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Muscle ultrasound emergy tool for assessment of quantity and quality of muscle in chronic kidney disease patients

[1]Dlmeida B, Nephrology Specialist, Parma.

[2]Aellido D, Nephrology Specialist, Parma.

Corresponding Author: Dlmeida B, Nephrology Specialist, Parma.

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Abstract

Objective: This study aimed to explore the usefulness muscle ultrasound as tool for evaluation muscle parameters in CKD patients.

Methods: Ultrasound muscle evaluation of the right rectus femoris, hand grip strenght, biochemical parameters, right calf circumference and bioelectrical impedance analysis measurement of the right lower limb were performed in CKD patients. The correlations between the changes in the corresponding ultrasound and bioelectrical impedance analysis variables were analyzed.

Results: Have been evaluated total of 78 patients, 68 in CKD stage G5, G4, G3b non in dialysis and 10 on peritoneal dialysis (PD), with mean age of 71.54 ± 11.76 years, 59% were male and 48% Diabetes Mellitus**.** **Compared to** advanced CKD patients, the measurements of cross-sectional area and axes didn´t find significant difference between CKD and DP**.** In relation with muscle mass ultrasound parameters in CKD patients the possible factor can influence favorizing better values were: Exercice, lower age, and good hand grip strenght as phase angle and intracellular water adecuate can influence a good muscle mass parameters.

Conclusions: CKD results in lower values in the eco-muscular assessment than healthy people in both CKD and DP. The transverse and longitudinal diameters and muscle area are smaller than those described in the healthy population. Having performed physical exercise conditions better parameters in the muscle ultrasound. Muscle ultrasound appears as an emerging, economical, easy tool that does not provide ionizing radiation. It´s necessary more study in order stablish the normal values according age groups.

Keywords: CKD, DXA, MRI, Radiation

Introduction

Chronic kidney disease favors the appearance and with a higher percentage in its progression of protein energy wasting, which leads to a decrease in muscle mass.[1]

This occurs due to a decrease in anabolism and an increase in catabolism that affects muscle mass and can produce muscle wasting and thus deterioration of functionality unless it is adequately prevented. As CKD progresses, it becomes more evident, especially in elderly patients, that the loss of muscle mass may already be favored by age.[3]

These alterations in muscle mass are not only in the amount of muscle mass but also in the composition of fibers and their functional capacity, so there are a series of requirements that must be met when talking about sarcopenia.

The European sarcopenia group made 2 consensuses in 2010-(4) and later in 2019 with the intention of establishing how we could establish the diagnosis of sarcopenia by evaluating muscle strength, muscle mass and functionality (muscle strength or dynapenia, muscle mass and finally functionality).[5]

Sarcopenia can be seen in more than 10% of the general elderly population and leads to greater morbidity and mortality, with a greater risk of falls due to loss of functionality and worse quality of life.[6,7] The intrinsic repair capacity of skeletal muscle when it has received damage decreases with age because the capacity for muscle regeneration is reduced, and sarcopenia and fibrosis are favored. If we also have a disease such as kidney disease that favors catabolism and sedentary lifestyle adds enhancing effects.[8]

An important problem is how we measure muscle mass and with what tool, in addition to finding the appropriate cut-off points to diagnose its deficit. The tools used are Bioimpedance, DXA, MRI and computed tomography. For a long time, DXA has been the gold standard, but for kidney patients, CT and MRI are currently more common.[9]

These tools are not very accessible and in the case of CT they can promote excess radiation.[10]

Bioimpedance is very useful but it is not a direct measurement, which is why a tool that is easy to perform and seems to have a promising future has emerged: muscle ultrasound.[11-13]

There is evidence that measuring the muscle mass of the rectus femoris in the thigh can constitute an early diagnostic criterion to determine the presence of sarcopenia.[14]

The measurement of the rectus femoris of the quadriceps is a referenced measurement for its correlation with muscle mass, strength and functional tests. The most used are muscle area and thickness (transverse and fascicle length)[15]

