Bulletin de la Dialyse à Domicile

Home Dialysis Bulletin   (BDD)

International bilingual journal for the exchange of knowledge and experience in home dialysis

(English edition) (version française disponible à la même adresse)

Contributions of connected devices and telemonitoring in home dialysis

(Apports des objets connectés et du télémonitoring en dialyse à domicile)

Inès Dufour[1] (ID), Luis Da Costa[1] (ID), Eléonore Ponlot[1] (ID), Eric Goffin[1] (ID)

[1]Département de Néphrologie, Cliniques universitaires Saint-Luc, Bruxelles, Belgique

Summary

Home dialysis, including peritoneal dialysis and home hemodialysis, is a treatment option for patients with end-stage renal disease that offers greater independence and improved quality of life. However, its widespread use remains limited by safety concerns, technical complexity, and challenges with remote clinical monitoring.

In this context, the development of connected devices and telemonitoring represents a significant advance. Telemonitoring platforms enable continuous transmission of clinical and technical data from dialysis sessions, promoting a proactive approach to monitoring, early detection of complications, and rapid prescription adjustments. Numerous studies, mainly in automated peritoneal dialysis, have shown improved treatment adherence, reduced hospitalizations, better technical survival, and more recently, a positive impact on mortality. Emerging data also show benefits for manual peritoneal dialysis and home hemodialysis, although the literature remains more limited for the latter modality. Beyond improving care, the data generated by telemonitoring are a valuable resource for clinical research and the development of data-driven personalized medicine. Despite promising prospects, technological, organizational, regulatory, and medico-economic barriers remain, and the level of evidence supporting the benefits of telemonitoring is still largely based on observational studies.

Thus, telemedicine applied to home dialysis could emerge in the near future as a major lever for transforming practices, enhancing patient safety and autonomy, improving care efficiency, and paving the way for predictive monitoring strategies incorporating artificial intelligence.

Résumé

La dialyse à domicile, incluant la dialyse péritonéale et l'hémodialyse à domicile, constitue une modalité de traitement de l'insuffisance rénale chronique terminale, offrant une meilleure autonomie et une amélioration de la qualité de vie des patients. Toutefois, son déploiement reste limité par des enjeux de sécurité, de complexité technique et de suivi clinique à distance.

Dans ce contexte, le développement des objets connectés et du télémonitoring représente une avancée significative. Les plateformes de télémonitoring permettent la transmission continue des données cliniques et techniques issues des séances de dialyse, favorisant une approche proactive du suivi, une détection précoce des complications et une adaptation rapide des prescriptions. De nombreuses études, principalement en dialyse péritonéale automatisée, montrent une amélioration de l'adhésion au traitement, une réduction des hospitalisations, une meilleure survie technique et, plus récemment, un impact positif sur la mortalité. Les données émergentes suggèrent également un bénéfice en dialyse péritonéale manuelle et en hémodialyse à domicile, bien que la littérature reste plus limitée dans cette dernière modalité.

Au-delà de l'amélioration des soins, les données générées par le télémonitoring constituent une ressource précieuse pour la recherche clinique et le développement d'une médecine personnalisée fondée sur les données. Malgré des perspectives prometteuses, des barrières technologiques, organisationnelles, réglementaires et médico-économiques persistent, et le niveau de preuve soutenant le bénéfice du télémonitoring repose encore majoritairement sur des études observationnelles.

La télémédecine appliquée à la dialyse à domicile pourrait ainsi apparaître dans un futur proche comme un levier majeur de transformation des pratiques, renforçant la sécurité, l'autonomie des patients et l'efficience des soins, tout en ouvrant la voie à des stratégies de suivi prédictives intégrant l'intelligence artificielle.

Keywords: home dialysis, connected devices, safety, remote monitoring, telemedicine, telemonitoring

Mots-clés : dialyse à domicile, objets connectés, sécurité, suivi à distance, télémédecine, télémonitoring

journal officiel du Registre de Dialyse Péritonéale de Langue Française RDPLF www.rdplf.org

Introduction

Home dialysis, whether peritoneal dialysis or hemodialysis, performed at the patient's home, is playing an increasingly important role in the management of end-stage renal disease. It promotes patient autonomy, improves quality of life, and aligns with a patient-centered approach. However, despite these well-established benefits, home dialysis remains associated with major challenges: fear of potentially serious acute events, technical complexity, perception of a heavy therapeutic burden, and the need for strict adherence to treatment.

