Editorial
Investig Clin Urol 2022;63:123-125.
https://doi.org/10.4111/icu.20220051
pISSN 2466-0493 • eISSN 2466-054X

INVESTIGATIVE AND CLINICAL UROLOGY
ICUROLOGY

Use of artificial intelligence to characterize renal tumors

We are living in the era of the 4th industrial revolution, which is characterized by the convergence of information and communication technologies. Among the elements of the 4th industrial revolution, artificial intelligence (AI), which is the biggest component, refers to the computational capability of machines to mimic and perform human cognitive tasks. Such developments are already affecting many aspects of our lives, such as shopping, music, art, autonomous driving, and the medical field. AI can deliver consistent results without personal feelings, save time and money, and reduce human labor via automation. Machine learning uses algorithms to analyze data, learn from that data, and make informed decisions based on what it learns. Deep learning is a technique for creating artificial neural networks that can learn on their own and make intelligent decisions by organizing algorithms into layers. An artificial neural network can be created by stacking several mathematically modeled artificial neurons. The word deep in deep learning does not mean that you gain any deep insights. Rather, it simply represents the concept of learning in successive layers, where through these layers, reliability increases. A well-trained artificial neural network can perform complex data processing quickly and powerfully. The success of deep learning is due to the development of algorithms that overcome the limitations of existing neural networks, as well as hardware improvements such as graphics processing unit and big data. Today, AI is applied in medicine and health care to improve clinical decision-making.

Renal cell carcinoma (RCC) is a heterogeneous tumor and each of its subtypes has an associated biological behavior, clinical course, and response to therapy. AI-based applications and research to characterize renal tumors have significantly increased recently, demonstrating diagnostic, prognostic, and predictive accuracy.

DIFFERENTIATION OF BENIGN AND MALIGNANT RENAL TUMORS

Because fat-poor angiomyolipoma (AML) and oncocytoma are frequently misclassified as RCC, it is important to accurately differentiate between benign and malignant tumors to avoid unnecessary biopsy or surgery. Machine learning and deep learning algorithms developed through the use of radiomics have shown potential to accurately differentiate between benign and malignant renal tumors.

Most of these algorithms use inputs extracted from quantitative features of medical imaging data. Radiomics features, including intensity, shape, and texture, can provide valuable information that cannot be achieved by human imaging interpretation alone. These quantitative data are collected and fed into machine learning and deep learning algorithms to create models that can accurately characterize renal masses by differentiating between benign and malignant renal tumors [1].

Erdim et al. [2] constructed a prediction model using machine learning algorithms based on texture features extracted from unenhanced and contrast-enhanced computed tomography (CT) images of 21 benign and 63 malignant renal masses, using 8 machine learning algorithms for these classifications. A random forest algorithm demonstrated the best predictive performance using 5 selected contrast-enhanced CT texture features. The accuracy and area under the curve (AUC) metrics were 90.5% and 0.915, respectively [2].

Uhlig et al. [3] reported a comparison between two experienced radiologists. They found that the random forest algorithm demonstrated superior diagnostic accuracy for renal mass assessment based on CT imaging (AUC 0.83 vs. 0.68, p=0.047).

Pedersen et al. [4] constructed convolutional neural networks based on features extracted from 20,000 CT images to facilitate differentiation of oncocytoma from RCC with a 93.3% accuracy and 93.5% specificity (AUC 0.973) [4].

DIFFERENTIATION OF RCC SUBTYPES

Three major subtypes of RCC (clear cell, papillary, and chromophobe) constitute more than 90% of RCC cases. In an attempt to distinguish the subtypes of RCC, machine learning and deep learning models based on radiomics analyses have been developed.

Kocak et al. [5] created externally validated machine learning models to distinguish three major subtypes of RCC using 275 textural features extracted from unenhanced and corticomedullary-phase CT images. Machine learning–based quantitative CT texture analysis could distinguish non–clear cell RCC from clear cell RCC with a satisfying performance. On the other hand, the performance of this method for distinguishing the three major subtypes was poor. Corticomedullary-phase CT images provided much more valuable texture parameters than unenhanced images [5].

We constructed a dataset consisting of 1,035 CT images from 308 patients containing five major subtypes of renal tumors, including both benign and malignant tumors: oncocytoma, AML, clear cell RCC, papillary RCC, and chromophobe RCC. We compared the diagnostic performance of the model with that of six radiologists and constructed a deep learning model for the differential diagnosis of five major histologic subtypes of renal tumors. The performances of the radiologists and AI were similar only in the diagnosis of clear cell RCC. AI showed better performance than the radiologists for diagnosis of the other types of RCC. In diagnosing benign tumors of oncocytoma and fat-poor AML, AI performed significantly better than the radiologists [6].

FUTURE DIRECTIONS

In computer science, “garbage in, garbage out” (GIGO) is the concept that flawed or nonsense input data produce nonsense output. There is no way that a proper AI can be created when using nonsensical data. Therefore, to create excellent AI algorithms, it is necessary to build high-quality AI training datasets. With the growing volume of clinical, radiographic, pathologic, and genomic data of patients with renal tumors, AI algorithms will become more powerful. However, most of the current early literature has been limited to algorithms trained using a single type of clinical, radiographic, pathologic, or genomic data. To mimic human decision-making, AI algorithms must be able to synthesize all available relevant information before making accurate predictions. Despite these anticipated initial challenges, AI will play an important role in the clinical management of patients with renal tumors.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

FUNDING

This work was supported by the Korea Medical Device Development Fund grant funded by the Korean government (Ministry of Science and ICT, Ministry of Trade, Industry and Energy, Ministry of Health & Welfare, Republic of Korea, Ministry of Food and Drug Safety) (Project Number: KMDF_PR_20200901_0096).

AUTHORS’ CONTRIBUTIONS

Research conception and design: Hokun Kim and Sung-Hoo Hong. Data acquisition: Hokun Kim. Drafting of the manuscript: Hokun Kim and Sung-Hoo Hong. Obtaining funding: Sung-Hoo Hong. Administrative, technical, or material support: Hokun Kim. Supervision: Sung-Hoo Hong. Approval of the final manuscript: all authors.

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