For kidney patients, we need a tool that is easy to perform, affordable, reproducible and that helps us evaluate changes in the size of muscle mass when CKD progresses and especially when we intervene with physical exercise to improve muscle mass and functionality. It is also necessary to establish the limitations that states of hyper hydration and inflammation exert on some tools that affect nutritional and body composition parameters such as BIA.[16]

Independently the possible limitations of the toll that we have to can measure muscle parameters, due to accesibility, early to assess and no risk radiation, musclesqueletal ultrasound is being developed as an emerging alternative in recent last years to assess body composition within morpho functional evaluation.[17]

There are not many published articles on patients with CKD and only two talks about a control group for comparison. Few articles has been carried out comparing it with nuclear magnetic resonance to establish the possible usefulness of ultrasound to assess changes in the rectus femoris muscle of the quadriceps.[18-19]

Material and methods

Retrospective cross-sectional unicentric study with data collected from usual clinical practice that includes patients over 18 years of age, with the absence of myopathy, neurological or skeletal diseases that affect the muscles and who were in advanced CKD (ACKD) consultation with periodic assessments of nutrition and functionality in the CKD Unit.

The aim of this study was to assess the usefulness of ultrasound parameters of muscle mass in CKD patients and correlate it with age, gender, hand grip strenght, exercise, biochemistry and body composition by BIVA.

We evaluated 78 ACKD patients stages 3,4,5 not on dialysis (68 patients, 87.2%) and peritoneal dialysis assessed for nutritional status (10 patients, 12.8%) according to the usual practicum measuring by ultrasound the rectus femoris of the quadriceps since october 2022 to october 2023.

Exclusion criteria were limb amputation; hospitalization within the previous one month; bedridden or immobilization syndrome.

Inclusion criteria: Patients over 18 are included, with the absence of myopathy, neurological or orthopedic diseases that affect the muscles. Also presence of cardiac pacemaker, implantable cardio verter-defibrillator, or metallic non-removable pieces. Patients from Outpatient advanced CKD consult with monitorization nutritional parameter routinely.

Demographic, clinical and anthropometric data were collected, and routine biochemistry was measured at the time of US and BIVA measurement. Body mass index (BMI) was calculated as weight (kg)/height2 (m2).

We perform muscle ultrasound at the same time as BIVA AKHERn101, calf circumference, hand grip strenght (Hydraulic dynamometer Baseline® model 12-0240. to evaluate body composition and muscle strength using dynamoter, as well as analytical parameters from the same review for comparison. Likewise, we asked if they had done and/or did physical exercise or not because of the impact on muscle mass. For hand grip strenght we considered 16 kg for female and 27 for male as cut of point.

Ultrasound muscle study

Ultrasound Technique for quadriceps rectus femoris muscle (QRFM) thickness was measured using ultrasound portable sonosyteportable device. Patients are evaluated in the supine position in knee extension and muscles relaxed, the measurement is made at the junction between the proximal 2/3 between the anterior superior iliac spine and the superior pole of the patella. The measurement is done with ultrasound with straight transducer. The transducer was placed perpendicular to the long axis of the thigh, with minimal pressure to avoid compression of the muscle.

The measurement was carried out coinciding with the advanced CKD outpatient consultation and after the bioimpedance and was repeated two times.

The muscleultrasound parameters evaluated were: Transverse axis(A), Longitudinal axis(B), Circumference and muscle area and ratio B/A.

Vectorial BIA body composition

The mono frequency (50 KHz) BIVA (AKERN 101, with hydrasite technology) was used to obtain Rz, resistance, Xc, reactance and PA, phase angle)[23]. Body cell mass (BCM), extra-cellular mass (ECW), basal metabolic rate (BMR) were estimated from BIVA parameters. The electrodes were placed on the arm and leg free of vascular access according to the usual technique, connecting the clamps to the electrodes to obtain the measurements. Today the normal values are: Aperdicular muscle mass(AMM) the 20 kg for males and 15 kg for females, or elvalor de la AMM/Kg^2, stablising as cut-off point 7 Kg/m^{2}for males and 6 Kg/m^{2}for males.