In this context, the rapid development of connected devices and telemonitoring is a major innovation. Telemedicine applied to home dialysis aims to make this modality safer, more reliable, and accessible to a greater number of patients while supporting healthcare teams. This article provides an overview of the current and future contributions of telemonitoring and connected devices to home dialysis, based on recent literature.

Issues and challenges of home dialysis

The success of home dialysis depends on several critical factors: technical proficiency on the part of the patient, precise execution of the prescription (ultrafiltration, clearance, volumes, and flow rates), prevention of complications (peritonitis, catheter dysfunction, and drainage problems), and maintaining good adherence to the protocol [1].

From the caregivers' perspective, home dialysis requires standardization of care in a context where monitoring is less direct than in a hospital unit. Supporting patients who are often isolated in terms of their technique is a key issue. Therefore, telemedicine appears to be a key tool in addressing these issues, strengthening the link between the home and the dialysis team.

General benefits of telemedicine in home dialysis

Several expected benefits of telemonitoring have been described: improved treatment adherence, improved technical survival, reduced hospitalizations, improved clinical outcomes, and better achievement of therapeutic goals (e.g., dialysis adequacy, blood pressure control, and volume management) [2]. Telemonitoring would also enable faster management of complications and could ultimately broaden eligibility for home dialysis. Telemedicine is therefore changing the monitoring paradigm, shifting from retrospective and ad hoc assessment during monthly consultations to continuous and proactive monitoring.

Telementoring and telesupport: building confidence and autonomy

Telementoring is an essential first step in telemedicine in the context of home dialysis. Nurses can remotely guide patients during dialysis sessions thanks to video communication tools (tablets, smartphones, and apps such as WhatsApp). This support is particularly useful for resolving technical difficulties, such as alarm management, technical incidents, or bag changes, especially for nocturnal dialysis, both in automated peritoneal dialysis and home hemodialysis.

Beyond the technical aspect, this visual contact builds patient confidence, promotes a sense of security, and supports patient autonomy.

However, notably, the patient and nurse share the responsibility of ensuring that only appropriate content is visible to the camera during exchanges, particularly when using messaging applications such as WhatsApp.

Treatment telemonitoring: toward a proactive approach
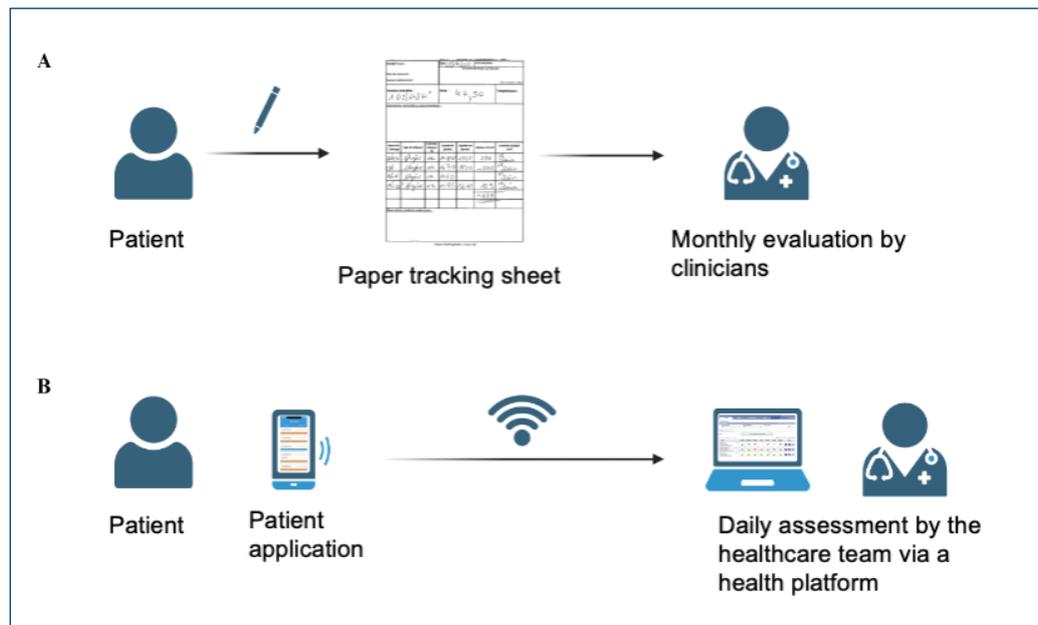
Figure 1. Diagram of paper and electronic documentation flow

Treatment telemonitoring is based on the automated collection and transmission of dialysis data, including ultrafiltration volumes, pressures, alarms, session durations, and clinical parameters, such as weight and blood pressure. Unlike paper records, which are analyzed retrospectively during monthly consultations, these electronic data can be evaluated daily by the healthcare team *(Figure 1)* [3]. This continuous monitoring enables early detection of clinical or technical deviations, such as uncontrolled high blood pressure, excessive weight gain, loss of ultrafiltration, or drainage difficulties, thereby facilitating rapid and targeted treatment adjustments.

