

Short Review

Cervical Cancer Cell Lines: Cellular Models Bridging Human Papillomavirus Biology, Tumor Progression, and Therapeutic Discovery

Christensen D, Novellino W, Radnaeva A, Kulbacka A, Piccinin S, Friedrich S

Medical International Center for Chemical and Biological Sciences, Russia

***Corresponding Author:** Radnaeva A, International Center for Chemical and Biological Sciences, Russia

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Abstract

Cervical cancer remains a major global health challenge, particularly in regions where screening and preventive vaccination are not uniformly accessible. Persistent infection with high-risk human papillomavirus (HPV), especially HPV-16 and HPV-18, represents the principal etiological factor in cervical carcinogenesis. Although clinical specimens provide essential insights into disease biology, the complexity and heterogeneity of cervical tumors make controlled experimental investigation challenging. Cervical cancer cell lines therefore serve as valuable in vitro models for studying malignant transformation, HPV-associated oncogenic mechanisms, cellular signaling, drug response, and therapeutic resistance. Commonly investigated cell lines, including HeLa, SiHa, CaSki, C33A, and ME-180, exhibit distinct genetic, phenotypic, and virological characteristics that influence their experimental applications. HPV-positive models are particularly useful for investigating viral oncogenes and their interactions with tumor-suppressor pathways, whereas HPV-negative models provide complementary systems for exploring HPV-independent mechanisms of cervical carcinogenesis. This article discusses the biological characteristics, applications, advantages, and limitations of major cervical cancer cell lines. It also highlights the importance of model selection, authentication, genomic characterization, and experimental reproducibility.

Introduction

Cervical cancer is one of the most important malignancies affecting women worldwide. The disease develops predominantly as a consequence of persistent infection with high-risk types of human

papillomavirus (HPV). While most HPV infections are transient and are eliminated by the host immune system, persistent infection can lead to progressive cellular abnormalities, precancerous lesions, and eventually invasive malignancy. The development of cervical cancer is a multistep process involving viral oncogene activity, alterations in cell-cycle regulation, genomic instability, epigenetic changes, immune evasion, and disruption of cellular signaling networks. Understanding these processes requires experimental models that reproduce relevant features of human cervical cancer.

Cervical cancer cell lines have become fundamental tools in cancer research. They allow investigators to study tumor-associated molecular mechanisms under controlled laboratory conditions and to evaluate potential anticancer compounds before progression to animal or clinical studies.

HPV and Cervical Cancer Cell Biology

High-risk HPV types are central to cervical carcinogenesis. Two viral proteins, E6 and E7, are particularly important.

HPV E6

The E6 oncoprotein contributes to malignant transformation by interfering with tumor-suppressor mechanisms, particularly the p53 pathway. E6 promotes degradation or functional inhibition of p53, reducing cellular responses to DNA damage and apoptosis.

HPV E7

E7 primarily interferes with the retinoblastoma protein (pRb) pathway. Disruption of pRb-mediated cell-cycle control promotes inappropriate progression from the G1 phase toward S phase.

Consequences of E6/E7 activity

Persistent activity of E6 and E7 can contribute to:

- Uncontrolled cellular proliferation
- Impaired DNA-damage responses
- Reduced apoptosis
- Genomic instability
- Altered cell-cycle regulation
- Accumulation of additional genetic abnormalities

HPV-positive cell lines are therefore particularly useful for investigating the molecular relationship between viral oncogenes and host-cell signalling.

Anticancer Drug Screening

Cell lines are frequently used during the early stages of anticancer drug development.

Researchers can expose cervical cancer cells to candidate compounds and assess:

- Cell viability
- Growth inhibition
- Apoptosis
- Cell-cycle arrest
- Mitochondrial dysfunction
- DNA damage
- Migration and invasion

This approach enables researchers to compare the relative sensitivity of different cervical cancer models. Importance of Cell-Line Authentication and Quality Control

Reliable research depends heavily on the quality of the experimental model.

Before conducting major experiments, investigators should consider:

- Cell-line authentication
- Mycoplasma testing
- Verification of HPV status
- Appropriate passage-number monitoring
- Confirmation of expected morphology
- Appropriate culture conditions
- Reproducibility between experiments

Authentication is particularly important because contamination or misidentification can produce scientifically misleading conclusions

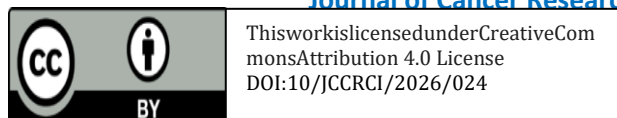
Conclusion

Cervical cancer cell lines remain indispensable experimental models for investigating the molecular and cellular mechanisms underlying cervical carcinogenesis. Models such as HeLa, SiHa, CaSki, C33A, and ME-180 provide complementary systems for studying HPV-associated and HPV-independent cancer biology. Their applications extend from fundamental research into viral oncogenes and cell-cycle regulation to anticancer drug screening and investigation of treatment resistance. However, their limitations—including genetic drift, lack of tumor microenvironment, and limited representation of patient heterogeneity—must be considered when interpreting experimental findings.

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