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TELEMEDICINE APPLIED TO THE FOLLOW UP OF PATIENTS WITH END STAGE RENAL FAILURE

La télémédecine appliquée au parcours de soins des patients insuffisants rénaux chroniques

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Résumé

Au 21ème siècle, l'insuffisance rénale est une maladie chronique qui touche plusieurs millions de personnes en France et environ 600 millions dans le monde. Sa prévalence dans la population générale augmente avec l'allongement de l'espérance de vie qui marque les pays développés et qui commence à apparaître dans les pays en voie de développement. L'hémodialyse chronique est un traitement qui a sauvé au 20ème siècle de nombreux enfants ou jeunes adultes dont les reins étaient détruits par plusieurs agents infectieux, toxiques et par des accès d'hypertension maligne dus à des hypertensions non traitées. Ces causes ont été maitrisées grâce aux mesures d'hygiène, les agents pharmacologiques anti-infectieux ou protecteurs du système cardio-vasculaire. Les causes de l'insuffisance rénale terminale sont aujourd'hui dominées par les maladies dégénératives du vieillissement que sont le diabète et la maladie vasculaire chronique. La prévention de l'aggravation d'une insuffisance rénale chronique est aujourd'hui possible grâce à un meilleur contrôle de l'hypertension artérielle et du diabète qui sont les deux principales causes de la destruction des reins. Le traitement par hémodialyse ne peut pas être toujours relayé par la transplantation rénale. De nombreux patients restent en hémodialyse chronique jusqu'à leur décès. Il importe d'adapter les conditions du traitement à la vie sociale des patients touchés par cette maladie chronique afin que celles-ci soient les meilleures possible. C'est l'objectif de la télémédecine qui permet de surveiller à distance

Abstract

In the 21st century, renal failure is a chronic disease that affects several millions people in France and around 600 millions worldwide. Its prevalence in the general population increases with the lengthening of the life expectancy that characterizes the developed countries and which begins to appear in the developing countries. Chronic hemodialysis is a treatment that saved many children and young adults in the 20th century whose kidneys were destroyed by several infectious and toxic agents and by untreated malignant hypertension. These causes have been controlled by hygiene measures, anti-infective agents or protective pharmacological agents of the cardiovascular system. Today the causes of end stage renal failure are dominated by degenerative diseases due to aging, such as diabetes and chronic vascular disease. The prevention of the worsening of chronic renal failure is now possible due to better control of high blood pressure and diabetes which are the two main causes of kidney destruction. Hemodialysis treatment cannot always be relayed by renal transplantation. Many patients remain on chronic hemodialysis until they die. It is important to adapt the conditions of treatment to the social life of patients affected by this chronic disease so that these are the best possible. This is the goal of telemedicine that allows to remotely monitor the main clinical and biological factors associated with the worsening of the disease. Teledialysis (hemodialysis and peritoneal dialysis) allows to perform dialysis sessions at home or at the nearest in home substitutes (nursing home) or in satellite units of

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les principaux facteurs cliniques et biologiques qui sont associés à l'aggravation de la maladie. La télédialyse (hémodialyse et dialyse péritonéale) permet de réaliser les séances de dialyse au domicile ou au plus proche dans des substituts du domicile (Ehpad) ou dans des structures de soins hors centre (UDM, UAD). De même, lorsque le patient est transplanté, on peut soit alléger ou intensifier la surveillance en fonction du risque d'aggravation grâce à la téléconsultation à domicile.
Les outils de l'ère numérique que sont la télémédecine, la santé connectée avec les objets connectés et applis mobiles à finalité médicale, dont la performance augmente avec les algorithmes autoapprenants de l'intelligence artificielle, loin de déshumaniser la relation du patient avec son médecin, permettent au contraire de la renforcer à la condition qu'une réflexion éthique accompagne toutes ces innovations. L'exercice de la profession médicale va en être considérablement enrichi grâce à du temps médical davantage consacré à la relation avec le patient. Les nouvelles organisations de soins rendues possibles grâce à ces technologies numériques doivent être enseignées aux nouvelles générations de néphrologues.

