Correlation between Intensive Care Unit Acquired Weakness and Hyperglycemia in Critically Ill Geriatric Patients

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Abstract

Background: the incidence of ICU-acquired weakness (ICUAW) is rising from 25 to 31% worldwide, with 3.25–6.2 million new patients annually.This may be due to the ageing process and the intensive care units (ICUs) stay. **Objective:** To determine the correlation between ICU-acquired weakness and hyperglycemia in critically ill geriatric patients.**Design:** Adescriptive research design was used to conduct this study. The study was conducted at six intensive care units from Smouha university hospital and Alexandria main university hospital in Egypt.**Tools:** Two tools were used, tool one was patients' clinical and demographic data. Tool two was patients Simplified Medical Research Council (SMRC) Scale**. Sample**: A purposeful sample of four hundreds and ninety newly admitted geriatric patients, aged > 60 years, Glasgow Coma Scale>9, oxygen saturation ≥88%, no brain stem problems, spinal cord lesions, myasthenia gravis or Guillain-Barresyndrome were included at this study. **Results:** the study showed that 37.1 % of geriatric patients had ICU-acquired weakness, 57% had hyperglycemia, and 33.7% of them had both ICU-acquired weakness and hyperglycemia.There was a highly statistically significant correlation (p=0.008) between the acquired muscle weakness and hyperglycemia among the geriatric patients.**Conclusion:** A significant correlation was found between ICUAW and hyperglycemia among critically ill geriatric patients. **Recommendation**s: Health education program should be offered to the critical care nurses who are working with critically ill geriatric patients to foster early detection of ICU-acquired weakness, and control of hyperglycemia.

Keywords: Intensive care unit acquired weakness, hyperglycemia, critically ill geriatric patients

Introduction:

Globally, growing elderly populations provide huge socioeconomic challenges, resulting in a rapid increase in the number of geriatric patients admitted to intensive care units (ICUs).Patients in ICUs can now be saved thanks to innovative medical technologies, but there are still a number of issues that need to be addressed in order to improve their long-term prognosis (Inoue et al., 2019). Geriatric patients may acquire muscle weakness during a long duration of hospitalization in ICUs, which might limit their functional independence after discharge (Lopes et al., 2020). In critically ill geriatric patients, a condition known as ICU-acquired weakness (ICUAW) is common due to persistent critical illness. It is marked by symmetrical global weakness that affects limbs (proximal more than distal) and respiratory muscles (Vanhorebeek et al., 2020). ICUAW may be due to critical illness critical illness myopathy (CIM),polyneuropathy (CIP), or a combination of CIM and CIP, which is sometimes called "critical illness neuromyopathy" (Intiso et al., 2022). Muscle atrophy occurs with prolonged immobilization and muscle disuse. Atrophy can exceed 10% muscle mass reduction over the first week in the ICU. The incidence of ICUAW varies depending on age, sex, primary disease, and treatment (Wang et al., 2020). Up to 70% of ICU geriatric patients may experience muscular atrophy problems. As the skeletal muscle is associated with immune function, glucose, and protein metabolism, such patients have a significantly higher mortality rate (Wagenberg et al. 2020).

As a result of the natural ageing process, the elderly are at a particularly high risk of muscular atrophy. Increases in insulin resistance, glucocorticoids, and myostatin, as well as age-related changes, decrease the anabolic hormones

such as insulin-like growth factor 1, testosterone, and growth hormone, that can induce muscle atrophy and further diminish protein synthesis (Elias et al. 2019). The pathogenesis of ICUAW is thought to be complex. Skeletal muscle wasting can be caused by microvascular ischemia, catabolism, and immobility, whereas critical illness-related neuropathy, myopathy, or both can be caused by microvascular injury with resulting nerve ischemia, sodium channel dysfunction, and injury to nerve mitochondria. (Kress et al., 2014; and Vanhorebeek et al., 2020). Because there is no effective treatment for ICUAW that has been identified, the focus is on reducing the risk factors. There are two types of risk factors for ICUAW: non-modifiable and modifiable risk factors (Yang et al., 2018).

