Moderate Versus Low Intensity Aerobic Exercise on Bone Mineral Density in Patients on Hemodialysis

Shimaa N.Aboelazm[1]

[1] Cairo University, Misr University for Science and Technology.

Received: 9 April 2013 Accepted: 30 April 2013 Published: 15 May 2013

Abstract

Chronic kidney disease (CKD) is recognized as a major health problem reflecting the growing elderly population and increasing numbers of patients with diabetes and hypertension. Medical researches confronted with mana-gement of complex medical problems that are unique to patie-nts with chronic renal impairment and renal dialysis where pati-ents suffer from hypocalcemia that subjected them to oste-oporosis.Objective: The aim of this study was to compare the effect of two different intensities of aerobic exercises on bone mass density in patients on haemodialysis.

Index terms— bone mass density /osteoporosis/ renal haemodialysis/ aerobic exercises

1 Introduction

hronic kidney disease (CKD) is a progressive condition that often comes with other multiple complications, such as diabetes, hypertension, re-nal osteodystrophy, anemia, cardiovascular disease, and malnutrition. The earlier the recognition of CKD and trea-tment of its complications the better the long-term out-comes (1). kidneys have many important roles, such as regulating fluid and minerals in the body, they stimulate bone marrow to make red blood cells, synthesize vitamin D, regulate blood pressure, excrete waste chemicals in the urine and regulate acid-base levels. In kidney failure, the blood concentrations of calcium and phosphorus become abnormal. Calcium level drop is a condition called hypocalcaemia that can cause muscle weakness and nerve problems. In contrast, phosphorus levels rise. This is a condition called hyperp-hosphatemia, which can cause bone problems and itching. (2).

Hypocalcaemia occurs in kidney failure for at least two reasons. First, kidneys cannot synthesize vitamin D which normally raises the level of calcium in the body. Without vitamin D, calcium is not absorbed from the diet. Second, high levels of phosphate that could not bind to calcium deposit in the tissues as the diseased kidney could not excrete it. Low calcium levels encourage the release of parathyroid hormone (PTH). This hormone increases blood calcium by reabsorbing calcium from the bones. This can lead to a condition called renal osteodystrophy(ROD) . (3) . The syndrome known as chronic kidney disease-mineral and bone disorder (CKD-MBD) is composed of clinical, biochemical and radiological abnormalities where progressive bone loss and muscle cramping frequently occur (4) .

Bone strength reflects the integration of two main features: bone density and bone quality. Bone density is expressed as grams of mineral per area or volume, and in any given individual is determined by peak bone mass and amount of bone loss. Bone quality refers to architecture, turnover, damage accumulation (e.g.,microfractures) and mineralization (5) .Normal bone density is dfined as being (-1 standard deviation) or greater than the mean at 30-40 years (peak bone mass). Bone density between -1 SD and -2.5 SD of peak bone mass (T sc-ore between ?1.5 and ?2.5) has been defined by the WHO as osteopenia, and equal or below 2.5 SD of peak bone mass (a T score ? ? 2.5), as osteoporosis (6)

2 (D D D D) I

Renal osteodystrophy (ROD) is a spectrum of bone mineral changes that could range from the high-turnover lesions of secondary hyperparathyroidism to the low-turnover lesions of a dynamic bone disease .The impact of different types of ROD on bone density in patients with CKD remains undefined. Dual energy X-ray absorptiometry (DXA) is the commonest method used to screen for osteoporosis in adults due to its precision and accuracy, short scan time and low radiation (3) .

Aerobic exercise increases bone mass by using body weight as the resistance. Walking and running are great ways to increase or maintain bone mass while increasing cardiovascular fitness. (8) Exercise training in adults with CKD can affect the following factors: Muscular hypotrophy, strength, endurance & physical functioning (9, ??0) .The structure and number of capillaries and mitochondria ??11) . Glucose meta-bolism ??12) . Aerobic capacity (13). Blood pressure (14) and Cardiac performance ??11).

It is known that inactivity, muscle wasting and reduced physical functioning especially for those on long-term dialysis are associated with increased mortality in CKD. Exercise in patients receiving regular dialysis as a treatment for end-stage renal disease was first introduced 3 decades ago, but is still only offered in a minority of renal units around the world, despite a significant body of evidence to support its use. Work is needed to increase awareness of the potential benefits of increased physical activity for patients with advanced CKD (15) .

