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Home haemodialysis: trends in technology

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Abstract
Self management and home-based dialysis therapies offer the prospect of improved patient experience and outcomes. To allow more patients to realize these benefits requires changes in technology which focus on maximizing the ease and minimizing the burdens of undertaking home dialysis. These developments are underway.

Keywords: home haemodialysis; technology

About every other generation or so, there is a resetting of belief structures within society resulting in what might be called a revivalist mindset. This has been most commonly encountered in the fields of popular music, fashion and religion. Some might say that the current revival of interest in home haemodialysis is a further example. However, even a passing glance at the issues will reveal that the drivers of this revival are far more pragmatic and down to earth.

Throughout the course of its evolution from a laboratory phenomenon to a life-sustaining long-term treatment for the people with end-stage kidney failure, dialysis has had to negotiate a series of brick walls [1]. The need for suitable membranes, anticoagulation and vascular access were all overcome by a combination of technological advances and by the ingenuity and persistence of pioneering individuals. The first coming of home haemodialysis in the early to mid-1960s involved an impromptu swerve around the brick wall of limited economic resources. This allowed continued expansion of the service permitting access to the, by current standards, limited population that the then prevailing wisdom deemed would benefit. This role was subsequently subsumed by the advent of continuous ambulatory peritoneal dialysis (CAPD), at least in countries such as the UK. Further extension of access, to include older patients and those with other complicating illnesses, brought with it the need to expand facilities for centre-based treatment. Thrice-weekly haemodialysis sessions in these facilities became established as the norm. Almost a decade ago, in the form of the HEMO study [2], haemodialysis hit its latest brick wall. In defining the limits of thrice-weekly treatment, the study prompted consideration of the benefits of increased session frequency to increase the dose of dialysis and in doing so provided the impetus to take a fresh look at home-based treatments.

Home haemodialysis in the sixties involved the adaptation of the then current haemodialysis technology into the home setting. Dialysers and dialysis machines were large and cumbersome, and major alterations to the home were usually required often including significant building and plumbing works. During the following decades, there were considerable technological advances. Haemodialysis had become centre based and session times had been shortened considerably. The emphasis was on throughput and the efficient use of resources. This industrialization of haemodialysis required a different type of dialysis machine, which was focussed on providing the means to maximize safety and minimize session time. In addition to standard monitoring and safety devices, a number of additional tools were introduced. These included blood volume monitors, blood temperature monitors and online conductivity monitors. Such 'tools and toys' may provide potential benefits but increase machine cost, bulk and complexity. In addition, machine preparation and cleaning is time consuming and the large volumes of consumables used generate enormous waste. Furthermore, there are physiological and pathophysiological limits to what can be achieved during a short thrice-weekly dialysis session and deploying technology in an attempt to circumvent these limits may not be the most productive way forward. To facilitate the second coming of home haemodialysis, a radical change is necessary in our thinking about what we need from technology.

In this meeting, a number of people dialysing at home were asked to put forward their recommendations to improve the functions offered by their current haemodialysis machines. Suggestions for improved functionality included modifications to reduce set-up and clean-up time, to allow re-use of lines, to reduce obtrusion (including reduced machine footprint, display design and noise reduction), to increase the capacity for interaction with the user and facilitate transportability to allow dialysis away from the home. Kjellstrand and Kjellstrand [3] in providing a nephrologists' perspective on the ideal home haemodialysis machine echoed many of the users' views suggesting that the machine should do all the work during and between dialysis sessions including sanitizing itself by heat, that the machine should interact with and teach the patient user and that the dialyser and blood-tubing set should be part of the machine and need to be replaced only infrequently. In addition, they outlined a number of other functional and technical aspirations. These included improved reliability—requiring to be

serviced only twice yearly, supplying water of 'beyond ultrapure' quality, requiring no systemic anticoagulation, incorporating a 'rescue function'—to allow administration of a rapid intravenous fluid injection at the push of a button and offering a flexible menu of treatments including short daily, nocturnal, high volume haemodiafiltration employing a push–pull system—utilizing a single-needle system if necessary. Suffice it to say that no such systems yet exist. However, over the last few years, there have been advances in meeting some of these aspirations.

The NxStage machine addresses some of these issues. It embodies new concepts in dialysis machine design. Dialysis-fluid is lactate based (like CAPD fluid) and flows are reduced to ~120 mL/min while high blood flows are maintained. The efficiency of small solute clearance is thus maximized and approximates the volume of fluid used. The design is modular and the footprint is small, similar to that of an automated peritoneal dialysis (APD) machine, which it resembles. Dialyser and lines are provided in a cartridge to simplify set-up and clean. For home use, a dialysate preparation system is used which is also cartridge based, thus avoiding the need for extensive building and plumbing work and to reduce the volume of fluid storage that can be problematic in peritoneal dialysis. The machine is portable and, when travelling, utilizes bagged dialysis fluid. Short daily dialysis is the standard mode, but nocturnal treatment**,** say, every other night, is also supported. There is a significant body of experience in the USA [4], with a number of European centres beginning to use the device.

A machine in the late stages of development by QUANTA adopts a similar modular approach, with all the fluid pathways within the machine being consolidated into a loadable cartridge, thus facilitating easy set-up and take-down. Short daily and nocturnal regimes are supported. Fluid is bicarbonate based. The footprint is small and the machine portable, though the requirement for a separate Reverse Osmosis machine makes dialysis away from the home perhaps a little challenging. Other anticipated developments in portable machine technology include the potential being explored by DEKA for extended use blood/dialysate cartridges through heat sterilization and the application of MECS technology (Microtechnology-based Energy and Chemical Systems) to enhance the prospects for miniaturization and portability.

These developments in portable systems do not preclude the use in the home of more traditional technology, and this applies to both haemo- and peritoneal dialysis. On the contrary, they offer solutions to different problems and make important contributions to the menu of choice available for the person who wishes to dialyse at home. Perhaps, the major change in mindset is not in technology but in the philosophy that recognizes the crucial role of self-management and home-based therapies in improving patient experience and outcomes at an affordable cost. In the past, technology has led and the philosophy followed. We now have the opportunity to turn this around.

Conflict of interest statement. None declared.

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