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Blood calcium balance and dialysate calcium concentration in heamodialysis patients in Thi-Qar Province, Iraq

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ABSTRACT:

Objective: This study designed to assess whether dialysate calcium concentration is adequate to maintain blood calcium balance in patients receiving hemodialysis therapy or not adequate.

Patients and Methods: We evaluated 170 patients undergoing chronic kidney disease in dialysis unit at AL- Hussein teaching hospital in Thi - Qar province.

Results: The 170 patient included 70 (30%) were female and 100 (70 %) were male, aged from 19 to 90 years, the duration of dialysis session 3hour per day, number of dialysis session per week was two time per week for all heamodialysis patients, and dialysate calcium concentration was 1.75 mmol/L. Results show normal calcemia in pre and post dialysis session in 30 patients (17.65%) their serum calcium was within normal range 2.24 - 2.5 mmol/L with no significant change ($p > 0.05$), and 48 (28.24%) show changes in serum calcium from 1.75 ± 0.11in pre to 2.32 ± 0.24 mmol/L in post HD session with no significant changes ($p > 0.05$), but 92 (54.24%) patients were diagnosed with hypocalcemia in pre 1.48 ± 0.16 and post 1.72 ± 0.20 dialysis session also with no significant change ($p > 0.05$).

Conclusions: the concentration of dialysate calcium 1.75 mmol/l (3.5 mEq/L) was adequate and frequently used with the aim of obtaining positive blood calcium balance especially in patients with normal ([Ca] < 2.40 mmol/L) or Pre hypocalcaemia ([Ca] ≥ 1.75 mmol/L). But in patients with severe degree pre - hypocalcemia ([Ca] ≤ 1.48 mmol/l) dialysate Ca concentration (1.75 mmol/L) should be increased by ~ 0.25 mmol/L to maintain comparable balances as possible as or treated with calcium gluconate (10 % w/v) injection ampoule 10 ml (1ml ≈ 0.23 mmol/L) after HD session.

Keywords: Blood calcium balance, heamodialysis, dialysate calcium concentration.

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Introduction:

In medicine dialysis is a process for removing waste and excess water from the blood, and is used primarily to provide an artificial replacement for lost kidney function in people with renal failure. Dialysis may be used for those with an acute disturbance in kidney function (acute kidney injury, previously acute renal failure), or progressive but chronically worsening kidney function a state known as chronic kidney disease stage 5 (previously chronic renal failure or end stage renal disease). The latter form may develop over months or years, but in contrast to acute kidney injury is not usually reversible, and dialysis is regarded as a "holding measure" until a renal transplant can be performed, or sometimes as the only supportive measure in those for whom a transplant would be inappropriate[1]. Patients with end-stage kidney disease (ESKD) have a disruption in systemic Ca homeostasis as a result of limited excretion of phosphate and diminished hydroxylation of 25-hydroxyvitamin D to calcitriol (1,25-dihydroxyvitamin D) resulting hypocalcemia, there is an effect on bone, the gut, and the parathyroid glands. Hyper secretion of PTH is initially appropriate by increasing calcium and phosphate release from bone and enhancing urinary phosphate excretion (via a decrease in proximal reabsorption)[2]. Serum calcium's effect on outcomes has been the focus of attention mainly in dialysis patients, where calcium metabolism is significantly distorted [3].

