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RESEARCH ARTICLE (ORIGINAL)

Analysis of local complications associated with peripheral venous catheterization in critically ill patients

Análise das complicações locais associadas ao cateterismo venoso periférico no doente crítico

Análisis de las complicaciones locales asociadas al cateterismo venoso periférico en el paciente crítico

Sérgio Miguel Rodrigues Peixoto Pinto da Mota [1, 2]
https://orcid.org/0000-0003-4125-6435

Matilde Delmina da Silva Martins [2, 3]
https://orcid.org/0000-0003-2656-5897

[1] Northeastern Local Health Unit, Hospital Unit of Bragança, Intensive Care Unit, Bragança, Portugal

[2] Polytechnic Institute of Bragança, Health School, Bragança, Portugal

[3] Health Sciences Research Unit: Nursing (UICISA: E), Nursing School of Coimbra, Coimbra, Portugal

Correwponding author
Sérgio Miguel Rodrigues Peixoto Pinto da Mota,
E-mail: sergiomiguelmota@outlook.pt

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Abstract
Background: The scarcity of studies on local complications associated with peripheral venous catheterization in critically ill patients in Portugal compromises the implementation of adequate preventive measures.
Objective: To analyze the local complications associated with peripheral venous catheterization in critically ill patients in an Intensive Care Unit in Portugal.
Methodology: Prospective analytical cross-sectional study, carried out through the application of a registration grid developed by the researcher to a sample of 48 patients.
Results: Mostly male sample (54.2%), with a mean age of 70.13 years, with a 20G peripheral venous catheter (58.5%), placed in the upper limb /58.5%) and diagnosed in the admission of infectious and parasitic diseases (33.3%). Local complications associated with peripheral venous catheterization were 11.6%, with 6.4% phlebitis, 2.3% infiltrations and 2.9% obstructions. These were associated with the catheter permanence time ($p < 0.05$).
Conclusion: The frequency of complications was significant and the catheter length of stay influenced the frequency of complications. We suggest reducing catheter permanence time or using an alternative route whenever possible.

Keywords: critical care; peripheral venous catheters; infection

Resumo
Enquadramento: A escassez de estudos sobre complicações locais associadas ao cateterismo venoso periférico em doente crítico em Portugal compromete a implementação de medidas preventivas adequadas.
Objetivo: Analisar as complicações locais associadas ao cateterismo venoso periférico no doente crítico num Serviço de Medicina Intensiva em Portugal.
Metodologia: Estudo transversal analítico prospetivo, realizado através da aplicação de uma grelha de registo elaborada pelo investigador a uma amostra de 48 doentes.
Resultados: Amostra maioritariamente masculina (54,2%), com média de idade de 70,13 anos, com cateter venoso periférico de calibre 20G (58,5%), colocados no membro superior (58,5%) e com diagnóstico na admissão de doenças infeciosas e parasitárias (33,3%). As complicações locais associadas ao cateterismo venoso periférico foram de 11,6%, sendo 6,4% flebites, 2,3% infiltrações e 2,9% obstruções. Estas associaram-se ao tempo de permanência do cateter ($p < 0,05$).
Conclusão: A frequência de complicações foi significativa e o tempo de permanência do cateter influenciou a frequência de complicações. Recomendamos reduzir o tempo de permanência do cateter ou, quando possível, utilizar uma via alternativa.

Palavras-chave: cuidados críticos; cateteres venosos periféricos; infecção

Resumen
Marco contextual: La escasez de estudios sobre las complicaciones locales asociadas al cateterismo venoso periférico en pacientes críticos en Portugal compromete la aplicación de medidas preventivas adecuadas.
Objetivo: Analizar las complicaciones locales asociadas al cateterismo venoso periférico en pacientes críticos de una unidad de cuidados intensivos de Portugal.
Metodología: Estudio transversal analítico prospectivo, realizado mediante la aplicación de una tabla de registro elaborada por el investigador a una muestra de 48 pacientes.
Resultados: La muestra fue mayoritariamente masculina (54,2%), con una edad media de 70,13 años, con catéter venoso periférico de calibre 20G (58,5%) colocado en el miembro superior (58,5%) y con diagnóstico de enfermedad infecciosa y parasitaria al ingreso (33,3%). Las complicaciones locales asociadas al cateterismo venoso periférico fueron del 11,6%, con un 6,4% de flebitis, un 2,3% de infiltración y un 2,9% de obstrucción. Estas se asociaron a la duración de la estancia del catéter ($p < 0,05$).
Conclusión: La frecuencia de las complicaciones fue significativa y el tiempo de permanencia del catéter influyó en la frecuencia de las complicaciones. Se recomienda reducir el tiempo de permanencia del catéter o, si es posible, utilizar una vía alternativa.

