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Current Approaches in Diagnosis and Management of Cervical Cancer: A Literature Review

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Abstract

Background: Cervical cancer is one of the leading causes of cancer-related morbidity and mortality among women globally, particularly in low- and middle-income like India. It arises from persistent infection with high-risk human papillomavirus (HPV) types. Early detection through screening programs and the introduction of HPV vaccination have significantly improved prevention. However, once diagnosed, management strategies vary based on the stage of the disease, histological type, patient's general condition, and availability of treatment modalities.

Method: A literature review of cervical cancer cases was conducted, categorizing patients based on disease stage and treatment modality such as surgical, radiotherapy, chemo radiation, or palliative care. Clinical parameters including tumor stage, lymph node involvement, histopathological findings, and patient outcomes were reviewed to evaluate the effectiveness of various management approaches.

Result: Early-stage cervical cancer was effectively managed with surgery, showing favorable survival rates. Advanced stages required concurrent chemo radiotherapy, with moderate outcomes, although delays in treatment initiation negatively impacted prognosis. Patients receiving palliative care had poor outcomes, often presenting with metastasis or severe comorbidities. Early diagnosis and access to comprehensive treatment significantly improved survival and quality of life.

Conclusion: Effective management of cervical cancer depends on early detection and appropriate staging. Multimodal approaches, particularly chemo radiotherapy, are essential for advanced cases, while surgery remains the cornerstone for early-stage disease. Strengthening screening programs, HPV vaccination, and timely referral systems are crucial for reducing the burden of cervical cancer.

Keywords: Cervical Cancer, Human Papilloma virus, Chemo radiotherapy, Surgical Management, Cancer Screening, Oncology.

INTRODUCTION

Cervical cancer is a malignant condition that arises in the cells of the cervix, which is the lower, narrow end of the uterus that connects to the vagina. It is one of the most common cancers affecting women worldwide, particularly in developing countries where access to healthcare services, including screening and vaccination, is limited. The disease develops gradually over time, often beginning with precancerous

changes in the cervical cells, which may eventually evolve into invasive cancer if not detected and treated early.

The primary cause of cervical cancer is persistent infection with high-risk types of the HPV, a common sexually transmitted infection. HPV types 16 and 18 are responsible for approximately 70% of cervical cancer cases globally. While most HPV infections resolve on their own without causing any health problems, persistent infection with oncogenic strains can lead to cellular changes that increase the risk of cancer development.[1] Other contributing risk factors include early sexual activity, multiple sexual partners, a weakened immune system, smoking, and long-term use of oral contraceptives.

Cervical cancer typically progresses slowly, beginning with pre-invasive changes known as cervical intraepithelial neoplasia (CIN). These abnormal changes in the cervical cells can be detected through regular screening methods such as the Pap smear, which examines cells from the cervix for abnormalities. In addition, HPV DNA testing can identify the presence of high-risk virus strains, further aiding in early detection. With timely identification and treatment of precancerous lesions, cervical cancer can often be prevented entirely.

Symptoms of cervical cancer may not be apparent in the early stages.[2] As the disease advances, common signs include abnormal vaginal bleeding especially after intercourse, between menstrual periods, or after menopause, unusual vaginal discharge, and pelvic pain. In more advanced stages, the cancer may spread to surrounding tissues and organs, causing additional complications such as urinary or bowel obstruction and back or leg pain.

Prevention strategies play a crucial role in reducing the incidence and mortality associated with cervical cancer. The most effective preventive measure is vaccination against HPV.[3] Vaccines such as Gardasil and Cervix provide protection against the most common high-risk HPV types and are recommended for preadolescents, ideally before the onset of sexual activity. Regular cervical screening, public education about HPV and safe sexual practices, and smoking cessation are also essential components of comprehensive cervical cancer prevention programs.