Several connected platforms are now available. In automated peritoneal dialysis, connected cyclers transmit data via the cloud to secure interfaces accessible to medical teams. Systems developed by industry players such as Vantive's Sharesource platform [4] and Fresenius' Kinexus portal illustrate this development. These tools provide a detailed overview of each session, facilitate consultation preparation, and enable rapid prescription adjustment.

There are many practical benefits: fewer unnecessary visits to the clinic, time saving for both caregivers and patients, a greater focus on dialogue and therapeutic education during consultations, and a greater sense of security for patients.

Dedicated applications have also been developed for home hemodialysis. The Nx2me Connected Health® application, designed for patients using NextStage® dialysis systems, enables the direct electronic transmission of monitor data and vital signs (weight, blood pressure, and temperature) to the dialysis center [5]. It includes two-way messaging, photo sharing, and alarm support features, strengthening the link between the patient and the healthcare team and facilitating rapid

intervention if necessary [5]. However, this application is currently only available in the United States and not yet in Europe.

Similarly, PhysiNums®, developed by Physidia, is a secure platform for the remote monitoring of daily home hemodialysis sessions. It gives clinicians near real-time access to detailed session data (duration, volumes, pressures) via dashboards that simplify longitudinal monitoring and remote analysis while complying with data security requirements.

Taken together, these tools illustrate the central role of connected devices and telemonitoring applications in the evolution toward more proactive, reliable, and personalized care for home dialysis patients.

Clinical data and impact on outcomes

Several studies have demonstrated the clinical impact of telemonitoring in automated peritoneal dialysis. In 2020, Milan Manani et al. reported in a retrospective cohort study of 73 patients on automated peritoneal dialysis that telemonitoring was associated with improved treatment adherence, reduced hospitalizations, and better quality of life and satisfaction with care [6].

In the same year, a retrospective study by Chaudhuri et al. of 6343 patients undergoing automated peritoneal dialysis showed an association between the use of a telemonitoring system and a decrease in hospitalization rates, length of hospitalization, and technical failure rates, indicating a clinical benefit linked to early identification of complications and rapid treatment adjustment [3]. More recently, Paniagua et al. reported in a randomized controlled cluster trial of 801 patients on automated peritoneal dialysis that remote monitoring was associated with significant reductions in all-cause mortality, cardiovascular mortality, and hospitalization rates [7]. However, notably, there were differences between the groups at inclusion, with patients in the telemonitoring group being younger, on average, and having less hypertension and lower limb arterial occlusive disease, factors that may have influenced the results observed. These results were corroborated by Centellas-Perez et al. in a prospective multicenter cohort study of 232 patients undergoing automated peritoneal dialysis in Spain. The authors found a significant improvement in patient survival and technical survival but no difference in the incidence of peritonitis or the occurrence of cardiovascular disease [8]. However, the association with mortality was no longer statistically significant after propensity score matching, demonstrating that these results should be interpreted with caution.

The benefits of telemonitoring have also been demonstrated in a pediatric population. In a single-center prospective observational study involving 17 children, Chan et al. showed that the use of a connected platform in automated peritoneal dialysis was associated with a decrease in the rate of unplanned hospitalizations, shorter hospital stays, better volume control, and better treatment adherence [9]. In addition, this system reduces the number of hospital visits, thereby improving school attendance among children.

In manual peritoneal dialysis, data remain more limited, but emerging observations are interesting. In 2025, de Fijter et al. evaluated the implementation of a smartphone app dedicated to manual peritoneal dialysis [10]. This app allows patients to enter clinical data such as blood pressure, weight, and ultrafiltration on a daily basis. Patients can also contact the dialysis team

journal officiel du Registre de Dialyse Péritonéale de Langue Française RDPLF www.rdplf.org

via the app for nonurgent questions. The app also allows for the secure sharing of photographs of the catheter exit site or dialysis effluent, without the need for systematic visits to the hospital. The app includes educational and instructional features, such as images of foods indicating their sodium, potassium, or phosphate content, as well as educational videos on healthy eating, physical activity, and living with kidney failure. One section focuses on monitoring subjective well-being, with the addition of a simple weekly question, "How are you feeling?", rated on a numerical scale from 1 to 10. Alerts can be configured to automatically flag abnormal values (blood pressure, weight, and ultrafiltration) or a significant change in the well-being score. All data is evaluated daily by a nurse specializing in peritoneal dialysis, who can initiate targeted action if necessary (telephone contact, treatment adjustment, and early consultation). The authors reported decreased hospitalizations, increased satisfaction, and a greater sense of security among patients using the app, highlighting the potential of telemonitoring in this historically less-connected form of peritoneal dialysis [10].

