Preparation for surgery: optimal time for blood collection following haemodialysis

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Abstract

Introduction

In a tertiary Australian teaching hospital, patients on haemodialysis (HD) requiring surgery are routinely scheduled for HD on the day prior to surgery. The existing protocol requires patients to remain at the hospital for an additional four hours following dialysis, to have a blood sample taken to assess serum electrolytes prior to surgery. There is little evidence to support this practice. We sought to examine the kinetics of serum potassium changes following routine dialysis in our unit, with a view to understanding the optimal time for post-dialysis electrolyte sampling.

Method

Following routine dialysis in otherwise stable patients (n=30), blood samples for serum potassium were collected at pre-dialysis, end dialysis (0 minutes) and 30, 60, 120 and 240 minutes post-dialysis. Data were plotted against time, to determine a clinically relevant interval before sampling.

Results

The major, clinically relevant shift in potassium levels was observed in the first hour following dialysis. Mean serum potassium levels (+/– SD) at pre, 0, 30, 60, 120 and 240 minutes were 4.3 (0.63) mmol/L, 3.26 (0.43) mmol/L, 3.36 (0.42) mmol/L, 3.5 (0.37) mmol/L, 3.54 (0.46) mmol/L and 3.76 (0.53) mmol/L respectively.

Conclusion

We conclude that a four-hour wait for sampling is longer than necessary and that a reasonable estimate of serum potassium for clinical purposes should be apparent 60 minutes following routine dialysis.

Keywords
Haemodialysis, potassium, preoperative surgery, time, blood sampling.

Introduction

Alterations in serum electrolytes may have serious implications for the dialysis patient undergoing anaesthesia and surgery, most notably cardiac arrhythmias (Sanchez *et al.*, 2007; Krishnan, 2002). The use of depolarising muscle relaxants may precipitate clinically significant hyperkalaemia, and the activity of non-depolarising muscle relaxants is influenced by potassium and magnesium levels. These electrolyte abnormalities may be exacerbated by acid-base disturbances associated with changes in ventilation (Salifu *et al.*, 2008; Gilbert *et al.*, 1991). General anaesthesia also requires an optimised fluid state. It is, therefore, considered ideal for these patients to have haemodialysis (HD) within 24 hours prior to surgery (Sladen, 2000; Hamper, 1968) and to ensure that the serum potassium level is within the normal range prior to surgery.

The optimal timing for blood collection and acceptable perioperative ranges for serum electrolytes are not clear. In a review of several major anaesthesiology textbooks, Olson (2003) suggests that the serum potassium threshold for postponing surgery is between 5.5 mmol/L and 5.9 mmol/L but noted there is little evidence on which to select such a threshold. Tarif *et al.* (2008) also concludes that the acceptable preoperative serum potassium range remains controversial.

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Caring for Australasians with Renal Impairment (CARI) guidelines (2005), suggest that serum potassium should be regularly monitored to reduce hyperkalaemia development in chronic kidney disease (CKD) patients but does not recommend frequency of monitoring nor give suggestions for perioperative preparation.

Muto (2003) examined factors influencing serum potassium levels at pre-, during and post-HD and showed an increase in potassium at five hours post-HD, but did not resolve when serum potassium equilibrates.

Preoperative preparation for HD patients often includes blood sampling for electrolyte levels following HD. Remaining at the hospital for four hours following dialysis treatment represents a significant burden for patients and some require overnight admission for blood sampling reasons alone. Despite a thorough literature search, there is a paucity of evidence with which to guide our practice and little consensus amongst practitioners about this process.

The aim of this study was to observe the kinetics of equilibration of electrolytes in otherwise stable patients following routine HD and to establish an optimal time for blood collection in preparation for surgery in our hospital. Our hypothesis was that waiting four hours following routine dialysis was unnecessarily conservative.

Method

This prospective observational study included a retrospective data review of the previous two months' pre-dialysis potassium from the date of enrolment of participants.

Inclusion criteria: Patients who had been HD-dependent for at least two months, were medically stable and able to give informed consent.

Exclusion criteria: Patients who were acutely unwell at the time of enrolment, or unable to give informed consent.

