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NEPHROLOGY - REVIEW

Informatic nephrology

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Abstract Biomedical informatics in Health (BIH) is the discipline in charge of capturing, handling and using information in health and biomedicine in order to improve the processes involved with assistance and management. Informatic nephrology has appeared as a product of the combination between conventional nephrology with BIH and its development has been considerable in the assistance as well as in the academic field. Regarding the former, there is increasing evidence that informatics technology can make nephrological assistance be better in quality (effective, accessible, safe and satisfying), improve patient's adherence, optimize patient's and practitioner's time, improve physical space and achieve health cost reduction. Among its main elements, we find electronic medical and personal health records, clinical decision support system, tele-nephrology, and recording and monitoring devices. Additionally, regarding the academic field, informatics and Internet contribute to education and research in the nephrological field. In conclusion, *informatics nephrology* represents a new field which will influence the future of nephrology.

Keywords Nephrology · Informatics · Informatics nephrology

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Introduction

Biomedical informatics in Health (BIH) is the discipline in charge of capturing, handling and using information in health and biomedicine, with the objective of obtaining and applying the information in the medical context, improving the communication processes among all the people involved in health activities. There are health institutions in different countries which have department areas, residency programs and virtual courses related to this new discipline and even an international society known as International Medical Informatics Association (IMIA) [1]. There are several disciplines included in BIH, the main ones are informatics sciences, computing, medicine (medical practice and management) and those related to the processing of information (epidemiology, biostatistics and theory of decision). The interaction of BIH with various medical subspecialties has developed new branches which we are going to mention in this article.

Informatics nephrology

Informatics nephrology has appeared lately as a product of the combination between conventional

nephrology with BIH, and its development has been considerable in the medical practice as well as in the academic field. Regarding the former, there is increasing evidence that informatics technology can make nephrological assistance better in quality (effective, accessible, safe and satisfying), improve patient's adherence, optimize patient's and practitioner's time, improve physical space and achieve health cost reduction. As a consequence of these facts, there has been increasing interest worldwide with increasing demand for health assistance based on informatics technology as well as for professionals trained for its application.

Among the main elements of *informatics nephrology,* we find those related to the medical practice such as electronic medical record, personal health records, clinical decision support system, tele-nephrology, recording and monitoring devices; and those related to the academic field: nephrological education and research [2].

Nephrological assistance

Electronic medical record (EMR)

This type of medical electronic record allows for the integration of all the patient's information which can be accessed simultaneously by all the health team who assist patients (ambulatory, emergency and admission) thus avoiding the typical fragmentation of the records on paper, also providing more legibility, privacy, confidentiality (access passwords), security (electronic signature, security copy of the clinical information in a repository) and being easy to store. Another important aspect is that EMR comes from a source of information which can also be used for administrative processes, evaluating medical performance, scientific activity, prescription handling (tests orders, cross-consultations, treatment indications) and Public Health reports, all which are based on the ability to reorganize the data around the information desired. In the same way, the ability of the system to understand others who "speak another informatic language" (syntactic and semantic interoperability) allows for the correct exchange of information between the EMR and the data of the ancillary system like imaging and laboratory departments, thus making it possible to include important complementary data in the patient's EMR such as tests and CT scan results, etc. The aforementioned interoperability also allows for the electronic records of different hospitals to connect and share information obtaining a more integrated health system [1, 3]. Since there is a group of specific data obtained from the patient that is relevant for some specialists and not for others (for instance, *Kt/V* value, renal ultrasound report for nephrologists), it is frequently observed that each specialist has his/her own patient's record. This situation leads to the existence of parallel records which scatters the patient's data instead of the ideal objective of integrating them. The EMR, which offers the possibility of reorganizing the stored data around a desired record, can deliver particular information to each specialist taken from the general patient data repository (for instance: a structured nephrological chart incorporated to the general electronic one).