Palabras clave: atención crítica; catéteres venosos periféricos; infección

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Introduction

Healthcare-associated infections (HAIs) are a growing problem worldwide (Shang et al., 2019). Critically ill patients are most affected by this type of infection (Zaha et al., 2019) due to the multiple contexts of intervention and the specialized care required to perform many invasive, diagnostic, and therapeutic measures (Ordem dos Enfermeiros [OE], 2018) that can extend hospital stay (Zaha et al., 2019). Peripheral venous catheters (PVCs) are the most common invasive devices used in hospitals (Marsh et al., 2021). Phlebitis and PVC-related complications are very common in critically ill patients (Yasuda et al., 2022). The lack of studies on PVC-related local complications in critically ill patients in Portugal hinders the implementation of appropriate, evidence--based preventive measures. Therefore, this study aims to analyze PVC-related local complications in critically ill patients in an Intensive Care Unit (ICU) of a hospital in northern Portugal.

Background

Critically ill patients are those who are unable to maintain physiological stability or are at risk of physiological instability and multiorgan failure and whose survival depends on monitoring, intensive care, and treatment (OE, 2018). HAIs and increasing antimicrobial resistance (AMR) have negative consequences for patients, health units, and the community, such as increased morbidity, mortality, healthcare costs, and prolonged hospitalization (Direção-Geral da Saúde, 2019). This issue is particularly relevant among critically ill patients. The utilization of more advanced and invasive technology enhances life expectancy and the number of patients undergoing immunosuppressive therapy. However, broad-spectrum antibiotic therapy not only increases survival but also raises the risk of infection. (OE, 2018). PVCs are the most common invasive medical devices used in hospitalized patients, but these patients often develop complications and do not complete treatment (Marsh et al., 2021). Phlebitis, infiltration, and obstruction are among the most common local complications associated with PVCs (Yasuda et al., 2022). Risk factors include prolonged hospital stay, duration of infusion, frequency of access, intravenous medication, and dwell time (Chen et al., 2021). The longer the indwelling period, the more vulnerable patients are to developing complications due to microbial colonization (Nobre et al., 2018). Female gender has been a consistent variable in PVC-related complications due to women's smaller vessel caliber, hormonal differences, and adipose tissue characteristics (Marsh et al., 2021). Age is another significant risk factor due to impaired vascular structure and function, resulting in vascular stiffness, endothelial dysfunction, and hypoperfusion (Chen et al., 2021).
Phlebitis is an inflammatory process in a vein caused by blood clots or injured tissue, with signs and symptoms including pain/sensitivity, erythema, warmth, edema, induration, purulence, or palpable venous cord (Gorski, 2021). Risk factors for phlebitis in ICUs have not been adequately studied (Yasuda et al., 2022). Infiltration is one of the most common complications of PVC infusion therapy. It is defined as the inadvertent administration of a non-vesicant solution or medication into the tissue surrounding the PVC (Wang et al., 2022). The most common symptoms include edema, erythema, fluid leakage from the catheter insertion site, and local pain (Gorski, 2021). On the contrary, extravasation is the inadvertent administration of irritant or vesicant solutions or medications from the intravascular space (Santos et al., 2022). Nurses should regularly assess PVCs used to administer irritant or vesicant drugs (Chen et al., 2021). Different drugs cause varying degrees of irritation to blood vessels (Fan et al., 2022). High concentrations of irritant drugs can increase osmotic pressure, resulting in a shift of intravascular fluids into the extravascular space (Chen et al., 2021). According to Braga (2018), obstruction is defined as poor PVC functioning due to the absence of reflux and the inability to administer solutions. In case of obstruction, catheter retrieval is preferable to catheter removal (Gorski, 2021).

Research question

What is the frequency and nature of local complications associated with peripheral venous catheterization in critically ill patients in an Intensive Care Unit in Portugal?