The dialysate calcium (Ca) concentration for hemodialysis (HD) patients can be adjusted to manage more optimally of the body's Ca and phosphate balance, thus improve bone metabolism as well as reduce accelerated arteriosclerosis and cardiovascular mortality. The appropriate dialysate Ca concentration allowing this balance should be prescribed to each individual patient depending on factors relating to Ca load [4]. The diffusion of Ca in HD depends on the Ca gradient between the serum concentration and the dialysate concentration. Worldwide use of dialysate Ca varies throughout different countries. Kidney Disease Outcome Quality Initiative (K/ DOQI) guidelines ranged between 1.25 to 1.75 mmol/L [5]. In table 1 we can see the potential advantages and disadvantages of different dialysate calcium concentrations.Some studies recommend a dialysate Ca concentration of 1.25 mmol/L rather than 1.5 mmol/L to avoid excess Ca load and prevent vascular calcification [5]. QTc dispersion increases during hemodialysis with low-calcium dialysate [6]. On other hand some studies have shown that when the dialysate Ca is greater than 1.5 mmol/L, there is an expected gain in Ca balance [7-9]. Other studies show that high concentration of dialysate calcium (1.75 mmol/l) impaired cardiac relaxation, and some patients may develop hypercalcemia if the calcium intake is increased or if the dialysate calcium is high and may result in calcification in the blood vessels and other

tissues because calcium uptake by the bone is reduced

So, this study aimed to assess whether dialysate calcium concentration which used in heamodialysis unit at AL- Hussein teaching hospital is adequate to maintain the balance in plasma calcium level or not.

Table 1 : The potential advantages and disadvantages of different dialysate calcium concentrations according to K/DOQI guide lines [5].

Dialysate calcium Concentration	Advantages	Disadvantages
Low (1.25-1.5 mmol/l)	-Reduces risk of hypercalcemia -Allows greater use of vitamin D and calcium-containing phosphate binders -Benefit in dynamic bon disease	-Potential for negative calcium balance and stimulation of PTH -Increase in intra dialtic hypotension
Higher(1.5-1.75 mmol/l)	-Improves hemodynamic stability Suppression of PTH -Beneficial for bone protection in nocturnal hemodialysis	-Greater risk of hypercalcemia -Limits use of vitamin D and calcium based binders -Possible risk of vascular calcification

PTH= parathyroid hormone.

Patients and methods:

The study was comprised of 170 patients with chronic kidney disease stage 5, who underwent HD treatment, with the dialysate calcium concentration 1.75 mmol/L, using polysulfone high-flux dialyzer 17 L, its membrane area 1,7 m^2 (Germany). Data obtained are the duration of dialysis session per day (hour), number of dialysis session per week (time) and serum calcium levels measured during pre- and post- hemodialysis dialysis session.

Statistical analysis

The means and standard deviations of all variables were calculated. Student's *t*-test for paired samples analyses was used to determine statistical significance, and *P* values ≤ 0.05 were considered significant. The Statgraphicst ® (version 15) statistical package was used.

Results:

Table (2) shows the characteristics of the 170 heamodialysis patients, their age ranged (19-90), of them 70 (30%) were female and 100 (70%) were male. The mean duration of dialysis sessions was 3 Hours per day, patients have dialysis sessions 2 time per week.In table (3) and

figure (1) we can show the calcification of 170 patients into three groups according to the concentration of serum calcium in pre and post hemodialysis session with dialysate calcium mmol/L.

Table 2: The characteristics of the 170 heamodialysis patients .

Patients Data	Number (Percentage)
Age (year)	19 – 90
Gender (F/M)	**70 (30%) / 100(70 %)**
Duration of dialysis sessions per day (hour)	**3.00 (100 %)**
Duration of dialysis session per week (time)	**2.00 (100%)**

Table 3: The calcification of 170 patients into three groups according to the concentration of serum calcium in pre and post hemodialysis session with calcium dialysate concentration 1.75 mmol/L. (The normal concentration of serum calcium is 2.05-2.55 mmol/L [12]).

Patients group	Patients number (%)	Pre-hemodialysis serumcalcium (mmol/L) mean ±SD *	Post- hemodialysis serum calcium (mmol/L) mean ±SD
A	**30 (17. 65%)**	**2.30 ± 0.09** [a]	**2.50 ± 0.06** [a]
B	**48 (28.24%)**	**1.75 ± 0.11** [a]	**2.32 ± 0.24** [a]
C	**92 (54.11%)**	**1.48 ± 0.16** [a]	**1.72 ± 0.20** [a]
Total	**170 (100%)**		

