

The advantages and challenges of increasing the duration and frequency of maintenance dialysis sessions

Charles Chazot* and Guillaume Jean

SUMMARY

The duration and frequency of hemodialysis was determined empirically when this therapy first came into use, and treatment was commonly three 8 h sessions per week by the end of the 1960s. Subsequently, however, the growing number of patients who required this therapy had to be reconciled with the shortage of equipment; therefore, dialysis time was decreased to three 4 h sessions per week. At the same time, on the basis of data from the first randomized controlled trial of dialysis—the National Cooperative Dialysis Study— Kt/V_{urea} was devised as the optimum measure of dialysis adequacy. Nowadays, although Kt/V_{urea} targets are fulfilled in an increasing number of patients, observational studies show that individuals on hemodialysis continue to experience a high rate of complications, including hypertension, left ventricular hypertrophy, cardiac failure, hyperphosphatemia, malnutrition and death. Although no randomized controlled trial has yet been published, observational data indicate that increasing hemodialysis time and/or frequency improves a number of these complications, especially the death rate. This Review outlines the advantages of longer and/or more frequent dialysis sessions and highlights the barriers to adoption of such regimens, which largely relate to economics, patient willingness, and organization of dialysis units.

KEYWORDS extracellular volume, frequency, hemodialysis, phosphate, time

REVIEW CRITERIA

Data for this Review were obtained from peer-reviewed articles, reviews and letters indexed on PubMed. Search terms included “dialysis”, “daily”, “frequency”, “long”, “short” and “nocturnal”. No date or language restriction was placed on the search.

CME

Medscape **Continuing Medical Education online**
Medscape, LLC is pleased to provide online continuing medical education (CME) for this journal article, allowing clinicians the opportunity to earn CME credit. Medscape, LLC is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide CME for physicians. Medscape, LLC designates this educational activity for a maximum of 0.75 **AMA PRA Category 1 Credits™**. Physicians should only claim credit commensurate with the extent of their participation in the activity. All other clinicians completing this activity will be issued a certificate of participation. To receive credit, please go to <http://www.medscape.com/cme/ncp> and complete the post-test.

Learning objectives

Upon completion of this activity, participants should be able to:

- 1 List the alternative options to conventional hemodialysis.
- 2 List the adverse effects of dialysis associated with a high ultrafiltration rate.
- 3 Describe the main benefits associated with increasing the frequency and duration of dialysis.
- 4 Identify the dialysis approach associated with more effective phosphate removal.
- 5 Describe the survival advantage associated with greater dialysis frequency and duration.

Competing interests

The authors have declared an association with the following company: Fresenius Medical Care. See the article online for full details of the relationships. The Locum Journal Editor C Harman and the CME questions author D Lie declared no competing interests.

INTRODUCTION

Since the early 1960s, patients with end-stage renal disease (ESRD) have benefited from hemodialysis, which prolongs their survival. The usual hemodialysis prescription is currently thrice-weekly sessions of 3–4 h each (conventional hemodialysis [CHD]); this regimen was gradually defined after the introduction of hemodialysis. The first dialysis session for Clyde Shields, who was the first patient to be treated with this modality, lasted for 76 h¹. At the end of the 1960s, chronic hemodialysis usually involved three 8–12 h sessions per week.^{2–5} As the demand for therapy became overwhelming, the treatment time was shortened to three 4 h

C Chazot and G Jean are Nephrologists at the Centre de Rein Artificiel, Tassin, France.

Correspondence

*Centre de Rein Artificiel, 42 Avenue du 8 Mai 1945, 69160 Tassin, France
chchazot@wanadoo.fr

Received 3 July 2008 Accepted 12 September 2008 Published online 25 November 2008

www.nature.com/clinicalpractice
doi:10.1038/ncpneph0979

sessions per week, since the clinical outcomes of this regimen were considered to be acceptable.⁶ However, a registry analysis by Degoulet *et al.*⁷ in 1982 revealed a high incidence of intradialytic adverse effects and a high rate of cardiovascular mortality in patients on hemodialysis, although no direct relationship between hemodialysis practice and patient outcome was identified. Patients on dialysis are now known to have a significantly increased rate of death, mainly of a cardiovascular cause, compared with the general population,⁸ and nephrologists who care for these individuals are actively looking for ways to improve their patients' outcomes. To this end, a number of alternative dialysis strategies, such as short daily hemodialysis (SDHD), long nocturnal daily hemodialysis (LNDHD), long conventional hemodialysis (LHD) and hemodiafiltration, are currently being investigated. This Review summarizes the benefits of and barriers to adoption of these regimens.