Methodology

A prospective analytical cross-sectional study was conducted at an ICU in Portugal. The target population consisted of all patients with one or more PVCs admitted to the ICU in August 2022. The following exclusion criterion was applied: patients who already had a PVC at admission. This criterion was necessary because we could not assess all factors related to the initial placement of the catheter. After applying the criterion, a final sample of 48 patients was obtained. The number of PVCs varies according to patients' clinical needs and length of stay, and the catheter should always be changed after 72 hours. A total of 173 observations were recorded. Ninety-four PVCs were observed: 15 were removed in the first 24 hours, with one observation; 45 in the first 48 hours, with two observations; and 34 remained in place for the scheduled 72 hours, with three observations. The data collection instrument was a registration grid developed by the researcher. The PVC was numbered, and data were collected about patients' sociodemographic and clinical data, age, gender, admission diagnosis, and medications, PVC gauge, dwell time, reason for removal, insertion site, local complications using the Portuguese versions of the Phlebitis Scale (Braga, 2016a) and the Infiltration Scale (Braga, 2016b), and compliance with the PVC insertion, maintenance, and replacement or removal bundles in force at the hospital. Nursing care in peripheral venous catheterization is often described

in structured nursing interventions (bundles) developed to recommend safe nursing care for PVC handling, thus preventing complications and promoting the safety and effectiveness of this procedure. Descriptive analysis was performed using absolute and relative frequencies (for nominal variables) and measures such as mean, standard deviation, minimum, maximum, and median (for quantitative variables). Chi-squared tests of independence were performed to assess the association between the frequency of local complications and the medications administered, nursing care, PVC insertion site, dwell time, and gauge. Student's *t*-tests were used to compare independent samples and identify statistically significant differences in local complications in terms of age.

All statistical analyses were performed using IBM SPSS Statistics software, version 28.0 for Windows 11. The significance level was set at .05. The study received a favorable opinion from the Ethics Committee (No. 74/2022) and approval from the Unit Director. Patients' sociodemographic and clinical data were requested from the ICU director. These data were coded and recorded on the grids with a code number. The researcher went to the unit every day for 8 hours, in August to observe the PVC insertion site and apply the Portuguese versions of the Phlebitis Scale (Braga, 2016a) and the Infiltration Scale (Braga, 2016b). These data were recorded on a separate sheet with a sequential code number and later transferred to a computer database for analysis and statistical treatment. The process was completely anonymous. Only strictly necessary data were collected.

Results

Most patients were men (54.2%), with a mean age of 70.13 ± 13.1 years, 64.6% aged over 65. They were mainly diagnosed at admission with infectious and parasitic diseases (33.3%), uncertain etiology (COVID-19; 16.7%), diseases of the circulatory system (14.6%), diseases of the respiratory system (10.4%), and symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified (10.4%; Table 1).

Table 1

Distribution of participants by gender, age group, and admission diagnosis (n = 48)

Variables	*n*	%
Gender (*n* = 48)		
Male	26	54.2
Female	22	45.8
Age group (*n* = 48)		
≤ 65 years	17	35.4
> 65 years	31	64.6
X = 70.13 years (*SD* = 13.1); Min: 38; Max: 91		
Admission diagnosis (*n* =48)		
Infectious and parasitic diseases	16	33.3
New diseases of uncertain etiology (COVID-19)	8	16.7
Diseases of the circulatory system	7	14.6
Diseases of the respiratory system	6	12.5
Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified	5	10.4
Diseases of the genitourinary system	2	4.2
Endocrine, nutritional and metabolic diseases	2	4.2
Diseases of the nervous system	1	2.1
Injury, poisoning and certain other consequences of external causes	1	2.1

Note. X = Mean; *n* = Sample; % = Percentage; *SD* = Standard deviation.

Table 2 shows that most PVCs (58.5%) were 20-gauge catheters. The most common insertion sites were the left and right upper extremities, respectively 25.5% and 23.4%. It also shows that 60.6% of PVCs were removed due to the insertion of a central venous catheter (CVC). A total of 173 observations were made, with a higher frequency of observations in the first moment (54.3%; after 24 hours,) followed by the second moment (26.0%; after 48 hours), and the third moment (19.7%; after 72 hours).

