The Tele Nephrology: A New Frontier for the Realization of a Holistic Care Model for Kidney Disease

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Abstract

Nephrology is ready to transform itself in the digital age, creating a holistic model of care that involves all the complex aspects of kidney disease. The author describes a digital care model that includes all stages of the disease and its comorbidities, connecting the patient to a network that encompasses specialists from hub hospitals, spokes, and family doctors, a care model that can be applied anywhere.

Keywords: • Telenephrology • Kidney disease, Care Model (CM) • Single digital platform • Mobile Health • Electronic Health Record (HER) • Internet of Things (IoT) • Artificial Intelligence (AI)

Introduction

Chronic Kidney Disease (CKD) is a condition not yet sufficiently understood but one that affects about 10% of the world's adults. It increases the morbidity and mortality of those affected and is disproportionately costly to society. In most cases the patient with kidney disease comes to the attention of the nephrologist too late, even today the specialty of nephrology is little known in the population. The increase in hypertension, diabetes, and obesity are likely to contribute to the future increase in kidney failure and heart disease that are prerequisites for replacement therapy. Preventing the progression of chronic renal failure will be the key to containing the high costs of renal replacement therapy. It is estimated that in 2024 many countries will lack doctors also in Europe, a shortage that will also affect nephrology, therefore the gap between the increase in kidney patients and the reduction in the number of nephrologists is progressive; the numbers relating to the shortage of nursing staff are no longer encouraging. It has also been calculated that the possibility of delaying the progression of renal damage for at least five years for 10% of subjects suffering from CKD stage III to stage IV, postponing the referral of patients on dialysis for five years [1], and saving economic resources. Educational programs for patients with stage G5 chronic kidney disease, could delay the start of dialysis, and contribute to the better preparation of vascular access placement and a smoother start of dialysis [2], so educational programs for all stages of the disease should be encouraged.

Digitization could play a very important role in assessing strategies to delay the progression of kidney disease and save money. It is important to work to create a digital health philosophy, below is the author's opinion on what should be this new philosophy.

The digital philosophy should be to give the patient the right care in every moment with a holistic care model

- The patient is always at the centre of the model without a social discrimination.
- The Care Model (CM) must active round the clock and every speciality has to be part of it.
- The service should expand according to the patient's needs.
- Health professional figures must work hard to keep up with technology.
- The CM must be autonomous, transparent and accountable to the patient and the community.
- It must provide research data when needed.
- Patient privacy must always be respected.
- The doctor and all professional figures must be able to work in the best conditions and always be able to provide high-quality care.
- Low income patients must be able to receive free all technical tools to be included in the holistic care model for free.
- All the devices and apps must be certified by the Minister of Health.
- Constant surveillance of the cyber security must be maintained by IT engineers proving maximal data protection.

Materials and Methodology

The project aims to create a network platform, named NephroCM providing a quality remote telenephrology service. It is mandatory that a single platform is created using the same software and a single Electronic health record (HER) shared between different hospitals (Spoke and Hub), Family doctors, and patients. The Government must provide a "Technology-Driven" infrastructure so the internet is made available everywhere, to realize an Interoperability Architecture with patients, family doctors, and Spoke-Hub-Spoke-Spoke interconnectivity [3].

Technical aspects

Some technical requirements are mandatory:

- Internet connection: the patient must have a mobile phone/tablet and PC and if they are experiencing financial hardship, the Government will cover the equipment costs and will alsoprovide all the devices necessary for monitoring and treatment.
- Access to a computer and/or mobile devices with a good and stable Webcam with Audio andmicrophone
- HL7 in its latest FHIR version for exchanging messages between applications;
- FHIR, Web Services.
- Cloud service and Specialist Working in every hospital.
- A Clinical Integration Layer to enable the integration of data and processes resident "in the cloud" or generated and supported with wearable health tools, usable anywhere including the patient's home, connected to the network, in a nutshell with the world of the Internet of Medical Things (IoMT).
- Basic skills in the use of computer/mobile devices and apps for video calling.
- The presence of a caregiver/ family member for assistance if the above skills cannot beensured.
- A Chatbot used to schedule appointments, reminders to take medicines, suggest patient tips to maintain their health, provide crucial medical information, etc.
- It important to include a Teleradiology System on the platform designed to facilitate the distribution, viewing and management of DICOM (Digital Imaging and Communications in Medicine),commonly used to store imagines in a PACS server (Picture archiving and communication system).

