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RESEARCH ARTICLE

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Vascular complications in extremities of physically restrained intensive care unit patients: A prospective, observational study

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Abstract

Background: Physical restraint is used to prevent agitation, to continue treatments and to ensure safety in intensive care patients. Physical restraint has negative effects on physical and psychological health, and physical restraint should not be used unless necessary.

Aims: The purpose of this study was to evaluate the development of vascular complications in extremities of physically restrained patients hospitalized in the intensive care unit (ICU) and the associated factors.

Study Design: A prospective, observational study. The study was conducted between September 1, 2022, and March 31, 2023 in eight ICUs of a hospital located in the inner regions of Türkiye. The development of vascular complications (discolouration, distemperature, variations in capillary refill time, fluctuations in peripheral pulse, skin ulceration and oedema in the area of physical restraint) rate in patients hospitalized in the ICUs who were physically restrained. Independent sample *t* test, Mann–Whitney *U* test and Pearson-χ^2 test were used to analyse the data.

Results: During the study, 2409 patients were admitted to ICUs. Physical restraint was applied to 209 of these patients. Of the 209 patients, 112 patients who met the inclusion criteria were included in the study. The physical restraint site of the patients was evaluated an average of 230.12 times and physical restraint was terminated in 9.8% of the patients ($n = 112$) because of vascular complications that developed in the physical restraint site. The rate of vascular complications at the site of physical restraint was higher in patients with endotracheal tubes ($p < .05$), lower GCS scores ($p < .05$) and higher INR values ($p < .05$). Patients with skin ulceration at the restraint site received more massages and cream applications (%95CL = 1. 1.692–34.734, OR = 7.667, $p = .032$). It was determined that more massage was applied to patients with changes in skin temperature at the restraint site (%95CI = 1.062–11.599, OR = 3.510, $p = .032$).

Conclusions: Vascular complications may develop at the restraint site in patients hospitalized in the ICU. This may be more common in ICU patients with endotracheal tube, lower GCS score and higher INR values.

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Relevance to Clinical Practice: Nurses should closely monitor ICUs patients with endotracheal tube, lower GCS score and higher INR values, and implement care interventions to prevent the development of vascular complications.

KEYWORDS
critical care, intensive care unit, nursing, physical restraint, vascular complication

1 | INTRODUCTION

Physical restraint is defined as any action or procedure that prevents the free movement of a person's body into a choice position or normal access to their body, using any method involving the person's body.[1–5] In intensive care patients, physical restraint is employed as a last resort to prevent agitation, restlessness,[4,6,7] to prevent patients from voluntarily or involuntarily removing medical devices, to maintain their treatment,[1,3–8] to maintain their safety and thus contribute to their recovery process.[7,8] Intensive care nurses utilize alternative techniques such as counselling and reminding the patient before utilizing physical restraint, and if physical restraint is employed, they terminate this practice at the first possible opportunity.[5] Nurses should evaluate the patient's need for physical restraint every 12 h and terminate its use as soon as possible.[4] It is reported in the literature that physical restraint is used between 0% and 100% in various intensive care units (ICUs).[1,3,5,8–10] Commonly used restraint methods include physical restraints such as tying, fixation and chemical restraints, which are used to a lesser extent.[11]

There is evidence in the literature about the benefits of physical restraint as well as its negative impacts on physical and psychological health.[4,12,13] Although physical restraint increases the risk of skin trauma, pressure sores, muscle atrophy, nasocomial infections, constipation, incontinence, limb injury, contracture, agitation, delirium, anxiety, decline, depression and decreased functionality,[14–16] it can also cause neurovascular complications such as oedema, erythema, numbness, increased body temperature, discolouration and nerve damage.[17] In addition, physical restraint is a risk factor for unintended extubation in critically ill patients,[18] and there is no evidence of benefit in preventing unintended extubation. For these reasons, it is recommended to reduce the practice of physical restraint as much as possible.[4,8]

Circulation problems,[10,19,20] tissue injury[16,21,22] and nerve damage may occur with decreased perfusion of the extremities because of external pressure application caused by reasons such as prolonged casted and tight bandaging.[23] Intensive care nurses should evaluate the vascular status in the extremities where physical restraint is performed to eliminate these possible risks. Clinical assessment is one of the basic components of intensive care nursing and vascular problems are of great significance in the early identification of problems. Oxygenation and circulatory functions of the limb at risk should be monitored, especially when fixation is performed.[19] Physical restraint should be terminated as soon as possible to prevent possible complications caused by physical restraint, appropriate materials and restraint methods should be selected, and care interventions should be implemented. Patients should be carefully evaluated to see whether there is a treatable cause for their agitation. Non-pharmacological methods (noise and lights management, sleep hygiene, etc.) should be used to prevent and treat delirium. Each ICU should have a delirium assessment and management guideline.[4] In addition, standards should be developed for physical restraint application, and these standards should be used by the staff of the institution and the level of knowledge of nurses about the subject should be increased.[4,17] It should be remembered that reducing the use of physical restraints in intensive care is an important indicator of nursing care quality.[24]

Although there are guidelines,[4,13] expert opinions[11] and review studies,[10,13,15,18,25] and observational studies[1,3,5,26] on the monitoring and care of the physical restraint site in the literature, only a few follow-up studies evaluate the duration and frequency of vascular complications and the factors affecting the development of complications are available.[16,17,19–21] Although these studies include findings regarding the existence of complications, it appears that factors that may be effective in the development of complications are not evaluated. Douglas et al. also reported that research focuses more on psychological and social issues related to physical restriction, while biological complications are less evaluated. They emphasized that pain and physical injuries frequently occur as biological complications.[27]

What is known about the topic

- Although the use of physical restraint in intensive care has decreased, it is still used for patient safety.
- There is limited information in the literature about vascular complications because of physical restriction.