Global health initiatives, such as those led by the World Health Organization (WHO), aim to eliminate cervical cancer as a public health problem through a strategy that includes widespread vaccination, screening, and timely treatment. Cervical cancer is a largely preventable but still prevalent disease that affects hundreds of thousands of women each year. Early detection through regular screening, preventive vaccination, and public health education are critical to reducing its impact.[4]

According to the WHO, cervical cancer is the fourth most frequent cancer in women globally, with an estimated 604,000 new cases and 342,000 deaths in 2020. The management of cervical cancer depends on the disease stage, patient's age, and fertility desires. Stage I is treated with surgery such as hysterectomy or fertility-sparing trachelectomy. Stage II–III are managed with concurrent chemo radiation using cisplatin and external beam radiation with brachytherapy. Stage IV are metastatic case require systemic chemotherapy, targeted therapy e.g., bevacizumab, or immunotherapy e.g., pembrolizumab. Palliative care is essential in end stage disease to relieve symptoms. Regular follow-up and surveillance are vital post-treatment to monitor for recurrence and manage long-term complications. Fertility and psychosocial support are also key components.

1.Epidemiology

Cervical cancer was the fourth most common cancer among women globally, with an estimated 604,000 new cases and 342,000 deaths in 2020.[5] The disease burden was disproportionately high in low- and middle-income countries LMICs, accounting for over 85% of global cases and deaths, largely due to limited access to HPV vaccination, screening and treatment services.[2]

The highest incidence rates were reported in sub-Saharan Africa, Latin America, South Asia, and Southeast Asia, where organized screening programs were either absent or poorly implemented. In contrast, countries with well-established HPV vaccination and cytology-based screening programs had seen a significant decline in both incidence and mortality rates.[6]

Cervical cancer primarily affected women aged 30 to 50 years and was closely associated with persistent infection by high-risk HPV types, especially HPV-16 and HPV-18.[6] The introduction of HPV vaccines and the WHO's 90-70-90 strategy aimed to eliminate cervical cancer as a public health problem by 2030. However, widespread implementation and equity in health services remained key challenges.

1. Etiology and Pathogenesis

The main cause of cervical cancer was chronic infection with high-risk HPV, including strains 16 and 18, which together caused around 70% of cervical cancer cases.[7] The majority of HPV infections were temporary and were eradicated by the immune system, but chronic infections could cause CIN, which over time might have develop into invasive cancer.

When high-risk HPV incorporated its DNA into host cervical epithelial cells. Tumor suppressor genes p53 and retinoblastoma protein (pRb) were rendered inactive as a result of the overexpression of oncogenic proteins E6 and E7. Uncontrolled cell proliferation, genetic instability, and ultimately malignant transformation resulted from the breakdown of these regulatory mechanisms.

The most susceptible area for HPV-induced carcinogenesis was the cervix's transformation zone, where the squamous and glandular epithelia converged. The progression from infection to cancer might have been accelerated by additional co-factors such as smoking, immunosuppression such as HIV and long-term oral contraceptive use.[8]

Clinical approach of cervical cancer

Early detection, precise diagnosis, staging, and suitable treatment are all part of the clinical approach to cervical cancer. In order to detect risk factors, including early sexual activity, multiple partners, persistent HPV infection particularly types 16 and 18, smoking, and immunosuppression, a thorough history is first taken.[9] Although early stages may be asymptomatic, common symptoms include post-coital bleeding, atypical vaginal bleeding, and foul-smelling discharge. Early detection, precise diagnosis, staging, and suitable treatment are all part of the clinical approach to cervical cancer.[9] In order to detect risk factors, including early sexual activity, multiple partners, persistent HPV infection particularly types 16 and 18, smoking, and immunosuppression, a thorough history is first taken. Although early stages may be asymptomatic, common symptoms include post-coital bleeding, atypical vaginal bleeding, and foul-smelling discharge.

Regular pelvic exams and imaging are part of the follow-up to check for recurrence. Prevention is essential, and the HPV vaccine, regular screening, and quitting smoking are all important ways to lower incidence. For individuals with cervical cancer, prognosis and survival are greatly enhanced by early detection and all-encompassing care. The HPV vaccine, which targets the most prevalent oncogenic HPV strains that cause about 70% of cervical cancer cases, is the cornerstone of cervical cancer prevention.