This study was conducted to compare the effect of two different intensities of aerobic exercises on bone mass density in patients with haemodialysis.

3 II.

4 Subjects, Materiales and Methods

5 a) Subjects

Thirty male patients with mean age (52.75-±4.51) years were enrolled in this study; they underwent renal haemodialysis for 2 years ago with rate of 3 times/week. They were randomly selected from Police hospital using one to one base.

6 b) Inclusion crieteria

All patients gave their written informed consent for the participation in the stu-dy that had been preceded by the explanation of the aim of the study and its course, their role in it with regard to time and money, assurance of protection of the obtained data, and information about free-willingness to participate in the study and the possibility to withdraw from the study at any time.

? body mass index ranged from 25 to 29 kg/m 2 .

? systolic blood pressure ranged between 130-190 mm Hg. ? diastolic blood pressure between 85-100 mm Hg).

? T-score between -1.1and -2.4 SD according to DEXA measurements. ? Male subjects with age ranged from 45 to 55 years c) Exclusion crieteria

? chest ,cardiac, or hepatic diseases.

? severe life limiting illness (e.g. malignancy).

? marked anaemia(Ht<25%).

? using of weight-loss medications.

? smoking.

? neurological or other endocrinal disorders.

? Laboratory investigation kit. The other 2 steps of evaluation were assessed at the beginning of the study and after 8 weeks of training: (a) Laboratory investigations (Before dialysis sessions), blood samples are collected by venipuncture for detecting the levels of Serum Calcium and Phosphorus. (b) A DEXA scanner was used for evaluation of BMD.

Subjects were placed in a supine position or on their side while the x-ray scanner performed a series of transverse scans, moving from top to bottom of the region being measured at 1-cm intervals. Three separate scans were performed: 1) AP view of the lumbar (L1-L4) spine.

2) AP view of the left hip providing information on the femur.

3) AP view of the left wrist with the subject supine.

While the scanner moved across the left hip, providing information on the femur neck (whole hip), left wrist (33% of left radius), and measure lateral view of the lumbar (L1-L4) spine. Regional and total body BMD measurements with this technique are highly reliable when subject positioning is carefully standardized (16) .. The test results included the following scores: T score, Z score, Bone mineral density, Percentage, Age matched percentage.

7 f) Training program

Patients were randomly assigned into two groups of equal number, Group A and Group B (each gro- Group A received a program of moderate intensity aerobic exercise (60%-70% MHR) with an exercise period of 40 minutes divided as warming up phase:3-5 min. with 30% MHR, actual phase:20-30 min. with 60%-70% MHR and cooling down phase:3-5 min. Group B received a program of light intensity aerobic exercise (40%-60% MHR) with an exercise period of 40 minutes divided as warming up phase : 3-5 min. with 30% MHR, actual phase: 20-30 min. with 40%-60% MHR and cooling down phase:3-5 min. with 30% MHR three times weekly for six month. The training program was performed under careful supervision for both groups.

8 III.

9 Results

10 Discussion

Changes in calcium metabolism during exercise are dependent on the exercise intensity. Moderate endurance exercise increases serum calcium level (17) but decreases serum PTH (18) . In bone, endurance exercise increases bone mineral density (BMD), bone strength (19) and bone formation rate (20) . Thus, moderate endurance exercise seems to induce positive calcium balance, and has a beneficial effect on bone metabolism. In addition, a combination of moderate-impact exercise and adequate calcium intake can increase bone strength during childhood (21) . Interestingly, modes of exercise, such as running (weight-bearing exercise) and swimming (nonweight-bearing exercise) can affect bone calcium metabolism in a different way.

that physical activity before dialysis treatment increases urea Kt/V through improved perfusion of muscle, the main urea-containing body compartment. Similar effects have been described for phosphate removal with predialysis physical activity increasing phosphate removal by 6% and intradialytic activity even by 9% (22) .

Even moderate exercise is related to an enhanced bone mineral density in peripubertal boys and also in young men compared to controls with a low level In the present study there were significant difference between the two groups (group A &B) in serum blood sample of calcium and phosphorus, as there were significant increase in groups (A& B) in serum calcium (12.29%, 4.23%) respectively, and significant decrease in serum phosphorus in group A compared to group B (21.67%, 6.52%) respectively in response to the designed aerobic exercise program.

