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Original article

Reliability of ultrasonographic arm muscle thickness measurement by various levels of health care providers in ICU

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SUMMARY

Purpose: Reliability of arm muscle thickness measurement using ultrasonography (USG) by operators of varied experience is unknown. Hence, we planned this study to determine the reliability of arm muscle thickness measured using USG by 5 observers with variable experience.

Materials and method: This was a cross-sectional observational study which included critically ill patients with sepsis. Arm muscle thickness was measured in triplicate on Siemens ACUSON X300™ USG machine by each of 5 observers. Intra-class correlation coefficient (ICC) was computed to assess intra-observer and inter-observer variability of multiple observations.

Results: This study included 45 (30 – male) patients. Mean ($\pm$ SD) age, APACHE and SAPS score of the participants were 54.95 ($\pm$ 15.97) years, 14.66 ($\pm$ 4.57) and 2.6 ($\pm$ 1.37), respectively. There were 135 observations by each observer. ICC (95%CI) for intra-observer reliability study for observer 1, 2, 3, 4, and 5 were 0.997 (0.995–0.998), 0.996 (0.993–0.998), 0.997 (0.996–0.998), 0.997 (0.994–0.998) and 0.998 (0.986–0.999), respectively. ICC (95%CI) for inter-observer reliability study for 1st, 2nd and 3rd reading were 0.963 (0.943–0.977), 0.992 (0.988–0.995) and 0.992 (0.988–0.995), respectively.

Conclusions: There was an excellent intra- and inter-observer agreement among 5 observers for measurement of arm muscle thickness using bedside USG among patients with sepsis.

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1. Introduction

Loss of muscle mass among critically ill is common and associated with in-hospital as well as post-discharge adverse outcome [1–3]. Loss of muscle mass is a generalized phenomenon involving skeletal muscles of limbs as well as diaphragm [3,4]. Arm muscle dysfunction has been shown to be an independent predictor of worse outcome among patients admitted in ICU [5]. Hence, accurate and objective measurement of muscle loss of arm muscles is essential for any preventive and therapeutic intervention.

Assessment of muscles functions using anthropometric parameters (mid-arm circumference) or by strength assessment

using either medical research council (MRC) score or hand-held dynamometer are not very sensitive and of limited use among critically ill patients [1,3,6]. Campbell and colleagues in 1995 reported that ultrasonography (USG) is feasible and a good tool for assessment of muscle mass among critically ill patients [7]. Since then, there has been multiple studies which have described the utility of USG in ICU for assessment of muscle functions [7–9]. It's non-invasive nature, bedside availability, repeatability over multiple time with zero adverse effect makes it a tool of choice among critical care physicians. Also, its accuracy is comparable with computerized tomographic (CT) scan or magnetic resonance imaging (MRI) [8,10].

USG has been shown to be very useful tool in the hands of critical care physicians as shown by excellent intra- and inter-observer reliability with minimum variability for measurement of muscle thickness [11–14]. However, this has added significant additional workload to the critical care physicians in ICU. We propose that nurses in the ICU, after minimal training, can measure

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arm muscle thickness using USG. If they could perform this successfully it would reduce the work of critical care fellows and consultant significantly.

There is no study describing the comparison of variability and reliability of arm muscle thickness measurement using USG by consultant, fellows and untrained nurses. Therefore, we conducted this study with the aim to assess the intra- and inter-observer reliability and variability of arm muscle thickness measured by critical care consultant, fellows and nurses.

2. Material and methods

2.1. Settings and patient population

This study included critically ill patients admitted in the ward or intensive care unit (ICU) of the Pulmonary Medicine and Critical Care services at a tertiary care hospital in India during July 2016 to June 2017. Participants were excluded if they already had a diagnosis of neuromuscular weakness due to any prior illness – neuropathy, myopathy, stroke etc. Also, patients who refused to participate in the study were also excluded. The study protocol was approved by institutional ethics committee. The study was conducted following the good clinical practice involving human subjects [15,16].

2.2. Observers

The observers who participated in this study included 3 critical care physicians (1 – consultant and 2 – fellows) and included two nurses. The consultant (VH) had an experience of 3 years in ultrasonography and muscle thickness assessment. First fellows (RK) had an experience of 2 years whereas second fellow had 3 months of experience in using USG for muscle thickness measurement. Two nurses who were working in the department had no prior training and were novice to the use of USG for muscle thickness measurement. Before actual measurement of muscle thickness for this study both the nurses were given a short hands-on training (10–15 measurements, each) led by the consultant with the specific ultrasound imaging protocol used in the study.