Personal health records (PHR)

This is a home electronic application which patients can access, administrate and share their renal and health information in general, with others who they authorized and in a safe, private and confidential environment. The information consists of data which comes from the patient's EMR, data entered by the patients themselves and/or sources external to the EMR such as: pharmacies, diagnostic centers, etc. The idea is that independently of where the patient is assisted, he/she can provide doctors with all the information available regarding their condition, so the personal health record works as a support for medical decision making and is part of the strategies of patient empowering in the assistance act [2, 3].

A chronic renal disease patient, as any kind of chronic patient, has to attend many times to different sort of medical consults (for instance, dialysis patients have to see many doctors for their controls: cardiologist, endocrinologist, nutritionist, cardiovascular surgeon, pre-transplant evaluation, etc.). In this sense, PHR which allows patients to get the results of their complementary studies, contact their nephrologists, and even deliver their personal data (peritoneal dialysis fluid picture, etc.) to them, makes their evaluation process simpler, preserving its medical quality and increasing patient's quality of life.

Clinical decision support system (CDSS)

These are programs additional to the EMR which help with the medical tasks to reduce errors. Due to their

characteristics the CDSS, they are very useful for chronic renal disease–handling programs.

These informatics tools come in many forms

(a) *Reminders*: they are instructions shown in the EMR which help reminding doctors to perform certain actions, for instance: to check serum liver enzymes in a patient on simvastatin.
(b) *Alarms*: they are signs which warn physicians against certain clinical circumstances, for instance patient's allergies.
(c) *Decision tools*: they are validated recommendations (diagnostic/therapeutic algorithms, heuristic rules and clinical practice guidelines, etc.) which help doctors in their decision-making process.
(d) *Infobuttons*: they are accessing icons in the EMR which allow practitioners to reach medical information sources useful for their medical decisions, in the place and at the time of the medical act. For instance, This tool brings the possibility for the nephrologist to access an updated lupus nephritis review when he/she has to start treating a patient who suffers from this disease [1, 3]. From some information stored in the patient data repository, such as serum creatinine, the informatics system can detect a reduced glomerular filtration rate in a patient and consequently suggest a dose adjustment for prescribing a particular drug, for instance acyclovir in a dialysis patient.

Recording and monitoring devices

New hemodialysis machines and peritoneal dialysis cyclers have the possibility of being technologically fitted with devices that allow the continuous monitoring of certain parameters of the patient (venous and arterial pressure, etc.) so as to achieve a better care of the person during the dialytic session. This higher capacity of measuring and registering useful variables for the monitoring of the evolution of the patient makes it easier to reach a higher quality of nephrological attention and even integrating these data into the health information system [4, 5]. For instance: All the information delivered by the dialytic devices (artificial kidneys, etc.) used for treating patients can be automatically sent to the clinical electronic record in order to increase the patient's database.

Tele-nephrology

It is the remote nephrological assistance of the patient using methods such as the phone, e-mail and/or videoconference. There are some studies that have demonstrated that this modality improves the communication among patients, physicians (nephrologist, surgeon, etc.) and allied health staff (dietician, social worker, etc.), quality of patient's care, satisfaction, education, and time saving (for both, the health team and the patient) and resources (clear reduction in sanitary transport and use of space). The videoconference session allows the patient to have a "face-to-face" doctor–patient relationship, despite being a virtual consult. It can also be used to send the patient's information to his nephrologists, which can be carried out via a sound channel—doctor–patient dialog—and/or visual: photographs of the vascular access, peripheral edemas, appearance of drained peritoneal bag and/or medication prescribed by other specialists which requires evaluation of its doses adjustment [6–9].

There are many forms of tele-nephrology, which even can be applied in a combined way:

(a) *Tele-consult*: This modality can be synchronic, the response to the consult takes place immediately (videoconference or chat), or asynchronic: the response to the consults is deferred (e-mails or phone messages). The idea is not to replace the traditional consult but to reduce them in number [10–12].
(b) *Tele-dialysis*: It uses informatics for handling patients under hemodialysis treated in satellite units (virtual dialysis ward) or home dialysis. These tele-case reviews are performed by a nephrologist and a dialysis nurse of the distant hospital as well as the entire local clinical team: nurses, nutritionist and general practitioners. In peritoneal dialysis, it helps for re-training patients in the manual or automated modality [13–16].
(c) *Tele-visit*: It consists of performing a home evaluation (using videoconference system) in saturated health regions or in remote areas or with difficult access, or to monitor old or fragile patients, or young but with difficulty to access the dialysis center on their own means, treated with automated peritoneal dialysis. Virtual visits can also be performed by nurses (assessment of peritoneal catheter exit site), dieticians

(explanation of prescribed dietary regime) and social workers (discussion of social service, housing and transport issues) [15, 17].

