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Role of Muscle Ultrasonography in the Study of Frailty in the Elderly

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Abstract

Background: Muscle ultrasound [MUS] is a popular tool for detecting muscle loss in sarcopenia, but to a lesser extent in frailty. The purpose of this study is to investigate the correlation between the frailty index obtained from the comprehensive geriatric assessment [FI-CGA] and the MUS measurement of the anterior thigh in elderly populations.

Aim of the study: Evaluating the role of muscle ultrasonography in the Study of frailty in the elderly

Patients and Methods: A cross-sectional study was carried out on 150 individuals, 96 [64% male] and 54 [36% female] aged 65 years or older. We identify patients with frailty using the multidimensional domains CGA-based FI, which consisted of 38 variables focusing on the number and nature of the patient's health deficits. Total muscle thicknesses [TMT] of the rectus femoris [RF] and vastus intermedius [VI] were measured using MUS in an axial cross-section.

Results: The individuals examined had an average frailty index [FI] of 0.23 ± 0.05. According to the predetermined FI cut-off point, 99 [66%] respondents were frail [FI ≥0.25] and 51 [34%] were deemed non-frail. Study discovered a strong correlation between MUS thickness of the anterior thigh and frailty determined by FI-CGA. In addition, an RF cutoff point of less than 1.33 cm for identifying frailty was observed. Further research is needed to confirm the MUS as a method of detection for frailty among elderly populations.

Conclusion: FI approach can be beneficial in both evaluation and management. MUS measurements of the RF and TMT of the RF and VI muscle thickness appeared to be strongly associated with FI.

Keywords: Muscle; Ultrasound, Frailty, Frailty Index; Geriatrics.

INTRODUCTION

Frailty is a state that old persons exposed to unfavorable health outcomes, mainly because of aging-related declines in physical abilities [1]. Sarcopenia is characterized by a decline in muscle mass and strength with aging [2]. Both are often assessed in different ways using clinical examinations, anthropometric measurements, and multiple questionnaires. Both may exert serious effects on a person's well-being and quality of life [3].

A precise and reliable method of measuring frailty and sarcopenia is necessary for medical practitioners to evaluate and manage these conditions [4].

Of the numerous instruments used in geriatric medicine to measure frailty, frailty index [FI] appears to be the most appropriate for assessing individual health outcomes. In fact, FI is highly correlated with the risk of mortality and could be viewed as a measure of biological aging, which is more closely linked to morbidity and mortality than chronological age [5]. Furthermore, FI makes it possible to accurately assess physiological reserve, which is believed to be crucial for the body's reaction to various stressors [6].

Muscle ultrasound [MUS] offers a quick, easy-to-use, affordable, harmless, and patient-friendly diagnostic method for evaluating muscle conditions [7]. It is useful for determining alterations to the muscular structure in addition to estimating the size and thickness of muscles [4].

MUS could serve as a useful tool for muscle measurements and locating possible frailty indicators in the elderly, assisting in improving our understanding of frailty as it relates to muscle evaluation. In order to accomplish this goal, we investigated the relationship between MUS measurements and frailty in a group of elderly hospitalized individuals.

THE AIM OF THE WORK

We aimed to investigate the role of muscle ultrasonography in the Study of frailty in the elderly.

PATIENTS AND METHODS

Study Participants Patients aged 65 or older were recruited from a university hospitals geriatric units.

Cachexia, morbid obesity, patients on hemodialysis and/or end-stage organ dysfunction, neurological diseases, myositis or muscular atrophy-causing diseases, major lower-limb operations, and scarring at measurement sites were all excluded. All patients' medical histories were obtained, clinical examinations were conducted, and key demographic and clinical parameters were assessed. The results of the key biochemical laboratory tests were also documented. Each person who participated in this study was properly informed and signed a consent form. The study protocol was reviewed and approved by the Local Ethics Board under the number 000145, and the research complied with the ethical standards outlined in the Declaration of Helsinki.