The initial site of measurement was marked by the first critical care fellow (RK or TH) and all the subsequent measurements were recorded by all other observers at the same site. All the five observers evaluated each participant and all the measurements were taken within few hours of the first reading. All observers were blinded to the measurement of each other's.

2.3. Equipment

For this study Siemens ACUSON X300™ machine was used for acquisition and measurement of muscle thickness. Images of the muscles were acquired in B-mode using a 5.0–13.0 MHz linear array USG probe [7,13]. Electronic onscreen callipers were used for muscle thickness measurement from fat muscle interface to the periosteum.

2.4. Posture, image acquisition and thickness measurement

The protocol followed regarding posture, image acquisition and thickness measurement was similar to described previously [7,13]. Briefly, arm muscle thickness measurements were done while the patient lying supine, the elbow extended and forearm supinated with palm facing the ceiling. A circumferential mark was applied at the midway between the greater tuberosity and tip of the olecranon process of humerus. The linear probe of USG was placed on this circumferential line, perpendicular to the skin and was moved

along this line till a suitable image was obtained. A vertical line was placed on the circumferential line which was corresponding to the center of the probe providing a suitable image. This point was used as the reference point for all subsequent measurements. The measurement of thickness of muscles of the flexor compartment was recorded between the superficial fat-muscle interface and the periosteum of the humerus (Fig. 1). This includes both the biceps brachialis and coracobrachialis muscles. The force applied to achieve contact with skin was just sufficient to get a suitable image to avoid the compression of muscle due to unnecessary excessive force. Three measurements of muscle thickness were recorded by each observer while arm kept in fixed position.

2.5. Statistical analysis

Data were analysed using SPSS version 24 (IBM Corp., Armonk, NY) for windows. Intra-class correlation coefficient (ICC) was computed to assess to assess intra-observer and inter-observer variability of multiple observations. For intra-observer ICC calculation 3 pairs of readings (1st and 2nd, 1st and 3rd, 2nd and 3rd) by each observer were compared. Cronbach's alpha was computed for assessment of reliability of multiple measurements. Inter-observer ICC was computed for 10 possible pairs of observers for each observation. ICC were expressed as 95% confidential interval (CI). All other values are expressed as mean $\pm$ standard deviation (SD); p – value less than 0.05 was considered significant.

3. Results

Forty-five (male – 30) patients admitted with sepsis included in this study. Mean ($\pm$ SD) age, APACHE and SAPS score of the participants were 54.95 ($\pm$ 15.97) years, 14.66 ($\pm$ 4.57) and 2.6 ($\pm$ 1.37), respectively.

There were total 675 observations, 3 each by all 5 observers on 45 patients, which were included in the analysis. Measurements of anterior arm muscle thickness are summarized in Table 1.

3.1. Intra-observer reliability

All five observers took 3 measurements in every patient. Thus, there were total 135 readings by each observer, obtained as 1st, 2nd and 3rd observations. ICC was computed for 3 pairs of readings (1st and 2nd, 1st and 3rd, 2nd and 3rd) as well as for overall (135

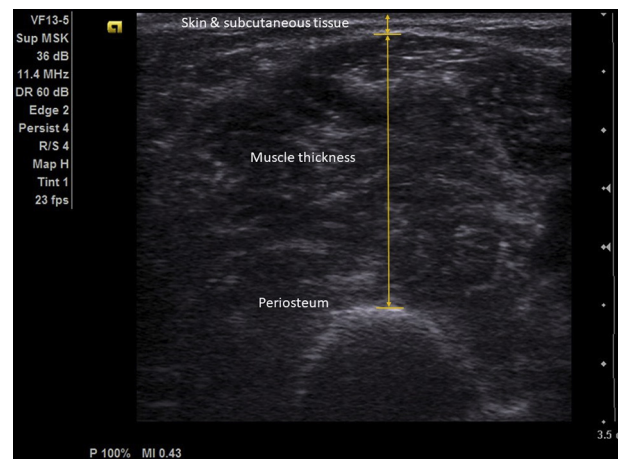


Fig. 1. Ultrasonographic assessment of arm muscle thickness. The muscle thickness was measured from subcutaneous fat – muscle interface to periosteum of the humerus.

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