



◆ A24-039 ◆

居家腹膜透析智能助理

HomeDIA: Home Dialysis Intelligence Assistant

隊伍名稱 | 健康領航者 Health Navigator

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研究領域

人工智慧聯網應用技術、雲端服務應用技術、智慧製造數位轉型技術

◆ 作品摘要 ◆

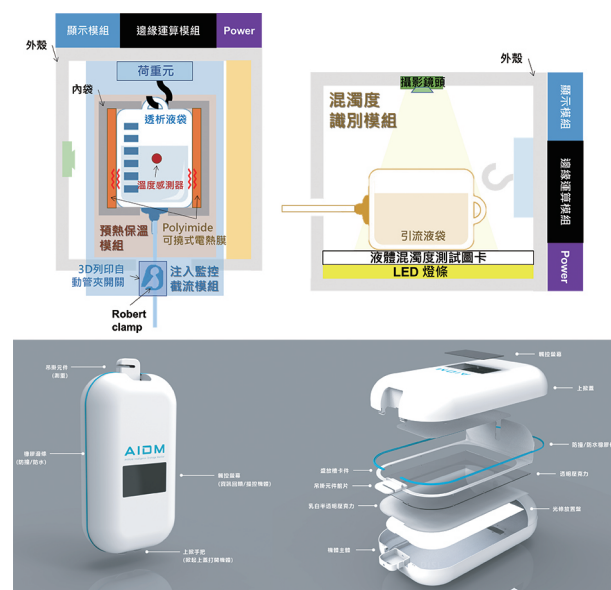
根據美國腎臟登錄系統 (USRDS) 的資料顯示，近年來臺灣罹患末期腎臟病 (ESRD) 的患者數量居全球之冠，有近10萬人正在接受透析治療。雖然血液透析需要固定時間在院治療，這對於時間運用的彈性與生活品質 (Quality of Life, QoL) 產生影響，並且需要忍受打針疼痛、嚴格飲食控制以及容易貧血等困擾，但仍然是多數病友的首選。這主要是因為血液透析的治療過程由醫護人員執行，讓病友與家屬較為安心。然而，血液透析的醫療成本遠高於腹膜透析，對整個醫療系統造成巨大負擔。此外，在COVID-19流行期間，血液透析病友更暴露於群聚感染的風險中。

諸多文獻調查指出，腹膜透析的治療效果與血液透析相當，其在家自行執行治療的方式無需忍受血液透析的不適與不便，並且具有較低的醫療成本，理應更為普及。然而，無論是對病友端還是醫院端，腹膜透析的治療模式仍面臨透析液加熱不精確、注入量難以控制、併發症難以即時監測等問題，這些問題大大影響了治療效果與病友的選擇意願。

為了解決上述問題，我們團隊提出了HomeDIA居家腹膜透析智能助理，其系統架構如圖一所示，包含智慧加熱恆溫袋、注入量偵測與引流液混濁度識別智慧艙體，以及雲端監控平台。HomeDIA的智慧加熱恆溫袋透過雙向矽控整流技術精準控制雙片Polyimide可撓式電熱片的發熱溫度，實現10分鐘內將透析液預熱至37°C，並維持恆溫。智慧艙體具有荷重元及自動管夾開關，通過荷重元監控透析液袋重量變化換算注入量，在達到預定注入量時自動關閉管夾，以精確控制每次透析液的注入量。智慧艙體內建攝影鏡頭、混濁度測試圖卡與LED背光模

組，用於拍攝引流液袋的影像，並通過AI深度學習圖像分類技術識別液體的混濁程度，輔助病友掌握狀況並適時主動就醫。

HomeDIA的雲端監控平台是讓醫院端落實遠端病患管理 (RPM) 的重要工具。通過這個平台，醫護人員可實時監測病友的透析數據，及時發現並處理異常情況，提供適時的關懷。病友與家屬也可以通過手機或電腦查看自己的透析紀錄與健康狀況。這種資訊化的管理方式，不僅提高了治療的精確度與安全性，還減少了病友因頻繁就診帶來的不便，增強了他們的自主性與順從性。對醫院端而言，這更有助於降低醫療系統管理負擔，避免潛在的群聚感染風險。