Vaccination programs show significant success in lowering HPV infections and associated precancerous lesions, particularly when implemented early in life before the initiation of sexual engagement.[10] Cultural tolerance, accessibility, cost, and public awareness are crucial for the success of cervical cancer prevention programs. Expanding HPV vaccination coverage is essential, especially in underserved areas. The aggressive nature of recurring or metastatic cervical cancer and scarcity of treatments make therapy difficult. Systemic therapies are expanding to include targeted treatments like bevacizumab and immunotherapy, particularly checkpoint inhibitors like pembrolizumab, for patients with PD-L1-positive or microsatellite instability. These innovative treatments enable more customized treatment regimens, reflecting the growing focus on precision medicine in cancer.

Human papillomavirus (HPV) infection

The development of almost all precancerous and cancerous lesions requires HPV infection. Epidemiological studies clearly show that HPV infection is a considerably greater risk factor than other known risk factors for the development of pre-invasive or invasive cervical cancer.

It is believed that over 6 million women in the US are infected with HPV. Cervical cancer is uncommon, although transient HPV infection is frequent, especially in young women.[6]Precancerous and cancerous lesions are more likely to form if an HPV infection persists. Another significant factor in determining risk is the kind of HPV infection. Humans can contract HPV from a variety of subtypes, but the two most strongly linked to high-grade dysplasia and cancer are variants 16 and 18.[11] According to studies, acute HPV types 16 and 18 infection increased the probability of developing high-grade CIN rapidly by 11–16.0 times. According to another research, HPV 16 or 18 infection is more predictive than cytological screening for high-grade CIN or more severe illness, and the predictive power lasts for up to 18 years following the initial test[7]. Two commercially available vaccinations target HPV strains associated with the anogenital area. The vaccines are intended for young adults and adolescents who have never been exposed to HPV. Significant drops in HPV-related illnesses have been reported, despite the vaccine's moderate uptake.

Stages Information for Cervical Cancer

Cervical cancer could spread by the circulation, regional lymphatics, or local invasion. The size and invasiveness of the local lesion typically determined how widely a tumor spread. Cervical cancer usually advanced in a systematic fashion, although on rare occasions, a small tumor with distant metastases was observed.[12] Patients needed to be closely assessed for metastatic disease.

STAGE 1[13]

Stage	Description
I	The carcinoma is strictly confined to the cervix (extension to the corpus should be disregarded).
IA	Invasive carcinoma that can be diagnosed only by microscopy, with maximum depth of invasion ≤5 mm.b
IA1	Measured stromal invasion ≤3 mm in depth
IA2	Measured stromal invasion >3 mm and ≤5 mm in depth.
IB	Invasive carcinoma with measured deepest invasion >5 mm (greater than stage IA); lesion limited to the cervix uteri with size measured by maximum tumor diameter.c

–IB1	Invasive carcinoma >5 mm depth of stromal invasion and ≤2 cm in greatest dimension.
IB2	Invasive carcinoma >2 cm and ≤4 cm in greatest dimension.
IB3	Invasive carcinoma >4 cm in greatest dimension.

STAGE 2

Stage	Description
II	The cervical carcinoma invades beyond the uterus but has not extended onto the lower third of the vagina or to the pelvic wall.
IIA	Involvement limited to the upper two-thirds of the vagina without parametrial involvement
– IIA1	Invasive carcinoma ≤4 cm in greatest dimension.
– IIA2	Invasive carcinoma >4 cm in greatest dimension.
IIB	With parametrial involvement but not up to the pelvic wall.

STAGE 3[13]

Stage	Description
III	The carcinoma involves the lower third of the vagina and/or extends to the pelvic wall and/or causes hydronephrosis or nonfunctioning kidney and/or involves pelvic and/or para-aortic lymph nodes.
IIIA	Carcinoma involves the lower third of the vagina, with no extension to the pelvic wall.
IIIB	Extension to the pelvic wall and/or hydronephrosis or nonfunctioning kidney (unless known to be due to another cause)
IIIC	Involvement of pelvic and/or para-aortic lymph nodes (including micrometastases)b, irrespective of tumor size and extent (with r and p notations).
– IIIC1	Pelvic lymph node metastasis only.
– IIIC2	Para-aortic lymph node metastasis.