Elderly female patients with systemic inflammation or sepsis, patients with multi-organ failure, extended mechanical ventilation, and prolonged critical illness, which is a poor prognostic factor for mortality in ICU patients, are all non-modifiable risk factors for ICUAW (Herman et al., 2013, and Chlan et al., 2015). The modifiable risk factors include hyperglycemia, which can be caused by the stress of critical illness or by parenteral nutrition, and immobility (Yang et al., 2018, and Herman et al., 2013). Also, several types of drugs, such as vasoactive drugs, anti-biotics, sedatives, and corticosteroids, may be considered as modifiable risk factors (Yang et al., 2018 &Vanhorebeek et al., 2020).

Although short-term and moderate hyperglycemia may be beneficial during acute stress such as trauma or illness to ensure glucose supply to immune cells when the host is unable to feed normally, there is evidence that severe and/or persistent hyperglycemia can be harmful. Hyperglycemia and insulin resistance are common in critically ill patients, especially those suffering from trauma, myocardial infarction, major surgery, or sepsis. Hyperglycemia and glucose intolerance may occur in critically ill patients with or without a history of diabetes. Iatrogenic causes of hyperglycemia, include administration of steroids, sympathomimetic drugs, total parenteral nutrition, and in particular, excess administration of dextrose (El Shebiny et al., 2021). The term "stress hyperglycemia" reflects the pathogenesis of glucose-tolerant patients. Stress hyperglycemia is defined as an increase in blood glucose above 200 mg/dl in the presence of acute illness without previously diagnosed diabetes (Temel et al., 2018). Excessive glucose accumulation, which can happen under stress, leads to increased inflammatory responses, reduced complement activity, immune system imbalance, and mitochondrial damage. Hyperglycemia triggers pathways that cause muscle atrophy and cause long-term damage to target tissue, including continuous destruction in neurons and skeletal muscle, even after blood glucose levels are restored. The direct toxic effect on mitochondria evoked by hyperglycemia may contribute to ICUAW (Giri et al., 2018, and Hermans et al., 2015). Recent studies have shown that hyperglycemia induce respiratory muscle weakness and increases patient mortality (Herman et al. 2014).

Intensive care unit acquired weakness is associated with increased duration of mechanical ventilation, longer ICU and hospital stay, slow and incomplete recovery. Physical functioning is still impaired in patients with ICUAW six months after hospital discharge (Wieske et al., 2015). ICUAW is associated with higher morbidity and an increased mortality rate (Wagenberge et al., 2020). Muscle wasting and a loss in functional capacity are common among critical illness survivors, which can have major health consequences for geriatric people. Hospitalized geriatrics with lower level of mobility and less independence in performing activities of daily living had higher risks of functional ability, and mortality rate (Puthucheary et al., 2013, and Yende et al., 2016). Geriatric patients with ICUAW suffered from persistent disabling weakness with reduced quality of life up to one year after ICU discharge (Guarneri et al. 2008). These negative effects can have a financial impact on the health care system, as muscle weakness caused by new infections can result in a 58.5 % rise in hospital costs (Norman et al., 2019) also the onset of ICUAW may be difficult to be recognized.

Therefore, critical care nurses are the key to successful implementation of early rehabilitation program for ICU patients. Early mobilization consists of various activities ranging from passive range of motion activities to walking with or without assistancein order to restore the strength of muscles, prevent ICUAW and shorten the duration of mechanical ventilation. To coordinate, care for, and offer safe rehabilitation program for ICU patients this requires a

multidisciplinary team consists of clinical nurse specialist, charge nurses, physical, an occupational and a respiratory therapists, medical director, a nutritionist, a psychologist, a social worker, and the intensivist should be coordinated to improve joint range of motion, ventilation outcomes, and reduce activity limitations. Active mobilization can improve respiratory muscle strength at ICU discharge (Tipping et al. 2017). Even passive exercises can prevent muscle atrophy. Nurses should also plan for physical and occupational therapies to improve functional outcomes. Daily exercises, especially targeted at the diaphragm and respiratory muscles, help greatly in the process of weaning from mechanical ventilation.Nurses should also guard blood glucose levels to maintain tight glycemic control, guided by normal fasting levels with insulin infusion.

Significance of the study:

Intensive care unit is a major cause of ICU morbidity and mortality. There is no specific treatment for ICUAW, avoiding or limiting triggering events such as hyperglycemia is crucial to improve the recovery of affected critically ill geriatric patients. (Young et al., 2018, Fan et al., 2014, and Lopes et al., 2020). Therefore, nurses should identify and prevent ICUAW among geriatric patients in relation to the hyperglycemia as a modifiable risk factor. So, this study was done to determine the correlation between ICUAW and hyperglycemia in critically ill geriatric patients.

