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EXHALED BREATH CONDENSATE AS A POTENTIAL DIAGNOSTIC TOOL FOR ASSESSING SPACE RADIATION-INDUCED CARCINOGENESIS

Abstract

Purpose: With the ambition to expand human space exploration to the Moon and Mars, prolonged exposure to ionising radiation significantly increases the risk of radiation-induced cancer. Despite existing prediction models, strategies for non-invasive and sensitive monitoring of early biological changes are limited. This study aims to evaluate exhaled breath condensate (EBC) as a potential diagnostic tool for early molecular monitoring of the space radiation-induced carcinogenesis process.

Methodology: This study is based on a critical review of the existing clinical literature on the use of EBC in molecular analyses in the field of oncology and an examination of the translational applicability of these findings to space medicine. Molecular data from studies comparing tissue, plasma, and EBC samples, particularly in lung cancer patients, were analyzed, and the biomarker detection capacity of EBC was interpreted in the context of space radiation.

Results: Clinical studies in the literature show that oncogenic driver mutations such as EGFR, KRAS, and PIK3CA can be detected in EBC samples and that this method may be complementary to plasma-based liquid biopsy. Furthermore, the repeatability, low invasiveness, and suitability for long-term storage of EBC suggest that it may offer advantages for continuous health monitoring during long-term space missions. However, methodological limitations such as sample dilution variability, lack of standardized collection protocols, and low analyte concentrations may affect analytical sensitivity.

Conclusions: The EBC-based molecular monitoring approach offers an innovative strategy for non-invasively tracking radiation-induced early biological changes in deep space missions. Supporting this approach with standardization and technical validation processes could contribute to the development of personalized cancer risk modeling. Furthermore, space radiation research has the potential to provide translational contributions to radiation exposure studies on Earth.