Table 2

Distribution of participants by PVC gauge, insertion site, catheters removed, reason for removal, and number of observations

Variables	*n*	%
PVC gauge (*n* = 94)		
18G	20	21.3
20G	55	58.5
22G	19	20.2
Insertion site (*n* = 94)		
Left upper extremity	24	25.5
Right upper extremity	22	23.4
Right antecubital fossa	12	12.8
Back of the right hand	10	10.6
Back of the left hand	10	10.6
Left antecubital fossa	7	7.4
Left lower extremity	5	5.3
Right lower extremity	4	4.3
Catheter removed (*n* = 94)		
No	37	39.4
Yes	57	60.6
Reason for removal (*n* = 57)		
CVC insertion	33	63.2
Phlebitis	11	19.3
Infiltration	4	7.0
Death	4	7.0
Obstruction	5	8.8
Number of observations (*n* = 173)		
1st observation	94	54.3
2nd observation	45	26.0
3rd observation	34	19.7

Note. PVC = Peripheral venous catheter; CVC = Central venous catheter; *n* = Sample; % = Percentage.

Table 3 shows that intravenous therapy was administered in all cases. Vesicant drugs were administered in 23.1% of the observations and irritant drugs in 48.0%. The highest number of medications was administered at the first observation.

Table 3

Distribution of participants by intravenous therapy and number of observations

Variables	Total observations (*n* = 173)		1st observation (*n* = 94)		2nd observation (*n* = 45)		3rd observation (*n* = 34)	
	n	***%***	***n***	***%***	***n***	***%***	***n***	***%***
Intravenous therapy	173	100	94	100.0	45	100.0	34	100.0
Vesicant drugs	40	23.1	30	31.9	8	17.8	2	5.9
Sodium bicarbonate	2	1.2	2	2.1	0	0.0	0	0.0
Potassium chloride	13	7.5	11	11.7	2	4.4	0	0.0
Calcium gluconate	25	14.5	17	18.1	6	13.3	2	5.9
Irritant drugs	83	48.0	50	53.2	21	46.7	12	35.3
Azithromycin	6	3.5	4	4.3	1	2.2	1	2.9
Cefazolin	3	1.7	3	3.2	0	0.0	0	0.0
Ceftriaxone	14	8.1	10	10.7	3	6.6	1	2.9
Gentamicin	13	7.5	7	7.4	4	8.9	0	0.0
Imipenem	6	3.5	5	5.3	1	2.2	2	5.9
Piperacillin Tazobactam	31	17.9	16	17.0	9	20.	6	17.6
Sulfamethoxazole	6	3.5	1	1.1	3	6.7	2	5.9
Vancomycin	4	2.3	4	4.3	0	0.0	0	0.0

Note. n = Sample; *%* = Percentage.

Table 4 shows that local complications were found in 11.6% of observations (6.4% phlebitis, 2.3% infiltration, and 2.9% obstruction). The highest percentage (20.6%) of local complications was found in the third observation.

Table 4

Distribution of local complications by number of observations and total observations

Variables	Total observations (*n* = 173)		1st observation (*n* = 94)		2nd observation (*n* = 45)		3rd observation (*n* = 34)	
	n	***%***	***n***	***%***	***n***	***%***	***n***	***%***
Local complications								
No	153	88.4	89	*94.7*	*37*	*82.2*	*27*	*79.4*
Yes	20	11.6	5	*5.3*	*8*	*17.8*	*7*	*20.6*
Phlebitis	11	6.4	0	*0.0*	*3*	*6.7*	*8*	*23.5*
Grade 1	9	5.2	0	*0.0*	*2*	*4.4*	*5*	*20.6*
Grade 2	1	0.6	0	*0.0*	*0*	*0.0*	*1*	*2.9*
Grade 3	1	0.6	0	*0.0*	*1*	*2.2*	*0*	*0.0*
Infiltration	4	2.3	1	*1.1*	*3*	*6.7*	*0*	*0.0*
Grade 1	3	1.7	1	*1.1*	*2*	*4.4*	*0*	*0.0*
Grade 2	1	0.6	0	*0.0*	*1*	*2.2*	*0*	*0.0*
Obstruction	5	2.9	3	*3.2*	*1*	*2.2*	*1*	*2.9*
Concomitant infection	136	78.6	79	*84.0*	*34*	*75.6*	*23*	*67.6*

Note. n = Population; *%* = Percentage.

Table 5 shows a statistically significant difference between PVC dwell time and the development of local complications ($p < .05$). No association was found between insertion site ($p = .400 > .005$), age group ($p = .831 > .05$), gender ($p = .153 > .05$) and therapy or nursing care. Although the mean age was higher in the group with complications, this difference was far from statistically significant.

