Chapter (31)

Present and Future Dialysis Challenges

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CHAPTER OUTLINES

- Historical Perspective
- Alternatives To Dialysis
- Dialysis Challenges
- Current Best Practice
- Addressing Main Challenges
- Research Challenges
- Conclusion

CHAPTER OBJECTIVES

- Give overview of renal replacement therapy goals
- Define scope of dialysis strengths and limitations
- Describe areas of clinical need priority
- Describe desirable future developments.

KEY TERMS

- Haemodialysis
- Peritoneal dialysis
- Haemodiafiltration
- Transplantation
- Dialysis frequency
- Experimental alternatives
- Wearable artificial kidney

ABSTRACT

A brief historical review of the successful development of dialysis as treatment for replacing lost renal function is given here. A discussion on the short-comings of different dialysis treatments is followed by references to the merits and limitations of kidney transplantation, xeno-transplantation, of newer biological systems and of novel ideas and devices. A discussion on current unmet dialysis challenges includes the design of services suitable for an aging and frail population, quality of life and acceptability of treatments taking into account cultural social and individual diversity. A general review of current dialysis Best Practice includes references to national and international guidelines with the need for technical improvements in different modalities and variations of different therapies aimed at solving individual patient problems. The need for more attention

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and for better solutions to the problem of chronic fluid overload is presented with the place for new dialysis technology in addressing it.

31.1 HISTORICAL PERSPECTIVE

The original description of dialysis was made by Thomas Graham of Glasgow University in 1854 when he demonstrated the passage of urea and sodium from urine to the other side of a membrane made of an ox bladder. He coined the term dialysis and predicted that it would be used for treating renal failure (Graham 1854). Experiments with animal dialysis since 1889 (Richardson 1889) were helped by the development of collodion membranes and tubing in 1907 (Bigelow 1907) culminating in the first successful animal dialysis using collodion and anticoagulation with Hirudin derived from leeches by Abel et al published in 1914 at John Hopkins University School of Medicine (Abel et al. 1914). The first human hemodialysis was performed by Haas from the University of Giessen, Germany in 1924 (Haas 1925), but the first human haemodialysis that survived acute renal failure was treated by Kolff in 1943 (Kolff and Berk 1943) who introduced the rotating drum and used cellophane membranes (Kolff and Berk 1944).

Alwall modified the dialyzer and applied hydrostatic pressure to produce ultrafiltration, publishing his ideas in 1947 (Alwall 1947) and 1963 (Alwall 1963). The coil dialyzer was developed by Kolff in the mid 1950's (Kolff and Watschinger 1956) and by 1960 Kiil developed a low resistance flat dialyzer that did not require blood pump and could be re-assembled repeatedly (Kiil 1960). All these developments were rapidly adopted by different hospitals in America and Europe interested in the urgent need to improve the appalling survival of patients in acute kidney failure.

Since vascular access for dialysis was found to be increasingly difficult as patients arteries and veins were damaged by the procedures the development of dialysis for chronic kidney failure had to wait until 1960 when Quinton and Scribner developed their external arterio-venous shunt made of silastic allowing continuous circulation while not in use (Quinton et al. 1960) and thereafter Brescia and Cimmino developed their internal arterio-venous fistula (Brescia et al. 1966).

The dialysis industry was born and was responsible for much of the subsequent improvements and developments, including the design of disposable dialyzers and lines that would be proven safer, preventing transmission of viral diseases. Also the development of progressively sophisticated dialysis machines capable of preventing air embolism, facilitating and minimizing anticoagulation needs, having volumetric controls that facilitate accurate fluid removal, computerized memory allowing access to individual patient history, as well as of auditing treatment standards of groups of patients, etc. The development of newer dialysis membranes capable of better clearances of uraemic toxins and more biocompatible also contributed to the current success of chronic dialysis programmes in operation in most countries in the world today.

31.2 ALTERNATIVES TO DIALYSIS

Patients reaching end stage renal failure (Chronic Kidney Disease CKD-5) can no longer maintain the various essential kidney functions like fluid balance, acid-base balance, removal of toxins, endocrine function, etc. with the immediate threat to their survival that the lack of those functions entails. If this failure happens rapidly like in Acute Kidney Injury (AKI) the survival is poorer even if treatment is instituted (Uchino et al. 2005). Frequently the reasons for having acute renal failure are also reasons for other systems and organs failing simultaneously and renal replacement therapy is only part of the solution to a wider problem that requires holistic management. Equally, chronic renal impairment is frequently complicated by intercurrent illness that can make critical demands to the failing kidneys that have lost their spare capacity to deal with this. These situations can bring the need for urgent and appropriate replacement of renal function to be established earlier than in the previously accepted plan. The management of situations like fluid overload treated with parenteral diuretics or like hyperkalaemia treated with cationic exchange resins is usually temporarily useful. Strict fluid and dietary restrictions although needed are not a substitute for dialysis in the long term.

