Artificial Intelligence for the Identification of Endometrial Malignancies: Application of the Learning Vector Quantizer

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ABSTRACT

Aim of this article is to investigate the potential of Artificial Intelligence (AI) in the discrimination between benign and malignant endometrial nuclei and lesions. For this purpose, 416 histologically confirmed liquid-based cytological smears were collected and morphometric characteristics of cell nuclei were measured via image analysis. Then, 50% of the cases were used to train an AI system, specifically a learning vector quantization (LVQ) neural network. As a result, cell nuclei were classified as benign or malignant. Data from the remaining 50% of the cases were used to evaluate the AI system performance. By nucleic classification, an algorithm for the classification of individual patients was constructed, and performance indices on patient classification were calculated. The sensitivity for the classification of nuclei was 77.95%, and the specificity was 73.93%. For the classification of individual patients, the sensitivity was 90.70% and the specificity 82.79%. These results indicate that an AI system can have an important role in endometrial lesions classification.

KEYWORDS

Artificial Intelligence, Artificial Neural Networks, Cytopathology, Endometrium, Image Analysis, Learning Vector Quantizer, Morphometry

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INTRODUCTION

The endometrium is a human system with inherent complexity because it undergoes cyclic regeneration under estrogen effects during each menstrual cycle. These effects, as well as sex steroids, oncogene products, growth factors and various peptides (Murphy, Murphy, & Friesen, 1987; Shyamala & Ferenczy, 1981) may cause premalignant and malignant transformation of the endometrium. Early diagnosis is crucial because it is associated with patient management and therapy. However, and despite that in the last decades the incidence of endometrial cancer has increased (Jemal et al., 2006), there is still not a global and well-established screening method for the early detection of endometrial cancer. Moreover, there is no automated procedure.

Artificial Intelligence (AI) techniques are not new in medicine (Adams, Bello, & Dumancas, 2015; Darcy, Louie, & Roberts, 2016; Foran, Chen, & Yang, 2011; Grabe et al., 2010; Karakitsos et al., 1996; Luo et al., 2015; Seffens, Evans, Minority Health, & Taylor, 2015; Su, Xu, He, & Song, 2016). During the last decades, numerous applications have been reported; these involve the use of classical statistical models (Karakitsos et al., 2004), as well as more advanced techniques, such as neural networks. In the field of oncology related medical disciplines there are numerous efforts (Cruz & Wishart, 2006; Hassan, Ruusuvuori, Latonen, & Hutunen, 2015; Karakitsos et al., 1997; Kourou, Exarchos, Exarchos, Karamouzis, & Fotiadis, 2015; Pouliaakis et al., 2016; Simões et al., 2014). However, the literature related to endometrial cytological material evaluation by AI and especially publications reporting the comparison of machine learning performance are rather poor.

In this article, a methodology aiming to classify endometrial lesions based on cell nuclei morphometry data will be presented. Initially, the morphometrical features and their biological relation will be described and then the construction of machine learning systems classifying individual nuclei will be outlined. Furthermore, according to the nuclei classification results, a second stage classifier aiming to categorize individual cases will be constructed. The validation of the results will be based on the histological result, which will be considered our gold standard. The applied Machine Learning Algorithm (MLA) was the Learning Vector Quantizer (LVQ) ANN and was selected because it has the capability to provide solutions by creating clusters. The applied classifier was compared with the performance of the cytological outcome.

MATERIALS AND METHODS

Biological Sample, Material Collection and Diagnoses

For this study, cytological samples from the endometrial cavity were collected from 416 female patients. The biological material was taken using the EndoGyn® Sampler (Biogyn S.n.c., Mirandola, Italy). Subsequently, the sampling device was withdrawn, and the material was immersed into a vial containing CytoLyt® solution (Cytyc Corporation). The use of this methodology (i.e. Liquid Based Cytology - LBC) for material collection and preservation is essential, not only because it facilitates the cytological diagnosis through the microscope, but also provides a clear material for subsequent image analysis, as required by this study and therefore ensures a constant sample quality. The vials with the biological material were used to prepare a single cytological slide via an automated slide processor (ThinPrep® TP2000, Cytyc Corporation). TP2000 prepares a smear in a 2 cm diameter area containing cells in a single layer with almost no overlap in 90 seconds. Each slide was stained with Papanicolaou stain, using an automated staining machine (Varistain® 24-3 Thermo Electron Corporation [formerly Shandon], Runcorn, U.K.).

Both the cytological and histological examination results were available for every patient included in this study. The histological examination was performed on biological material harvested via endometrial curettage and/or surgically. Women without histological examination results were excluded from the study. Histological confirmation is imperative, as it is the golden standard and the lack of it makes it impossible to have an accurate final diagnosis and therefore evaluate the results and performance of the proposed methodology.
Patient Safety Concerns among Emergency Medical Staff and Patients
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