What this paper adds

- In our study, patients were followed hourly and physical restraint was terminated in 9.8% of the patients because of the development of vascular complications in the physical restraint area.
- The rate of vascular complications at the site of physical restraint was higher in patients with endotracheal tubes, lower Glasgow Coma Scale (GCS) scores and higher International normalized ratio (INR) values.

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According to the information obtained, it appears that there is little evidence. For this reason, our study will contribute to the literature by evaluating possible vascular complications by monitoring the physical restriction area. Given this information, the present study was conducted to investigate the development of vascular complications in patients hospitalized in the ICUs who were physically restrained and to determine the factors affecting the development of vascular complications in the physical restraint site.

1.1 | Aim of research

The purpose of this study was to evaluate the development of vascular complications in extremities of physically restrained patients hospitalized in the ICU and the associated factors.

2 | MATERIALS AND METHODS

2.1 | Setting and sampling

The present study is a prospective, observational study conducted between September 1, 2022, and March 31, 2023 in eight ICUs of a city hospital located in the inner regions of Turkey. Of the ICUs in which the study was conducted, two were secondary medical ICUs, five were tertiary general ICUs and one was tertiary surgical ICU where the patient was hospitalized when there was no bed in other ICUs because of medical illness. The minimum sample size was found to be 112 units, taking the prevalence to 22.97% with a 99% confidence interval and 10% sampling error.[17]

The inclusion criteria were as follows:

- 18 years and above.
- Physical restraint applied for the first time.
- Patients who underwent physical restraint of the extremities.

The exclusion criteria were as follows:

- Patients with circulatory disorders, paralysis, oedema, fractures and dislocations in the physical restriction area.
- Individuals with impaired skin integrity in the area where physical restriction will be applied.
- Patients whose physical restraint is on another part of the body other than the extremity.
- Patients who underwent surgery were excluded.

2.2 | Measures

The Physical Restraint Monitoring Form and Glasgow Coma Scale (GCS) were used to monitor the patients, and the Patient Information Form was used to collect data about the patients.

Patient Information Form, developed by the researchers of the present study based on the literature,[17,20] consists of a total of 14 questions including information about socio-demographic characteristics, illness status, laboratory findings, treatment and care process.

Physical Restraint Monitoring Form, which was prepared by the researchers in line with the relevant literature,[17,20] consists of questions about the physical restraint start date and time, physical restraint application method and equipment, nursing interventions applied to the physical restraint site, physical restraint termination date and time. Each item in this form was evaluated by five specialist intensive care nurses using the triple three-point likert assessment tool. The answers received from the specialist were analysed using the Lawshe technique. Four out of 20 items were removed, and the Content Validity Index value of the remaining 16 items was found to be 1. In addition to the aforementioned queries, the form incorporates a segment dedicated to recording data pertaining to the monitoring and examination findings conducted by the attending nurses. This includes observations such as changes in skin colour, alterations in skin temperature, variations in capillary refill time, fluctuations in peripheral pulse, skin ulceration and the presence of oedema in the area affected by physical restriction. The intensive care nurse monitors the physical restraint area and distal part in terms of colour and records it if the colour is pink, normal if the colour is red, pale or cyanotic if it is recorded as problematic. The skin temperature of the physical restraint area is assessed by the nurse placing the back of both hands on the skin (one hand back on the skin of the patient's physically restrained extremity and the other hand back on the skin of the other parallel extremity) and comparing them. If the skin of the area where physical restraint is performed is hot or cold compared with the skin of the other extremity, it is considered pathologic, and if it is at the same temperature, it is considered normal. Nurses evaluate the capillary filling time by pressurizing the nail bed of the extremity where physical restraint is performed. Nurses consider it normal if the nail bed is pale or white after the pressure is performed and the nail bed turns pink in <2 s when the pressure is removed. Conditions with capillary refill time longer than 2 s are recorded as impaired circulation.[23,28] In pulse examination, nurses evaluate the radial and ulnar peripheral pulse points at the distal end of the upper extremity where physical restraint is performed and the posterior tibialis pulse point at the distal end of the lower extremity where physical restraint is performed for 1 min. The result obtained is recorded as one of the options "pulse is present" or "pulse is absent".[23] In the evaluation of oedema, nurses pressurize the skin distal to the physical fixation site and the same area of the parallel extremity, and if a collapse occurs in the skin of the physical fixation site because of the pressure, oedema is considered to be present. The depth of the skin collapse is evaluated using a measuring tape and the time for the skin to regain its original position is evaluated using a stopwatch and recorded as absence of oedema, (+), (++), (+++), and presence of oedema (+++), (++++).[28]

