Application of Artificial Intelligence in the Diagnosis of Cardiac, Liver and Kidney Disease – An Update

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Abstract-Recent data from many hospitals have shown increasing prevalence of diseases associated with Diabetes Mellitus (DM), Cardio Vascular Disease (CVD), Liver Disease (LD) and Kidney Disease (KD)globally. Recent developments for the diagnosis of many human diseases are driven by computer based algorithms, web based storage data and Artificial Intelligence (AI) based Machine Learning (ML). All these emerging applications are now increasingly used in almost all technologies, society challenges, schools, research organizations and hospital based health care companies integrated to the different modules to support diagnosis of diseases.The present review explores the possibility of application of AI and ML to improvise and effectively produce rapid results with greater efficiency and less manpower. The literature clearly proves the applicability of AI in detection of diabetes, heart disease, liver functions and kidney functions which could be of great help to the clinicians to strategize their treatment modalities more effectively. ML based artificial intelligence will be the best tool to diagnose and treat the diseases in the most time effective and non invasivemanner to manage critical health problems in a systematic and quick approach and thereby eradicating complexity of medical problems.AI is more efficient than human time wise, it does not goes tired like human. Its intelligent magnitude is several times higher, but in spite of all that the human touch by a doctor cannot be replaced. AI lacks empathy and comparison. What is most required for a patient could not be replaced by machines . Anyway, AI can assist the clinician to do productive work in short span of time. More research should be done in the field of AI for its application for every disease associated with humans.

Key words: AI, ML, CVD, DM, KIDNEY, LIVER, EHR

.I. INTRODUCTION

Recent data from many hospitals in the world have shown increasing prevalence of diseases associated with Diabetes Mellitus (DM), Cardio Vascular Disease (CVD), Liver Disease (LD) and Kidney Disease (KD) and recent developments for the diagnosis of many human diseases are driven by computer based algorithms, web based storage data and Artificial Intelligence (AI) based Machine Learning (ML). All these emerging applications are now increasingly used in almost all technologies, society challenges, schools, research organizations and hospital based health care companies. Majority of investments made in 2018 was to develop AI in hospitals to improve patient care and to reduce health care costs. Application of the principles of AI has greatly enhanced the traditional statistical analyses in many domains, especially bringing out the hidden information in many highly complex data sets. Many health care professionals in hospitals are still unaware that AI could improve patient care [1].

II. AI and CVD

Correct diagnosis and decision making in modern medicine are based on structural knowledge available on laboratory data and interpretation. All automated algorithms (AA), otherwise known as AI could be used to extract meaningful pattern for final clinical decision making process. Of late, AI are penetrating medical field, especially to treat CVD, as it is the number one killer worldwide. AI could help to store multi-modality images, electronic health records (EHR) and mobile health care devices for each patient. AI could improve the status quo, as it has vast capacity to learn from the massive data stored by the above devices. As AI could predict each heart beat in CVD patients, it should be practiced towards personalized and precise patient care [2] [3].

ML based AI has now set to poise every aspect of human health and diseases, and its applications to CVD patients are on the increase. AI could be successfully applied to identify the development of CVD, predictive modelling concepts, pitfalls in identifying CVD patients such as improper dichotomization. AI could be easily linked to any data such as common algorithms. It could also be applied to deep learning such as unsupervised learning, understanding contextual examples in CVD medicines, all of which could help cardiologists to understand and to enable precision outcome for improved patient care [4].

CVD is the number one killer worldwide which claimed 17.6 million deaths in 2016, a 14.5% increase compared to 2006 statistics. It is increasing on yearly basis, notably in the developing countries. Low and middle income countries have shown that 80% of death was related to CVD. Economic transformations in developing regions are the major factors leading to environmental and life style changes, both of which cause CVD. Hence it is important to provide strategies to improve CVD in the near future. AI could be successfully used to tackle and solve the above problems. Application of AI in health care may lead to unemployment, but the current research data on AI did not provide any solution for it [5]

Early and timely diagnosis and treatment will considerably reduce the cost, mortality and morbidity of CVD. Patient's data based approach will serve to discover tacit knowledge to help doctors for better decision making. Past records of patients are the most useful treasures to uncover heart diseases origin, which could be effectively utilized by doctors, nurses and other supporting staff in a hospital. Data mining in heart disease field, diagnosing heart attacks from various signs and symptoms, risk factors and algorithms data collection from previous treatment will help doctors to gain maximum benefits in treating CVD patients [6].