Patients presenting early in their CKD-4 where there is enough time for planning and choosing the type of renal replacement could also receive pre-emptive renal transplantation avoiding the need for dialysis while having a better outcome (Meier-Kriesche and Schold 2005). Nevertheless most patients do require dialysis treatment for a period before renal transplantation, as the arrangements for transplantation are time-consuming and the patient has to be in optimal condition to stand this major surgical procedure. In the long-term successful renal transplantation remains the best current treatment to improve survival and quality of life (Schnuelle et al. 1998; Wolfe et al. 1999) and as such is likely to continue to be the obvious alternative to regular dialysis.

Renal transplantation has improved patients quality and possibly length of life, but is only partially available and suitable for no more than 40% of advanced renal failure patients due to both limited kidney supply and unsuitable characteristics of potential recipients. The dangers of viral infections transmission across species have dampened the hopes for xeno-transplantation, and other biological processes of creating or harvesting suitable kidneys are still far from being available (Cascalho and Platt 2001)

Novel ideas for the treatment of acute kidney injury have included animal studies giving intravenous injections of modified cells producing SAA serum amyloid A protein. The recovery of kidney function was remarkable and those cells were found to be integrated into the architecture of healing tubules (Kelly et al. 2010). It is possible to contemplate future therapies involving administration of human cultured tubular cells or similar that might stop or retard the progression of renal disease significantly. Nevertheless unintended harmful results of therapies with cell injections can happen (Thirabanjasak et al. 2010) and this approach is still experimental.

31.2.1 Other New Experimental Technologies

As cultured human proximal renal tubular cells can now be produced in sufficient quantities they can be arranged on hollow fibre scaffolds and a renal tubule cell assist device (RAD) created. This was successfully tried in acute renal failure patients treated with veno-venous haemofiltration, improving metabolic and acid base balance. The use of this RAD for the treatment of acute kidney injury proved to be promising as it appeared to improve patient survival when compared with conventional renal replacement therapy alone (Tiranathanagul et al. 2005; Tumlin et al. 2008) Another new concept for renal replacement technology is the construction of very specialised membranes using nanotechnology with engineered pores capable of recognising and allowing passage to individual molecules only (Nissenson et al. 2005). These membranes with pores for all useful molecules can ensure that they are re-infused while others are discarded in the ultrafiltrate. There is no need for dialysate and there is hope that this continuous convective and portable treatment can also be small and wearable.

Recently a new prototype for a portable and wearable artificial kidney utilizing an adsorption cartridge was developed (Gura et al. 2006; Davenport et al. 2007; Gura et al. 2009a, b). It uses a hollow fibre dialyzer with continuously regenerated dialysate using cartridges with sorbents. The device is operated with batteries, weighs less than five pounds and is worn as a belt. It was successfully tried for several hours in eight patients and, although there were some problems with clotting and dislodging of a fistula needle, it showed promise and future technical breakthroughs might make similar devices practical.

31.3 DIALYSIS CHALLENGES

Dialysis is the main form of renal replacement treatment for an increasingly older population of patients who depend on it for their survival but who also hope to enjoy good quality of life with as little interference from the treatment as is possible. Quality of Life (QoL) could be good in different groups of patients with end stage renal disease. Concerns for patients perception of the burden of disease and on overall patient satisfaction should be explored when new interventions are planned (Gayle et al. 2009). Chronic kidney disease patients, not yet on dialysis, already have impaired QoL when compared with healthy controls but still better than those on dialysis (Perlman et al. 2005). This health-related QoL can be an indicator of the effectiveness of the medical care, but is also dependent on the disease itself. There are physical, psychological and social factors determining QoL that require to be specifically addressed. Many studies have shown that treatment of anaemia and of depression can improve QoL independent of effects on hospitalisation or survival. Renal transplantation appears to have the best QoL when compared to haemodialysis or with peritoneal dialysis (Valderrábano et al. 2001). The challenge for the next decade will be to continue to devise interventions that meaningfully increase the QoL of patients with CKD at all stages (Kimmel and Patel 2006). The impact of well-meaning and well indicated interventions like over-prescription of phosphate binders on QOL has to be taken into account (Chiu et al. 2009). Encouraging behavioural changes to lifestyle could have a positive impact to QOL (van Vilsteren et al. 2005).

