023). The burden of global ovarian cancer is expected to increase in the coming decade. Estimates suggest an increase of 10% in incidence and an increase of 4.5% in mortality by 2030, especially in low- and middle-income countries (LMICS) (Wang et al., 2023), adding tension to healthcare systems. These trends highlight the need for targeted strategies to prevent the waste of clinical and treatment resources worldwide.

II. Pathophysiology and Classification

Ovarian cancer comprises different tumor types with a separate origin, behavior, and molecular characteristics. In the World Health Organization 2020 classification, five main epithelial histotypes are identified: high-grade serous carcinoma, low-grade serous carcinoma, endometrioid carcinoma, clear-cell carcinoma, and mucinous carcinoma (Leo et al., 2021). HGSC is a highly aggressive and significant (70–80%) subtype, most frequently imaged to arise from the fimbrial end of the fallopian tube. It is characterized by almost universal mutations in TP53 and deficiencies in homologous recombination repair, including the

BRCA1/2 mutations (Leo et al., 2021). In contrast, LGSC develops extra slowly from benign serous tumors, shows well-known genomic stability, and frequently features KRAS and BRAF mutations without TP53 changes.

Endometrioid and clear cell carcinomas are often associated with endometriosis and show specific genetic changes, like EC exhibits PTEN, ARID1A, CTNNB1, and MSI-associated mutations; CCC often includes ARID1A and PIK3CA alterations (Leo et al., 2021). Mucinous carcinoma often follows an adenoma-scarcity sequence in the ovary and is characterized by CDKN2A loss, KRAS, and TP53 mutations. At the molecular level, ovarian cancer activates several oncogenic pathways, including MAPK/ERK, PI3K/AKT/mTOR, WNT/β-catenin, and JAK/STAT, driving spread, invasion, and chemoresistance (Maioru et al., 2023). Understanding these distinct pathological and molecular profiles is critical for accurate diagnosis, risk stratification, and targeted therapy choices in a framework for precision medicine.

III. Diagnosis

Early detection of ovarian cancer is still challenging due to the lack of symptoms and definitive screening tools. The biomarker for this disease is CA 125, and the sensitivity for early-stage disease is not adequate; besides, benign diseases like endometriosis also elevate it (Li et al., 2024). Newer biomarker HE4 offers specificity, in particular with CA 125. A study reported that this combination achieved 80.1% sensitivity and 69.1% specificity and surpassed about 125 alone (Li et al., 2024). Advanced risk algorithms such as Rome and OVA1 integrate several biomarkers and patient factors, improving the triage accuracy of adnexal masses (Ghose et al., 2024). Imaging remains the cornerstone of diagnosis. The transvaginal ultrasound (TVUS) is usually the first line, which shows 85% sensitivity and 98% specificity to detect a suspected mass. However, its positive forecast value is low (Hong & Ding, 2025). A 2025 study combining TVus with CA 125 and HE4 reported a clinical accuracy of 85.6%, highlighting the importance of multimodal evaluation (Luu & Han, 2025).

Emerging technologies such as liquid biopsy and AI-operated analytics promise to detect cancer-related DNA pieces and protein patterns. A 2024 report describes the AI-powered liquid biopsy ("DELFI-Pro "), which receives up to 72% sensitivity for early-stage disease and improves detection compared to protein tests alone (Johns Hopkins Medicine, 2024). Other novel Biomarkers, such as miRNAs, exosomal proteins, VEGF, osteopontin, and advanced imaging modalities such as PET/CT and MR, are being investigated (Ghose et al., 2024). While these techniques remain largely experimental, multimer cards and

multimodal approaches improve clinical accuracy and can support future screening strategies in high-risk populations.

IV. Staging and Prognosis

The staging of ovarian cancer follows the FIGO system, which is the standard of gold to guide pregnancy and treatment. In localized disease (stage I), the overall five-year survival rate is more than -90%, but there is a rapid decline with the spread of the disease. For example, Stage III disease provides moderate survival benefits, with about 50% rates, while about 20% in Stage IV is a poor, stagnant existence for five years. Stage IV patients with pleural participation (stage IVA) had an average overall existence of around 31 months, compared to 45 months, with 45 months (stage IVB) for people with only distant metastases (Métairie et al., 2023). The state of BRCA mutation further affects pregnancy: carriers often experience prolonged progression-free and overall survival, which are caused by platinum-based chemotherapy and greater sensitivity to PARP inhibitors. The completion of optimal surgical Gatorade and adjacent chemotherapy is predicted in consecutive stages (Xiao & Linghu, 2023). Accurate staging based on a fully surgical-pathological evaluation thus anticipates the disease and the individual treatment plan.