AI is mainly used to mimic human thought processes, learning capacity and knowledge storage by using computer simulation and it could be effectively used to explore both genotypes and phenotypes in existing disease, improve quality of patient care, cost effectiveness and to reduce remission and mortality rates. AI have been in existence several decades ago based on ML techniques, for the diagnosis of CVD prediction, treatment and prognostic out come. Understanding CVD problems in terms of medicine and statistics and then applying the optimal ML algorithms will help to reduce mortality among patients. Although use of AI in treating CVD is much beneficial, ignorance of the challenges may overshadow its potential clinical impact [7].

In recent year's attention have been diverted towards AI in clinical decision making and management of stroke and heart disease. This was made possible by technological advancements and the interest shown by researchers in this emerging field. Use of novel analysis approach based on bibliometrics, abstract content using exploratory factor analysis and latent Dirichlet? Allocation will uncover emerging research domains, all of which will be very useful in the diagnosis, treatment and prognostic outcome of CVD patients. AI growth has been based on web of science database, robotic prosthesis, robotic assisted stroke rehabilitation and minimally invasive surgery. AI could also detect emerging landscape of research centred on population specific and early detection of stroke and heart diseases. Application of AI will help in health behaviour tracking and improvement as well as use of robotics in medical diagnosis and prognosis. AI model rehabilitee as well as validation of its clinical utility need to be further explored [8].

New ways of treating patients are now available using Information and Communication Technology(ICT) and data collected by mobile health information. Telemonitoring systems will help as predictive models for clinical support to improve several pathologies related to heart failure (HF). As of date, clinicians mostly use simple rules to generate large number of false alerts. In a study involving the collection of mobile clinical data HF patients in a public health services in Basque (Osakidetza), they have established that a combination of alerts based on monitoring data along with a Bernoulli a questionnaire (BQ) distribution revealed that predictive model detected 67% of patients with Area Under the Curve (AUC) and reduced the false positive per patient per year from 28.64% to 7.8%. This study has concluded that the system followed predicted with higher reliability than current alerts [9].

Application of AI based on ML system linked to Coronary Computed Tomography Angiography (CCTA) provided important information on steroids severity, lesion length, plaque alternation and degree of calcium deposition. However, the comprehensive analysis of these factors may be difficult using patient characteristics and CCTA findings. Application of AI random forest has increased the AUC from 0.89 to 0.95 (logistic regression Vs random forest). Hence ML models may be helpful for the interpretation of CCTA for detecting ischemia-related coronary lesion [10].

A study done in Spain has recommended the use of Picture Archiving and Communication System (PACS) to acquire and treat angiography studies on CVD patients. This system will help the decision made by arterial model for patients using Image Segmenting Techniques (IST)and arterial labelling after which algorithms could be used for detecting stenos in the arterial tree. This technique will help precise quantification for diagnosis bypassing heavy additional laboratory tests on patients and saving of hospital resources [11].

Application of AI is fast emerging and within the next 5 years, AI driven automation for the analysis and interpretation of CCTA may certainly be established in all cardiac units. This technique once established will enhance deep learning, and by using image and adjunctive data mining will generate more accurate and personalized diagnosis and risk merits[12]. A study has predicted the neural network at 99.4% accuracy at classifying beats from the testing data set against the opinions of the internal core laboratory, but at 98.7% accurate when compared against the opinion of external core laboratory. The neural network used was 100% sensitive with no beats classified as damped misclassified and the positive and negative predictive values were 98.1% and 99.5% respectively. Use of arterial waveforms based on neural networks will predict rapid and accurate identification of damping. Hence ML techniques could assist patient safety and the quality of procedures [13].