Frailty Assessment: All patients were evaluated according to the multidimensional Comprehensive Geriatric Assessment [CGA] domains, which include nutrition, psychological cognition, health, functional status and socio-environmental conditions. Based on a standard procedure, a FI-CGA is a valid and reliable tool used to assess frailty [8]. This tool evaluated 38 variables relating to health impairments, including concurrent illnesses, laboratory tests, medical information, and illness signs and symptoms. Each component was evaluated for deficits by a trained healthcare professional, who gave a score of 1 for deficits that existed or 0 if they were absent. FI was calculated as the ratio of points received to the total number of items evaluated, which may range from zero to one. In order to evaluate frailty, a 0.25 cut-off value was determined.

Muscle ultrasound: All MUS exams were performed by a well-trained certified musculoskeletal sonographer [A.I.A.]. Patients were examined while lying supine with extended knees. Using standard guidelines, the dominant thighs' RF and VI were measured at a point halfway between the femoral greater trochanter and the patellar proximal border [9]. The axial images were obtained using a linear probe, the Toshiba Aplio 400 [Toshiba Medical Systems, Otawara, Japan], placed perpendicular to the midline of the anterior thigh. A porous amount of gel was applied to the probe and the scanned skin surface in order to prevent pressure on the examined structure. Following the acquisition of the images, the RF and VI muscle thicknesses were measured in axial cross-section [10]. Total muscle thickness [TMT] was determined as the mean of the three measurements of the length measures between the anterior and posterior fascia of the RF and VI muscles [Figure 1].

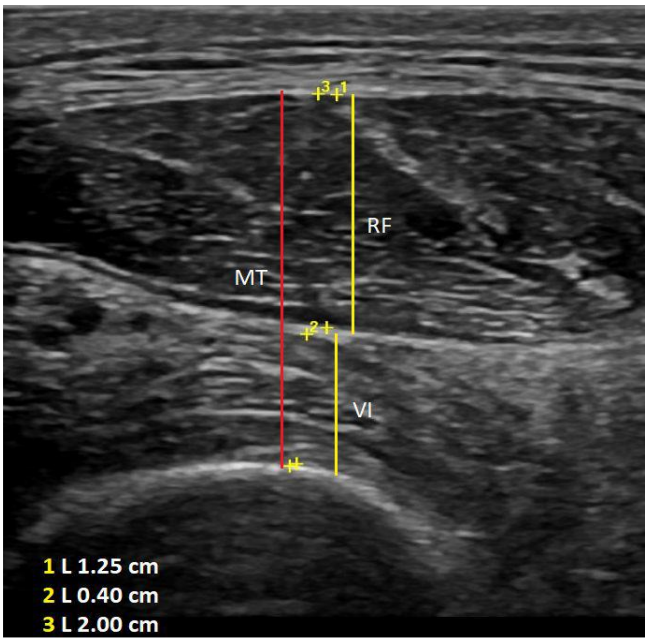

Figure [1]: An illustration of an ultrasound image of a muscle. Total muscle thickness [TMT] is the sum of the lengths from the anterior to the posterior fascia of the rectus femoris [RF] and vastus intermedius [VI].

Statistical analysis: The data were analyzed using the Statistical Package for Social Science [SPSS] version 24. Qualitative data were presented as frequencies and percentages. Quantitative data were presented as mean ± SD. The independent sample "*t*" test was used to compare two sets of normally distributed data. A Chi-square test was used to compare non-parametric data. The Receiver Operating Characteristic [ROC] Curve was used to determine cutoff values, sensitivity, specificity, positive predictive value [PPV], and negative predictive value [NPV]. Sensitivity is the possibility that a test result will be positive when the illness is present. Specificity is the possibility that a test result will be negative when the illness is not present. When

a test is positive, the positive predictive value indicates the likelihood of the illness being present. When a test is negative, the negative predictive value indicates that the illness is not present. P-values < 0.05 were deemed significant.

RESULTS

The study included 150 individuals, 96 [64% males] and 54 [36% females], with an average age of 67.1 ± 6.9 years and the BMI of 27.8±4.1 kg/m^2. In terms of chronic medical disorders, 87 [58%] of patients had diabetes mellitus, whereas 54 [36%] had cardiovascular disease. The individuals examined had an average frailty index [FI] of 0.23 ± 0.05. According to the predetermined FI cut-off point, 99 [66%] respondents were frail [FI ≥ 0.25] and 51 [34%] were deemed non-frail [Table 1]. MUS thickness values revealed that the RF and VI average thicknesses were 1.19±0.42 [0.7–1.9] cm and 1.18 ± 0.28 [0.7–1.8] cm, respectively, whereas the average TMT, which represents the thickness of both RF and VI was 2.6±0.53 [1.98–3.8] cm.