Aim of the study:

To determine the correlation between ICUAW and hyperglycemia in critically ill geriatric patients.

Research question:

Is there a correlation between ICUAW and hyperglycemia in critically ill geriatric patients?

Operational definition:

Intensive care unit acquired weakness:

Decreased muscle strength two weeks after ICU admission in which the total score of Simplified Medical Research Council Scale was from 0-27.

Research methods

Research design:

A descriptive research design was utilized to conduct this study.

Setting:

The study was conducted at six intensive care units from Smouha university hospital and Alexandria main university hospital in Egypt. These units receive patients who have a variety of disorders in the acute stage of illness.

Sample:

A purposeful sample of 490 newly admitted geriatric patients were daily assessed for the first two weeks. The inclusion criteria were as follows: age> 60 years, Glasco Coma Scale>9, and oxygen saturation ≥88%. The exclusion criteria were: patients diagnosed with brain stem problems, spinal cord lesions, myasthenia gravis, and Guillain-Barresyndrome. Sample size was estimated by power analysis using Epi Info program (population size400,expected frequency 50%,accepted error 5% and confidence coefficient 95%), 10% of the required sample size was added to overcome rolled out patients.

Tool:

Two tools were used to collect the data for this study. Tool one was patients' clinical and demographic data. This tool was developed by the researcher to assess patients' demographic and clinical data. It contains two parts, part one include patients' demographic data as age, and six and part two include patients' clinical data as patients diagnosis, vital signs and blood glucose level on admission and follow up measurements. Tool two was "Simplified Medical Research Council Scale (SMRC Scale)".The scale was adopted from Latronico, N., & Gosselink, R. 2015.This scale was used to evaluate the strength of the patients' peripheral muscles. The scale comprises of six items: abduction of the arm, flexion of the forearm, extension of the wrist, flexion of the leg or hip, extension of the knee, and dorsal flexion of the foot. A simplified version of the scale with only four categories and improved clinometric properties was proposed. This version has been validated in a small cohort of 60 critically ill patients with excellent inter-rater reliability and high sensitivity and specificity in diagnosing ICUAW compared to complete full MRC**(Latronico, N., & Gosselink, R. 2015).**

The score for each limb movement is graded from 0 (complete paralysis) to 3 (normal strength).The scoringof the six items for each limb is graded from 0 to 18. The total sum score of both limbs is graded from 0 to 36. The total score is classified from 0 to 27, indicating muscle

weakness, and from 28 to 36, indicating normal muscle strength. In addition to demographic data (age and gender), and clinical data (diagnosis, random glucose level, and vital signs of temperature, heart rate, respiratory rate, mean arterial pressure) were obtained. Content validity of the tools was done by five experts in the field of the study, and necessary modifications were done. Reliability of the tools was done using Cronbach's alpha test with a 0.74 result (Cuthbert & Goodheart, 2007). A pilot study was carried out on 50 patients (about 10% of the total subjects) to assess the clarity and applicability of the research tool and necessary modifications were done. They are excluded from the study sample.

Data collection:

Data was collected for twelve months from 10 March 2020 to 12 February 2021. In the current study, a convenient sample of 535 newly admitted critically ill geriatric patients was included in this study considering the exclusion criteria. Thirty patients declined to participate in this study, and 15 patients died. So, the study was completed with 490 patients (Figure 1). Patients' demographicwas recorded using part one of the first tool and clinical data as vital signs, blood glucose level was determined by analysis of a random venous sample on admission and after 2 weeks from the patient's admission using part two of tool one. The researchers assessed muscle strength of the right and left limbs, and the score was recorded using this tool on admission day and two weeks after the ICU admission using tool two.

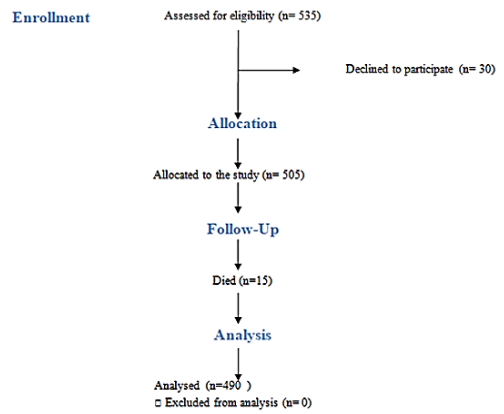

Figure (1): Flow diagram of participants enrolment

Ethical consideration:

Permission was obtained from the Ethics Research Committee, Faculty of Nursing, Alexandria University. Also, permission from the administrative authorities of the mentioned settings was obtained before conducting the study. Informed consent was obtained from patients after explaining the aim of the study, potential benefits, risks, discomforts, and the right to refuse to participate in the study.