Statistical analysis

It was performed with SPSS (version 23, IBM Corp. Armonk, NY, USA). Data were expressed as means and standard deviations or median and interquartile range (IQR) based on their distribution for continuous variables; and as frequencies (percentage) for categorical variables.

Results

We evaluated muscle parameters by ultrasound 78 CKD patients, with stages 3,4,5 not on dialysis (68 patients, 87.2%) and (10 patients, 12.8%) in peritoneal dialysis as complement as assessed for nutritional status.

X Age 71.54 ± 11.76 years, 59% were male and 41% were female and 48% were diabetic although it was not the cause of CKD in all diabetic patients.

Global results from ultrasound parameters

The mean of muscle ultrasound parameters in all patients were: A 0.99±0.43, B 2.63±0.77, Circunference (C) 6.31±1.83, muscle area 2.23±1.23 and ratio B/A 2.97±0.94.

The values describing in one article in healthy population A=1,31±1,2 cm, B=3,21±3,4 cms), higher than patients with CKD evaluated in this study.

The global data with the differences between men and women (46 men and 32 women) are shown in table. In the only parameters that we did not find a significant difference according to gender were: B/A ratio in ultrasounds and in BIA: phase angle, Body Cell mass, lean mass, fat mass, albumin, prealbumin, CRP, or Hb.

Table 1: Differences in ultrasound and BIA parameters in relation with gender in the global of the patients.

	Gender	Number	Standard Mean deviation		p
A	M	46	1,0920	43601	0,012
	F	32	8453	38888	
B	M	46	2,8318	65879	0,007
	F	32	2,3569	84708	
C	M	46	6,7611	1,63777	0,009
	F	32	5,6744	1,93955	
Muscle Area	M	46	2,5731	1,18578	0,003
	F	32	1,7491	1,14165	
Ratio B/A	M	45	2,8380	,77408	0,131
	F	32	3,1727	1,13793	
Phase Angle (Ph A)	M	46	5,0522	,80215	0,594
	F	32	4,9484	,88237	
BMI	M	46	29,3848	4,62928	0,013
	F	32	26,3355	5,43388	
Body Cell Mass (BCM)	M	46	28,4478	6,55939	0,001
	F	32	20,9290	4,36151	
Muscle Mass	M	46	28,9565	5,05484	0,001
	F	32	17,3110	3,52679	
Intracelular wáter (ICW)	M	46	22,3283	4,88656	0,001
	F	32	15,3226	3,10416	
Hand Grio Strenght	M	46	30,9333	7,41744	0,001
	F	32	22,0125	6,34633	

Didn´t find significant differences in lean mass, fat mass, albumin, prealbumin, CRP or Hemoglobin.

Comparing results of muscle ultrasound parameters between advanced CKD and peritoneal dialysis didn´t find significant difference between muscle ultrasound parameters, x age was lower but not significant72.75±10,71 years' vs 63.30±15.57 p 0.092 and dindn´t find some dinapenia patients perhaps by only 10 patients in this group.

Muscle Mass by BIVA and relation with muscle ultrasound and muscle strenght

We have calculate cut off point cut percentils in muscle mass by BIVA in the CKD patients: 25% =19,24 kg rs, 50% = 24,92 kg rs y 75%= 29,75 kg rs. Analysing divided in for groups, we have showed significant difference in ultrasound parameters according muscle mass by BIVA, hand grip strenght and calf circumference.

Table 2: Anova muscle ultrasound parameters, hand grip strenght and calf circumference in relation with percentiles of muscle mass by BIVA.