Table 5

Distribution of local complications by gender, age group, PVC gauge, dwell time, insertion site, vesicant drugs, irritant drugs, and adherence to bundles

	Local complications				
	No		**Yes**		
	n	**%**	***n***	**%**	***p***
Gender					
Male	19	39.6	8	16.6	0.153
Female	13	27.1	12	25	
Age group					
≤ 65 years	11	22.9	6	12.5	0.831
>65 years	21	43.8	10	20.8	
	X=69.8±13.7		*X*=70.±12.6		*0.819
PVC gauge					
18G	17	85	3	15	0.654
20G	42	76.4	13	23.6	
22G	15	78.7	4	21.3	
Dwell time (hours)					
24	91	94.8	5	5.2	<0.05
48	37	82.2	8	17.8	
72	25	78.1	7	21.9	
Insertion site					
Back of the right hand	17	81.0	4	19.0	0.400
Back of the left hand	14	87.5	2	12.5	
Right antecubital fossa	18	100.0	0	0.0	
Left antecubital fossa	11	91.7	1	8.3	
Right lower extremity	7	87.5	1	12.5	
Left lower extremity	9	100.0	0	0.0	
Right upper extremity	35	81.4	8	18.6	
Left upper extremity	42	91.3	4	8.7	
Vesicant drugs					
No	118	88.7	15	11.3	0.783
Yes	35	87.5	5	12.5	
Irritant drugs					
No	81	90.0	9	10.0	0.635
Yes	72	86.7	11	13.3	
Adherence to bundles					
No	22	88.8	3	12.0	1.000
Yes	131	88.5	17	11.5	

Note. PVC = Peripheral venous catheter; *X* = Mean; *n* = Sample; *%* = Percentage; *SD* = Standard deviation; * = Student's *t*-test.

Discussion

Although PVC-related local complications have been widely studied in the past, our research shows that it is the first time that the specificity of critically ill patients and ICUs has been addressed in Portugal. The researchers conducted 173 observations of 94 PVCs in 48 patients and identified several PVC-related local complications (rate of 11.6%), including phlebitis (6.4%), infiltration (2.3%), and obstruction (2.9%).