The Cloud platform will be provided as a Telehealth model in varying ways, with, minimum services': televisit teleconsultation, telemonitoring, (synchronous and asynchronous, remote monitoring, mobile health), and "non-clinical services" that aim to increase access to healthcare and improve health outcomes they are fundamental for programming and the monitoring of the telemedicine process and they include:

Business glossary serving to standardize the "languages" used by all software applications;

Data collection

Necessary to collect all the information that allows the platform to process data for programming and monitoring, (for example the start and end of the telemonitoring of a specific patient) and interacting with the infrastructure of the electronic health record to collect a subset of clinical data and documents, to be able to evaluate the process outcome.

The management of medicine solutions

It serves to compile the list of telemedicine solutions integrated with the platform, i.e. that meet the functional and interoperability requirements of the project. They also take in Workflow engine: used to check that the events and the related data associated with them have been collected, to verify, with asynchronous modality (i.e. without ever interrupting the treatment process), the presence of all the same information, the correct coding of the data, and the consistency and correct sequencing of the messages, for example, it cannot reach a telemonitoring closing message if the opening message has never been sent [4]. The validations and the errors identified by the workflow engine will then be returned to the healthcare company so that it can intervene to remove the causes that generated them. It needs to underline, also, the importance of the presence of IoT architecture that integrates with the network platform, which is indispensable. IoT architecture consists: of the tangible and integrated components in the environment constituted of the sensors and the actuators, which are the system terminals. They are responsible for continuously monitoring and acquiring various parameters (such as temperature, blood pressure, saturation, sugar, etc.) or carrying out actions based on instructions received. The sensors interface with the network,i.e. the connection structure, which serves the function of connecting. The network permanently transfers data to the cloud, which has the task of collecting and storing it. Within the cloud lies the analytical component, the heart of the IoT structure, and there, finally, the analysis takes the form of decisions, sent to the actuators to be carried out, or results shown in the user interfaces to allow the end user to make decisions. In brief, it is indispensable to the presence of an IoT architecture that integrates with the Network platform; the IoT architecture includes sensors and actuators, i.e. the system terminals, which are responsible for continuously monitoring and acquiring various parameters (such as weight, temperature, blood pressure, saturation, sugar, etc.) or for carrying out actions based on the instructions received (for example rapid weight gain due fluid accumulations).

The network: Differences in the connection between patient, hospital, and family doctor concerning the different stages of disease and comorbidities

It is therefore essential to create a single cloud platform that must have an interface with the electronic medical record system of nephrology but also that of other departments, even in hospitals belonging to the network but also with family doctors. The platform must also be used for the exchange and consultation of documents in pdf, and offer the possibility to consult previous investigations and therapy prescriptions. The network will also support the serious emergencies of nephropathic patients such as stroke, heart ischemia, and trauma. The Care Model has to include: all the stages of CKD, patients in replacement therapy, patients with kidney transplants, and Telenephropathology.