HISTORICAL IMPORTANCE OF DIALYSIS TIME VERSUS DOSE

In the first randomized clinical trial of dialysis—the National Cooperative Dialysis Study (NCDS)⁹—patients were divided into four groups on the basis of blood urea nitrogen level and dialysis time. The statistical relationship between treatment time and patient outcome in this study was considered to be nonsignificant because the *P* value for this correlation was 0.056. On the basis of data from the NCDS, the concept of 'dialysis dose' was introduced in the form of the Kt/V_{urea} formula (where *K* = urea clearance, *t* = dialysis time and *V* = total body water), which uses urea as a marker of uremia. The concept of Kt/V_{urea} was a major breakthrough and became so popular that, for more than two decades, hemodialysis treatment adequacy has remained predicated on the capacity to clear low-molecular-weight uremic toxins. Several guidelines recommend minimum target values of Kt/V_{urea} , with the goal of delivering an adequate dialysis dose to all patients.^{10,11}

As a result of the NCDS, dialysis time has not been considered to be a key factor in the dialysis prescription; however, more than 25 years later, the interpretation of the NCDS is now once more being actively discussed, with Gotch¹² as the co-inventor and leading proponent of the Kt/V_{urea} formula and Twardowski¹³ as his main opponent. To summarize their vivid debate, Gotch believes that the actual (as opposed to intended)

distribution of patients across the arms of the NCDS should have clearly advantaged dialysis time over urea clearance; however, longer dialysis time had no clear benefit.¹² By contrast, to Twardowski, the Kt/V_{urea} formula suggests that dialysis time can be decreased as long as urea clearance is proportionately increased, but he does not believe that patient outcomes remain the same.¹³

The randomized controlled HEMO trial did not take dialysis time into account because of the belief that this parameter is not a key determinant of outcomes independent of its contribution to Kt/V_{urea} . This trial compared the effects of standard versus high Kt/V_{urea} and high versus low membrane flux on patient outcomes. No clear difference in outcomes was found for either comparison;¹⁴ hence, it seemed that a high dialysis dose is of no benefit to the patient. However, this conclusion deserves to be reconsidered, given the poor health of patients on hemodialysis.

LESSONS FROM DOPPS AND OTHER OBSERVATIONAL STUDIES

The Dialysis Outcomes and Practice Patterns Study (DOPPS) has provided a large amount of information on patients receiving hemodialysis all over the world, including data on complications and differences in practice. Recently, DOPPS investigators¹⁵ showed that the mean dialysis prescription in the US in terms of Kt/V_{urea} has progressively increased during the past two decades, from 1.11 in 1991 to 1.52 in 2002. Between phase I (1996–2001) and II (2002–2004) of the DOPPS, the proportion of patients with a single-pool Kt/V_{urea} below 1.2 decreased from 34% to 10%.¹⁵ These data show that the great majority of patients fulfill the guideline recommendations for small-molecule clearance. At the same time, despite the large discrepancies between countries revealed by the DOPPS, rates of severe complications, such as hypertension, malnutrition, congestive heart failure, bone mineral disorders and death, remain high (Table 1). Thus, dialysis adequacy clearly has to take into account important factors beyond small-molecule clearance, such as extracellular volume (ECV) control, phosphate metabolism, nutrition and last but not least, patient survival, the indisputable end point. Alternative dialysis strategies involving longer and/or more-frequent treatment might provide a means of achieving this goal.

Table 1 Prevalence of clinical complications in patients on hemodialysis.