III. AI AND LIVER FUNCTION

AI based on deep learning algorithms are excellent techniques in image recognition tasks. These techniques will automatically analyse quantitatively complex medical image characteristics with a higher efficiency for accurate diagnosis. AI is now recognised as the state of art techniques in the medical imaging of the liver that will cover radiology, ultrasound and nuclear medicine. Application of AI will reduce physicians work load as it could accurately predict reproductive imaging diagnosis. AI could be effectively and successfully utilized in the convolution of neural networks in the medical imaging of liver disease such as detecting and evaluating focal liver lesions, facilitating treatment and predicting response. Hence machine assisted medical services will be a promising solution for future liver medical care [14].

Studies related to liver diseases have predicted that globally 1 in 12 people have the Hepatitis B or Hepatitis C virus (HBV, HCV). Liver biopsy is the confirmatory diagnosis of choice. However, biopsies are costly and carry some risks for the patient. As non– invasive methods like serum markers, image tests and genetic studies have not achieved sufficient acceptance and hence invasive biopsies are still considered as gold standard as Clinical Decision Support System (CDSS). The goal of CDSS is to make use of AI techniques based on historical clinical data to establish the relation between these two to help clinicians in the decision making processes. AI predictive techniques could be successfully applied as a link between serum markers and biopsy results. Web application based techniques could also be used as a prototype for presenting AI predictive results in a CDSS environment based on these models [15].

Clinical data such as demographic, use of anthropomorphic, medical history, laboratory results, Magnetics Resonance Imaging (MRI) are used to evaluate the presence of liver fat. Use of Magnetics Resonance Electrograph (MRE) and mean liver fat stiffness are the best performance tools to predict clinical and radiomic features. The diagnostic performance was assessed using Receiver Operating Characteristics (ROC) AUC values. It is better to use combination of clinical and radiomic out come. A model generated using clinical and radiomic features was found to have good diagnostic performance for classifying liver stiffness [16].

In recent years, a dramatic increase in computational capacity and the volume of available patient data have fuelled progress in ML methodologies and hence AI techniques could be linked to all the above data to arrive at a better diagnostics outcome. It could accurately facilitate the diagnosis of several conditions such as arterial fibrillation to stroke, depression and anxiety. The field of Hepatology could see significant change soon with the introduction of AI, but some challenges should be met before ensuring successful integration and implementation [17].

AI now is ascending to greater height towards futuristic things like watching science fiction movies like the matrix trilogy, but its application in the diagnosis of liver disorders is in its infancy level. It could be successfully linked to CNN, natural language processing (NLP), deep convolution neural networks (DCNN) for the diagnosis of a wide range of human disorders, particularly related to liver function. There are recent articles highlighting its application in all algorithms to generate “Heat maps” for radiologists to detect liver abnormalities. Traditionally, radiologists provide complex inputs from images to computers to get output results. AI suggests the “reverse training” in which human outputs are fed into the computers first to learn. Radiology is more a science of perception and in future these perspective algorithms will get better than human when AI is effectively applied [18].

An Intelligent System (IS) uses Hepatitis Prognosis and Liver Transplantation Decision Support (HEPAR)evaluation. This system confirms the elements related to prognosis and liver transplantation by combining the risk scores dynamically through fuzzy calculations. The first procedure involves the design and development of the fuzzy system and the computer environment. Introduction of HEPAR architecture with the medical characteristics will then generate few details for implementation. This expert system is called fuzzy C Language Integrated Production System(CLIPS). These fuzzy rules are then organized in groups to generate the diagnostic process. Experimental outcome were found to be encouraging and useful [19].