Although much progress has been achieved making dialysis safer and more acceptable to these patients, there are major challenges that continue to exist in this field including the relatively poor long-term patient survival. Although these renal patients constitute a heterogeneous population of people with different co-morbidities (some of which are associated with poor survival independent of the renal failure) there are reasons to believe that by improving dialysis quality it is possible to improve the outlook of many of these patients. Another challenge to finding a universally suitable form of treatment for chronic kidney disease is the diversity of cultural, social and individual situations that patients have and that affect the type of treatment available. For every one of the young independent and capable individuals that would flourish with self-delivered home dialysis there are many others that require assisted and supervised treatments. Different configurations of health service providers try to respond to these needs minimising the ensuing personal and family problems like adequate transport, home care, etc. For these reasons it is unlikely that improved home systems of renal replacement therapy will alone be able to solve all these problems. A growing population of renal patients will remain dependent on intermittent dialysis for the foreseeable future.

31.4 CURRENT BEST PRACTICE

The success of dialysis therapy depends on multiple factors that require individual attention. National and international organizations like K/DOQI and European Best Practice have been created to define and obtain acceptable standards of renal replacement treatments. A continuous effort by leading researchers and acknowledged clinical experts is necessary to update these guidelines or recommendations. This set of standards has been made relevant and available to clinical workers (doctors, nurses, dietitians, etc) and its implementation has been aided by the presence of national and international renal registries. Although the epidemiology of renal disease is not easily separated from the epidemiology of the prevalent co-morbid conditions, this recording of treatments and outcomes has been helpful in improving the prognosis of patients receiving renal replacement therapy. Another function of organizations like the British Renal Registry is the annual publication of comparative results from different renal units in the country. As they are usually provided with similar resources it is possible to encourage healthy competition to achieve improvements in outcomes and accepted surrogate markers of health.

The National Cooperative Dialysis Study (NCDS) showed that for hemodialysis patients the timed urea concentration and protein catabolic rate (PCR) were associated to patient outcomes (Lowrie et al. 1981; Harter 1993). Emphasis was made in differentiating low pre-dialysis urea levels produced by good dialysis from those produced by insufficient protein intake and malnutrition.

Individualization of treatments was possible by urea kinetic modeling (Kt/V) that was introduced as a way of quantifying treatment prescribed and delivered. In this model the clearance of the dialyzer (K) is multiplied by the treatment time (t) and divided by the volume of urea distribution (V) of the individual patient. Another way of quantifying dialysis treatment is by calculating the Urea Reduction Ratio (URR) that although less accurate correlates with the Kt/V and is easier to calculate requiring only pre and post dialysis blood urea levels. This was accepted and integrated on the guidelines for treatment in most countries as a way to guarantee minimal treatment levels (NKF-K/DOQI 2006; EBPG for hemodialysis 2002; Jindal et al. 2006) although under-treatment was also found to be heavily dependent on shorter times (Held et al. 1996).

HEMO was the largest prospective study designed to find the optimal dose of dialysis, but it had disappointing results, as not all those with higher Kt/V had better outcomes (Eknoyan et al. 2002; Depner et al. 2004; Port et al. 2004). There is no universal agreement about urea kinetics being the only way to measure adequacy of dialysis and the better outcomes of more prolonged or/and more frequent treatments despite equivalent Kt/V are an indicator of the need for continuing the search for better ways of prescribing individualised dialysis treatments (Kooistra et al. 1998; Keshaviah 1995; Cheng et al. 1998). Increasing dialysis time is probably more important than increasing the efficiency of dialysis per se but arrangements to allow the patients to have a non-over-medicalised existence are essential for their quality of life. This early concern leads to the establishing of daily home dialysis by Shaldon in the 1960's (Shaldon 1968). The better patient survival observed in the well-known dialysis French centre in Tassin (Charra et al. 1992) was associated with increasing dialysis times and frequency and this beneficial effect on survival has been observed in many centres advocating daily dialysis and nocturnal dialysis programmes (Udall et al. 1994; Saran et al. 2006). The challenges that some of these programmes present include the avoidance of over-treatment and depletion of nutrients and blood components like calcium and phosphate. Solutions to this problem have included both the supplementation of the deficiency (ies) (Ing et al. 1992; Al-Hejaili et al. 2003) and the reduction of the intensity of dialysis. As blood and dialysate flows are lower than in conventional dialysis there is less concern about under-treatment and systems like single-needle and central venous catheters are sufficient and recommended. All major manufacturers of dialysis machines have produced models suitable for daily home dialysis (Kjellstrand et al. 2004; Ledebo and Fredin 2004; Trewin 2004; Schlaeper and Diaz-Buxo 2004; Ash 2004; Kelly 2004) including the user friendly Nxstage system (see Fig. 30.1 and Fig. 30.2) that is truly portable incorporating disposable cartridges and a small water treatment (Clark and Turk 2004). An important challenge is providing safe systems for use at home by patients with only minimal supervision. The risks of major bleeding through accidental equipment or lines disconnection appears to have been minimised with the use of connection boxes, moisture sensors and enuresis pads triggering an alarm to the patient or by remote monitoring via internet or phone line (Pierratos 1999; Hoy 2001; Heidenheim et al. 2003) frequently while these patients are asleep.