As well as increased percent of improvement in T score for group A in the measured sites lumbar spine, left hip and left wrist by 18.2%,13.3% and 7.69% respectively. Regarding to group B the percent of impovement was less as shown in lumbar spine by 11.3% and left hip by 2% with no change in the left wrist. That dragged the emphasis to the effect of the moderate exercise applied to group A that gives significant increase in bone mineral density for patients on The results of the study after the suggested period of treatment confirmed the findings of John et al., 2007 (24) who stated that moderate exercise intensity results in regional increase in bone mass.

This Coincided with Asadi et al., 2007 (25) who studied the effects of exercise in reducing phosphorus levels and reported that although exercise decreased the level of phosphorus, the significant effects and changes could be observed in long-term and perhaps more intense exercise might be required for some patients.

The rehabilitation of the hemodialysis patients is enh-anced, most likely because aerobic exercise induces elongation and an increase in the diameter of the striated muscle fibre, improves their capillary vasculature, as well as their aerobic capacity, and positively affects their blood pressure measurements, their brain function and the lipid profile. The increased ionic calci-of physical activity. Animal studies have demonstrated that such an increase in bone mass is the result of an enhanced formation of organic bone matrix and a higher apposition rate of minerals such as calcium (Ca). A moderate level of physical exercise can already acutely influence various Ca metabolic parameters in untrained human subjects: Alterations can include a decrease in ionized serum Ca levels and an increase in serum parathyroid hormone (PTH) levels (23) . um of the cell sarcoplasma in the skeletal muscles, which is prevalent during the muscle contractions (26) . The results of numerous studies have shown that exercise training to be of benefit for dialysis patients (27) during haemodialysis on physical perfo-rmance and nutrition assessment that agreed with resu-lts of this study. In addition to its well-known ben-eficial effects on cardiovascular fitness and mortality (28) exercise also has an anabolic effect and has been shown to reduce muscular atrophy in dialysis patients (29) . The results of the present study showed significant improvement in calcium and phosphorus electrolytes with aerobic exercise during hemodialysis that coincided with the data presented by Vaithilingam et al., 2004 (22) , who suggest that an aerobic exercise movement's regimen for 15 minutes during hemodialys is sessions improve serum phosphate and calcium levels in a period of 8 weeks. This observation might be due to direct beneficial effects of aerobic exercise or general effects of regular intradialytic exercise.

These findings agree with Hagberg et al., 2001 (30) who stated that prolonged low-to-moderate-intensity physical activity was associated with higher BMD.

The results supports the findings of Vencint and Braith, 2002 (31), who reported that, regional BMD can be increased via high-intensity resistance exercise even in healthy elderly persons. The results also indicate that both high-and low-intensity resistance exercises can change biochemical indices of bone turnover. As evidenced by increased OC/PYD and BAP/PYD ratios, these changes seemingly favor increased bone form-ation.

The results of this study are also consistent with that stated by Hurley and Stephen ,2000 (32) who reported that strength training is considered a promising inte-rvention for reversing the loss of muscle function and the deterioration of muscle structure that is associated with advanced age as well as osteoporotic effects due to renal dialysis. This reversal is thought to result in imp-rovements in function abilities and health status in pati-ents on dialysis by increasing muscle mass, strength and power and by increasing bone mineral density (BM-D).

V.

11 Conclusion

The results of this study supported the good effect of aerobic exercise on serum calcium and phosphorus in patients under renal hemodialysis. Aerobic exercise showed a significant increase serum calcium and significant decrease serum phosphorus in both groups in addition to increased BMD. The result of this study concluded that moderate intensity aerobic exercise (60%-70%MHR) is beneficial than light intensity aerobic exercise (40%-60%MHR) in modulating serum calcium and phosphorus in hemodialytic patients reflected on BMD. [1]

Figure 1:

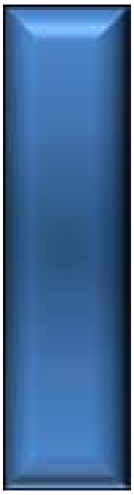


Figure 2: I

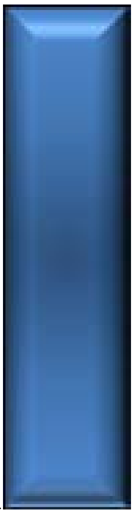
1 

Figure 3: Figure 1 :