Medical decision making is a challenging task for clinicians as huge amount of available data are to be used with correct interpretation to arrive at the exact diagnosis. Many tools are now available which could reduce the risk for patients if they are properly used by applying technological assistances. Technology will provide assistances in every area of human disease as they employ pragmatism, repeatability, efficiency, immunity towards perturbation factors which are specific to human problems like fatigue, stress and diminished attention. Technology only help in assisting the clinicians and not decision making. Application of IS like AI will enable correct diagnosis for HBV or HCV infections. The IS make use of generalized regression neural network which gives the result whether the patient is HBVor HCV positive or not and the severity of the patient [20].

Along with AI, data mining is emerging as knowledge extraction platform which uses large data set to discover hidden or non-obvious patterns. Application of data mining on patient restricts will form a suitable mechanism to arrive at the correlation between patient’s system and disease. This extracted knowledge could be used to provide personalized recommendation to the patient in collaboration with the framework developed which in turn could be integrated to the different modules to support liver disease diagnostic systems. The impact of ML techniques in liver disorder detection could be implemented if more than one data base is used. A study done in the United State (US) based on the above principle revealed a 4 – 5 decision free algorithms and the random tree algorithm produced 100% accuracy in the classification of liver disorders and the application of this IS will enable a precise and accurate diagnostic system for clinical ailments of diverse kind[21].

Automatic prediction of liver disease is a problem in the medical world and diagnosis of liver disease was now principally depends on physician’s subjective knowledge. An Enhanced Hierarchical Clustering – End stage Liver Failure (EHC-ERF) based intelligent integrated model is being developed to predict different types of liver disease including alcoholic liver damage (ALD), primary hepatoma, liver cirrhosis and cholelithiasis. These diseases may cause many clinical complications making the differential diagnosis difficult EHC may help to provide more information for disease prediction. The ERF error rate is directly correlated to the strength of each individual tree and is directly proportional to forest error rate and inversely related to the forest rate. Two individual and three integrated classifications models will enhance predictions for liver disease types. Application of these models achieved better outcome in terms of accuracy, true positive rate, precision, F-measure, Kappa statistics, mean absolute error and root mean square error. This model showed the highest accuracy rates compared to state-of-art techniques [22].

Liver diseases are most common in Taiwan, but no correct methods are available to diagnose them. A study done there using classification and regression tree (CART) and case based reasoning (CBR) to structure an intelligent diagnosis model has shown 92.94% accuracy based on using CART and CBR models accounted for 90.00% accuracy and combining both the models showed considerable improvement in accuracy. This study recommends the use of CART model to diagnose liver disease in general and this differential diagnosis could be done using CBR model. Application of the above two models could help differential diagnosis of liver diseases by reducing diagnostic errors[23].

For the differential diagnosis of HBV, a multi-Layered Mamdani fuzzy Interference System (ML-MFIS) was developed. It is an automated model for the diagnosis of HBV using the above system. This model was capable of classifying different stages of HBV such as no hepatitis, active HBV and chronic HBV. The whole expert system functions are based on input layer I and seven input layer II. At layer I, the input variables are Alanine Transaminase

(ALT) and Aspartate Transaminase (AST) that detect the output condition as normal, hepatitis or HBV. The input variables at layer II are Hepatitis b surface Antigen (HbsAg), anitHbsAg, anitHbsAg, anti-HbcAg-IgM, anti HbcAg and HBV-DNA that determines the output condition of hepatitis such as no hepatitis, acute hepatitis or chronic hepatitis. The overall accuracy achieved using these two models were 92.2% [24].

In a study for the diagnosis of hepatitis disease as combination of two models, Particle Swam Optimization (PSO) when combined with CBR was a weight vector for every feature was extracted. Then a particle swam optimization was assembled for decision making system based on the selected features and diseases recognized. This method when compared with five other classification methods could diagnose hepatitis disease with an accuracy of 93.25% [25].