Ethical approval: The study was approved by the Human Research Ethics Committee, Concord Repatriation and General Hospital, Sydney, Australia.

Within the unit, patients typically receive HD three times a week, for a four to five hour session, using standard dialysate solutions and dialysis cartridges, as per unit protocol. Patients enrolled in the study were treated in the same way. Eight enrolled patients used dialysate with 1 mmol K+, 21 patients used dialysate with 2 mmol K+ and one was not specified. All dialysate contained standard concentrations of glucose (5 mmol/L) and bicarbonate (SB 35 mmol/L).

Blood samples were drawn before dialysis (pre-dialysis), at dialysis end (0 minutes) and at 30, 60, 120 and 240 minutes following cessation of dialysis. Outpatients participating in the study agreed to remain an additional four hours until the last sample was collected. A positive pressure displacement valve (Ultrasite®) was applied at the end of the dialysis cannula to allow blood specimen collection without further venepuncture.

For each sample, 10 ml of dead-space blood was withdrawn via the cannula or dialysis catheter and placed aside. Four millilitres of blood was collected via a new syringe as the sample, the previous 10 ml of dead space blood was then replaced and the line flushed with 10 ml of saline. If the sampling was from an arteriovenous fistula, the cannula was removed after the last sample was collected. If the sampling was via a dialysis catheter, it was then heparin locked. Standard transport and laboratory procedures were followed.

Analysis

Mean and standard deviations were calculated at each time point and plotted against time (Table 1). Overtly haemolysed samples (n=6), as defined by the laboratory and two other samples were excluded from analysis. The student t-distribution was used to calculate the probability of observing a result greater than 5.5 mM.

Results

Thirty-seven patients were initially recruited to the study but seven subsequently withdrew consent and 30 patients completed the study. Nineteen of the participants had been on HD for three years or more and two patients had been on HD for less than one year (Figure 1). There were equal numbers of males and females. The mean age was 68 years (range 40–85 years). Fifteen sets of samples were collected via a central venous HD catheter, 14 via an arteriovenous fistula or graft and one via a peripheral cannula.

Twenty-two patients had all five blood samples collected, six patients had four samples collected and two patients had three samples collected. Four participants had one sample collected that was haemolysed. Two participants had two samples collected that were haemolysed, one sample went missing and one participant self-discharged after the third sample was collected. Inspection of the previous two months' biochemistry highlighted the stability of pre-dialysis serum potassium levels (Figure 3). Results of the Paired t-test between two and one month pre-dialysis were $t(2)=0.06$ and $p=0.954$. There were no significant

