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NIR-Hyperspectral Imaging and Artificial Neural Networks for the Characterisation of Renal Calculi

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The formation of kidney stones is a disorder consisting on the formation of precipitates at any point in the urinary system, and is affecting more than 10% of the population in the European Union along their lives. Besides, the percentage of patients having a kidney stone for a second time is as high as 45-75%, during the five years following the first episode of lithiasis1. This disease is strongly influenced by different variables, of physiological, psychological or environmental nature. These lithiasic episodes might be spontaneously solved, when the stone is expelled from the body. Nevertheless, many cases require further medical treatment, even surgery. The medical expenses considered directly related to renal lithiasis, namely calculi fragmentation, surgery and later treatments do cause huge expenses to medical systems.

The abovementioned reasons make clear the importance to identify the causes of the disorder which ends in a lithiasic episode to assess on the prevention of additional episodes. The main methods used for the diagnostic of the causes are urine analysis and, specially, the careful study of the kidney stone itself, in particular structural aspects. Therefore, a correct characterisation and description of the structure of the stone will provide the key information on the conditions producing the growth of the stone2. Conventional characterization of calculi structure can be a tedious and, in particular, expert dependent process.

This study is basically related to this aspect of the stone structure characterization, since a new most robust methodology for the characterisation and classification of kidney stones has been developed trying to avoid expert dependence. More than 200 samples of renal calculi, including all main types of calculi, were analysed by means of stereoscopic microscopy and SEM, as shown in the literature3,4,so as to get a conventional classification of the stones, which served as reference classification. The use of Near Infrared Spectroscopy coupled to the hyperspectral imaging technique proved to be able to show the spectral characteristics for every compound. Moreover, the chemometric analysis of the data allowed the selection of some regions in the spectra which have stronger classification capabilities. The data was used for creating a model, using some considered pure samples, by means of Artificial Neural Networks. This computational model showed a really good performance for the classification of the main groups of kidney stones, including those which are actually mixtures of some compounds. Furthermore, the main advantage this model exhibits is the faster and more confident classification of the stones, compared to the conventional methodologies.

This work constitutes a new insight into the comprehension and characterisation of the structure of kidney stones, as well as the urinary conditions which lead to their formation. The results seen in this study emphasise the new possibilities shown by the mentioned techniques in the field of renal lithiasis, being this knowledge directly focused on the improvement of the quality of life of patients.

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