Statistical analysis:

Collected data were coded, computed and statistically analysed using statistical package of social sciences (SPSS), version 26. Data was presented as numbers, percentages, mean and standard deviation. Chi square (χ^2) was used for comparison of categorical variables and was replaced by the Mont Carlo Exact test if the expected value of any cell was less than 5. The difference was considered significant at $P \leq 0.05$.

Results:

Table (1) shows the distribution the studied geriatric patients according to demographic and clinical data. The majority of the geriatric patients were in the age group 66-70 years. The most common diagnosis was respiratory diseases.

Table (2) shows the distribution of the studied geriatric patients according to the presence of acquired muscle weakness and hyperglycemia. It was noted that 37.1 %of patients had ICUAW, 57% had hyperglycemia, and 33.7% had both ICUAW and hyperglycemia.

Table (3) & figure (2) reveal the correlation between the acquired muscle weakness and hyperglycemia among the geriatric patients. There was a highly statistically significant correlation (p=0.008) between the acquired muscle weakness and hyperglycemia among the geriatric patients.

Table (1): Distribution of the studied geriatric patients according to demographic and clinical data

Parameters		The studied geriatric patients (490)
Age (years) n (%)		
60-65		132 (26.9)
66 -70		358 (73.1)
Gender n (%)		
Males		229 (46.7)
Females		261(53.3)
Current diagnosis n (%)	Cardiovascular disease	127 (25.9)
	Respiratory disease	154(31.4)
	Renal disease	59(12.0)
	Gastrointestinal disease	57(11.6)
	Poisoning	93(19.0)
Vital signs (Mean ± SD)	Temperature (°C)	36.99 ± 0.71
	Heart rate (beat/min)	77.56 ± 7.33
	Respiratory rate (cycle/min)	19.17 ± 3.56
	Mean arterial pressure (mmHg)	74.02 ± 21.68

Table (2): Distribution of the studied geriatric patients according to the presence of acquired muscle weakness and hyperglycemia

The studied geriatric patients (n= 490)			
Presence of hyperglycemia	**Presence of acquired muscle weakness n (%)**		**Total**
	Yes	**No**	
Yes	165 (33.7)	114 (23.3)	279 (57%)
No	17 (3.5)	194(39.6)	211 (43.1%)
Total	182 (37.2)	308 (62.9)	490 (100%)

Table (3): Correlation between the acquired muscle weakness and hyperglycemia among the geriatric patients

Correlation of blood glucose level		ICUAW
Blood glucose	Pearson Correlation	-.779**
	Sig. (2-tailed)	.008
	Sum of Squares and Cross-products	-5435.000
	Covariance	-603.889
**. Correlation is significant at the 0.01 level (2-tailed).		

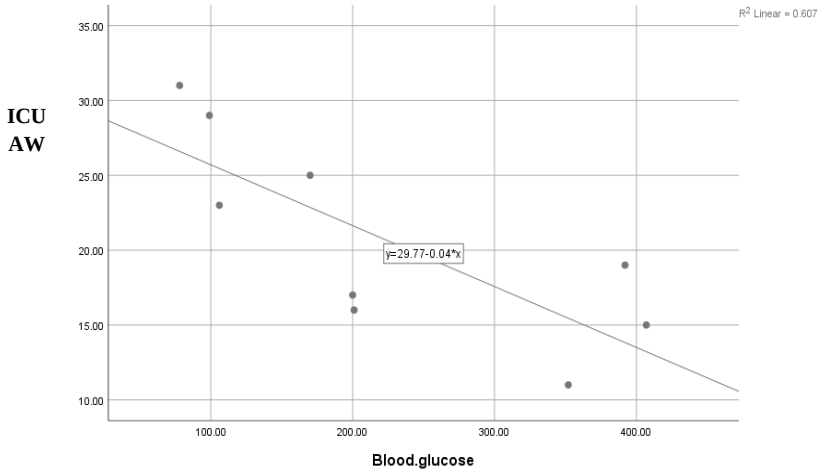

Figure (2): Correlation between the acquired muscle weakness and hyperglycemia among the geriatric patients