However, a potential bias in nonrandomized studies should be noted: patients who use these tools are often the most committed to their treatment and may therefore have better health literacy.

The literature is more limited in home hemodialysis. Weinhandl et al. evaluated the Nx2me Connected Health® app in patients treated with home hemodialysis using the NextStage system [5]. The authors showed that using this app was associated with a reduced risk of technical failure and greater success in the training phase.

Taken together, these data indicate that connected devices and telemonitoring applications are a major lever for more proactive, safer, and more personalized care for home dialysis patients, particularly those on peritoneal dialysis, although the mortality data need to be confirmed by other large-scale randomized controlled trials.

Telemonitoring data: from clinical follow-up to research

Beyond their immediate clinical usefulness, the data generated by telemonitoring platforms are a valuable source of information for research purposes. Individual data, collected continuously and in a standardized manner, enable detailed analysis of treatment profiles, such as ultrafiltration profiles based on dialysate type or prescription parameters, for example. At the center level, aggregating these data makes it possible to identify clinically relevant patterns, evaluate practices, and explore predictors of adverse outcomes. For example, Eibensteiner et al. published in 2022 showed that certain ultrafiltration profiles, identifiable from telemonitoring data in peritoneal dialysis, were associated with an increased risk of transfer to hemodialysis [11]. These approaches pave the way for more personalized, data-driven medicine and continuous improvement in the quality of home dialysis care.

Emerging technological innovations

Among recent technological innovations in peritoneal dialysis, automated measurement of dialysate turbidity represents a particularly promising advance. The CloudCath system [12, 13] relies on the use of optical sensors placed on the drainage line, which can continuously analyze the physical properties of the dialysate. This technology enables early detection of cloudy effluent, a sign of peritonitis, and generates a simultaneous alert to the patient and healthcare team, thereby

promoting rapid and potentially more effective management of infectious episodes [12]. The initial clinical results, reported by Mehrotra et al., indicate an improvement in the detection time for peritonitis and an increased sense of security for patients at home [12].

Limitations and barriers
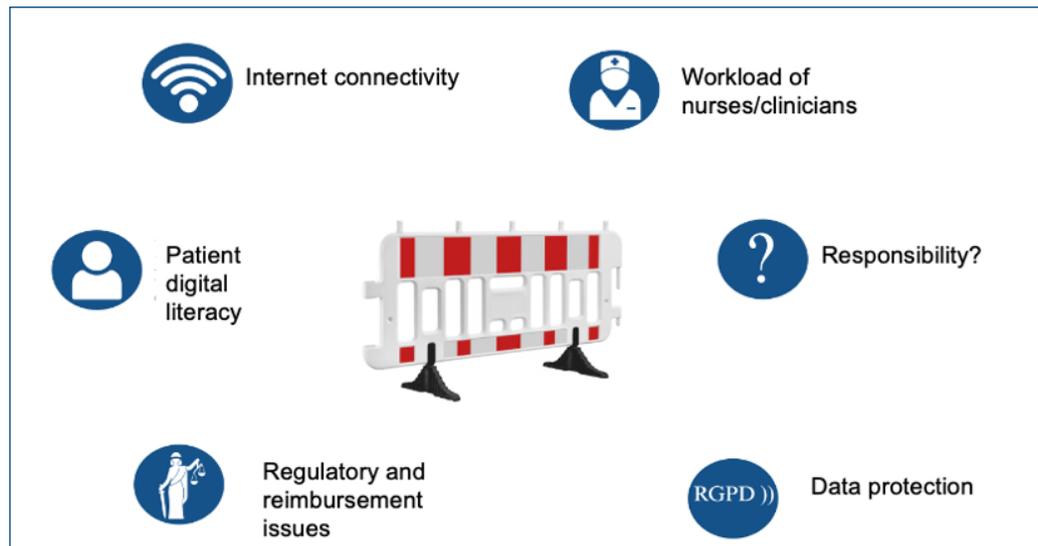
Figure 2. Limitations and barriers to telemedicine