Mots clés : insuffisance rénale chronique, dialyse chronique, télé dialyse, greffe rénale, télémédecine, téléconsultation, télésurveillance.

hemodialysis. Similarly, when the patient is transplanted, it makes possible to either lighten or intensify the surveillance according to the risk or not of graft rejection through home teleconsultation.
The tools of the digital era such as telemedicine, health connected with connected objects and mobile apps for medical purposes, the performance of which is increasing with the algorithms of artificial intelligence (machine learning, deep learning), can improve the relationship between the patient and his doctor. An ethical reflection must be associated with all these innovations. New exercise of the medicine will be greatly enriched due to medical time more devoted to the relationship with the patient. The new care organizations made possible by digital technologies must be taught to the new generations of nephrologists.

Keywords : chronic renal failure, chronic dialysis, telediálysis, kidney graft, telemedicine, teleconsultation, remote monitoring.

A LITTLE HISTORY...

The telemedicine term, a remote medical practice, first appeared in 1920 in the license granted by the US authorities to a New York radio station that provided remote medical service to passengers on transatlantic ships. Telemedicine was then used whenever the need for medical advice could not be met by a face-to-face consultation of the patient, especially among workers who worked on oil rigs, astronauts staying on the international station, Inuit living in north Canada, Indians living in the Amazon rainforest, etc. If the medical need was obvious, the communication technology (telex, telephone) was clearly insufficient before the digital era. It is from the beginning of the 90's that the telemedicine took a real growth. France and Norway were the pioneering countries in Europe. From the beginning of the 2000s, public access to the Internet launched the concept of connected health or e-health and the arrival of smartphones in 2007, that of mobile health [1].

Nephrologists were the first specialists to develop home dialysis treatment in patients with end-stage renal disease. The first dialysis patient at home was in the late 1960s. At that time, dialysis patients were younger with an average age, at when started dialysis, under 50 years old. It was possible to educate them to become fully autonomous in the conduct of their home treatment. The latest data from the R.E.I.N. (Epidemiological Network and Information in Nephrology) of 2015 reveal that the average age of onset of dialysis in France is now 71 years [2]. Patient autonomy in dialysis treatment has become more rare and home dialysis education is more difficult to achieve because of cognitive impairment associated with aging. Today, more than 80% of dialysis patients are treated in centers or in medicalized dialysis units (MDUs) ; the proportion patient out of centers (self-dialysis unit or DSUs or home hemodialysis or peritoneal dialysis) has become weak [2].

We are in the 21st century in the era of chronic diseases, the majority of which is related to aging. Their prevalence increases with the increase in life expectancy. Epidemiological studies, about the elderly population, reveal that a 85-year-old person has an average of 8 chronic diseases, including chronic renal failure [3].

Can telemedicine promote a coordinated care pathway for patients with chronic renal failure? We will try to answer this question which is debated in the nephrological environment.

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TELEMEDICINE, A MEANS OF REMOTELY MONITORING PATIENTS WITH CHRONIC DISEASES.

The professional practices of telemedicine [1] are defined in the French Public Health Code in Article R.6316-1: medical telemonitoring which is intended to allow a medical professional to remotely interpret the data necessary for medical follow-up of a patient and if necessary, to make decisions relating to the care of this patient. The recording and transmission of the data can be automated or performed by the patient himself or a non-medical health professional ; the teleconsultation which is intended to allow a medical professional to give a remote consultation to a patient, a health professional being present or not with the patient and, where appropriate, assist the medical professional ; and the tele-expertise which is intended to enable a medical professional to solicit from a distance the opinion of one or more medical professionals because of their training or special skills, based on medical information related to the care of a patient.

Medical telemonitoring of sick people at home is a practice that is disrupting traditional care. It aims to prevent hospital emergency visits and hospitalizations. This is the most promising form of telemedicine recalls the Court of Auditors in its report 2017 (4).