Discussion:

The results of the present study revealed that the majority of the patients was older and in age group from 66 to 70 years. The most common diagnosis was respiratory diseases followed by cardiovascular diseases. A study of Mohamed et al. Egypt 2019 supported the present findings and reported that the majority of the studied patients were older and suffered from respiratory disorders followed by cardiovascular disorders. Also, Antonela et al. 2020 Argentina were in the same vein of the present study and reported that most of the study subjects were older than 64 years. While, they contradicted the present finding in which the majority of the patients had hypertension. It can be justified as old ages are associated with many life style diseases due to smoking, unhealthy food and sedentary life style which increased the risk of respiratory and cardiovascular diseases.

The findings of the present study revealed that more than one third of the geriatric patients had ICUAW. Antonela et al. 2020 came in the line with the present study and reported in their result that the incidence of ICUAW was about one third of the studied patients. Also, Ballve et al. 2017 supported the present finding and revealed that accumulative incidence of ICUAW was more than one third observed during the follow up period of the study. While, Mohamed et al. 2019 contradicted the present finding and revealed that more than half of the studied patients had ICUAW. Also, Lopes et al. 2020 Brazil contradicted the present finding and reported that the majority of critically ill geriatric patients were functionally dependent related to muscle weakness. The present results may be attributed to that almost one third of the geriatric patients had respiratory and/or cardiovascular diseases, and there is a correlation between the occurrence of ICUAW and presence of respiratory and cardiovascular diseases.

The findings of the present study reported that more than half of the critically ill geriatric patients developed hyperglycemia during their hospitalization in the ICU. Ballve et al. 2017 in their study confirmed the present findings and concluded that more than half of the ICU patients developed hyperglycemia during their hospital stay. El Shebiny et al. 2021 came in accordance with the present finding and revealed that hyperglycemia was common in critically ill patients on ICU admission and after forty eight hours of admission respectively. Hyperglycemia was associated with increased morbidity in the form of difficult weaning from mechanical ventilation and long ICU stay. Also, Temel et al. 2018 agreed with the present study and found that two thirds of ICU patients acquired stress hyperglycemia. Whereas Cely et al. 2004 USA contradicted the present finding and reported that the incidence of hyperglycemia occurred in one quarter of ICU patients. The present finding can be explained by that the most of geriatric patients suffered from some forms of age-related glucose intolerance. This may be associated with stress hyperglycemia due to their acute illness.

The present finding showed that there is a significant relation between the ICUAW and hyperglycemia in ICU geriatric patients who suffered from muscle weakness. Ballve et al. 2017 came in the same context with the present study and revealed that the development of ICUAW was associated with hyperglycemia. Also, Callahan et al. 2014 confirmed the present finding and found that hyperglycemia was a risk factor for ICUAW that prolonged the duration of mechanical ventilation. Other studies of Yang et al. 2018, and Hermans et al. 2013 supported the present study and revealed that stress hyperglycemia caused by patients' critical illness and indicated a higher risk for developing ICUAW. Mongeli et al. 2015 contradicted the present findings and revealed that there is no significant correlation and/or difference could be found between blood glucose variability and ICUAW. Critical illness activates the release of cortisol, high cortisol levels contribute to muscle wasting, and hyperglycemia with insulin resistance.

Limitation of the study:

Decline of 30 patients to participate at the study and death of another 15 patients lead to decreased number of the study sample.

Conclusion:

It can be concluded from the present study that more than half of the critically ill

geriatric patients developed hyperglycemia during their hospital stay in ICU, and almost one third of them developed ICUAW. A significant correlation was found between ICUAW and hyperglycemia among critically ill geriatric patients.

Recommendations:

- Health education program should be offered to the critical care nurses who work with critically ill geriatric patients to foster early detection of ICUAW and apply nursing measures to prevent it.
- Critical care nurses who work with geriatric patients should give an attention on early detection and the management of hyperglycemia.
- The use of the Medical Research Council (MRC) Scale to diagnose ICUAW should begin with a routine physical and neurological evaluation of geriatric patients.
- Further research should be done to study the impact of early mobilization and glycemic control on ICUAW of critically ill geriatric patients.

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