***Each value represents mean ± SD values with non identical superscript (a , b or c …etc.) were considered significantly different (P ≤ 0.05).**

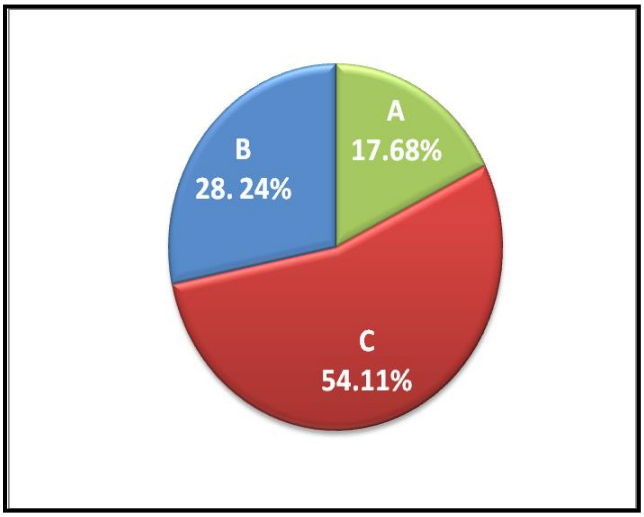

Figure 1 : The percentage of the calcification of 170 patients into three groups according to the concentration of serum calcium in pre and post hemodialysis session with calcium dialysate concentration 1.75 mmol/L (GROUP A : normal in pre and post HD session , GROUP B : hypo in pre and normal in post HD session and GROUP C: hypocalcemia in pre and post HD session).

In group A (Figure 2), there are 30 (17.65 %) patients of all 170 patients with normal serum calcium level in pre (2.30 ± 0.09 mmol/L) and post (2.50 ± 0.06 mmol/L) hemodialysis session with increasing about 0.18 mmol/L , there are no significant changes (P > 0.05).

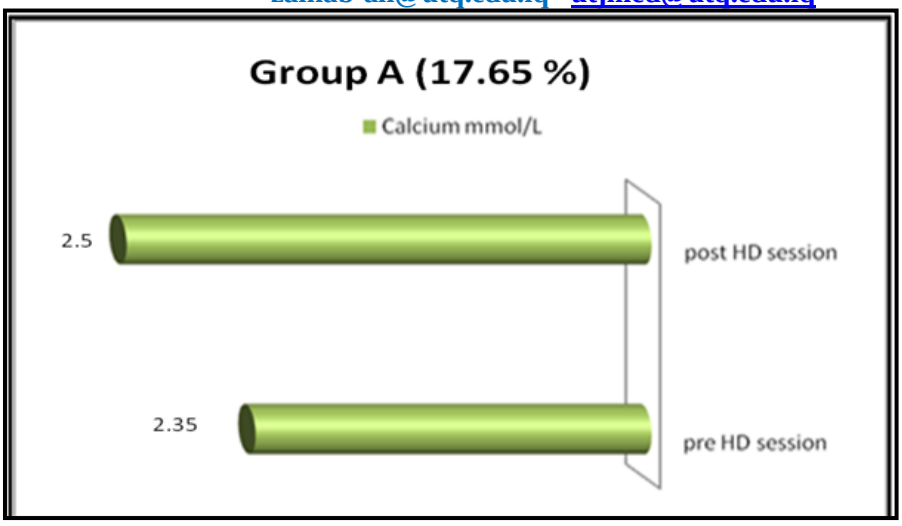

Figure 2: The change in blood calcium concentration in 30 (17.65%) patients of all 170 patients (group A) in pre and post

Also, forty eight (28.24 %) patients (Figure 3) could enjoy a successful management according to the K/DOQI recommendations with increasing about 0.57 mmol/L and show no significant changes (P > 0.05) in serum calcium from 1.75 ± 0.11 mmol/L in pre to 2.32 ± 0.24 mmol/L in post HD session.