Medical telemonitoring of chronic diseases is one of the 5 priorities of the national telemedicine program launched in June 2011 by the public authorities. Today, these innovative solutions of care are the subject of the experimental program ETAPES (Experiments of Telemedicine for the Improvement of the Paths in Health) within the framework authorized by the law of financing of Social Security (LFSS) 2018 up to LFSS 2022. This program involves five chronic diseases: severe chronic heart failure, chronic renal failure with hemodialysis or transplantation [5], chronic respiratory insufficiency with respiratory support, uncontrolled insulin-dependent diabetes and cardiac rhythm disorders treated with implanted medical devices. The evaluation will be made by the High Authority for Health (HAS) in 2021 and presented to the French Parliament at the time of the discussion of the LFSS 2022 [6]. The latter will decide on the continuation of financing in the common social security law of the remote surveillance practice, as it did for teleconsultation and telexpertise practices in the LFSS 2018.

MEDICAL TELESURVEILLANCE OF THE COURSE OF CARE OF PATIENTS WITH CHRONIC RENAL INSUFICIENCY.

In patients with advanced chronic renal failure.

The review of the literature published in 2013 [7] showed that collaboration between primary care physicians and nephrologists could bring benefits to patients with chronic renal failure (CKD) by slowing the progression of their disease. This review shows that care coordination and multidisciplinary cooperation, including primary care physicians, other medical specialties and non-medical health professionals, significantly improves morbidity and mortality in patients with renal impairment (CRF) and delays evolution towards the terminal stage of the disease (IRCT). The authors show that telemedicine applied to nephrology (telenephrology) can promote or even improve this multidisciplinary collaboration through the use of videotransmission teleconsultating, telexpertise between different medical disciplines and home medical telemonitoring of patients with advanced CKD; and thus slow the evolution towards the IRCT phase. Some studies show the interest of web-based nephrological telexpertise to increase the adherence of patients and treating physicians to a closer collaboration with the nephrologist. One of the immediate results of this web-based telexpertise is a decrease in the number of canceled appointments with the nephrologist due to distance. The coordinated care path of CKD patients was improved [8].

North Australia has been a pioneer in the development of telenephrology, with early publications dating back to the early 1990s [9]. In 1997, a study analyzed the clinical impact of a telemedicine network linking the nephrology department at Queen Elizabeth Hospital in Adelaide to three satellite nephrology-dialysis centers in South Australia [10]. In two and a half years of practice, there were more than 6,000 teleconsultations with these remote centers to assist them. The evaluation of this organization was carried out through interviews with 18 members of the medical, nursing and paramedical staff working in these satellite centers. All the medical staff (surgeons, nephrologists, nurses and paramedics) had successfully used teleconsultation. This was the first Australian study to demonstrate that telenephrology enabled health care providers to remotely deliver a wide range of specialized clinical care, from scheduled nephrology teleconsultations for outpatients to diagnosis of dialysis infections and possible decision of a surgical decision.

Another Australian team of pediatric nephrologists in

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Queensland conducted a retrospective study of their experience with pediatric telenephrology [11]. Over a period of 10 years (2004-2013), these pediatric nephrologists performed 318 pediatric teleconsultations for 168 young patients (56.5% of boys) with a median age of 8 years (from 3 weeks to 24 years). The reason for the teleconsultation was a pediatric nephrology-specific situation, such as congenital kidney and genitourinary abnormalities, nephrotic syndrome in children, kidney transplant follow-up, or treatment of pathway infections. urinary tract in the presence of a malformation of the urinary tract (reflux). Tele-nephrology has improved access to pediatric nephrology services for these children and their families. It has also made it possible to train regional medical teams remotely in pediatric nephrology. Approximately $ 31,837 was saved by tele-nephrology in 2013, representing savings of approximately $ 505 per teleconsultation.

