POSITIVE ALUMINIUM BALANCE IN PATIENTS ON REGULAR PERITONEAL TREATMENT: AN EFFECT OF LOW DIALYSATE pH?


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Summary

Aluminium concentration was determined in dialysates used for HD and for PD and in the serum of normal subjects and of uremic patients on treatment with HD and with PD.

The main finding of this study was that serum Al levels are significantly higher in patients on PD than in patients on HD. We conclude that the use of dialysates with pH < 5.5 could contribute to a positive balance of Al during PD.

Introduction

Previous reports suggest that serum aluminium levels (SAL) are significantly higher in uremic patients than in normal subjects [1–5].

The increase of SAL has been related to two sources: intestinal absorption from antacids and transfer of aluminium from dialysates to plasma.

The aim of the present study was to compare the distribution of SAL in normal subjects with that of patients on regular peritoneal treatment (PD) and with that of patients on regular haemodialysis treatment (HD).

Methods

Aluminium concentrations were determined by flameless atomic absorption [6] in:

1. Dialysates used for haemodialysis and for peritoneal dialysis;
2. Serum of 44 normal subjects (22 men; 22 women), aged 14–70 years (mean 44.55 ± 14.11);
3. Serum of 69 uremic patients (32 men; 37 women), aged 18–75 years (mean 53.39 ± 13.82), taking Al(OH)₃, 2–5g/daily, on treatment for 19.43 ± 20.26 months with regular haemodialysis;
4. Serum of 23 uremic patients (10 men; 13 women), aged 42–78 years (mean
58.91 ± 8.85), taking Al(OH)₃, 2–6g/daily, on treatment for 11.96 ± 8.37 months with peritoneal dialysis, carried out at first as intermittent dialysis (three times a week, with 40 litre exchanges, 5 to 7 hours each session) and then (for the last 2–3 months) as continuous ambulatory peritoneal dialysis (exchanging 2 litres of dialysate 4 times a day, 7 days a week).

Results

The concentration of aluminium in dialysates was always < 30µg/L: 7.70 ± 7.51 µg/L in 40 dialysates used for haemodialysis and 10.07 ± 6.30µg/L in 40 dialysates used for peritoneal dialysis (p = N.S.). The SAL are shown in Figure 1.

![Figure 1. Serum aluminium concentration](image-url)
Figure 2. Correlation between SAL and time on HD treatment
Figure 3. Correlation between SAL and time on PD treatment

Figures 2 and 3 show the correlation between SAL and time on HD and between SAL and time on PD, respectively.

Discussion

Our results confirm a different distribution of SAL between normal subjects and uraemic patients. Aluminium concentration is significantly higher in patients on HD (p < 0.01) and in patients on PD (p < 0.001) than in normal subjects.

Since the aluminium concentration of dialysates was always very low (<30μg/L), it could be suggested that this increase of serum aluminium is most likely a result of intestinal absorption of some aluminium from the aluminium-containing phosphate-binding gels routinely administered to the patients.

However, we found a low correlation between SAL and time on HD and no correlation between SAL and time on PD. In the same way we did not find any correlation between time on dialytic treatment and presumed intake of Al(OH)₃.

These data indicate that serum aluminium level does not reflect total body
aluminium content, probably because the concentration of aluminium in serum is only a transient part of the redistribution of aluminium from the plasma pool to the tissues.

The main finding of our study, however, is that SAL are significantly higher (p < 0.001) in patients on PD than in patients on HD, although protein binding of aluminium has been described and protein loss is increased in PD.

The difference of amount of Al(OH)₃ ingested and/or the duration of dialytic treatment between the two groups studied is not sufficient to account for this finding. On the other hand, there have been conflicting reports regarding aluminium dialysability.

Kaehny et al [2] reported that aluminium is readily transferred from dialysates to plasma during haemodialysis and that aluminium continues to move from dialysate to blood, although plasma aluminium exceeds dialysate aluminium concentration. These findings should indicate that aluminium is strongly bound to a plasma component.