3 

Figure 4: Figure 3 :

4

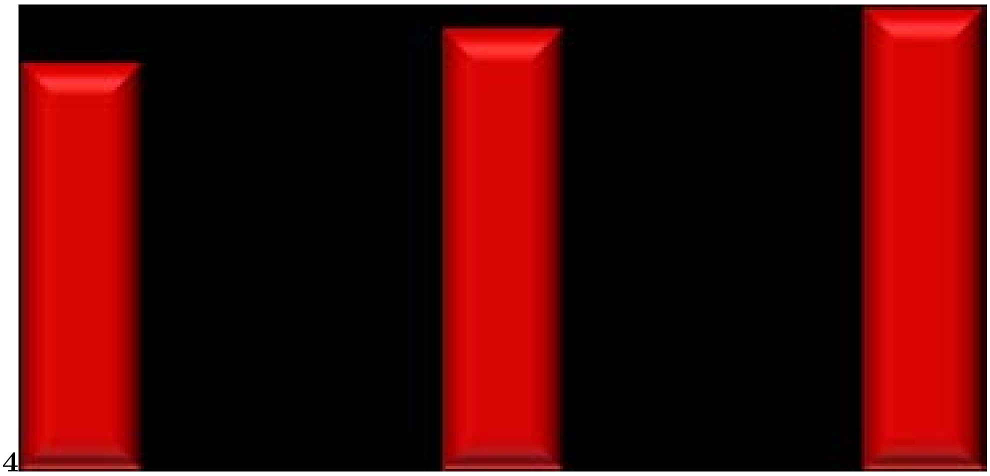


Figure 5: Figure 4 :

1

Items	Group A		Group B	Comparison				
	Mean	±SD Mean		±SD t-value		P-value		S
Age (yrs)	51.86	±4.22 53.6		±4.82 1.04		0.3	NS	
Weight (Kg)	86.26	±10.0 6	84.66	±7.37 0.49		0.62	NS	
Height (cm)	172.26	±5.68	169.33	±6.97	1.26	0.21	NS	
BMI (Kg/m 2)	29.02	±2.61	29.56	±2.53	0.57	0.57	NS	
Systolic blood pressure (mmHg)	162.66	±17.91	165.33	±15.52	0.43	0.66	NS	
Diastolic blood pressure (mmHg)	93.66	±5.49	91.66	±5.87	0.96	0.34	NS	

[Note: Yrs: years, Kg.: Kilograms, Cm. centimeters, Kg/m 2 : Kilogram per meter square, mmHg: millimeters mercury]

Figure 6: Table 1 :

2

Calcium level	Group A Pre	Post
Mean ± SD	7.97±0.72	8.95±0.61

t-value P-value Percentage improvement SD: Standard Deviation, *: Significance 7.5 0.0001* of 12.29 % Gro

Calcium level	4 6 8 10 2 0	7.97	8.03
		Pre treatment	

[Note: © 2013 Global Journals Inc. (US) with 30% MHR three times weekly for six months.]

Figure 7: Table 2 :

3

Phosphorus level	Group A	Group B			Between both groups	
	Pre	Post	Pre	Post	Post	post
Mean ± SD	6.46±1.39	5.05±1.21	6.44±0.8	6.02±0.78	0.01	0.96
t-value	6.71	3.09			0.03	2.59
P-value	0.0001*	0.008*			0.97	0.01*
Percentage improvement of	21.67 %	6.52 %				

SD: Standard Deviation, *: Significance

[Note: Figure 2 : Mean and ±SD of Phosphorus level pre and post treatment of groups (A,B)]

Figure 8: Table 3 :

4

Group A	pre exercise	Post exercise	T-value	P-value	Percentage of change
Lumbar spine	1.30 ± 0.747	1.10 ± 0.759	6.96	0.001*	18.2%
Left hip	1.36 ± 0.894	1.20 ± 0.928	6.07	0.001*	13.3%
Left wrist	1.40 ± 0.692	1.30 ± 0.776	7.22	0.001*	7.69%

*[Note: *: Significance]*

Figure 9: Table 4 :