In table [2], there was a significant difference in age and gender between frail and non-frail individuals. Patients with frailty were substantially older [68.8±7.5 vs. 63.7±4.1] and had a lower male predominance [51.5 vs. 88.2%, p < 0.001] than non-frail ones. There was no statistically significant difference between patients with and without frailty in terms of BMI.

Patients with frailty exhibited substantially lower MUS thickness values [p < 0.001] compared to non-frail individuals [Table 3]. The ROC curve was used to determine cut-off values for MUS thickness that would differentiate between frail and non-frail patients [Figure 2]. The diagnostic value of RF-MUS thickness was the most reliable domain for predicting frailty among our patients, followed by TMT and VI thickness, as shown in Table [4]. The MUS thickness of RF could distinguish frail patients at a cutoff level of < 1.33, with 97% sensitivity and 100% specificity [AUC = 0.99, p-value < 0.001]. Furthermore, the TMT could distinguish frail individuals at a cutoff level of < 2.7, with 100% sensitivity and 94.1% specificity [AUC = 0.99, p-value.

Table [1]: Description of demographic data in the studied patients.

		Studied patients [N = 150]
Sex [n,%]	Male	96 [64%]
	Female	54 [36%]
Age [years]	Mean ±SD	67.1 ± 6.9
	Min - Max	60 – 92
BMI [kg/m^2]	Mean ±SD	27.8 ± 4.1
	Min - Max	18.51 – 35.2
Chronic diseases [n,%]	DM	87[58%]
	CVD	54[36%]
Frailty index	Mean ±SD	0.23 ± 0.05
	Min - Max	0.11 – 0.3
Frail [n,%]	No	51[34%]
	Yes	99[66%]
RF [cm]	Mean±SD	1.19±0.42
	Min. – Max.	0.7 – 1.9
VI [cm]	Mean±SD	1.18±0.28
	Min. – Max.	0.7 -1.8
MT [cm]	Mean±SD	2.6±0.53
	Min. – Max.	1.9 – 3.8

FI: Frailty Index. DM: Diabetes Mellitus. CVD: Cardiovascular Diseases. RF: Rectus Femoris. VI: Vastus Intermedius. TMT: Total Muscle Thickness.

Table [2]: Comparison of demographic data as regard frailty index.

		Frail		Stat. test	P-value
		No [N = 51]	**Yes [N = 99]**		
Sex [n,%]	**Male**	45 [88.2%]	51 [51.5%]	**X^2 = 19.6**	**< 0.001***
	Female	6 [11.8%]	48 [48.5%]		
Age [years]	**Mean ±SD**	63.7±4.1	68.8±7.5	**t = 4.5**	**< 0.001***
BMI [kg/m^2]	**Mean ±SD**	27.2±3.6	28.1±4.4	**t = 1.28**	**0.201**

t: independent sample student "t" test. * indicates statistical significance; **X^2:** Chi Square test

Table [3]: Comparison of MUS data as regard frailty index.

		Frail		t	P-value
		No [N = 51]	**Yes [N = 99]**		
RF [cm]	**Mean ±SD**	1.72±0.15	0.92±0.20	25.1	< 0.001*
VI [cm]	**Mean ±SD**	1.42±0.16	1.06±0.24	9.7	< 0.001 *
MT [cm]	**Mean±SD**	3.26±0.28	2.27±0.25	22.2	< 0.001*

t: independent sample student "t" test. * indicates statistical significance, RF: Rectus Femoris VI: Vastus Intermidus MT: Muscle Thickness

Table [4]: Diagnostic performance of MUS data in discrimination of patients with frailty.

	Cut off	AUC	Sensitivity	Specificity	PPV	NPV	p-value
RF	< 1.33	0.99	97%	100%	100%	94.4%	< 0.001
VI	< 1.2	0.89	81.8%	94.1%	96.4%	72.7%	< 0.001
MT	< 2.7	0.99	100%	94.1%	97.1%	100%	< 0.001

PPV: Positive Predictive Value. AUC: Area Under the Curve. NPV: Negative Predictive Value.