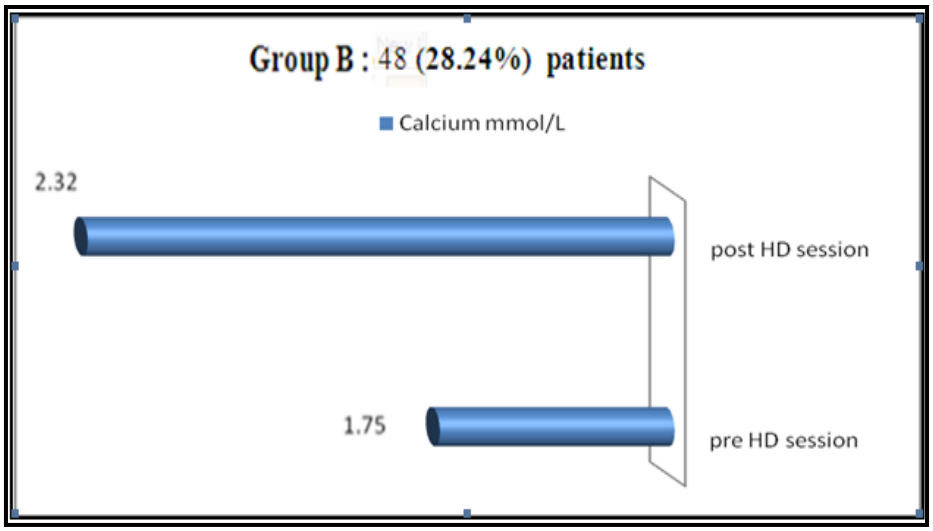

Figure 3: The change in blood calcium concentration in 48 (28.24%) patients (Group B) in pre and post hemodialysis session in pre and post hemodialysis session.Out of 170 HD patients there are 92 (54.11 %) patients with hypocalcaemia in pre HD session (1.48 ± 0.16 mmol/L) and in post HD session (1.72 ± 0.20 mmol/L) with increasing about 0.24 mmol/l , but there are no significant changes (P > 0.05) as in figure 4.

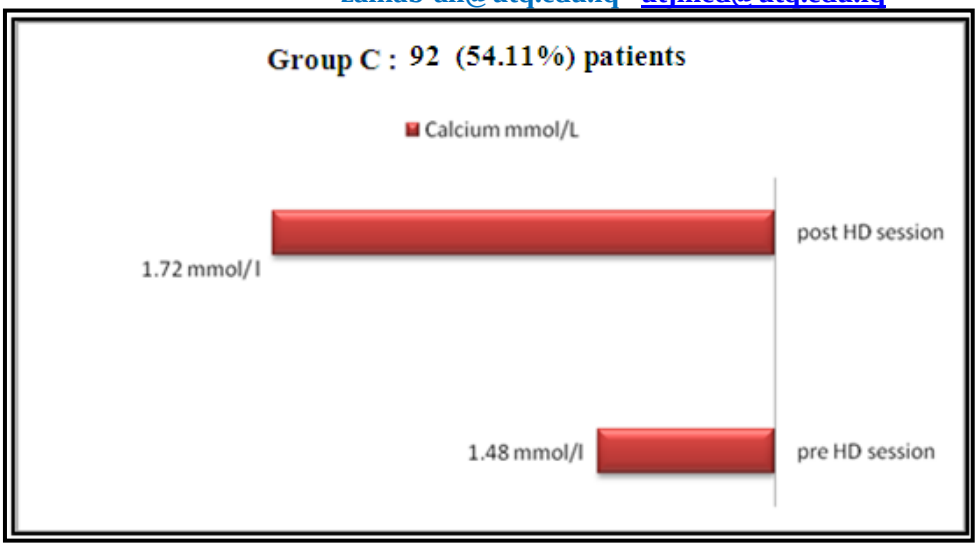

Figure 4: The change in blood calcium concentration in 92 (54.11%) patients (group C) in pre and post hemodialysis session in pre and post hemodialysis session.

