21. FROM VIRAL STRUCTURE TO MOLECULAR DETECTION: DIAGNOSTIC ADVANCES IN HEPATITIS C VIRUS

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Introduction. Hepatitis C Virus is one of the leading causes of cirrhosis, hepatocellular carcinoma, and liver failure, with almost 58 million people worldwide chronically infected, making it a significant global health concern. Characterized by extensive genetic diversity, this single-stranded RNA virus poses a challenge to diagnosis due to the lack of proofreading activity of its RNA-dependent RNA polymerase. HCV infection is frequently asymptomatic and has yet to have an available vaccine, therefore diagnosis is crucial, as early detection could prevent liver damage and interrupt transmission. Fortunately, the ongoing progress in molecular virology has significantly shifted conventional diagnostic techniques to highly sensitive approaches.

Aim of the study. This analysis evaluates current diagnostic strategies for HCV infection in the context of the virus's molecular and structural characteristics, with a particular focus on recent innovations in early microbiological detection and monitoring methods.

Methods and materials. A systematic literature review of studies published over the last 5 years was conducted using biomedical databases, such as PubMed, NCBI and Web of Science.

Results. According to studies, serological screening for anti-HCV antibodies remains the primary diagnostic method. Nevertheless, it cannot differentiate between active and resolved infection, which is why real-time PCR is used for detecting HCV RNA. This confirms active infection by means of its high specificity and sensitivity, allowing precise viral quantification during the pre-seroconversion window period. Recent innovations, including loop-mediated isothermal amplification, CRISPR-associated detection systems, digital PCR and microfluidic platforms offer enhanced detection with high accuracy while requiring minimal equipment, enabling point-of-care testing. Additionally, HCV core antigen evaluations provide practical and cost-effective alternatives where molecular testing is limited, indicating a strong correlation with viral RNA levels.

Conclusions. Understanding HCV molecular structure has led to the development of sophisticated and highly sensitive diagnostic tools that offer the chance of early, accurate and more accessible detection. Making them a part of routine clinical practice may considerably accelerate the efforts toward global elimination of HCV infection.

Keywords. Hepatitis C Virus, Digital PCR, Molecular diagnostics.

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