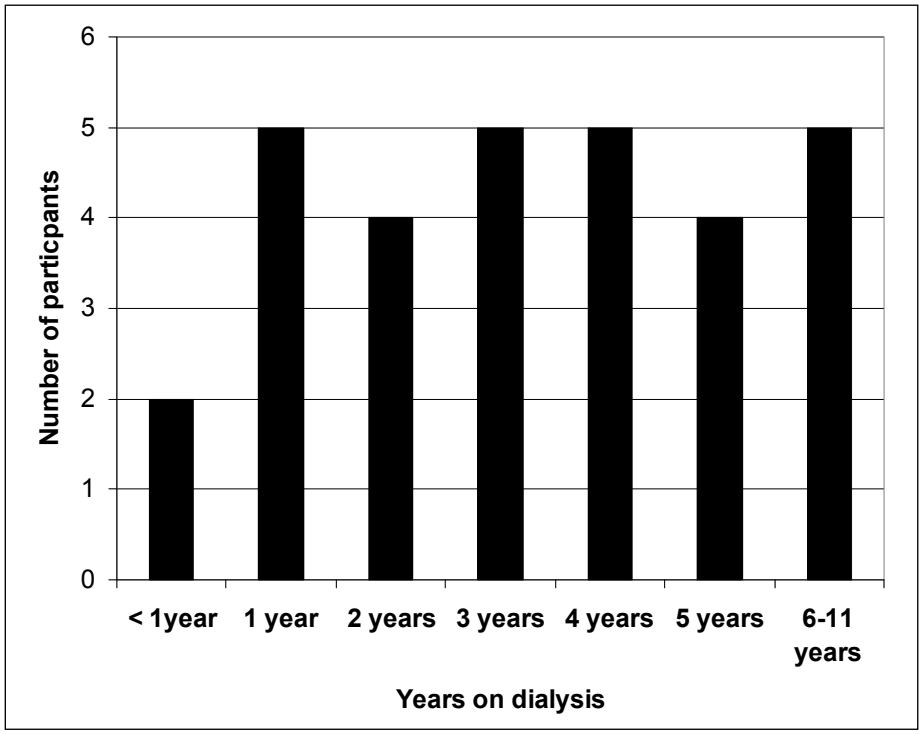

Figure 1. Time on dialysis.

differences which indicates these serum potassium levels were stable.

Examination of the raw data demonstrated an expected reduction in serum potassium levels during dialysis, which rose with equilibration following dialysis (Figure 2). The mean potassium level immediately following dialysis (0 minutes) was 3.26 mmol, a fall of 1.04 mmol from the pre-dialysis value. The mean change from 0 to 60 minutes was 0.3 mmol (SD 0.5). The mean change from 0 to 240 minutes was 0.5 mmol (SD 0.6) and the mean change from 60 to 240 minutes was 0.2 mmol (SD 0.3). The details have been summarised in Table 1 and Figure 3. At 240 minutes, the probability of a result above 5.5 mM occurring was 0.14%, being 3.26 SD from the mean (2-tailed t-distribution). At 60 minutes, the probability of a result above 5.5 mM occurring was negligible, being 5.27 SD from the mean. The absolute difference in the probability of finding a result above 5.5 mM, between sampling at 60 minutes and at 240 minutes, is no more than 0.14%, inferring a number needed to treat (NNT) of approximately 700 patients.

Discussion

Although perioperative morbidity from hyperkalaemia is rare (Olson *et al.*, 2003), measurement of serum potassium following dialysis and prior to surgery is an established perioperative procedure. There is a paucity of recent evidence to guide our existing practice of collecting blood four hours following HD. Information was not available regarding the origins of this policy.

It was observed in this study that the most substantial change in serum potassium levels post-dialysis occurred in the first 60 minutes. Consequently, it was determined that a delay of four hours following dialysis was unlikely to lead to improved decision-making, compared with that based on information apparent at the 60 minutes point.

By way of contrast, following dialysis of the hyperkalaemic patient, the magnitude of change would be expected to be greater, given the need to re-equilibrate

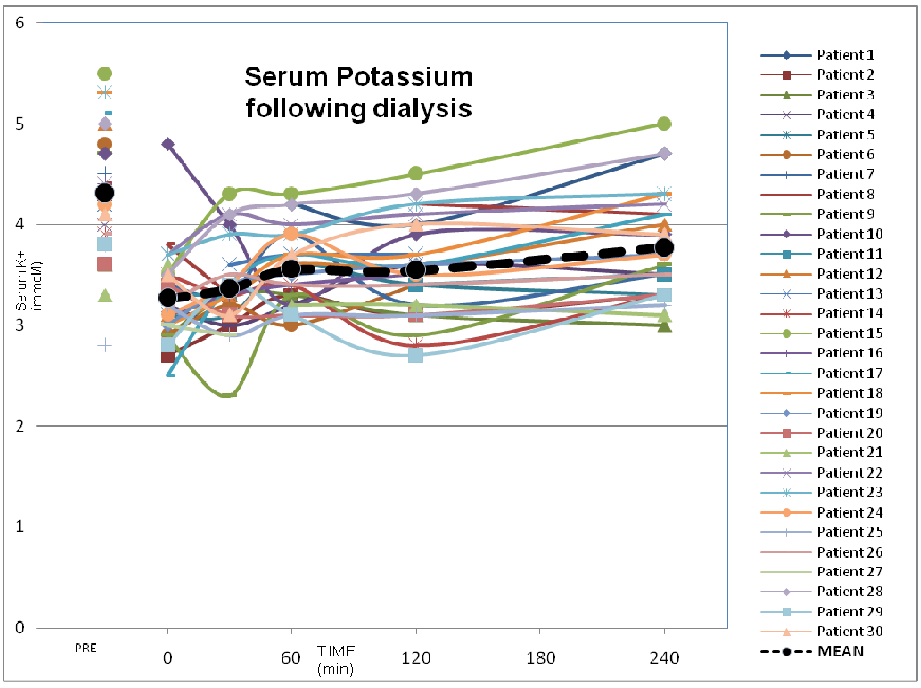

Figure 2. Serum potassium levels post haemodialysis (n=30).