	Prevalence (%)
Hypertension ^{26,83}	56–83
Congestive heart failure ²⁶	6–46 ^a
Serum phosphate level above KDOQI target ¹⁵	47
Malnutrition ⁵⁷	20–36 ^b
Mortality ²⁶	6.6–21.7 ^c (annual rate)

^aThe prevalence of congestive heart failure varies considerably between regions: 6% in Japan, 25% in Europe and 46% in the US. ^bThe four criteria used to define malnutrition were: BMI <20 kg/m², serum prealbumin level <0.3 g/l, serum albumin level <35 g/l and protein intake (as assessed by normalized protein catabolic rate) <1 g/kg per day. ^cMortality rate is lowest in Japan and highest in the US; the mortality rate in Europe is 15.6%. Abbreviation: KDOQI, Kidney Disease Outcomes Quality Initiative.

CARDIOVASCULAR EFFECTS OF DIALYSIS TIME AND FREQUENCY

Ultrafiltration rate is defined as the interdialytic weight gain divided by the treatment time. In several studies, interdialytic weight gain was positively associated with nutritional markers and survival.^{16,17} However, recent data stress the deleterious effect of a high ultrafiltration rate. DOPPS¹⁸ data show that mortality is increased in patients with an ultrafiltration rate over 10 ml/kg per hour and that these individuals have a 30% greater risk of intradialytic hypotension. The relationship between ultrafiltration rate and mortality was confirmed in a 5-year prospective study by Movilli *et al.*,¹⁹ who found that an ultrafiltration rate of over 12.4 ml/kg per hour was associated with worse survival, after multivariable adjustment.

The mechanism of the deleterious effect of high ultrafiltration rate is unknown, although hypotension episodes are related to high ultrafiltration rate (as described above) and Shoji *et al.*²⁰ reported that such episodes correlated with an increased risk of mortality in a cohort of 1,244 patients. In another study, hemodialysis-induced hypotension was associated with impaired aortic elasticity and decreased survival.²¹ Alternatively (or additionally), patients with adverse effects of dialysis related to a high ultrafiltration rate (e.g. hypotension) might fail to achieve the prescribed dry weight and still have ECV overload (Figure 1)²² as a result of decisions taken to treat the complication, such as stopping ultrafiltration, infusing saline, or increasing dry weight prescription or the dialysate sodium concentration. Inability to reach and maintain the dry weight exposes the patient to hypertension, left ventricular hypertrophy and congestive heart failure, conditions known to be

associated with decreased patient survival.^{23–25} As previously mentioned, congestive heart failure is an important comorbid condition in many patients on hemodialysis in Europe and the US (25–46% prevalence in the DOPPS report).²⁶ Toz *et al.*²⁷ showed a significant improvement in ejection fraction following fluid withdrawal in patients on hemodialysis who had severe heart failure; therefore, it is highly probable that inadequate handling of ECV excess contributes to the high prevalence of cardiac failure in the hemodialysis setting. Increasing dialysis time or frequency enables the ultrafiltration rate to be decreased. Increasing session time enables better session tolerance^{18,28,29} and increasing frequency reduces the risk of dialysis-induced hypotension.³⁰

Increasing dialysis time and frequency have other important cardiovascular effects in patients on hemodialysis, including correction of hypertension,^{31–35} correction of left ventricular hypertrophy,^{33–36} improvement of ejection fraction in individuals with heart failure,^{27,36} reduction of peripheral resistance,³⁷ improvement of the vasodilatory response,³¹ and reduction of sleep hypoxemia³⁸ (Box 1). These beneficial effects are in part attributed to improvement of ECV control,^{35,39} but the effects are also sometimes obtained without substantial changes in ECV.^{40,41} This observation suggests that longer or more-frequent dialysis might increase the clearance of or reduce the exposure to toxins that affect the endothelium. However, Chan *et al.*⁴² pointed out that restoration of endothelial reactivity by use of LNDHD was independent of asymmetric dimethylarginine plasma level. This molecule, which accumulates in patients with ESRD, alters the activity of nitric oxide synthase and thereby influences endothelium-mediated vasodilation.