STAGE 4 [12]

Stage	Description
IV	The carcinoma has extended beyond the true pelvis or has involved (biopsy proven) the mucosa of the bladder or rectum. A bullous edema, as such, does not permit a case to be allotted to stage IV.
IVA	Spread of the growth to adjacent pelvic organs.
IVB	Spread to distant organs.

COMORBIDITY OF CERVICAL CANCER

When a nonsurgical search for metastatic cancer was unsuccessful, pre-treatment surgical staging in cases of large but locally treatable disease was considered necessary.[14] Prior to performing a surgical staging technique, fine-needle aspiration had to be negative if problematic nodes were found by lymphangiography or computed tomography (CT) scan.

Because of their higher risk of toxicity and decreased organ function, diabetes and hypertension which were frequently observed in older populations made treatment alternatives like chemo therapy or radiation therapy more difficult. Obesity and cardiovascular disease potentially raised perioperative risk and decreased surgical eligibility. Treatment tolerance, responsiveness, and recovery were all impacted by these factors taken together.[15]

The management of cervical cancer required a multidisciplinary approach due to morbidities. Coexisting conditions were evaluated during pre-treatment assessments in order to provide individualized treatment strategies that struck a balance between safety and effectiveness.[13] Quality of life and survival were increased when oncologists, internists, infectious disease specialists, and mental health specialists provided integrated treatment.

AI IN DIAGNOSIS AND MANAGEMENT OF CERVICAL CANCER

Cervical cancer morbidity and mortality could be significantly decreased with early detection and treatment. Traditional screening techniques like Pap smears and HPV tests, however, had drawbacks such as restricted accessibility, exorbitant expenses, and the requirement for specialized staff.[16] The potential of AI as a game-changing tool for cervical cancer early detection, diagnosis, therapy, and care was being increasingly investigated.

AI has been used in image-based screening for cervical cancer, detecting precancerous or malignant abnormalities with accuracy levels equivalent to or better than expert pathologists. AI also aids in cytology analysis and HPV DNA testing, determining high-risk genotypes and predicting cancer course. It also aids in patient triage by prioritizing high-risk individuals for further testing and care.

AI has significantly improved cervical cancer treatment by assisting oncologists and radiologists in understanding imaging tests, enabling efficient treatment planning, and providing real-time assistance for histopathological analysis. AI also supports personalized treatment plans, predicting treatment outcomes based on patient characteristics.[17] It also improves patient follow-up and monitoring through wearable technology and mobile health apps, particularly in rural and disadvantaged areas. However, issues with data privacy, dataset size, and regulatory permissions hinder its use.

Artificial intelligence had the potential to revolutionize the treatment of cervical cancer. AI-driven solutions had the capacity to improve outcomes, lessen inequities, and even save lives through early detection and diagnosis, individualized therapy, and follow-up. The careful incorporation of AI into healthcare systems was essential in the worldwide battle against cervical cancer as research and development progressed.

Treatment of cervical cancer

The stage, age, desired fertility, and general health of the patient all influenced how cervical cancer was treated. Surgical procedures were preferred in cases of early-stage illness, Stage IA to IB1.[17] These included radical hysterectomy combined with pelvic lymphadenectomy for larger tumors or conization for microinvasive malignancy. Young women with early lesions were considered candidates for fertility-sparing operations such as radical trachelectomy.

Concurrent chemoradiation, which combined external beam radiation therapy (EBRT) and intracavitary brachytherapy with weekly cisplatin-based chemotherapy to increase radiation effects, was the usual treatment for locally advanced stages IB2 to IIIB. Palliative care was the mainstay of treatment for Stage IV or recurring instances.[18]

Additionally, radiation therapy was utilized to relieve pain or bleeding symptoms. Social support, psychiatric counselling, and dietary assistance were essential for enhancing quality of life throughout therapy.[19] After treatment, routine follow-up was crucial for managing problems and identifying recurrences early. Quality of life and survival were greatly enhanced by multidisciplinary care.