Table 1. Mean and SD potassium level and number of samples at each time point.

	2 months prior	1 month prior	Pre-dialysis	0 minutes	30 minutes	60 minutes	120 minutes	240 minutes
Mean se. K+	4.78	4.69	4.31	3.27	3.36	3.55	3.55	3.77
SD	0.73	**0.81**	**0.63**	**0.43**	**0.42**	**0.37**	**0.46**	**0.53**
(n)	**17**	**30**	**30**	**29**	**29**	**27**	**29**	**26**

Table 2. Day before surgery admission rates.

Year	No. of access surgery cases	No. of HD patients	No. requiring admission day prior to surgery	Rate
2007	83	19	11	58%
2008	73	22	11	50%
2009	76	12	3	25%

with increased total body potassium stores. In such circumstances, clinically relevant differences may become apparent with time and would justify a longer interval post-dialysis. In a study of hyperkalaemic patients undergoing urgent HD, Blumberg *et al.* (1997) noted a substantial rebound in serum potassium following dialysis, which levelled out over four-six hours (Figure 4).

For the purposes of anaesthetising patients after HD, the present study suggests a minimum of one hour's wait is appropriate, to allow a period of re-equilibration, and to avoid the medical complications associated with hypokalaemia. Many anaesthetists request a potassium level on blood drawn on the morning of surgery. This may be more reliable than sampling post-dialysis patients after four hours.

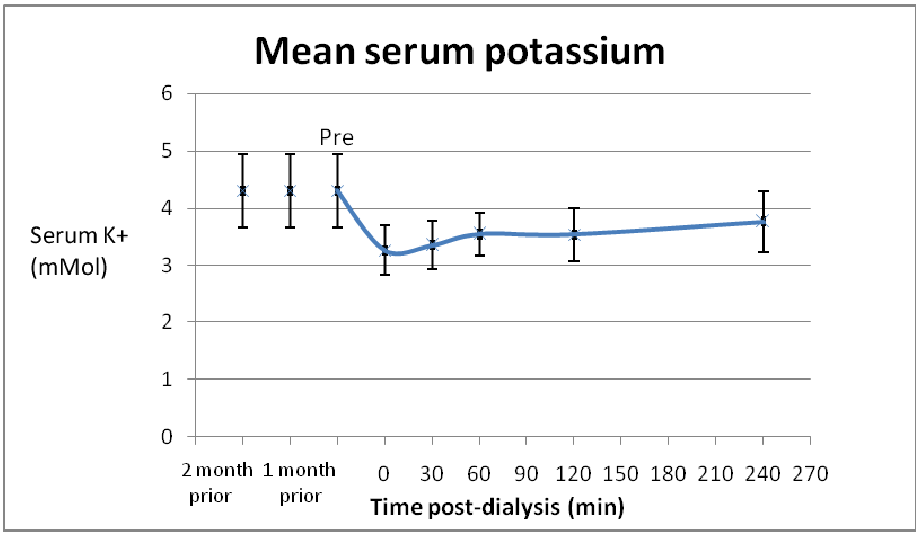

Figure 3. Mean at each time interval.

In addition, this may be appropriate when dialysis is not routine and has been for treatment of hyperkalaemia; in which case re-equilibration of elevated total body potassium stores will cause a prolonged and potentially concerning rise in potassium. Indeed, the pre-dialysis potassium level may be the best guide to appropriate timing of post-dialysis measurement of electrolytes. In the routine patient, however, where potassium levels are not markedly and consistently elevated prior to dialysis, the rise following dialysis will be similarly less marked. In such circumstances, it would seem that for clinical purposes, a sample drawn at one hour is as valid as a sample at four hours.