The GCS was developed in 1974 by Graham Teasdale and Bryan Jennett in Glasgow, Scotland, and is an internationally recognized scale frequently used in the evaluation of comatose patients. It conveys information about the patient's state of consciousness quickly

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and reliably.[29] Cronbach's alpha coefficient of GCS was calculated as 0.83 in patients hospitalized in the neurology ICU.[30]

2.3 | Data collection

In this study, physical restraint procedure was defined as the procedure used to prevent free movement of the patient's body to a position of choice using cloth on the patient's wrist and/or ankle. Physical restraint procedures were carried out by intensive care nurses following the physician's order according to the physical restraint application procedure of the hospital. Intensive care nurses were responsible for the primary care of patients, closely followed the patients 24/7, and were knowledgeable and experienced in the application of physical restraints. The nurse-to-patient ratio is 1:3 in secondary-level ICUs, and the nurse-to-patient ratio is 1:2 in tertiary-level ICUs. Physical restrain was performed using a green padd supported by soft material to the wrist/ankle. During the physical restrain, space was left for the patient to move his body a little, and the restraint material was secured to the bed frame. The physical restrain area was evaluated with hourly observation and examination techniques. Intensive care nurses rested the physical restraint area for 10 min every 2 h, preferably applied massage and had extremity exercises performed.

In this study, vascular complications were defined discolouration, distemperature, variations in capillary refill time, fluctuations in peripheral pulse, skin ulceration and oedema in the area of physical restraint. Vascular complications identified during the follow-up of the patients were reported to the physician. Nurses suspended physical restraint for 2 h in patients with changes in skin temperature and colour, and applied physical restraint once again when the skin colour and temperature returned to normal. In the presence of other vascular complications (change in capillary refill time, change in peripheral pulse, oedema, skin ulceration), physical restraint was terminated in line with the physician's order. In this process, no intervention was made by the researcher for the physical restraint of the patients.

The Patient Information Form was completed and filled out by the researcher after file review, interviews with the patient's relatives and evaluation of the patient. In the study, information about the patients' diagnosis, treatment, laboratory findings, body mass index, medical equipment support and nutritional status were taken from the file. Information was obtained from the patient's relatives about patients' health histories and whether physical restraints had been used in the past. During the study, the Physical Restraint Monitoring Form and GCS form were completed by intensive care nurses who were trained and experienced in filling out the forms and monitoring the area where physical restraint was applied, by making hourly evaluations.

The starting point and endpoint for the follow-up of the patients for vascular complications in the physical restraint site were determined as follows:

Starting point: The point in time when physical restraint was first applied following the physician's order.

Endpoint: The point at which any of the vascular complications (change in skin colour, change in skin temperature, change in peripheral pulse, change in capillary refill time, oedema) occurred in the area where physical restraint was applied and the physical restraint was terminated with the physician's approval, the patient who was subjected to physical restraint died or was transferred to another clinic or discharged. The follow-up of the patient ended at the endpoint.

2.4 | Data analysis

SPSS (IBM SPSS Statistics 27) package programme was used for statistical analysis. Frequency tables and descriptive statistics were used to interpret the findings. Normally distributed measurement values were analysed by parametric methods. In accordance with parametric methods, the "Independent sample *t*" test (*t*-table value) was used to compare the measurement values of two dependent groups (with/without skin colour, skin temperature, skin ulceration, peripheral pulse, capillary refill time). Non-parametric methods were used for non-normally distributed measurement values. In accordance with non-parametric methods, "Mann–Whitney *U*" test (*Z*-table value) was used to compare the measurement values of two independent groups (with/without skin colour, skin temperature, skin ulceration, peripheral pulse, capillary refill time). The relationship between two qualitative variables (gender, BMI category, mechanical ventilator support, nutrition, medical equipment support, nursing interventions) was tested using "Pearson-χ^2" cross-tabulations. The results were deemed statistically significant when $p < .05$.

2.5 | Ethical considerations

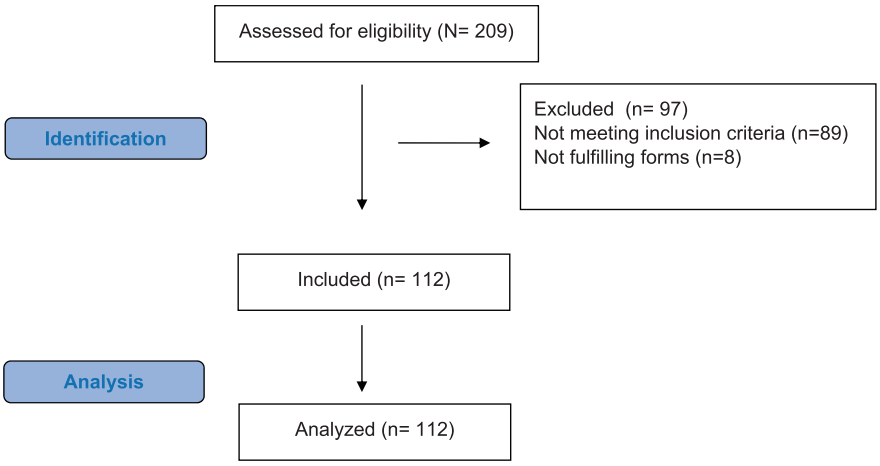
The written permission was obtained from the relevant Ethics Committee, numbered 26 and dated 26.10.2021, and written permission from the relevant hospital, dated 08.04.2022, prior to the study. In accordance with the hospital's protocol for applying physical restraint, all patient relatives are informed about the physical restraint application, which is determined to be necessary for the safety of the patient, and their approval is obtained for this application. In this study, intensive care nurses volunteered to provide the researchers with data on restraint practices in patient follow-up.

