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| **Title:** | | New TG Proposal on Nephrology: Role of Artificial Intelligence in Kidney Disease | | |
| **Purpose:** | | Discussion | | |
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| **Abstract:** | The rising prevalence of end-stage renal disease (ESRD) and its related morbidity is a major global public health issue. The number of new ESRD cases in the United States in 2015 was 124,111, according to the 2017 US Renal Data System (USRDS) Annual Data Report. As the number of people diagnosed with ESRD rises, so does the supply for renal replacement therapy (RRT). In China, hemodialysis (HD) is used by approximately 86 % of the dialysis population. In many countries, patient outcomes with peritoneal dialysis are comparable to or better than those with hemodialysis, and peritoneal dialysis is also more cost-effective. Current estimates suggest that more than 272,000 patients receive peritoneal dialysis worldwide, representing approximately 11% of the global dialysis population[6](https://www.nature.com/articles/nrneph.2016.181#ref-CR6). Use of this modality differs dramatically, however, between different regions and countries. The annual global growth rate of peritoneal dialysis is estimated to be 8%, which is higher than that of hemodialysis (approximately 6–7%). |

**1 Overview**

Kidney disease is a major public health concern, in part for its widely known etiology, which includes diabe tes, hypertension, obesity, and aging; the incidence of such conditions is rising. According to the Global Burden of Diseases, Injuries, and Risk Factors Study 2015, kidney disease affected 750 million people globally. The kidneys are damaged in people with kidney disease, and they are unable to filter blood properly, causing waste to build up in the body. Kidney disease raises the chances of having a stroke or going into cardiac arrest. ESRD is defined as complete, irreversible kidney failure that can only be treated with a kidney transplant or dialysis. Kidney disease places a considerable burden on society. Including a 2017 survey, the annual cost for a patient with stage 3 chronic kidney disease (CKD3) was approximately $1,205, $1963 for a CKD4 individual, $8,035 for a CKD5 individual, and $34,554 for a hemodialysis patient. Various complications are associated with vascular access in hemodialysis patients and abdominal catheters in patients receiving continuous ambulatory peritoneal dialysis (CAPD). Furthermore, because the catheter acts as a foreign body and provides a portal of entry for pathogens from the external environment, patients are at risk of peritonitis and local infection. Electrolyte imbalances can occur as a result of renal disease or as an iatrogenic complication. Hyperkalemia, hypocalcemia, hyponatremia, and hypermagnesemia are among them. Headache, dialysis dementia, and stroke are examples of neurologic complications that can occur directly or indirectly as a result of hemodialysis.

**2 Relevance**

The clinical applications of AI in the development to ESRD and dialysis can be divided into 3 major topics: (a) anticipate potential events including mortality and hospitalization; (b) offering treatment and decision aids like automating drug prescription; and (c) identifying patterns such as phenotypical clusters and arteriovenous fistula aneurysm.

At the moment, through use of estimation methods in the treatment of patients with kidney disease is in its infancy, and more evidence is needed to determine its relative value. AI is not supposed to replace nephrologists' medical decision-making, but rather to help them provide the best personalized care for their patients.

**3 Impact**

The number of patients requiring dialysis has increased dramatically over the last decade, but HD is a highly-priced method for treating that places a substantial burden on the public healthcare system. In China, the amount of ESRD patients grow by 120,000 yearly, necessitating more than 1.4 billion dollars for their survival and treatment. This attributed to 1–3% of national healthcare expenses and put a lot of stress on the national healthcare foundation. The aging population and rising prevalence of diabetes mellitus pose significant challenges to the provision of peritoneal dialysis in Asia. Diabetes accounted for 66 percent and 61 percent of incident ESRD patients in Singapore and Malaysia, respectively, in 2012. Peritoneal dialysis costs about USD$14,380 per year in China, while in-center haemodialysis costs about USD$15,910.

**4 Existing Work**

The role of AI in kidney disease is primarily focused on 4 aspects: Alerting Systems, Diagnostic Assistance, Treatment Guidance, and Prognosis Evaluation.

**5 Feasibility**

Alerting Systems: Alerting CKD is based on algorithms that have been trained to identify at-risk patients and order a CKD screening test. AI has been explored in the early detection of CKD complications. The application of AI to the ECG may allow CKD patients to be screened for hyperkalemia. AI can predict patient costs and mortality. AI modeling could aid in the provision of reliable info about one-year outcomes upon dialysis in the elderly and super-aged populations.

Diagnostic Assistance: Computer-Aided Diagnosis (CAD) is a technology that combines medical images and computer image analysis to accurately measure and evaluate the qualities of the focus, potentially assisting clinicians in identifying and analyzing lesions in a timely and accurate manner.

Treatment Guidance: Dialysis is the primary treatment for end-stage renal disease. Dialysis has a deep influence on the patient's life, and several patients are unable to tolerate the hemodynamic instability of intermittent dialysis. Wearable dialysis devices could analyze device alerts, dialysis variables, and patient-related info as well as provide direct feedback.

Prognosis Evaluation: Through evaluating datasets, AI could indeed recognize factors influencing diagnosis and build a model that evaluates the relationship between factors and diagnosis.

**6 Data Availability**

Training data were from tertiary hospitals in China. After anonymizing and data masking, sample data including patients’ clinical data, dialysis data, and laboratory data, etc were analyzed.

**7 Data quality**

Data samples are with high quality, and comply with international standards such as HIMSS.

**8 Annotation/label quality**

Data samples were annotated and masked. Exclusion and inclusion criteria were based on clinical design.

**9 Data provenance**

Sample data were provided from real-world clinical data in Chinese hospitals.

**10 Benchmarking**

For the early prediction of chronic kidney disease and its complications, we take the clinical and biochemical features (biomarkers) as input to predict the probability of a patient suffering from a certain complication, e.g., diabetes. Therefore, we form a binary classification task for each individual complication. Furthermore, for each of the complication, we perform a feature selection to find the most relevant features. Thereafter, we build six different machine learning algorithms, i.e., Naive Bayes, Support Vector Machine, Random Forest, XGBoost, Factorization Machine, and Deep neural network for kidney disease diagnosis. Among these models, Naive Bayes is chosen as the benchmark model. This is because the Naive Bayes is a first-order model, i.e., all the variables/features are considered independently and no interactions between features are considered. All models will be evaluated via confusion metrics to check its F1-Score, Precision, False Positive rate, and Recall. The significance between the models will be tested using t-test. The performances of the models can be visualised using ROC and PRC charts.

For tasks that do not form a classification problem, e.g., patient dietary advice, we test the accuracy and reliability of the model manually. Specifically, experts from hospitals would check the outputs of our system to ensure the correctness of our model.

**11 Organizer**

The project of Ark Health Solution (Shanghai) Ltd. focuses on the chronic kidney disease big data platform and renal artificial intelligence development.

Currently, our data platform has cooperated with nephrology departments nationwide.

Our final goal is to leverage artificial intelligence technique to develop reliable renal medical devices for kidney diseases.

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