V. Current Treatment Modalities in Ovarian Cancer

Platinum-based chemotherapy remains the cornerstone of the first-line treatment for advanced ovarian cancer, usually after curative surgery. The combinations of carboplatin and paclitaxel are standard, with neoadjuvant therapy reserved for patients with high-risk tumors or comorbidity. In recent years, targeted treatment, especially PARP (Poly-ADP-Ribose polymerase) inhibitors, has improved the results significantly. The landmark phase III tests, such as SOLO-1, PRIMA, and PAOLA-1, demonstrated that maintenance therapy with PARP inhibitors such as olaparib, niraparib, and rucaparib, either alone or in association with bevacizumab, enhances progression-free survival in patients responding to platinum chemotherapy. These therapies are the most effective in patients with BRCA mutations or homologous recombination deficiency (HRD), although the benefits extend to a broader population.

For platinum-resistant ovarian cancer, recent innovation includes mirvetuximab soravtansine, an antibody-drug conjugate targeting folate receptor-alpha. It received FDA approval in 2022, depending on the favorable response rates in heavily pre-treated patients. Immunotherapy is emerging, although single-agent checkpoint inhibitors show limited efficacy. Tests, including

Anti-PD-1/PD-L1 agents such as niraparib plus pembrolizumab or durvalumab plus olaparib, reported incentive rates including BRCA wild-type and HRD-Negative tumor (e.g., 25–63%), including BRCA wild-type and HRD-Negative tumor. Early-phase studies of CAR-T and CAR-NK cells, engineered to target ovarian cancer-specific antigens. Additionally, hyperthermic intraperitoneal chemotherapy (HIPEC) in platinum-sensitive patients shows the promise to survive long after curative surgery with minimal coupled toxicity.

VI. Personalized and Precision Medicine

Personalized medicine in ovarian cancer speeds through molecular profiling, targeted therapy, and advanced calculation tools. Multi-omics analyses, which include genomic, transcriptomic, and proteomic data, have enabled clinicians to stratify patients based on molecular subtypes and predict treatment response. For example, a protein-based prognostic signature derived from TCGA data, integrated reverse phase protein array, and RNA sequencing exceeded traditional clinicopathological factors and identified patients more likely to benefit from immunotherapy (Chen et al., 2024). Similarly, integrative risk models that combine genetic, clinical, and immunological markers have shown improved survival prediction and supervisory personal treatment decisions. Clear-cell ovarian carcinoma, a chemotherapy-resistant subtype, is now being addressed through novel strategies targeting Arid1A and Pik3CA routes. Therapeutic approaches such as ferroptosis induction, immune checkpoint blockade, and angiogenesis prohibit site-specific interventions (Liu et al., 2024). In high-class serous ovarian cancer, single-cell RNA sequencing has identified the immunogenic tumor microcirculation profiles associated with favorable reactions, suggesting possible benefits from individual immunotherapy (Balan et al., 2024).

Artificial intelligence and system studies, in addition to beautifying personalization efforts. Histopathology-based fashions carried out on whole-slide images achieved 86% accuracy in predicting the reaction to bevacizumab (Mallya et al., 2024). Moreover, emerging AI-driven frameworks aim to integrate multi-omics affected person records, growing "virtual twins" that generate personalized treatment suggestions and counterfactual outcomes. Therefore, ovarian cancer in the ovaries gradually transforms into precision oncology: Profiling of tumor biology enables the choice of optimal therapies, AI improves predictive accuracy, and sub-specific interventions provide renewed hope for refractory cases. These advances signal a shift towards truly individualized care that improves the results and can reduce over-treatment.

VII. Challenges and Limitations

Cancer care for the ovaries faces several critical barriers that prevent progress and equity. A major challenge is the limitations of current screening tools, such as about 125 and ultrasound, which often provide false negatives or positives, especially in blacks and Indians, leading to diagnostic delays and poorer outcomes. In addition, racial and socio-economic differences are clear in participation in clinical studies and access to guideline-based care. For example, only 5% of qualified ovarian cancer patients enroll in clinical drug experiments, with Latin American, black, and Medicaid-insured individuals (Smith et al., 2023). Black women also experience high mortality, despite access to similar treatment, indicating the underlying systemic prejudices. Finally, resistance to therapy and limited post-recurrence treatment options are other major clinical applications because even emerging therapies often lack data on efficacy in diverse populations. The above limitations point toward completely different needs.

VIII. Future Directions

The future of ovarian cancer research and care is moving towards more targeted, inclusive, and preventive strategies. One of the most promising directions is the advancement of molecular and genetic profiling, which will help tailor treatment for specific tumor types and mutations, such as BRCA1/2 and HRD (lack of homologous recombination). This will probably improve existence and reduce side effects. In addition, integrating liquid biopsy technologies that detect tumor DNA in blood samples provides the potential for earlier diagnosis and monitoring without invasive procedures. Another priority is reducing inequalities in results by promoting widespread participation in clinical trials and improving access to high-quality care for the underserved population. AI-based equipment and decision support systems are also developing to help doctors make rapid and more accurate diagnoses and treatment decisions (Yuan et al., 2023). Finally, future directions include immunotherapy and the development of vaccine-based approaches, showing initial promise in clinical trials. Combined with better patient education and awareness, these efforts will lead to more individual, effective, and equitable ovarian care.