3 | RESULTS

Throughout this research, a cumulative total of 2409 patients underwent hospitalization in ICUs. Within this cohort, 209 patients experienced the application of physical restraint. Among those individuals subjected to physical restraint, a subset of 112 patients, meeting the specified inclusion criteria for the study, were meticulously monitored and observed (Figure 1).

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FIGURE 1 Flow diagram of the study.



3.1 | Demographic and medical characteristics

The mean age of the patients was 75.06 ± 11.65 (years), 65.2% were male and 53.6% had a normal body mass index (BMI). Analysing the medical characteristics of the patients, it was found that 35.7% had endotracheal tubes, 97.3% had Foley catheters, 45.5% were orally fed and 95.5% did not receive any nursing intervention for the physical restraint site. All patients were administered medications that affected the heart and circulatory system (Table 1).

3.2 | Vascular complication development at the physical restraint site

In the study, 9.8% ($n = 11$) of 112 patients developed vascular complications (change in skin temperature, change in skin colour, change in peripheral pulse, change in capillary refill time, skin ulceration, oedema) in the area where physical restraint was during the follow-up, which was performed an average of 230.12 ± 14.22 times (Table 1). It was determined that some patients developed a single vascular complication, while some patients developed more than vascular one complication.

3.3 | Vascular complication development at the physical restraint site by certain demographic and medical characteristics of the patients

Change in skin colour, skin temperature and peripheral pulse did not show a statistically significant difference by gender, BMI, nutrition, medical equipment support, nursing interventions applied to the physical restraint site, age, INR, platelet (PLT), red blood cell (RBC) and haemoglobin (Hgb) values ($p > .05$, Tables 2–5).

The GCS scores of patients with changes in skin colour, peripheral pulse and capillary refill time were lower than those with no changes ($p = .035$, $p < .001$, $p < .001$ respectively) (Table 5). The rates of patients with changes in skin colour ($p = .024$), peripheral pulse ($p = .047$) and capillary refill time ($p = .013$) were statistically different depending on mechanical ventilator support. It was determined that patients with changes in skin colour, peripheral pulse and capillary refill time received ventilator support with endotracheal tube at a higher rate (51.7%, 55.6%, 55.9% respectively) (Table 2).

There was a difference in capillary refill time by nutrition of the patients ($p = .030$); those with changes in capillary refill time were predominantly enterally fed (55.9%) (Table 2). In addition, INR values were higher in patients with skin ulceration and changes in capillary refill time ($p = .026$, $p = .034$, Table 5). Patients with changes in skin temperature in the physical restraint site received more massages (68.7%) (%95CI = 1.062–11.599, OR = 3510, $p = .032$, Table 4). Oedema (Grade+) was found in three patients in the physical restraint site during the follow-up period.

4 | DISCUSSION

The physical restraint sites of 112 patients hospitalized in ICUs were evaluated an average of 230.12 times in the study and 9.8% ($n = 11$) developed vascular complications at least once. Although complications developed at least once because of physical restraint, some complications recurred during follow-up and some patients had more than one complication. In the literature, skin abrasions, redness, bruising,[10,16,20] prolonged capillary refill time[16,17] and localized oedema were found in the physical restraint site in ICU patients.[10,16,17] Ertuğrul and Özden (2020) followed intensive care patients who underwent physical restraint for 4 days and reported that redness, change in colour and oedema in the physical restraint site were more common on the second day compared with the first day, and the number of patients with reduced pulse volume increased on the fourth day compared with the second day.[17] Gürlek Kısacık and Coşğun (2019) followed intensive care patients for 5 days and reported that the number of oedema and discolouration cases increased significantly on the fifth day compared with the first day.[20] In another study, the researchers found that redness increased significantly in the evening hours compared with the morning hours in the physical restraint site of intensive care patients.[31] Turna and Gürsoy (2021) reported redness in 42.9%, swelling and oedema in 42.7%, skin

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TABLE 1 Distribution of demographic and medical characteristics of patients.