Anova mean muscle ultrasound parameters in muscle mass percentile		N	Media	Desviación estándar	p	95% del intervalo de confianza para la media: Límite inferior	Límite superior	Mínimo	Máximo
A	1,00	18	,7388	,31379	,00090	,5965	,9116	,23	1,35
	2,00	20	,9380	,41022		,7460	1,1300	,30	1,83
	3,00	19	1,0374	,28474		,8981	1,1748	,36	1,32
	4,00	21	1,2088	,54071		,9582	1,4567	,46	3,01
	Total	78	,9888	,43231		,8939	1,0882	,23	3,01
B	1,00	18	2,3422	,78999	,00700	1,9448	2,7388	1,03	3,78
	2,00	20	2,4980	,93787		2,0978	2,8823	,87	3,91
	3,00	19	2,8963	,65982		2,5787	3,2139	1,56	4,19
	4,00	20	2,7930	,71759		2,4572	3,1288	1,39	3,91
	Total	77	2,6344	,77424		2,4587	2,8101	,87	4,19
C	1,00	18	5,4017	2,01723	,11680	4,4585	6,4649	1,08	8,79
	2,00	20	6,2800	1,87338		5,4082	7,1618	3,27	8,73
	3,00	19	6,7420	1,42088		6,0045	7,4718	4,02	9,37
	4,00	21	6,8529	1,33398		5,8189	7,4877	1,98	9,07
	Total	78	6,3155	1,69817		5,9013	6,7292	1,08	9,73
Muscle area	1,00	18	1,5985	1,06088	,00880	1,0409	2,1161	,22	3,79
	2,00	20	1,9670	1,13182		1,4373	2,4967	,48	5,04
	3,00	19	2,5011	1,05130		1,9940	3,0081	,86	4,54
	4,00	21	2,8030	1,34159		2,1931	3,4149	,78	5,88
	Total	78	2,2350	1,23080		1,9577	2,5124	,22	5,88
Hand grip strenght (Right)	1,00	18	16,3089	4,78441	,00160	13,8269	18,8792	10,00	28,00
	2,00	19	27,8421	4,83980		25,4831	30,2211	20,00	39,00
	3,00	19	31,2632	6,24380		28,2338	34,2729	20,00	40,00
	4,00	21	30,9667	8,02484		26,9590	34,7746	20,00	48,00
	Total	77	27,2280	8,73793		25,3162	29,0988	10,00	54,00
Hand grip strenght left	1,00	17	15,2941	5,38053	,00180	12,5888	18,0194	4,00	24,00
	2,00	19	26,2632	4,18747		26,2834	30,2429	20,00	34,00
	3,00	18	31,1053	6,24486		28,6087	34,1148	14,00	42,00
	4,00	21	31,8476	7,05787		27,4187	34,6245	10,00	39,00
	Total	78	26,8421	8,72785		24,8479	28,6363	4,00	39,00
Calf right circumference	1,00	18	32,8722	3,84280	,00180	31,1081	34,7643	27,00	43,00
	2,00	20	36,0500	3,88047		36,2217	37,8763	29,00	43,00
	3,00	14	35,8158	2,38646		34,8848	36,8467	31,00	40,40
	4,00	20	39,8290	3,07082		37,3539	40,8961	30,00	45,50
	Total	77	36,8485	3,98784		36,1415	35,8484	27,00	45,50
Calf left circumference	1,00	17	32,4412	4,35840	,00180	30,2383	34,6821	23,00	42,00
	2,00	19	35,5264	3,59280		33,8087	37,2791	30,00	42,00
	3,00	18	36,3889	2,07656		35,3584	37,4213	32,00	39,50
	4,00	18	40,3283	5,79145		37,2340	42,8177	35,00	59,00
	Total	73	36,1946	4,91083		35,8477	37,3421	23,00	59,00

Muscle strength and its relationship with muscle ultrasound parameters

We consider normal or low dynamometry according to the cut-off points of the European sarcopenia group 17 kg for female and 26 kg for male. Overall, we found dynapenia in 16 patients (20.8%) in the analyzed sample. Didn´t find some Dialysis peritoneal patients with dinapenia. Normal or low hand grip strenght does not lead to significant differences in echo-muscular parameters. Table.

Table 3: Differences in muscle parameters in relation with hand grip strenght normal or low.