(d) *Tele-analysis*: Modern dialysis equipment has devices for the monitoring and recording information concerning the patient's clinical data (arterial blood pressure, cardiac frequency, body temperature, etc.), as well as the ability to send such records in real time to a center controlled by nephrologists, from where such professionals can also change the dialysis prescription for the patient directly [18]. In this sense, we have recently studied the potential benefit of tele-nephrology applied to the evaluation of the characteristics of drained peritoneal fluid. In our experience, the evaluation of this fluid by means of observation of a digital photograph did not differ from that obtained by direct observation (Figs. 1, 2). This means that perhaps the digital photograph of drained peritoneal fluid sent by the patient to his nephrologist via the Internet could facilitate the diagnostic and treatment of peritoneal complications, especially in those patients who live far from their dialysis center [19].

(e) *Tele-pharmacy*: After the virtual visit, the nephrologist can write a prescription which is automatically sent through the system to the pharmacy and concomitantly the pharmacist is alerted by the system about the new performed prescription, and then he/she checks the patient's recorded data in order to evaluate his/her compliance with the treatment [1].

The heterogeneity of the population concerned and the large number of potential users require more moderately priced, user-friendly systems which are adapted for patients who have no experience and no particular aptitude for computers [20].

The current problem of an increasing number of chronic renal disease patients and a relative deficit in the number of nephrologists for assisting them can be solved by using the tele-nephrology alternative, improving patient's accessibility to nephrological evaluation, diagnosis, treatment and follow-up.

Drawbacks in tele-nephrology

Various human, technical and logistic errors have to be avoided in order to provide an adequate telemedicine practice. Among the main errors are lack of data integrity and/or legal compliance, incorrect patients data, unreliable transmitted information and poor quality images. Practitioners have to be aware of these pitfalls, taking the appropriate countermeasures for making the patient consult effective and safe. Integration of a checklist to the telemedicine practice, adherence to privacy and confidentiality regulation (passwords, electronic signature, etc.), and several technical barriers (firewalls, filters, etc.) can help to achieve this objective [21].

Fig. 1 Normal peritoneal fluid (digital picture)

Fig. 2 Cloudy peritoneal fluid (digital picture)

Nephrological education and research

Regarding the academic field, informatics, telemedicine and Internet greatly contribute to nephrological teaching and investigation, and also to the information

exchange among scientists of different countries, as well as to the extensive release of such investigation in scientific electronic journals. But undoubtedly "data mining", the exploration of data gathered by computer analysis for searching new biomedical phenomena (new syndromes, etc.), is another of its great contributions at this level. Besides, Internet has led to a greater access to medical information and its distribution. Another teaching aspect which is extremely useful and interesting is the lifelong virtual medical learning. This new way of learning, known as *e-learning*, consists of conferences, discussion forums, recommended readings, and self-assessing multiple choice tests, and nephrology congresses which take place on Internet:

American Medical Informatics Association: www.amia.org
Journal of the American Medical Informatics Association: http://jamia.bmj.com
European Society of Medical Informatics: www.efmi.org

As regards the educational aspect, it not only includes, as mentioned above, health professionals, but also the patient itself, since e-education has proved to be effective in modifying risk behaviors. Therefore, this aspect of medical informatics in general and nephrology in particular causes the patient to care for himself, which is key in the general strategy of patient empowering [2, 22].

Conclusion

Informatics nephrology is a new field of knowledge which is changing the current nephrological education, research and practice, integrating all ways of information, ensuring quality and continuity of care and involving patients in their care.

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