Variable	Mean ± SD
Age (year)	75.06 ± 11.65
Sex	*n* (%)
Male	73 (65.2)
Female	39 (34.8)
BMI category	
Underweight	5 (4.5)
Normal	60 (53.6)
Overweight	38 (33.9)
Obese	9 (8.0)
Disease	
Cardiovascular disease[a]	17 (15.2)
Diabetes mellitus	2 (1.8)
Respiratory diseases[b]	12 (10.7)
Multiple chronic diseases[c]	81 (72.3)
Treatment	
Low molecular weight heparin treatment and other medications	79 (70.53)
Antiaggregan treatment and other medications	30 (26.77)
Other medications	3 (2.7)
Mechanical ventilator support	
None	59 (52.7)
With CPAP	13 (11.6)
With endotracheal tube	40 (35.7)
Medical equipment support	
Tracheostomy	3 (2.7)
NG	49 (43.8)
Foley catheter	109 (97.3)
Condom catheter	2 (1.8)
Peripheral catheter	99 (88.4)
Central venous catheter	14 (12.5)
Dialysis catheter	10 (8.9)
Artery catheter	4 (3.6)
Nutrition	
Oral	51 (45.5)
Enteral	42 (37.5)
TPN	19 (17.0)
Nursing interventions applied to the physical restraint site	
Massage	73 (65.2)
Cream	43 (38.4)
Massage+Cream	8 (7.1)
None	107 (95.5)
Vascular complication development at the physical restraint site	
No complication development	101 (90.2)
	11 (9.8)
Physical restraint terminated by the physician because of complications	
Total	112 (100)

Note: Other medications: Use of at least three of the following medications: antibiotic, antihypertensive, antidiabetic, antipsychotic, neuroleptic, analgesic, bronchodilator, diüretic, proton pump inhibitors and inotropics.

[a]Coronary heart disease, heart failure, hypertension, cardiac arrhythmia and cerebrovascular disease.

[b]Asthma, chronic obstructive pulmonary disease, lung cancer and pneumonia.

[c]The coexistence of at least three of the following diseases: Dementia, renal failure, cardiovascular diseases, respiratory diseases, diabetes mellitus and cancer.

depression in 22.2%, cyanosis in 13.8%, skin ulceration in 2.7% and skin erosion in 2.9% of 81 patients hospitalized in the ICU in a 24-hour follow-up.[16] Ang et al. (2015) found that 2.4% of patients over the age of 65 developed pressure ulcers as a result of physical restraint.[32]

In studies where nurses working in the ICU were asked about the complications they witnessed in the physical restraint site in patients undergoing physical restraint, the nurses reported disruption of skin integrity in the physical restraint site,[33] oedema, bruising[35] and hemodynamic changes.[34] Formal caregivers who followed individuals in nursing homes reported that individuals with physical limitations developed more pressure sores.[36] When the results of our study and the results of the studies in which patients were closely followed and the observations were reported by nurses are evaluated, it is possible that complications may develop in the area of physical restraint and many factors may affect this process.

According to the findings of the present study, the patients with low GCS scores had changes in skin colour, peripheral pulse and capillary refill time in the restraint site, while the patients with skin ulceration had higher INR values as well as GCS scores. The mean GCS score of the patients with changes in skin colour, peripheral pulse and capillary refill time in the physical restraint site was approximately 10, which indicates that the patient is in stupor. The patients with stupor are in deep sleep, do not respond to stimuli or respond briefly to severe and repetitive, sometimes painful stimuli.[37] As the GCS score increases, the patient's sensory and perceptual awareness as well as motor mobility increases. Patients with full orientation can immediately communicate any possible problem that may arise in the restraint site to the nurse, thus preventing the problem before it occurs, while the mobility of patients who are confused and in delirium may cause nurses to visit the patient more frequently than routine hourly follow-up and may help early recognition of possible complications in the restraint site. The patients with a lower GCS score in our study had poor sensory perception, were immobile or less mobile, were usually attached to a mechanical ventilator with an

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TABLE 2 Vascular complication development at the physical restraint site by gender, BMI, nutrition and mechanical ventilator support of the patients.