In the United States, the health care system is more fragmented than in Australia, between private and public insurance, which distinguishes it from most nationalized health care systems in other developed countries [9]. The private health insurance system specifies which health care services are reimbursed and treatment decisions are influenced by the policy coverage of health insurance. The regulatory environment is more important in the United States than in Europe and is an important obstructive factor in the development of tele-nephrology. Licensing to practice telemedicine is regulated at the level of the state where the doctor resides, without extension to other states. Computerized medical records are individual and do not interfere with other records of a neighboring state. Strict rules of confidentiality limit the exchange of information about patients. Thus, few studies on teleconsultation and nephrology tele-expertise were conducted in the United States. Only the Veterans Health Administration (VHA) has a single payer system funded by the government and uses a single computerized medical record at the national level. The VHA manages 8.9 million veterans each year, 36% of whom live in rural areas. Due to the demographics of veterans and the centralized administrative infrastructure, VHA has been a pioneer in the United States in the use of telemedicine, including teleconsultation. In 2012, Veterans Affairs funded a Nephrology Special Needs Access Program in the Seattle area as part of the ECHO (Expanding Results to Community Health Care) program. It also included a curriculum for health professionals on 16 basic nephrological topics [12].

The adoption of tele-nephrology in the United States is thus limited by several factors. First, the limited reimbursement of telemedicine practices by Medicare and private insurance. The reason given by insurers is that no randomized controlled trial has so far shown improved clinical outcomes and / or reduced costs. Third-party payers fear that the overuse of digital services will increase costs without producing better clinical results. A randomized controlled trial that demonstrates equivalent, lower-cost clinical outcomes (fewer hospitalizations and emergency department visits) would provide funding for tele-nephrology by public and private insurers. In a selected population that has limited access to nephrology care, tele-nephrology is able to provide quality specialized care through the positive impact on the respect of clinical visits to nephrologists. This was demonstrated by the Bronx VAMC-Hudson Valley telemedicine program with a significant reduction in specialized follow-up cancellations, the main cause being the remoteness of the nephrology center [13].

Finally, few studies have been conducted to demonstrate the benefit of tele-nephrology, particularly for telemonitoring patients who have advanced chronic renal failure, while many studies exist in patients with diabetes, chronic heart failure or those with chronic heart failure. with obstructive respiratory diseases [1]. In France, the absence of an economic model before 2018 partly explains the lack of commitment of the nephrological medical community in the field of tele-nephrology, despite some early attempts to abort [1,14]. However, like the United States, France has just initiated several remote monitoring programs for patients with chronic renal failure who are advanced or treated by dialysis and transplantation, the results of which will not be known until 2022 [5,15].].

In patients treated with dialysis

Hemodialysis by telemedicine

Medical telemonitoring of patients with chronic end stage renal disease treated with chronic hemodialysis was one of the first applications of telemedicine to remote surveillance of chronic diseases. Initiated in the early 2000s, almost simultaneously in Canada (New Brunswick region), Norway (Nord-Halo Galand region), France (Brittany region) [16] and South Australia [9], tele-dialysis demonstrated a medical service offeredo patients [17]. In these frontier regions, the main reason for the development of dialysis was to

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prevent patients the long, tiring journeys they had to perform two to three times a week in order to benefit from treatment sessions in an outpatient health facility. .

In January 2010, the concept of dialysis was adopted in France in a report of the HAS (sigle for High Authority of Health) , entitled «the conditions of implementation of telemedicine in medicalized dialysis units». The definition was as follows: tele-dialysis consists in implementing a communicating system between a main center where the team of nephrologists is located and a satellite or UDM unit where the patients and the health care team are located [18]. For the HAS, the dialysis system is composed of several bricks: visualization and storage of the parameters generated by the hemodialysis monitors and intended for remote medical monitoring; videoconferencing for end-of-session nephrology teleconsultation, tele-assistance of nurses during the session and the possible tele-expertise of another specialty; the support applications needed to perform remote medical procedures [19].