CONCLUSION

Cervical cancer remains a major worldwide health concern, especially in low- and middle-income nations where access to efficient treatment and early screening is restricted. The therapy of cervical cancer is changing significantly due to advancements in medical technology, a better understanding of the biology of the illness, and the widespread use of preventive measures. Disparities still exist**,** though, and resolving them calls for an all-encompassing strategy that incorporates palliative care, early diagnosis, treatment, and prevention.

The management of cervical cancer is being influenced by the development of personalized medicine, minimally invasive surgical methods, and new therapeutic approaches such as gene therapy, cancer vaccines, and innovative immunotherapeutic drugs. Digital health tools and artificial intelligence have the potential to further transform screening and diagnosis, particularly in underprivileged or rural areas. In order to ensure that technological advancements result in significant benefits for all populations, health policy must remain based on fairness and inclusivity.

It was concluded from recent research that, When the right steps are taken throughout the range of care, cervical cancer is a disease that is mainly preventable and treatable. Continued international efforts to increase vaccination coverage, scale up efficient screening, provide access to high-quality treatment, and offer supportive care are necessary to successfully eradicate cervical cancer as a public health concern. To lessen the impact of cervical cancer and save millions of lives globally, governments, healthcare professionals, communities, and foreign partners must take a coordinated, patient-centered approach.

S.No	Authors	Title	Focus Area	Result
1.	Schiffman M., Wentzensen N 2013	Cervical cancer: prevention and early detection	Screening	HPV testing is more sensitive than cytology. Early detection significantly reduces progression. Integration of HPV screening improves prevention programs.
2.	Ronco G., Dillner J., et al. 2014	Cervical cancer screening with HPV DNA testing	Screening Methods	HPV DNA tests detect precancerous changes earlier than cytology. Reduces risk of invasive cancer. Fewer screenings are needed over time.

3.	Denny L., et al. 2014	Cervical cancer treatment in HIVpositive women	HIV & Cervical Cancer	HIV increases the risk of persistent HPV and progression to cancer. Requires frequent screening and early treatment. Integration with HIV care is critical.
4.	Sankaranarayanan R., et al. 2015	Cervical cancer in low-resource settings	Global Health	Visual inspection (VIA) is cost-effective. Training and outreach improve coverage. Resource-sensitive strategies are essential for LMICs

5.	Mitra A., MacIntyre D.A., et al. 2016	Role of microbiome in cervical cancer	Microbiome	Altered vaginal microbiota may support HPV persistence. Lactobacillus dominance is protective. Microbiome-based interventions could be future preventive tools.
6.	Marth C., Landoni F., Mahner S., et al. 2017	ESMO Clinical Practice Guidelines for Cervical Cancer	Clinical Guidelines	Treatment is based on FIGO staging. Chemoradiation is standard for locally advanced stages. Fertility-sparing surgery is an option for early disease.
7.	Drolet M., Bénard É., et al. 2019	The impact of HPV vaccination on cervical cancer	Vaccination	HPV vaccines significantly reduce infection and high-grade lesions. Herd immunity benefits are evident. Early introduction yields better outcomes.
8.	Huang R.Y., et al. 2020	Advances in immunotherapy for cervical cancer	Immunotherapy	Immune checkpoint inhibitors (PD-1/PD-L1) show promise in advanced cervical cancer. Biomarker testing is crucial. More trials are needed for widespread use.

9.	Arbyn M., Weiderpass E., et al. 2020	Global burden of cervical cancer: Current status and future trends	Epidemiology	Cervical cancer is preventable but remains a major global burden. Highest incidence is in low- and middle-income countries. HPV vaccination and screening are underutilized.
10.	WHO Guideline Group	WHO guidelines for screening and treatment of	Screening	Recommends HPV testing every 5 years. Thermal ablation and cryotherapy for precancerous lesions. Focuses on accessible methods in low-resource settings.

		precancerous lesions		

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