Variable	Change in skin colour		Change in skin temperature		Skin ulceration		Change in peripheral pulse		Change in capillary refill time	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Gender *n* (%)										
Male	19 (65.5)	54 (65.1)	62 (62.6)	11 (84.6)	8 (50)	65 (67.7)	15 (55.6)	58 (68.2)	22 (64.7)	51 (65.4)
Female	10 (34.5)	29 (34.9)	37 (37.4)	2 (15.4)	8 (50)	31 (32.3)	12 (44.4)	27 (31.8)	12 (35.3)	27 (34.6)
χ^2	0.002		2.448		1.895		1.452		0.005	
p-value	.965		.118		.169		.228		.945	
OR	1.020		0.305		0.477		0.582		0.971	
95% CI	0.420–2.482		0.064–1.451		0.164–1.389		0.240–1.411		0.417–2.257	
BMI category *n* (%)										
Underweight	–	5 (6)	4 (4)	1 (7.7)	1 (6.3)	4 (4.1)	1 (3.7)	4 (4.7)	1 (2.9)	4 (5.1)
Normal	1886 (2.1)	42 (50.6)	51 (51.5)	9 (69.2)	6 (37.5)	54 (56.3)	12 (44.4)	48 (56.5)	17 (50)	43 (55.1)
Overweight	10 (34.5)	28 (33.8)	36 (36.4)	2 (15.4)	7 (43.7)	31 (32.3)	11 (40.7)	27 (31.7)	13 (38.2)	25 (32.1)
Obese	1 (3.4)	8 (9.6)	8 (8.1)	1 (7.7)	2 (12.5)	7 (7.3)	3 (11.2)	6 (7.1)	3 (8.9)	6 (7.7)
χ^2	3.303		2.509		2.027		1.505		0.675	
p	.347		.474		.567		.681		.879	
Mechanical ventilator support *n* (%)										
None	14 (48.3)	45 (54.2)	49 (49.5)	10 (76.9)	8 (50)	51 (53.1)	10 (37)	49 (57.6)	12 (36.3)	47 (60.3)
With CPAP	–	13 (15.7)	13 (13.1)	–	1 (6.3)	12 (12.5)	2 (7.4)	11 (12.9)	3 (8.8)	10 (12.8)
With endotracheal tube	15 (51.7)	25 (30.1)	37 (37.4)	3 (23.1)	7 (43.7)	33 (34.4)	15 (55.6)	25 (29.5)	19 (55.9)	21 (26.9)
χ^2	7.495		4.006		0.824		6.114		8.687	
p	.024		.135		.662		.047		.013	
Nutrition *n* (%)										
Oral	9 (31)	42 (50.6)	46 (46.5)	5 (38.4)	8 (50)	43 (44.8)	11 (40.7)	40 (40.7)	11 (32.3)	40 (51.3)
Enteral	15 (51.7)	27 (32.5)	36 (36.4)	6 (46.2)	7 (43.7)	53 (36.4)	13 (48.1)	29 (34.1)	19 (55.9)	23 (29.5)
TPN	5 (17.3)	14 (16.9)	17 (17.1)	2 (15.4)	1 (6.3)	18 (18.8)	3 (11.1)	16 (18.8)	4 (11.8)	15 (19.2)
χ^2	3.920		0.477		1.539		1.974		7.040	
p	.141		.788		.493		.373		.030	

endotracheal tube, had more medical equipment support, and had a worse general condition compared with the patients with a higher GCS score. Therefore, in addition to lower GCS score, each of these factors may have caused changes in skin colour, peripheral pulse and capillary refill time. A review of the studies on the subject revealed a study examining whether physical restraint was performed according to the GCS score; however, the mentioned study did not investigate the relationship between GCS score and the development of complications in the restraint site.[16] Cramer et al. (2019) reported that pressure ulcers developed more commonly in patients with lower GCS score.[38] The lack of studies in the literature investigating the relationship between GCS score and the development of complications in the restraint site limits this part of the discussion. Therefore, prospective studies are recommended.

Delirium and anxiety can become a problem in patients hospitalized in ICUs, especially in those receiving mechanical ventilation support. These patients may displace the endotracheal tube, harm themselves because of agitated behaviour and even cause an increased risk of death. Physical restraint is applied to prevent these outcomes.[3,33] However, Devlin et al (2018) also emphasize that the use of physical restraint paradoxically does not prevent these situations.[5] In this study, an objective assessment tool was not used to evaluate the agitation states of the patients, and information obtained from our observations was included. Therefore, evidence is needed to state that there is a relationship between patients' agitation level and vascular complication status. According to our observations, the duration of physical restraint in patients receiving mechanical ventilation support may be longer than others. The evidence from the literature suggests that the risk of neurovascular complications increases as the duration of restraint prolongs.[16,20] Ertuğrul and Özden (2020) found that pulse rate decreased significantly as the restriction duration increased.[17] In our study, changes in skin colour, peripheral pulse and capillary refill time were observed to be more

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TABLE 3 Vascular complication development at the physical restraint site by medical equipment support of the patients.[a]