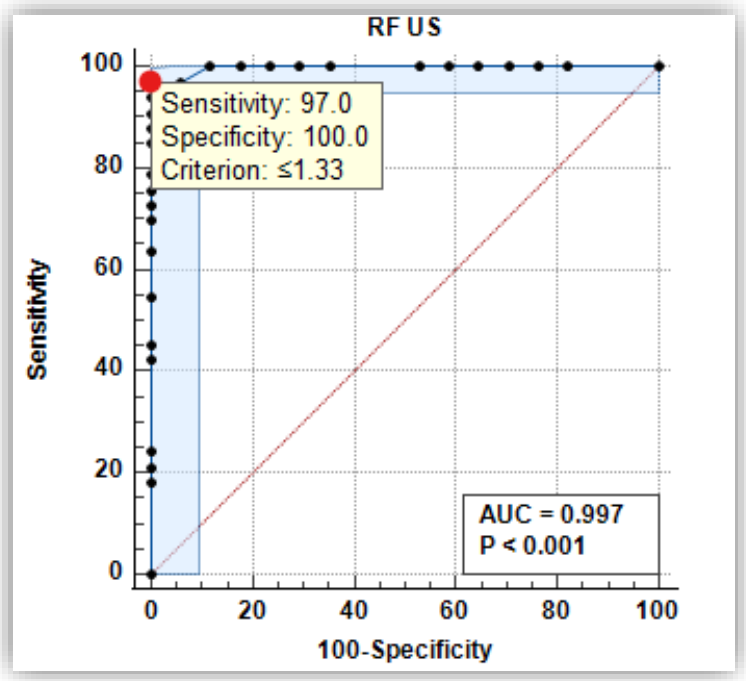

Figure [2]: Receiver operating characteristic curve of RF MUS thickness in predicting frailty

DISCUSSION

Frailty is a geriatric condition that has been extensively studied in seminal research using a variety of reliable assessment tools. Frailty has been linked to poor health outcomes in various care settings. An increasing number of clinical decision procedures consider frailty status using valid assessment tools like FI-CGA when selecting patients for the most appropriate interventions [such as cardiac valve surgeries] or offering treatment plans [11].

Sarcopenia, the clinical phenotype of frailty, is becoming a more popular subject for scientific research. As a result, MUS has recently been proposed as an effective diagnostic tool for estimating muscle mass. MUS is a potentially useful, portable, cheap, and less harmful diagnostic technique that can be used to evaluate the muscle condition of older adults in particular. It outperforms the present gold standard of dual-energy X-ray absorptiometry [DXA], computed tomography [CT], and magnetic resonance imaging [MRI] [12].

The purpose of this study was to examine the relationship between frailty in a sample of hospitalized older adults as determined by the validated CGA-based FI tool and anterior thigh muscle thickness as measured by MUS, which is frequently used for sarcopenia assessment. In addition, the study attempted to determine whether MUS could be used as a possible diagnostic modality complementary to the multidimensional CGA-based approach. In the current research there was a substantial relationship between frailty as measured by CGA-based FI and the thigh muscle thickness measured by MUS. MUS has been shown in a number of studies to be an effective method for precisely and consistently assessing sarcopenia [9,13,14].

As sarcopenia affects various muscle groups differently [15,16], particular muscle groups, like those in the abdomen and anterior thigh, may atrophy faster than others [17].

The rectus femoris or anterior thigh muscles are the most commonly examined muscles, and a number of studies have shown that precise ultrasound measurements of muscle tissue, such as muscle thickness and cross-sectional area [CSA], may accurately determine sarcopenia in older people [18-21].

Despite the fact that MUS has been extensively studied in sarcopenia, there has been little research on its use in detecting frailty. 4 This study determined that frail individuals were significantly older than non-frail ones [68.8±7.5 vs. 63.7±4.1] and had a lower male predominance [51.5 vs. 88.2%, p = < 0.001]. This was consistent with previous research indicating that female participants tend to be frailer than their male counterparts [22].

Bencivenga *et al.* [23] discovered a strong correlation between MUS measured quadriceps muscle thickness and the CGA based FI tool, supporting our findings. They also found that, in multivariable regression analysis, FI was strongly and independently associated with both age and TMT.