Despite its promising prospects, the application of telemedicine to home dialysis has several limitations that should be considered *(Figure 2)*. Technological barriers remain, including unequal access to digital tools, poor internet connectivity, and varying levels of digital literacy among patients, which may limit the uptake of these devices. In addition to these aspects, there are organizational constraints, such as the potential increase in workload for medical and paramedical teams, the need for specific training, and the adaptation of workflows within healthcare facilities. The deployment of telemonitoring requires an appropriate infrastructure and a structured organization, including a trained nursing team available to regularly analyze the data transmitted. The alerts generated by the platforms cannot replace clinical expertise and must be interpreted by the medical and paramedical team before any therapeutic decision is made. Without prior human validation, direct, automated interaction between intelligent systems and the patient does not appear desirable or sufficiently secure at this stage.

Furthermore, the integration of telemonitoring into clinical practice remains inconsistent. At present, there are no standardized protocols defining the frequency of data analysis, alert thresholds, or methods for tracking interventions. Therefore, practices between centers vary considerably, highlighting the need to develop organizational recommendations to harmonize usage and optimize the effectiveness of these tools.

Financing and reimbursement arrangements for telemonitoring activities remain insufficiently defined in many healthcare systems, constituting a potential barrier to their large-scale deployment. Regular, even daily, evaluation of the data transmitted is a significant time investment for teams, which is not specifically reimbursed in many contexts. This lack of medico-economic recognition

is a major obstacle to the sustainability of dedicated teams and the large-scale development of these systems.

Ethical and regulatory issues are also central, particularly regarding the security, confidentiality, and governance of health data, as well as the clarification of medical-legal responsibilities in the event of an adverse event.

Finally, some patients may perceive telemonitoring as excessive surveillance, which may undermine their sense of autonomy or provoke apprehension about constant monitoring.
Although the available data are encouraging, the evidence base remains largely observational. This highlights the need for randomized controlled trials and robust health economic evaluations to better define the real impact of telemonitoring on clinical outcomes, patient quality of life, and healthcare costs.

Future prospects

The prospects for future developments are particularly exciting. The potential integration of artificial intelligence into telemonitoring platforms could eventually pave the way for predictive monitoring, which is capable of early detection of weak signals that may indicate complications [14]. However, to date, these applications remain largely exploratory, and there is still no robust clinical evidence demonstrating a direct benefit on the outcomes of home dialysis patients. Smart, connected dialysis machines, coupled with integrated telehealth platforms (laboratories, connected devices, and electronic records), could profoundly transform home patient monitoring [15]. However, these developments are currently in the research phase and require rigorous clinical validation before they can be integrated into routine practice.

Conclusion

Telemedicine applied to home dialysis is now emerging as a real lever for transforming practices, far beyond a simple convenience tool. Real-time monitoring of clinical and technical parameters improves treatment fluidity and safety by promoting early detection of abnormalities and rapid, targeted interventions. This proactive approach helps maintain high standards of clinical performance while enhancing the autonomy and sense of security of patients at home.

The growing integration of connected devices, telemonitoring platforms, and artificial intelligence tools will pave the way for increasingly personalized and proactive care in the coming years. These innovations reinforce the role of home dialysis as an essential component of the overall strategy for managing chronic kidney disease by optimizing patient support and assisting healthcare teams.

Authors' Contributions

ID and EG wrote the manuscript. LDC and EP contributed to its critical review and provided constructive comments.

Ethical Considerations

Not applicable

Patient Consent

Not applicable

Data Availabilité Statement

Not applicable

Funding

Acknowledgments

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Data availability

ORCID iDs
Inès Dufour : https://orcid.org/0000-0002-2108-5280
Luis Da Costa : https://orcid.org/0009-0000-1693-2396
Eléonore Ponlot : https://orcid.org/0000-0001-7642-3366
Eric Goffin : https://orcid.org/0000-0001-9242-7148

References

1. Perl J, Brown EA, Chan CT, Couchoud C, Davies SJ, Kazancioglu R, et al. Home dialysis: conclusions from a Kidney Disease: Improving Global Outcomes (KDIGO) Controversies Conference. Kidney Int. 2023;103(5):842-58. Epub 20230131. doi: https://doi.org/10.1016/j.kint.2023.01.006.