In the remainder of this report, the telemedicine decree of 19 October 2010 was incorporated into the decrees n ° 2002-1197 and 2002-1198 of 23 September 2002 relating to the activity of treatment of the chronic renal insufficiency by the practice of the Extra-renal purification and the technical conditions of implementation. This new decree n ° 2012-202 of February 10, 2012 [20] modified the technical operating conditions of health establishments that exercise the activity of treatment of chronic renal insufficiency by the practice of extrarenal treatment by allowing nephrologists and public and private health facilities to develop dialysis under legal and regulatory conditions. However, the lack of funding of these new professional practices by the Compulsory Health Insurance has delayed their implementation. It will be necessary to wait for the ministerial decree of December 6, 2016 which defines the conditions of implementation of the remote medical monitoring of the hemodialysis patients and its derogatory method of financing during the experimentation, to revive with the nephrologists this alternative solution to the hemodialysis in outpatient center. This derogatory financing will end in 2021.

Peritoneal dialysis by telemedicine

The first application of telemedicine in automated peritoneal dialysis (APD) at home was published by a Japanese team in 2000 [21]. The system used consisted of two parts: a data collection and transport system, and an oral and visual exchange system between the patient and the health care team. The first system was integrated within the APD cycler, complete with an automated blood pressure recorder and a connected scale. The system of dialogue between the patient and the nursing staff of the CAPD center was the combination of a digital camera, a television and a decoder. The APD system contained recording and data transport sequences, an alarm device, and a graphical function for representing the data. All data collected by the APD system was sent directly in real time to the nephrologist's office. Patients could easily use the videoconferencing system to contact the medical staff of the PD Center at Saitama Medical School and inquire about their clinical condition. In addition, caregivers could directly modify the APD program (dose and duration) remotely. Seven patients, some over the age of 90 or disabled, had been using this telemedicine system for 1 to 6 months (mean: 3 months) at the time of publication [21]. The preliminary conclusions of this first experiment of peritoneal tele-dialysis were that the elderly and disabled patients who benefited from this system could be kept on PD at home, without major problems and without accidents, the quality of life of these patients being significantly improved. This same Japanese team published again in 2007 and confirmed the benefit of telemedicine to monitor patients on PD at home thanks to the evolution of technologies used [22].

In 2007, a Spanish team published its results at 2 years | 23]. From this controlled study (25 patients under telemedicine versus 32 patients without telemedicine), conducted from September 2003 to August 2005, the telemedicine group benefited from teleconsultations (n = 172) with an average duration of 22 +/- 9 min versus 33 +/- 8 min for usual hospital consultations (p <0.01), that medical treatment was modified after 148 teleconsultations and that, in only 4 cases, a visit to the hospital had been necessary, finally, that in all patients the exit site of the dialysis catheter could be examined during the videotransmission teleconsultation. The estimated cost of a follow-up by telemedicine was 198 euros / patient while the cost of the visit to the hospital was 177 euros / patient. The mean duration of hospitalizations in the telemedicine group was only 2.2 days / year / patient versus 5.7 days / year / patient in the group without telemedicine (p <0.05). The authors concluded that telemedicine in home-based PD patients was clinically useful in the long-term follow-up of stable patients, and that the savings generated were significant and encouraging to continue this organization with telemedicine.

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In France, the Diatélic system for telemonitoring patients on home peritoneal dialysis was tested from 1999 to 2002 at the ALTIR (Lorraine Association for the treatment of renal failure), with the assistance of the LORIA IT team. (Lorraine research laboratory and its applications). It was then developed in some French centers. The principle is based on an expert system. Such a system is a set of software capable of modeling logical reasoning from known facts and rules. From these and using an inference engine, the software establishes a response adapted to the question asked. Diatélic's expert system is based on a «Bayesian and Markovian» analysis of the patient's hydration status by referring to different criteria [24]. Bayesian analysis aims to establish a diagnosis of the hydration status of the patient. Then Markovian analysis will model the evolution of this state based on past and present. The expert system is based on two interpretations, a static and a dynamic. The data is sent by the patient via a secure connection to the Diatélic server, analyzed by him and transmitted to the doctor responsible for the patient if abnormalities arise. The doctor can thus after receiving the message transmit his recommendations to the patient or the attending physician. The evaluation criteria of the Diatélic experiment relate to the morbidity rate, the quality of treatment, the number of unplanned transports and the lower cost of the treatment. LORIA has estimated the cost of Diatélic for 150 patients at 2140 euros per year / patient. By comparison, a day of hospitalization was evaluated in 2001 to 1100 euros, an outpatient peritoneal dialysis session at 305 euros (about 50 000 euros / year) and the cost of peritonitis avoided at 11030 euros. For the promoters of this system, the economic model of the care pathway for chronic end-stage renal failure necessarily includes peritoneal dialysis as a first step in locum treatment [25]. The development of the Diatelic system in peritoneal dialysis involved only a few centers that had a sufficient population of patients treated with peritoneal dialysis. This system is now integrated into the eNephro study of the coordinated care pathway for patients with CKD and Chronic Renal Insufficiency treated by dialysis or renal transplantation, a real digital care pathway for chronic renal failure at its various stages [15].