In a small study done by **Canales and coworkers** [24], pre-operative muscle measurements obtained from CT and ultrasound were compared in 18 frail patients and 20 healthy volunteers. According to their findings, sonographic quadriceps muscle thickness can detect frailty [AUCs of 0.80 [95% CI, 0.64 to 0.97]], which was in line with our results.

Furthermore, **Shah *et al.*** [25] investigated the correlation between the FRAIL scale and MUS measurements in 65 older adults with blunt trauma in the emergency department. When compared to the reference standard, MUS results for the biceps and quadriceps muscles were fairly consistent [diagnostic accuracy of 0.75].

Another study carried out on 223 patients receiving hemodialysis investigated the relationship between ultrasound-derived bilateral anterior thigh thickness [BATT], sarcopenia, and frailty, using widely used frailty measures such as the Frailty Phenotype, Frailty Index, Edmonton Frailty, and Clinical Frailty Scale. The relationship between frailty and quadriceps muscle thickness measured by ultrasound was significant and differed depending on the frailty assessment tool [26].

Our findings contradict the study of **Madden and colleagues** [27] on the relationship between vastus medialis MUS thickness and frailty in older adults. Using the Frailty Phenotype and the Clinical Frailty Scale [CFS] to assess frailty, the researchers discovered a modest relationship between MUS data and frailty. The discrepancy between our results and those of Madden's could be attributed to differences in the protocols used, such as differences in the muscles tested and the frailty assessment tool used.

We chose to measure the TMT of the RF and VI based on previous research [10], allowing us to combine measurements from two adjacent muscles in the same group. Moreover, it has been stated that not all anatomical regions exhibit the exact same age-related decline in muscle mass [28]. As a result, it was suggested that the RF muscle mass declines earlier than the other muscle groups [14]. Another significant difference between the two studies is the way frailty is evaluated.

Although CFS has many limitations, particularly in dementia patients, some authors have stated that it is a reliable tool for an initial evaluation of frailty [29]. Conversely, it has been reported that FI outperforms CFS as a discriminative tool due to the subjective nature of clinical assessment [30].

In the present study, we established that the muscle thickness of RF evaluated by MUS can differentiate frail individuals in the research population with 97% sensitivity and 100% specificity [AUC = 0.99; p value < 0.001]. Furthermore, we observed that an RF thickness of less than 1.33 cm accurately predicted frail individuals in 100% of cases, suggesting that MUS technology is a valid tool for screening for regional sarcopenia and consequently frailty in the elderly population.

In line with our results, **Tada *et al.*** [31] established cut-off values for the MUS thickness of the anterior thigh muscle to distinguish between excess weight and sarcopenia in rheumatoid arthritis patients.

Rustani *et al.* [32] suggested ultrasound-measured thickness of RF muscle as a useful measure for detecting sarcopenia and offered cut-off values for elderly patients. Furthermore, recent research suggests that sarcopenia can be accurately predicted by measuring the thickness of the RF and rectus abdominis muscles, as well as the RF cross-sectional area. The proposed cut-off value for the RF muscle was 13/15.5 mm [AUC: 0.760/0.736 mm], which was consistent with our findings [33].

Despite the fact that MUS has acceptable intra- and inter-rater reliability [34], individual variations in ultrasonographic measures may occur due to variable individual factors such as age, sex, physical activity and fitness state, diet, and even more. Thus, multifactorial aspects may complicate the interpretation of the findings and make defining precise cut-off levels difficult.

The first constraint of our study was that the study participants were drawn from a single geriatric care clinic, a group that is frailer than average individuals due to multiple long-term comorbid medical conditions. The absence of a control group was the second drawback. Third, other MUS measures, such as the cross-sectional area and fascicle angle data, were not addressed in the current study. In future investigations, the study population might be enlarged to encompass more MUS parameters for assessment. Finally, further research is needed to establish consistent muscle measurement criteria for practical frailty evaluation and treatment strategies.

Conclusion:

Frailty is a complex geriatric condition, and the CGA based FI approach can be beneficial in both evaluation and management. MUS measurements of the RF and TMT of the RF and VI muscle thickness appeared to be strongly associated with FI among our patients. Considering the heterogeneity of definitions and evaluations of frailty, additional research is needed to support the utility of MUS for its identification, with the goal of designating MUS as a novel imaging modality for frailty assessment.

Conflict of interest: none

Financial disclosure: none

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