2. Simon P. Telemedicine applied to hemodialysis or connected machine. Bulletin de l'Académie Nationale de Médecine. 2018;202(3-4):559-71. doi: https://doi.org/10.1016/S0001-4079(19)30323-1.

3. Chaudhuri S, Han H, Muchiutti C, Ryter J, Reviriego-Mendoza M, Maddux D, et al. Remote Treatment Monitoring on Hospitalization and Technique Failure Rates in Peritoneal Dialysis Patients. Kidney360. 2020;1(3):191-202. doi: https://doi.org/10.34067/kid.0000302019.

4. Caudwell VP, A.; Hanafi, L.; Vittoz, N.; Chargui, S.; Housset, P. Presentation and implementation of the first connected system of automated peritoneal dialysis in France. Bull Dial Domic. 2018;1(3). doi: https://doi.org/10.25796/bdd.v1i3.64.

5. Weinhandl ED, Collins AJ. Relative risk of home hemodialysis attrition in patients using a telehealth platform. Hemodial Int. 2018;22(3):318-27. Epub 20171206. doi: https://doi.org/10.1111/hdi.12621.

6. Milan Manani S, Baretta M, Giuliani A, Virzi GM, Martino F, Crepaldi C, Ronco C. Remote monitoring in peritoneal dialysis: benefits on clinical outcomes and on quality of life. J Nephrol. 2020;33(6):1301-8. Epub 20200810. doi: https://doi.org/10.1007/s40620-020-00812-2.

7. Paniagua R, Ramos A, Avila M, Ventura MD, Nevarez-Sida A, Qureshi AR, et al. Remote monitoring of automated peritoneal dialysis reduces mortality, adverse events and hospitalizations: a cluster-randomized controlled trial. Nephrol Dial Transplant. 2025;40(3):588-97. doi: https://doi.org/10.1093/ndt/gfae188.

8. Centellas-Perez FJ, Ortega-Cerrato A, Vera M, Devesa-Buch RJ, Munoz-de-Bustillo E, Prats M, et al. Impact of Remote Monitoring on Standardized Outcomes in Nephrology-Peritoneal Dialysis. Kidney Int Rep. 2024;9(2):266-76. doi: https://doi.org/10.1016/j.ekir.2023.10.034.

9. Chan EY, Liu MS, Or PC, Ma AL. Outcomes and perception of cloud-based remote patient monitoring in children receiving automated peritoneal dialysis: a prospective study. Pediatr Nephrol. 2023;38(7):2171-8. doi: https://doi.org/10.1007/s00467-022-05828-3.

10. de Fijter CWH, Jorritsma W, Rutten L, Vermeulen A, Zuijderduijn D. Implementation and evaluation of a smartphone-based application for continuous ambulatory peritoneal dialysis (CAPD) patients: a prospective feasibility cohort study and collaborative effort of patients and the peritoneal dialysis team. Clin Kidney J. 2025;18(5):sfaf102. doi: https://doi.org/10.1093/ckj/sfaf102.

11. Eibensteiner F, Flores KO, Unterwurzacher M, Herzog R, Kratochwill K, Alper SL, et al. Monitoring Daily Ultrafiltration in Automated Peritoneal Dialysis. Clin J Am Soc Nephrol. 2022;17(1):107-10. doi: https://doi.org/10.2215/cjn.08180621.

12. Mehrotra R, Williamson DE, Betts CR, Greco BA, Yu E, El-Badry A, et coll. A Prospective Clinical Study to EvaluAte the AbiliTy of the CloudCath System to Detect Peritonitis During In-Home Peritoneal Dialysis (CATCH). Kidney Int Rep. 2024;9(4):929-40. doi: https://doi.org/10.1016/j.ekir.2024.01.033.

13. Lambie M, Wilkie M. Realtime Remote Detection of Evolving Peritonitis in Peritoneal Dialysis. Kidney Int Rep. 2024;9(4):749-51. doi: https://doi.org/10.1016/j.ekir.2024.02.1430.

14. Lew SQ, Ronco C. Use of eHealth and remote patient monitoring: a tool to support home dialysis patients, with an emphasis on peritoneal dialysis. Clin Kidney J. 2024;17(Suppl 1):i53-i61. doi: https://doi.org/10.1093/ckj/sfae081.

15. Lew SQ, Manani SM, Ronco C, Rosner MH, Sloand JA. Effect of Remote and Virtual Technology on Home Dialysis. Clin J Am Soc Nephrol. 2024;19(10):1330-7. doi: https://doi.org/10.2215/cjn.0000000000000405.