Various certified apps will be available for the patient with differences related to the stage of the disease

An e- learning platform: It is created by the medical and nursing staff (both of the Spoke and the Hub) and with the support of family doctors will guide the patient towards the knowledge of kidney disease, supporting him with advice related to diet, the post-kidney transplant lifestyle, the management of hypertension and diabetes, AVF, etc. The e-learning platform, in addition to helping the patient suffering from chronic pathology in everyday life, will make him a more informed and therefore more aware person, this will also help the specialist in his management; some clinical trials show that the patient educated and informed of his pathology can delay the start of replacement therapy with dialysis for up to six months [2]. Two different paths could be created depending on the severity of the patient, an app will be used for routine cases that allow remote monitoring, with a self-assessment questionnaire related to several parameters and the sending of values such as temperature and pressure, saturation, creatinine device, etc. For more complex cases, the app is connected with amulti-performance kit, including a tablet, a scale, a Bioelectrical Impedance Analysis device, a Bluetooth sphygmomanometer, a small device for recording ECG and Holter monitor, a glucometer, the tensor type, and Blue drop Delta for a patient with associated diabetes. The addition of different devices will be related to the stage of CKD and the associated comorbidities. According to the patient's needs, the administrator's financial office provides him with a kit of devices (tablet, oximeter, multiparameter scale tourniquet, etc.) that enable the detection and monitoring of parameters. If necessary, the automatic alarm system is activated. Separate apps will be created for haemodialysis and peritoneal dialysis patients and another for transplant patients.

The use of this care model in haemodialysis patients refers to its use, not for home haemodialysis but to be used remotely in case of medical and social emergencies on non-dialysis days. Shortly the home haemodialysis program, with the support of the IoT, integrated with AI will be inevitable and devices such as a "fluid storage vest" based on chest bioimpedance for heart congestion detection [4-6] will offer significant help for a digital home haemodialysis model. Today telenephrology can help patients with haemodialysis in daily life via direct contact, through an app, to transmit hemodynamic data, sugar levels, and saturation to its dialysis centre, in case of hypotensive or hypertensive episodes post-session, sudden fever; It is a support system for the surveillance of the AVF(Arterio-Venus Fistula) and central catheters in case, for example, of an AVF block or if excessive catheter bleeding is noticed, so that you can sit down promptly with a vascular surgeon or an interventional radiologist and save the vascular access which is life for the dialysis patient. Digital contact must be possible not only with the nephrologist but also with the cardiologist, the diabetologist, the vascular surgeon, the sonographer, the pharmacy, the psychologist, the nutritionist, the physiotherapist etc [7]. The involvement of multiple disciplines always guarantees rapid intervention and high-quality care. Peritoneal dialysis can be easily supported by telehealth because it is a dialysis method that is already carried out at home and not in the hospital, with this eHealth project when the patient undergoes the procedure, a video-assisted home peritoneal dialysis could therefore be realised, with the Hub and the staff following the procedure live and intervening in case of need or if the patient asks for help. The alert to the Renal Unit of the Hub, when the patient starts the procedure, can be given through the app dedicated to dialysis patients. The same app can help peritoneal dialysis and haemodialysis patients, also covering all other medical and social needs.

Kidney transplant recipients are a particular group of nephrology patients. They must follow a well- timed follow-up with very experienced operators. The use of telenephrology in this particular group of patients can be very useful even if it is very important to select those suitable for a televisit. There are experiences in this regard both in the USA and in Europe and recently under a pandemic also in Italy [5]. Transplant patients must be followed for life to prevent and diagnose many possible problems, in the short and long term: acute rejection, infections, the onset of diabetes, cancer, vasculopathy, and chronic rejection, immunosuppressive therapy monitoring is also essential, ensuring that the patient is constantly adhering to it. According to the guidelines, the follow-up has a standard of several times a week during the initial month, every 2 weeks-6 weeks in 4 months-12 months after the transplant; then every 3 months-6 months thereafter. Also in this case there is a discrepancy between the increasing number of transplant recipients and the decreasing number of nephrologists, moreover, the transplant patient often does not live near the reference transplant centre. For all these reasons, in selected patients, the digitalization associated with the IoT and, in the future ever closer, link to AI, can simplify the life of transplant recipients, maintaining or improving the standard of quality of care. Today, televisit can be used for adult patients and clinically, 10-12 months after transplant, this range shortly or in the event of a pandemic could extend to a younger patient of transplant age. The frequency of televisit could be decided based on the patient's clinical and personal situation, health emergency, distance and ability to reach the Renal Unit. The creation of an App dedicated to transplantation would be very useful from the post-transplant discharge onwards. In addition to being in constant contact with the Transplant centre and sending the basic parameters, the patient could also have more practical information from the app, for example on diet on the first practical exercise, on the therapy, to remind them of their immunosuppressive medication and thus improve adherence etc. Furthermore, the creation of new professional figures such as the ultrasound technician who goes to the patient's home with a small ultrasound system (with a probe connected with a mobile or tablet), connected to the cloud and therefore with the DICOM system of the Hub could even the nephrologist with in real-time data, even with data on the graft, and this service can be extended to all specialities and all types of patients.