Whether LHD (as prescribed at our center in Tassin), SDHD or LNDHD is better for the cardiovascular system remains unknown at the moment, but this question might be answered in part by the ongoing Frequent Hemodialysis Network trials.⁴³

EFFECTS OF DIALYSIS TIME AND FREQUENCY ON PHOSPHATE BALANCE

Block *et al.*⁴⁴ identified serum phosphate level as a prognostic factor in patients on hemodialysis. A high serum phosphate level increases the risk of vascular calcifications *in vitro*⁴⁵ and is associated with increased cardiovascular mortality in patients on hemodialysis.^{46,47} Individuals on hemodialysis tend to have a high phosphate

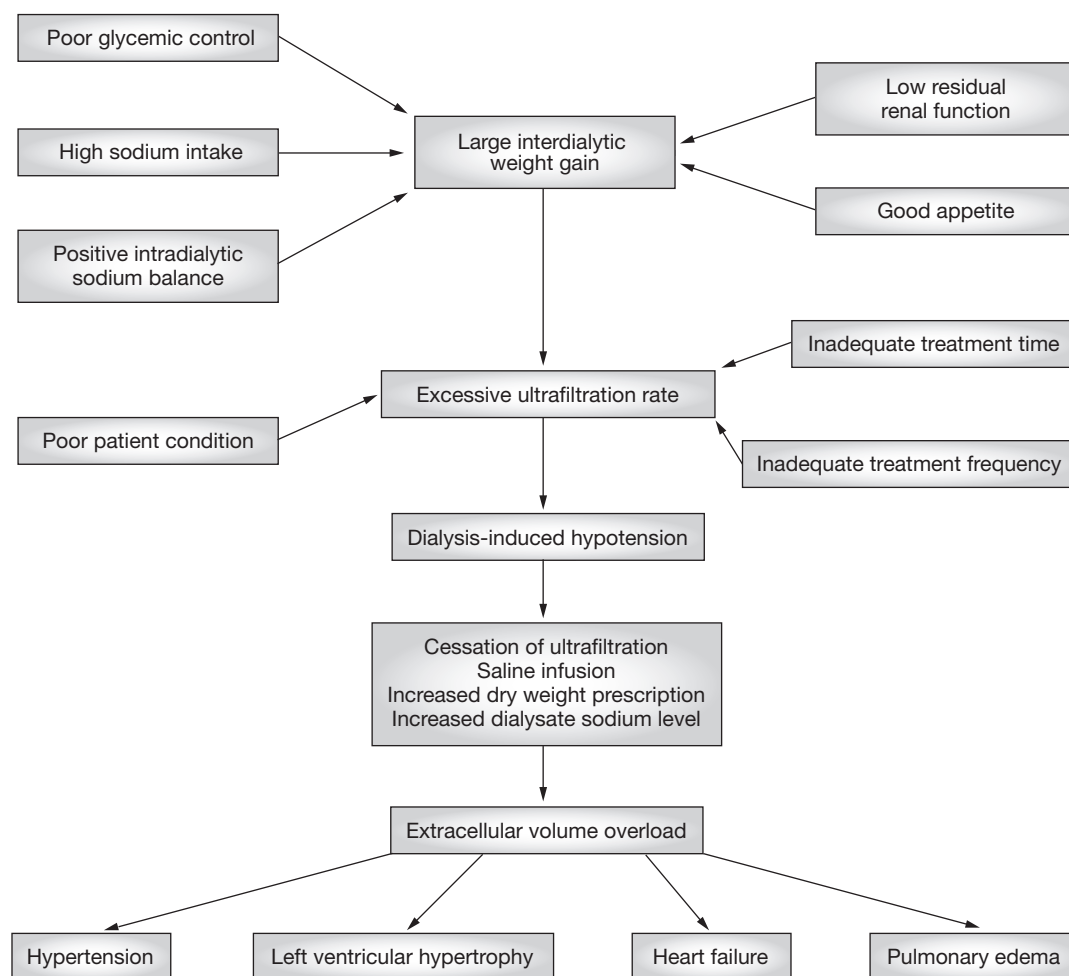


Figure 1 Relationship between ultrafiltration rate, dialysis-induced hypotension and extracellular volume overload, and the role of dialysis time and frequency.