IV. AI AND KIDNEY FUNCTION

Dr. Van der Laak in his research on the application of AI on kidney transplant tissue has found out highly accurate and reproducible data that characterized disease processes and in the long term led to improved diagnosis for transplant patients. He noted that the performance of CNN exceeded the expectations and it accurately distinguished proximal and distal tubule. However, among the 8 more tissue classes, the AI network did not do equally well. Both human and the network did not determine if a tubule is in the atrophic state. ML has only sparsely applied in the kidney field and more works are to be done from kidney tissues in order to fully support graft assessment [26].

As pointed out earlier, AI is poised to support clinical judgment in all medical disciplines. A new AI support model using natural language and longitudinal big data based on ML with the support of electronic medical record (EMR) was used to detect diabetic kidney disease (DKD) on a large number of diabetes patients. AI collected raw data from the previous 6 months as reference and 24 factors were used to find out time series relating to 6-month DKD aggravation by the help of convolutionauto encoder. AI could predict DKD aggravation with 71% accuracy. The group with DKD aggravation had a significantly higher incidence of haemodialysis than the non-aggravated group. The new predictive model by AI could detect progression of DKD and may contribute to more effective and accurate interventions to reduce haemodialysis[27].

Recently medical sciences are relying on the use of technology to solve many problems associated with diseased patients. Many such applications of technologies are based on non-invasive procedures. Technologies also support therapies for specific pathologies. The technology based artificial kidney (AK) has now become the target for intensive research to generate useful benefits for dialysis patients. However, research on AK is only in the developmental stage and there are challenges that must be overcome before it becomes a clinical practice in nephrology[28].

The presently used dialysis devices are not able to react when unexpected changes occur during dialysis treatment. Research is still going on to develop AKs to achieve personalized dialysis therapy to improve the patient’s quality of life. Such devices should be fitted with a real time monitoring equipment, alarms, and parameters to be dialyzed and patient related data monitoring. The large scale data on the use of Aks may need real-time predictive models. Both ML and computational intelligence and AI should be suitably modeled to simulate intelligence behavior. AI should be designed in such away to provide fully new approach for data analysis in personalized dialysis therapies.AI model should be devised to fit interpretability and comprehensibility of data analysis when applied to decision making during dialysis. Currently ANN and medical decision support systems have been successfully used to make predictions about anemia, body water and intra dialysis hypotension. Although current dialysis machines are continuously improving due to innovative technological developments, patient’s safety is now a key challenge. Real-time monitoring systems and automated instant feedback are the need of the hour in dialysis therapies. Data collected from dialysis parameters could be coupled to ML to derive a comprehensive AI for use is dialysis therapy [29].

Different pattern of decline in kidney functions have been observed in patients with autosomal dominant polycystic kidney disease (ADPKD), but there is no solution to predict individual disease progression. A study has designed a neural network 2, 3 to predict individual estimated glomerular filtration rate (Egfr) decline in patients with ADPKD. It employed feeding 5 consecutive Egfr values in the network for a two-year period and the output has predicted Egfr at 5 years. This neural network designed could be used to predict ADPKD disease outcome [30].

Egfr are routinely used in clinical practice to grade kidney disorders. Studies done in the past have shown Artificial Neural Networks (ANNs) could achieve a better prediction than traditional equations based Egfr values. Using a Genetic algorithm coupling a back propagation neural (GA-BPPN) in which six input variables creatinine, urea nitrogen, age, height, gender and Egfr as output variable was then compared with equations of Cockcroft-Gault Modification of Diet in Renal Disease (MDRD) and CKD Epidemiology Collaboration (EPI) for better diagnosis kidney disorder grading. In the external validation data, use of Bland-Altman analysis showed the highest precision of the six variables used in GA-BPPN network. Both precision and accuracy also improved when additional external validation data were used. Hence, a new GA-BPPN model for CKD patients could be successfully used for GFR and CKD classifications than traditional equations [31].

Renal transplantation is the final mode of treatment for CKD patients. Due to various medical conditions, most of the patients survive on dialysis therapy. Hence wearable dialysis devices are important in clinical tolerance and for the need of majority of CKD patients. Contributions from AI and ML for real time analysis of equipment alarms, dialysis parameters and patients related data will be very useful for all CKD patients. Technological advances could easily replace human intelligence such as learning, problems solving, speech understanding or planning a decision making. AI could be successfully applied for visual perception, speech recognition and language translation [32].