5. Basic Results

Ovarian cancer continues to constitute a significant global health challenge, which is evident from epidemiological data in recent years. Despite modest falls in age-standardized

occurrences, the absolute number of cases and associated deaths continues to increase, primarily driven by aging populations and regional differences in risk factors and detection methods (El-Shakanny et al., 2024). Regions with high human development remain disproportionately affected, although increasing incidence and mortality in settings with lower resources emphasize an urgent need for global equity in cancer care.

From a pathological point of view, epithelial ovarian cancer has a high OUs grade serous sub-avoidance for most cases. Molecular drivers such as TP53 and BRCA mutations, along with PI3K/AKT and WNT pathway changes, with size classification and notification response. LGSC, Clear-SAL, mucous, endometrioid histotypes, like KRAS, ARID1A, and PIK3CA alterations, and perform different genetic profiles and behave differently clinically, strengthening the importance of accurate molecular classifications.

Diagnostic performance is still moderate. About 125, and transvaginal ultrasound provides moderate sensitivity to advanced disease, but misses early-stage tumors. Combined use, often integrated with newer markers such as HE4 in algorithms such as Rome and OVA1, improves triage efficiency (Ghose et al., 2024). Emerging tools like AI-augmented imaging and liquid biopsy processes could similarly improve early detection. Early pilot information suggests promising sensitivity, but massive-scale studies are yet to demonstrate definitive mortality benefits. Staging remains a key prognostic indicator. Five-12 months survival declines sharply from above 90 percent in stage I sickness to under 30 percent in stage IV. BRCA-mutated sufferers, but show advanced results, probably because of better chemotherapy response rates.

Standard treatment combines surgery and platinum-based chemotherapy. Maintenance therapy with PARP inhibitors such as olaparib and niraparib has prolonged dramatic progression-free survival in both new diagnoses and recurrent cases, especially in BRCA or HRD-positive patients. However, adverse incidents are common (Tew et al., 2020). Connecting regimens such as olaparib-bevacizumab (PAOLA-1) and mirvetuximab soravtansine have received regulatory approval, although long-term survival data are still emerging. Clinical trials report moderate response rates with joint PARP and checkpoint inhibitors, including Keytruda and durvalumab, especially in classic platinum-resistant cases. Intraperitoneal methods such as hyperthermic intraperitoneal chemotherapy have also shown better efficacy with tolerable safety profiles (Hawkings & Miller, 2023). Persistent challenges include clinical testing participation and quality of care, including racial and socio-economic inequalities. Only 5 percent of ovarian patients enrolled in trials represented ethnic minorities and Medicaid individuals, which contributes to frequent disparities in the outcomes. Following the trial to

improve the existence of inequalities by race, the results can reduce intervals, suggesting increased access to testing.

Therefore, this review underscores key outcomes where ovarian cancer prevalence and mortality continue to increase; molecular type permits personalized treatment; diagnostic enhancements remain incremental; PARP inhibitors and aggregate regimens have stronger progression-free survival; and care gaps persist because of access disparities. Taken collectively, these findings advise that ongoing advances in precision oncology have to be matched by efforts to enhance screening performance and equity in care delivery.

6. Conclusions

Ovarian cancer is usually a major cause of cancer-related mortality in women due to late diagnosis and an aggressive disease course. This review highlights our understanding of the disease, with molecular genetics, clinical strategies, and significant progress in the fields of individual medicine. Epidemiological figures show global events and mortality adaptations, primarily influenced by healthcare access, genetic tendency, and public awareness. One of the most important insights emerging from current research is the variety of ovarian cancer. Different histological subtypes, especially high-grade serous carcinoma, display unique molecular profiles that affect the diagnosis and treatment results of the disease. Advances in molecular diagnosis have given rise to the regular inclusion of BRCA mutation tests and homologous recombination deficiency screening, which help direct the use of targeted treatments. Despite advances in treatment, including the use of PARP inhibitors, angiogenesis blockers, and immunotherapy, the total survival rate for ovarian cancer remains low. Surgical intervention remains the mainstay in treatment in combination with platinum-based chemotherapy, though resistance and relapse continue to dominate the management. Implementing personalized and precision medicine improves disease management with these genetic alterations, but significant barriers remain, including accessibility and cost in many regions. The biggest challenges, such as ovarian cancer control, face the lack of practical tools for early detection, differences in health access, and limited inclusion of different populations in clinical studies. Addressing these problems will be crucial to improving the results. Further, research in the novel biomarker, liquid biopsy, and immunotherapy combinations first promises more durable reactions. Better engagement, not just between clinicians, researchers, and policymakers but also across the entire care continuum, will be needed to eliminate the care gaps and get the best modern treatments to every patient, no matter their geographic or

socioeconomic status. Together, these efforts can help change the future of ovarian cancer care.

Author`s contribution

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