	Change in skin colour		Change in skin temperature		Skin ulceration		Change in peripheral pulse		Change in capillary refill time	
Variable	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Tracheostomy *n* (%)	2 (6.9)	1 (1.2)	3 (3)	–	–	3 (3.1)	2 (7.4)	1 (1.2)	2 (5.9)	1 (1.3)
χ^2	2.671		0.40		0.51		2.506		1.922	
p-value	.102		.52		.47		.14		.16	
OR	6.074		–		–		6.720		4.813	
95% CI	0.530–69.655		–		–		0.585–77.225		0.421–54.971	
NG *n* (%)	16 (55.2)	33 (39.8)	40 (40.4)	9 (69.2)	5 (31.3)	44 (45.8)	12 (44.4)	37 (43.5)	18 (52.9)	31 (39.7)
χ^2	2.07		2.79		1.185		0.007		1.67	
p-value	.15		.07		.27		.93		.19	
OR	1.865		0.301		0.537		1.038		1.706	
95% CI	0.794–4.379		0.087–1.046		0.173–1.664		0.434–2.484		0.757–3.841	
FC *n* (%)	28 (96.6)	81 (97.6)	96 (97)	13 (100)	16 (100)	93 (96.9)	27 (100)	82 (96.5)	33 (97.1)	76 (97.4)
χ^2	0.08		0.40		0.51		0		0.01	
p-value	.76		.52		.47		1.0		.91	
OR	0.691		–		–		–		0.868	
95% CI	0.060–7.921		–		–		–		0.076–9.914	
CC *n* (%)	1 (3.4)	1 (1.2)	2 (2)	–	–	2 (2.1)	–	2 (2.4)	1 (2.9)	1 (1.3)
χ^2	0.61		0.27		0.33		0.64		0.37	
p-value	.43		.78		.56		.42		.54	
OR	2.929		–		–		–		2.333	
95% CI	0.177–48.392		–		–		–		0.142–38.434	
PC *n* (%)	25 (86.2)	74 (89.2)	88 (88.9)	11 (84.6)	14 (87.5)	85 (88.5)	23 (85.2)	76 (89.4)	30 (88.2)	69 (88.5)
χ^2	0.18		0.20		0.01		0.35		0.001	
p-value	.66		.65		.90		.55		.97	
OR	0.760		1.455		0.906		0.681		0.978	
95% CI	0.215–2.685		0.284–7.437		0.181–4.528		0.192–2.417		0.279–3.426	
CVC *n* (%)	6 (20.7)	8 (9.6)	13 (13.1)	1 (7.7)	2 (12.5)	12 (12.5)	3 (11.1)	11 (12.9)	4 (11.8)	10 (12.8)
χ^2	2.40		0.31		0.00		0.06		0.02	
p-value	.12		.57		1.000		.80		.87	
OR	2.446		1.814		1.000		0.841		0.907	
%95 CI	0.769–.7.778		0.217–15.138		0.202–4.955		0.216–3.267		0.263–3.122	
DC *n* (%)	1 (3.4)	9 (10.8)	8 (8.1)	2 (15.4)	1 (6.3)	9 (9.4)	3 (11.1)	7 (8.2)	–	4 (5.1)
χ^2	1.445		0.75		0.16		0.20		0.48	
p-value	.22		.38		.68		.64		.48	
OR	0.294		0.484		0.644		1.393		1.600	
95% CI	0.036–2.425		0.091–2.571		0.076–5.463		0.334–5.807		0.421–6.080	
AC *n* (%)	–	4 (4.8)	4 (4)	–	–	4 (4.2)	–	4 (4.7)	–	4 (5.1)
χ^2	1.449		0.54		0.69		1.31		1.808	
p-value	.22		.46		.40		.25		.17	
OR	–		–		–		–		–	
95% CI	–		–		–		–		–	

Abbreviations: AC, artery catheter; CC, condom catheter; CVC, central venous catheter; DC, dialysis catheter; FC, foley catheter; NG, nazogastric; PC, peripheral catheter.

[a]One patient received more than one medical equipment.

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TABLE 4 Vascular complication development at the physical restraint site by nursing intervention.[a]

Variable	Change in skin colour		Change in skin temperature		Skin ulceration		Change in peripheral pulse		Change in capillary refill time	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Massage *n* (%)	21 (72.4)	52 (62.7)	68 (68.7)	5 (38.5)	12 (75)	61 (63.5)	16 (59.3)	57 (67.1)	23 (67.6)	50 (64.1)
χ^2	0.903		4.625		0.793		0.549		0.131	
p-value	.342		.032		.373		.459		.717	
OR	1.565		3.510		1.721		0.715		1.171	
95% CI	0.619–3.958		1.062–11.599		0.516–5.747		0.293–1.742		0.498–2.752	
Cream *n* (%)	13 (44.8)	30 (36.1)	40 (40.4)	3 (23.1)	10 (62.5)	33 (34.4)	13 (48.1)	30 (35.3)	15 (44.1)	28 (35.9)
χ^2	0.685		1.459		4.583		1.431		0.676	
p-value	.408		.227		.049		.232		.411	
OR	1.435		2.260		3.182		1.702		1.410	
95% CI	0.609–3.385		0.585–8.728		1.063–9.523		0.708–4.089		0.621–3.201	
Massage + Cream *n* (%)	2 (6.9)	6 (7.2)	7 (7.1)	1 (7.79)	4 (25)	4 (4.2)	2 (7.4)	6 (7.1)	2 (5.9)	6 (7.7)
χ^2	0.004		0.007		6.108		0.004		0.117	
p-value	.952		.935		.014		.951		.732	
OR	0.951		0.913		7.667		1.053		0.750	
95% CI	0.181–4.996		0.103–8.077		1.692–34.734		0.200–5.553		0.144–3.919	
None *n* (%)	29 (100)	78 (94)	94 (94.9)	13 (100)	13 (81.3)	94 (97.9)	27 (100)	80 (94.1)	34 (100)	73 (93.6)
χ^2	1.829		0.687		5.452		1.662		2.281	
p-value	.176		.407		.020		.197		.320	
OR	–		-		0.092		–		–	
95% CI	–		–		0.014–0.605		–		–	

[a]One patient received more than one nursing intervention.

common in patients who received physical restraint and mechanical ventilator support with endotracheal tube compared with the others.

The patients with higher INR values in the present study had more skin ulcerations as well as a more significant change in capillary refill time. An increased INR value is a factor that increases the tendency to bleed and causes subcutaneous haemorrhages.[39] Physical restraint can exacerbate this situation even more.[35,40] Subcutaneous bleeding may accelerate the deterioration of skin integrity and cause ulcerations.[41] The findings of our study suggest that higher INR values may be effective in the formation of skin ulcerations because of physical restraint, and nurses should practice more caution for patients with higher INR values to prevent this issue.

