Abstract

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Finding a non-invasive diagnostic method with sufficient diagnostic power is crucial for early detection of malignant tumor diseases. The main goal of the presented work is to observe changes in the spectral characteristics of urine and extracellular vesicles isolated from urine between patients diagnosed with bladder cancer and control subjects. We also investigated changes in the size and concentration of extracellular vesicles isolated from blood, as well as their potential therapeutic use. Data were obtained through fluorescence spectroscopy and high-performance liquid chromatography (HPLC). The data obtained from multiple fluorescence spectra measurements were graphically represented as excitation-emission matrices (EEMs). In both EEMs and chromatograms, statistically significant peaks and regions were identified, which were evaluated using various statistical methods and machine learning techniques (logistic regression, OPLS-DA, convolutional neural networks). We also examined the possible impact of data standardization and dimensionality reduction on the performance of individual models. The analysis of urine EEMs did not yield satisfactory results; the highest accuracy was achieved using convolutional neural networks, with a maximum accuracy of 72.1% for the training model. For EEMs of extracellular vesicles, sensitivity, specificity, and model accuracy values approached 100% using OPLS-DA analysis for identified peaks. Regarding chromatograms, the best results were obtained by applying convolutional neural networks to chromatogram data, achieving an accuracy of 95.3% for the training model. Established methods of data standardization did not improve performance of discrimination models. The size of exosomes isolated from blood was lower in patients with bladder cancer compared to control subjects. Exosomes also represent a promising model structure for studying biophysical and chemical properties of nanoparticles that can affect the targeted drug delivery. Exosomes have potential not only in targeted therapeutic solutions but also in cancer diagnostics research, along with spectral characteristics of urine specimen.

Keywords: urine, exosomes, fluorescence, machine learning, bladder cancer