intake due to a high-protein diet, as nutritional recommendations call for such a diet to maintain nitrogen balance.⁴⁸ Gutzwiller *et al.*⁴⁹ thoroughly studied phosphate removal during hemodialysis. These investigators found that during the first 2 h, the level of phosphatemia decreases and phosphate removal is maximal; during the next 3 h, both the level of phosphatemia and phosphate removal remain stable. This observation clearly shows that the amount of phosphate removed during the dialysis session is time-dependent. Eloit *et al.*⁵⁰ analyzed patients treated with hemodialysis sessions of 4 h, 6 h, and 8 h, and reported that the amount of phosphate removed increased with session time and was significantly higher during the 8 h session than during the 4 h or 6 h sessions. Gotch and Levin⁵¹ modeled phosphate balance according to protein intake, dialyzer

clearance, and session time and frequency. The investigators showed that, in patients who ingested the recommended daily amount of protein, phosphate balance is likely to remain positive with CHD (sessions of 3–4 h) even when using a dialyzer with a high phosphate clearance, whereas phosphate removal by LHD (sessions of 6–8 h) should be sufficient to produce a neutral phosphate balance. These predictions are confirmed by data from Photo-Graph®, a French registry for bone mineral metabolism in patients on hemodialysis, which show adequate phosphate balance and a lower incidence of hyperparathyroidism in patients on LHD in Tassin (mean treatment time 6 h 20 min ± 1 h 15 min) than in those on CHD in the Rhône–Alpes area of France (mean treatment time 4 h ± 30 min), despite reduced administration of phosphate binders in the former (Figures 2 and 3).

Box 1 Cardiovascular parameters and complications reported to be positively affected by alternative hemodialysis modalities involving increased session time and/or frequency.

Long conventional hemodialysis

- Predialysis hypertension³⁹
- Paradoxical hypertension⁸⁴
- Heart failure²⁷
- Left ventricular hypertrophy³⁴
- Peripheral resistance³⁷

Short daily hemodialysis

- Left ventricular hypertrophy^{35,85}
- Hypertension^{35,86}
- Sympathetic activity⁸⁷

Long nocturnal daily hemodialysis

- Hypertension^{31,86}
- Left ventricular hypertrophy³⁶
- Heart failure⁴⁰
- Vascular reactivity and endothelial function^{31,88}
- Sleep hypoxemia³⁸

Gotch and Levin also created another model, which showed that LNDHD provides more-effective phosphate removal than does SDHD.⁵¹ This prediction has been clinically confirmed by Lindsay *et al.*⁵² who found nonsignificant decreases in serum phosphate level and phosphate binder use after the switch from CHD to SDHD, whereas the switch from CHD to LNDHD resulted in achievement of a normal serum phosphate level and enabled the discontinuation of phosphate binders. In another study by Gotch *et al.*,⁵³ patients treated with SDHD surprisingly required more phosphate binders than did those on CHD, although SDHD removed 21% more phosphate than CHD. These findings were confirmed by Kumar *et al.*⁵⁴ who noted better nutritional status, but increased use of phosphate binders, in 12 patients who switched from CHD to SDHD and were followed up for 3 years. These observations are explained by the substantial increases in protein and phosphate intakes that are seen in patients who receive SDHD, as discussed in the next section.

Dialysis time seems to be the most important factor for phosphate clearance. Thrice-weekly LHD—and particularly LNDHD—provides

adequate control of bone mineral metabolism and reduces the need for phosphate binders. Increasing frequency alone by switching to SDHD might have a limited effect on phosphate control, especially in patients with a high protein intake. In a study by Ayus *et al.*,⁵⁵ SDHD significantly improved phosphatemia and increased phosphate removal compared with CHD, but the weekly treatment time was higher in the SDHD group (18 h vs 12 h).