In the present study, the change in capillary refill time was found to be higher in patients who received mechanical ventilator support with endotracheal tube, were fed enterally, had high INR and aPTT values, and had low GCS score. Capillary refill time is an important indicator that provides information about circulatory adequacy. In capillary refill time test, capillary refill time is prolonged in case of peripheral vasoconstriction and capillary refill time is shortened in case of peripheral vasodilation.[42] Capillary refill time may be affected by the patient's body temperature, age, gender, ambient temperature and use of cardiovascular system medications.[43] These results suggest that there are many factors that cause changes in capillary refill time. In our study, it was determined that almost all of the patients used antithrombotic treatments (low molecular weight heparin and *antiaggregants*). Therefore, more research is needed by increasing sample size in order to achieve more accurate results.

5 | LIMITATIONS

The strength of this study is that it is a follow-up study. There are several limitations in the research. In our study, the majority of patients had more than three chronic diseases and all patients were administered multiple medications. Therefore, the development of vascular complications according to the diseases and medications could not be analysed. Additionally, the development of vascular complications according to disease severity, agitation status and body temperature was not examined. In our study, the pain experienced by the patients in the physical restraint site could not be evaluated directly because of sedation, endotracheal tube application and altered consciousness, and the pain identified during routine follow-up of the patients may indicate pain in any part of the body. Therefore, the study could not directly evaluate the presence of pain, which is an important sign of perivascular complications related to physical restraint, in detail.

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TABLE 5 Vascular complication development at the physical restraint site by age, GCS score and some laboratory results of the patients.

	Age			GCS			INR			aPTT			PLT			Hgb			RBC		
Variable	Median [IQR]	Z	*p*-value	Median [IQR]	*Z*	*p*-value	Median [IQR]	*Z*	*p*-value	Median [IQR]	*Z*	*p*-value	Median [IQR]	*Z*	*p*-value	Median [IQR]	*Z*	*p*-value	Median [IQR]	*t*	*p*-value
Change in skin colour																					
Yes	78.0 [13.5]	−0.542	.588	11.3 [4.0]	−2.106	.035	1.1 [0.3]	−0.103	.918	33.6 [13.5]	−0.894	.372	216 [129]	−0.197	.844	10.4 [3.5]	−1.597	.110	3.7 [1.4]	−0.965	.337
No	77.0 [13.0]			13.3 [3.0]			1.1 [0.3]			32.4 [8.6]			204.5 [146.5]			11.3 [3.5]			4.1 [1.4]		
Change in skin temperature																					
Yes	77.0 [13.0]	−1.609	.108	13.3 [3.7]	−0.565	.572	1.2 [0.3]	−1.749	.080	32.6 [9.1]	−1.403	.161	213 [140]	−1.066	.286	11.3 [3.4]	−0.445	.656	4.1 [1.2]	0.547	.586
No	78.0 [12.5]			13.4 [3.1]			1.0 [0.1]			29.5 [12.8]			192 [130.3]			10.9 [3.9]			3.8 [2.1]		
Skin ulceration																					
Yes	79.0 [15.0]	−1.232	.218	10.5 [9.4]	−2.252	.024	1.2 [0.5]	−2.223	.026	37.6 [10.2]	−1.582	.114	234 [126.5]	−0.965	.334	11.5 [2.6]	−0.294	.769	4.2 [0.9]	0.684	.495
No	77.0 [13.8]			13.3 [3.1]			1.1 [0.3]			32.4 [9.6]			206 [140]]			11.2 [3.5]			4 [1.3]		
Change in peripheral pulse																					
Yes	78.0 [14.0]	−0.034	.973	10.6 [2.9]	−4.184	<.001	1.2 [0.6]	−1.925	.054	37.3 [9.5]	−2.306	.021	210 [175.5]	−0.029	.977	11.1 [3.3]	−0.029	.977	4.2 [1]	−0.376	.707
No	77.0 [14.0]			13.4 [2.5]			1.1 [0.3]			31.9 [8.0]			208 [130.5]			11.3 [3.4]			4 [1.4]		
Change in capillary refill time																					
Yes	78.5 [16.5]	−0.364	.716	10.8 [3.6]	−4.422	<.001	1.2 [0.5]	−2.123	.034	37.4 [13.5]	−3.339	<.001	232 [169.8]	−1.479	.139	10.7 [3.2]	−1.366	.172	3.8 [1.1]	−1.286	.201
No	77.0 [13.3]			13.4 [2.7]			1.1 [0.2]			31.6 [7.1]			201 [126]			11.4 [3.4]			4.1 [1.4]		

Abbreviations: *t*, Independent sample *t* test; *Z*, Mann–Whitney *U* test (*Z*-table value).

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6 | CONCLUSIONS

Vascular complications may develop in patients hospitalized in the ICUs because of physical restraint applied to the extremities. Low GCS score and the presence of an endotracheal tube may be a risk for the development of vascular complications in the area of physical restriction. It is recommended that nurses should closely monitor the physical restraint site and recognize possible complications early.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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