Opposing this theory, Berlyne [7,8] demonstrated that about 40% of serum aluminium is ultrafiltrable through dialysis membranes and that it is removable both by haemofiltration and by dialysis. He has also demonstrated removal of aluminium by regular dialysis with low aluminium dialysate.

Graf et al [9] confirmed that a negative aluminium balance could be reached during each haemodialysis session when a dialysate with a low aluminium content was used.

Elliot et al [10] reported that aluminium is nearly all protein-bound; at high serum levels, however, about 30% of the serum aluminium is ultrafiltrable. Their studies [11] indicate that 60–70% of aluminium is bound to high-molecular-weight proteins, 10–20% is bound to albumin and 10–30% is ultrafiltrable, with a tendency for the ultrafiltrable fraction to decrease as the total plasma aluminium falls below 200µg/L.

To our knowledge, there are no reports about aluminium dialysability across the peritoneal membrane. These conflicting results can be explained by the investigation of Gacek et al [12]. They reported that aluminium dialysability is strongly affected by slight changes in dialysate pH. Slight fluctuations in pH have a dramatic effect on aluminium solubility in dilute aqueous solutions: aqueous aluminium molecules are water-soluble at low and high pH, but are highly water-insoluble near neutral pH.

Therefore aluminium clearance is negligible in the pH range 6.5 to 7.6, increasing dramatically to 73.6 and 44.3ml/min at low and high pH, respectively.

Peritoneal dialysis was carried out with dialysate pH < 5.5 and we can hypothesise that acidic pH, although rapidly corrected in the peritoneal cavity, contributes to a positive balance of aluminium during peritoneal dialysis, because the concentration of soluble (dialysable) aluminium species in dialysate is independent of total aluminium concentration (low in our dialysates) and strongly dependent on pH.

It can be concluded that:

1. SAL are significantly higher in uraemic patients on dialytic treatment than in normal subjects;
2. This increase of SAL is most likely related to intestinal absorption of aluminium;

3. SAL are significantly higher in uraemic patients on PD than in uraemic on HD;

4. This increase of SAL can be related to the use of low dialysate pH;

5. The use of low dialysate pH for PD should be re-examined.

References

11. Elliot HL, MacDougall AI, Fell GS, Gardiner PHE. Lancet 1978; ii: 1255

Open Discussion

SHALDON (Montpellier) I am very sorry to have to do this to you, but your conclusions 3, 4 and 5 are not justified. You see, your data clearly show skew distribution and you are not entitled to use Student’s t test to determine the significance of that data. Therefore you have no right to say that the dialysate aluminium level in peritoneally dialysed patients was significantly higher because you have used the wrong statistical method to analyse your results.

GILLI We don’t use Student’s t test. In fact we use a non-parametric statistical test, the Kendall S test.

LEGRAIN (Paris) If what you say is true for IPD then it is not true for CAPD. So when you speak of data on dialysis be careful to state it is only IPD. Our experience of serum aluminium levels in patients treated on CAPD have proved that they are lower than you can get in other dialysed patients, that’s one point. Another point; if there are some differences in your two groups, don’t you think that one explanation could be not only pH but also the fact very often the patients on IPD are underdialysed, with hyperparathyroidism and as your two groups were taking large quantities of aluminium hydroxide it could explain your experiment better without any other explanation related to the pH of your fluid. This is a comment — I don’t know whether I am right or not.

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GILLI I would say that CAPD is less dangerous than IPD, because of the different number of exchanges per week. We think that the number of exchanges is very important.

BOULTON-JONES (Glasgow) Have you looked to see whether peritoneal dialysis increases intestinal absorption of aluminium itself?

GILLI I have no data about this.

BOULTON-JONES Is it possible that could explain your findings?

GILLI Because the intestinal absorption of aluminium could be related to PTH, we have tried to compare the values of PTH in patients on peritoneal dialysis and in patients on haemodialysis but these data are not sufficient to explain our results.

FARMER (USA) Your normal patients, were they on aluminium antacids and if they were not, do you have any data as to the serum aluminium level in individuals of normal renal function?

GILLI Our control group was not on aluminium antacids, while the amount of aluminium hydroxide was the same for two other groups studied.