Furthermore, the newly certified devices that measure creatinine would add another piece to the fundamental information bank for the remote nephrologist. A recent example was in Italy during the Covid 2020 pandemic: transplant surgeons and nephrologists, from the six major Italian transplant centres, gathered in a scientific webinar to address the post-operative monitoring of kidney transplants in the situation of work overload and health crisis generated by the COVID pandemic, Televisit have been consensually recognized and with the most relevant for the follow-up of kidney transplant recipients, many advantages. [5]. In this NephroCM network, there are many potential benefits for the patients, we have to consider also the benefit of avowing the use of transportation, often they live far from the nephrology unit of reference, with the risk of a car crash, extra cost and time and with the production of CO_2, energy saving is another important benefit of digitalization in every sector that should not be underestimated. Another possible application of this digital platform project

is the TeleNephropathology: Histopathology is another important area of nephrology and there is the possibility of performing all the pathology tasks remotely, thanks to digital technology. The digital application in telepathology is possible for micro and macroscopy but not for cytology. The benefits of telenephropathology are the same as the general benefits that we see with telepathology [8]. A reduced risk of slide loss and damage, diagnostic efficiency, improved collaboration, easier measurement of the slide, enhanced access to a second opinion, the synchronous review of slides and the review of archived material. There are also benefits for the patient: A faster time to receive the diagnosis, improved access to a second opinion, and improved patient safety. The required instruments are A storage system, one or more scanners to transfer the glass slides to digital slides, the network has to be connected to storage, a workstation with reliable access to the same software.

A complex system

It is important to underline that a successful digital project needs a complex structure both from an IT and organizational point of view, which involves many actors but which always has the patient as the main protagonist with their need to receive the best quality of care at the right time a priority. Electronic health records can include a series of data, including demographic data, medical history, medications, allergies, immunization status, laboratory reports, radiological images, vital signs, personal statistics such as age and weight, and research data may also be extrapolated, if useful. Everyone involved in the network will receive a period of training and updates from the IT staff, including patients and caregivers or family members. It is also mandatory and vital to establish a Scientific Technical Coordination Committee (STCC), led by a Director of the Ministry of Health This Committee should be divided into working groups, for example, a working group for IT aspects, a working group for regulatory aspects and the study of outcomes etc. These working groups must draft the technical document of the Chronic Care Model and Network Project. The ST Committee will have to define the clinical-organizational and technological requirements that the project structures must possess so that they can be proposed to the Ministry of Health, as it identifies the characteristics and requirements of the organizational structures of kidney transplant recipients and many advantages that will carry out the various roles including operational protocols, training etc. This commission must renew its members every two years to avoid conflicts of interest.

The care model staff

It should have a Telenephrology Coordinator Nurse with extensive experience working with a patient with chronic kidney disease, and therefore, able to screen patients to determine their suitability for telenephrology consultation, based on if they have CKD Stage III or chronic kidney disease with eGFR <45, haematuria and or proteinuria. Patients who have never met a nephrologist are excluded from televisits, unless there are health emergencies that make hospital access risky [6].