Discussion:

Our findings in this study , show that calcium balance varies from patient to patient**,** out of 170 patients about 17.65 % patients their serum calcium still with normal level in pre (2.35 ± 0.09 mmol/L) and post (2.50 ± 0.06 mmol/L) hemodialysis session with no significant changes, may be related to facts: the intradialytic and interdialytic calcium balance depends on diffusive calcium transport across the dialyzer membrane and convective calcium transport during ultrafiltration, that meaning calcium flux across the dialysis membrane is determined by the diffusion gradient [13]. In addition, diet plays a vital role in dialysis patients . A well balanced diet is necessary for them to stay fit as their kidneys are no longer functioning at its full capacity also they take their medication correctly as prescribed by the doctor . If these HD patients didn't care with above conditions hypercalcemia mainly well be induced with the use of a standard dialysate calcium (dCa) concentration of 1.75 mmol/l [14], but on other hand, if dialysate free of Ca has been used symptomatic hypocalcemia produce within the first 60 min of dialysis for chronic HD patients [15] and hypotension can also result from inadvertent use of a Ca-free dialysate [16]. That make problems in the treatment control. Also, the concentration of dialysate calcium was adequate in 28

% of patients (Group B), and show significant changes in serum calcium

from 1.75 ± 0.11 in pre to 2.32 ± 0.24 mmol/L in post HD session. Those patients have the ability to maintain blood calcium and their pre serum calcium equal 1.75 mmol/l can be maintains easily with dialysate calcium concentration (1.7 mmol/l).

Another finding in this study is 92 patient (54% , group C) ware failure to comply with the guideline, they were with severe hypocalcaemia in pre HD session (1.48 ± 0.16 mmol/L) and in post HD session (1.72 ± 0.20 mmol/L) . The strict maintenance of serum calcium level within the ranges recommended by the K/DOQI guidelines difficult in these patients group to achieve due to multifactorial reasons might affect calcium balance during dialysis besides [dCa], several factors are the lowering concentration of pre-dialysis serum calcium 1.48 ± 0.16 mmol/L (hypocalcemia), parathyroid and vitamin D status, type and severity of concomitant bone disease, dietary habits, dialysis modality and they may be carless and didn't take their medication correctly as prescribed by doctors so they develop hypocalcemia with secondary hyper-parathyroidism of end-stage renal disease (ESRD) [17] Lowrie and Lew (1990) [18] , Foley and *et al* (1996) [19] showed that a serum calcium < 2. was associat ith mortality. These data have been challenged by data from Block *et al* (2004) [20] and Young *et al* (2005) [25]. Block *et al* (2004) [20] showed that low serum calcium < 1.96 mmol/L (8.0 mg/dL) was associated with a lower relative risk of all-cause mortality compared to the normal range of 2.25–2.5 mmol/L [12] and a similar result was demonstrated by Young and *et al* (2005) [21] for serum calcium < 1.96 mmol/L (< 7.8 mg/dL).

In 2013 Zhang D.L . and *et al* make a study on 120 HD patients in Chinese results indicate that increasing dialysate Ca to 1.75 mmol/L can decrease the elevated levels of serum iPTH and phosphorus, reduce the doses of calcium and vitamin D3, and be safe for short periods of time[22] that was agree with our results.Adverse with our results , it seems that blood calcium was better controlled when 1.5 mmol/l dialysate calcium concentrations were used, compared to 1.75 mmol/l and 1.25 mmol/l. It is worth pointing out that other published studies on the subject have proved the failure to comply with the guideline, when Maduell and colleagues analyzed the data of their 925 and 1123 patients who received 1.25 mmol/l and 1.5 mmol/l dialysate calcium concentration, respectively, they found that 41.8% of former group showed intact PTH levels higher than 300 pg/mL versus 24.9% of the latter group [23]. For all results we can see that, the use of a 1.75-mmol/L d[Ca] was associated with a significantly

normal ([ca] < 2.40) or Pre hypocalcimia ([Ca] ≥ 1.75 mmol/l),

we would like to take issue with this statement and warn against the indiscriminate use of a low calcium dialysate in all patients receiving haemodialysis therapy. May be another choice use dialysate calcium 1.5 if the concentration of blood calcium 2.4 mmol/l to avoid hypercalcimia and calcification.