The present observational study demonstrates that there is little justification for the existing protocol, requiring collection at four hours post-dialysis. A sample taken after one hour gives clinically similar information. Additional benefits include less waiting time for the patient, optimisation of booked surgery time and the capacity to fast-track patients to theatre, thus

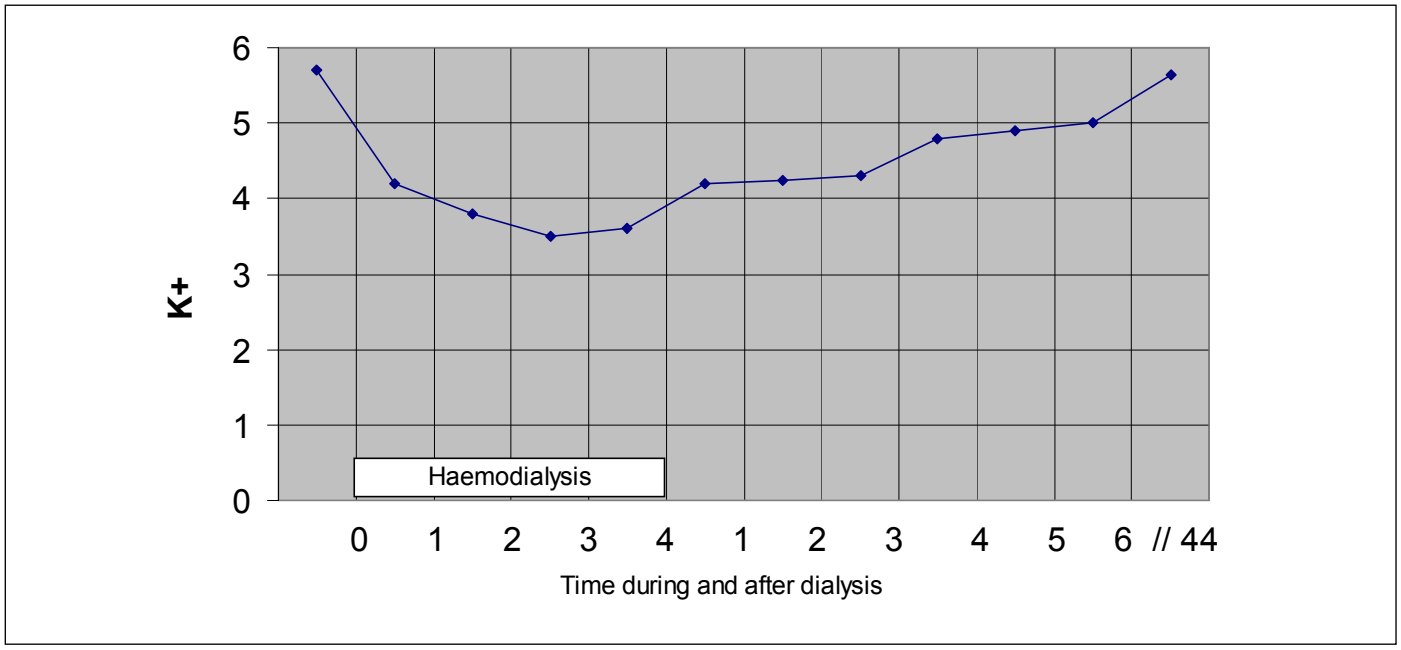

Figure 4. Adapted from Blumberg et al. (1997). 12(8), 1631.

minimising bed block. These benefits lead to a reduction in direct and indirect costs to both patient and the health-care facility.

Following a review of protocol in our unit, there has already been a significant reduction in hospital admission rate (prior to vascular access surgery), which has decreased from 58% to 25% during the period 2007–2009 (Table 2). Repeating this study across different hospital settings and increasing sample size may add strength to these findings.

Limitations

The authors recognise that small sample size and enrolment of stable HD patients may limit the generalisability of the findings and conclusions.

Conclusion

The outcomes of the study suggest that waiting four hours post-HD for blood sampling is not necessary. The study findings further demonstrate that the point of significant rise in potassium level occurs at one hour post-HD and that there is little justification for the protocol which required blood collection four hours post-HD. A revised version of the current protocol is in place, which has led to a marked reduction in extended and overnight stays.

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