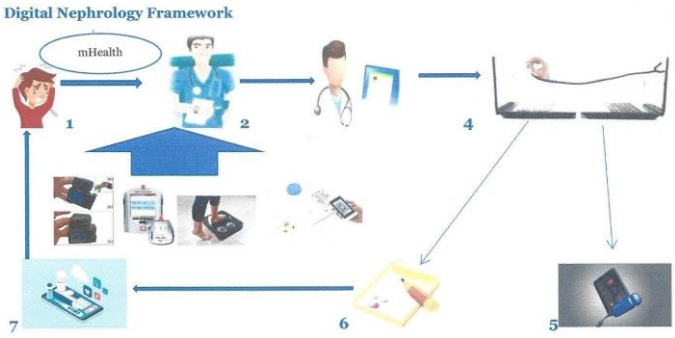

Figure 1. Digital Nephrology Framework

Figure 1, can be elaborated further:

1. The patient requests a televisit through the app.
2. The specialist nurse submits patient data to the scheduler and
3. A remote-based doctor gets the patient data and history so they decide on the patient's suitability for televisits or if they must revert to face-to-face examinations.
4. Patient and doctor are connected in real-time through audio/video and the nurse can use a digital stethoscope with app and transfer the dates by PC to the doctor.
5. An Xray or ultrasound, or another diagnostic test can be transmitted via the DICOM to the teleradiology platform.
6. A digital therapy prescription with a digital signature is then sent to the digital pharmacy that delivers the therapy to the patient's home by carrier or drone

The patient is not suitable : An urgent appointment is scheduled at the Hospital at the Spoke or Hub depending on the clinical case. At the beginning of each televisit, the patient must sign the consent format and at the end of each televisit, the patient will have to fill in a questionnaire to evaluate the quality of the televisit in all its aspects. The doctor has three hours to close the televisit file and complete the digital signature.The remote report must be sent to the electronic health record and, if requested, also directly to the patient, through a suitable authentication system of the platform that also intervenes at the health level when necessary. Televisits and teleconsultations are prescribed by the doctors who are in charge of the patient and the evaluation of adequate safety conditions is always their responsibility. Televisits and teleconsultations can be performed at any time and the duration of the individual service depends on the specific case. The televisit is always in real-time, while teleconsultations can also be deferred, based on the greater usefulness for the patient and the operator. When teleconsultation takes place with the connected patient, it assumes the modalities of a televised performance. For the service provider, the patient's informed consent is required [9]. The healthcare professional who provides the service is responsible for assessing the achievement of the defined objectives, and rescheduling the service as an in-person one if these have not been achieved, for technical or clinical-related reasons. The healthcare organization and not the medical staff is instead responsible for the proper provision of hardware, software, and telecommunication resources for the correct technical performance of the service. It is also important to consider special categories of patients:

- The disabled: They must allow the support of any type of caregiver while he continues to look after the disabled person; For hearing impairments, written communication systems overlapping the video image and screen sharing are required; for total or partial blindness, systems are needed that facilitate assistance by the caregiver with the possibility of using other possible technological aids [10].
- For seniors, access to the video call for televisits can be used independently taking into account possible physical limitations and age;
- For children, the televisit must be usable by those exercising parental authority.

Discussion & Conclusion

The telenephrology is an opportunity could potentially be applied anywhere, with variations with difference, according to geographical areas. There are many points to be addressed, for example, data security in general and the responsibility of clinical data entered by other centers and colleagues on which to rely for subsequent investigations and the formulation of new diagnoses. There is no clear legislation on the matter, therefore, in the case of errors, who is responsible? This and also many other complex aspects, determine that many doctors see digitalization not as an important support to their work, but as an additional problem, considering it a drain on energy in tackling the problem of the lack of doctors and nurses. Digitization instead, should be considered as a tool for technologically centralized assistance, one that is more precise and personalized and which over time will also reduce economic costs. The nephrological population can benefit from digitization more than any other category of chronic disease sufferers, and the improvement of the quality of follow-ups over time; digitalization may realize 4P medicine (predictive, precise, preventive, and personalized) resulting in a more attainable goal within chronic kidney disease patient care.

Conflict of Interest

No conflict of interest or financial sources were declared

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