In 2022, Yasuda conducted a study in 23 ICUs in Japan, including 2,741 patients and 7,118 PVCs, and found a local complication rate of 7.5%. The author concluded that PVC-related local complications were common in critically ill patients. In a prospective randomized controlled trial in a medical ICU at a tertiary hospital in France, Günther et al. (2016) included 628 patients and observed 873 PVCs. The overall complication rate was high, with an incidence of 267 PVC-related complications (30.6%). According to the authors, the lack of a maintenance bundle and nursing staff training in access management could explain these high values and the discrepancy between these results and those found in our study. Ray-Barruel et al. (2019) conducted a systematic literature review on the effectiveness of insertion and maintenance bundles in preventing PVC-related complications and bloodstream infections in hospitalized patients. Despite the strong adherence to the bundles, full compliance with the insertion and removal protocol, and an 85.5% adherence rate to the maintenance protocol, the data suggest that improving this indicator could reduce the rate of local complications. Our study included 26 men and 22 women. Although our sample consisted mostly of male patients (54.2%), the incidence of local complications was higher among women (20.8%). A prospective cohort study conducted by Nassaji-Zavareh and Ghorbani (2007) with 145 men and 155 women found an incidence of phlebitis of 26%. They found a statistically significant association with the female gender, suggesting hormonal differences between women and men as a risk factor. A secondary analysis of 12 prospective studies aimed at identifying risk factors for PVC failure (Marsh et al., 2021) supported this finding. The authors found that the female gender was a consistent variable associated with infiltration, obstruction, and phlebitis, suggesting that it may be related to the small caliber of female vessels compared to male vessels. Chen et al. (2021) conducted a prospective cohort study with 5,345 patients in three tertiary hospitals in China and found a local complication rate of 30.1%. According to the authors, older age can explain these high values given that more than 50% of patients were aged over 60 years and aging affects vascular stiffness and permeability. The mean age in our study is higher than in Chen et al. (2021), with 60.4% aged over 65, which may contribute to the high rate of local complications. A prospective cohort study conducted at two emergency departments in Australia and New Zealand (Carr et al., 2018) with 391 patients and 118 PVCs also identified age as a key risk factor for PVC-related local complications. They found a direct association between older age and increased risk, with a 95% confidence interval (p = .0001). The highest percentage of local complications was recorded in the third observation (between 48 and 72 hours), corresponding to 20 local complications per 100 catheters. These data are corroborated by Nobre (2018), who assessed the prevalence of phlebitis in 221 observations of 78 PVCs in 58 patients. Regarding the rate of PVC-related local complications and dwell time, the author found that PVC dwell time was longer in patients with phlebitis than in those without phlebitis. Intravenous medications were administered in all cases. Vesicants were administered in 23.1% of observations and irritants in 48.0%. A 5-month observational prospective study conducted by Liu et al. (2022) in a Chinese hospital with a sample of 1,069 patients concluded that infusing irritant drugs increased phlebitis and infiltration rates. Our study found no statistically significant association with the administration of intravenous therapy, noting, as in Yasuda et al. (2022), that standardized drug administration measures in ICUs can reduce the risk of phlebitis. We found that 63.2% of PVCs were removed for CVC insertion, reflecting the sensitivity of the ICU team to replace them in case of high-risk medications or longer treatments and avoid prolonged PVC dwell time. Some limitations in this analysis hinder our understanding of the real impact of pharmacological administration and the existence of PVC-related local complications, namely the lack of dosage, time of administration, and the use or not of an infusion pump. There was a higher rate of complications in PVCs placed in the back of the right hand (19%) and in the right upper extremity (18.6%). However, the differences in PVC insertion sites were not significant (p = .400). Very similar results were found in a systematic literature review of 24 studies involving 16,562 PVCs aimed to compare the incidence of PVC-related complications between catheterization in the forearm and back of the hand (Fan et al., 2022). The authors found no significant differences between PVC placement in the forearm and back of the hand in terms of the incidence of complications. These data are consistent with those found by Liu et al. (2022) in an observational and prospective study in a single hospital in China with a sample of 1,069 patients over a 5-month period. Liu et al. (2022) found that the risk of complications was higher when PVCs were inserted in the back of the hand and antecubital fossa. Our study shows a higher incidence of local complications with 22-gauge PVCs. These results are aligned with the secondary analysis of 12 prospective studies aimed to identify risk factors associated with PVC failure (Marsh et al., 2021). These authors found a higher risk of PVC-related local complications in 22- and 24-gauge catheters than in 14- and 18-gauge catheters. They suggested that the size of polyurethane catheters may be responsible for this difference, which is shorter in the PVCs mentioned above (2.5 cm and 1.9 cm, respectively), reducing the movement of the catheter inside the blood vessels and leading to irritation or damage.

Conclusion

The sample consisted mainly of male patients (54.2%). The frequency of local complications was higher among women (20.8%). The mean age was 70.13±13.1 years, with 60.4% over 65. The mean age was higher in the group with local complications (70.8 years). Local complications were more frequent in the group of patients over 65, in the back of the hands, and with 22-gauge PVCs. The results also show that local complications are more frequent when irritant drugs are administered and when there is a lack of adherence to the bundles. An association was found between PVC dwell time and the frequency of complications, with longer dwell times increasing the number of complications. Therefore, we consider it appropriate to continuously assess the need for PVCs, remove them when they are no longer necessary, and use other methods for intravenous administration of vesicant or irritant drugs. The limitations of this study include the small sample collected in a short period of time and the fact that important aspects such as the training of nurses responsible for handling PVCs and the route of drug administration (e.g., dilution and infusion pumps) were not considered. Future studies in Portugal should include larger samples of critically ill patients and address these limitations.

Author contributions

Conceptualization: Mota, S. M., Martins, M. D.
Data curation: Mota, S. M., Martins, M. D.
Formal analysis: Mota, S. M., Martins, M. D.
Investigation: Mota, S. M., Martins, M. D.
Methodology: Mota, S. M., Martins, M. D.
Project administration: Martins, M. D.
Resources: Mota, S. M., Martins, M. D.
Supervision: Martins, M. D.
Validation: Mota, S. M., Martins, M. D.
Visualization: Mota, S. M., Martins, M. D.
Writing - original draft: Mota, S. M., Martins, M. D.
Writing - review and editing: Mota, S. M., Martins, M. D.

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