Muscle parameters		Mean ±St Deviation	
A	Normal	0.9949±0.4388	0.928
	Low	0.9837±0.4331	
B	Normal	2.6543±0.7978	0.536
	Low	2.5181±0.6984	
C	Normal	6.3787±1.8742	0.459
	Low	5.9925±1.7369	
M. Area	Normal	2.2870±1.2510	0.453
	Low	2.0271±1.2028	
Ratio B/A	Normal	2.9725±0.8629	0.884
	Low	2.9242±1.2238	

We found significant direct correlations from muscle área with:

Hand grip strength right r0,324, p0,01 and calf circumference right r0,296, left r0,323 p0,01, Phase angle r= 0,353 p0,01,

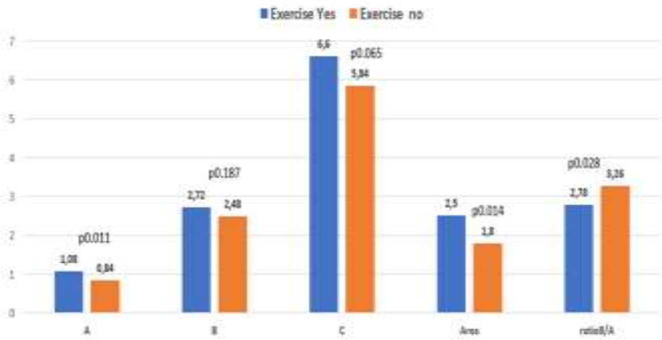
BIVA parameters: A-fase r0,353 , Masa celular (BCM) r0,389 , Masa muscular(MM)r0,404 y agua intracelular (AIC) r0,379 (p0,01)

Age inverse significant relation only in males not in females: r= -0,388, p0,05. The correlations in the different parameters appeared mainly in males.

Physical exercise and its influence on muscle ultrasound parameters.

Analysing whether they did physical exercise we found significantly better parameters in some muscle ultrasound parameters: A1.10±0.48 vs 0.82±0.33 p 0.003, area 2.50±1.36 vs 1.72±1 .03 p0.004 (B and C not next).

Graph 1: Differences between ultrasound parameters in relation to exercise performed.



Given the good correlation between muscle area and phase angle, which in men is r=0.421 p0.004, and since the phase angle in patients with CKD below 4 with BIVA can influence mortality, we performed a regression using the phase angle as dependent variable with cut-off point 4.

The result of lineal regression study was

Muscle area: OR B4.90, CI 95% 1.09-22.30, p0.038, Intracellular Water (L) OR 2.73 CI 95% 1,42-5.19, p 0.002, muscle mass percentiles OR 0.084, CI95% 0.13-0.53, p 0.009, Cte OR 0.000 CI 95%.

Table 4: Values of variables in multivariate regression analysis

	OR	CI 95%	p	Wald
Muscle area	4.90	1.09-22.30	0.038	4.30
Intracellular water	2.73	1.42-5.19	0.002	9.17
Muscle mass percentils(higher percentil)	0.084	0.13-0.53	0.009	6.87

Discussion

Chronic kidney disease (CKD) is estimated to be the 5th leading cause of death worldwide by 2040. (20)It affects 8–16% of the global population of the world (21) and is considered a major health problem due to its potential to increase morbidity and mortality in these patient

In our study carried out for muscle assessment by ultrasound in CKD patients, we found decreased values in some muscle parameters with respect to the little evidence of cut off points in the healthy population, being significantly higher in males.

Conclusions

1. CKD results in lower values in the eco-muscular assessment than healthy people in both CKD and PD.
2. The transverse and longitudinal diameters and muscle area are smaller than those described in the healthy population and larger in men with good correlation with Phase angle, BCM, MM, AIC by BIA
3. Having performed physical exercise conditions better parameters in the muscle ultrasound
4. Muscle ultrasound appears as an emerging, economical, easy tool that does not provide ionizing radiation.
5. It´s necessary more study in order stablish the normal values according age groups.

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