Standard measures of kidney function are sparingly used for accurate prediction of risks associated with Acute Kidney Injury (AKI). Both clinical and biomarkers data could predict AKI more accurately. A prediction model developed using ML techniques based on dimensionally reduced and supervised classification, when subjected to sequential selection and Fisher's discriminate analysis was used to improve performance of the system. This system when used along with clinical and biomarker data will predict AKI accurately. Such predictors of AKI could be identified using ML and final prognostic model developed with least absolute shrinking and selection operator (LASSO). An elevated score was predictive of procedural AKI in the subject's studies [33].

Advanced data mining techniques could help in the early prediction of kidney stone diseases which will reduce its incidence and associated costs. When this model was applied, parameters such as sex, uric acid, calcium, hypertension, diabetes, nausea and vomiting, flank pain and Urinary Tract infections (UTI) were the most vital parameters for predicting the chance of nephrolithiasis. The final ensemble-based robust model could be safety applied in future studies to predict the chances of developing nephrolithiasis as this model showed 97.1% accuracy. This model will provide a novel way to study stone diseases by deciphering the complex biological variables in an early identification and reduction in diagnostic time [34].

AI could be effectively used in urology by utilizing radiomic imaging or ultrasonic echo data to improve or automate cancer detection or outcome prediction. Further, digitized tissue specimens' images could be used to automate for detecting cancer on pathology slides or patient clinical data biomarkers or gene expression could be combined to assist disease diagnosis or outcome prediction. While some studies used AI to plan branchy therapy and radiation treatments, others used video based or automated performance metrics to evaluate surgical skills. 71% of studies have established that AI was superior is diagnosis and outcome prediction [35].

In recent times, the diagnosis and management of urolithiasis had undergone many changes. One major advance to treat renal colic is the application of non-contrasthelical CT. The helical based CT allows urolithiasis diagnosis with ease as it excludes contrast media. The use of effective pain control using narcotics and non-steroidal anti-inflammatory drugs in selected patients could help in identifying the site and stone size and some of the procedures to be followed for an effective treatment of urolithiasis [36].

V. CONCLUSIONS

- The present study clearly indicates that AI based ML has multifaceted importance in clinical decision making through insights from past data is the essence of evidence-based medicine. Traditionally, statistical methods have approached this task by characterizing patterns within data as mathematical equations like linear regression.
- AI provides techniques that uncover complex associations which cannot easily be reduced to an equation and ML simultaneously observes and rapidly processes an almost limitless number of inputs.

- CVD has been the most common killer globally. Data mining in heart disease field, diagnosing heart attacks from various signs and symptoms, risk factors and algorithms data collection from previous treatment will help doctors to gain maximum benefits in treating CVD patients.
- Clinical trials using AI to calculate target zones such asCART and CBR may be more useful as accurate modelsto detect cardiac disease.
- AI could be effectively used in urology by utilizing radiomic imaging or ultrasonic echo data to improve or automate cancer detection or outcome prediction far more quickly than a human being.AI has shown potential in interpreting many different types of image data including neural network designed to predict ADPKD disease outcome.
- A single AI system is able to support a large population and therefore it is ideally suited to situations where human expertise is a scarce resource. At will save time and improve efficiency, and if we follow adequate testing it will also directly guide patient management.
- AI could automatically prepare the most important risks and actions given the patient's clinical record. It could also automatically convert recorded dialogue of the consultation into a summary letter for the clinician to approve or amend.
- AI research should be directed towards selected tasks that broadly align with the trends outlined in this article. Integrating these systems into clinical practice will definitely build a relationship between AI and clinicians in the fields of radiology, neurology, nephrology, Cardiology and hepatology, which will not only reduce the mortality and morbidity but also enhance treatment modalities of these diseases more effectively and efficiently.

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