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RESEARCH ARTICLE

Implementation of Ultrasound Measurement of Quadriceps Thickness in Routine Clinical Practice

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Abstract

Objectives: Cachexia, frailty, sarcopenia impact the prognosis of patients with heart failure (HF). Ultrasound-based measurement of quadriceps thickness during the rest and contraction helping to determine severity of sarcopenia and has prognostic value. Ultrasound(US) a valuable tool for assessing skeletal muscle mass and function due to its non-invasive nature, real-time imaging capability, and accessibility.

The aim of this pilot study was to evaluate possibility of implementation of measurement of quadriceps thickness at rest and during contraction in routine practice of cardiology department.

Materials and Methods: 23 patients, 8 female,15 male,mean age 55,3 (31-75), mainly pts with heart failure with reduced ejection fraction, hospitalized in the cardiology department represented study population. Quadriceps muscle thickness was measured by linear sensor 7L4A, 3.5 - 13.0 MHz, ultrasound device DC N6 Mindray, China. The examiner was specialist who had conducted evaluations using ultrasound in a clinical setting for at least 10 years. Measurement of quadriceps thickness at rest and during contraction has been done not separately but in addition to planned ultrasound examination of other organs (liver, kidneys, thyroid gland, etc.)

Results: Only one of 23 participants of study drops out. Measurement of quadriceps thickness at rest and during contraction takes 2-4 minutes.

Conclusions: Measurement of quadriceps thickness at rest and during contraction by ultrasound is a simple and short in time procedure and could be implemented in routine clinical practice.

Keywords: Ultrasound, Quadriceps, Heart failure.

Introduction

Sarcopenia is a progressive and generalized skeletal muscle disorder that is associated with increased likelihood of adverse outcomes including falls, fractures, physical disability and mortality. The original operational definition of sarcopenia by European Working Group on Sarcopenia in Older People (EWGSOP) was a major change at that time, as it added muscle function to former definitions based only on detection of low muscle mass [1]. Sarcopenia is a condition with many causes and varying outcomes. While sarcopenia is mainly observed in older people, it can also develop in younger adults.

Sarcopenia is now formally recognized as a muscle disease with an ICD-10-MC Diagnosis Code that can be used to bill for care in some countries. [2,3]

EWGSOP2's updated recommendations aim to increase awareness of sarcopenia and its risk. With these new recommendations, EWGSOP2 calls for healthcare professionals who treat patients at risk for sarcopenia to take actions that will promote early detection and treatment, encourage more research in the field of sarcopenia in order to prevent or delay adverse outcomes that also incur a heavy burden for patients and healthcare systems. Most cachectic individuals are also sarcopenic, but most sarcopenic individuals are not considered cachectic. Sarcopenia is one of the elements of the proposed definition for cachexia .Very recently, a consensus paper expanding this definition of cachexia and identifying relevant issues on how to differentiate cachexia and sarcopenia was published by ESPEN, one of the EWGSOP-endorsing societies. Cardiac cachexia is defined as an advanced stage of chronic heart failure (CHF) associated with involuntary loss of at least 5% of non-edematous body weight. Muscle wasting, also known as sarcopenia, can occur earlier than cachexia in the course of the body-wasting process and might not be associated with weight loss. The prevalence of sarcopenia

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in CHF patients is higher at 20% compared with control subjects of the same age.11 An even higher prevalence of sarcopenia (47%) has recently been suggested in patients below the age of 55 years suffering from dilated cardiomyopathy.12 This particularly high incidence may be due to mitochondrial dysfunction combined with an abnormal energy metabolism and a transition of type I to type II myofibers.13, 14

Sarcopenia in CHF may ultimately progress to cardiac cachexia,15, 16 which is associated with an exceptionally poor prognosis.17 Earlier numbers showed a rate of up to 40% of CHF patients progressing to cardiac cachexia, which has significantly improved because of improved treatment of heart failure itself and is currently estimated to have a prevalence of 10% 18 Other studies estimate a prevalence of cardiac cachexia of 5–15% in CHF. Mortality rates of cachectic patients range from 10–15% per year in chronic obstructive pulmonary disease to 20–30% per year in CHF and chronic kidney disease. Cardiac cachexia has a dramatic prognostic impact with an 18 month mortality rate of up to 50% 19 mortality is particularly high in obese cachectic CHF patients.20 Patients with cardiac cachexia show higher rates of atrial fibrillation,21 possibly contributing to the increased mortality.