圖一 HomeDIA系統架構圖。

◆ Abstract ◆

According to data from the United States Renal Data System (USRDS), Taiwan has the highest number of patients with end-stage renal disease (ESRD) in the world, with nearly 100,000 people currently undergoing dialysis treatment. Although hemodialysis requires fixed times for in-hospital treatment, affecting flexibility in time management and quality of life (QoL), and involves enduring needle pain, strict dietary control, and a high risk of anemia, it remains the preferred choice for most patients. This preference is mainly because healthcare professionals handle the treatment process, providing a sense of security for patients and their families. However, the medical costs of hemodialysis are significantly higher than those of peritoneal dialysis, placing a considerable burden on the healthcare system. Additionally, during the COVID-19 pandemic, hemodialysis patients face a higher risk of cluster infections.

Numerous studies indicate that the therapeutic effects of continuous ambulatory peritoneal dialysis (CAPD) are comparable to those of hemodialysis. The ability to perform treatments at home avoids the discomfort and inconvenience associated with hemodialysis and has lower medical costs, suggesting it should be more widespread. However, patients and hospitals face challenges with CAPD, such as inaccurate heating of the dialysis fluid, difficulty controlling injection volumes, and complications that are hard to monitor in real-time. These issues significantly impact treatment efficacy and patient willingness to choose this method.

To address these problems, our team has developed the HomeDIA: Home Peritoneal Dialysis Intelligent Assistant. The system architecture, as shown in Figure 2, includes a heating and thermal preservation (HTP) bag, a smart device with infusion volume detection and turbidity recognition, and a cloud monitoring platform (CMP). The HTP bag uses bidirectional silicon-controlled rectifier technology to precisely control the heating temperature of dual Polyimide flexible heating elements, preheating the dialysis fluid to 37°C within 10 minutes and maintaining a constant temperature. The smart device features a load cell and an automatic clamp switch, monitoring changes in the weight of the dialysis fluid bags to calculate infusion volumes and automatically closing the clamp when the predetermined volume is reached,

ensuring precise control of each infusion. The smart device is also equipped with a camera, turbidity test card, and LED backlight module to capture images of the drainage bags. Using deep learning image classification technology, it identifies the turbidity level of the drainage fluid, helping patients monitor their condition and seek medical attention when necessary.

The CMP platform of the HomeDIA system is a game-changer for hospitals, enabling the implementation of remote patient management (RPM) for CAPD patients. As shown in Figure 3, through this platform, healthcare professionals can monitor the dialysis data of the patients in real-time, detect and address abnormalities promptly, and provide timely care. Patients and their families can also access their dialysis records and health status via mobile phones or computers. This information-based management approach not only enhances treatment accuracy and safety but also reduces the inconvenience of frequent hospital visits, increasing patient autonomy and compliance. For hospitals, it helps lower the burden on the healthcare system and reduces the risk of potential cluster infections.

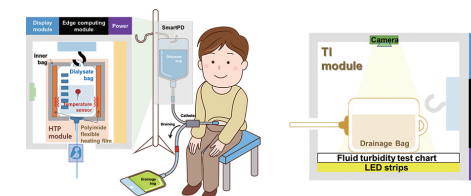


Fig. 2 Home Peritoneal Dialysis Intelligent Assistant.

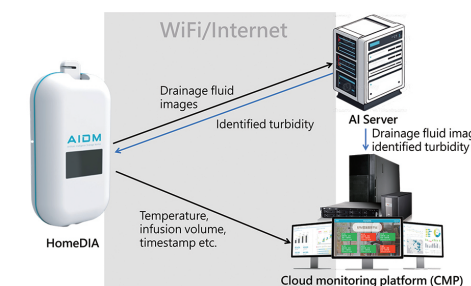


Fig. 3 RPM cloud service platform.