In general, to maintain a neutral calcium balance in adult haemodialysis patients with severe degree pre - hypocalcemia ([Ca] ≤ 1.48 mmol/l) dialysate Ca concentration (1.75 mmol/l) should be increased by ~ 0.25 mmol/l to maintain comparable balances or treated with calcium gluconale (10 % w/v) injection ampoule (1ml ≈ 0.23 mmol/l) after HD session or increased hemodialyzing session number per week.The debate on the most adequate dialysate calcium concentration for intermittent haemodialysis therapy is ongoing. There is probably no one optimal concentration. Ideally the dialysate calcium would be adapted to each patient's needs this is not feasible , so the choice of an appropriate dialysate calcium (Ca) concentration and measured serum calcium in pre and post HD session are crucial in the management of dialysis patients, these results may provide insight into the status of current practice in the era of such guidelines.

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توازن كالسيوم الدم وتركيز كالسيوم الديلزه لدى مرضى غسل الكلى ألدموي في محافظة ذي قار / العراق

م. زينب علي كاظم *

هدف الدراسة:

تهدف الدراسة الحالية الى تحديد ما اذا كان تركيز كالسيوم الديلزه الدمويه كافيا لتحقيق توازن في مستوى تركيز كالسيوم الدم لدى المرضى الذين يتلقون علاج الديلزه الدموية أو غير كافيا.

المرضى وطريقة العمل:

تم تجميع 170مريض يعانون من فشل كلوي مزمن في وحدة الديلزه في مستشفى الحسين التعليمي في محافظة ذي قار.

النتائج:

170مريض تضمن 70 (30 %) امرأة و100 (70%) رجل وبعمر يتراوح من 19 الى 90 سنة , مدة جلسة الديلزه باليوم (3) ساعة , عدد مرات الديلزه كانت **مرتان في الاسبوع لكل المرضى** , إضافتا إلى ان تركيز كالسيوم الديلزه المستخدم 1.75 ملي مول/لتر .
بينت النتائج وجود توازن طبيعي لكالسيوم الدم قبل وبعد الديلزه بدون فرق معنوي ($p > 0.05$) لدى 30 مريض (17.65%) حيث كان مستوى كالسيوم المصل ضمن المستوى الطبيعي (2.24- 2.55 ملي مول/لتر) كما لوحظ تغير عند 48 مريض (28 .24%) لكن ليس ملحوظ ($p > 0.05$) من 0.11 ± 1.75 الى 0.24 mmol/L ± 2.32 بينما وجد انخفاض لدى 92 (54.11 %) مريض قبل 1.48 ±0,16 ملي مول/لتر وبعد 1.72 ±0,20 ملي مول/لتر الديلزه وبدون فرق معنوي أيضا .
($p > 0.05$).

الاستنتاجات:

أن تركيز كالسيوم الديلزه 1.75 ملي مول/لتر **كافي لتحقيق توازن طبيعي في تركيز كالسيوم الدم بالأخص المرضى ذوي تركيز طبيعي اقل من 2.4** ملي مول/لتر **أو في حالة مستوى كالسيوم الدم ≤ 1.75** ملي مول/لتر. **أما بالنسبة للمرضى ذوي الانخفاض الحاد في مستوى كالسيوم الدم ≤ 1.75** ملي مول/لتر **فيفضل زيادة تركيز كالسيوم الديلزه 1.75** ملي مول/لتر **بنسبة مقاربة إلى0,25** ملي مول/لتر **لتحقيق التوازن قدر الإمكان أو يعالج المريض بعد انتهاء عملية الديلزه بمادة كليكونات الكالسيوم(10% w/v) امبول 10 مل .**

الكلمة المفتاح: توازن كالسيوم الدم , الديلزه الدموية , تركيز كالسيوم الديلزه الدموية.

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