5

Group B	Pre exercise	Post exercise	T-value	P-value	Percentage of change
Lumbar spine	2.17 ± 0.72	1.95 ± 0.90	6.96	0.001*	11.3%
Left hip	1.53 ± 0.91	1.50 ± 0.95	6.07	0.001*	2%
Left wrist	1.89 ± 1.0	1.87 ± 0.97	7.23	0.345	———

*[Note: values of T score pre and post treatment at lumbar spine, left hip, left wrist for group B *: Significance]*

Figure 10: Table 5 :

6

	Group A	Group B	T-value	P-value
Lumbar spine	1.95±0.82	1.10±0.75 -2.779		0.010*
Left hip	1.50±0.95	1.20±0.92 -0.735		.467
Left wrist	1.90±0.96	1.40±0.77 1.51		0.14
IV.				

Figure 11: Table 6 :

013	013
2	2
Year	Year
( ) I	10. Mcintyre CW, Selby NM, Sigrist M, Pearce LE, Mercer TH, Volume XIII Issue V Version I (D D D D) I

Figure 12:

[Pechter et al. (2003)] *Beneficial effects of wat-er-based exercise in patients with chronic kidney disease. International journal of rehabilitation research Internationale Zeitschrift fur Rehabilit-ationsforschung*, U Pechter , M Ots , S Mesikepp , K Zilmer , T Kullissaar , T Vihalemm . 2003. Jun. 26 p. .

[Beck and Snow ()] 'Bone health across the lifespan exercising our options'. B R Beck , C M Snow . *Exerc Sport Sci Rev* 2003. 31 p. .

[Woolf and Akesson ()] 'Book of An Atlas of Investigation and Manegement'. Anthony D Woolf , Kristina Akesson . *Clinical Publishing* 2008. (book1.

[Welch and Weaver ()] 'Calcium and exercise affect the growing skeleton'. J M Welch , C M Weaver . *Nutr Rev* 2005. 63 p. .

[Deligiannis ()] 'Cardiac adaptations following exercise training in hemodialysis patients'. A Deligiannis . *Clin Nephrol* 2004. 61 p. .

[Asadi et al. ()] *Critical care nursing ICU, CCU, dialysis. Salemi publiccation*, N A Asadi , S H Bassampour , M Zolfaghari . 2007. p. . (2th ed.; p.)

[Yeh and Aloia ()] 'Effect of physical activity on calciotropic hormones and calcium balance in rats'. J K Yeh , J F Aloia . *Am J Physiol* 1990. 258 p. .

[Yasumura ()] 'Effect of physical activity on calcium and phosphorus metabolism in the rat'. S Yasumura . *Am J Physiol* 1989. 256 p. .

[Huang et al. ()] 'Effects of different exercise modes on mineralization, structure, and biomechanical properties of growing bone'. T H Huang , S C Lin , F L Chang , S S Hsieh , S H Liu , R S Yang . *J Appl Physiol* 2003. 95 p. .

[Heiwe et al. ()] 'Effects of regular resistance training on muscle histopathology and morphometry in elderly patients with chronic kidney disease'. S Heiwe , N Clyne , A Tollback , K Borg . *Physiatrists* 2005. 84 (11) p. . (American journal of physical medicine & Rehabilitation /Association of Academic)

[Suki ()] 'Effects of sevelamer and calciumbased phosphate binders on mortality in hemodialysis patients: Results of a randomized clinical trial'. W N Suki . *J Ren Nutr* 2008. 18 p. .

[Zittermann et al. ()] 'Evidence for an acute rise of intestinal calcium absorption in resp-onse to aerobic exercise'. A Zittermann , O Sabatschus , S Jantzen , P Platen , A Danz , P Stehle , P . *EurJNutr* 2002. 2002. 41 p. .

[Johansen ()] 'Exercise in the end-stage renal disease population'. K L Johansen . *Journal of the American Society of Nephrology* 2007. 18 p. .

[Konstantinidou et al. ()] 'Exercise training in patients with end-stage renal disease on hemodialysis: comparison of three rehabilitation programs'. E Konstantinidou , G Koukouvou , E Kouidi , A Deligiannis , A Tourkantonis . *J Rehabil Med* 2002. 34 p. .