EFFECTS OF DIALYSIS TIME AND FREQUENCY ON NUTRITION

The HEMO study has provided a very clear picture of the nutritional status of patients on CHD.⁵⁶ During the 36-month follow-up period of this trial, patients in all four arms exhibited a progressive decline in body weight, serum albumin level and protein intake, as assessed by the normalized protein equivalent of nitrogen appearance (nPNA). Furthermore, in a cross-sectional study by Aparicio *et al.*,⁵⁷ 20–36% of patients on CHD presented with at least one criterion for malnutrition. Alternative dialysis strategies seem to have more-positive nutritional effects than CHD. Patients who were switched from CHD to LHD had increased their body weight in a few months,^{58,59} whereas patients whose treatment time was reduced from 8 h to 5 h had, after 1 year, a dry weight reduction of 2.5 kg and an increase in predialysis mean arterial pressure.⁵⁹ Moreover, in contrast to the HEMO study, our group has shown that food intake, nPNA, body weight and serum albumin level remained stable for 5 years in prevalent hemodialysis patients who were treated with LHD.⁶⁰ In a report by Galland *et al.*,⁶¹ patients who switched from CHD to SDHD experienced dramatic increases in food intake, serum albumin and prealbumin levels, body weight and lean body mass after 1 year. As previously mentioned, Gotch *et al.*⁵³ reported increased protein intake in patients on SDHD compared with CHD. Improvements in amino acid profile have been described in patients who switched from CHD to LNDHD,⁶² but in another study, Spanner *et al.*⁶³ reported no significant increase in nPNA and a decrease in serum albumin and prealbumin levels with LNDHD. Increasing dialysis time or frequency improves patients' appetites and LHD provides nutritional stability. Why no consistent improvement in nutritional parameters has been reported when both time and frequency are increased is unclear.

Why do alternative dialysis strategies improve nutritional stability? The Modification of Diet in Renal Disease study showed that protein intake decreases as glomerular filtration rate declines,⁶⁴ and Bergström demonstrated in rats that uremic plasma contains anorectic compounds in the range of 1–5 kDa.⁶⁵ Accumulation of these anorectic compounds could contribute to malnutrition. LHD might remove these molecules more efficiently than CHD, and SDHD might reduce patient exposure to the molecules. This hypothesis is supported by a recent DOPPS analysis, in which appetite was found to be related to session time.⁶⁶ Eloit *et al.*⁵⁰ have shown that the removal of middle molecules, such as β_2 -microglobulin, increases with session time. By use of computer simulation, Goldfarb-Rumyantsev *et al.*⁶⁷ showed that SDHD increases the β_2 -microglobulin clearance only slightly compared with CHD, whereas clearance of this molecule is significantly increased with LHD compared with CHD.

EFFECTS OF DIALYSIS TIME AND FREQUENCY ON SURVIVAL

Observational data suggest that the positive effects of prolonged dialysis time or increased dialysis frequency translate into improved patient survival. In Tassin, every year for more than a decade, we have compared the mortality of our patients on LHD to that of US patients on CHD, by use of data from the US Renal Data System.⁶⁸ For each calendar year and despite the worsening of the case-mix over time, LHD has been associated with a survival advantage of approximately 50% (Table 2). This finding is dependent on treatment time (Table 3); patients treated for at least 7 h per session have better survival than those patients treated for shorter times. Observational data from the US, Japan, Australia and New Zealand confirm the importance of treatment time for survival.^{69–71} Saran *et al.*¹⁸ also reported a significant effect of session time on patient survival in the DOPPS. Compared with patients who had a thrice-weekly session time greater than 240 min, the adjusted risk of dying was 19% higher in patients treated for 211–240 min and 34% higher in patients whose sessions lasted less than 211 min. The time benefit varied among the continents—being greatest in Japan, intermediate in Europe and lowest in the US—but it was significant in all cases. Moreover, this study found a significant synergistic effect of time and Kt/V_{urea} . Although no mortality data