Magnetic resonance imaging (MRI) and computed tomography (CT) are considered to be gold standards for non-invasive assessment of muscle quantity/mass . However, these tools are not widely used because of high equipment costs, lack of portability, and the requirement for highly-trained personnel to use the equipment. Moreover, cut-off points for low muscle mass are not yet well defined for these measurements.

Ultrasound is a widely used research technique to measure muscle quantity, to identify muscle wasting, and also as a measure of muscle quality. It is reliable and valid and is starting to be used at the bedside by trained clinicians. Ultrasound is accurate with good intra- and inter-observer reliability, even in older subjects [4]. Assessment of pennate muscles such as the quadriceps femoris can detect a decrease in muscle thickness and cross-sectional area within a relatively short period of time, thus suggesting potential for use of this tool in clinical practice, including use in the community [5,6].

The use of ultrasound has recently been expanded in clinical practice to support the diagnosis of sarcopenia in older adults. The European Working Group on Sarcopenia in Older People recently proposed a consensus protocol for using ultrasound in muscle assessment, including measurement of muscle thickness, cross-sectional area, fascicle length, pennation angle and echogenicity [7]. Echogenicity reflects muscle quality, since non-contractile tissue associated with myosteatosis shows hyper-echogenicity [8,9]. Thus, ultrasound has the advantage of being able to assess both muscle quantity and quality.

A systematic review on the use of ultrasound to assess muscle in this population concluded that the tool was reliable and valid for the assessment of muscle size in older adults, including those with comorbid conditions such as coronary artery disease, stroke, and chronic obstructive pulmonary disease [9]. Ultrasound was shown to have good validity to estimate muscle mass as compared to DXA, MRI and CT. While data are available for older adults, more research is needed to validate prediction equations for those with varying health conditions and functional status [8–10].

Aim of study

Possibility of rational leverage ultrasound for the measurement of quadriceps thickness in patients admitted to the hospital.

Study population

Inpatients, admitted at the clinical cardiology department of hospital-based research facility in October 2024 to February 2025 represented study population .

Method

Patients admitted to the cardiology department, mainly, with diagnosis of heart failure with reduced ejection fraction (HFrEF) underwent face to face interview with detailed information about study. Oral consent for participation was obtained from 23 patients agreed to participate. (Characteristic of patients took part in the study presented in Table 1).The hospital have three ultrasound diagnostic rooms with 3 doctors performing non-cardiac ultrasound examination. 1 out of 3 doctors agreed to participate study and to perform ultrasound measurement of quadriceps muscle. Ultrasound specialist was not aware of this method ever before. This ultrasound specialist conducted evaluations using ultrasound in a clinical setting for more than 10 years therefore a short period of introduction with this method was needed for to conduct correct evaluation. Linear sensor 7L4A, 3.5 - 13.0 MHz, ultrasound device DC N6 Mindray, China was used to obtain ultrasound images of the thigh muscles, including the rectus femoris and vastus intermedius. The linear sensor was placed at the point of study strictly perpendicular to the long axis of the thigh and the skin surface. Measurements were taken without pressing the sensor. The distance between the broad fascia and the bone surface was measured using a perpendicular line connecting the layers. To reduce the error, the measurements were repeated three times, the average value was calculated. The thickness of the quadriceps muscle was also measured after straining without support of dynamometer device assessment.

Measurement of quadriceps thickness at rest and during contraction has been done not separately but in addition to planned ultrasound examination of other organs (liver, kidneys, thyroid gland, etc.)