Fig 31.1 "NxStage System One" a compact FDA approved home dialysis system shown over "Pureflow SL" system for production of high purity dialysate from tap water. [Adapted from NxStage Medical, Inc with permission].

Fig 31.2 Patient working in his boat while dialyzing simultaneously. [Adapted from NxStage Medical, Inc with permission].

For peritoneal dialysis the National Kidney Foundation Dialysis Outcomes Quality Initiative (NKF-DOQI) guidelines recommend a weekly total solute removal in terms of Kt/V_{urea} for CAPD of greater than 2.1 per week (Chatoth et al. 1999), but lower clearances have not necessarily worse outcomes as shown by the ADEMEX randomised prospective trial (Paniagua et al. 2002) that lead to lowering the recommended targets to more achievable weekly Kt/Vurea levels of 1.7 and 1.8 (Moran and Correa-Rotter 2006). Different modalities of delivering peritoneal dialysis either continuously or intermittently have been successfully and widely used. The automated nocturnal systems are an improvement facilitating treatment for many patients (Rabindranath et al. 2007; Michels et al. 2009; Mehrotra et al. 2009) and different variations with shorter dwelling times, such as tidal peritoneal dialysis (TPD) and continuous flow peritoneal dialysis (CFPD) are limited by the increasing cost of using more dialysate fluid (Dombros et al. 2005). The obvious advantage of APD over CAPD is the freeing of time for the patient to have more social activities or work.

While there is a clear need for expansion of these home hemodialysis programmes that have been proven successful in improving patient survival their cost-effectiveness has not been their only barrier to their expansion. The real or perceived difficulties in applying them to an increasingly older and frequently frail patient population has brought the growth of other intermittent forms of dialysis supervised or actually delivered by dialysis nurses and other suitably trained staff . The highest relative cost of in-hospital dialysis should not be paid for potentially independent patients or for others with low levels of dependence and there is a continuous challenge to find alternative ways of delivering high-quality and low-cost treatments.

For many patients the use of intermittent haemodiafiltration (HDF) where the value of convective treatments is added to that of conventional haemodialysis has proven to be a convenient way of maximising therapy within the constraints of time. Although continuous or daily treatments, such as with normal kidneys, do not allow for the accumulation of fluid and toxins and are superior, they have the inconvenience of occupying large amounts of a patient's time. Unless treatments are done at home or during the night this could adversely affect their quality of life: "live in order to dialyze instead of dialyze in order to live". Any arrangements for in-centre delivered treatment have to take into account the considerable time wasted by the patients on the transport and waiting for transport before and after each dialysis frequent the reason for lack of satisfaction. This can limit the acceptable number of dialysis sessions to three times per week. Since time is precious for this group of patients there is some sense in trying to maximise the efficiency of each session while maintaining enough time to allow the safe removal of fluid , the normalisation of blood pressure and the achievement of validated metabolic and nutritional targets like phosphate levels (Velasco 2006). HDF has been favourably compared with conventional haemodialysis and the observational DOPPS study suggested a substantial improvement in survival of 35% when compared to HD (Canaud et al. 2006). Further prospective studies like the Convective Transport Study (CONTRAST) comparing HDF and low flux HD recently completed appeared to show better survival only to patients receiving more than 20 litres convection (Grooteman et al. 2011) while the Turkish HDF Study, comparing HDF and high-flux HD, also showed better outcomes for HDF only when substitution volume fluid were above 17.4 litres (Ok et al 2011) both studies were presented at ERA-EDTA XLVIII Prague June 24, 2011). Our own experience of converting all conventional HD patients to HDF in our centre has been associated to a marked improvement in 5 year patient survival and lower standardized mortality rate than comparative Scottish dialysis populations (Scottish Renal Registry Report 2009).