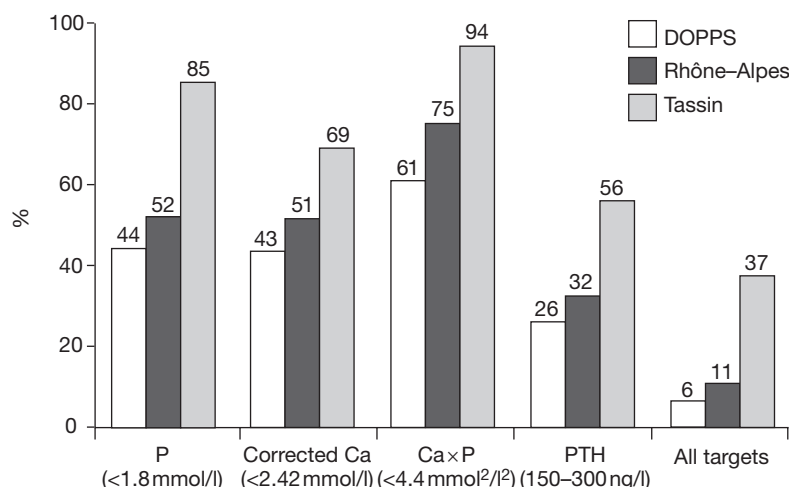


Figure 2 Achievement of the KDOQI targets for bone mineral metabolism among patients on conventional hemodialysis from the DOPPS ($n = 6,864$), and from the Rhône-Alpes area of France ($n = 1,842$; mean treatment time $4 \text{ h} \pm 30 \text{ min}$) and patients on long conventional hemodialysis at the Centre de Rein Artificiel, Tassin, France ($n = 195$; mean treatment time $6 \text{ h } 20 \text{ min} \pm 1 \text{ h } 15 \text{ min}$). Data obtained from Photo-Graph[®], a French registry for bone mineral metabolism in patients on hemodialysis. Abbreviations: Ca, calcium; Ca × P, calcium-phosphate product; DOPPS, Dialysis Outcomes and Practice Patterns Study; KDOQI, Kidney Disease Outcomes Quality Initiative; P, phosphate; PTH, parathyroid hormone.

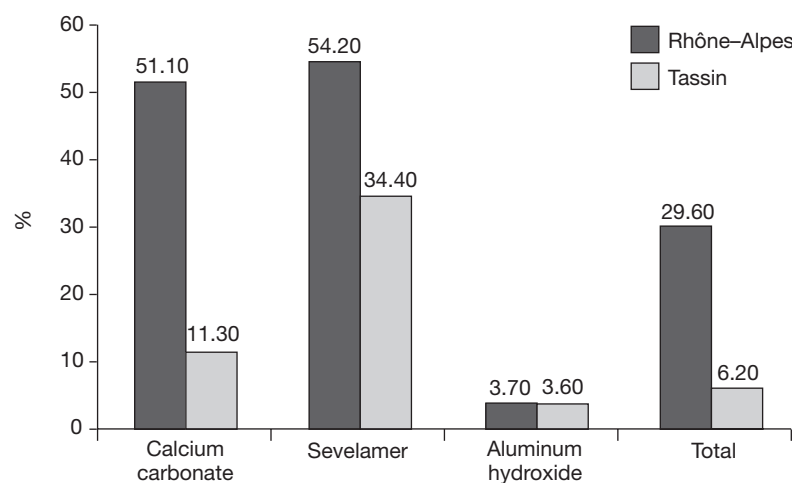


Figure 3 Use of phosphate binders among patients on conventional hemodialysis in the Rhône-Alpes area of France ($n = 1,842$; mean treatment time $4 \text{ h} \pm 30 \text{ min}$) and patients on long conventional hemodialysis at the Centre de Rein Artificiel, Tassin, France ($n = 195$; mean treatment time $6 \text{ h } 20 \text{ min} \pm 1 \text{ h } 15 \text{ min}$). Data obtained from Photo-Graph[®], a French registry for bone mineral metabolism in patients on hemodialysis.

have yet been reported for LNDHD,⁷² experience from five centers in the US, Italy, France and the UK of 415 patients on in-center or home SDHD shows that the standardized mortality ratio is 0.34 compared with patients in the US