Table 1: Characteristic of patients and obtained data

S. No.	*Date of birth*	*QMT at rest (mm)*	*QMT during contraction (mm)*	*BMI (kg/m2)*	*EF%*	*EQ-5D-Y-5L*	*Sex*	*Age (In Years)*	*Diagnosis*	*Comorbidities*
1	1958	27	17	23,5	35	65	m	66	IHD,MI,HF	No comorbidity
2	1993	26	*	29,9	25	75	m	31	DCM,HF	Greyce disease, AF
3	1966	28	23	24,6	35	40	m	58	CHD,SA,MI, HF	HTN,T2D
4	1976	22	15	*	19	*	m	48	IHD	ICD
5	1968	18	15	34.7	27	10	f	56	DCM,HF	No comorbidity
6	1964	31	23	*	25		m	60	DCM,HF	T2D
7	1964	27	20	28,4	25	70	m	60	IHD,UA,MI, HF	No comorbidity
8	1962	27	20	*	20	*	m	62	IHD,MI(ac)	T2D,adenoma prostate
9	1967	43	35	32.3	32	100	m	57	IHD,MI,HF	T2D
10	1957	39	29	*	53	80	f	67	IHD,SA,HF	T2D
11	1977	32	28	28,7	30	30	m	47	DCM,HF	HTN,PAH,AF
12	1968	28	20	*	40	*	f	56	IHD,MI,HF	AT,T2D,AF
13	1949	32	25	*	60	50	f	75	IHD,SA	HTN
14	1977	28	20	24,6	30,32		f	47	Mitral prosthetic valve	T2D, AH, AF, Hypothyroidism, Hepatitis C
15	1969	30	23	23,8	18	20	m	55	HF	HTN,STROKE
16	1955	38	34	33.3	45	50	f	69	IHD,HF	HTN,AF
17	1958	38	31	33,3	60	40	f	66	HTN	Hypertensive Encephalopathy
,18	1982	34	26	37	60	80,85	m	42	HTN	T2D,AF
19	1972	34	24	*	25		m	52	DCM,acute LV failure	T2D
20	1978	47	42	20,7	20	*	*	46	IHD,SA,MI, HF	Mitral prosthetic valve,ICD.CRT
21	1977	34	26	36.7	55	30,40	f	47	PAH,HF	T2D
22	1975	28	20	*	30	*	m	49	DCM,HF	AF

Notes: QMT- Quadruple Muscle thickness, BMI- Body Mass Index, IHD – Ischemic Heart Disease, MI – Myocardial Infarction (in anamnesis),SA –Stable Angina, UA – Unstable Angina, MI(ac)-Acute Myocardial Infarction, HF-Heart Failure, DCM – Dilated Cardiomyopathy, HTN – Hypertension,T2D – Diabetes Mellitus type 2,EF-Ejection Fraction, AF – Atrial Fibrillation, PAH – Pulmonary Artery Hypertension,EQ-5D-Y-5L- European Quality of Life questionnaire, ICD- implantable cardioverter defibrillator,CRT-Cardiac Resynchronization Therapy pacemaker,*-No data

Results

Only one of the 23 participants drops out of the study. Measuring the thickness of the quadriceps muscle at rest and during contraction took 2-4 minutes.

Limitation of study

Measurement isometric contraction not assisted by dynamometer device could affect the accuracy of the measurements.

Discussion

This is a pilot study of utility ultrasound for the primary evaluation for sarcopenia in patients with heart failure. Considering that most patients with heart failure undergo ultrasound examination of kidneys, liver, thyroid, etc. due to comorbidities, adding ultrasound assessment of quadriceps thickness to the routine practice of ultrasound specialists will serve to increase awareness and detection of sarcopenia.. This is a smaller-sized study, large-scale clinical studies needed to justify validity and cost-effectiveness.

Conclusion

Measurement of quadriceps thickness at rest and during contraction by ultrasound in in-patients with heart failure is a simple and short in time procedure and could be implemented in routine clinical practice.as a primary examination of quadriceps muscles thickness and muscles strength for the further more detailed evaluation for confirmation of diagnosis of sarcopenia.

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