Not all dialysis systems or modalities would be suitable for all patients and through the life of a single patient different renal replacement systems are usually required. Combination of systems could also be used and variations or adaptations of those systems can make them suitable for individual patient needs. For instance developing home haemodialysis and peritoneal dialysis programmes where these treatments are delivered or supervised by a trained health worker rather than the patient or relatives have been successful (Assisted Peritoneal Dialysis APD) (Brown et al. 2007).

A North American prospective study on patient suitability for different treatment modalities showed that 98% of chronic kidney disease III and IV (CKD3-4) patients were considered medically eligible for haemodialysis (HD), 87% of patients were assessed as medically eligible for peritoneal dialysis (PD) and 54% of patients were judged medically eligible for transplant. Age was the leading cause of non-eligibility for both PD and transplantation (Mendelssohn et al. 2009). Although intermittent three times per week HDF is probably suitable for most if not all hemodialysis patients and it is also clear that other more frequent modalities should be considered for patients for whom this is acceptable and affordable. It is possible to envisage future technological breakthroughs that could make home treatments more widely used. There is a need for innovations that lower the complexity of the treatment from the patient point of view with user-friendly equipment and safer fool-proof procedures due to be developed.

31.5 ADDRESSING MAIN CHALLENGES

Successful haemodialysis requires continuous existence of suitable access to the circulation and this is not always possible to maintain throughout every patients life. Developing new surgical techniques and better materials remains a challenge for the foreseeable future. Equally, peritoneal dialysis requires a healthy peritoneum acting as a suitable membrane and there is a need for developing more bio-compatible dialysis solutions that preserve its function. Any developments that can reduce or abolish infection related to dialysis access would produce immediate clinical benefits and better patient survival.

The short-comings of dialysis are related to the failure to adequately replace the function of the normal kidneys. While understandably a lot of attention has been paid over the years to the replacement of the lost metabolic and endocrine functions of the diseased kidneys, comparatively less research has been done on the optimal ways to replace the lost ability to regulate fluid balance appropriately. Dialysis patients frequently die of cardiovascular diseases associated to hypertension, left ventricular hypertrophy, vascular calcification and accelerated atherosclerosis, all of which are produced or aggravated by chronic fluid overload. Robust dialysis systems that continuously address this recurrent problem are required in order to prevent the worsening of these disease processes and perhaps even inducing their regression. We have just completed a prospective study on the clinical benefits of using a novel semi-automated system for diagnosis and correction of subtle chronic fluid overload with very promising results

(Velasco et al. 2011a, b) although this field is ripe for further creative bio-engineering technical solutions.

The individualisation of treatments is more than likely the best solution for improving the quality of current treatments and improving patient survival. This would take into account regular data generated by the machines involved in dialysis, as well as by the individual patient responses with adjustments to the treatment. Online technology allows HDF, monitoring adequacy, etc, but future developments can expand the safety of dialysis systems to monitor and maintain adequate fluid balance as well. General improvements to treatment are possible like our adoption of a programme of Haemodiafiltration for All that has been responsible for lower rates of hypotension episodes and for improved pre-dialysis blood pressures (Spalding and Velasco 2008) obviating the need for the use of lower dialysate temperatures for patients with recurrent intra-dialytic hypotension. Semi-automation of fluid removal with computerised memory of previous treatments and records of patient tolerability coupled with regular measures of bioimpedance generated body composition can form the basis for delivering a more physiological dialysis treatment trying to replicate the role of the native kidneys. Short-term future improvements are based on current technology and therefore more realistic of being implemented. Other long-term developments to this individualisation are also required to make life for renal failure patients better and hopefully with comparable survival to the general population.

31.6 RESEARCH CHALLENGES

From the above discussions it is possible to see that there is a need for improving survival of the dialysis patients with new strategies that decrease the main causes of premature death like cardiovascular disease and infection. Some factors intrinsic to the dialysis process itself may contribute to this higher risk, examples are the failure of normalization of fluid overload and the increasing risk of acquiring infection via dialysis access. Research includes the development of technological answers to better patient monitoring and treatment strategies that go beyond the single dialysis session tolerability to the attaining of healthier mid and long term goals. The design and manufacturing of safer and simpler dialysis machines for home use remains a continuous challenge that when resolved would make home dialysis possible for many more patients with its decreased cost to society. There is obvious need for continuous research for the development of new surgical techniques and strategies to improve dialysis access and new materials to minimize and abolish thrombosis and infection. The continuous support for exploring more experimental models above mentioned is required while maintaining the search for better and more available biological treatments like transplantation. Perhaps more importantly there is a pressing need for finding new ways to slow or stop the deterioration of renal function of CKD patients to limit the number of future dialysis patients.