Table 2 Standardized mortality ratios⁶⁸ for patients who received long conventional hemodialysis at the Centre de Rein Artificiel, Tassin, France, compared with US patients who received conventional hemodialysis.^a

Year	Observed LHD versus expected CHD deaths	Standardized mortality ratio	P value
1989	23/43.7	0.53	<0.005
1990	14/42.4	0.33	<0.001
1991	18/44.7	0.40	<0.001
1992	15/46.1	0.33	<0.001
1993	23/47.7	0.48	<0.001
1994	20/50.3	0.40	<0.001
1995	23/57.0	0.40	<0.001
1996	27/56.4	0.51	<0.001
1997	25/48.5	0.52	<0.001
1998	26/47.6	0.52	<0.005
1999	27/67.5	0.41	<0.001
2000	38/71.1	0.53	<0.001
2001	27/74.1	0.36	<0.001
2002	32/75.3	0.42	<0.001
2003	35/70.6	0.64	<0.01
2004	31/59.3	0.52	<0.001
2005	30/65.5	0.46	<0.001

^aData obtained from the US Renal Data System. Abbreviations: CHD, conventional hemodialysis; LHD, long conventional hemodialysis.

Table 3 Standardized mortality ratios for patients who received long conventional hemodialysis at the Centre de Rein Artificiel, Tassin, France (compared with US patients who received conventional hemodialysis), according to prescribed duration of thrice-weekly treatment sessions.^a

Year	Standardized mortality ratio	
	Duration of treatment <7 h	Duration of treatment ≥7 h
1996	0.82	0.41
1997	0.59	0.51
1998	0.66	0.51
1999	0.63	0.35
2000	0.76	0.33
2001	0.66	0.36
2002	0.65	0.42
2003	0.73	0.56
2004	0.70	0.30
2005	0.70	0.22
Mean	0.69	0.40

^aData courtesy of Dr Charra, Centre de Rein Artificiel, Tassin, France.

Renal Data System (Figure 4), and the survival rate is identical to that of deceased-donor kidney transplant recipients.⁷³

The Frequent Hemodialysis Network is currently conducting two trials to compare CHD with in-center SDHD and home LNDHD in terms of mortality, left ventricular hypertrophy and quality of life.⁴³ No trial has so far compared LHD with CHD or SDHD with LNDHD.

EFFECTS OF DIALYSIS TIME AND FREQUENCY ON OTHER FACTORS

By mimicking physiological kidney function more closely than CHD, increasing dialysis time and/or frequency might provide benefits other than those reported above. Erythropoietin consumption is usually reduced by SDHD and LNDHD.^{74,75} However, positive results are not consistently found with regard to this parameter, quality of life or cognitive function, and such data have usually been obtained from small groups that may or may not include controls.^{76,77} No data are available on the effects of different dialysis strategies on male fertility, but six successful pregnancies have been reported in five women who underwent LNDHD at one center.⁷⁸ In the study, the rate of live birth (86%) and the average newborn weight (2,417.5 ± 657.0 g) were both higher than those obtained from pooled data that included 131 pregnancies in patients treated with various dialysis regimens (live-birth rate 70.9% and average newborn weight 1,483 ± 116 g).⁷⁹

BARRIERS TO INCREASING DIALYSIS TIME AND/OR FREQUENCY

The ‘cons’ of increasing dialysis time and/or frequency are largely barriers to adoption of these alternative modalities rather than genuine disadvantages. The main barrier is the fact that no randomized controlled trial has yet demonstrated the clinical advantage of these strategies over CHD. As stated by Gotch,¹² only Kt/V_{urea} is known to affect patient outcome; hence, this formula remains the main tool for determining dialysis adequacy. Without denying the importance of Kt/V_{urea}, however, there is evidence that the formula does not take into account important factors such as control of ECV or phosphate balance. If these parameters are inadequate despite sufficient dialysis dose in terms of small-molecule clearance, dialysis time and frequency are the only tools that can be used to improve the situation.