[Fauci ()] *Harrison's Principles of Internal Medicine*, A S Fauci . 2008. 2008. (17th Edition 268:1373, 1313)

[John et al. ()] C John , Michael S Stevenson , Marsh . *An Atlas of Osteoporosis*, 2007. (third edition)

[Hagberg et al. (2001)] 'Moderate physical activity is associated with higher bone mineral density in post-menopausal women'. J M Hagberg , J M Zmuda , S D Mccole , K S Rodgers , R E Ferrell , K R Wilund , G E Moore . *J Am Geriatr Soc* 2001. Nov. 49 (11) p. .

[Carter and Bouxsein ()] 'New approaches for interpreting projected bone densitometry data'. D Carter , M Bouxsein , MarcusR . *J Bone Miner Res* 1992. 7 (1) p. .

[Kosmadakis et al. ()] *Physical Exercise in Patients with Severe Kidn-ey Disease Nephron Clin Pract*, G C Kosmadakis , A Bevington , A C Smith , E L Clapp , J L Viana , Bishop , J Feehally . 2010. 115 p. .

[Karamouzis et al. ()] 'Physical training in patients on hemodialysis has a beneficial effect on the levels of eicosanoid hormone-like substances'. Ioannis Karamouzis , Dimitrios Grekas , Michael Karamouzis , Konstantinos Kallaras , Vassiliki Stergiou-Michailidou , Evangelia Kouidi . *HORMONES* 2009. 8 (2) p. .

[Prevention and management of osteoporosis : report of a WHO scientific group WHO Scientific Group on the Prevention and Ma 'Prevention and management of osteoporosis : report of a WHO scientific group'. *WHO Scientific Group on the Prevention and Manaement of Osteoporosis*, (Geneva, Switzerland) 2000. 2003. 2007-05-31.

[Renal Data and System ()] U S Renal Data , System . `http:-//www.usrds.org/adr.htm` *USRDS 2006 Annual Data Report: Atlas of End-Stage Renal Disease in the United States*, (Bethesda, MD) 2006. (National Institute of Diabetes and Digestive and Kidney Diseases)

[Vincent and Braith ()] *Resistance exercise and bone turnover in elderly men and wo-men. Medicine and science in sports and exercise*, R K Vincent , W R Braith . 2002. p. .

[Kumar ()] *Robbins and Cotran Pathologic Basis of Disease*, V Kumar . 2009. (8th Ed, 2)

[Gilbert et al. ()] 'Role of Physiotherapy in Renal Rehabilitation'. M C Gilbert , Amy W L Ho , Helen K Y Chung , Luk . *Physiotherapy Department, Queen Elizabeth Hospital* 2003. 8 (2) .

[Hurley and Stephen (2000)] 'Strength Training in the Elderly. Effects on Risk Factors for Age-Related Diseases'. F B Hurley , M R Stephen . *Sports Med* 2000. Oct. 30 (4) p. .

[Department Of Health and Services ()] *Surgeon General's Report on Physical Activity and Health. Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion*, Human Department Of Health , Services . 1996. U.S.

[Hart et al. ()] 'Swim-trained rats have greater bones mass, density, strength, and dynamics'. K J Hart , J M Shaw , E Vajda , M Hegsted , S C Miller . *J Appl Physiol* 2001. 91 p. .

[Depaul et al. (2002)] 'The effectiveness of aerobic and muscle strength training in patients receiving hemodialysis and EPO: a randomized controlled trial'. V Depaul , J Moreland , T Eager , C M Clase . *Am J Kidney Dis* 2002. Dec. 40 (6) p. .

[Cappy et al. ()] 'The effects of exercise'. C S Cappy , J Jablonka , E T Schroeder . *J Ren Nutr* 1999. 1999. 9 p. .

[Kouidi et al. ()] 'The effects of exercise training on muscle atrophy in haemo-dialysis patients'. A Kouidi , M Albani , K Natsis . *Nephrol Dial Transplant* 1998. 13 p. .

[Wluka et al. ()] 'Tibial plateau size is related to grade of joint space narrowing and osteophytes in healthy women and in women with osteoarthritis'. A E Wluka , Y Wang , S R Davis , F M Cicuttini . *Ann Rheum Dis* 2005. 64 p. .

[Vaithilingam et al. ()] 'Time and exercise improve phosphate removal in hemodialysis patients'. I Vaithilingam , K R Polkinghorne , R C Atkins , P G Kerr . *Am J Kidney Dis* 2004. 43 p. .