31.7 CONCLUSION

This research into developing new forms of treatment discussed in this chapter should be centred on the solution to real patients' needs rather than be limited to the development of commercially viable modifications to current treatments. In a progressively better informed public and with a better worldwide communication among health care workers in this field of renal replacement therapy it is also possible to obtain rapid commercial success when a solution to a real and perceived need is demonstrated. While biological treatments like successful renal transplantation continue to appear superior it should not be forgotten that most end stage renal disease patients today are being kept alive by technological means like dialysis and that survival of those patients is comparatively better today than even a few years ago. As most general populations are now living longer and patients now can survive diseases that were once lethal, the population requiring renal replacement therapy is increasing in numbers and presents new challenges for improving their QoL and length of life.

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ESSAY QUESTIONS

1. List four essential technical inventions necessary for the development of hemodialysis
2. List four systems that have replaced dialysis or have this potential.
3. List four reasons for one single dialysis system not being suitable for treating all patients?
4. Name two recognised organisations publishing consensus on dialysis standards.
5. What are the main factors in the prescription of dialysis affect clinical outcomes?
6. Name a method of quantifying dose of dialysis treatment
7. Name a way of controlling the cost of increasing dialysis duration and frequency?
8. Name a way of improving current in-centre dialysis
9. Describe a technological way to diagnose dialysis patients fluid overload
10. Name two areas of development to improve outcomes of dialysis patients.

SELF-TEST QUESTIONS

Mark the following statement as either True (T) or False (F)

1. First dialysis treatments were developed first for chronic renal failure.
2. Human dialysis was tried before animal dialysis.
3. Dialysis procedures success was dependent on the development of anticoagulation.
4. Survival of acute renal failure patients is better than chronic renal failure.
5. Dialysis should be commenced as early as possible e.g. CKD3.
6. Successful kidney transplant has better survival than dialysis.

7. The transplantation of modified organs from animals could be immediately available.

8. Nanotechnology on hollow fibre scaffolds is required for Renal Tubule Assist Device (RAD).

9. Portable and wearable artificial kidney will be on sale in 2012.

10. Specially designed membranes could be permeable to selected blood proteins.

11. Wearable artificial kidney does not require anticoagulation.

12. Quality of Life of dialysis patients is superior to QoL of CKD 4-5 patients.

13. QoL of dialysis patients is not dependent on anaemia.

14. All dialysis patients should expect similar QoL and survival.

15. All dialysis patients should be treated at home.

16. Guidelines from K/DOQI and European Best Practice do not need updating.

17. All world dialysis units should have similar outcomes.

18. Shorter dialysis times are ideal if Kt/V is kept to a minimum.

19. High Kt/V does improve patient's outcomes.

20. HEMO Study showed conclusively Kt/V is not useful.

21. It is more important to increase the dialyzer efficiency than the time.

22. Poor patient survival with prolonged dialysis times was shown in Tassin (France).

23. Daily dialysis has better survival than thrice weekly.

24. Danger of over-treatment is present in daily dialysis.

25. Nocturnal daily dialysis requires higher blood flows.

26. Alarm systems are required for nocturnal home dialysis.

27. If Kt/V is less than 2.1 per week Continuous Peritoneal Dialysis (CAPD) should be abandoned.

28. Automated Peritoneal Dialysis (APD) demands more patient time than CAPD

29. Haemodiafiltration (HDF) can improve In-centre dialysis.

30. Transport to dialysis centres is a major cost concern.

31. High-volume HDF can have better patient survival compared to conventional HD.

32. All dialysis patients should be on HDF.

33. All dialysis patients should be suitable for transplantation.

34. Patient can use more than one modality of dialysis through time.

35. Thrice weekly HDF is superior to daily dialysis.

36. Adequate vascular access lasts for life for most patients.

37. Peritoneal dialysis fluids can damage the peritoneum.

38. Chronic fluid overload is not always easy to detect and can produce cardiovascular disease.

39. Bioimpedance body composition monitoring can be useful to detect fluid excess.