In kidney transplanted patients

Renal transplantation is an alternative to chronic dialysis, which allows a longer life expectancy at a cost that is 3 to 4 times lower than chronic hemodialysis after the first year of transplantation [26]. It is now possible, thanks to a score built with 8 clinical and biological criteria, to recognize, from the first year of transplant, patients who have a risk of losing their graft within 8 years after transplantation. When the score is greater than 4.17, 93% of patients still have their graft at 8 years, whereas for a lower score, only 70% of patients retained their graft at the end of the 8th year of grafting [27]. It then becomes possible to set up a strategy for monitoring transplant patients, adapted to the risk of graft loss.

The load of consultations in university kidney transplant centers has become increasingly burdensome with the steady progress of the active patient file. Some transplantation centers are turning to telemedicine and connected health solutions to lighten this surveillance in low-risk patients or, on the contrary, to intensify it in patients at high risk of graft loss. The algorithmic telemonitoring system for dialysis patients is now applied to the follow-up of renal transplant patients in the Lorraine region. The Transplantelic study has been in place for several years and gives encouraging results [28] which should be confirmed by the eNephro study conducted by the same team [15].

Three university renal transplant centers (Nantes, Paris, Lyon) launched in 2015 [29] the controlled and randomized study Telegraft which aims to verify whether the use of teleconsultations in the home is useful, on the one hand to lighten the surveillance in patients at low risk of rejection, on the other hand to intensify it in patients at high risk of graft loss. A remarkable thesis carried out in this study shows that renal transplant patients prefer teleconsultation follow-up at home rather than going to the transplant center [30].

PERSPECTIVES

In the 21st century, medicine becomes more personalized and adapted to the evolution of chronic diseases, more preventive of complications, and even predictive of their occurrence. It is less hospitable and aims to improve the social life of sick people by keeping them in the environment of their daily lives. The tools of the digital age are telemedicine, connected health with connected objects and mobile apps for medical purposes, whose performance increases with artificial intelligence self-learning algorithms, far from dehumanizing the patient's relationship with his doctor , on the contrary, allow it to be strengthened on the condition that ethical reflection accompanies all these innovations. The practice of the medical profession will be considerably enriched by medical

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time devoted more to the relationship with the patient.

This is also the case for the profession of nephrologist. This community has long hesitated to launch telemedicine while other specialties have adopted it for several years and demonstrate the benefits for both patients and the organization of professional exercise [1]. Telemedicine will help redevelop nephrology home care for which nephrologists were pioneers almost half a century ago. This is particularly the case for daily home hemodialysis (HDQ). Telemedicine must be taught to new generations of nephrologists. Patients with renal failure, like those with other chronic diseases, can benefit from all these technological innovations in health provided that economic models evolve and that ethical reflection is present. This is the case today in France where the Health Insurance has decided to reimburse from September 2018 the practices of telemedicine in the common law of the Social Security and the will to integrate the ethical reflection on the digital innovations in the new bioethics law. Telemedicine, in the 21st century, becomes a normal practice of medicine.

CONFLICTS OF INTEREST

the author declare that they have no conflict of interest in this article.

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